PROCEEDINGS

NATIONAL CONVENTION OF AGRICULTURAL AND FOOD ENGINEERING 2019

MSAE

MALAYSIAN SOCIETY OF AGRICULTURAL ENGINEERS

Est. 1982

21 MARCH 2019

WISMA TANI, PUTRAJAYA

Scan me

Second Edition Published in 2019 by the Malaysian Society of Agricultural Engineers.

ISBN 978-967-16145-1-8

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Malaysian Society of Agricultural Engineers (2019 : Faculty of Engineering, UPM, Malaysia)
Convention MSAE 2019

Editors: Azman Hamzah, Hasfalina Che Man, Muhammad Hazwan Hamzah, Nurulhuda Khairudin, Mohd Zuhair Mohd Nor, Rosnah Shamsudin.

All the published papers has been reviewed by Prof. Ir. Dr. Desa Ahmad, Prof. Ir. Dr. Azmi Dato' Yahya, Assoc. Prof. Dr. Rosnah Shamsudin, Assoc. Prof. Dr. Hasfalina Che Man, Dr. Muhammad Razif Mahadi, Dr. Muhammad Hazwan Hamzah, Dr. Mohd. Zuhair Mohd. Nor, Dr. Nurulhuda Khairudin, Puan Aeshah Ismail, Dr. Azman Hamzah, Dr. Zainun Mohd Shafie, Dr. Badaruzzaman Mohamad Noh, En. Hasmin Hakim Hasbullah, En. Yahya Sahari, Sharifah Hafiza Binti Mohd Ramli, Pn. Afiqah Aina Rahim, En. Mohd Taufik Bin Ahmad, En. Rohazrin Bin Abdul Rani, Ir. Dr. Badril Hisham Bin Abu Bakar, Dr. Siti Noor Aliah Binti Baharom, Pn. Arina Binti Mohd Noh, En. Amir Syariffuddeen Bin Mohd Adnan and Dr. Masniza Binti Sairi.

MAIN ORGANISER

Malaysian Society of Agricultural Engineers

VENUE ORGANISER

Department of Agriculture Malaysia

CO-ORGANISERS

Department of Biological and Agricultural Engineering, Universiti Putra Malaysia

Department of Process and Food Engineering, Universiti Putra Malaysia

Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA

Farmers' Organisation Authority (LPP)

Malaysian Palm Oil Board (MPOB)

Malaysian Agricultural Research and Development Institute (MARDI)

National Hydraulic Research Institute of Malaysia (NAHRIM)

Malaysian Rubber Board (LGM)

Forest Research Institute Malaysia (FRIM)

Department of Fisheries Malaysia

Kemubu Agricultural Development Authority (KADA)

Politeknik Kota Bharu

Integrated Agricultural Development Area (IADA), Northwest Selangor

Federal Land Consolidation and Rehabilitation Authority (FELCRA)

BACKGROUNDS OF MSAE

MALAYSIAN SOCIETY OF AGRICULTURAL ENGINEERS
Est. 1982

The Malaysian Society of Agricultural Engineers or MSAE is a learned society established in 1982. It is a professional and technical organization with members who are interested in engineering knowledge and technology for food, agriculture, associated industries and related resources. The founding members are mainly lecturers in the Department of Biological and Agricultural Engineering or DBAE, University Putra Malaysia or UPM who have obtained their highest degrees from US universities. Hence, they are very familiar with the American Society of Agricultural and Biological Engineers or ASABE, which is an active professional engineering organization internationally with more than 8000 members worldwide.

Agricultural Engineering education in Malaysia started as far back as 1961. However, a full bachelor degree program in Agricultural Engineering was introduced at the Faculty of Agricultural Engineering (now Faculty of Engineering), Universiti Pertanian Malaysia (now Universiti Putra Malaysia or UPM) in 1975. The first batch of agricultural engineers graduated in 1979. The diploma program in Agricultural Engineering was introduced at the Faculty in 1980.Since then, the Agricultural Engineering professionals (i.e Agricultural Engineers and Agricultural Engineering Technical Assistants) have significantly contributed to the development of agriculture in the country. To date there are about 1500 Agricultural Engineers and Agricultural Engineering Technical Assistants in Malaysia involving in both agricultural and non-agricultural fields.

MSAE members are employed mainly by government departments and agencies, universities and colleges, palm oil mills and plantations, agricultural machinery companies, irrigation companies, and agricultural and food processing plants. In the government departments and agencies, they are either in the research fields such as in the Malaysian Agricultural Research and Development Institute (MARDI), Malaysian Palm Oil Board (MPOB), Malaysian Rubber Board (LGM), Malaysian Cocoa Board (LKM), Malaysian Pineapple Industry Board (MPIB), and (Forrest Research Institute Malaysia (FRIM) or in the service fields such as in the Department of Agriculture (DOA), Department of Environment (DOE), and Farmers' Organization Authority (LPP).

The main activities of MSAE include organizing short courses, seminars, workshops and conferences; publications; social, sports and recreational activities and technical visits especially for members of the MSAE-Student Chapter. A national conference entitled 'Engineering SMART Farming' was organized by MSAE and DBAE-UPM in March 1999 to commemorate 25 years of teaching, research, consultancy and extension in agricultural engineering in Malaysia. The national founding landmark of AE curriculum and the national founding landmark of MSAE were officially launched at UPM in 2016 to commemorate the 41 years of teaching, research, consultancy and extension in agricultural engineering in Malaysia and the 34 years establishment of the professional engineering association in Malaysia.

COMMITTEE MEMBERS OF MSAE CONVENTION 2019

Chairman	: Assoc. Prof. Dr. Rosnah Shamsudin
Vice Chairman	: Ms. Airul Asmiza Khaeruddin
Secretary I	: Dr. Mohd. Salahuddin Mohd Basri
Secretary II	: Mr. Mohamad Razi Mad Amin
Treasurer I	: Dr. Noor Zafira Noor Hasnan
Treasurer II	: Ir. Dr. Mohammad Effendy Ya'acob
Publication	: Dr. Azman Hamzah
Editorial Board	: Assoc. Prof. Dr. Hasfalina Che Man
	: Dr. Muhammad Hazwan Hamzah
	: Dr. Nurulhuda Khairudin
	: Dr. Mohd Zuhair Mohd Nor
	: Dr. Azman Hamzah
Registration	: Dr. Mohamad Firdza Mohamad Shukery
	: Dr. Mahirah Jahari
Promotion and Sponsor	: Mr. Ahmad Puzi Abu Bakar
Publicity	: Dr. Anas Mohd Mustafah
	: Dr. Mohd Nazren Radzuan
Technical and Protocol	: Ms. Airul Asmiza Khaeruddin
Food and Beverages	: Dr. Mohd Zuhair Mohd Nor
	: Dr. Diyana Binti Jamaludin
	: Ms. Rosnani Hassan
Certificate and Appreciation	: En. Zamzuri Zabidin
	: Dr. Intan Syafinaz Mohamed Amin Tawakkal
	: Miss Nur Hamizah Abdul Ghani @ Hashim
Media	: Ms. Zanariah Mohd Dom
Speech text	: Dr. Muhammad Razif Mahadi
Emcee	: Dr. Mohd Zuhair Mohd Nor

Agency Representatives:
Assoc. Prof. Dr. Siti Khairunniza Bejo - Department of Biological and Agricultural Engineering, UPM
Assoc. Prof. Dr-Ing Mohd Noriznan Mokhtar - Department of Process and Food Engineering, UPM
Ms. Airul Asmiza Khaeruddin - Department of Agriculture Malaysia
Dr. Azman Hamzah - Malaysian Agricultural Research and Development Institute (MARDI)
Dr. Goh Sou Sheng - Malaysian Rubber Board (LGM)
Mr. Noor Azme Omar - National Hydraulic Research Institute of Malaysia (NAHRIM)
Mr. Zaifiwan Mat Zin - Integrated Agricultural Development Area (IADA) Northwest Selangor
Mr. Mohd Ikmal Hafizi Azaman - Malaysian Palm Oil Board (MPOB)
Ir. Mazelan Ramli - Department of Fisheries Malaysia
Dr. Alawi Sulaiman - Faculty of Plantation and Agrotechnology, UiTM Melaka
Ms. Rosnani Hassan - Politeknik Kota Bharu
Mr. Mohd. Fairus Mohamad Yusuf - Federal Land Consolidation and Rehabilitation Authority (FELCRA)
Mr. Mat Zaini Mohd Yusof - Farmers' Organisation Authority (LPP)
Ir. Mohd Anuar Musardar Yusoff - Kemubu Agricultural Development Authority (KADA)
Dr. Faszureena Jamaludin- Forest Research Institute Malaysia (FRIM)

POSTHARVEST AND FOOD ENGINEERING (PFE)

AGRICULTURE MACHINERY AND AUTOMATION (AMA)

AGRICULTURE INFORMATION AN TECHNOLOGY (AIT)

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian dan Industri Asas Tani, Putrajaya

MSAE2019-ARWM01

Peranan Jurutera Jabatan Pertanian : Merealisasikan Sumber Rezeki Baru (Durian, Kelapa , Jagung Bijian Dan Napier)

S.S Mohd Yusoff[1],K.Airul Asmiza[2], M.A Mohamad Razi[3], S.Mohd Khairulnizam[3]
Bahagian Kejuruteraan Pertanian, Jabatan Pertanian, Kementerian Pertanian Dan Industri Asas Tani, 43400, Serdang, Selangor, Malaysia.
Corresponding Author : Tel: 03-89486302, Email : airul@doa.gov.my

Abstrak
Pertanian kini dilihat sebagai suatu bidang yang sangat penting dalam menjamin pembangunan ekonomi negara dan mampu menjana pendapatan serta sumber rezeki kepada para petani dan usahawan pertanian. Dalam memastikan bekalan makanan Negara mencukupi dan kebergantungan terhadap barangan/produk import, peralihan era globalisasi kearah pemodenan sektor pertanian adalah amat perlu melalui penerimaan atau pengaplikasian teknologi serta cetusan-cetusan idea inovasi baru. Hasrat kerajaan untuk merealisasikan "Sumber Rezeki Baru" melalui komoditi durian, kelapa, jagung dan napier memberi satu cabaran kepada jurutera Bahagian Kejuruteraan Pertanian, Jabatan Pertanian Malaysia untuk bersama-sama menjalankan tanggungjawab dari segi idea dan sumbangan tenaga serta khidmat sokongan teknikal untuk memastikan kelancaran dan kelestarian pelaksanaan projek-projek pembangunan pertanian . Justeru peranan jurutera pertanian penting dalam memacu kearah pencapaian matlamat Pembangunan Industri Pertanian Negara.

Kata kunci : Era Globalisasi, Pemodenan, Pengaplikasian Teknologi, Sumber Rezeki Baru, Kelestarian.

Pengenalan

Rancangan Malaysia kesebelas (RMke-11) bagi tempoh 2016 hingga 2020 bagi teras merekayasa pertumbuhan negara memberi tumpuan kepada pengukuhan asas ekonomi dalam memacu Malaysia ke arah transformasi daripada negara berpendapatan sederhana kepada negara berpendapatan tinggi. Sektor pertanian telah mendapat perhatian khusus melalui Bajet 2019 di mana bagi meningkatkan sumbangan pertanian dalam ekonomi negara kerajaan telah mewujudkan 'Sumber Rezeki Baru' (SRB) untuk meningkatkan pendapatan golongan sasar. Pelbagai inisiatif telah dirancang dan dilaksana berteraskan konsep memodenkan sektor pertanian dengan mempercepat penerimagunaan teknologi pertanian, menyediakan infrastruktur yang cekap dan menggalakkan pendekatan berasaskan kluster bagi tanaman terpilih iaitu tanaman durian, kelapa dan jagung bijian.

Jabatan Pertanian terlibat secara langsung di dalam merealisasikan SRB ini secara teratur dan memberikan impak positif kepada rakyat. Di dalam pelaksanaan program ini, Bahagian Kejuruteraaan Pertanian, Jabatan Pertanian (BKP) dengan kekuatan 32 orang Jurutera Pertanian dengan 9 buah Pusat Kejuruteraan Pertanian seluruh negara telah memainkan peranan penting di dalam memberikan sokongan teknikal dan khidmat nasihat kejuruteraan pertanian di dalam pelbagai urusan perolehan kerajaan dan bantuan teknikal kepada agensi, usahawan dan petani. Jurutera-jurutera ini membantu didalam memastikan jenis dan pakej amalan teknologi kejuruteraan dapat digunakan dengan berkesan dan seterusnya memastikan pelaksanaan projek pertanian berada pada kos yang terkawal.

Sumber Rezeki Baru - SRB

Pembangunan Industri Durian, Kelapa , Jagung Bijian dan Napier

Dalam merealisasikan hasrat murni kerajaan untuk meningkatkan pendapatan golongan sasar khasnya petani, dasar SRB yang telah diumumkan; telah dilaksanakan oleh Jabatan Pertanian. Semua proses pembangunan ini dirancang dan melibatkan pelbagai pihak sama ada kerajaan pusat, kerajaan negeri, pihak swasta dan petani supaya proses transformasi ini dapat diuruskan dengan baik dan penyelarasan setiap aktiviti terlibat dipermudahkan. Status terkini tanaman terpilih dan sasaran pembangunan SRB ditunjukkan seperti Jadual 1. Jabatan Pertanian telah mengesyorkan beberapa varieti terpilih bagi setiap tanaman SRB seperti Jadual 2 berdasarkan permintaan yang tinggi dan harga pasaran yang menarik.

Jadual 1: Keluasan bertanaman, pengeluaran dan sasaran bagi tanaman Sumber Rezeki Baru (SRB) (Laporan Sumber Kekayaan Baru, Jabatan Pertanian - 2018)

Tanaman	Keluasan Bertanam (Ha)	Pengeluaran (Mt)	Sasaran SRB (Ha)
Durian	66,037.00	302,645.80	1,050
Kelapa	84,600	504.8	2,800
Jagung Bijian	742.09	959.68	1620
Rumput Napier	131	630	920

Jadual 2: Tanaman Sumber Rezeki Baru (SRB) dan pengesyoran varieti oleh Jabatan Pertanian - Laporan Sumber Kekayaan Baru, Jabatan Pertanian (2018)

Tanaman	Varieti Disyorkan
Durian	Musang King (D197), D24, IOI (D168) Duri Hitam (D200)
Kelapa	Mataq, Pandan, MRD, MYD
Jagung Bijian	GWG 111, GWG 888

Peranan Jurutera Pertanian Jabatan Pertanian

Jurutera Pertanian telah memainkan peranan penting di mana kepakaran teknikal yang diberikan merangkumi pelbagai aspek pembangunan SRB bermula daripada fasa perancangan strategik, rekabentuk struktur, infrastruktur dan sistem pengairan, perolehan bekalan dan kerja, khidmat mekanisasi jentera dan mesin, pengendalian lepas tuai, penilaian projek swasta sehingga kepada perkongsian ilmu melalui program *Farmers Field School*. Jadual 3 menunjukkan penglibatan Jurutera Pertanian di Jabatan Pertanian sama ada secara langsung atau tidak langsung yang mana melibatkan sejumlah peruntukan sebanyak RM58.6 Juta di dalam peruntukan pembangunan SRB yang disalurkan kerajaan persekutuan pada Tahun 2018.

Aplikasi Teknologi Terkini dalam Pelaksanaan Sumber Rezeki Baru (SRB)

Bagi menjayakan program SRB di mana peruntukan yang diterima daripada kerajaan persekutuan perlu dibelanjakan pada tahun semasa dan mengikut garis panduan pelaksanaan projek pembangunan yang dikeluarkan Jabatan Pertanian, Jurutera Pertanian perlu sekurang-kurangnya membuat perolehan bekalan atau kerja bermula setiap Mac mengikut kalendar tahun semasa. Oleh itu, jurutera pertanian perlu mengadaptasi teknologi baru melaksanakan setiap aktiviti pembangunan SRB ini. Aplikasi teknologi terkini seperti penggunaan UAV (*Unmanned Arial Vehicle*), GPS (*Global Positioning System*), perisian CAD (*Computer Aided System)* dan GIS (*Global Information System*) terbukti menjadi penggalak di dalam kejayaan pelaksanaan projek SRB ini.

Aktiviti pemilihan kawasan merupakan nadi kepada kejayaan sesebuah projek pertanian. Penggunaan UAV telah terbukti memberikan dimensi baru di dalam aktiviti pemilihan kawasan projek. Jurutera pertanian di Jabatan Pertanian telah menguasai teknologi ini di mana penggunaan UAV jenis Fixed Wing dan Quadcopter membantu dalam aktiviti survei keseluruhan tapak cadangan kawasan pertanian selain dapat membantu jurutera membuat andaian kasar mengenai keadaan topologi sesebuah kawasan. Penggunaan UAV ini amat bertepatan dengan kehendak pelanggan Jabatan Pertanian pada masa kini di mana pihak stakeholder memerlukan data yang baik supaya keputusan dapat dibuat dengan cepat dan tepat. Daripada pengalaman Jabatan Pertanian, sebuah UAV jenis fixed wing dapat dioperasikan selama 30 minit dan dapat mencerap sehingga 80Ha bagi setiap penerbangan mengikut ketinggian tertentu manakala UAV jenis Quadcopter dapat beroperasi selama 20 minit dengan hasil cerapan kurang daripada 40 Ha. Bagi menghasilkan data peta kawasan yang baik ketinggian UAV antara 70 m ke 100 m diperlukan supaya resolusi sehingga *centimeter per pixel* dapat dihasilkan.

Keputusan daripada data UAV digabungkan dengan kemajuan teknologi GPS submeter gred, perisian CAD seperti AutoCAD, Autodesk Revit dan perisian GIS seperti ArcGIS dan QGIS telah menghasilkan keputusan yang memberangsangkan dalam penghasilan pelan kawasan dengan ketepatan kontor 1m. Ini banyak membantu jurutera pertanian dalam merekabentuk infrastruktur ladang seperti jalan ladang dan sistem saliran selain merekabentuk sistem pengairan dan sumber air yang berkesan. Tambahan lagi, penggunaan UAV ini telah membantu kerajaan menjimatkan kos dari aspek perkhidmatan pengukuran kawasan, tenaga kerja aktiviti survei kawasan daripada 5 hingga 6 orang kepada 2 orang dan menjimatkan masa sebanyak 70% untuk proses penghasilan peta topologi kawasan dan rekabentuk terperinci.

Teknologi sistem pengairan juga telah mendapat perhatian daripada golongan petani masa ini. Jurutera Jabatan Pertanian telah membantu pelbagai agensi seperti Felda, Lembaga Pertubuhan Peladang (LPP) dan usahawan di dalam proses merekabentuk sistem pengairan dan sumber air. Penyesuaian sistem pengairan ladang telah dilaksanakan oleh Jurutera Jabatan Pertanian dengan mengambil kira keperluan air tanaman, sumber air dan kedapatan barangan dan kos supaya pelaksanaan SRB ini memberikan pulangan yang lumayan kepada *stakeholder*. Jadual 4 menunjukkan penyesuaian sistem pengairan bagi pelaksanaan SRB ini.

Jadual 3: Keterlibatan JuruteraPertanian di Jabatan Pertanian bagi menjayakan program SRB.

Tanaman: Kelapa						
Program	**Tanam Semula/ Baru/ Pemulihan/ Transformasi Ladang**	**Peningkatan Pengeluaran Benih**	**Integrasi Tanaman/ Quick Win Project**	**Penyertaan Sektor Swasta**	**Pelan Strategik dan Pembangunan**	**Jumlah Peruntukan Keseluruhan SRB, RM**
Agihan Peruntukan, RM	35 Juta	10.6 Juta	3 Juta	0.3 Juta	0.8 Juta	50 Juta
Peranan Jurutera Pertanian	Infrastruktur asas spt Jalan Ladang dan Saliran.	Infrastruktur asas spt Jalan Ladang dan Saliran, Pembersihan Kawasan melalui khidmat mekanisasi, Rumah Naungan, Sistem Pengairan, Sumber Air, Inovasi Penuaian Kelapa (Pasca Tuai)				
Tanaman: Durian						
Tanaman / Program	Transformasi Ladang	Pengeluaran Benih Durian Premium	Pemerkasaan Teknologi	Pembangunan Piawaian Durian dan Tracebility		
Agihan Peruntukan, RM	12 Juta	1.0 Juta	4.0 Juta	3.0 Juta		20 Juta
Peranan Jurutera Pertanian	Khidmat Mekanisasi ke atas Pembersihan dan Penyediaan Kawasan, Penyediaan sistem pengairan, saliran dan perparitan, pembinaan titi, jalan ladang, pagar, bangsal & papan tanda, Pembinaan pusat pengumpulan & pemprosesan, stor dan peralatan, pengendalian lepas tuai, inovasi alat pembuka dan pemprosesan isi durian	Pusat Jualan Benih Durian, Sistem Pengairan dan Latihan (Farmers Field School)				
Tanaman: Jagung Bijian						
Tanaman / Program	Pembangunan Infra & Penyediaan Kawasan serta Pembangunan Tanaman	Penyediaan Jentera dan Mekanisasi	Kajian Penilaian Varieti	Penyelidikan/ Pembangunan Kawalan Kualiti		
Agihan Peruntukan, RM	10.58 Juta	7.76 Juta	5.58 Juta	5.50 Juta		29.42 Juta
Peranan Jurutera Pertanian	Rekabentuk ladang, Pembangunan Infrastruktur Asas, Sistem Pengairan dan Sumber Air, Pembersihan dan Pembangunan Kawasan menggunakan mekanisasi, Pembinaan Pusat Pengumpulan dan Pemprosesan/Loji	Mekanisasi penanaman, penuaian dan kerja-kerja lepas tuai termasuk kerja menaiktaraf loji sedia ada.				

Tanaman: Rumput Napier				
Tanaman / Program	Penyediaan Kawasan	Perolehan Mesin Penanam, Traktor dan Forage Havester	Kerja-Kerja Pengembangan & TOT	Jumlah Peruntukan Keseluruhan SRB, RM
Agihan Peruntukan, RM	2,936,000	1,000,000	300,000	4,236,000
Peranan Jurutera Pertanian	Rekabentuk ladang, Pembangunan Infrastruktur Asas, Sistem Pengairan dan Sumber Air, Pembersihan dan Pembangunan Kawasan dengan mewujudkan ladang perintis	Mekanisasi penanaman, pembajakan, penuaian dan selepas tuai.	Seminar, Kursus dan Lawatan.	

Jadual 4: Penyesuaian sistem pengairan bagi tanaman SRB dan jenis kepala perenjis yang disyorkan. (Laporan Sumber Kekayaan Baru, Jabatan Pertanian - 2018)

Tanaman	Bilangan Pokok / Hektar	Anggaran Keperluan Air Tanaman (Liter/ Pokok/ Hari)	Sistem Pengairan/ Emitter
Durian	121	40	Titis/ Perenjis Octa8 4l/hr
Kelapa	270	14	Titis/ Perenjis Octa8 4l/hr
Jagung Bijian	58000	1	Renjis/ Perenjis 353 4gpm

Mekanisasi bagi Sumber Rezeki Baru

Mekanisasi telah menjadi input yang paling intensif dalam pertanian moden. Kebanyakan Pakar dalam bidang pertanian telah bersetuju bahawa faedah mekanisasi atau penggunaan jentera/mesin pertanian yang paling jelas adalah ia dapat mengurangkan kos pengeluaran dengan menggantikan operasi tunggal kepada penggabungan operasi yang secara tidak langsung menggurangkan penggunaan tenaga buruh. Selain meningkatkan kecekapan dan operasi Kerja serta menjimatkan masa; penggunaan mekanisasi dapat menjadikan kerja yang dilaksanakan lebih menarik dan mudah dilakukan.

Jurutera-jurutera Jabatan Pertanian telah diberi mandat untuk mengenalpasti dan membuat penilaian teknikal terhadap kesesuaian penggunaan jentera dengan sesuatu komoditi khususnya di bawah Sumber Rezeki Baru melibatkan pelaksanaannya di Semenanjung Malaysia, Sabah dan Sarawak. Di bawah Peruntukan yang disalurkan, perolehan terhadap Jentera Berat dan Mesin yang perlu dan bersesuaian di sepanjang nilai rantaian makanan komoditi-komoditi di bawah Sumber Rezeki Baru dipertingkatkan. Ini merangkumi aspek pembangunan kawasan, penuaian dan pengendalian lepas tuai bagi merealisasikan hasrat Kerajaan terhadap pembangunan industri Pertanian ini.

Bahagian Kejuruteraan Pertanian yang merupakan salah satu bahagian sokongan teknikal dalam Jabatan Pertanian dipertanggungjawabkan juga oleh Kementerian Pertanian untuk memberi khidmat penggunaan Jentera/mesin serta operator kepada para petani dan usahawan serta agensi di bawah Kementerian Pertanian.

Teknologi dan Inovasi Pertanian bagi Sumber Rezeki Baru (SRB)

Pengembangan agroindustri untuk meningkatkan nilai tambah petani serta usahawantani terus digalakkan dan dipertingkatkan. Peranan inovasi teknologi makin strategis dalam usaha meningkatkan produktiviti dan efisiensi sistem pengeluaran. Pengembangan agroindustri tidak terlepas dari pemanfaatan teknologi mekanisasi. Pertumbuhan agroindustri desa yang mandiri dan disokong oleh teknologi mekanisasi merupakan lonjakan dalam mewujudkan industri pertanian yang efisien, berdaya saing dan berdaya maju.

Pelbagai alat dan mesin telah direkabentuk dan ditambahbaik bagi memudahkan operasi kerja melibatkan petani dan usahawantani. Sehingga kini Jabatan telah menghasilkan lebih kurang 120 inovasi bukan sahaja melibatkan komoditi di bawah sumber rezeki baru malah kesemua komoditi di bawah Jabatan Pertanian. Antara alat yang telah direkabentuk dan diubahsuai adalah seperti alat penanam biji benih jagung secara manual, mesin pelerai Jagung Bijian, Alat Pemanjat Pokok Kelapa, Mesin Pengupas Sabut Kelapa, Alat Pembuka Durian Secara Manual dan Alat Pengasing Biji Durian. Prototype yang dihasilkan dikongsi bersama dengan para usahawan dan petani serta Jabatan dan Agensi bagi memudahkan operasi kerja. Jabatan Pertanian sentiasa/akan mencari kaedah bagi memudahkan kerja-kerja petani ataupun usahawan di lapangan. Justeru itu, Pihak industri juga dilibatkan sebagai rakan strategik bagi merealisasikan hasrat Kerajaan ke arah Pencapaian Industri Pertanian yang produktif dan Progresif serta berdaya Maju menjelang tahun 2020 melalui penghasilan inovasi dan penggunaan teknologi terkini.

References

Ahmad, Z.M.S (2016). Garis Panduan Pelaksanaan Projek Pembangunan di bawah Peruntukan Jabatan Pertanian, 150 p. Putrajaya: Jabatan Pertanian.

M. Azmin, A. (2018). Kajian Separuh Penggal Rancangan Malaysia ke-11, 348 p. Putrajaya: Kementerian Hal Ehwal Ekonomi.

Laporan Sumber Kekayaan Baru di bawah Peruntukan Jabatan Pertanian (2018). Putrajaya: Jabatan Pertanian.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019 ***MSAE2019-ARWM02***
21 Mac 2019, Wisma Tani, Kementerian Pertanian & Industri Asas Tani Malaysia, Putrajaya

Pembangunan Kaedah Pembiakan Tongkat Ali Daripada Biji Benih Di Stesen Penyelidikan FRIM Maran, Pahang

Syazwan A.[a], Nadiah Salmi N.[b], Fadzureena J.[a], Hada Masayu I.[a], Sharmizi I.[a] & Nor Azah M. A.[a]
Bahagian Hasilan Semulajadi, Institut Penyelidikan Perhutanan Malaysia (FRIM). 52109 Kepong, Selangor
Tel : 09-546 9918 E-mail : syazwan@frim.gov.my

Abstrak
Pembangunan kaedah pembiakan tongkat ali daripada biji benih telah dijalankan di Stesen Penyelidikan FRIM Maran, Pahang. Tujuan membaik biak tanaman tongkat ali adalah untuk menghasilkan bahan tanaman yang berkualiti tinggi dan menjamin variasi genetik dalam populasi baka. Ia turut menekankan aspek peningkatan pengeluaran biji benih dan efisien. Kaedah ini melibatkan beberapa fasa iaitu pemilihan biji benih, pengeringan dan pra-rawatan, semaian, pemindahan, serta penjagaan sebelum di tanam ke plot. Pelbagai aspek telah diambil kira untuk memastikan keberkesanan kaedah pembiakan antaranya kualiti biji benih, jenis medium, kelembapan persekitaran serta penjagaan menyeluruh. Faktor lain yang mampu merencatkan pertumbuhan juga perlu diberi perhatian seperti serangan penyakit, serangga perosak dan haiwan liar serta pembiakan rumpai. Kaedah ini juga sesuai diaplikasikan bagi pembiakan tanaman tongkat ali untuk skala besar.

Kata Kunci : Pembiakan,Baik biak, Biji benih, Tongkat Ali, Genetik

Pengenalan

Tongkat ali atau dikenali juga sebagai pasak bumi adalah sejenis tanaman saka yang terdapat di hutan Malaysia ,Indonesia dan beberapa kawasan di Thailand, Vietnam dan Laos. (Rajeeev *et al.*,2010) Nama botaninya ialah *Eurycoma longifolia* daripada keluarga Simaraubaceae.,Tongkat ali merupakan sejenis tumbuhan yang dikatakan mempunyai kemampuan merawat pelbagai penyakit seperti malaria, demam, ulser, sitotoxic dan lemah tenaga batin (Jagananth,2000). Dalam keadaan semulajadinya di hutan, ia tumbuh dengan kadar yang perlahan, boleh mencapai ketinggian sehingga 10 ~15 m dengan garis pusat batang berukuran 20 cm. Bunganya tersusun padat pada tangkai yang bercabang keluar dari pangkal daun.Daunnya berbentuk bujur tersusun secara berpasangan pada satu tangkai . Terdapat 20–30 pasang anak daun bagi setiap tangkai daun. Tangkai daun tersusun secara "spiral", sama ada mengikut pusingan jam atau melawan pusingan pada paksi batang.
Stesen penyelidikan FRIM Maran, Pahang melakukan pembiakan tongkat ali untuk di tanam di lapangan bagi tujan penyelidikan dan sebagainya. Pelbagai kaedah yang digunakan seperti pemilihan biji benih, pengeringan dan rawatan, semaian, pemindahan dan juga penjagaan.

Bahan Dan Kaedah

Beberapa kriteria perlu diberi penekanan bagi memastikan pengeluaran tanaman Tongkat Ali adalah banyak dan berkualiti tinggi. Pemilihan biji benih dilakukan dengan kutipan daripada pokok ibu yang mempunyai ciri-ciri yang bagus. Pemantauan fenologi (perubahan fisiologi pokok yang berlaku secara berkala dengan perubahan cuaca dan musim) akan membantu kutipan pada peringkat kematangan yang diingini. Biji benih yang telah dikutip perlu melalui proses pengeringan yang menyeluruh di kawasan teduhan yang kering. Skarifikasi biji benih dengan menggunakan kertas pasir sebagai kaedah pra-rawatannya adalah penting dalam mempercepatkan proses percambahan Tongkat Ali ini. Seterusnya proses semaian menggunakan pasir sungai sebagai medium dan dibiarkan selama tempoh 4-8 minggu adalah bertujuan memudahkan proses pengakaran. Proses pemindahan dilakukan apabila anak pokok mempunyai dua pelepah daun yang diletakkan dalam polibeg berukuran 5 inci x 8 inci ke rumah teduhan. Anak-anak pokok ini memerlukan rawatan dan pemerhatian setiap 3 bulan dan memerlukan pembajaan yang cukup menggunakan baja NPK dan organik. Racun serangga dan kulat digunakan sekiranya terdapat ancaman terutama daripada ulat harimau yang sering merosakkan tanaman Tongkat Ali. Pokok akan mengeluarkan akar serta daun yang banyak dan sedia ditanam ke lapangan setelah berumur antara 6 ke 12 bulan sepertimana Gambarajah 1.

Gambarajah 1: Anak Pokok Tongkat Ali 6-12 Bulan

Keputusan Dan Perbicangan

Kaedah pengutipan biji benih perlu betul iaitu dari atas pokok untuk jaminan kualiti . Biji benih yang telah gugur atas tanah mudah rosak dan terdedah kepada serangan kulat dan serangga. Pemilihan biji benih yang telah matang juga amat penting untuk menjamin kadar peratusan percambahan yang tinggi. Biji benih dengan majoriti warna perang kehitaman pada keseluruhan merupakan pilihan utama. Ujian percambahan yang dilakukan di Makmal Teknologi Biji Benih FRIM mencapai peratus percambahan 82.5 % melalui pra-rawatan dengan bilasan racun kulat *benlate* dan skarifikasi biji benih dengan menggunakan kertas pasir. Biji benih yang dilakukan pra-rawatan skarifikasi ini akan menipiskan lapisan kulit luar biji benih (seed coat) yang mempercepatkan proses percambahan.

Medium pasir sungai digunakan bagi membolehkan akar biji benih tumbuh dengan mudah kerana mempunyai kepadatan yang rendah. Kebiasaan anak benih akan bercambah selepas 25-30 hari penanaman dengan peratusan mencecah 85 %. Manakala, mengikut Chan L.K. et al., 2002, pengunaan pelet jiffy mengambil masa antara 35 hingga 85 hari dengan kadar hanya 46% percambahan.

Kelembapan persekitaran dan kadar hujan yang tinggi penting untuk pembuahan pokok tongkat ali dan kutipan anak benih. kebiasaannya berlaku pada awal tahun dan pertengahan tahun. Buah akan sepenuhnya matang selepas 1 hingga 2 bulan dari tempoh putik buah terbentuk dan sebelum sedia dikutip. Tempoh masa yang diperlukan untuk melalui kesemua proses ini dinyatakan dalam Jadual 1.

Jadual 1 : Tempoh penanaman Tongkat Ali di Stesen Penyelidikan FRIM pada 2017

Peringkat	Tempoh Masa
Kutipan biji benih	1 minggu
Penyediaan Biji Benih	1-2 Bulan
Peringkat Semaian	4-8 Minggu
Peringkat Pembesaran	6-12 Bulan
Penuaian Hasil	3 Tahun Ke Atas

Kesimpulan

Pembiakan tongkat ali melalui biji benih merupakan satu kaedah yang berkesan dan optimum kerana mempunyai peratus percambahan yang tinggi dan mampu menghasilkan kuantiti yang banyak dalam satu-satu masa. Aplikasi penanaman Tongkat Ali dalam skala yang lebih besar adalah digalakkan agar pihak industri sentiasa mendapat bekalan yang mampan dan berkualiti bagi tujuan komersialisasi.

Rujukan

Chan Lai Keng, Su Tiing Sai & Chris K.H. Teo (2002). A Preliminary Study on the Germination of *Eurycoma longifolia* Jack (Tongkat Ali) Seeds

Jaganath IB, NG LT. Herbs. (2000) The Green Pharmacy of Malaysia, Kuala Lumpur, Vinpress and Malaysia Agricultural Research and Development Institute. 2000:95-9

Rajeev Bhat, A.A Karim. (2010) Tongkat Ali (*Eurycoma longifolia Jack*) : A Review on its ethnobotany and pharmacological importance. Fitoterapia,2010:81:669-679.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019 ***MSAE2019-ARWM03***
21 Mac 2019, Wisma Tani, Kementerian Pertanian dan Industri Asas Tani Malaysia, Putrajaya

Usaha Penanaman Secara Organik Herba Daripada Hutan Bagi Menjamin Kelestarian Sumber Bahan Mentah

Sharmizi I, Syazwan A, Hada Masayu I, Fadzureena J, Nor Azah M A, Mohd Shahidan A.,Khairul Kamilah A. K., Fadhilah Z., Mahmud Husni A. H.
Bahagian Hasilan Semulajadi, Institut Penyelidikan Perhutanan Malaysia (FRIM) 52109 Kepong, Selangor
Tel : 09-546 9919 E-mail : sharmizi@frim.gov.my

Abstrak
Pembangunan plot penanaman herba organik telah dijalankan oleh FRIM bermula pada tahun 2008. Stesen Penyelidikan FRIM di Maran, Pahang telah dipilih sebagai lokasi untuk penanaman herba Patawali (Tinospora crispa) berdasarkan kesesuaian kawasan. Kesesuaian bagi mewujudkan plot tanaman organik herba pertama di Malaysia. Kesesuaian yang dimaksudkan termasuklah lokasinya yang strategik bersebelahan Hutan Rezab Betung, aktiviti stesen yang ditumpukan kepada penghasilan bahan tanaman herba berkualiti serta fasiliti lengkap seperti ladang herba, fasiliti fizikal ladang serta sebuah Pusat Pemprosesan Herba Lepas Tuai (PHT). Survei terhadap kesesuaian kawasan dan keadaan tanah telah dilakukan pada plot tanaman bagi memenuhi keperluan MyOrganik. Keperluan teknikal juga menjadi perkara utama bagi pembangunan plot tanaman termasuklah pengurusan tanah, sumber air dan penghasilan bahan tanaman.

Kata Kunci : Patawali, Organik, SPF Maran, MyOrganik,, Survei, Pusat Pemprosesan Herba Lepas Tuai (PHT)

Pengenalan

Di dalam Rancangan Malaysia ke-10 (RMK10), Stesen Penyelidikan FRIM Maran, Pahang (SPF Maran) telah merangka usaha bagi menjadikan stesen ini sebagai pusat rujukan untuk aktiviti penanaman herba secara ladang. Penyediaan dan pembangunan plot penanaman spesies herba dengan mengikut garis panduan Jabatan Pertanian Malaysia telah dijalankan. Pertanian organik mula popular di negara ini meskipun berkembang secara perlahan berbanding negara-negara rantau ASEAN yang lain. Situasi tersebut menunjukkan petanda negatif dalam pembangunan industri pertanian negara memandangkan masyarakat Malaysia mula mencari produk makanan berasaskan organik sebagai keperluan mereka. Berdasarkan potensi yang cerah dalam pasaran serta peningkatan pemahaman orang ramai terhadap produk organik ini telah mendorong FRIM menceburi bidang penyelidikan berkaitan.

Usaha FRIM dalam mewujudkan plot tanaman secara organik dilihat sangat signifikan selari dengan perkembangan industri pertanian organik ladang herba yang berstatus organik dengan berkeluasan 1 ekar ini memberi nilai tambah kepada produk penyelidikan yang bakal dihasilkan. Selain tanaman herba yang dihasilkan lebih sihat, ia juga bebas dari baki sisa racun. Kajian yang bermula pada tahun 2008 dan masih dijalankan ini akan memastikan produk yang bakal dihasilkan berkualiti dan selamat digunakan. Selain itu, kualiti herba di peringkat ladang juga diambilkira dengan mengkaji penentuan masa penuaian bagi mendapatkan hasil yang optimum. Kajian seumpama adalah sangat perlu terutamanya bagi meningkatkan mutu produk negara memandangkan industri pertanian organik secara mesra alam dan mapan semakin mendapat tempat di pasaran tempatan mahupun antarabangsa. Ini dilihat dengan lambakan bukan sahaja produk-produk organik tempatan malahan produk-produk organik dari luar juga turut menembusi pasaran tempatan.

Pekerja yang terlibat secara langsung dalam industri pertanian organik juga dapat meningkatkan pengetahuan,
kesedaran dan kemahiran. Di Stesen Penyelidikan FRIM Maran, Pahang, kakitangan didedahkan tentang cara-cara penggunaan racun perosak dan baja kimia yang betul. Selain itu, kaedah penuaian dan pengendalian pasca tuai hasil turut diterangkan bagi mengelakkan kerosakan dan memelihara kualiti fizikal hasil tuaian.

Kebanyakan produk organik di pasaran lebih tertumpu kepada kategori buah-buahan dan sayur-sayuran. Pada tahun 2010 hanya satu sahaja tanaman dalam kategori herba dipersijilkan dengan pensijilan organik, iaitu plot penyelidikan patawali (*Tinospora crispa)* yang terletak di Stesen Penyelidikan FRIM Maran, Pahang, malah mendapat anugerah pensijilan Malaysia Book of Records (MBOR) kerana berjaya mendapatkan pensijilan MyOrganik melalui penanaman kategori herba. Antara objektif SPF Maran adalah i) penghasilan sumber bahan mentah herba yang berkualiti dan selamat, ii) menyokong penghasilan produk herba yang berkualiti, dan selamat dan iii) mewujudkan plot tanaman organik herba yang akan menjadi sumber rujukan industi herba setempat. Pensijilan organik bagi tanaman dalam kategori herba ini dijangka akan meningkat dari tahun ke tahun memandangkan kesedaran yang tinggi oleh pengguna dan pihak industri terhadap faedah membeli hasil pertanian yang dikeluarkan melalui ladang-ladang yang diiktiraf pensijilan MyOrganik.

Kaedah dan Perbincangan

Menurut manual piawai skim MyOrganik, terdapat 9 perkara teknikal yang perlu diberi perhatian (Malaysian Standard MS 1529:2015). Di bawah dibincangkan perkara teknikal utama melibatkan kerja-kerja di lapangan bagi pembangunan tanaman organik di SPF Maran, Pahang.

Pengurusan Kawasan dan Tanah

Patawali tumbuh baik dihampir semua jenis tanah dan berbagai keadaan iklim. Di SPF Maran, patawali ditanam di puncak bukit. Oleh yang demikian, pemuliharan tanah perlu diamalkan bagi mengelak hakisan di puncak bukit seperti lebar teres, tanaman penutup bumi, sungkupan dan bahan organik perlu dititikberatkan. Jarak penampan juga perlu diambil kira bagi memenuhi kriteria penilaian. (Jadual 1)

Jadual 1 : Laporan Pemeriksaan Tapak SPF Maran

Kedudukan Zon	Utara	Selatan	Timur	Barat
Jenis Penampan	**Hutan Sekunder**	**Hutan**	**Hutan**	**Belukar**
Lebar Zon (m)	**>5**	**>5**	**>5**	**>5**
Ketinggian Penampan	**>5**	**>5**	**>5**	**<2**
Kepadatan Penampan (%)	**70%**	**90%**	**90%**	**50%**
Perbezaan levasi (±m)	**<3**	**>5**	**>5**	**<3**
	3	**>3**	**>3**	**>3**

Pengurusan Air

Terdapat 3 sumber air utama iaitu anak sungai dan 2 telaga tiub.Sumber air dipastikan bersih dan selamat untuk tujuan pengairan. Jadual 2 merupakan analisa makmal bagi penentuan kualiti air yang digunakan (**Laporan keputusan ujian logam berat,2008**).

Jadual 2 : Laporan keputusan ujian logam berat 2008

	Logam berat			
	Plumbum	**Merkuri**	**Kadmium**	**Arsenik**
Air sungai	**Tidak melebihi 5.0 ppm**	**Tiada**	**Tidak melebihi 0.6 ppm**	**Tidak melebihi 5.0 ppm**
Air telaga tiub	**Tidak melebihi 5.0 ppm**	**Tiada**	**Tidak melebihi 0.6 ppm**	**Tidak melebihi 5.0 ppm**

Penghasilan Bahan Tanaman

Patawali adalah herba boleh menjalar sehingga 15 m dan boleh didapati di dalam hutan hujan primer kerana tumbuh meliar (Rasadah *et al.* 2010). Tumbuhan ini disemai melalui keratan batang. Selepas 4 minggu, keratan tanpa menggunakan hormon mula mengeluarkan akar. Keratan tersebut kemudiannya dipindahkan ke kawasan penanaman terbuka. Kaedah keratan juga terbahagi kepada 3 iaitu:

1) 5 % Rooting Misting Chamber
2) 10 % Rooting Misting Chamber
3) 90 % Rooting Direct Poting

Pengurusan Kesuburan Tanaman

Patawali ditanam tanpa mengunakan baja dan racun kimia. Pematuhan kepada MyOrganik, membenarkan penggunaan baja organik iaitu dengan kadar 5.0-10.0 mt/ha (Malaysian Standard MS 1529 : 2015)

Tempoh Peralihan

Tempoh peralihan atau jangkamasa untuk pensijilan MyOrganik adalah 2 tahun. Namun, kerana kawasan tersebut tiada sejarah penggunaan bahan kimia dan hormon dan ianya hutan sekunder, tempoh peralihan dapat dikurangkan menjadi satu tahun sahaja. Seperti Gambarajah 1 dan 2.

Gambarajah 1: Pensijilan MyOrganik 2010

Gambarajah 2 : Pensilan MyOrganik 2011

Keselamatan Sampel

Dengan pensijilan MyOrganik dari Jabatan Pertanian, sampel yang dituai selamat dari sisa racun dan logam berat merbahaya.

Malaysian Book of Records

Pada 15 Julai 2010, Institut Penyelidikan Perhutanan Malaysia (FRIM) telah dianugerahkan dengan pensijilan rekod Malaysia (Malaysia Book of Records) kerana berjaya mendapatkan pensijilan MyOrganik melalui tanaman Patawali **(***Trinospora crispa***)** seperti dalam gambarajah 3.

Gambarajah 3 : Sijil Malaysia Book of Records

Kesimpulan

Pengambilan bahan mentah berterusan dari sumber hutan tanpa penanaman bakal merencatkan bekalan bahan mentah pada masa akan datang. Penanaman organik herba daripada hutan oleh FRIM dapat menjamin kelestarian sumber bahan mentah perlu diteruskan bagi menjamin kuantiti tanaman dan plot tanaman juga dapat dijadikan sebagai rujukan syarikat-syarikat.

Rujukan

Laporan keputusan ujian logam berat. 2008. FRIM394(T)/HL 490/1/2 (Sub 1) Klt. 2(no. 32). Institut Penyelidikan Perhutanan Malaysia.

Malaysian Standard MS 1529 : 2015 Plant-based organically produced foods-requirements for production, processing, Handling, labelling & Marketing, Jabatan Pertanian Malaysia.

Rasadah M.A., Zainon A.S., Nik Musaadah M., Norhara H., 2010. ASEANHerbal and Medicinal PLANTS. *Tinospora crispa* : 261

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya
MSAE2019-ARWM04

Development and Design of Household Composter

A. Mohd Shahrir[1,*], S. Yahya[1], M.A. Amir Syariffuddeen[1], A. Saiful Azwan[1], S. Masniza[1], M.S. Zainun[1], M.Y. Mohd Akmal[1], M.S. Zainun[1], H. Azman[1], A. Sha'fie[1], M.A.T. Mohd Hafiz[1], S. Amir Redzuan[1], Z.A. Mohd Zaimi[1], J. Shukri[1] and S. Mohd Azmirredzuan[1]
[1]Engineering Research Centre, MARDI Headquaters, Persiaran MARDI-UPM, 43400 Serdang, Selangor
*Corresponding author. Tel.: +603-8953 6600, Email: shahrir@mardi.gov.my

Abstract
As urbanization influenced the lifestyle of folks in the city, the problem with solid waste management is rapidly becoming a huge consequences. Treating household's waste at source would help to ease the waste management problem before turning into a crisis. A new prototype household composter was designed to accommodate the city households which can manage, dispose and utilize kitchen and food waste. This two-tier household composter with a capacity of 5 kilograms kitchen and food waste and duration taken for composting process between 7 to 8 days, easy maintenance and user friendly. The results indicated the effective operational performance of the prototype household composter in practice and the output compost complies with standard with no bad odour (soil earth odour) and ready to use for plant application. The household composter hence effectively replaces the kitchen waste bin with significant value addition and can help to minimizes greenhouse gases emissions. This will also help to cultivate a culture among householders in adopting the composting practice in their daily activities as common practice.

Keywords: solid waste management, household composter, kitchen waste, food waste, composting process

Introduction

Without a doubt, solid waste management is one of the biggest problems in the world of modern societies. Waste management is an important part which relates to the population lifestyle and economic stature. Management of solid waste can be defined as a discipline connected with control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes (Tchobanoglous, 1993). Population increasing at an exponential rate leading to increasing of solid waste produce (Phiri, 2012). Our earth is facing a tough challenge in order to become and remain sustainable due to the increasing number of global populations over the years (Kevin, 2009). Countries around the world are reacting to these challenges by adopting policies to minimize waste outputs. Landfill space availability is decreasing and increasing cost of creating new landfills, local authorities are having trouble in coping to develop alternative means of waste disposal management. Number of communities in United States and European countries are steadily growing which attracted to the interest of urban solid waste composting as an alternative to the disposal of waste stream in sanitary landfills (Renkow and Rubin, 1996). Local authorities have identified composting as a potentially viable means which can help to lessen the volume of waste entering landfills by diverting the organic fractious. Composting is a controlled biological process which increment rate of biological decomposition of organic materials is through a natural aerobic process. Thus, an equipment or machine is required for this purpose suitable for home domestic usage. The development of home composter has genuine chance of to cater the issues faced. This work consists in the aspects considered neccessary to design and developed a composter for batch-feeding of kitchen and food waste of household usage. The results and conclusion achieved through this study will be applied for better design in the future.

Materials and methods

To review and compare existing compost bins (household and industrial), various composting process, identifying downsides in the existing compost bins and processes. To develop a full-scale working prototype using affordable materials of composter for household kitchen.

Composter Requirements

Frequency of usage: The food waste is input everyday. Due to busy lifestyle of the urban community, the output of compost should be ready within 1 weeks.
Output compost handling: The output compost should be in a convinient form for people handling it and easily used for gardening purpose.
Composter size and location: The composter to be placed in the kitchen with ergonomic dimension to avoid any issues.
Odourless: The composter should not produced unpleasant or bad odour.
Easy operation and mobile: The composter should be easy to operate by everyone in the house and mobility to move about within the kitchen area.

Composter Prototype Design

The composter consists of two parts. The first part is composting and compost-starter storage part. The second unit is the compost product collection area. Batch-feeding food waste can be mixed with compost-starter by a simple mechanism. The first part, which consists of mixing stirrer is attached to a single-phased motor which help to rotate the stirrer to mixes food waste with compost-starter continuously. Maintaining good ventilation inside the composter is vital to have aerobic condition of the decomposition process. The air filter which contains activated charcoal are used to keep away bad odour and acts as a disinfectant. The second part is a collection tray for final product compost collection. It takes around a week for composting the food waste.

Results and Discussion

Figure 1 shows one of the proposed designs for household prototype composter based on the composter requirement identified. Figure 2 and Figure 3, exhibited composting process using the composter. The process as follows:

• Food waste is placed inside the first part of the composter.

• Compost-starter was added into food waste and mixed thoroughly. Food waste weighed 5kg same as the maximum capacity of the composter.

• Continuous mixing of food waste and the compost-starter for effective composting with the help of mixing stirrer attached to a single-phased motor. The mixer will rotate for 1 minutes for every 3 hours until completion of composting process.

• Use of an air filter (activated charcoal) for avoiding the foul odour and to avoid insects or rodents.

• Use of calcium oxide with the compost starter mixture to maintain the initial heat and to start the composting process.

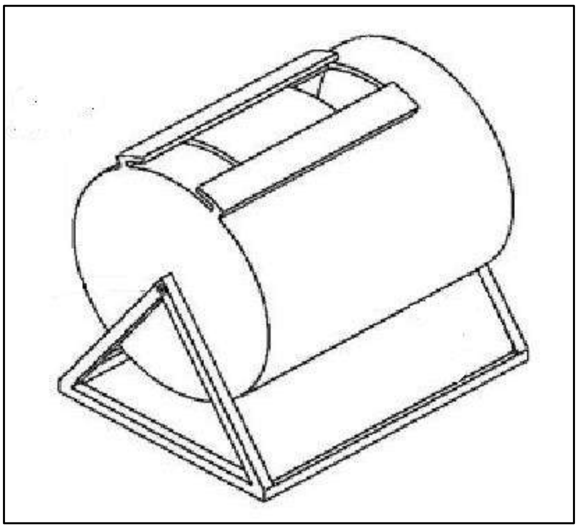


Figure 1: One of propose early design of household prototype composter

Figure 2: Composting process mixture of food waste and compost-starter

Figure 3: Composting progress

Figure 4: Compost end product

Table 1, showed the final compost product achieved by using houshold prototype composter compared to the existing market composter. The final compost product from the household prototype composter have a similar results compared to the existing market composter but difference in the duration time for composting process to complete. Household prototype composter abel to complete the composting process in 7-8 days only. The proposed household prototype composter also able to compost food waste unlike the existing market composter that only able to compost kitchen and green waste only.

Table 1: Compost characterization between household prototype composter and existing market composter

Parameter	Household prototype composter	Existing market composter (NatureMill Composter)
pH	7.57	5.51
mc (%)	48.20	42.25
c/n ratio	15.94	21.46
composting duration	7-8 days	14-18 days

Conclusions

This household prototype composter can play an important role in solid waste management. As the prototype composter is easy to operate and mobile which can encouraged household user to buy and use it. This will in turn cultivated new culture among household user to start composting at their home.

Composting offers great solution to local authority in reduction of landfill and helps in solid waste management.

References

A. Phiri, L. Godfrey and D. Snyman (2012). Modeling the generation of domestic waste for supporting the planning of municipal waste services, *International Journal of Water Resources and Environmental Engineering*, **4** (2012), 171-191. http://dx.doi.org/10.5897/ijwree11.030

Kevin.J.V (2009). Towards more sustainable urban surface drainage: a comparative case study of impervious cover polices in Portland, Oregon and Seattle.

Renkow.M.A and Rubin.A.N (1996). Does municipal solid waste composting make economic sense.

Tchobanoglous,G. Theisen,H. and Vigil,S. (1993). Integrated solid waste management engineering: principles and management issues. McGraw-Hill, New York.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya
MSAE2019-ARWM05

Evaluation of Performance for Young Coconut Husk Processing Machine and Its Product Quality

Wan Mohd Aznan, W.A.[1], Mohd Shahmihaizan, M.J.[1], Md Akhir, H.[2], Zawayi, M.[1] and Norahshekin, A.R.[1]
[1]Engineering Research Centre, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
[2]Director General Office, MARDI Alor Setar, Peti Surat 105, Jalan Kuala Kedah, 05719 Alor Setar, Kedah, Malaysia.
**Corresponding Author, Tel: +03 89536565, E-mail: wanaznan@mardi.gov.my*

Abstract
Fresh coconut water industry in Malaysia has grown as its demand has increased tremendously at about 32.12 million young coconuts per month. Hence, production of husk from the coconut industry has also increased and contributed to the problem at disposal level. A young coconut husk processing machine to produce cocopeat and fiber has been developed to provide added value to the residue. An assessment of performance for the machine and its products quality has been done. The assessment of quality for cocopeat was done by using rotary screener that equipped with 16 mesh nets and multi-layer shaker. The evaluation results showed that the machine capacity of the young coconut husk extractor was up to 514.9 kg / hour with the average weight ratio of unfiltered cocopeat and fiber produced at 65.4% and 34.6% respectively. Meanwhile the results of cocopeat quality evaluation have found only 5.7% and 0.6% fiber contained in the cocopeat mixture after extraction and filtration respectively. Utilization of this technology by small entrepreneurs is necessary to develop a new dimension of waste management from the young coconut water industry and also create a competitive industry chain for building local socio-economic.

Keywords: young coconut husk, cocopeat, fiber, husk processing machine, rotary screener

Introduction

Coconut is a popular palm and is grown in more than 90 countries worldwide. In Malaysia, it is the 4th important crop in terms of acreage after oil palm, rubber and paddy (Christoper J.B., 2018). The coconut industry has significant socio-economic implications as it provides a source of revenue and employment to households. In addition, it supports a number of vibrant small and medium coconut-based processing industries and exporters.

In Malaysia, 95% of coconut growers are smallholders with an average yield of 5,966 kg coconuts / hectares in 2016. Coconut production is increasing from 2016 to 2018 at 504,773 MT to 538,685 MT (Anon, 2018). The demand for young coconut has begun to grow with government initiatives, especially the Ministry of Agriculture in the 1990s through the encouragement of drinking water young coconut (Mohd Rashid, R. et al., 2016). Young coconut can be defined as at an immature stage, contains mainly water and a little jelly-like meat instead of the hard white flesh found in mature coconuts. The young coconut which was initially just as a non-commercialized beverage has turned out to be popular. The high demand and market price has attracted the interest of farmers to grow coconuts.

Based on the results of the survey conducted by Mohd Hafizudin et al. (2016) showed that 46.0% of consumers preferred Pandan varieties and followed by Matag (12.3%). Meanwhile, another 24% did not show a tendency to young coconut variety. A total of 32.12 million young coconuts per month were estimated to fulfill the demand based on the results of the study.

The increase in demand for young coconut has contributed to the increase in residual products such as coconut husk. As much as 44% of coconut husk is underutilized and disposed of in open field (Tafsir S. and Mohd Hafizudin Z., 2018). Disposal methods of coconut husk that are not systematically removed and burned openly can cause environmental pollution. The collection of young coconut husks in the coconut processing center can be benefited by establishing a local mechanization system to process the husk into value-added products such as cocopeat and coir fiber. Cocopeat can be sold at RM 7 / bag or RM 1.40 / kg while coir fiber can be sold at RM 1.20 / kg (Mohd Zaffrie, MA et al. 2018). Cocopeat can be used as planting media in fertigation cropping system while coir fiber can be used as industrial input material. Evaluation of the machinery that developed for the processing of young coconut husk has been carried out to identify its performance. It is able to improve the efficiency, quality and production of cocopeat and coir fiber systematically. Consequently, the use of this processing machinery may ensure the sustainability of the country's coconut industry as well as the local socio-economic development.

Materials and Methods

A young coconut husk processing machine was developed by the Engineering Research Center, MARDI. Performance assessment has been carried out on the machine and quality of the products produced namely cocopeat and coir fiber. The young coconut husk used in this machine evaluation was obtained from the young coconut water stalls around Bandar Baru Bangi.

Young Coconut Husk Processing Machine

The processing machine of young coconut husk as shown in Figure 1. It consists of two main function sections which are extraction mechanism and scraper mechanism. Both of these mechanisms were driven by 11 HP capacity engine via belting mechanism. The extraction mechanism comprises of several key components to enhance efficiency of the mechanical extraction process such as spike, cylinder drum, combing devices, filtering rods and fin plate whereas the scraper mechanism was installed under the filtering rod to smoothen the extraction operation by preventing the clogging of cocopeat. The scraper mechanism has been designed to operate continuously at speed of 0.03 m/s through mechanical concepts. It was equipped with components such as speed reducer, chain and sprocket.

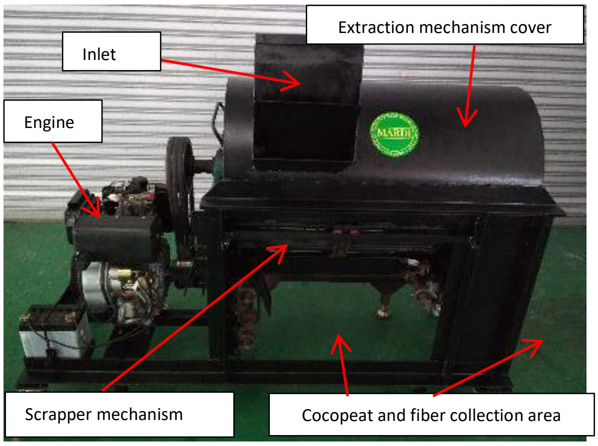


Figure 1: Young Coconut Husk Processing Machine

Extraction Process of Cocopeat and Coir Fiber from Young Coconut Husk

Operation of young coconut husk processing was repeated 10 times to determine the actual processing capacity of the machine. A total of 300 kg of young coconut fiber was used for the entire assessment operation. The assessment operation was performed by using an operator to fill the young coconut fiber to be processed through the input funnel. The outputs from the extractor were discharged and collected at different outlet path. Data such as the weight of the young coconut fiber, cocopeat and fiber produced and the processing period were recorded for calculation of machine capacity and gross product ratio. The machine capacity was calculated by using the following formula:

$$Machine\ Capacity\ (\tfrac{kg}{h}) = \frac{Total\ Weight\ of\ Material\ (kg)}{Duration\ of\ Processing\ (h)} \quad (1)$$

Meanwhile, the gross product ratio was calculated using the following equation:

$$Percentage\ of\ gross\ cocopeat\ weight\ (\%) \quad (2)$$

$$= \frac{Weight\ of\ gross\ cocopeat\ (kg)}{Weight\ of\ gross\ cocopeat\ and\ fiber\ (kg)} x\ 100$$

$$Percentage\ of\ gross\ fiber\ weight\ (\%) \quad (3)$$

$$= \frac{Weight\ of\ gross\ fiber\ (kg)}{Weight\ of\ gross\ cocopeat\ and\ fiber\ (kg)} x\ 100$$

Moisture content of the young coconut husk and cocopeat also recorded as a reference. Determination of moisture content for these materials was performed by using moisture balance AND MX-50. A total of 1g sample was used for each assessment at a temperature of 105 ° C (Mani et al. 2004). Five samples for each material were used to perform this evaluation.

Quality Evaluation of Cocopeat from Young Coconut Husk

Quality evaluation of cocopeat produced via young coconut husk processing machine was performed for 5 samples to measure its product ratio only. Control of cocopeat quality was necessary to prevent the excessive content of fiber in the cocopeat mixture. Filtering process of cocopeat was done by using a rotary screener as displayed in Figure 2 at a speed of 7 RPM. The rotary screener is developed by MARDI and equipped with a 16 mesh of a plastic net.

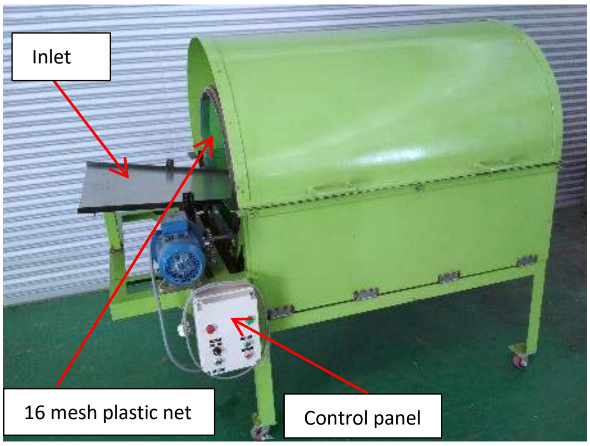


Figure 2: Rotary Screener for Filtering Process of Cocopeat

Total weight of filtered cocopeat and fiber were recorded for calculation of the weight ratio. Then, the cocopeat mixture that filtered by using rotary screener was further analyzed in the laboratory by using a multi-layer shaker to determine the percentage of fiber that was still contained. The weight of fiber obtained from the analysis was recorded for computation of cocopeat and fiber ratio in ready-to-sell products. The percentage of the cocopeat and fiber is calculated using the following formula:

$$Percentage\ of\ cocopeat\ weight\ (\%) \quad (4)$$

$$= \frac{Weight\ of\ filtered\ cocopeat\ (kg)}{Weight\ of\ filtered\ cocopeat\ and\ fiber\ (kg)} x\ 100$$

$$Percentage\ of\ fiber\ weight\ (\%) = \frac{Weight\ of\ filtered\ fiber\ (kg)}{Weight\ of\ filtered\ cocopeat\ and\ fiber\ (kg)} x\ 100 \quad (5)$$

Results and discussion

Machine Capacity of Young Coconut Husk Extractor

Results of machine capacity analysis for the young coconut husk processing machine as shown in Figure 3. In average, the extractor was able to process 387.0 kg/h of the husk. The value has indicated an upward trend.

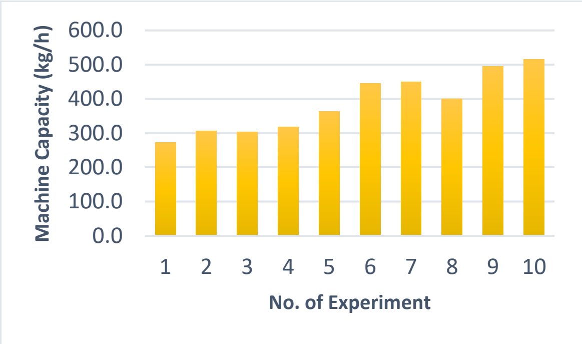


Figure 3: Results of Machine Capacity for Young Coconut Husk Processing Machine

The factors that influence this trend were the operator efficiency during processing and the factors of material used such as size and moisture content. Moisture content of the collected young coconut husk varies from 75.21% to 93.72% due to several factors. The factor that may affect moisture content was the exposure of the material to the environment within a certain period before being collected for processing and irregular size of the young coconut husk pieces. Direct exposure to sunshine and small cutting size have contributed to faster drying rates and reduced the moisture content of the husk (Onwuka U.N and Nwachukwu G., 2013).

Meanwhile, result of the gross product ratio for cocopeat and fiber that extracted by the machine as shown in Table 1. The average result has indicated that the outputs were containing 34.6% and 65.4% of fiber and cocopeat respectively.

Table 1: Results of product ratio of cocopeat and fiber after extraction process

Sample N	Cocopeat (%)	Fiber (%)
1	57.9	42.1
2	60.2	39.8
3	67.9	32.1
4	68.3	31.7
5	72.7	27.3

Product Quality of Cocopeat from Young Coconut Husk

Cocopeat from the extractor was filtered by using the rotary screener to determine fiber content in the cocopeat mixture. Results of the screening process as shown in Table 2. The average value of fiber in the cocopeat was 5.7% only and the picture of cocopeat before screening process as displayed in Figure 4.

Table 2: Results of product ratio for cocopeat mixture after filtered via rotary screener

Sample N	Fiber (%)	Cocopeat (%)
1	5.8	94.2
2	4.6	95.4
3	5.4	94.6
4	6.1	93.9
5	6.4	93.6

Figure 4: Extracted cocopeat before screening process

Meanwhile the result of product ratio for cocopeat after filtered via rotary screener and multi-layer shaker as displayed in Table 3. Based on the result of the analysis, the cocopeat that ready to market only contains 0.62 % of fiber in average. At this level of fiber content, the product quality can be accepted by consumer. The picture of cocopeat after screening process as indicated in Figure 5.

Table 3: Results of ready to market product ratio for cocopeat after analyzed via multi-layer shaker

Sample N	Fiber (%)	Cocopeat (%)
1	0.8	99.2
2	0.5	99.5
3	0.7	99.3
4	0.6	99.4
5	0.5	99.5

Figure 5: Cocopeat after screening process

Conclusion

Development of young coconut husk processing machine is necessary to enhance the agro-waste to more valuable products. This machine is capable to process 514.9 kg / h of the coconut husk that contains 65.4% of cocopeat and 34.6% of fiber. Utilization of rotary screener to improve cocopeat mixture quality has decreased the amount of fiber to 0.62%. Therefore, processing of the young coconut husk by using both machines developed by MARDI is capable of producing quality value-added products. It needs to be beneficial to ensure the sustainability of the growing coconut industry.

Acknowledgment

The authors would like to gratefully acknowledge MARDI for funding this project under the code of P-RM 413. The appreciation also extended to Mr. Mohd Nadzim Nordin, Ms. Siti Ashah Abdul Rahim, Mr. Hakimi Zulkifli, and Mr. Mohd Syukri Hassan for their assistance during machine evaluation. My gratitude as well to others either directly or indirectly involved in the development of young coconut husk processing machine.

References

Anon, (2018). Booklet Statistik Tanaman 2018 (Sub-Sektor Tanaman Makanan, Jabatan Pertanian Malaysia.

Christoper J.B., (2018). Implementation of Coconut Policies and Initiatives: The Real Challenges to Empower the Industry, National Coconut Conference, 7-9 August 2018, Ipoh Perak.

Mani S., Tabil L.G. & Sokhansanj S., (2004). Grinding performance and physical properties of wheat and barley straws, corn stover and switchgrass. Biomass and Bioenergy, 27(4), pp.339-352.

Mohd Hafizudin Z., Mohd Zaffrie M.A., Nor Amna A'liah M.N., Mohd Rashid R. & Mohd Tarmizi H. (2016). Kajian Potensi dan Kecenderungan Pengguna Terhadap Kelapa Segar dan Produk Makanan Berasaskan Kelapa (PMBK) di Malaysia, Laporan Kajian Sosioekonomi 2016.

Mohd Rashid R., Nor Amna A'liah M.N., Mohd Hafizudin Z. & Mohd Dainori M.S., (2016). Potensi Pembangunan Industri Kelapa Negara dari Perspektif Rantaian Nilai, Laporan Kajian Sosioekonomi 2016.

Mohd Zaffrie, M.A., Mohd Hafizudin Z. & Azahar H., (2018). The market potential of non-food coconut-based products in Malaysia, National Coconut Conference, 7-9 August 2018, Ipoh Perak. eISBN 978-967-936-663-1

Onwuka U.N. & Nwachukwu G., (2013). Grain Size and Heat Source Effect on the Drying Profile of Cocoa Beans. Nigerian Journal of Technology (NIJOTECH), Vol. 32. No. 3, pp. 417-423, ISSN: 1115-8443

Tafsir S. and Mohd Hafizudin Z., (2018). Industry Outlook and Consumer Preference for Fresh and Processed Coconut Products, National Coconut Conference, 7-9 August 2018, Ipoh Perak.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian & Industri Asas Tani, Putrajaya

MSAE2019-ARWM06

Sifat fizikal dan mekanikal batang pokok sagu (*metroxylon spp.*)

W.A. Wan Mohd Fariz[1,2], S. Rosnah[1,*]dan H. Azman[2]

[1]Jabatan Kejuruteraan Proses dan Makanan, Falkulti Kejuruteraan, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
[2]Pusat Penyelidikan Kejuruteraan, Ibu Pejabat MARDI, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +603-89466366, Email:rosnahs@upm.edu.my

Abstrak

Pokok sagu rumbia (*metroxylon spp.*) *mempunyai batang yang tegak, lurus, berkulit keras dan berteras lembut yang terbina daripada serat berorentasi selari dengan arah batang pokok. Kanji yang dihasilkan oleh pokok disimpan di bahagian terasnya sebagai makanan simpanan. Dalam proses- pengekstrakan sagu, teras batang sagu perlu dipecahkan kepada saiz yang lebih halus/kecil melibatkan penggunaan sistem mekanikal yang bergantung kepada sifat fizikal dan mekanikal pokok. Oleh itu, satu kajian ke atas batang pokok sagu dijalankan untuk mengenal pasti sifat fizikal dan mekanikalnya. Tiga sampel bagi setiap empat pokok sagu berukuran 50 cm panjang telah diukur sifat fizikal dari segi diameter (45.41±2.81 cm), ketebalan kulit (1.43±0.19 cm) dan nisbah berat kepada panjang keratan (1.12±0.21 kg/cm). 12 sampel blok teras batang pokok sagu berukuran 4cm x 4cm x 4cm disediakan dan ditentukan kandungan lembapan (MC%). Sampel blok diletak pada kedudukan orentasi serat berselari dengan arah pergerakan jarum penguji (P/5: 5mm Dia Cylinder Stainless Steel) yang dipasang pada Texture Analyzer untuk mengukur daya kerapuhan, dan proses ini diulang dengan kedudukan orentasi serat blok sampel secara berserenjang. Berdasarkan keputusan ujikaji, daya kerapuhan pada arah selari dengan orentari serat (*529.15±19.*14 **N/cm²**) lebih tinggi berbanding arah serenjang (317.91±22.08 **N/cm²**) di mana nilai $P<0.05$. Ini menunjukkan kehadiran orentasi serat dalam teras mempengaruhi daya kerapuhan.*

Keywords: Sagu, Orentasi serat, Daya kerapuhan

Pengenalan

Pokok sagu rumbia (*metroxylon spp.*) merupakan sejenis tumbuhan tropika yang hidup di persekitaran lembab termasuk di kawasan berpaya (Jong, 1995). Ianya juga dipercayai antara tumbuhan yang terawal dituai untuk mendapatkan batang pokok dan diproses untuk menghasilkan kanji (Mathur 1998). Antara kelebihan pokok sagu adalah kandungan kanjinya empat kali ganda daripada makanan ruji Asia Timur iaitu beras seperti dinyatakan oleh Yamamoto (2014). Oleh itu, ianya berpotensi besar untuk dijadikan salah satu daripada sumber bahan mentah bagi industri pembuatan melibatkan penggunaan kanji. Di Malaysia, Sarawak merupakan salah satu negeri yang mempunyai kawasan berpaya yang luas dan bersesuaian bagi penanaman pokok sagu. Industri sagu di Sarawak telah berkembang maju dan penting kerana menjadi salah satu penyumbang kepada pendapatan nilai ekport negara. (Kamal, 2007; Karim, 2008). Mengikut laporan Jabatan Statistik Malaysia (MDS, 2005), nilai eksport kanji sagu gred makanan adalah sebanyak 45,300 tan metrik, bersamaan RM40.4 juta. Pada tahun 2015, sebanyak 184,163 metrik tan sagu telah dikeluarkan oleh Malaysia (DOA, 2015) dengan anggaran nilai sebanyak RM 164.2 juta.

Kaedah pengestrakan kanji sagu daripada batang pokok adalah melalui kaedah yang sama dengan pemprosesan kanji daripada sumber lain seperti daripada akar tumbuhan atau bijirin secara amnya. Tambahan, pemprosesan sagu secara moden dan tradisional tidak mempunyai perbezaan yang ketara kecuali dari segi penggunan teknologi yang lebih moden dan kuantiti pengeluaran yang lebih tinggi.

Secara amnya, kulit batang sagu dikupas dan dibelah kepada beberapa bahagian sebelum ianya diproses. Seterusnya, dengan kaedah tradisional batang sagu akan diparut menggunakan pemarut daripada ceracak buluh dan parutan sagu dimasukan ke dalam bakul anyaman daun pokok sagu. Kemudian, parutan sagu disiram dengan air serta diperah dengan tangan, manakala larutan air yang mengandungi kanji sagu mengalir ke dalam takungan. Larutan berkenaan dibiarkan seketika supaya kanji sagu mendap ke dasar takungan. Akhir sekali, air di permukaan takungan dialirkan keluar dan mendapan yang terhasil adalah sagu basah (Flach, 1983; Singhal, 2008; Yamamoton 2014). Bagi kaedah pemprosesan moden, batang sagu akan dipindahkan dari kawasan tuaian ke kilang pemprosesan. Ia berbeza dengan cara tradisional di mana ianya diproses terus di kawasan tuaian. Batang sagu yang telah dipotong akan diikat pada rakit dan dipindahkan melalui laluan sungai. Kepingan batang sagu yang telah dikupas kulit akan diparut menggunakan cakera atau aci berpaku dalam keadaan berpusing yang berkuasakan enjin diesel. Setelah itu, parutan sagu akan dipindahkan ke ruang penapisan yang diperbuat dari jaring besi dan akan dibilas dengan air. Seperti kaedah tradisional, larutan kanji sagu akan dikumpul dalam takungan dan dibiarkan selama 2 jam untuk proses mendapan. Setelah air di ruang atas takungan dikeluarkan, sagu basah akan kelihatan di dasar takungan dan akan dikering secara jemuran di bawah sinar matahari (Cecil, 2002; Oates, 2002; Darma, 2017).

Berdasarkan laporan oleh Vikineswary (1994), 65.7% kanji sagu masih terdapat di dalam hampas setelah diekstrak. Dengan anggaran jumlah pengeluaran sagu hanya pada kadar 34.3% bersamaan 184,163 metrik tan pengeluaran pada tahun 2015, jika nilai kehilangan sebanyak pada kadar 65.7% adalah bersamaan 352,755 tan metrik dengan nilai RM 314.5 juta. Kehilangan ini berlaku disebabkan oleh ketidakcekapan semasa proses pengekstrakan kanji sagu. Antara salah satu faktor yang menyumbang kepada ketidakcekapan ini ialah faktor saiz batang sagu seperti dinyatakan oleh Cecil (1992) dan Wan Mohd Fariz (2018a), di mana ianya bergantung kepada saiz batang sagu yang pecah semasa proses memarut. Selain itu, faktor bilah pemarut (saiz, bentuk dan susunan) juga memainkan peranan seperti yang dinyatakan oleh Wan Mohd Fariz, (2018b). Oleh itu, faktor yang berkaitan dengan proses memarut amat penting untuk dikaji seperti sifat fizikal dan mekanikal batang sagu bagi meningkatkan kecekapan proses memarut kerana ianya mempengaruhi kuantiti hasil kanji sagu yang diperolehi.

Objektif kajian ini dijalankan untuk mengkaji sifat fizikal dan mekanikal batang sagu. Maklumat ini penting sebagai rujukan atau keperluan untuk merekabentuk mesin memarut.

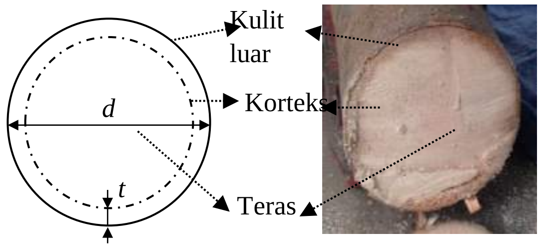
Bahan dan kaedah

Bahan Ujikaji

Pemilihan pokok sagu yang dituai berdasarkan ciri-ciri kematangan pokok sebagai penanda aras. Ini disebakan oleh kematangan pokok mempengaruhi hasil kanji sagu setelah diproses. Oleh itu, pemilihan pokok adalah berdasarkan kematangan yang berupaya menghasilkan kanji sagu yang tinggi setelah diproses. Mengikut kajian yang dijalankan oleh Jong (1995), dilaporkan bahawa hasil kanji sagu yang tinggi diperolehi setelah diproses ketika kematangan pokok berada di antara peringkat pertumbuhan dan berbunga. Berdasarkan pemerhatian yang dijalankan, amalan pemilihan ini juga diamal oleh para petani tempatan. Pokok sagu yang dituai bagi menjalankan ujikaji ini diambil dari kawasan Labu, Negeri Sembilan.

Pemeriksaan Fizikal Batang Pokok Sagu

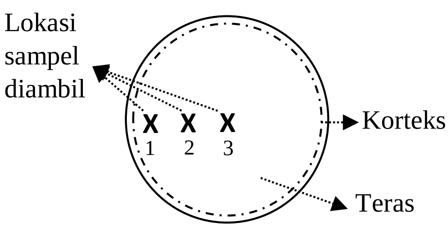
Bagi ujikaji pemeriksaan fizikal batang pokok sagu, pokok sagu telah ditebang secara berperingkat bertujuan bagi pemeriksaan fizikal secara berterusan. Setiap pokok yang ditebang akan dipotong kepada tiga bahagian dengan setiap satu sepanjang 50 cm. Tiga sampel batang pokok yang diambil ini merangkumi bahagian bawah (c: berhampiran dengan pangkal), bahagian tengah (b) dan bahagian atas (a: berhampiran dengan dahan pokok). Setiap sampel batang pokok akan ditimbang dengan penimbang digital 100 kg (DE-A11N, Kern, German) untuk mendapatkan berat. Dengan menggunakan pita pengukur, diameter (*d*) setiap sampel direkodkan dan manakala ketebalan kulit (*t*: jarak antara kulit luar dengan korteks; rujuk Rajah 1) batang sagu diukur menggunakan angkup vernier.



Rajah 1: Keratan rentas batang pokok sagu

Analisis Kandungan Kelembapan

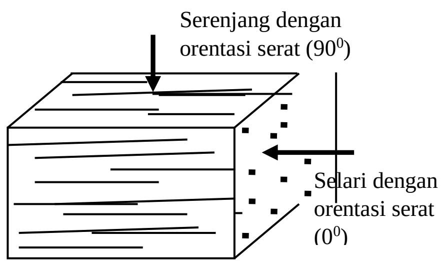
Setiap sampel batang pokok dalam ujikaji ini ditentukan peratusan kandungan kelembapan (MC%) menggunakan pengukur digital (HE53 230V, Mettler Toledo, USA). Bacaan diambil sebanyak 3 kali di lokasi berbeza bagi setiap sampel batang pokok sagu untuk mendapatkan bacaan purata; sampel 1 diambil di bahagian sisi teras batang pokok (berdekatan dengan korteks), sampel 2 diambil di antara bahagian tengah teras dan sisi teras pokok dan sampel 3 diambil di bahagian tengah teras batang pokok (Rajah 2).



Rajah 2: Kedudukan sampel diambil pada keratan rentas batang pokok sagu

Analisis Tekstur

Untuk ujikaji sifat mekanikal teras batang sagu, setiap sampel batang sagu daripada pokok berbeza dikupas kulit menggunakan kapak. Teras batang sagu dipotong menggunakan bilah pisau kepada sampel kecil berbentuk blok berukuran kira-kira 4 cm x 4 cm x 4 cm. Kemudian, blok sampel ditanda garis lurus mengikut arah orentasi serat teras batang sagu menggunakan dakwat kekal. Daya kerapuhan (N/cm^2) teras batang sagu ditentukan menggunakan alat penganalisis tekstur (TA.XTplus, Stable Micro Systems, UK). Dalam ujikaji ini, radas penembusan yang digunakan berbentuk silinder, berdiameter 0.5 cm, diperbuat daripada besi tahan karat dan dihubungkan kepada komputer untuk tujuan merekod. Kedalaman penembusan ditetapkan pada 2 cm dengan kelajuan pergerakan 190 mm/min. Kaedah yang sama digunakan untuk menentukan daya kerapuhan dan kekerasan oleh Rico (2006). Setiap sampel blok dari setiap bahagian batang sagu diuji analisa penembusan pada dua arah berbeza iaitu secara selari (0^0) dan serenjang (90^0) dengan arah orentasi serat batang sagu (Rajah 3).



Rajah 3: Arah penembusan pada sampel blok batang sagu

Keputusan dan perbincangan

Pemeriksaan Fizikal Batang Pokok Sagu

Pemeriksaan fizikal ke atas batang pokok sagu telah dijalankan bertujuan untuk mengenalpasti saiz, berat dan kandungan kelembapan. Maklumat asas ini penting sebagai panduan untuk membangunkan mesin memarut untuk kajian seterusnya. Berdasarkan keputusan (Jadual 1), batang pokok sagu yang dituai di kawasan Labu, Negeri Sembilan mempunyai purata diameter 45.41±2.81 cm. Nilai yang diperolehi adalah seperti yang dilaporkan oleh Jong (1995) iaitu saiz diameter pokok sagu matang yang direkodkan di kawasan Dalat, Sarawak dalam lingkungan 44 hingga 53 cm (P>0.05). Jika dibandingkan, nilai tertinggi diameter yang direkodkan oleh Jong (1995) adalah sedikit lebih tinggi berbanding nilai yang diperolehi iaitu 50 cm dengan peratus perbezaan 5.83% (Persamaan 1). Ini disebabkan oleh perbezaan lokasi tanaman memberi kesan kepada faktor persekiran, cuaca dan kesuburan tanah. Faktor-faktor ini kebiasaanya mempengaruhi kadar pembesaran pokok, seperti faktor cuaca yang dilaporkan oleh Michael C.D. (2000) dan faktor kesuburan tanah atau penerimaan nutrisi oleh pokok seperti yang dilaporkan oleh Fageria V.D. (2001). Bagi perbezaan saiz diameter antara bahagian atas (a), tengah (b) dan bawah (c), ianya menunjukan bahagian atas lebih kecil berbanding bahagian bawah bagi keseluruhan batang pokok sagu yang sama tetapi perbezaanya adalah tidak ketara (peratus perbezaan bagi sampel 1, 3 dan 4 ialah 4.08 %, 4.44% dan 2.41% dengan nilai SD=1.93) bagi semua sampel kecuali sampel 2 menunjukan tiada perubahan saiz diameter pada keseluruhan batang. Kebiasaannya, bahagian bawah batang pokok lebih besar daripada bahagian atas bertujuan untuk menampung beban keseluruhan pokok. Edi Suhaimi B. (2008) merekodkan saiz diameter batang pokok kelapa sawit (spesis pokok sawit) boleh mencecah 60 cm dibahagian bawah berbanding atas hanya 50 cm. Namun, berdasarkan pemerhatian ianya berlaku sebaliknya pada sifat fizikal batang pokok sagu.

Jadual 1.Maklumat fizikal batang pokok sagu;Diameter, ketebalan kulit, nisbah berat kepada panjang dan kandungan kelembapan teras batang pokok sagu.

Ukuran fizikal		Diameter; *d* (cm)	Ketebalan kulit; *t* (cm)	Berat/ panjang (kg/cm)	MC (%)
Sampel	1a	48.00	1.40	1.40	59.29±3.76
	1b	49.00	1.50	1.42	61.67±2.56
	1c	50.00	1.50	1.53	61.65±2.10
	2a	46.00	1.50	0.96	60.90±1.31
	2b	46.00	1.50	0.99	61.98±0.56
	2c	46.00	1.60	1.05	61.96±1.09
	3a	44.00	1.60	0.97	51.23±1.72
	3b	45.00	1.50	0.98	51.40±0.23
	3c	46.00	1.60	1.22	52.52±0.66
	4a	41.00	1.10	0.92	62.34±1.68
	4b	42.00	1.10	0.98	61.04±0.24
	4c	42.00	1.20	1.01	62.04±1.24
Purata		45.41±2.81	1.43±0.19	1.12±0.21	59.00±4.47
Minimum		41.00	1.10	0.96	51.23±1.72
Maksimum		50.00	1.60	1.53	62.04±1.24
Mod		46.00	1.50	N/A	N/A

Seterusnya, nilai ketebalan kulit batang sagu yang diperolehi adalah dalam lingkungan 1.1 hingga 1.6 cm dengan nilai purata 1.43±0.19 cm. Nilai yang direkodkan oleh Jong (1995) adalah dalam lingkungan 1.00 hingga 1.20 cm, manakala Hiroshi (2000) dalam lingkungan 0.80 hingga 1.88 cm dengan nilai purata 1.2 cm yang menunjukkan tiada perbezaan ketara dari segi purata (P>0.05). Ini disebabkan oleh pokok yang dituai telah mencapai tahap kematangan dan dari spesis yang sama.

Dari segi berat pula, keputusan yang diperolehi menunjukkan nisbah berat batang sagu kepada panjang secara puratanya ialah 1.12±0.21 kg/cm, manakala nilai yang dilaporkan oleh Jong (1995) ialah 1.48±0.06 kg/cm secara purata semasa pokok pada peringkat mengeluarkan putik bunga dengan peratus perbezaan sebanyak 27.69% (Persamaan 1). Selain itu, peratusan kelembapan teras batang sagu yang direkodkan menunjukan nilai purata sebanyak 59.00±4.47 %, dan dalam lingkungan 51.23 hingga 62.04 %. Batang pokok sagu mengandungi peratusan kelembapan yang lebih tinggi berbanding spesis pokok sawit yang lain seperti kelapa sawit sebanyak 11.83 % (Ahmad A.L., 2007).

$$\frac{|\Delta N|}{\frac{\sum N}{2}} \times 100\% \qquad (1)$$

Analisis Tekstur

Satu ujikaji sifat mekanikal telah dijalankan ke atas teras batang pokok sagu untuk menentukan nilai daya kerapuhan. Ujikaji ini adalah bertujuan untuk menentukan daya yang diperlukan bagi memecahkan ikatan antara bebenang serat batang pokok sagu semasa proses memarut dilakukan. Maklumat ini amat penting bagi membantu proses pemilihan bahan binaan dan rekabentuk bilah pemarut. Berdasarkan keputusan (Jadual 2), secara puratanya daya kerapuhan penembusan lebih rendah pada arah berserenjang dengan orentasi serat ianya itu 317.91±22.08 N/cm^2 berbanding pada arah selari dengan orentasi serat iaitu 529.15±19.14 N/cm^2 dengan peratus perbezaan 49.87% (Persamaan 1) dimana nilai P<0.05. Jika dibandingkan dengan nilai daya kerapuhan bagi pokok jenis sawit lain seperti pokok kelapa sawit, nilai 4662.08±12.90 N/cm^2 telah direkodkan yang merupakan nilai tertinggi dalam kajian yang dijalankan oleh Thanate R. (2006). Ini menunjukkan teras batang pokok sagu lebih lembut jika dibanding dengan pokok kelapa sawit. Walaupun kedua-dua pokok dalam kategori sawit, sifat fizikal yang berbeza mempengaruhi kekuatan bahan. Sebagai contoh kepadatan serat dan kandungan air selain daripada kekuatan serat itu sendiri.

Jadual 2: Keputusan ujikaji penilaian daya kerapuhan ke atas blok batang sagu mengikut arah penembusan

Arah penembusan	Daya kerapuhan (N)						Purata (N)	Daya kerapuhan/luas **(N/cm^2)**
	1	2	3	4	5	6		
Selari dengan orentasi serat (0^0)	98.73	107.86	100.59	105.11	103.50	107.86	103.94±3.76	529.15±19.14
Serenjang dengan orentasi serat (90^0)	64.36	61.70	69.96	61.85	58.86	57.95	62.45±4.34	317.91±22.08

Kesimpualan

Berdasarkan keputusan ujikaji penembusan terhadap batang teras sagu, daya kerapuhan pada arah selari dengan orentari serat (529.15±19.14 **N/cm^2**) lebih tinggi berbanding arah serenjang (317.91±22.08 **N/cm^2**) di mana nilai P<0.05. Ini menunjukkan kesan orentasi serat dalam teras mempengaruhi daya kerapuhan sesuatu bahan. Oleh itu, semasa proses memarut dijalankan, daya (tenaga) lebih rendah diperlukan jika pemotongan dilakukan pada arah berserenjang dengan orentasi serat.

Penghargaan

Terima kasih diucapkan kepada penyumbang dana untuk kajian ini iaitu CRAUN Research Sdn Bhd dan MARDI (Kod projek: FS024210). Ucapan terima kasih juga kepada pihak ahli kumpulan daripada MARDI dan Universiti Putra Malaysia yang banyak membantu dari segi tenaga, kemudahan, cadangan dan galakan dalam menjayakan projek ini.

Petunjuk

SD(±)= *Standard Deviation* (Sisihan piawai)

P-Value (P)= *Probability value* (Nilai kebarangkalian)

Nota: Pengiraan menggunakan perisian Microsoft Office Excel 2007

Rujukan

Ahmad A.L., Loh M.M., Aziz J.A. (2007). Preparation and characterization of activated carbon from oil palm wood and its evaluation on Methylene blue adsorption. Dyes and Pigments 75: 263-272

Cecil J. E. (2002). The development of technology for the extraction of sago. In: Kainuma K, Okazaki M, Toyoda Y, Cecil JE, editors. Proceedings of the International Symposium on Sago (Sago 2001). Tokyo, Japan: Universal Academy Press Inc. p 83–91.

Cecil J. E. (1992). Small Medium and Large Scale Starch Processing, FAO Agriculture Services Bulletin 98, Rome.

Darma, Santos, B., Reniana (2017). Development of Cylinder Type Sago Rasping Machine Using Pointed Teeth .International Journal of Engineering & Technology IJET-IJENS Vol:17 No:01.

DOA, (2015). Department of Agriculture. Malaysia Industrial Crops Statistics, Putarajaya.

Edi Suhaimi B., Mohd. Hamami S., dan Paik San H. (2008). Anatomical Characteristics and Utilization of Oil Palm Wood. Juruaudit: Nobuchi T, Sahri M.H. The Formation of Wood in Tropical Forest Tress: A Challenge from the Perspective of Functional Wood Anatomy, Chapter: 12, Publisher: UPM Press , pp.161-180

Fageria V. D. (2001). Nutrient Interactions In Crop Plants, Journal of Plant Nutrition, 24:8, 1269-1290

Flach, M. (1983). The sago palm. FAO plant production and protection paper 47, AGPC/MISC/80. Rome, Italy: Food and Agriculture Organization of the United Nations.

Hiroshi E., Slamet S., Chitoshi M., Shohei H., Tadashi M. (2000). Sago Palm (Metroxylon Sagu, Arecaceae) production in the Eastern Archipelago of Indonesia: Variation in morphological characteristics and pith dry-matter yield. Economic Botany. 54. 197-206.

Jong, F. S., (1995). Distribution and Variation in the Starch Content of Sago Palms (Metroxylon sagu Rottb.) at Difference Growth Stages. Agriculture Research Center, Department of Agriculture, Kucing, Sarawak, Malaysia. SAGO PALM 3: 45-54

Karim, A. A., Pei-Lang Tie, Manan, D. M. A., and Zaidul, I. S. M. (2008).Starch from the Sago (Metroxylon sagu) Palm Tree-properties, Prospect, and Challenges as a new Industries Source for Food and Other Uses. Comprehensive Reviews in Food Science and Food Safety. Institute of Food Technology.

Kamal, S. M. M., Mahmud, S. N., Hussain, S. A. and Ahmadun, F. R., (2007). Improvement on sago flour processing, International Journal of Engineering and Technology, 4(1), pp. 8-14

M.D.S. 'Malaysia Dept. of Statistic' (2005). SARAWAK Export of Sago Starch, SITC Code: 592-150

Michael C.D. , William E.S. (2000), The effect of soil nutrition, soil acidity and drought on northern red oak (Quercus rubra L.) growth and nutrition on Pennsylvania sites with high and low red oak mortality. Forest Ecology and Management 136, 199-207

Mathur PN, Riley KW, Rao VR, Zhou M. (1998). Conservation and sustainable use of sago (*Metroxylon sago*) genetic resources. In: Jose C, Rasyad A, editors. Proceedings of the Sixth International Sago Symposium. Pekanbaru, Riau, Indonesia: Riau Univ. Training Centre. p 1–6.

Oates C. G., Hicks A. (2002). Sago starch production in Asia and the Pacific—problems and prospects. In: Kainuma K, Okazaki M, Toyoda Y, Cecil JE, editors. Proceedings of the International Symposium on Sago (2001). Tokyo, Japan: Universal Academy Press Inc. p 27–36.

Rico. D., Martın-Diana. A.B., Frıas. J.M., Barat. J.M., Henehan. G.T.M., Barry-Ryan. C. (2006). Improvement in texture using calcium lactate and heat-shock treatments for stored ready-to-eat carrots. Journal of Food Engineering 79: 1196–1206

Singhal, R.S., Kennedy, J.F., Gopalakrishnan, S.M., Kaczmarek, A., Knill, C.J., Akmar, P.F., (2008). Industrial production, processing, and utilization of sago palm-derived products. Carbohydrate Polymer *72*, 1–20.

Thanate R., Tanong C. Dan Sittipon K. (2006). An Investigation On The Mechanical Properties Of Trunks Of Palm Oil Trees For The Furniture Industry. Oil Palm Research. Journal Of Oil Palm Research. Special Issue - April 2006: 114-121

Vikineswary, S., Shim, Y. L., Thambirajah, J. J., and Blakebrough, N., (1994). Possible microbial utilization of sago processing wastes. Resources, Conservation and Recyling, 11: Elsevier Science B.V. p 289-296

Wan Mohd Fariz W.A., Rosnah S., Azman H., Mohd Shahrir A., Saiful Azwan A., Asnawi S.H. and Zainun M.S. (2018a). Effect of grater position on the size of grated sago (*Metroxylon* spp.). Food Research 2 (6) : 572 – 577

W. A. Wan Mohd Fariz, S. Rosnah, H. Azman, A. Mohd Shahrir, A. Saiful Azwan, S. Asnawi, R. Afiqah Aina, M. A. Amir Syariffuddeen, H. Hasmin Hakim, H. Ishak, S. Masniza, A. W. Ruwaida, M. R. Sharifah Hafiza, S. Yahya, M. S. Zainun[2], S. Amir Redzuan, A. K. Faewati[2], J. Mohammad Shukri[2], S. Mohd Azmirredzuan[2], M. A. T. Mohd Hafiz, Z. A. Mohd Zaimi, J. Muhammad Aliq dan A. Sha'fie (2018b). Study of machines performance in producing different sizes of grated sago. National Conference on Agricultural and Food Mechanization. Proceeding 17-19 April: 211-213

Yamamoto, (2014). Sago as an Approach to Food and Nutritional Security. The Global Food Security Forum, Kuala Lumpur.

Hot Water Treatment of Oil Palm Decanter Cake (OPDC) For Bio-organic Media of Oil Palm Seedlings

Osman, S. F.*, Hashim, M. M., Sulaiman, A. and Abdullah, M. Y.
Faculty of Plantation and Agrotechnology, Universiti Teknologi Mara (UiTM), 40450 Shah Alam, Selangor
*Corresponding author. Tel.: +60145455292, Email:sitiosman1210@gmail.com

Abstract
OPDC has high potential to be used as organic media for oil palm seedlings due to its substantial nutrient content. However, residual oil in OPDC could give negative effect to plant growth. This study was conducted to examine the potential of hot water-treated OPDC as bioorganic media and its effects on growth performance of oil palm seedlings. OPDC was treated with hot water to remove oil content and chemical analysis was determined on N, P, K, Ca and Mg. Then, treated OPDC was mixed with MPOB F1 fertilizer and soil at 25%, 50% and 75% to be used as bioorganic growing media. The results showed that after hot water treatment, residual oil was reduced from 15% to 10-11%. Once applied as planting media, highest growth performance and biomass accumulation was recorded by mixture of 25% treated OPDC with soil and MPOB F1 fertilizer. Plant height, stem girth, leaf number, leaf area, leaf dry weight, stem dry weight and root dry weight were improved by 28%, 15%, 10%, 60%, 72%, 45% and 18%, respectively as compared to control. In conclusion, appropriate amount of treated OPDC addition in growing media could improve the growth of oil palm seedling after oil content removal.

Keywords: Oil palm decanter cake, Oil content, Bioorganic media, Growth performance

Introduction

Oil palm industry is continuously expanding since it has been planted more than 100 years ago in Malaysia. Currently, Malaysia is the second largest country with oil palm cultivation after Indonesia. Oil palm plantation area in Malaysia has increased from 5.23 million hectares in 2013 to 5.81 million hectares in 2017 (MPOB, 2018). As the oil palm plantation industry has expanded, the waste productions from the palm oil mills has also increased. Approximately, there are about 416 palm oil mills operating in Malaysia. From the mill, the estimated waste generation from 1 ton of fresh fruit bunch (FFB) is in the range from 0.6 to 0.8 m^3 of palm oil mill effluent (POME), 22 to 23% of empty fruit bunch (EFB), 3.5% of oil palm decanter cake (OPDC) and 13.5% palm mesocarp fibre (PMF) (Ooi and Kumar 2008; Ng et al. 2011). In recent years, OPDC has been produced in higher amount due to more decanter machine installation in the mills to recover the remaining oil from the underflow of the sludge tank. Usually OPDC is dumped and left to degrade naturally in the dumping ponds. Despite high generation of OPDC, its utilization is still low and not yet commercialized. Several studies have been conducted to utilize OPDC as natural polymer composite (Adam et al. 2014), as solid fuel (Husin et al. 2012), cellulose and polyoses production (Razak et al. 2012), composting, and alternative energy and protein source for growing goats (Anwar, 2012). Up to date only a few studies have focused on the utilization of OPDC as bio-organic media. OPDC is known to be rich in N (2.42%), P_2O_5 (0.51%), K_2O (1.24%), CaO (1.68%) and MgO (0.54%) (Haron et al. 2008). Its application together with inorganic fertilizer had showed synergic effects and improved crops nutrient uptake by plants (Haron et al. 2008). Thus, OPDC has a potential as bio-organic media. Previous studied by (Embrandiri et al. 2013) utilized raw OPDC as fertilizer supplement at different rates. However, it gave negative effect to plant growth performance due to excess of nutrient present and high oil content in the raw OPDC used. Theoretically, the residual oil OPDC need to be removed before it can be used as fertilizer supplement and bioorganic media. This study was conducted to determine the physicochemical properties of raw and hot water treated OPDC and the effects of treated OPDC on the growth performances and biomass production of oil palm seedlings.

Materials and methods

Oil content removal

The raw OPDC was obtained from Sime Darby Kempas Oil Palm Mill, Melaka. The experiments for the oil content removal from OPDC and seedlings planting was performed in UiTM Jasin, Melaka. Raw OPDC was mixed thoroughly with hot water and soaked until the oil layer move upward. The oil layer and water were removed and the step was repeated 3 times. In order to determine the oil content loss, 10g treated OPDC was extracted by using 300ml hexane in soxhlet extractor for 8 hour. Then, the extracted oil was concentrated in vacuum rotary evaporator and dried in an oven. The oil content removal was then calculated.

$$Oil\ (\%\ dry\ basis) = \frac{Weight\ of\ extracted\ oil\ (g)}{Initial\ weight\ of\ dry\ sample\ (g)} \times 100\%$$

Physicochemical analysis of OPDC

Wet raw and treated OPDC were weighed and dried in an oven at 104°C until constant weight obtained. Then, the samples were weighed again to calculate the moisture content. pH value was determined by using 1:10 (w/v) method, while total nutrients were determined by using dry ashing method (Pushparajah, 1977). Dried raw and treated OPDC were grounded separately and passed through 2mm sieve. 1g of each samples were put in porcelain crucible and placed in the muffle furnace at 300°C for 1 hour then gradually increased to 550°C for next 7 hours. After completed, few drops of deionized water and 2ml of concentrated HCl were added before put on hot plate. After ash was slightly dried, 10ml of prepared nitric acid (20% volume/volume) was added and placed in a water bath for 1 hour. Then, all the mixture was transferred to a 100ml volumetric flask and deionized water was added to volume. The solution was shaken and filtered with Whatman No.2 filter paper. The solution afterward was analysed by using ICP-OES for P, K, Ca and Mg. The sample was also analysed for N.

Bio-organic media preparation

The ratio of media was calculated based on the nutrient content needed by seedling for 8 months. Approximately, 25%, 50% and 75% of the treated OPDC was mixed with 75%, 50% and 25% MPOB F1 fertilizer, 2kg soil and cocopeat in polybag and left for 2 weeks before seedlings transplanting. Then, the polybags were arranged in triangular planting design in the open field. 3-months oil palm seedling was transplanted in all polybags randomly.

Growth performance and biomass

Plant height was measured by using measuring tape from base of stem above soil surface to the tip of highest leaf, stem girth was measured at height of 2cm above soil surface with vernier caliper, leaf number was collected by counting number of leaves (Putra et al. 2015) for 8 months. The biomass was determined by destructive growth analysis technique (Danso et al. 2013). The leaves, stem and root were separated at the end of the experiment and washed under running water to remove the soil and dirt. Then, leaves, stem and root were dried in an oven at 70°C until obtained constant weight. Sample were weighed using digital balance for dryweight determination. Leaf area was calculated using leaf area meter.

Statistical analysis

The statistical analysis was performed using Minitab software. All data obtained were subjected to one way ANOVA to detemine the significant difference of treatments where p value ≤ 0.05. Turkey was conducted for means comparison.

Results and discussion

Oil content removal

Figure 1 shows the oil content in OPDC after treatment with hot water. During the first stage of hot water treatment, the oil content in OPDC has reduced approximately 1%, followed by 2-3% at second stage and finally reduced approximately 4-5%. Altogether the oil content in OPDC has reduced from 15% to 10-11%. Eventhough the oil was not completely removed, this method could be practiced to make OPDC more useful as bio-organic media in large scale plantation because it is simple and cost effective.

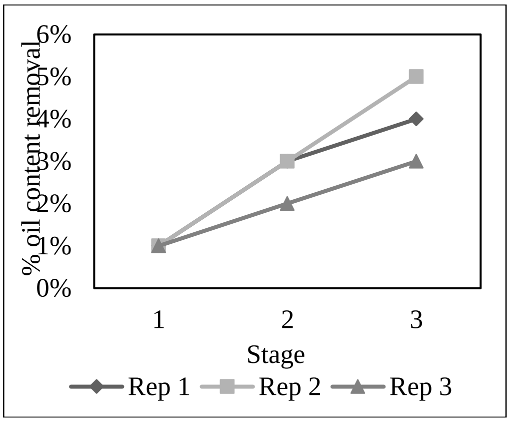


Figure 1: Percentage of oil content removal in different stages in three replicates (rep = replicate).

A study was conducted by Sahad et al. (2015) using n-hexane and d-limonene in sohxlet extraction to extract oil in OPDC. The oil was completely recovered. However, the method was expensive, time consuming, only small amount OPDC can be used at a time and not practical for large scale operation in plantation sector. In this study, the oil content in OPDC was partially removed before being used as bioorganic media for oil palm seedling in nursery stage. The amount of dried treated OPDC needed was about 80kg. In order to obtain 80kg of dried and treated OPDC, about 500 – 600kg raw OPDC was used.

Physicochemical properties of OPDC

Table 1 shows the physicochemical properties of OPDC used in this study as compared with the other related studies. The pH value of the raw OPDC is higher compare to other studies. After treated with hot water, the pH value has reduced from 5.47 to 4.86. According to Singh and Agrawal (2010), reduction in pH value to become more acidic can be attributed to the acidic nature of OPDC and also to release of humic acid as a result of OPDC degradation due to hot water treatment. The result show that oil content is higher while moisture content and nutrients contents of N, P, K and Mg are much lower than other studies which were 15%, 74.51%, 2.0%, 0.013%, 1.27% and 0.28% respectively. The Ca content is slightly higher than previous study by Yahya et al (2010) and Razak et al (2012) which is 1.18%. In this study, the OPDC sample was obtained from different oil palm mills with different way of handling the fresh fruit bunch (FFB) and processing. The FFB also came from different plantation sources resulting in different content of nutrients as well. The results also show that the nutrient content of OPDC has reduced after treated with hot water due to leaching process which are 2.2% N, 0.025% P, 0.20% K, 1.11% Ca and 0.10% Mg.

Growth performance and biomass

Figure 2, 3 and 4 show the growth performances, leaf area and total biomass of oil palm seedling for 8 months in nursery. Leaf area, leaf dryweight, stem dryweight and root dryweight were calculated at the end of experiment. The results show that the growth performances and biomass production of oil palm seedlings are significantly affected ($p \leq 0.05$) by the various ratios of treated OPDC. Maximum growth performances and biomass production are obtained for the experiment with the ratio of 25% treated OPDC where the plant height, leaves number, stem girth, leaf area, leaf dryweight, stem dryweight and root dryweight were 117.75cm, 22, 75.87mm, 11568cm², 108.31g, 150.93g and 82.63g respectively.

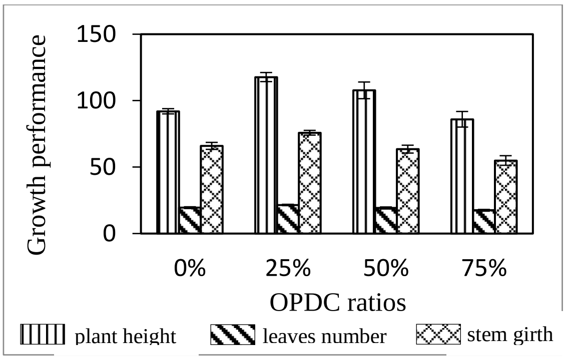


Figure 2: Growth performance of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

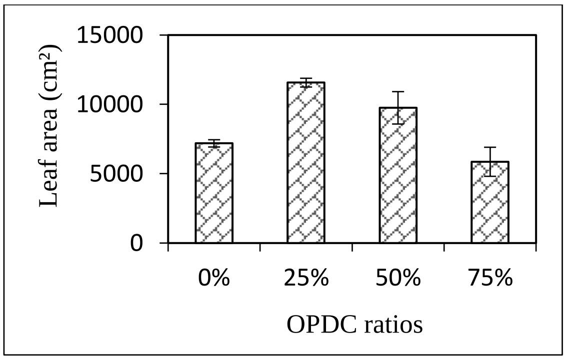


Figure 3: Total leaf area of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

From the above results it can been seen that the growth performances and biomass production had decreased as the ratios of the treated OPDC were increased. Plant height, leaves number, stem girth, leaf area, leaf dryweight, stem dryweight, and root dryweight had decreased from 107.75cm to 86.00cm, 19 to 17, 63.52mm to 54.97mm, 9752cm² to 5861cm², 84.06g to 49.06g, 132.1g to 68.91g, 62.33g to 30.8g of oil palm seedlings grown at 50% and 75% treated OPDC media. This could be due to the high nutrient content and toxicity effect of OPDC (Embrandiri et al, 2013). Similar result were observed by earlier studies using raw and decomposed OPDC on other types of crops.

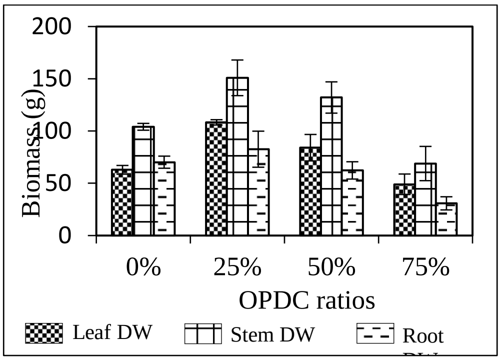


Figure 4: Biomass of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

Studied by Embrandiri et al (2013) and Singh and Agrawal (2009) reported that lady's finger maximum growth of shoot length and leaf number were obtained at 10% and 20% of raw OPDC and sewage sludge which were lower than this study. Studied by Radziah et al (1997) showed the highest growth of tomato and spinach by using 6% of decomposed OPDC. In this study, higher ratios of OPDC could be used compared to previous study which were between 25% to 75% treated OPDC after oil content removal. Oil content in media could cause stress to plant and created a situation of physiological drought where it interferes with water uptake and gaseous exchange (Omusun et al. 2008), blocks the xylem and phloem vessels and also slowing down root elongation (Bengough, 2003). Thus, removing oil content before used improved the efficiency of OPDC as bio-organic media. OPDC has high organic carbon which was 74.4 % (Embrandiri et al. 2016). Organic carbon encouraging microbes multiplication and enzymatic activities which leads to availability of nutrients in soil (Liu et al. 2016). Microbes decomposed the substrate and release the nutrients from it which will be absorbed by plants at suitable environmental condition. Thus, by reducing the oil content it has increased the rate of microbial activities that was previously blocked by the oil layer and also improved the media condition, water and nutrient uptake, gaseous exchanged and translocation process. These conditions enhance the growth of oil palm seedlings and biomass production. Besides that, OPDC has high nutrient contents and application of treated OPDC with MPOB F1 fertilizer showed synergic effects and gives better growth performances of oil palm seedlings. The result obtained from this study is in agreement with previous study by Haron et al. (2008) where seedlings treated with OPDC and inorganic fertilizer have better growth due to increasing in nutrient content and improve the efficiency of nutrient uptake by crops. OPDC is an organic by-product and possess certain amounts of amino acid, crude protein and fibre which can be used as fertilizer (Ramli et al. 2012). The use of OPDC as growing media for 8 months allowed the decomposition process to be completed within that time and therefore, the nutrients become available for plant uptake and further increase growth performances. Media mixed with OPDC compost had 46.4% nitrogen, 17.9% phosphorus, 17.7% potassium and 23.1% calcium more than that media without OPDC (Yahya et al. 2010). Thus, treated OPDC gives positives effect in plant growth performances and biomass accumulation.

Table 1: Comparison of physicochemical OPDC

Parameters	This study	Yahya et al. 2010	Sahad et al. 2014	Razak et al. 2012	Haron et al. 2008	Paepatung et al. 2009	Kandiah and Batumalai. 2013	Embrandiri et al. 2016
pH	5.47 ± 0.04 / 4.86*		5.03 ± 0.04	4.08 ± 0.02	4.8	-	-	4.40 ± 0.01
Moisture (%)	74.51 / 84.32*	76.83	78.20 ± 1.27	76.46 ± 0.8	78	76.7	-	-
Oil content (%)	15 / 10-11	-	13.60 ± 3.33	-	-	-	12.25	-
Nitrogen (%)	2.0 / 2.2*	2.38	2.33 ± 0.06	2.8	2.42	2.21	-	6.52 ± 0.03
Phosphate (%)	0.013 / 0.025*	-	0.41 ± 0.01	0.2	0.51	-	-	-
Potassium (%)	1.27 / 0.20*	2.39	2.73 ± 0.06	1.4	1.24	-	-	0.07 ± 0.02
Calcium (%)	1.18 / 1.11*	1.02	2.10 ± 0.00	0.9	1.68	-	-	0.35 ± 0.02
Magnesium (%)	0.28 / 0.10*	0.8	0.62 ± 0.03	0.3	0.54	-	-	0.012 ± 0.03
Organic carbon	-	51.7	43.73 ± 0.09	55.17	-	43.6	-	74.4 ± 0.02
C/N ratio	-	21.72		19.7	-	-	-	11.4 ± 0.02

*treated OPDC

Conclusions

OPDC is one of the promising waste materials generated in the palm oil mills suitable for bio-organic media once the oil is partially removed. In this study, it shows that OPDC has high moisture and nutrient contents required by the plants. Through hot water treatment, the oil content of OPDC was able to be reduced from 15% to 10-11%. The ratio of treated OPDC bio-organic media can be mixed with normal media up to 25-50% in order to give higher growth performances and biomass production. In conclusion, appropriate amount of treated OPDC addition in growing media could improve the growth of oil palm seedling after OPDC oil content removal.

References

Adam, G. and Duncan, H. (2002). Influence of diesel on seed germination. Environ. Pollut. 120: 363-370

Adam, M. A., Sulaiman, A., Said, C. M. S., Som, A. M., Bahruddin, A. S., Mokhtar, M. N. (2014). Preliminary study of oil palm decanter cake natural polymer composite (OPDC-NPC). Adv. Materials. Res. 911: 40-44

Agbogidi, O. M. And Ilondu, E. M. (2013). Effects of spent engine oil on the germination and seedling growth of *Moringa oleifera* (Lam). J. Agric. Sc. 3(5): 205-209

Anwar, A. G. (2012). Utilization of palm oil decanter cake as protein and energy sources for small ruminants. Proc. 33rd MSAP Annual Conference, Langkawi, Malaysia

Bengough, A. G. (2003). Root growth and function in relation to soil structure, composition and strength. Root Ecology. 151-171

Danso, F., Adu, C., Opoku, A., Danso, I., Anim, Okyere., Larbi, S. (2013). Raising oil palm seedlings using sole and amended green-gro compost. Int. Res. Jour. Agri. Sci. Soil. Sci. 3(10): 362-368.

Ekwuribe, C. S., Osakwe, J. A., Chuku, E. C., Epidi, T. T. (2008). Effect of oil plam sludge on cowpea nodulation and weed control in the humid forest zone of Nigeria. J. Biotech. 2869-2873

Embrandiri, A., Singh, R. P., Ibrahim, M. H. (2013). Biochemical, morphological and yield responses of lady's finger plants to varying ratios of palm oil mill waste (decanter cake) application as a biofertilizer. Int. J. Recyc. Org. Waste. Agric. 2(7): 1-6

Embrandiri, A., Rupani, P. F., Ismail, S. A., Singh, R. P., Ibrahim, M. H., Kadir, M. O. A. (2016). The effect of oil palm decanter cake on the accumulation of nutrients and the stomatal opening of *Solanum melongena* (brinjal) plants. Int. J. Recycl. Org. Waste. Agri. 5: 141-147

Haron, K. M. A. T., Halim, R. M., Din, A. K. (2008). Palm-based bio-fertilizer from decanter cake and boiler ash of palm oil mill. Malaysian Palm Oil Board (MPOB), Information Series (MPOB TT No.412). 1-4

Husin, M. H. M., Dewayanto, N., Nordin, M. R. (2012). Solid fuel from decanter cake: a preliminary study. Uni. Malaysia. Pahang.

Kandiah, S. and Batumalai, R. (2013). Palm oil clarification using evaporation. J. Oil. Palm. Res. 25(2): 233-235

Liu, Y., Wang, P., Ding, Y., Lu, H., Li, L., Cheng, K., Zheng, J., Filley, T., Zhang, X., Zheng, J., Pan, G. (2016). Microbial activity promoted with organic carbon accumulation in macroaggregates of paddy soils under long-term rice cultivation. Biogeosciences. 6565-6586.

Malaysian Palm Oil Board (MPOB) website (2018) Ng, F. Y., Yew, F. K., Basiron, Y. Sundram, K. (2011). A renewable future driven with Malaysian palm oil based technology. J. Oil. Palm & The. Env. 2: 1-7

Omosun, G., Markson, A. A., Mbanasor, O. (2008). Growth and anatomy of *Amaranthus hybridus* as affected by different crude oil concentrations. J. Sc. Res. 1: 70-74

Ooi, H. S. and Kumar, S. S. (2008). Co-composting for sustainable crude palm oil production in Malaysia. Jurutera Buletin. Ins. Engineers Malaysia (IEM). 22-26

Paepatung, N., Nopharatana, A., Songkasiri, W. (2009). Bio-methane potential of biological solid materials and agricultural wastes. Asian J. Energy. Env. 10(1): 19-27

Pushparajah, E., (1997). Leaf analysis and soil testing for plantation tree crops. In: The Proceedings of the Malaysian Seminar on the Fertility and Management Deforested Land. Soc. Agri. Sci.

Putra, E. T. S., Issukindarsyah., Taryono., Purwanto, B. H. (2015). Physiological responses of oil palm seedlings to the drought stress using boron and silicon applications. Jour. Agronomy.

Radziah, O., Azizah, H., Zaharah, A. R. (1997). The phytotoxic effects of palm oil dry solids on plant growth. Pertanika. J. Trop. Agric. Sci. 20(2/3): 91-99

Razak, M. N. A., Ibrahim, M. F., Yee, P. L., Hassan, M. A., Abd, A. S. (2012). Utilization of oil palm decanter cake for cellulose and polyoses production. Biotechnol. Bioprocess. Eng. 17: 547-555

Refdan, M. A. A. (2011). Effect of oil refinery sludge on plant growth and soil properties. J. Environ. Sc. 187-193

Sahad, S., Som, A. M., Baharuddin, A. S., Mokhtar, N., Busu, Z., Sulaiman, A. (2014). Physicochemical characterization of oil palm decanter cake (OPDC) for residual oil recovery. BioResources. 9(4): 6361-6372

Sahad, N., Som, A. M., Baharuddin, A. S., Mokhtar, N., Busu. Z., Sulaiman, A. (2015). Recovery of residual crude palm oil (RCPO) from oil palm decanter cake (OPDC) using D-limonene. Adv. Materials. Res. 1113: 405-410

Singh, R. P. and Agrawal, M. (2009). Use of sewage sludge as fertilizer supplement for *Abelmoschus esculentus* plants: physiological, biochemical and growth responses. Int. J. Environ. Waste. Mgt. 3: 91-106

Singh, R. P. and Agrawal, M. (2010). Effect of different sewage sludge applications on growth and yield of *Vigna radiata* L. field crop: metal uptake by plants. Ecol. Eng. 36: 969-972

Trofimov, S. Y. and Rozanova, M. S. (2003). Transformation of soil properties under the impact of oil pollution. Eurasian. Soil. Sc. 82-87

Yahya, A., Sye, C. P., Ishola, T. A., Suryanto, H. (2010). Effect of adding palm oil mill decanter cake slurry with regular turning operation on the composting process and quality of compost from oil palm fruit bunches. Bioresour. Technol. 101(22): 8736-8741

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019 ***MSAE2019-ARWM08***
21 Mac 2019, Wisma Tani, Kementerian Pertanian dan Industri Asas Tani Malaysia, Putrajaya

A Review of Fertilization Assessment Methods in Oil Palm Plantation

A. S. Mat Su[1] and S. Q. Tan[1,*]
[1]Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia
*Corresponding author. Tel.: +6012-934 9601, Email: tansq96@gmail.com

Abstract
Rising in production cost due to labour shortage, low efficiency of farm operation, low yield, and increase in input cost of materials were among the key factors faced by Malaysian oil palm industry. Thus, significantly affect the overall upstream performance and the annual budget for the plantation operation. Input cost, especially fertilizer accounted for more than 50% of the production cost annually. Highly weathered tropical soil, intensive and mono-cropping farming activities caused nutrient depletion over the availability of the nutrient to the plant. Among the agronomic practices, fertilizer application and saving become a limitation due to its increasing share of production cost, thus effect the annual targeted yield. Prior to the fertilizer application and recommendation rate, a proper fertilizer assessment program should be conducted for achieving economic, social and environmental sustainability. In this paper, several methods of fertilizer assessment for oil palm plantation were identified and discussed based upon the agronomic practices. In addition, the several techniques under proximal sensing technology for Precision Agriculture (PA) program to quantify the fertility and crop response also were listed. The adaptation of the technology and a new approach in reducing the fertilizer used will lead the input cost reduction in oil palm plantation while improves overall farm efficiency.

Keywords: oil palm, sustainability, plant nutrition, fertilizer, precision agriculture, proximal sensing

Introduction

According to "The Forum for Sustainable Palm Oil", oil palm (*Elaeis guineensis*) plantation had been criticized globally due to its cultivation activities, for instant, environmental destruction and human rights violations. Whilst Malaysian Palm Oil Council (MPOC), 2015 pointed out the local issues which are scarcity of competent manpower for plantation operation and scarcity of good arable land for oil palm plantation. Despite the challenges, we should not prejudge the worth of oil palm plantation by its negative reputation alone because it has the highest yield of any oil plant as all the palm oil and palm kernel oil are certified. In order to meet the scheme which designed by Roundtable on Sustainable Palm Oil (RSPO) economic, social and environmental sustainability criteria should be properly applied in the overall supply chain management especially upstream practices. But, there is no restriction for the expansion of the oil palm plantation due to the increasing world population.

United States Department of Agriculture (USDA) has reported that Malaysian palm oil companies have engineered a sustained long-term expansion of plantation area, increasing 3.85 million hectares since 1980 or 385%. Malaysian Palm Oil Board (MPOB) also estimate the maximum future oil palm area will be 5.6 Ha in year of 2020. This scenario had stretched the capability of the fertilizer manufacturing industry to meet the global demand. According to Shean (2011), the price volatility for rock phosphate was the highest, increased by 400% from 2007 to 2008. 90% of total imported fertilizer had been utilized in oil palm industry in Malaysia. The high price level had cost squeezed the industry as the share of fertilizer cost, including application in the overall field production cost increased from 30-35% in 2007 and even 50% in 2008 due to high dependency on imported fertilizer. Due to bad economic circumference and a number of factors have reportedly led to the sharply declining in average yields over the past 4 years (Simeh, 2010), including adverse weather also known as El Nino and La Nina, decreasing fertilizer use, and low replanting rates (Shean, 2011).

Therefore, judicious use of fertilizer is a must to achieve higher productivity, cost effective and at the same time maintain the sustainability in long-term management (Goh, 2003).

Oil Palm Nutrition Requirement and Recommendation

Generally, nutrient requirement of oil palm different which depend on target yield, type of planting material, planting density, palm age, soil type, ground cover conditions, as well as climate and other environmental factors. Referring to the Mulder's chart of antagonistic elements, each of the fertilizer element can be affected by other excess antagonistic element. In addition, Justus von Liebig's "Law of the Minimum" which emphasize the importance of nutrient balance by applying the optimum rate of macronutrient and micronutrient application should always bared in mind such as utilizing the nutrient from the biomass decomposition as mentioned by Tarmizi and Mohd Tayeb (2006).

The essential nutrients are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), Magnesium (Mg), Calcium (Ca), sulfur (S), chlorine (Cl), boron (B), copper (Cu), zinc (Zn) and

Manganese (Mn) (Fairhurst & Härdter, 2003)**.** Basic nutrition of oil palm and its suggested application rates of macronutrient fertilizer which planters focus on are listed in Table 2. The cost of fertilizer mainly varies by its type of source, solubility and reaction ability. In terms of fertilizer application, N fertilizer application should be avoided from applying immediately before or during high rainfall periods to prevent leaching and volatilization losses.

Table 1. Recommended application rates for macronutrients for immature and mature palm Year After Planting (YAP)

Nutrient Element	**Application rate (kg palm^{-1} year^{-1})**		**Particular details of recommendation**
	Immature palm (2-3 YAP)	**mature palm (>3 YAP)**	
Nitrogen, N	0.25 – 0.75	0.25 – 1.75	Range can be adjusted by taking into account palm age, planting density, soil analysis, leaf analysis and site yield potential.
Phosphorus, P	Soil type-based recommendation Coastal soil: 0.3 – 0.4 In-land soil: 0.4 – 0.7 Ultisols: 0.8		One time blanket application of 60 – 130 kg P for acidic and P deficient soil.
Potassium, K	0.3 – 3.0		Specific rate is depending on leaf and soil analysis
Magnesium, Mg	Maintenance application: 0.06 – 0.25 Corrective application: 0.30 – 0.75		Detection of Mg deficiency as the amount of Mg is <0.2 cmol kg^{-1}
Calcium, Ca	Peat soil: 100 – 150 (hectare basis)		In addition, 150 – 500 kg CaO can be applied to improve legume cover plants.
Sulfur, S	-	-	Generally applied with Ammonium Sulfate, Kieserite and Single Superphosphate

(Source: Fairhurst & Härdter, 2003)

Assessment of Oil Palm Fertilizer Requirement

Conventionally, there are four (4) approaches as shown in Table 2, including prediction based on permanent site properties such as climate, soil survey and initial soil analysis (Method I), evaluation of current soil nutritional status based on soil analysis (Method II), evaluation of current nutritional status of palm tissue analysis (Method III) and evaluation of current nutritional status of palm tissue analysis and fertilizer recovery efficiency from permanent site properties (Method IV) for assessing fertilizer requirement in oil palm plantation (Fairhurst & Härdter, 2003). Among the environmental factors, the most important climatic data is rainfall which will affect the timing of fertilizer application and equatorial conditions (1780–2280mm annual rainfall) for oil palm plantation. From soil survey data, parent material, slope, drainage conditions and soil consistency are the required key factors. Method I will be assessed by utilizing permanent and variable properties. While Method IV only focuses on permanent properties, for example, soil particle-size analysis, soil organic matter, soil buffering capacity and reserve nutrient levels and variable soil properties include the amount of extractable nutrient in soil. Meanwhile, Method II, which include only leaf nutrient analysis will be sufficient for correcting fertilizer rates in later years. Another element of Method II is analyzing fertilized soil which is not recommended because samples collected from areas where fertilizer had been broadcast give very high sampling errors. Evaluation of specific location required to establish important parameters and prediction equations before Method I, II and IV. But, Method III is also known as "Foliar analysis" which only relies on leaf nutrient analysis is important to assess nutrient deficiencies without any other local information. In order to select a better diagnostic tool for estimating the fertilizer application rate, variable factors, permanent factors and its functions should be encountered.

Since, fertilizer recommendation for oil palm is mainly based on calibrated soil or leaf test. The completed tests usually compare the soil and leaf nutrient concentration with a predetermined "critical" concentration and are used to make fertilizer application decision. Moreover, the sampling density is limited, and often used to predict the fertilizer recommendation, which may under or over fertilized. For those who have no appropriate trial information will thus depend on the basis of leaf analysis, infrequent soil analysis, nutrient content in the product, observable deficiency-symptom, past experience and opinion from experts of other farmers. All of these also called as field-by field basis which is not suitable to all smallholders (Webb *et al*., 2012). There is a significant variation in fertilizer recommendation preferences and options between large scale plantation and smallholder due to the gap of investment cost for upkeep management and fertilizer assessment. Large scale plantation tends to have higher allocation for soil analysis, leaf analysis, fertilizer trial block, equipment, manpower or combination of analysis, while, smallholder may depend on the fertilizer trial results for general application rate and observable nutrient deficiency symptoms. As a result, it causes delay in the effect of fertilizer on yield had been proven that additional return from the increased yield may be realized in full only after 8 months or even a few years (Goh & Teo, 2011). As mentioned in Goh *et al.* (1999), soil analysis results not taken into consideration of most fertilizer trials. The possible factors which affect the fertilizer recommendation preference are tedious workload and procedure, time consuming, and high cost consumption.

Table 2: Summary of methods of fertilizer assessment indicating data required

Source	Fairhurst & Härdter, 2003			
Method	**I**	**II**	**III**	**IV**
Climatic data	√			√
Soil survey data	√			√
Unfertilized soil analysis results	√			√
Fertilized soil analysis results		√		
Leaf Analysis results			√	√
Comments	Initial fertilizer rate selection	Not suitable for oil palm	Often adequate for oil palm	Recommended method

Technology for Assessment of Oil Palm Fertilizer Requirement

To date, the advances made in geospatial information technologies, for example, Global Positioning System (GPS) and Geographic Information System (GIS) have lead oil palm plantation management toward computer support system in decision-making. Coupling the GPS and GIS technologies often is the practice in order to establish oil palm databases. Besides that, GPS and GIS also have been proven useful for land evaluation for oil palm plantation. (Nordiana, *et al.*, 2013). Planters able to use the collected data to generate digitized maps with geographic coordinate at relatively low to high accuracy GPS that could eventually generate the elevation. All of the data is useful for calculating slope and aspects relevant to landscape. This positioning method often known as "map-based approach" (Adamchuk *et al.* 2004).

Proximal Sensing Technology

Two different types of proximal sensing; (i) non-destructive and (ii) destructive method. Both can be can positioned on the ground or from the sky level. As mentioned previously, foliar analysis and application is the most important and preferred by the growers to tackle the crop nutrient deficiency (Method III and IV) using the non-destructive device. There are several proximal sensors for example Chlorophyll ContentMeter (CCM) for indirect chlorophyll estimation which result higher correlation with N detection for nursery oil palm. Unfortunately, the SPAD result might be different due to leaf age and restricted for mature palm. There was also poor responses between N applied and foliar N detection. Furthermore, SPAD also might be influenced by leaf thickness, varieties, chlorophyll and sampling season. Nevertheless, N estimation also can be done by palm Diameter and Green Model (Diyana *et al.*, 2014).

Remote sensing technology by utilizing the image from the sky either from Unmanned Aerial System (UAS, also known as a drone) integrated with either with camera sensor and/or payload had been explored for map-based oil palm plantation monitoring, including land cover classification, planting on terrace, automatic tree counting, deforestation detection, age estimation, pest and disease detection, and yield estimation. Yield estimation and palm age estimation are the essential database for targeting the production, forecasting and aiding in decision-making process. Technically, oil palm yield can be affected by several factors which are internal factors and external factors. Internal factors of fresh fruit bunch (FFB) production are palm age and its breeds. While, external factors are environmental factor, soil properties, soil fertility, pest and disease infection and many more.

Regarding to the recent research, vegetation indices derived from QuickBird satellite image are strongly correlated with FFB yield, with Ratio Vegetation Index (RVI) showing strongest relationship. From the information of leaf area index (LAI), palm age can be estimated while palm health and FFB yield production can be roughly estimated. Besides that, Normalized Difference Vegetation Index (NDVI) sensor which can be integrated with UAS has the potential to estimate palm health with certainly detecting and calculating the electromagnetic spectrum wavelength in real time condition (Webb *et al*., 2012).

From aspect of soil analysis, on-the-go sensor can be a part of “map-based” and “real time” approach. No matter electrical and electromagnetic sensors, both are rapid response, low cost operation and high durability. These instruments are being used to measure the ability of soil to conduct electricity which quantified as electrical resistivity (ER) or electrical conductivity (EC). This method had been correlated to soil texture, salinity, organic matter, moisture content, and other soil attributes.

Besides that, optical and radiometric sensors determine the amount of energy reflected from the soil surface in particular spectral range is the most popular approach in agriculture. Near- and mid-infrared spectrophotometer has potential organic carbon determination and total N. In addition, real-time portable spectrophotometer use soil reflectance data from 400nm to 2400nm to produce soil properties mapping. The result shows that spectral reflectance data at four single wavelength is correlated with soil moisture, soil pH, soil EC and soil OM. Lately, spectrophotometer had been integrated with a digital camera, EC electrode and a mechanical load sensor was applied for both spatial and temporal variability of soil OM and nitrate content. Furthermore, ground penetrating radar (GPR) which using principle of seismic and sonar method. GPR also represents another radiometric method that has great potential in geophysics in general and agriculture in particular, especially to assist water management.

Mechanical sensor may help to measure soil strength and compaction level of soil. Meanwhile, acoustic and pneumatic sensors have been created as alternative of mechanical sensor which can measure soil texture and compaction separately. Last but not least, electrochemical sensors use ion-selective membranes that produce a voltage output in response to the activity of selected ions including H+, K+, NO3-, Na+, and soil pH measurement. (Adamchuk *et al.*, 2004).

Employment of either geospatial information technologies, remote sensors or proximal sensor is highly recommended for both smallholder and large scale oil palm plantation. Because technology advancement is not only contribute to national research and development also create a platform for smallholder to enhance their knowledge. Besides that, technology can also assist to minimize the gap between smallholder and large scale oil palm plantation. In addition, experts, technology advisors and service producers have been engaged in several research projects in order to improve the performance of the oil palm industry.

Conclusion

In the future oil palm plantation, precision agriculture play a crucial rule for production cost minimization, profit maximization and labour force dependency reduction. Further research and development of application technology is needed to achieve and maintain sustainable agricultural practices. Government and non-government sectors should emphasize dissemination and technology transfer in order to advance in mutual advantage.

References

Adamchuk, V. I., Hummel, J. W., Morgan, M. T., & Upadhyaya, S. K. (2004). On-the-go soil sensors for precision agriculture. Computers and Electronics in Agriculture, 44(1), 71–91. https://doi.org/https://doi.org/10.1016/j.compag.2004.03.002

Diyana, A., Muharam, F. M., & A Rahman, Z. (2014). Evaluation of Multiple Proximal Sensors for Estimating Nitrogen Nutritional Content of Matured Oil Palm. Asian Journal of Plant Sciences (Vol. 13). https://doi.org/10.3923/ajps.2014.136.146 Fairhurst, T., & Härdter, R. (2003). The Oil Palm. Management for Large and Sustainable Yields.

Goh, K. J. (2003). Fertilizing for maximum return. (R. Härdter, & T. F., Eds.) Oil palm: Management for large and sustainable yields, 279-306.

Goh, K. J. (2005). Fertilizer recommendation systems for oil palm: estimating the fertiliser rates. (P. S. Chew, & Y. P. Tan, Eds.) Proceedings of MOSTA Best Practices Workshops – Agronomy and Crop

Management. Malaysian Oil Scientists' and Technologists.
Goh, K., & Teo, C. B. (2011). Agronomic principles and practices of fertilizer management of oil palm. Agronomic Principles & Practices of Oil Palm Cultivation.
Goh, K., Teo, C., Chew, P., & Chiu, S. B. (1999, September). Fertiliser management in oil palm: Agronomic principles and field practices. Fertiliser management for oil palm plantations, 1-44.
Nordiana, A. A., Wahid, O., Esnan, A. G., Zaki, A., Tarmizi, A. M., Zulkifli, H., & Norman, K. (2013). Land Evaluation for Oil Palm Cultivation using Geospatial Information Technologies. Oil Palm Bulletin, 67, 17-29.
Ramme, O. (2015, November). Retrieved from Forum for Sustainable Palm Oil: https://www.forumpalmoel.org/en
Shean, M. (2011). Commodity Intelligence Report. United State Departement of Agriculture.
Shean, M. (2011). Foreign Agricultural Service-Commodity Intelligence Report. United States Department of Agriculture.
Simeh, M. A. (2010, May). Impact of increases in fertilizer prices on Long-term Economic Variability of Palm Oil Production. Oil Palm Bulletin 60, 1-16.
Tarmizi A.M and Mohd Tayeb D. (2006). Nutrient demands of Tenera oil palm planted on inland soils of Malaysia. Journal of Oil Palm Research, 18, 204-209.
Webb, M., Nelson, P., Gary Rogers, L., Curry, G., Pasuquin, J. M., & M Johnston, A. (2012). Site-Specific Fertilizer Recommendations for Oil Palm Smallholders Using Information from Large Plantations. Better crops (Vol. 94).

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019 ***MSAE2019-ARWM09***
21 Mac 2019, Wisma Tani, Kementerian Pertanian dan Industri Asas Tani Malaysia, Putrajaya

Temporal Variation of Ammonium in *Sulfic Tropaquept* Cultivated with Rice in Experimental Pots

Nurulhuda, K.[1], Husni, M.H.A.[2], Zawawi, M.A.M.[1], Zakaria, M.P.[3], Struik, P.C.[4], and Keesman, K.J.[5]
[1]Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, Malaysia.
[2]Land Management, Faculty of Agriculture, Universiti Putra Malaysia, Malaysia (*formerly*).
[3]Institute of Ocean and Earth Sciences, University of Malaya, Malaysia.
[4]Centre for Crop Systems Analysis, Wageningen University, The Netherlands.
[5]Mathematical and Statistical Methods-Biometrics, Wageningen University, The Netherlands.
**Corresponding author. Tel.: +03 8946 6409, Email: k_nurulhuda@upm.edu..my*

Abstract
Hypothetically, monitoring of soil solution NH_4^+-N dynamics may allow estimation of nitrogen (N) transformation rates such as the rates of nitrification, denitrification, mineralisation and immobilisation. Such observations can be used to evaluate and improve performance of N dynamics models for flooded rice systems. Therefore, the objective of this study was to evaluate temporal variation of ammonium dynamics in fertilised and flooded rice pots. Concentrations of NH_4^+-N were determined in soil solutions that were extracted by MacroRhizon samplers. MacroRhizon is a soil solution sampler with a pore size of 0.15 µm manufactured by Rhizosphere Research, the Netherlands. In comparison to typical soil sampling methods, some advantages of using MacroRhizon are repeated sampling at the same spot possible, easy to install and less disturbance to the soil due to the small diameter, and maximum pore size of 0.2 µm which requires no further filtering prior to chemical analysis. Results showed that under current agronomic and management practices, broadcast N application had no obvious and consistent influence on soil solution NH_4^+-N. Analysis of the results suggest that suitability of soil solutions extracted using the MacroRhizon samplers as alternatives for the labourious and destructive conventional soil samplings is subject to further investigation.

Keywords: Nitrogen, ammonium, Rhizon, soil solution, flooded soil, rice

Introduction

In 2012, about 184,047,280 kg of urea and compound fertilisers, which cost about RM 361,200,692, was subsidised by the Farmers Organisation Authority Malaysia to fertilise 693,654 hectares of rice fields in the Peninsular Malaysia (Farmers Organisation Authority Malaysia 2013). Nitrogen use effeciency in flooded rice systems is only about 50% (Ladha et al. 2005).

Hypothetically, monitoring soil NH_4^+ dynamics may allow estimation of N transformation rates such as the rates of nitrification, denitrification, mineralisation and immobilisation, and availability of N for rice uptake, and is useful to improve the accuracy of N dynamics model for flooded rice fields. However, there are only a few reports (Makarim et al. 1991; Dobermann et al. 1994) on temporal and spatial ammonium-nitrogen (NH_4^+-N) trends in the soil of flooded rice fields. Consequently, models that are developed to simulate the N dynamics of flooded rice fields, are not typically validated simultaneously against temporal floodwater and soil N trend (Gaydon et al. 2012; Katayanagi et al. 2013). Katayanagi et al. (2013) claimed that the soil available NH_4^+-N is a key factor in simulating N processes, and, therefore, N dynamics models must be validated against soil NH_4^+-N to improve simulation accuracy.

In the presence of the urease enzyme, urea applied in flooded rice fields hydrolyses into NH_4^+ and bicarbonate ion. NH_4^+ is either attached to the negatively charged clay particles or resides in the soil solution. Conventionally, NH_4^+ is determined in soil core samples, but this technique is destructive and laborious. An alternative is to use Rhizon or MacroRhizon for the determination of NH_4^+.

The Rhizon sampler, developed by Rhizosphere Research, Wageningen, the Netherlands, offers the following advantages: repeated sampling at the same sampling spot, portable, easy to install and less disturbance to the soil due to the small diameter, maximum pore size of 0.2 µm which requires no further filtering prior to chemical analysis, more inert compared to ceramic samplers and preserves the redox potential of the extracted solutions when used with vacuum test tubes (Shotbolt 2010). The Rhizon samplers have been used to extract solutions for monitoring of inorganic N or other ions or elements in soil microcosm studies (Bodelier et al. 2000; Wang et al. 2009; Yan et al. 2000; Murtaza et al. 2011).

To date, only two studies (Makarim et al. 1991; Dobermann et al. 1994) have evaluated the use of Rhizon samplers to collect soil solution for monitoring temporal and spatial variation in NH_4^+-N in flooded rice fields. The influence of split N application on temporal variation in NH_4^+-N in the soil solution was clearly observed in Makarim et al. (1991), but not in Dobermann et al. (1994). These contradicting results suggest that the use of Rhizon samplers to extract soil solutions is subject to further investigation.

Therefore, the objective of this study is to evaluate temporal variation of ammonium dynamics in fertilised and flooded rice pots using MacroRhizon samplers. In this study, we used the MacroRhizon to sample the soil solution instead of the conventional soil sampling.

Materials and methods

Four experimental pots were constructed (Fig. 1) and each pot was filled with soil taken from Plot 3153 at Block C, Sawah Sempadan, Tanjung Karang, Malaysia (3° 28' 09.63" N, 101° 13' 26.48" E). The soil is *Sulfic Tropaquept* or also known as Jawa Series. The soil texture is 43.9% clay, 47.8% silt and 8.2% sand (Aimrun and Amin 2009). The pots were placed outdoor, under a shed, near the Soil and Water Conservation Lab at Biological and Agricultural Engineering, Universiti Putra Malaysia. The soil was submerged with distilled water for approximately one week to eliminate the 'border effect' and to reduce the percolation rate to less than 4 mm/day. The topsoil was ploughed manually to emulate the practice in the fields.

Four germinated MR219 seeds (equivalent to 7 day after sowing) were transplanted in each pot. The floodwater level was maintained at about 5 cm by adding distilled water. The nitrogen treatments are described in Table 1. Fertilisation timing and rates were based on farmers' practice.

The soil solution samples were extracted using MacroRhizon samplers on 19, 21, 23, 27, 30, 32, 38, 40, 42, 44, 46, 52, 57 and 60 day after sowing (DAS). Extraction of one sample took about 8 hours. Samples were analysed immediately or stored at less than 4˚C when immediate analysis was not possible. The soil solutions were analysed for NH_4^+-N based on the Keeney and Nelson (1982) steam distillation method.

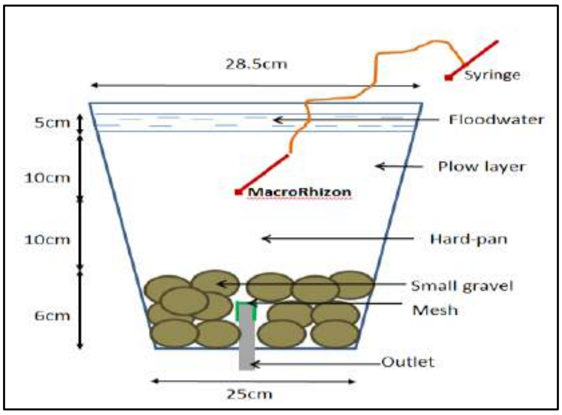


Fig. 1 Cross section of an experimental pot.

Table 1 Nitrogen treatments in the experiment

Treatment label	Rice plants	Rate of N in kg/ha		
		20 DAS	**37 DAS**	**54 DAS**
P1	√	24.5	36.8	34.5
P2	-	24.5	36.8	34.5
P3	√	24.5	36.8	34.5
P4 (control)	-	0	0	0

DAS is day after sowing. The nitrogen fertiliser was in the form of urea for application on 37 DAS. For 20 and 54 DAS, compound fertiliser, which contained urea, phosphorus, potassium and other micronutrients, was applied.

In addition, hourly soil temperatures were measured using sensors placed in the soil and connected to a data logger. The soil and floodwater pH were recorded only once per day.

Results and discussion

The soil temperature followed a diurnal trend ranging from 26˚C at 19:00 hrs to 32˚C at about 14:00 hrs. High soil temperature at mid-day was expected in soils flooded with shallow water depth. The temporal variations of soil solution NH_4^+-N in the four experimental pots are shown in Fig. 2.

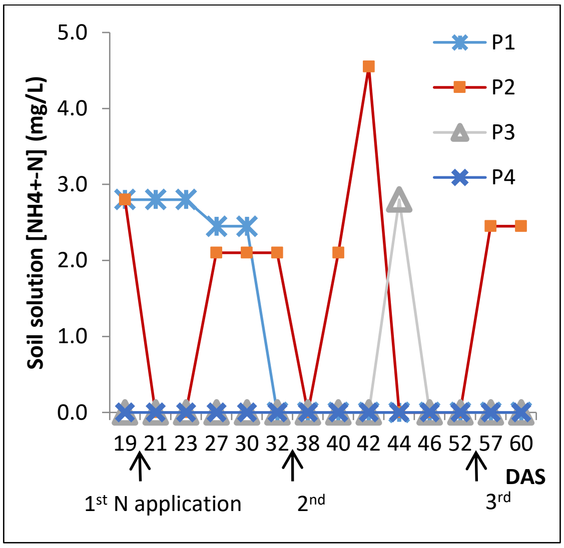


Fig. 2 Temporal variation of concentrations of NH_4^+-N in soil solutions extracted using MacroRhizon samplers.

The initial soil solution NH_4^+-N concentrations for P1, P2, P3 and P4 prior to nitrogen applications were 2.8, 2.8, 0 and 0 mg N L^{-1}, respectively. Fig. 2 shows that there was no obvious increase in soil solution NH_4^+-N in P1 and P3 after each fertilisation. P2 was fertilised and did not contain any rice plant, but no increase in soil solution NH_4^+-N was observed in P2 either. Visual inspection on P2 on 24 DAS revealed that application of nitrogen resulted in significant algae bloom and weed growth in the control pot.

Algae bloom and weed growth were also observed in P1 and P3. Concentrations of nitrate in the soil solutions were consistently below the detection limit for all four pots.

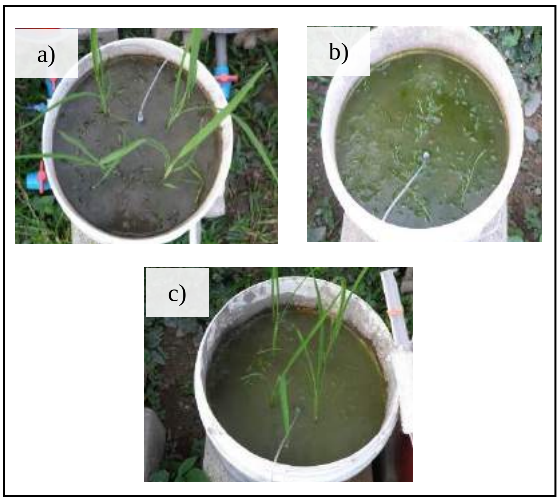


Fig. 3 a) P1, b) P2 and c) P3 observed on 24 DAS.

Overall, results showed that under current agronomic and management practices, broadcast N application had no obvious influence on soil solution NH_4^+-N concentrations. Three hypotheses were formulated: 1) The applied nitrogen may not be stored in the soil. The applied nitrogen may be lost due to either strong competition of nitrogen uptake between rice plants, weed and algae, or nitrogen may be emitted to the atmosphere in the form of gasses. 2) Some of the NH_4^+ may get strongly attached to the soil particles, and can only be extracted via rigorous shaking and chemical reaction. Conventionally, extraction of NH_4^+ in a soil sample involves mixing 3 g of the field-moist soil sample with 30 mL 2 M KCl at 140 rpm for 90 minutes (Maynard et al. 2008). 3) Dilution effect due to the distilled water added to maintain the floodwater at a constant depth was unlikely. Based on our calculations, about 4 mg N L^{-1} was expected in P2 6 days after the first fertilisation assuming the followings; a nitrogen gift of 24.5 kg N ha^{-1}, 50% soil void, well distributed solute in the whole floodwater-soil system, distilled water was added 7 times to maintain 5 cm of standing water depth, and no N sink such as plant uptake or ammonia volatilisation. The concentration of nitrogen in P2 was expected to be even higher than 4 mg N L^{-1} as the hard pan was well compacted to ensure very low saturated hydraulic conductivity. Fillery et al. (1984) reported that 2 days after a nitrogen gift of 30kg N ha^{-1} when rice crop panicle initiation stage, the floodwater contains about 40 mg N L^{-1}.

Conclusions

By analysing the soil solutions extracted using the MacroRhizon, results showed that under current agronomic and management practices, broadcast N application had no obvious and consistent influence on soil solution NH_4^+-N. Analysis of the results further suggests that the suitability of soil solutions extracted using the MacroRhizon samplers as alternatives for the labourious and destructive conventional soil samplings requires further investigation.

References

Aimrun, W. and Amin, M.S.M. (2009). Pedo-transfer function for saturated hydraulic conductivity of lowland paddy soils. Paddy Water Environ 7 (3):217-225. doi:10.1007/s10333-009-0165-y

Bodelier, P.L.E., Hahn, A.P., Arth, I.R., Frenzel, P. (2000). Effects of ammonium-based fertilisation on microbial processes involved in methane emission from soils planted with rice. Biogeochem 51 (3):225-257. doi:10.1023/A:1006438802362

Dobermann, A., Gaunt, J.L., Neue, H.U., Grant, I.F., Adviento, M.A., Pampolino, M.F. (1994). Spatial and temporal variability of ammonium in flooded rice fields. Soil Sci Soc Am J 58:1708-1717

Fillery, I.R.P., Simpson, J.R., and De Datta, S.K. (1984). Influence of field environment and fertilizer management on ammonia loss from flooded rice. Soil Sci Soc Am J, 48, pp.914-920

Gaydon, D.S., Probert, M.E., Buresh, R.J., Meinke, H., Suriadi, A., Dobermann, A., Bouman, B., and Timsina, J. (2012). Rice in cropping systems – modelling transition between flooded and non-flooded soil environments. Europ J Agron, 39, 9-24 doi:10.1016/j.eja.2012.01.003

Katayanagi, N., Ono, K., Fumoto, T., Mano, M., Miyata, A., and Hayashi, K. (2013). Validation of the DNDC-Rice model to discover problems in evaluating the nitrogen balance at a paddy-field scale for single-cropping of rice. Nutr Cycl Agroecosyst 95 (2):255-268. doi:10.1007/s10705-013-9561-1

Keeney, D.R., Nelson, D.W. (1982). Nitrogen - Inorganic forms. In: Page, A.L., Miller, R.H., and Keeney, D.R. (eds). Methods of soil analysis. Part 2: Chemical and microbiological properties, vol 9. Agronomy. Am Soc Agronomy, Wisconsin, USA, pp 643-693

Ladha, J.K., Pathak, H., Krupnik, J.T., Six, J., and Van Kessel, C. (2005). Efficiency of fertilizer nitrogen in cereal production: Retrospects and prospects. Advances in Agronomy. Academic Press, pp. 85-156.

Makarim, A.K., Hidayat, A., and Ten Berge, H.F.M. (1991) Dynamics of soil ammonium, crop nitrogen uptake and dry matter production in lowland rice. In: De Vries P (ed) Simulation and system analysis for rice production (SARP), PUDOC, Wageningen, the Netherlands, pp. 214-228

Maynard, D.G., Kalra, Y.P., and Crumbaugh, J.A. (2008). Nitrate and exchangeable ammonium nitrogen. In: Carter, M.R. and Gregorich, E.G. (eds) Soil sampling and methods of analysis. 2nd edn. CRC Press, Boca Raton, USA, pp. 71-77

Murtaza, G., Haynes, R.J., Naidu, R., Belyaeva, O.N., Kim, K-R, Lamb, D.T., and Bolan, N.S. (2011). Natural attenuation of Zn, Cu, Pb and Cd in three biosolids-amended soils of contrasting pH measured using rhizon pore water samplers. Water Air Soil Pollut 221 (1-4):351-363. doi:10.1007/s11270-011-0795-8

Shotbolt, L. (2010). Pore water sampling from lake and estuary sediments using Rhizon samplers. J Paleolimnol 44:695-700. doi:10.1007/s10933-008-9301-8

Yan, X., Du, L., Shi, S., and Xing, G. (2000). Nitrous oxide emission from wetland rice soil as affected by the application of controlled-availability fertilisers and mid-season aeration. Biol Fertil Soil 32 (1):60-66. doi:10.1007/s003740000215

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Residual crude palm oil resources and recovery method: A Review

Sulin, S.N. and Mokhtar, M.N.
Department of Process and Food Engineering,
Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
**Corresponding Author, Tel: +0148570180, E-mail: Sitinaderahsulin@gmail.com*

Abstract
Over the past few years, Malaysia is among countries who led the world's crude palm oil (CPO) production. This scenario however giving drawbacks due to a large volume of biomass in the form of oil palm empty fruit bunches (OPEFB), oil palm mesocarp fiber (OPMS), decanter cake (DC) and palm oil mill effluent (POME). Whilst they still contain valuable residual oil, which currently million tons of these biomass treated as solid and liquid waste. As opposed to the elimination approach, this review paper is aimed to give an overview on the residual crude palm oil recovery method from different types of biomass resources. Common method proposed in the industry is by extraction using an organic solvent such as n-hexane, but due to it classified as hazardous to air pollutant and highly flammable, many researchers tried to find better approaches such as green solvent D-limonene, sub-critical water, and supercritical CO_2 with or without ethanol. Apart from that, some of the researchers recovered the residual oil by physical means such as pressing, hydro solvent-assisted steam extraction (HYSASE), high pressure water spray (HPWS) and nanofiber absorption technique. For the time being, most of the researchers focused on the oil recovery for a specific type of biomass, but by understanding the method principle, it could bring possibility to treat another type of biomass or can be combined to get high yield of residual oil. Therefore, this strategy will pave the way for several potentials in residual oil utilization such as biodiesel, bio-lubricant, MAG and DAG productions.

Keywords: Residual crude palm oil, recovery method, POME, EFB, palm oil biomass

Introduction

Malaysia popularity in producing crude palm oil (CPO) cannot be debated indeed. Malaysia becomes second world's largest producer and exporter after Indonesia. 19 million tons of CPO produced by Malaysia in 2019 (MPOB 2019a).

The oil palm industry is a land intensive industry where the planted palm oil land area approximately 5.58 million hectares in 2019 (MPOB 2019b). Rather than new forest land explorations that lead to disturbance of the forest systems, loss of animal's habitats and pesticide pollutions in maintaining the plantation, the CPO industries has diverted its efforts to increase oil production by operating at optimum process conditions. One way to achieve this goal is by increasing the oil extraction rate (OER). OER has been used to evaluate the performance of mill by comparing the ratio of palm oil produced with the total fresh fruit bunch (FFB) processed per day (Hussain et al., 2003). The standard OER for Malaysian palm oil industry's is around 20%, which is about 0.2 ton of CPO per ton of FFB (Chung et al., 2017). However, according to the Palm Oil National Key Economic Area (Pemandu 2019), under the Entry Point Project 4, the expectation for Malaysia is to increase its OER up to 23% by 2020. Recovering the residual oil from palm oil wastes is one of strategies on increasing the OER to meet the government target.

The utilization of residual oil highly depends on its quality, either for edible or non-edible purposes. The quality of residual oil also depends on the method used in the recovery process. Residual oil that meets the standard requirement of CPO can be used for any edible purpose. Further analysis of residual oil is necessary to identify the potential use of residual oil such as in biodiesel, soap making, polymer, bio lubricant, monoacylglycerols (MAG) and diacylglycerols (DAG) productions. Turning the residual oil to beneficial product could bring extra side income to the mill.

Source of oil loss

The oil recovered in the mill process (OER), should not identified on its own but it is the outcome of total oil coming to the mill minus the total oil loss. The percentage of oil loss in palm oil mill were highlighted by Walat et al. (2013), indicating that the total oil loss about 1.93%.

Table 1: Percentage of oil loss during different stages of milling process (Walat et al, 2013).

Source of oil loss	Oil loss on Fresh fruit bunch (FFB) %
Steriliser condensate	0.16
EFB	0.56
Fruit loss in EFB	0.03
Unstripped bunches	0.02
OPMS	0.55
Nuts	0.06
Sludge/decanter	0.46
Washings/Spillages	0.09
Total oil losses	1.93
OER	20.8
Total oil (20.8+1.93)	22.73
Oil milling efficiency (20.8/22.73) × 100	92

Conventional method for residual oil recovery

The conventional method for residual oil recovery is by using solvent extraction or Soxhlet extraction method. It is widely used for oil recovery compared to other type of recovery methods.n-Hexane is commonly used in oil recovery method; however, it suffers several major drawbacks; highly flammable, non-renewable sources, and classified as hazardous air pollutants that can cause harmful effect on environment and on human health.

1. ***Solvent extraction***

Solvent extraction is the isolation of a substances or components from solid or liquid by using a solvent. Solubility, hydrophobicity or hydrophilicity, molecular weight, vapor pressure, and acid dissociation are the fundamental properties of substance that use for the selection of extraction solvent (Wells, 2003). Usually solvent to waste ratio can be increased or multiple extraction stages can be done to improve the process efficiency.

To study the extraction of residual oil from POME by organic solvent, Ahmad et al. (2003) used six different types of solvent; n-hexane, pentane, benzene, petroleum ether, and petroleum benzene. The effect of solvent ratio, mixing speed, mixing time, and pH were analyzed to determine the optimum conditions for the extraction. The results show that n-hexane is the best organic solvent to extract oil and grease from POME followed by benzene, petroleum benzene, petroleum ether, pentane and n-heptane. It was estimated around 0.54 g of oil and grease per liter POME can be extracted at optimum conditions; solvent to POME ratio 6:10, 200 rpm mixing speed, 20-minute mixing time and at pH 9.

2. ***Soxhlet extraction method***

Soxhlet system process start with the vaporized solvent passes through the side arm, condenses in the condenser and then floods in the thimble. Extraction occurs when the solvent interacts with the oil source in the thimble and the solvent with substance drains into the flask through the siphon device (Kou et al., 2003).

Fauzi et al. (2016) studied on the extraction of oil from filter cake sludge using Soxhlet extraction where three different solvents were used; n-hexane, methanol and acetone. After the sludge collected from International Foodstuffs Co (IFFCO) Malaysia, it dried for 6 days in the oven at 105ºC, until the weight of the sample become constant. Drying before extraction helps to rupture the matrix walls, thus it prepares the solvent to dissolve with the oil. The highest percentage of oil yield was extracted using methanol, which yielded 66.6% (by weight) followed by n-hexane 33.3%, and acetone 13.3%. This is because methanol is the most polar solvent, so it is more likely to extract most of the polar compounds from the matrix of the material. The methanol extraction from this study, had showed a greater concentration of esters (35.8%), indicating that the extraction involved esterification reaction and the extract could be further used for biodiesel production.

Recovery method for different types of biomass

At the time being, the innovation of residual oil recovery method was created for specific type of biomass.

Table 2: Summary of different method of residual oil recovery for different type of biomass.

Biomass	Recovery Method
POME	-Nanofiber absorption followed by manual pressing, (Chung et al, 2017).
EFB	-Extraction using Sub-critical water, (Kurnin et al, 2016) -Steam injection, (Gomez et al, 2014) -Mechanical Extraction; Pressing, (Jogersen, 1985). -Pressurized hot water, (Yunos et al, 2016)
OPMS	-Supercritical CO_2 extraction, (Nang et al, 2006).
DC	-Green Solvent; D-Limonene (Sahad et al, 2015).

1) ***Palm oil mill effluent (POME)***

POME is the effluent that generated from EFB sterilization and CPO clarification in the palm oil mill. According to Mohammad et al. (2008), it is a colloidal suspension that consist of several composition such as 95 - 96% water, 0.6 - 0.7% oil and 4 - 5% total solids including 2 - 4% suspended solids. There is a large portion of emulsified oil that had polluted the POME and the oil which in emulsified form cannot be separated by gravity separation. The treatment system is usually a combination of anaerobic and aerobic ponds. The residual oil in the effluent is approximately 4000 - 6000 mg/L, while the regulatory threshold value for oil and grease is 50 mg/L (Ahmad et al., 2005).

Chung et al. (2017) focused on the recovery of residual oil from POME by using polypropylene nanofiber (PP NF) in which the field trial had been conducted in palm oil mill. The PP NF was produced using melt-blown technique. It was melted and blew through a very thin nozzle and elongated into nano fibers. The NF was submerged in the sludge pit where the sterilizer condensate and sludge clarification mixed to form POME before passing to the cooling pond. The residual oil was desorbed by pressing with manual roller within the temperature range of 60 - 70ºC. The pressed NF was then tested using both solvent extraction and Soxhlet analysis while the pressed liquid from the NF comprises of water, oil and sludge, was brought to manual skimming to obtain the residual oil. The process recovered 12.19 g of oil/g NF from ~1070-ton POME for 34h of the mill production time. The oil holding capacity for NF was around 1.06 to 1.29 g oil/ g NF after the field test. The oil holding capacity indicated the ease of oil to desorb from the NF. The NF also remained effective after 4 rounds of reuse, which proven by GC-FID study of the recovered oil, indicating no trace of polypropylene contamination.

2) Empty fruit bunch (EFB)

The EFB is generated after the stripping process in which after sterilization, the fruits are separated from the stalks. According to Baharuddin et al. (2009), EFB can be used as a wood composite, fiberboard, soil mulching material, and composting. EFB comprised of about 20% cellulose, 23.9 - 25.1% hemicellulose, 23.5% lignin and 7.4% oil. The oil was previously transferred to EFB surface due to mechanical pressure imposed during the FFB conveying (movement) and threshing process, as well as due to increased contact time; prolonged sterilization and long delays between sterilizing and stripping (Majid et al., 2012).

According to Kronholm et al. (2007), sub-critical water (sub-cw) is defined as liquid water that lies under high temperature (between atmospheric boiling point to less than its critical temperature (374ºC)) and high-pressure condition to keep water in liquid state. The dielectric constant of water reduces from 78.5 at room temperature up to 29 at 250ºC, which make it behaves almost like ethanol to extract the oil. Kurnin et al. (2016) studied on the recovery of residual palm oil and valuable material from EFB by using sub-cw. The spikelet was treated with sub-cw in the temperature range 180 - 240ºC and the holding time of 2 - 5 minutes. The highest yield of oil was 0.075g-oil/g-dry EFB. The yield of oil strongly depends on the temperature and time; however, too high temperature can cause oil degradation (> 240ºC). The oil extracted through this method was comparable (84.5%) to that obtained oil by n-hexane-Soxhlet method. The oil that produced using sub-cw contained FFA between 3 - 12%, because of increment in temperature encouraged the FFA formation by hydrolysis of triglyceride at temperature >240ºC which also supported by (Kronholm et al, 2007 and Alenezi et al, 2008). This experiment also produce sugar (yield 0.20g-sugar/g-dry EFB) from hydrolysis of hemicellulose and cellulose which also supported by (Carrier et al., 2012 and Cocero et al., 2018) and tar from pyrolysis supported by (Ariffin et al, 2008).

Recovery of residual oil for palm oil using steam injection also gains attention lately as it already applied in petroleum industry for oil recovery. Gomez et al. (2014) used the combination of water and steam process to recover the residual oil from EFB. The proposed process was called as hydro solvent-assisted steam extraction (HYSASE). The spikelet was firstly loaded into the chamber and water was added until the spikelet was fully submerged. After that, the saturated steam was injected through the valve. This allowed the steam to bubble (provide agitation) and heat the water until 100ºC. Finally, the water and oil were drained out and further separated using hexane for oil content analysis. The overall process resulted in 83% residual oil removal from the spikelet due to reduction of oil viscosity (which brings the oil viscosity close to water viscosity) and creation of macro-turbulence by bubbling the water increased the interparticle collisions and penetration of micropores within the biomass which also support by (Vilkhu et al., 2008). However, the residual oil properties have high free fatty acids (FFA) due to hydrolysis of triglycerides occurred during the process due to high temperature and high water to oil ratio. The residual oil also reported to have poor bleachability index (DOBI) and peroxide value (PV) compared to the oil before going through the process. Monoglycerides and diglyceride produced through this method affecting the emulsification of oil and water as they are high hydrophilicity due to OH functional group which also support by (Gaonkar 1989).

Residual oil was traditionally recovered by using mechanical means. Jogersen. (1985) suggested to recover the residual oil by pressing the EFB. The bunches were splited longitudinally and were then passed into large single worm screw press for dewatering and removal of residual oil. The average oil recovery from EFB was minimum of 1.5%. The resultant fibrous material served as valuable fuel for steam generation. However, using this method, some portion of residual oil adsorbed to the inner layer of spikelet, and oil would not be fully recovered.

Yunos et al. (2016) studied on oil recovery using pretreatment with compressed water and steam to consider minimal damage of the lignocellulosic material. The method of using high pressure water system (HPWS) was developed to recover the residual oil that entrapped on the surface of EFB. The system consisted of high-pressure cleaner and vessel. The results show that, the highest residual oil recovery yield is 94.41 wt.% at 150ºC. As the temperature increased from 30 to 150ºC, the oil removal rate also increased since elevated temperature is capable in lowering the oil viscosity, thus increased the oil diffusion and solubility. The FFA, PV and DOBI of the residual oil show poor quality after using HPWS process. The DOBI decreases with the temperature increments due to carotene is broken down to secondary products which also supported by (Bonnie, 1999). Despite the low quality of residual oil produce using HPWS method, it complies with EN 14214 international biodiesel fuel standard thus suitable to use as biodiesel feedstock. The remaining EFB shows the increment of surface area, pore volume, cellulose and less lignin content thus suitable to be used as beneficial feedstock for value-added product such as ligno-ethanol.

3) Oil palm pressed mesocarp fiber (OPMS)

OPMS is a residue remains after extraction of oil from fresh fruit, which contains about 5 - 6% residual oil and minor components such as carotenoids, tocopherols, tocotrienols, phytosterols, and squalene (Choo et al., 1996). Usually, the mesocarp fiber was burned for electricity generator, along with palm kernel shells, which resulting in loss of much valuable oil and nutrients.

Nang et al. (2006) studied on the extraction of residual oil from OPMS by using supercritical CO_2 (SC-CO_2) with and without ethanol. CO_2 is often considered the preferable solvent compared to hexane because of its nontoxic, non-flammable, and environmentally friendly properties. The results show that, by using SC-CO_2, 0.054 g oil per g of dried fiber was recovered. Total SC-CO_2 residual oil recovery was 93.l%. The dried fiber produces higher yield compared to the fresh fiber due to the presence of moisture that can influence the phase characteristics of SC-CO_2. However, oxidative stability of fresh fiber is higher compared to the dried fiber. The polarity and solvating power of SC-CO_2 were increased when ethanol was added.

4) Decanter cake (DC)

Decanter is used to treat the underflow of clarification tank by separating the remaining oil from the solid. During the process, the fibrous solid trapped and absorbed the oil before discharging as OPDC (Sahad et al, 2015). Nowadays, most of the palm oil mills use OPDC as animal feed and fertilizer (oil palm plantation) due to its high nutrient content.

As part of searching for green solvent, the popularity of D-limonene also increased. It is one type of terpene, where this bio-solvent derived from citrus fruit through steam distillation. It is better than hexane due to its advantages of low toxicity, highly recyclable, low viscosity, low cost and high boiling point (175^oC) (Liu et al. 2004). Sahad et al. (2015) performed the extraction of residual oil from OPDC using D-limonene. As a result, D-limonene was able to recover 100% of the residual oil. D-limonene is slightly polar than n-hexane, therefore it attributed to higher dissolving power to triglycerides (Chemat et al., 2012). The high boiling point during extraction also could enhance the desorption rate of oil from OPDC due to lower viscosity. However, the quality of residual oil reduced due to deterioration shown high FFA and low DOBI.

Conclusion:

Biomass such as POME, EFB, OPMS and DC shows great potential as residual oil resources. Apart from using organic solvent, all the proposed methods (PP NF absorption, Sub-CW, SC-CO_2, HPWS, HYSAE, D-Limonene) can remove or recover the residual oil comparable to conventional method. Some of the method exposed the biomass toward high temperature and moisture, thus accelerated the rate of oil degradation reaction, which affect the residual oil quality such as PV, DOBI and FFA content.

References

Ahmad, A.L., Bhatia, S., Ibrahim, N., Sumathi. S. (2005). Adsorption of residual oil from palm oil mill effluent using rubber powder. *Braz. J. Chem. Eng.* Vol. 22(3): pp: 371–379.

Ahmad, A.L., Ismail, S., Ibrahim, N., Bhatia, S. (2003). Removal of suspended solids and residual oil from palm oil mill effluent. *J Chem Technol Biotechnol.* Vol. 78: pp: 971–978.

Alenezi, R., Baig, M., Wang, J., Santos, R., Leeke, G.A., (2008). Continuous Flow Hydrolysis of Sunflower Oil for Biodiesel. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects.* Vol. 32: Pp: 460-468.

Ariffin, H., Hassan, M.A., Kalsom, M.S.U., Abdullah, N., Shirai, Y. (2008). Effect of physical, chemical and thermal pretreatments on the enzymatic hyrdolysis of oil palm empty fruit bunch (OPEFB). *J. Trop. Agric. Fundam. Sci.* Vol.36: pp: 1-10.

Baharuddin, A.S., Wakisaka, M., Shirai, Y., Abd-Aziz, S., Abdul Rahman, N.A., Hassan, M.A. (2009). Co-composting of empty fruit bunches and partially treated palm oil mill effluent in pilot scale. *Int. J. Agric. Res.* Vol.4 (2): pp: 69-78.

Bonnie, T.Y.P., and Choo, Y.M. (1999). Oxidation and Thermal Degradation of Carotenoids. *J. Oil Palm Res.* Vol.11: pp:62-78.

Carrier, M., Loppinet-Serani, A., Absa;on, C., Aymonier, C., Mench, M. (2012). Degradation pathways of holocellulose, lignin and alpha cellulose from Pteris Vittata fronds in sub- and super critical conditions. *Biomass Bioenergy.* Vol. 43: pp: 65-71.

Chemat S., Valerie T., and Farid C. (2012). Limonene as green solvents for extraction of natural products. Green solvents Properties and Applications in Chemistry. Springer Science+Business Media Dordrecht.

Choo, Y.M., Yap, S.C., Ooi, C.K., Ma, A.N., Goh, S.H., Ong, A.S.H. (1996). Recovered Oil from Palm-Pressed fiber: A Good Source of Natural Carotenoids, Vitamin E and Sterols. *J. Am. Oil Chem. Soc.* Pp: 7359-9402.

Chung, C., Janaun, J., Semilin, V., & Balan, W. (2017). Recovery of residual oil from palm oil mill effluent using polypropylene nanofiber: A field trial. *MATTER: Int. J. Sci. Technol.* Vol. 3(2): pp: 276-294.

Cocero, M.J., Cabeza, A., Abad, N., Adamovic, T., Vaquerizo, L., M.Martínez, C., Pazo-Cepeda, M.V., (2018). Understanding biomass fractionation in subcritical & supercritical water. *J. Supercrit. Fluids.* Vol: 133: pp:550-565.

Fauzi, A.A., Arsad, A., Ahmad Zaini,M.A., Md Yunus, M.A., (2016). Extraction of oil from filter cake sludge using soxhlet extraction, *J. Eng. Appl. Sci.* Vol: 11 (12): pp: 2561-2565.

Gaonkar, A., (1989). Interfacial tensions of vegetable oil/water systems: Effect of oil purification. *J. Am. Oil Chem. Soc*. Vol. 66: pp:1090–1092.

Gomez, J.C., Mokhtar, M.N., Sulaiman, A., Zakaria, R., Baharuddin A.S., Busu, Z. (2015). Study on residual oil recovery from empty fruit bunch by combination of water and steam process. *J. Food Process Eng.* Vol. 38: pp: 385–394.

Husain, Z., zainal, Z.A., Abdullah, M.Z. (2003). Analysis of biomass-residue-based cogeneration system in palm oil mills. *Biomass Bioenergy.* Vol. 24: pp: 117–124.

Jorgensen, H. K. (1985). Treatment of Empty Fruit Bunches for Recovery of Residual Oil and Additional Steam Production. *J. Am. Oil Chem. Soc.* Vol. 62, no.2.

Kou. D., Mitra, S. (2003). Extraction of semi volatile organic compounds from solid matrices Sample Preparation Techniques in Analytical Chemistry 2003 162 (edited by Mitra S) 139-182 John Wiley & Sons publications, New Jersey. ISBN 0-471-32845-6.

Kronholm, J., Hartonen, K., Riekkola, M.L. (2007). Analytical extractions with water at elevated temperatures and pressures. *TrAC-Trends Anal. Chem.* Vol.26: pp:396-412.

Kurnin, N.A., Ismail, M.H.S., Yoshida, H., Izhar, S. (2016). Recovery of palm oil and valuable material from oil palm empty fruit bunch by sub critical water. *J. Oleo Sci.* Vol 65 (4): pp: 283-289.

Liu, Sx., Mamidipally, Pk., (2004). First approach on rice bran oil extraction using limonene. *Eur. J Lipid Tech.* Vol. 2: pp:122-125.

Majid, R. A., Mohammad, A.W., May, C.Y. (2012). Properties of residual palm pressed fiber oil. *J. Oil Palm Resour.* Vol.24: pp: 1310-1317.

Mohammad, A.W., Yeong, W.T., Md Jahim, J., Anuar, N. (2008). Palm Oil Mill Effluent (POME) Treatment and Bioresource Recovery Using Ultrafiltration Membrane: Effect of Pressure One Membrane Fouling, *J. Biochem. Eng.* Vol. 35(3): pp: 309-17.

MPOB. 2019a. Economics, and industry division. MPOB website. http://bepi.mpob.gov.my/index.php/en/statistics/production/186-production-2018/851-production-of-oil-palm-products-2018.html (accessed February 01, 2019a).

MPOB. 2019b. Economics, and industry division. MPOB website. http://bepi.mpob.gov.my/images/area/2018/Area_summary.pdf (accessed February 01, 2019b).

Nang, H.L.L., Choo, Y.M., Ma, A.N., Chuah, C.H. (2006). Quality of residual oil from palm-pressed mesocarp fiber (Elaeis guineensis) using supercritical CO_2 with and without ethanol. *J. Oil & Fat Ind.* Vol. 83(10): pp: 893 – 898.

PEMANDU. (2019). Palm oil and rubber national key economic area. Pemandu website. http://etp.pemandu.gov.my/upload/NKEA_Factsheet_Palm_Oil_Rubber.pdf (accessed February 01, 2019).

Sahad, N., Som, A.M., Baharuddin, A.S., Mokhtar, N., Busu, Z., Sulaiman, A. (2015). Recovery of residual crude palm oil (RCPO) from oil palm decanter cake (OPDC) using D-limonene. *J. Adv. Mat. Res.* Vol. 1113: pp: 405- 410.

Vilkhu, K., Mawson, R., Simons, L. and Bates, D. (2008). Applications and opportunities for ultrasound assisted extraction in the food industry:A review. *Innov. Food Sci. Emerg.* Vol.9: pp: 161-169.

Walat, O., Bock, N.S., (2013). Palm Oil Mill OER and Total Oil Losses. No.10: p11-16.

Wells. M. J. M., Chapter 2: Principles of extraction and the extraction of semivolatile organics from liquids Sample Preparation Techniques in Analytical Chemistry 2003 162 (edited by Mitra S) 37-138 John Wiley & Sons publications, New Jersey. ISBN 0-471-32845-6.

Yunos, N.S.H., Chu, C.J., Baharuddin, A.S., Mokhtar, M.N., Sulaiman, A., Rajaeifar, M.A., Larimi, Y.N., Talebi, A.F., Mohammed, A.F., Aghbashlo, M., Tabatabaei, M. (2017). Enhanced oil recovery and lignocellulosic quality from oil palm biomass using combined pretreatment with compressed water and steam. *J. Cleaner Prod.* Vol. 142: pp: 3834-384.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian & Industri Asas Tani, Putrajaya

A review of palm mesocarp maceration and separator machine

W. Hafizz[1,*], S. Rosnah[1,2] and Y. Robiah[2,3]
[1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[2]Institute of Advanced Technology, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3]Department of Chemical and Environmental Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +6019-8214173, Email:hafizzwondi@gmail.com

Abstract
The most usual method of extraction crude palm oil is by pressing mescarp fiber and nut together using screw press. Due to this reason, nut and kernel are tend to break by exerted pressing pressure from screw press thus resulting in high kernel loss. Over the years there are many tools and machine have been developed for fiber and nut separation. There are seeral technique hve been introduced to separate mesocarp from its nut including manual or power operated machine. Manual tools are depend on the skill of the worker itself thus, operated machine are developed to eliminate the limitation of manual tools. Most recent separation machine design and technology being discuss in this work has been conferred for various objectives and not only limited for fiber and nut separation before oil extraction. This review paper aims to bring a further understanding on the design, capabilities and limitation from differerent thechnique of fiber and nut separation have been used specifically for palm oil industries.

Keywords: separator, dehusker, fruitlet, fiber, nut

Introduction

Palm oil product contributes 31% of the world oil and fat production. Malaysia is the second largest palm oil exporter with 16.05 million tonnes of oil were recorded export in 2016 (Din, 2017). Palm oil is extracted from oil palm fruit mesocarp while palm kernel oil is similarly extracted from its kernel. Oil palm extraction processing involved five basic operations; fruit sterilization, fruit loosening/stripping, fruit digestion, oil extraction and oil clarification (Osei-Amponsah et al., 2012; Oseni K Owolarafe, Faborode, & Ajibola, 2002). After the palm fruitlets have been stripped from the bunches, the sterilized fruit together with accompanying calyx leaves will reheat and recondition inside digester to loosen the mesocarp from the nut before entering screw press for oil and kernel extraction.

The most usual method extracting process of oil palm mesocarp and kernel is by digestion and pressing in the mill. Several studies have shown that about 4% to 5% residual oil still remain in palm pressed fiber (PPF) after screw pressing(Choo, Yap, Ooi, & Ma, 1996). That remaining residual oil also contribute for the mill oil loss. This problem causes the mill to increase its hydraulic pressure limit for screw press to 70-80 bar compared to 50-60 bar commonly to ensure high oil extraction efficiency. However, the study also showed that this higher pressure exerted by the screw press will results in higher nut breakage as 40% (O K Owolarafe, Osunleke, Odejobi, Ajadi, & Faborode, 2008). The palm fruit mesocarp mash subjected to pressing is a heterogeneous mixture of nut, fibre and fluid. There is a limit to the amount of expression pressure that can be applied before the nut is not cracked. Many attemp have been introduced to overcome this problem either by research institute or by the industry itself. The findings from these attemps have their own advantage and disadvantages.

Dehusking using knife

Knife were used to dehusked the palm fruitlets mesocarp from its seed manually. The knife was design straight and sharp equipped with handle. Force is applied by hand so that the sharp area can peel off the mesocarp without breaking the nut or seed. By using this tool, all of the mesocarp can be fully utilized which can prevent oil loss. For example Federal Land Development Authority (FELDA) Sg. Tekam Mill and Research Centre (Vincent, Shamsudin, Baharuddin, & Yunus, 2016) used this method to dehusk 8000 fruitlets sample daily to analyse the quality and oil yield every fruitlets. This method is not only required longer time to complete this work, but also tiring.

Drupe dehusker

(Vincent et al., 2016) have developed a small scale drupe dehusker **PI 2014700853** with a capacity of 300 g load which is used to separate oil palm mesocarp and kernel. This machine have been developed in order to remove mesocarp from nut prior oil extraction. It consist of peeling basket with perforated sharp edges and rotatable operating disc powered by motor. Palm fruitlets is placed on the operating disc at the bottom section. The motor which is interconected with operating disc will revolve based at its designated speed. The revolution of operating speed makes the palm fruitlets throw outside and hit the sharp edges on the peeling basket wall through centrifugal force. The mesocarp then dehusked from nut by frictional contact between fruitlets and peeling basket wall. The revolution speed can be set up to 25,000 rpm. After dehusking operation complete, dehusked nut then were collected manually on the operating disc while operating disc need to remove to collect mesocarp at the bottom side.

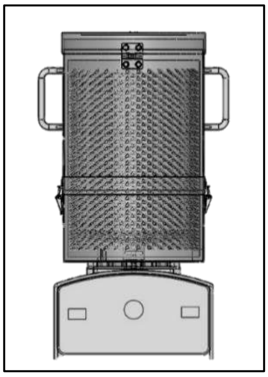


Figure 5: Drupe Dehusker

Palm Digester

Palm digester are machine reviewed by (Stork Amsterdam, 1960) to macerate or digest sterilized palm fruitlets prior pressing. This machine are improvise technology based on the primitive fruitlets processing technique. It is design vetical consist of main shaft, beater arms, cylinder vessel, steam injector and side bottom discharge.

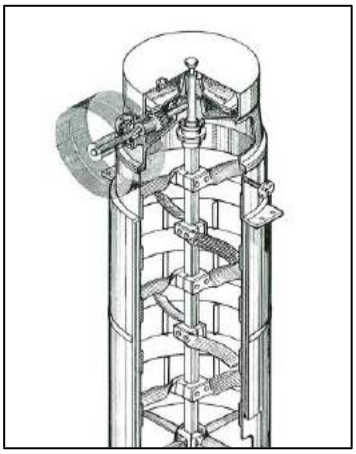


Figure 6: Internal design of palm digester

Stipped palm fruitlets are feed from the bottom of digester through hopper until ¾ of the volume. Shaft attached with 5 sets of beater arm comprised with long and short arm are rotate to stir the fruitlets inside digester. This stirring operation will create rubbing and pressing action to fruitlets in order to break up the oil cell at the mesocarp and loosen it from the nuts. Steam are supplied inside the vesses throughout this process to elavate and maintain the temperature until 90 degree celcius for maximum digestion operation. Complete digested mesh (mixture of mesocarp and nuts) are continously being remove through side bottom discharge for oil extraction. This technology currently are still being used at the existing palm oil mill in Malaysia.

Palm Nut-Fiber Separator

The palm nut-fiber separator machine developed by (Kwasi Adzimah & Seckley, 2009) purposely to separate nut and fiber from pressed cake after oil extraction. This machine are proposed to be installed after screw press machine and expected to increase the kernel recovery efficiency. This machine comprise with two horizontal shaft (top and bottom), metallic mesh, and outlet for nuts and fiber. With separation efficiency of 90%, this machine capable to process with capacity of 500kg/hr.

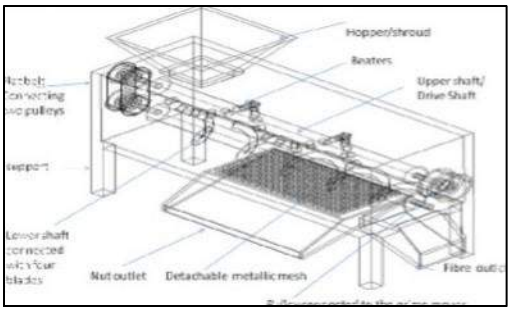


Figure 7: Palm nut-fiber separator

Pressed fiber (after screw press) are feed through top hopper then enter to top horizontal beater shaft to break and separate fiber from its nuts. The lower shaft equiped with worm blade with equal pitch are used to convey the fiber to funnel discharge at the left side. While, the nuts will fall through gravity force at the bottom of the machine.

Palm Nut-Pulp Separator

Nut and Pulp separator machine was developed by (Nduka, Okay, & Jonah, 2012) to separate digested mesh between palm nut and pulp or digested mesocarp. This machine design quite similar to the previous palm nut-fiber separator machine but this machine are proposed to be installed between the digester and screw press machine. With processing throughput of 120kg/hr, this machine consist of cake breaking unit and separating unit powered by electric motor. Digested mesh are feed through top hopper then enter to cake breaking unit section at the upper chamber. The rotaty motion of beater in this section makes the pulp that adhere to the palm nut detached.

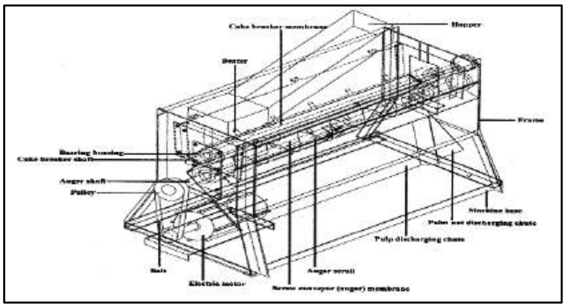


Figure 8: Palm nut-pulp separator

The entangle pulp need to detach at this section for effective separation. Then the minture of pulp and nut are further separate at separating unit section located at the lower chamber of this machine. The separating unit consist of adjustable blade and auger are used separate and convey the loosed digested mesh from right to the left side section of this machine. During this process, pulp will discharge through an opening of slit at 2.5mm wide while nuts will discharge at the end section of machine.

Kernel nut and Mesocarp Separator

Kernel nut and mesocarp separator are developed by (Foster & Yunus, 2016) for separating mesocarp surrounding a kernel nut of a fruitlets. This machine are comprised with tapered helical screw, protuding cutting cylider wall and steam nozzle.

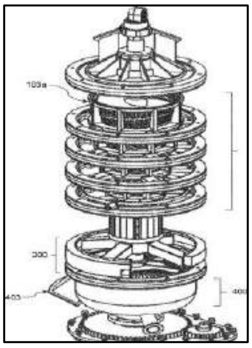


Figure 9: Kernel nut and mesocarp separator

The operation start with feeding the palm fruitlets from the top hopper. The fruitlets then are conveyed to the bottom by rotation movement of tapered helical screw. Throughout the movement of fruitlets from top section to the bottom section, the mesocarp were removed and separate from nut by protuding cutting wall along the helical path. The teared mesocarp then fall to the bottom discharge assisted with skimming arm while nut are removed to the nut discharge for nut washing process.

Conclusion

The palm mesocarp/fiber and nut separator machine specifically for oil palm industry has been reviewed. It is is obvious that the are two types of separation technique involved which are dry separation (without steam or hot water) and wet separation (using steam or hot water injection). It has been observed that there are several type of mechanism has been used; centrifugal separation, rotary beater or blade and rotary auger with conveyor. The adoptation and further improvement of these machine will improve the oil yield thus maximizing the mill revenue.

Acknowledgement

The authors would like to thank Universiti Putra Malaysia and Ministry of Education, Malaysia for the financial support through the Graduate Research Assistance (GRA) scholarship, Universiti Putra Malaysia Grant scheme (UPM/700-1/2/GPPI/2017 /9543300).

References

Choo, Y., Yap, S., Ooi, C., & Ma, A. (1996). Recovered Oil from Palm-Pressed Fiber : A Good Source of Natural Carotenoids , Vitamin E , and Sterols, 73(5), 599–602.

Din, A. K. (2017). Malaysian Oil Palm Industry Performance 2016 and Prospects for 2017. Http://Bepi.Mpob.Gov.My/Index.Php/En/Statistics/Production/186-Production-2018/851-Production-of-Oil-Palm-Products-201, Accessed M, 6. Retrieved from http://www.mpob.gov.my/images/stories/pdf/2017/2017_Dr.KushairiPALMEROS2017.pdf

Foster, G. L., & Yunus, R. (2016). Kernel Nut and Mesocarp Separator.

Kwasi Adzimah, S., & Seckley, E. (2009). Modification in the design of an already existing palm nut - fibre separator. African Journal of Environmental Science and Technology, 3 (11)(November), 387–398. http://doi.org/10.5897/AJEST09.051

Nduka, N. B., Okay, O. A., & Jonah, A. C. (2012). Design , Fabrication and Evaluation of Palm Nut-Pulp Separator. Journal Od Emerginr Trends in Engineering and Applied Sciences (JETEAS), 3(1), 144–151. http://doi.org/ISSN: 2141-7016

Osei-Amponsah, C., Visser, L., Adjei-Nsiah, S., Struik, P. C., Sakyi-Dawson, O., & Stomph, T. J. (2012). Processing practices of small-scale palm oil producers in the Kwaebibirem District, Ghana: A diagnostic study. NJAS - Wageningen Journal of Life Sciences, 60–63, 49–56. http://doi.org/10.1016/j.njas.2012.06.006

Owolarafe, O. K., Faborode, M. O., & Ajibola, O. O. (2002). Comparative evaluation of the digester – screw press and a hand-operated hydraulic press for palm fruit processing, 52, 249–255.

Owolarafe, O. K., Osunleke, A. S., Odejobi, O. A., Ajadi, S. O., & Faborode, M. O. (2008). Mathematical modelling and simulation of the hydraulic expression of oil from oil palm fruit. Biosystems Engineering, 101(3), 331–340. http://doi.org/10.1016/j.biosystemseng.2008.08.007

Stork Amsterdam. (1960). Stork Review. http://doi.org/10.1017/S0021911813002374

Vincent, C. J., Shamsudin, R., Baharuddin, A. S., & Yunus, R. (2016). Separation Performance of Oil Palm Mesocarp and Kernel using Different Blade Orientation. The International Symposium on Agriculture and Biosystem Engineering, (August), 9–11.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-ARWM12

The Potential Use of Palm Oil Fuel Ash (POFA) As Properties of Lightweight Concrete

Hasfalina, C.M[1,*], Corolin, B.[2], M. Rashid, M.Y.[3] and Muhammad Hazwan, H.[4]
[1,2,4]*Department of Biological and Agricultural Engineering, Faculty of Engineering, UPM, 43400 Serdang, Selangor, Malaysia*.
Air Resources Research Lab, Malaysian-Japan International Institute Technology, UTM, Jalan Semarak, Kuala Lumpur.
**Corresponding Author, Tel: +03 89464340, E-mail: hasfalina@upm.edu.my*

Abstract
Malaysia is well known as the main crude palm oil producer and exporter in the world. Million tonnes of agro wastes such as Palm Oil Fuel Ash (POFA) is being produced every year with no commercial return on it. Due to pozzolanic behaviour possessed by POFA, it could be significance if the POFA is being recycled and used in production of lightweight concrete. Thus, this study investigated the effects of Palm Oil Fuel Ash (POFA) on engineering properties in terms of compressive strength, flexural strength and splitting tensile strength. Three types of concrete were prepared, lightweight concrete with 100 % sand as control mix (CM), lightweight concrete with 10 % POFA replacement as part of filler (POFA10), and lightweight concrete with 20 % POFA replacement as part of filler (POFA20). All the specimens were water cured prior mechanical tests. The laboratory results showed that the incorporation of POFA into lightweight concrete has increased its compressive strength about 10%, flexural strength about 28% and splitting tensile strength about 23%. This shows that Palm Oil Fuel Ash has a great potential to be applied as part of lightweight concrete materials.

Keywords: palm oil fuel ash (POFA), lightweight concrete, flexural strength, compressive strength, mechanical tests

Introduction

Palm oil is extracted from the fruit and copra of the palm oil tree. After the extraction operation, waste products such as palm oil, fibres, shells, and empty fruit bunches are mostly burnt as biomass fuel to boil water, which generates steam for electricity and for the extraction process in palm oil factories. The combustion of palm oil husk and palm kernel shell in the steam boiler produces palm oil fuel ash (POFA), which is approximately 5 % of solid waste by-product, equivalent to 3.1 million tonnes in Malaysia in 2010 (Tangchirapat et al., 2007; Sooraj VM, 2013).

POFA has been identified as a good pozzolanic material, it is because POFA contains siliceous compositions produces a stronger and compact concrete (Sooraj VM, 2013). Pozzolanic is a natural or artificial material containing silica and alumina in a reactive form and only have little cementitious properties. However, in a smooth and moist form, pozzolanic will react with alkali to form cement compounds (Setina et al., 2013). The silica oxide content in POFA can react with calcium hydroxide ($Ca(OH)_2$) from the hydration process which is deteriorated to concrete and the pozzolanic reactions produce more calcium silicate hydrate (C-S-H) which is a gel compound as well as reducing the amount of calcium hydroxide. Due to high silica oxide content in POFA which met the pozzolanic property criteria, it is potentially utilized as cement replacement or as filler to produce hard and durable concrete (Munir et al., 2015) for example as lightweight concrete. Lightweight concrete is a special concrete which weights lighter than conventional concrete. Density of this concrete is considerably low about 300 kg/m^3 to 1850 kg/m^3 when compare to normal concrete is 2200 kg/m^3 to 2600 kg/m^3 (Islam et al, 2015). Lightweight concrete means that the concrete has more the following properties such as less specific gravity, high water absorption and less bulk density, relatively less compressive strength, and less modulus of elasticity.

Materials and methods

Preparation of Raw Materials

The making of lightweight concrete incorporated with POFA consist of four types of raw material, namely Ordinary Portland Cement (OPC), POFA, fine aggregates of sand and water. The POFA was obtained from Kilang Sawit LCSB Lepar at Gambang, Pahang. The OPC, POFA and sand were dried in an oven at temperature of 105 °C ± 5 °C for two hours. The OPC, POFA and sand were sieved through 300μm sieve

Mix proportions

OPC, Sand and POFA were weighted and mixed in a concrete mixer until the dry mix was uniformly mixed. Next, water was weighted and added into the dry mix to obtain the ratio of 100 % sand as filler (CM), 10 % POFA replacement as part of filler (POFA10) and 20 % POFA replacement as part of filler (POFA20). The slump test was carried out before fresh lightweight concrete is poured into the mould. The specimens for each mix proportions were water cured for 7, 14 and 28 days before undergoing compression test.

Slump test

The slump test was conducted by using a slump cone and flat base plate as complied with ASTM C995 (2001). Slump cone was placed at the centre of the base plate and filled with fresh lightweight foamed concrete until it was fully filled. Excessive fresh lightweight concrete was struck off and the slump cone was lifted to 1 ft. height. The four angle of dimension of spread was measured and recorded.

Compression test

The compression test was conducted by using compressive strength machine. The test was performed in accordance with BS EN 12390-3 (2002). The cubes were taken out from water tank and air-dried for two hours before the test is performed. Dimension of specimen was measured and loaded gradually with constant rate of loading of 0.02 mm/s until the specimen fails. The maximum load carried by the specimen was recorded and compressive strength was calculated based on the equation 1 (BS EN 12390-3, 2002).

$$\mathbf{Sc} = \frac{\mathbf{P}}{\mathbf{Width\ X\ Thickness}} \qquad (1)$$

Where
Sc = Compressive strength, MPa
P = Maximum load carried by specimen, N
Width = Width of specimen, mm
Thickness = Thickness of specimen, mm

Splitting tensile test

The test was performed in accordance with ASTM C496 (2004). The cylinders were taken out from water tank and air-dried for two hours before the test was performed. Using Concrete Compression Machine an axial load with a specified rate of loading was applied to cylinder with 100 mm of diameter and 200 mm of height until failure occurred. Test specimen was loaded gradually with constant rate of loading of 0.02 mm/s until the specimen fails. The maximum load carried by the specimen are recorded and splitting tensile strength was calculated based on equation 2 (ASTM C496, 2004).

$$\boldsymbol{T} = \frac{\boldsymbol{2P}}{\boldsymbol{\pi L D}} \qquad (2)$$

Where
T = Splitting tensile strength, MPa
P = Maximum load carried by specimen, N
L = Length of specimen, mm
D = Diameter of specimen, mm

Flexural stength test

Flexural test was performed in accordance with ASTM C293 (2002). The prisms will be taken out from water tank and air-dried for two hours before the test was performed. Using Concrete Flexural Machine a centre-point loading with a specified rate of loading was applied to prism with dimension of 25 mm x 25 mm x 250 mm until failure. An offset of 10 mm from both sides of prism was marked and the prism are placed on the support block. Test specimen was loaded gradually with constant rate of loading of 1.67 x 10^{-3} mm/s until the specimen fails. The maximum load carried by the specimen was recorded and flexural strength was calculated based on the equation 3 (ASTM C293, 2002).

$$\mathbf{R} = \frac{\mathbf{3PL}}{\mathbf{2bd^2}} \qquad (3)$$

Where
R = Flexural strength, MPa
P = Maximum load carried by specimen, N
L = Length of specimen, mm
d = Thickness of specimen, mm
b = Width of specimen, mm

Performance Index

The density of lightweight concrete was controlled to be within 1300 kg/m3 ± 50 kg/m3. The equation for performance index is shown in Equation 4 (Ramamurthy, 2009).

$$\mathbf{PI} = \frac{\mathbf{Sc}}{\left[\frac{\mathbf{hardened\ density}}{\mathbf{1000}}\right]} \qquad (4)$$

Where
PI = Performance Index, MPa per 1000 kg/m3
Sc = Compressive Strength, MPa

Results and discussion

Compression Test Profile

Figure 1 showed that the compressive strength is directly proportional to curing age for CM, POFA10 and POFA20, respectively. The highest compressive strength of CM required is 6.61 MPa which as obtained on the 90^{th} day of curing age. For POFA10, 7.82 MPa is the highest value of compressive strength with 0.54 of w/c mix proportion achieved in curing age 90 days.

It has been observed that incorporation of POFA into lightweight concrete has increased its compressive strength. This mainly due to the pozzolanic process happened in lightweight concrete incorporated with POFA. The pozzolanic process ensures continuous development of strength due to addition reactive silica content by the incorporation of POFA, which more C-S-H was produced due to the reaction of reactive silica with calcium hydroxide. This additional C-S-H gel caused the lightweight concrete denser. The additional calcium silicate hydrate gel formed improves the interfacial bonding between the aggregates and pastes at later ages (Karim, 2011). Thus, the compressive strength increased. The compressive strength of POFA10 at 90 days of age was 10 % higher than that of CM. On the other hand, compressive strength of POFA20 at 90 days of age was 8 % higher than of CM.

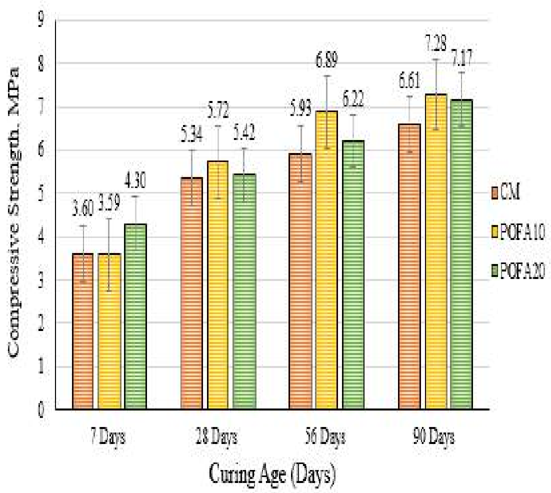


Figure 1: Compressive Strength from 7 to 90 Days Curing Age.

Slump Tests Profile

Table 1 presented the mix proportions used. The ration of water to cement (W/C) and the ratio of sand to POFA influenced the spread of the slump tests. An increase in the spread could be seen with a higher water to cement ratio, while the spread value decreased with high value of POFA in mix proportion.

Table 1: Mix Proportion

Mix Details	Sand : POFA[1]	W/C[2]	Slump Cone Spread Value (mm)
CM[3]	100:0	0.54	550-560
		0.56	580-590
		0.58	660-670
		0.60	690-695
POFA10[4]	90:10	0.54	460-500
		0.56	465-525
		0.58	480-530
		0.60	505-540
POFA20[5]	80:20	0.54	400-420
		0.56	410-450
		0.58	420-460
		0.60	470-510

Note:

[1] sand: POFA is in percent ratio
[2] W/C = water to cement ratio
[3] CM = lightweight concrete control mixture
[4] POFA10 = lightweight concrete with 10% of POFA
[5] POFA20 = lightweight concrete with 20% of POFA

Splitting Tensile Strength

Figure 2 shows the result of splitting tensile strength for CM, POFA10 and POFA20 for 7, 28, 56 and 90 days of curing ages. Both POFA10 and POFA20 have higher splitting tensile strength value compare to CM. POFA10 achieved the highest splitting tensile strength which is 1.002 MPa at 90 days curing age. Generally, the splitting tensile strength development shared the same trend with compressive strength development. Lightweight concrete incorporated with POFA shows higher splitting tensile strength than pure sand based lightweight concrete. Theoretically, splitting tensile strength is related to compressive strength, although this relationship depends on different factors namely aggregate type, particle size distribution, age of concrete, curing process and air content (Parra, 2011).

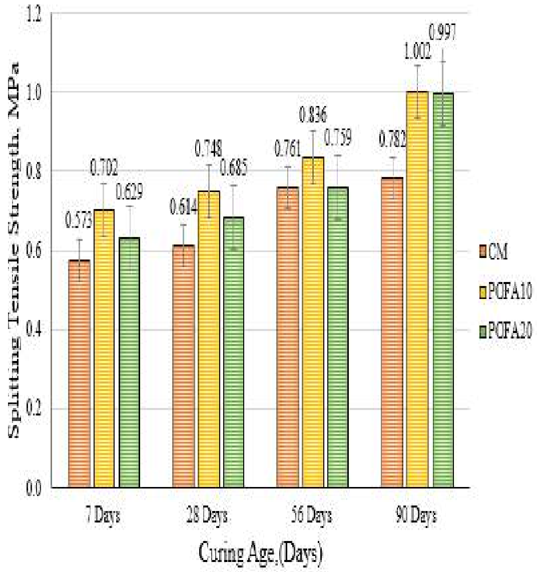


Figure 2: Splitting Tensile Strength Up To 90 Days Curing Age For CM, POFA10 and POFA20

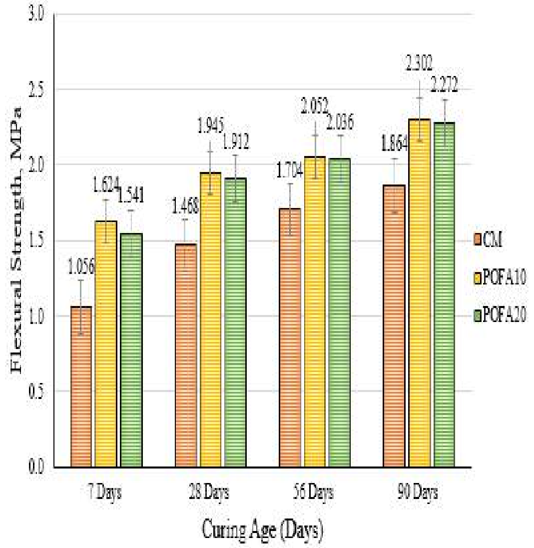


Figure 3: Flexural Strength Up To 90 Days Curing Age For CM, POFA10 and POFA20

The splitting tensile strength of POFA10 and POFA20 at 90 days of age were 28 % higher than that of CM. Generally, splitting tensile strength is much lower than compressive strength. This is because in this test, the cylinder specimen is placed with its axis horizontal between the plates of a testing machine. The load is increased until failure by indirect tension in the form of splitting along the vertical diameter takes places. It can be seen that a high horizontal compressive stress exists in the vicinity of the loads but, as this is accompanied by a vertical compressive stress of comparable magnitude, thus producing a state of biaxial stress. Hence, the cylinder fail at tension rather than failure in compression (Neville, 2010).

Flexural Strength

Figure 3 shows the flexural strength of each mix proportion increased with the curing age. Both POFA10 and POFA20 has higher flexural strength than CM at 90-day of age. The flexural strength of POFA10 at 90 days of age was 23 % higher than that of CM. On the other hand, flexural strength of POFA10 at 90 days of age was 22 % higher than that of CM. POFA10 achieved the highest flexural strength at 90 days of age which was 2.302 MPa.

In general, the flexural strength has same patterns with compressive strength. Lightweight concrete incorporated with POFA shows higher flexural strength than that of pure sand (CM) based lightweight concrete.

Performance Index

Table 2 presents the performance index of the lightweight concrete. The trend of performance index of lightweight concrete is similar as compressive strength, in which the performance index is directly proportional to curing age. The highest performance index was achieved by POFAF10 and followed by POFA20 at 90 days of age.

Generally, specimens with POFA as part of filler have higher compressive strength than that of 100 % sand as filler specimen. This is due to the pozzolanic behaviour possessed by POFA. A common trend can be obtained for flexural and splitting tensile strengths, where the flexural and splitting tensile strengths are directly proportional to its curing ages. Besides that, specimen incorporated with POFA has higher flexural and splitting tensile strengths than that of pure sand based specimens.

Table 2: Performance Index of Lightweight Concrete

Age (days)	CM: POFA Ratio	Performance Index
7	CM	2.80
	POFA10	2.77
	POFA20	3.26
28	CM	4.13
	POFA10	4.42
	POFA20	4.20
56	CM	4.51
	POFA10	5.40
	POFA20	4.72
90	CM	5.05
	POFA10	5.66
	POFA20	5.53

Conclusion

It can be concluded that the incorporation of POFA into lightweight concrete as sand replacement plays important role in improving the engineering properties of lightweight concrete in terms of compressive strength, splitting tensile strength, and flexural strength. The research work on lightweight concrete incorporated with POFA is still limited but it promises greater potential for industrial application.

References

American Society for Testing and Materials (2001). Standard Test Method for Time of Flow of Fiber-Reinforced Concrete Through Inverted Slump Cone (ASTM C995-01)

American Society for Testing and Materials (2002). Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading) (ASTM C292-02)

American Society for Testing and Materials (2004). Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens (ASTM C496-04)

Islam, M. M. U., Mo, K. H., Alengaram, U. J., & Jumaat, M. Z. (2015). Mechanical and fresh properties of sustainable oil palm shell lightweight concrete incorporating palm oil fuel ash. *Journal of Cleaner Production*, *115*, 307–314.

Karim, M. R., Zain, M. F. M., Jamil, M., Islam, M. N. (2011). Strength of Concrete as Influenced by Palm Oil Fuel Ash. *Australian Journal of Basic and Applied Sciences,* 5(5): 990 – 997.

Munir, A., Abdullah, Huzaim, Sofyan, Irfandi, & Safwan. (2015). Utilization of palm oil fuel ash (POFA) in producing lightweight foamed concrete for non-structural building material. *Procedia Engineering*, *125*, 739–746.

Neville, A. M. (2010). *Properties of Concrete* (4th ed.). London: Pearson, 10 – 17, 65 – 71, 83 – 86, 598-599, 688.

Parra, C., M. Valcuende, M. & Gomez, F., (2011). Splitting tensile strength and modulus of elasticity of self-compacting concrete. Construction and Building Materials. Vol. 25, pp.201-207.

Ramamurthy, K., Kunhanandan Nambiar, E.K., Indu Siva Ranjani, G. (2009). A Classification of Studies on Properties of Foam Concrete. *Cement & Concrete Composite,* 31: 388-396.

Setina, J., Gabrene, A., & Juhnevica, I. (2013). Effect of pozzolanic additives on structure and chemical durability of concrete. In *Procedia Engineering* (Vol. 57, pp. 1005–1012).

Sooraj VM. (2013). Effect of Palm Oil Fuel Ash (POFA) on Strength Properties of Concrete. *International Journal of Scientific and Research Publications*, *3*(6), 2250–3153.

Tangchirapat, W., Saeting, T., Jaturapitakkul, C., Kiattikomol, K., and Siripanichgorn, A. (2007). Use of waste ash from palm oil industry in concrete, *Waste Management,* 27: 81-88.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-ARWM13

Methane Production from Anaerobic Co-digestion of Sewage Sludge and Decanter Cake

Norshafiqah. K.A[1*], Hasfalina. C.M[1], M.Hazwan. H[1], Syazwani. I[2], Nik Norsyahariati. N.D[2], Wan Azlina. W.A.K.G[3]
[1] Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia,
[2] Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia,
[3] Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia
*Corresponding author. Tel.: +6018-3524763, Email:shafiqah.kn@gmail.com

Abstract
Increased production of sewage sludge from wastewater treatment and decanter cake from palm oil mill industry results in the generation of large quantities of waste that ends up difficulty to find the effective method of disposal. In this study, an anaerobic co-digestion has been considered to convert these organic pollutants into methane gas. Anaerobic co-digestion of sewage sludge and decanter cake was studied in 125mL serum bottles with 100mL working volume. The effect of different inoculum to substrate ratios (I/S) on biogas production was investigated. The batch study was conducted at the ratio I/S of 1:0.5, ratio 1:1 and ratio 1:2 and sewage sludge alone as control at ratio 1:0. Daily biogas collection for the ratio of 1:2 had resulted the highest cumulative biogas production of 247 mL. The highest methane yield was obtained at mixing ratio of 1:0.5 with 165.6 L CH4 / g VS. As a comparison, all co-digestion ratios produced more biogas than the sewage sludge alone. This proved that anaerobic co-digestion of sewage sludge and decanter cake can improve the production of biogas.

Keywords: Anaerobic co-digestion, Sewage sludge, Decanter cake, Lignocellulosic, Batch fermentation

Introduction

In Malaysia, palm oil industry gives the most sources of agricultural waste since palm oil is the largest producer.

More than 5.39 million hectares of land and 16.3% of the total land area were cultivated for oil palm in Malaysia in the year 2014 (Awalludin et al., 2015). It shows an increment from 11% of the total land area cultivated for oil palm in year 2003 (Hansen, 2005). Apart from crude palm oil (CPO) that produced from fresh fruit bunch (FFB), fibre, shell, decanter cake and empty fruit bunch (EFB) were also produced for 30, 6, 3 and 28.5% from the FFB respectively. It is estimated that about 26.7 million tonnes of solid biomass were generated from 381 palm oil mills in Malaysia in 2004 (Yacob et al. 2005). Abundance of this waste needs sustainable management to deal with to decrease the environmental pollution issues.

Decanter cake (DC) is one of the solid wastes from palm oil mill and produced from three-phase of CPO purification process in oil palm mill plant. It is about 3-5wt% of rate of DC production from FFB and estimated about 3.6 million tonnes of DC generated by palm oil mill in year 2012. DC becomes fire hazard to the mill when it is dried and increase the amount of suspended particles (Dewayanto et al., 2014). Decanter cake mostly used as animal feed that made in grade pellets (Chavalparit et al., 2006) and as digestate which is used as fertilizer (Holm-Nielsen et al., 2009). Currently DC has been utilized as feedstock for production of cellulose and polylose, bio-surfactant, bio-butanol and bio-diesel (Dewayanto et al., 2014). DC has also been used as a substrate in anaerobic digestion (Kanchanasuta & Sillaparassamee, 2017).

The decanter cake, composed of high biodegradable organic content and nutrient-rich composition, is ideal feed-stock for the production of bioenergy such as methane via fermentation. However, decanter cake is also lignocellulosic biomass which slow hydrolysis rates due to high fat and lipid content. Therefore, co-digestion of decanter cake with sewage sludge is considered as an attractive substrate for anaerobic digestion due to its high organic content (mainly in the form of proteins and fats) and due to its high methane potential (Pitk et al., 2012). A study by Kanchanasuta and Sillaparassamee (2016) co-digested DC and crude glycerol. Their results show that co-digestion could improve the production of methane gas. Another study by Kaosol and Sohgrathok (2014) co-digested the DC with frozen seafood wastewater, has resulted positive impact on the production of methane gas at the different organic loading rate.

The benefits of anaerobic co-digestion include improving the nutrient balance, increasing digestion rate, increasing load of biodegradable organic matter and producing better biogas yield (Sosnowski et al., 2003). The anaerobic co-digestion also may improve the biogas production due to carbon, nitrogen and nutrient balance (Yen and Brune, 2007).

Lignocellulosic biomass is mostly practiced in solid-state anaerobic digestion (SS-AD) rather than liquid anaerobic digestion L-AD, however, there are few challenges including low methane yield, potential instability and low values of end-product (Yang et al., 2015). Liquid anaerobic digestion (L-AD) operated with less than 15% of total solid (TS) content, while, solid-state anaerobic digestion (SS-AD) can operated with more than 15% of TS content (Yang et al., 2015). The advantages of SS-AD over L-AD are SS-AD can operated in small reactor volume, low demand of energy for heating, high production of volumetric methane, minimal material handling and low of total parasitic energy loss. L-AD always regarded with floating and stratification of fibrous material problems and these can be solved with SS-AD (Li et al., 2011; Yang et al., 2015).Therefore, the aim of this study is to determine the methane yield of anaerobic co-digestion from sewage sludge and decanter cake by SS-AD approach. The methane yield was measured at different ratio of inoculum to substrate. The daily biogas composition was also analyzed to determine the biogas produced in anaerobic co-digestion of sewage sludge and decanter cake.

Materials and methods

Substrate and inoculum

Sewage sludge was obtained from wastewater treatment plant of Indah Water Konsortium. The decanter cake was collected from Yee Lee Palm Oil Industries Sdn. Bhd, Bidor, Perak. The sewage sludge and decanter cake were stored at 4°C for later use as the inoculum and substrate, respectively. The substrate and inoculum were characterized based on total solid (TS), volatile solid (VS), pH, carbon (C) and nitrogen (N) content, chemical oxygen demand (COD) and ammonia nitrogen (NH3). All analytical procedures were performed in accordance with standard method (APHA, 1998).

Experimental setup

The batch fermentation was conducted in 125mL serum bottles enclosed with rubber stoppers at working volume of 100mL (Figure 1(a)). The samples were flushed with nitrogen gas for 2 min before seal to remove traces of oxygen and to ensure anaerobic condition. Batch fermentation was conducted in anaerobic mesophillic at 38±1°C temperature in a water bath (Memmert Waterbath WNB 45) for 30 days (Figure 1(b)).

Figure 1(a): The set up of sample in serum bottles

Figure 1(b): The serum bottles in waterbath

The digesters containing sewage sludge and decanter cake were mixed at inoculum to substrate (I/S) ratios of 1:0.5, 1:1 and 1:2 at 25% of total solid content. The sewage sludge alone at I/S ratio 1:0 was used as control and incubated in the same water bath. The pH samples were adjusted by using pH meter to 7±1.0 using sodium hydroxide (NaOH) to provide better growth conditions for methanogenic bacteria that can produce biogas and methane effectively at a pH value from 6.5 to 8.0 (Sibiya, 2014). The pH value was adjusted to the range of optimum pH value by using sodium hydroxide (NaOH).
The methane yield was expressed as the volume of methane produced based on the initial total VS of the feedstock. The parameters was analyzed at initial and final of the batch fermentation and the removal efficiency parameters such as TS, VS, COD and ammonia nitrogen was calculated. The biogas was collected daily and the cumulative biogas production was measured by water displacement method.
The biogas composition was measured by gas chromatoghraphy (GC) (Agilent 6890) with Thermal Conductivity Detector (TCD). The methane yield was expressed as the volume of methane produced based on the initial total VS of the feedstock and nitrogen and oxygen free basis.

Results and discussion

Biogas production from batch fermentation

The variations of inoculum to substrate ratio for co-digestion between sewage sludge and decanter cake was observed. There were I/S ratio of 1:0, 1:0.5, 1:1 and 1:2 with 25% of total solid content. Mesophilic temperature of 38°C was used in this study due to optimum condition for microorganism to grow. The pH value also one of the main factors which greatly affect to the digestion process. Different microorganism requires different optimal pH but in the anaerobic digestion, the most favorable range of pH value is 6.8 – 7.2 (Hagos et al., 2017).
The cumulative biogas production profile for all I/S ratios were shown as in Figure 2. Based on the results, ratio 1:2 produced the highest volume of biogas followed by ratio 1:1, 1:0.5 and 1:0 which are

247 mL, 211 mL, 150 mL and 39 mL respectively, in total of 30 days batch fermentation. At first stage, ratio 1:1 produced more biogas than other ratios till day 25. The fermentation process then becomes slower to the end of the batch fermentation. However, ratio 1:2 keep produced more biogas until the end of batch fermentation make it the highest ratio of biogas production. In this study, the ratio 1:1 and ratio 1:2 produce the lowest methane yield although both ratio generated high volume of biogas. High content of substrate makes the rate of fermentation process becomes slower due to low content of microorganism in the inoculum that inhibit the fermentation process to happen faster. Apart from that, all co-digestion ratios produced more biogas than the sewage sludge alone. This proved that anaerobic co-digestion can improve the production of biogas.

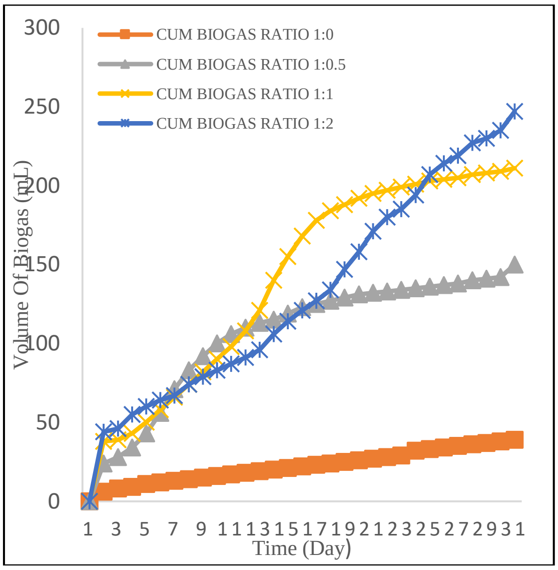


Figure 2: Cumulative biogas production for 30 days

Methane yield from batch fermentation

The methane yield in each biogas samples for each day were shown as in Figure 3. The result of the biogas production with the ratio 1:0.5 content has the highest methane yield. The fermentation shows faster rate of digestion process at early fermentation compared to other ratios. Although the methane yield production becomes lower till the end of 30 days of fermentation, the ratio of 1:0.5 still consistently produced the highest methane gas. In this study, ratio 1:1 and ratio 1:2 generated the lowest methane yield although both ratios produced high volume of biogas as compared to the others ratio.

The finding was in accordance with those reported by Suksong et al. (2015), who observed that methane yield of decanter cake and POME mixture decreased with increasing proportion of decanter cake in mesophilic conditions. It has also been reported by Suksong et al. (2015) that the lower methane yield could be due to difficulty of microorganism to degrade the decanter cake which has high amount of lignocellulose of 32.78%. Therefore, adding more lignocellulose material achieved longer acclimization period for methanogens.

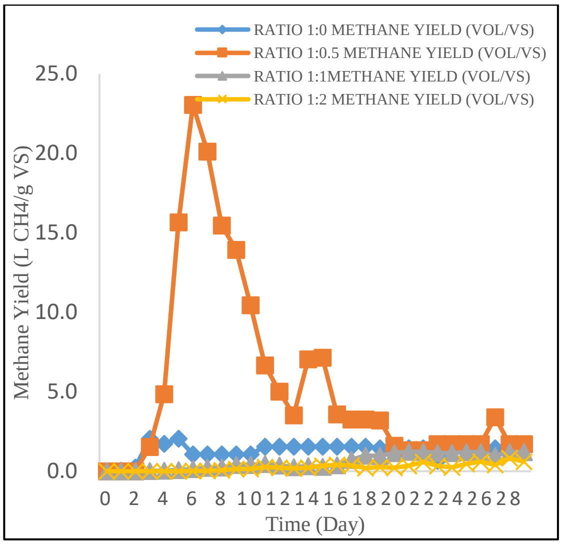


Figure 3: Daily methane yield for 30 days

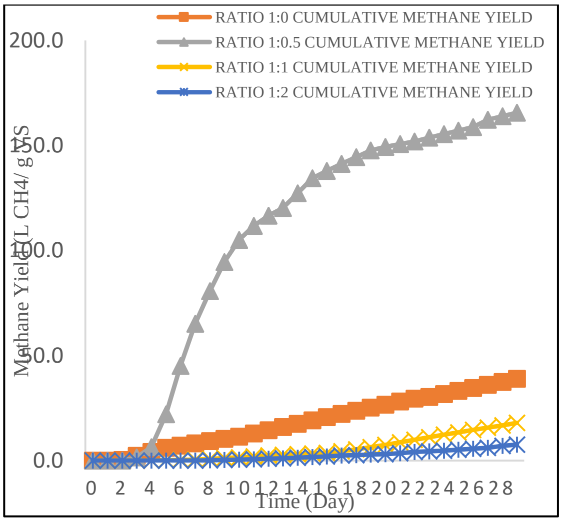


Figure 4: Cumulative methane yield for 30 days

Figure 4 shows the cumulative methane yield for four different inoculum to substrate ratios. Ratios 1:0.5 increase dramatically starting from day 5 till end of the batch fermentation. The maximum yield of methane generated is 165.6 L CH4/ g VS at the ratio 1:0.5 followed by ratio 1:0, 1:1 and 1:2 which was produced at 39.9, 18.0 and 7.4 L CH4/ g VS, respectively. The ratios of substrate shown a significant production on the methane gas. On the contrary, high concentration of lignocellulosic can inhibit the digestion process as the microorganism having difficulty to degrade the decanter cake.

Total solid and ammonia removal

Total solid removal in the organic loading was investigated for all ratios (Figure 5). Initial and final result was determined. The highest total solid removal at 25% TS content is 67.5 % at ratio 1:1 and 39.5% and 12% at ratio 1:0.5 and 1:0 respectively.

The lowest total solid removal was observed at the ratio of 1:2 as compared to the other ratios. This could probably due to the increasing amount of total solid content in the digester that may inhibit microbial activity.
The toxicity for the anaerobic digestion can happen when the ammonia-N level is higher than 1,500 mg/L (Weerapong & Thaniya, 2015). In this study, all ratios shows that ammonia-N level below 350 mg/L (Figure 6). Thus, the digestion process was not inhibited during the fermentation with no significant effect on ammonia-N removal. Sewage sludge shows the highest ammonia-N removal which is 1.8% of removal and 1.3% for ratio 1:0.5.

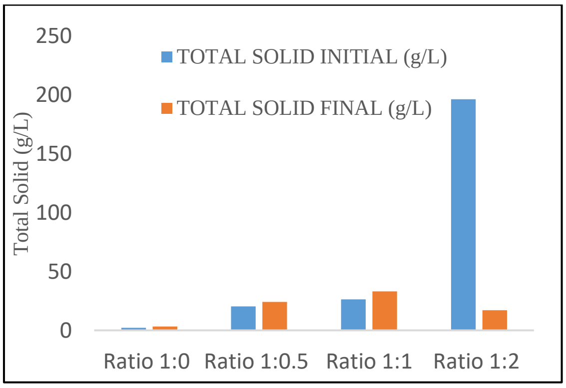


Figure 5: Total solid removal

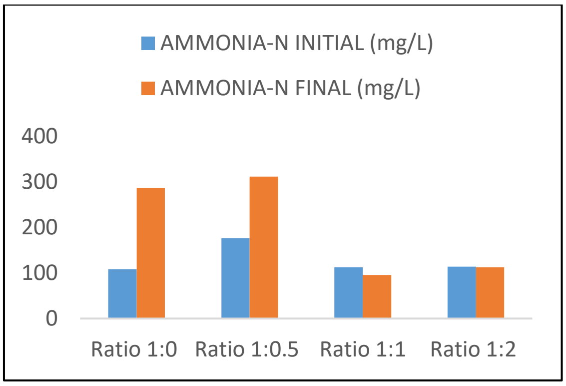


Figure 6: Ammonia-N removal

Methane and carbon dioxide end product comparison

Methane and carbon dioxide (CO_2) are both end product of anaerobic digestion. Theoretically, the biogas is mainly composed of methane (60%) and 40% of carbon dioxide (Abdeshahian et al., 2016). Both ratio 1:0 and ratio 1:0.5 shows significant results with the earlier stage of digestion while ratio 1:1 shows the significant from day 21 onwards.

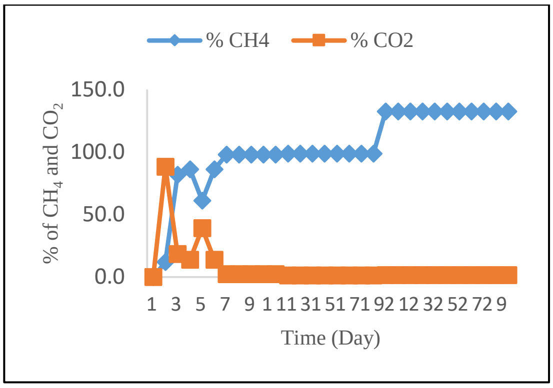


Figure 7(a): Methane and CO_2 at ratio 1:0

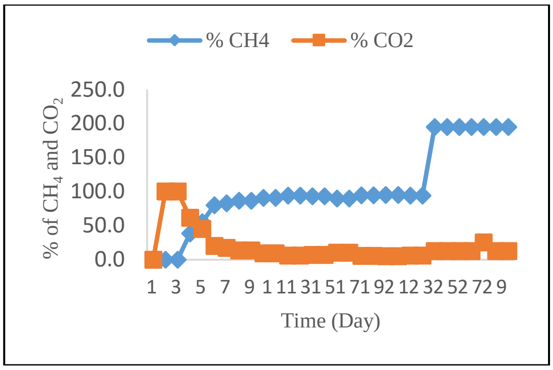


Figure 7(b): Methane and CO_2 at ratio 1:0.5

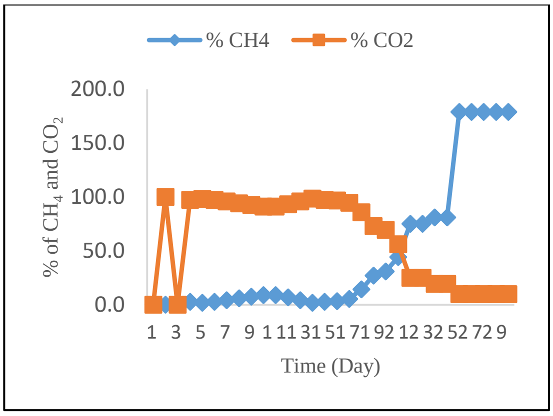


Figure 7(c): Methane and CO_2 at ratio 1:1

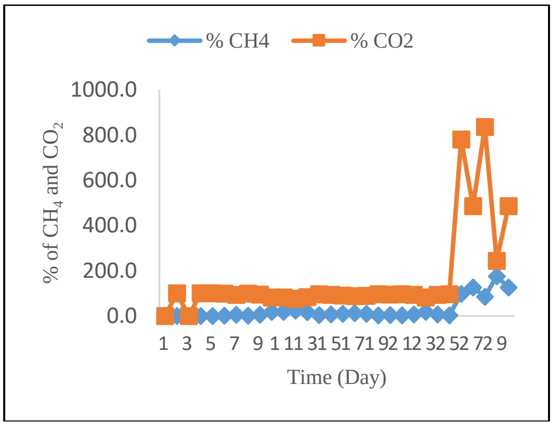


Figure 7(d): Methane and CO_2 at ratio 1:2

Conclusions

The results indicated that the methane gas can be generated by anaerobic co-digestion of sewage sludge and decanter cake. The maximum yield of methane gas produced is at I/S ratio of 1:0.5 which is 165.6 L CH_4 / g VS. This shows that the loading organic materials has significant effect on the digestion. An increased in the total solid content can inhibit the microbial activity with low production of methane gas. Mesophilic temperature of 38°C and neutral pH at initial are the optimum parameters for anaerobic digestion. In this study, the most suitable and optimum I/S ratio for anaerobic co-digestion of sewage sludge and decanter cake was ratio 1:0.5.

References

Abdeshahian, P., Lim, J., Ho, W., Hashim, H., & Lee, C. (2016). Potential of biogas production from farm animal waste in Malaysia. Renewable And Sustainable Energy Reviews, 60, 714-723.

APHA. (1998). Standard methods for the examination of water and wastewater. New York.

Awalludin, M., Sulaiman, O., Hashim, R., & Nadhari, W. (2015). An overview of the oil palm industry in Malaysia and its waste utilization through thermochemical conversion, specifically via liquefaction. Renewable And Sustainable Energy Reviews, 50, 1469-1484.

Chavalparit, O., Rulkens, W., Mol, A., & Khaodhair, S. (2006). Options for environmental sustainability of the crude palm oil industry in thailand through enhancement of industrial ecosystems. Environment, Development And Sustainability, 8(2), 271-287.

Dewayanto, N., Isha, R., & Nordin, M. (2014). Use of palm oil decanter cake as a new substrate for the production of bio-oil by vacuum pyrolysis. Energy Conversion And Management, 86, 226-232.

Hagos, K., Zong, J., Li, D., Liu, C., & Lu, X. (2017). Anaerobic co-digestion process for biogas production: Progress, challenges and perspectives. Renewable And Sustainable Energy Reviews, 76, 1485-1496.

Hansen, S. (2005). Feasibility Study of Performing an Life Cycle Assessment on Crude Palm Oil Production in Malaysia (9 pp). The International Journal Of Life Cycle Assessment, 12(1), 50-58.

Holm-Nielsen, J., Al Seadi, T., & Oleskowicz-Popiel, P. (2009). The future of anaerobic digestion and biogas utilization. Bioresource Technology, 100(22), 5478-5484.

Kanchanasuta, S and Sillaparassamee, O (2017) Enhancement of hydrogen and methane from co-digestion of palm oil decanter cake and crude glycerol using two stage thermophilic and mesophilic fermentation. Int. Journal of Hydrogen Energy. Article in Press

Muhammad Nasir, I., Mohd Ghazi, T., & Omar, R. (2012). Production of biogas from solid organic wastes through anaerobic digestion: a review. Applied Microbiology And Biotechnology, 95(2), 321-329.

Sosnowski, P., Wieczorek, A., & Ledakowicz, S. (2003). Anaerobic co-digestion of sewage sludge and organic fraction of municipal solid wastes. Advances In Environmental Research, 7(3), 609-616.

Suksong W, Kongjan P, Sompong O. (2015) Biohythane production from co-digestion of palm oil mill effluent with solid residues by two-stage solid state anaerobic digestion process. Energy Procedia, 79:943–9.

Weerapong, L & Thaniya, K (2015) Effect of mixing time of anaerobic co-digestion of palm oil mill waste and block rubber wastewater. Energy Procedia. 79, 327-334.

Yacob, S., Hassan, M., Shirai, Y., Wakisaka, M., & Subash, S. (2005). Baseline study of methane emission from open digesting tanks of palm oil mill effluent treatment. Chemosphere, 59(11), 1575-1581.

Yang, L., Xu, F., Ge, X., & Li, Y. (2015). Challenges and strategies for solid-state anaerobic digestion of lignocellulosic biomass. Renewable And Sustainable Energy Reviews, 44, 824-834.

Yen, H., & Brune, D. (2007). Anaerobic co-digestion of algal sludge and waste paper to produce methane. Bioresource Technology, 98(1), 130-134.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-ARWM14

Composting of Municipal Solid Waste of Kampung Bako Sarawak

Nozieana K.* and Sobri M.
Department of Basic Science and Engineering, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus, P.O. Box 396, Nyabau Road, 97008 Bintulu Sarawak, Malaysia
*Corresponding Author, E-mail: nozieana@upm.edu.my

Abstract
A preliminary study was conducted to assess the feasibility of composting of source separated organic matter of municipal solid waste (MSW) generated in areas of Kampung Bako, Kuching, Sarawak with a population over 3000. Results of MSW analysis indicate the presence of high percentage of biodegradable organic matter, acceptable moisture content and C/N ratio. On windrow composting, not only the volume of the waste was reduced but also produced a crumbly earthy smelling soil-like, compost material. All quality parameters in the compost samples were found to be within the acceptable limits set by international standard. The compost quality could further be improved by adding rice husk, poultry manure or yard waste etc. Its use in plant production or land reclamation may be helpful to maintain soil fertility and improve moisture holding capacity. MSW Composting could be adapted country wide to recycle/reuse the organic residue as solid waste management option.

Keywords: Municipal solid waste (MSW); Composting analysis; Rice husk

Introduction

The increasing amount of waste may create several problems to populations in the world. It requires application of several effective strategies for proper disposal of municipal solid waste (MSW). Composting is a process of microbial based aerobic which is now considered as an environmentally way to reduce organic waste and at the same time produce organic fertilizer or as a soil conditioner (Gautam et al., 2010). The average generation of MSW from urban cities in India estimated to have approximately 40 to 60 % organic matter could be recycled as compost. Malaysia generates about 0.5–1.9 kg/capita/day of MSW; a total of about 25,000 tonnes/day of MSW is currently generated and is estimated to exceed 30,000 tonnes/day by 2020. Malaysian MSW is mainly composed of 45 % food waste, 24 % plastic, 7 % paper materials, 6 % metal, 4 % wood and 3 % glass, which are commingled, and is thus characterised by 52–66 % moisture content. Currently, 80–95 % of collected MSW is landfilled and 5 % is recycled (Aja and Al-Kayiem, 2013). Some reasons associated are growing population, changes in consumption patterns and the expansion of trade and industry in urban centres. Developing countries striving to become industrial nations are generating MSW at an alarming rate.Composting is a natural biological process that been held under controlled conditions whereby it hastens the decomposition of MSW over time and reduces its volume, creating stable and high nutrient humus (Mutairi et al., 2014). Over past years, there have been a lot of approaches taken which have been used in order to investigate composting processes such as the study of thermodynamic and physicochemical changes taking place during composting processes (Ahmed et al., 2007), the microbial community dynamics and stability assessment during composting (Gazi et al., 2007). Apart from that, a study on characterization of MSW compost inoculated with effective microorganisms also conducted (Bakari et al., 2016). The inoculation of waste with microorganisms that produce extracellular enzymes such as cellulase, amylase, protease, pectinase and lipase at optimum level increase waste degradation, thus reducing waste dumping (Saha and Santra, 2014). This shows the MSW composting is being practiced throughout the world and researchers have experienced the benefits of using MSW compost in the field. This study aimed to analize the compost by municipal solid waste in Kampung Bako, Sarawak in terms of pH, moisture content, potassium, natrium, kalsium, and magnesium.

Materials and methods

The investigation was conducted at Pusat Pemrosesan Baja Kompos at Kampung Bako, located in Kuching, Sarawak and Makmal Sains Tanah, Jabatan Sains Tanaman, Fakulti Sains Pertanian dan Makanan, Universiti Putra Malaysia Kampus Bintulu in the month of February 2019. With the help from people in the village of Kampung Bako, MSW were collected. The organic material mainly vegetable, fruit and kitchen waste etc., were separated from other materials subjected to build windrows of compost. The weight of each windrow were recorded before and after composting. During the composting process, required operation conditions of composting were maintained. This windrow method will reduce particle sizes by frequent number of turning (Basnayake and Karunarathne, 2004) . A heap of manually separated mixed MSW of 4' high, 8'long was placed on ground on composting windrow type. The windrow was watered everyday to maintain moisture level between 50-60% and turned manually using scoop every 3-5 days for the first six weeks of composting cycle. From the seventh week, the moisture was allowed to drop when optimum biosolids decomposition was achieved. The process was completed in about 8-9 weeks. After this period the compost was allowed to cure for additional three weeks without turning. The finished compost was then screened out and weighed. A representative compost sample was taken from the homogenized compost heap for the sequential physicochemical analyses. Sub-samples (250 g) were taken from 4 different points of the compost heap (bottom, surface, side and centre). It was brought to the laboratory for further analysis. The following physical parameters pH, moisture, potassium, natrium, magnesium were measured.

Potentiometric Method were used to determine the pH content in the compost. 10g of air-dried compost were weighed and added with 25 ml distilled water, stopper it and shake at 180 rpm for 15 minutes. The sample were stayed overnight. The pH meter used in this experiment were calibrated with two buffer solutions which are pH 4.0 and pH 7.0. Meanwhile to determine moisture content, the Gravimetric Method were used. This method basically give the measurement of the amount of water lost before and after oven-dried. 10g of sample were weighed, oven dried it at 105 and 110°C overnight then the latest weight were measured. This method expresses the result in the form of percentage of water by using the equation below (Fathi et al., 2014);

$$\text{Dry mass (\%) water} = (\text{mass of water}/\text{mass of oven dry soil}) \times 100$$

To determine the amount of Potassium in the compost, Ammonium Acetate – Shaking Method were used. A volume of 1000ml of 1M ammonium acetate (NH_4OAc) solution with pH 7.0 were prepared. 10g of compost were weighed and placed in the flask. Then, 100ml of the solution were added into the flask and stayed for 5 to 6 hours. The sample were shaked using orbital shaker 180rpm for 1 hour. The sample were filtered and marked up to the volume of 1M ammonium acetate (NH_4OAc). Atomic Absorption Spectrometry (AAS) is a technique which is helpful in measuring the amount of trace elements available in compost. (Mishra, 2018) . The reading of P were measured in percentage. This method can also be used to determine Na, Ca, Mg, and most micro-elements. The calcium and magnesium concentrations in compost are important for growth of microbes.

Results and discussion

Table 1 listed the average of pH, moisture content, potassium, natrium, magnesium, and calcium. The result was compared to the standard values using Ohai- EPA standards and Canadian Council of Ministers of the Environment (CCME) standards (Manohara and Belagali, 2014). Based on the result, pH and moisture content were in the standard range values suitable for composting. Meanwhile the amount of potassium, natrium, magnesium, and calcium were all below the standard range value. However, in order to obtain high quality compost, the macronutrients and micronutrients level in the waste can be adjusted to an acceptable level by adding garden waste, cow manure, poultry manure, etc. As the study conducted by other researchers before that successful preparation of MSW composts depended upon the nature of the organic materials, the proportion of nitrogenous compound to carbohydrates, the temperature of decomposition and the microbial population involved in the process. For example, the study of MSW in India and New York City resulting different amount of nutrients contained in the compost. A study in Mysore, India determined the pH of 7.65, moisture content of 48%, potassium 0.27%, natrium 0.13%, magnesium 0.21%, and calcium 0.72% (S.P. Gautam, 2010). Meanwhile a study in New York City showed the pH of 7.5, moisture content of 23.5%, potassium 0.3%, natrium 0.56%, magnesium 0.38%, and calcium 2.6% (Robert, 2004).

Table 1: Average chemical composition of biofertilizer composted from municipal solid waste of Kampung Bako, Sarawak

S.No	*Parameters*	*Avg. Values*	*Standard values suitable for composting*
1.	pH	8.29	6.9-8.3
2.	Moisture (%dry basis)	62.80	45-65%
3.	Potassium	0.39	0.6-1.7%
4.	Natrium	0.66	NA
5.	Magnesium	0.12	0.2-0.4%
6.	Calcium	0.38	1.0-4.0%

Note: NA – Not Available

Conclusion

Based on the study it can be concluded that municipal solid waste is suitable for composting. It is because of the presence of acceptable percentage of biodegradable organic matter, acceptable moisture, and pH in the waste. However, the composting process and compost quality could further be improved in the future by adding inoculating agent like yard waste etc. in the municipal solid waste. Furthermore, the application of compost would be an investment in the long term for the health of soils and plants. Finally, it is concluded that a module of this type for the recover of hight value and economical organic fertilizer- the compost, can be applied to recycle the organic residues as one of waste management options.

References

Ahmed, M., A. Idris and S.R. Syedomar, (2007). Physicochemical Characterization of Compost of the industrial Tannery Sludge. J. Engineering Sci. Technol., 2: 81-94.

Aja, O. C and Al-Kayiem, H. H. (2013). Review of Municipal Solid Waste Management Options in Malaysia, With an Emphasis on Sustainable Waste-to-Energy Options. Journal of Material Cycles and Waste Management. 16. 10. 1007/s10163-013-0220-z.

Bakari, S. S., Moh'd L. M., Maalim, M. K., Aboubakari, Z. M., Salim, L. A., and Ali, H. R. Rashid. (2016).Characterization of Household Solid Waste Compost Inoculated with Effective Microorganisms. Modern Environmental Science and Engineering (ISSN 2333-2581). 2. 194-200.10.15341/mese(23332581)/03.02.2016/007.

Basnayake, B. F. A. and Karunarathne, A. K. (2004). A Comparative Study Of Windrow And Static Pile MSW Composting Methods In Sri Lanka. Journal of Agricultural Engineering Society of Sri Lanka. 8. 9-23.

Fathi, H., Zangane, A., Fathi, H., and Moradi H,. (2014). Municipal Solid Waste Characterization and It Is Assessment for Potential Compost Production: A Case Study in Zanjan City, Iran. American Journal of Agriculture and Forestry. 2(2), 39 – 44.

Gautam, S.P., Bundela, P.S., Pandey, A.K., Awasthi M.K. and Sarsaiya. S. (2010). Composting of Municipal Solid Waste of Jabalpur City. Global Journal of Environmental Research 4 (1), 43-46.

Gazi, A.V., Kyriacou, A., Kotsou, M. and Lasaridi, K.E. (2007). Microbial Community Dynamics and Stability Assessment during Green Waste Composting, 9(1): 35-41.

Manohara, B. and Belagali, S.L., (2014). Characterization of Essential Nutrients and Heavy Metals during Municipal Solid Waste Composting, International Journal of Innovative Research in Science, Engineering and Technology. vol 3(2), 9664-9672.

Maurya, A., Kesharwani, L., and Mishra, M. K. (2018). Analysis of Heavy Metal in Soil Through Atomic Absorption Spectroscopy for Forensic Consideration. International Journal for Research in Applied Science and Engineering Technology. 6(6), 1188 - 1192.

Mutairi, S. O., Ghoneim, A. M., Modaihsh, A. S., Mahjoub, M. O. and Abdel-Aziz, R. A. (2014).The Characterization and Composting of the Municipal Solid Waste of Riyadh City, Saudi Arabia. Waste Management and the Environment VII. 283-292.

Robert L. (2004). New York City MSW Composting Report Summary of Research Project and Conceptual Pilot Facility Design.

Saha, A., Santra S.C. (2014). Isolation and Characterization of Bacteria Isolated from Municipal Solid Waste for Production of Industrial Enzymes and Waste Degradation. Journal of Microbiology and Experiment. 1(1), 12–19.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-ARWM15

Peranan Pembiakbaka Tumbuhan Dalam Memperkasakan Industri Herba Negara: Pengalaman dan Usaha FRIM

Farah Fazwa, M.A., Mohd Zaki, A., Syafiqah Nabilah, S.B. & Norhayati, S.
Program Membaikbiak Tumbuhan, Bahagian Bioteknologi Perhutanan,
Institut Penyelidikan Perhutanan Malaysia (FRIM),52109, Kepong, Selangor, Malaysia.
**Corresponding Author, Tel: +0362797332, E-mail: farah@frim.gov.my*

Abstrak
Kertas kerja ini membincangkan mengenai peranan pembiakbaka tumbuhan khususnya untuk tumbuhan herba dalam membantu menghasilkan bahan tanaman berkualiti tinggi dalam menghadapi permintaan bekalan bahan mentah di dalam industri herba negara. Kebanyakan bahan mentah yang diambil adalah dikutip secara liar dari hutan semulajadi dan hanya sedikit yang ditanam secara perladangan. Hal ini jika dibiarkan berterusan akan menyebabkan berlakunya kepupusan dan hakisan sumber genetik di dalam hutan semulajadi. Oleh itu kajian-kajian dan usaha untuk mengekalkan sumber genetik tumbuhan dan bagi memilih dan mengenalpasti bahan tanaman/varieti yang berkualiti tinggi telah dilakukan oleh kumpulan penyelidik dari Institut Penyelidikan Perhutanan Malaysia (FRIM). Beberapa pendekatan seperti pengumpulan baka, penyaringan kandungan kimia/aktiviti biologi, pembiakan, penanaman dan penubuhan sourcebush dan germplasma telah dilakukan bagi memastikan bekalan bahan mentah yang berkualiti dan teruji dapat diperkenalkan kepada industri. Selain daripada itu, kombinasi bidang pembiakbakaan dan bidang kejuruteraan juga perlu diselaraskan agar hasil bahan mentah herba yang dikeluarkan dapat dipertingkatkan.

Kata kunci: Baka berkualiti, Sumber genetik tumbuhan, Bekalan bahan mentah, germplasma

Pengenalan

Industri herba telah dikenalpasti antara industri yang berpotensi untuk memacu pertumbuhan ekonomi Malaysia. Pihak kerajaan melalui pelbagai agensi berusaha untuk memastikan Malaysia mampu bersaing dengan negara-negara pengeluar utama produk herba melalui strategi produk herba bernilai tinggi. Umum turut telah maklum mengenai industri herba yang merupakan satu daripada fokus dalam projek (*Entry Point Project*-EPP) di bawah bidang Ekonomi Utama Negara (*National Key Economic Area*-NKEA) sektor pertanian melalui Program Transformasi Enonomi (*Economic Transformation Programme*-ETP).

Berdasarkan perangkaan yang disediakan oleh International Trade-Centre, pasaran tumbuhan ubatan Malaysia merekodkan jumlah import bernilai USD 89.3 juta pada tahun 2015 berbanding dengan jumlah eksport bernilai USD 6.4 juta pada tahun yang sama. Perbezaan antara nilai import dan eksport tumbuhan ubatan Malaysia memberikan gambaran tentang potensi besar untuk industri herba di Malaysia untuk terus diterokai. Secara globalnya, pembangunan perdagangan herba juga telah dianggarkan untuk meningkat dari USD200 bilion pada tahun 2007 kepada USD5 trilion pada tahun 2050. Nilai-nilai tersebut menggambarkan tentang ruang dan peluang dalam industri herba di Malaysia.

Menyedari kepentingan ini, adalah perlu untuk pengusaha tanaman mengeluarkan dan menghasilkan bahan tanaman bagi menampung industri herba dan perubatan yang semakin meningkat tinggi. Usaha memperkembangkan industri ini memerlukan penglibatan penanam dan pengusaha sama ada secara langsung atau tidak langsung. Banyak bahan mentah atau bahan tanaman diambil secara berleluasa di dalam hutan tanpa memikirkan kesan kepupusan spesis dan hakisan genetik yang mungkin berlaku. Kebanyakan bahan tanaman yang digunakan untuk pengeluaran produk herba pada hari ini adalah diperolehi secara liar di dalam hutan dan sedikit dari sumber perladangan tanpa diketahui akan kualitinya. Ini adalah kerana tiada aktiviti pembaikbiakan dilakukan bagi menghasilkan baka yang berkualiti tinggi dan keadaan ini secara langsung akan mempengaruhi kualiti sesuatu produk yang dihasilkan di dalam pasaran. Kajian terkini oleh Institut Penyelidikan Perhutanan Malaysia (FRIM) mendapati sebanyak 83% bahan mentah herba negara adalah diperolehi daripada hutan dan hanya 17% adalah di ambil secara perladangan (Rohana et al. 2017). Selain itu, didapati juga jumlah keluasan ladang herba di Semenanjung Malaysia adalah kecil dengan keluasan seluas 1,592 hektar dan melibatkan seramai 673 penanam herba. Ini menunjukkan purata bagi satu saiz ladang hanyalah 1.7 hektar (Rohana et al. 2012). Keluasan ini adalah tidak mencukupi dan bagi mencapat matlamat nasional bidang penanaman herba perlulah diperluaskan. Keadaan ini juga menunjukkan bahawa negara kita sedang mengalami kekurangan bahan mentah dan langkah untuk mengatasi masalah ini perlulah diambil dengan segera.

Melihat kepada permasalahan tersebut, usaha untuk menghasilkan bahan tanaman yang berhasil tinggi perlu dilakukan. Ahli pembiakbaka tumbuhan memainkan peranan penting untuk mendapatkan baka yang berkualiti dan berkuantiti tinggi dengan menjalankan beberapa strategi pembiakbakaan. Usaha pengeluaran bahan tanaman berkualiti ini juga boleh diteruskan dengan mengumpul dan mewujudkan satu germplasma tumbuhan yang boleh menyimpan genotip berkualiti tinggi yang boleh digunakan untuk tujuan pembiakbakaan di masa hadapan. Kepelbagaian germplasma perlu dipulihara bagi memastikan sumber tumbuhan tidak pupus untuk kegunaan generasi masa depan. Di antara 10 spesies herba yang telah ditetapkan oleh pihak kerajaan yang perlu diberi keutamaan dalam bidang industri herba negara ialah tongkat Ali (*Eurycoma longifolia*), misai kucing (*Orthosiphon stamineus*), kacip fatimah (*Labisia pumila*), dukung anak (*Phyllanthus niruri*), hempedu bumi (*Andrographis paniculata*), pegaga (*Centella asiatica*), mengkudu (*Morinda citrifolia*), roselle (*Hibiscus sabdariffa*), mas cotek (*Ficus deltoidea*) and halia (*Zingiber officinale*). Oleh yang demikian kertas kerja ini dihasilkan bagi memfokuskan dan membincangkan mengenai definisi, strategi-strategi dalam pembiakbakaan herba dan contoh kajian-kajian yang dijalankan bagi mengenalpasti klon/varieti yang bermutu tinggi. Selain daripada itu peranan pembiakbaka boleh digembleng bersama lain-lain bidang seperti bidang agronomi dan kejuruteraan bagi menghasilkan bahan tanaman yang berkualiti dan dalam jumlah yang tinggi. Hasil daripada kajian ini adalah diharapkan dapat menyokong dan menampung permintaan bahan mentah dan secara langsung memperkasakan industri herba negara pada masa akan datang.

Kaedah Kajian

Memahami definisi pembiakbakaan

Sebelum menetapkan sebarang strategi dalam pembiakbakaan, beberapa istilah perlu difahami agar program yang dijalankan adalah lebih berkesan. Seseorang perlu memahami maksud pembiakbakaan terlebih dahulu. Pembiakbakaan tumbuhan adalah satu proses mengubah dan memperbaiki kandungan genetik atau genotip individu/populasi kepada yang lebih superior atau yang dikehendaki. Ia merupakan kefahaman kepada kombinasi tiga bidang iaitu genetik tumbuhan, variasi genetik dan pembiakan tumbuhan. Dalam erti kata lain, pembiakbakaan tumbuhan juga adalah aplikasi beberapa akiviti pengurusan silvikultur seperti penyediaan tapak, pembajaan dan lain-lain dengan kemahiran pembiakbakaan tumbuhan bagi menghasilkan produk tumbuhan yang berkualiti tinggi dalam masa yang singkat dan memberikan keuntungan (Zobel & Talbert, 1984).

Mengenalpasti matlamat umum pembiakbakaan

Matlamat umum pembiakbakaan tumbuhan ialah untuk membentuk genotip tumbuhan tanaman yang lebih superior di mana ianya berbeza mengikut varieti yang hendak diperbaiki. Ia adalah berbeza mengikut jenis tanaman.

Berikut adalah matlamat pembiakbakaan bagi kebanyakan tanaman:

a. Hasil yang tinggi

   Pertambahan hasil yang tinggi boleh didapati melalui pemilihan ke atas pokok-pokok yang mempunyai genotip yang superior. Pertambahan hasil yang berlaku ke atas sesuatu tanaman adalah disebabkan perubahan genetik asal kepada yang lebih baik. Penjagaan yang baik juga boleh memberi sumbangan kepada pertambahan hasil, tetapi ianya tidaklah sebanyak sumbangan yang diberikan oleh faktor genetik. Sebagai contoh, hasil pengeluaran yang penting ialah hasil buah, hasil minyak pati dan hasil kandungan kimia aktif.

b. Sifat pokok yang baik

   Selain mempunyai hasil yang tinggi, varieti yang dihasilkan hendaklah mempunyai sifat-sifat pokok yang baik seperti bentuk susunan daun, ketinggian dan struktur akar yang sempurna.

c. Kerintangan terhadap serangga perosak dan penyakit

   Pengawalan serangga perosak dan penyakit dengan menggunakan racun perosak biasanya dapat memberikan kesan yang baik terhadap tanaman. Walau bagaimanapun, penghasilan varieti yang rintang terhadap penyakit atau serangga perosak melalui proses pembiakbakaan lebih menguntungkan kerana penggunaan racun dapat dikurangkan. Ianya dapat mengurangkan kos pengeluaran dan mengurangkan kesan kepada alam sekitar.

d. Kesesuaian pada pelbagai iklim dan kawasan geografi

   Melalui pembiakbakaan tanaman, masalah ketidaksesuaian iklim dan kawasan dapat diatasi dengan menghasilkan varieti yang mampu beradaptasi tumbuh di kawasan-kawasan yang berlainan iklim dan pelbagai keadaan geografi.

e. Ketahanan terhadap suhu

   Melalui pembiakbakaan, varieti tanaman yang dihasilkan mampu untuk tumbuh di kawasan yang mempunyai pelbagai keadaan suhu. Sebagai contoh, padi telah berjaya ditanam dan hidup di kawasan beriklim sejuk berbanding habitat asalnya di kawasan yang panas. Begitu juga dengan kubis yang merupakan tanaman di kawasan sejuk, kini telah berjaya ditanam di kawasan rendah bersuhu tinggi di Malaysia. Ini secara tidak langsung tanaman dapat beradaptasi dengan fenomena semasa seperti perubahan iklim.

f. Tempoh matang yang pendek

   Varieti pokok yang dihasilkan melalui proses pembiakbakaan mampu mencapai umur matang yang lebih pendek berbanding dengan pokok asal. Ini dapat mempercepatkan penuaian hasil.

g. Kualiti yang baik

Pembiakbaka juga perlu memberikan perhatian terhadap kualiti varieti yang dihasilkan selain dari kuantiti hasil tanaman. Sebagai contoh, beras dari varieti Ria yang dihasilkan pada suatu masa dahulu tidak mendapat sambutan kerana rasa nasinya yang kurang sedap walaupun ianya dapat memberikan hasil yang tinggi. Contoh klasik ini telah memberi pengajaran yang baik kepada para pembiakbaka semasa agar mengimbangi kepentingan kualiti dan kuantiti dalam penghasilan varieti baru.

Menjalankan Proses Pemilihan (Selection)

Pemilihan merupakan satu proses memilih individu tumbuhan atau pokok yang memiliki ciri-ciri dikehendaki untuk tujuan pembiakan. Kaedah pemilihan ini menjadi penentu kejayaan dalam bidang membaikbiak baka tanaman. Pemilihan juga adalah satu kaedah yang dijalankan bagi mendapatkan variasi untuk tujuan mengeluarkan hasil yang tinggi dan tanaman yang baik. Program pemilihan biasanya dilakukan dengan mempunyai objektif utama iaitu bagi mendapatkan hasil, faedah atau keuntungan yang tinggi dalam masa yang singkat dengan kos yang murah. Penekanan pemilihan perlu mengambilkira aspek kesesuaian spesies terhadap persekitaran selain dari aspek sifat pertumbuhan dan juga jaminan pasaran yang baik (FAO, 1985).

***Menetapkan kriteria pemilihan herba berkualiti*:**

Ciri-ciri atau kriteria yang dipilih bagi sesuatu program pemilihan itu adalah bergantung kepada spesies. Kebiasannya sebanyak dua hingga empat ciri yang terpenting diperlukan dalam sesuatu program pemilihan. Beberapa kriteria-kriteria pemilihan herba berkualiti adalah seperti:

a. Mempunyai pasaran yang baik. Bahan aktif bagi sesuatu spesies itu telah dikenalpasti dan mempunyai permintaan yang tinggi.
b. Mempunyai ekstrak bahan aktif yang tinggi seperti kandungan kimia yang penting dalam sesuatu tumbuhan herba yang memberikan kesan terhadap kawalan penyakit atau tujuan kosmetik. Contoh bahan aktif adalah eurikomanon, eurikomalakton dan eurikomanol ekstrak dari akar tongkat ali untuk fungsi kelakian, dan citronellal dalam limau purut untuk produk kosmetik dan pewangi.
c. Mempunyai daya pertumbuhan yang baik serta dapat mengeluarkan hasil dalam masa yang singkat.
d. Mempunyai tahap kerintangan yang tinggi kepada penyakit dan perosak seperti ulat harimau dan teritip yang menggemari pucuk muda tongkat ali, dan ulat peliang daun yang menyerang daun limau purut.
e. Berupaya mengadaptasi kepada pelbagai keadaan iklim dan jenis tanah
f. Mudah untuk dibiakkan melalui perambatan tampang atau pun biji benih

Keputusan Dan Perbincangan

Strategi pembiakbakaan yang telah dijalankan bagi spesies-spesies herba di FRIM

Di antara spesies-spesies herba yang telah dimulakan program pembiakbakaan di FRIM sejak tahun 2004 sehingga kini ialah seperti limau purut (*Citrus hystrix*), limau kasturi (*Citrus microcarpa*), kacip fatimah (*Labisia pumila*), tongkat ali (*Eurycoma longifolia*), kapal terbang (*Chromolaena odorata)*, hempedu bumi *(Andrographis paniculata*), gelenggang *(Cassia alata*), cucur atap *(Baeckia frutescens*), misai kucing (*Orthosiphon stamineus*), sabung nyawa (*Gynura procumbens)*, pecah beling (*Strobilanthes crispa)*, senduduk putih (*Melastoma decemfidum*), belalai gajah *(Clinacanthus nutans)* dan lain-lain lagi. Setiap spesies perlu melalui beberapa langkah atau strategi dalam pembiakbakaan bagi mengenalpasti dan menghasilkan baka yang berkualiti baik dari segi morfologi, kandungan kimia mahupun aktiviti bioaktiviti. Berikut ialah beberapa langkah yang perlu dilalui sebelum sesuatu baka elit terhasil:

a. Pengumpulan sampel pokok ibu dari hutan simpan/liar
b. Pemulihan pokok di tapak semaian
c. Pembiakan (sexual atau asexual)
d. Penubuhan plot germplasma/bank klonal
e. Penyaringan kandungan kimia/bioaktiviti
f. Pemilihan baka superior
g. Ujian klon/progeni
h. Pemilihan baka elit

Penubuhan plot germplasma atau plot stok pembiakbakaan (*breeding stocks plot*) adalah bertujuan untuk menempatkan pokok-pokok induk/genotip yang akan digunakan untuk kajian lanjut dalam program pembiakbakaan bagi spesies-spesies tersebut. Sebagai contoh satu germplasma kacip fatimah telah berjaya ditubuhkan di FRIM dengan keluasan seluas 0.7 hektar yang menempatkan lebih daripada 450 genotip yang dikumpul dari 11 hutan simpan di Semenanjung Malaysia (Farah Fazwa et. al 2012). (Gambarajah 1). Selain itu germplasma dari spesies kapal terbang juga ditubuhkan di Stesen Penyelidikan FRIM di Maran, Pahang pada tahun 2017 (Farah Fazwa et. al 2018) (Gambarajah 2). Tambahan daripada itu, koleksi baka dari spesies-spesies lain yang telah dikumpul oleh FRIM sehingga kini adalah seperti tersenarai di dalam Jadual 1. Semua koleksi spesies herba yang telah dikutip ini dijaga dengan baik.

Gambarajah 1. Germplasma spesies kacip fatimah yang telah ditubuhkan oleh FRIM sejak tahun 2010

Gambarajah 2. Germplasma spesies kapal terbang yang telah ditubuhkan oleh FRIM pada tahun 2017

Jadual 1. Maklumat dan status beberapa spesies herba yang telah ditanam sebagai plot germplasma atau stok pembiakbakaan berserta jumlah koleksi pokok ibu/genotip

Nama spesies	Maklumat dan status		
	Lokasi plot germplasma	Jumlah koleksi pokok ibu/genotip	Jumlah klon superior
Limau purut	Bukit Hari, FRIM	150	40
Limau kasturi	Bukit Hari, FRIM	150	40
Kacip Fatimah	Tapak semaian	450	30
Tongkat ali	Maran	150	10
Kapal terbang	Maran	150	Sedang ditentukan
Hempedu bumi	FRIM	150	Sedang ditentukan
Gelenggang	FRIM	150	Sedang ditentukan
Cucur atap	FRIM & Setiu	90	Sedang ditentukan
Misai kucing	Tangkak, Johor	30	Sedang ditentukan
Sabung nyawa	Tangkak, Johor	30	Sedang ditentukan
Belalai gajah	Tangkak, Johor	30	Sedang ditentukan
Selasih	Tangkak, Johor	30	Sedang ditentukan
Senduduk putih	Tangkak, Johor	30	Sedang ditentukan
Merunggai	Tangkak, Johor	10	Sedang ditentukan
Mengkudu	Tangkak, Johor	10	Sedang ditentukan

Dengan wujudnya koleksi baka-baka herba seperti ini, sebarang aktiviti pembiakbakaan yang ingin dijalankan bolehlah bertumpu terus kepada plot-plot yang telah ditubuhkan. Ia merupakan titik permulaan untuk sebarang strategi pembiakbakaan yang ingin dijalankan. Tanpa koleksi genotip, proses penyaringan, pemilihan dan langkah-langkah seterusnya untuk menghasilkan baka berkualiti tinggi tidak dapat dijalankan.

Peranan bidang kejuruteraan dalam meningkatkan hasil bahan mentah herba

Peranan pembiak baka bersama jurutera dalam bidang pertanian dan makanan khususnya dalam industri herba juga tidak dapat dinafikan. Kejuruteraan pertanian boleh didefinisikan secara ringkas sebagai satu disiplin kejuruteraan yang mengguna prinsip kejuruteraan dan sains dalam mereka bentuk sistem yang selamat, cekap serta mapan untuk pengeluaran, pemprosesan dan pengurusan pertanian, makanan serta sumber bahan biologi. Kedua-dua bidang ini perlu digembleng kepakarannya bagi memastikan bekalan bahan mentah herba terjamin serta dapat menjana pendapatan lumayan. Hasil daripada kajian mengeluarkan baka tanaman herba berkualiti perlu diselaraskan dengan kejuruteraan pertanian terutamanya dalam aspek kecekapan jentera, penggunaan struktur dan kemudahan, tanah, penggunaan air untuk aktiviti pertanian, pencemaran, isu alam sekitar, isu penyimpanan dan pemprosesan produk. Hasil daripada gabungan bidang-bidang ini dapat meningkatkan hasil bahan mentah herba dan secara tidak langsung dapat mengurangkan kos operasi. Beberapa elemen kejuruteraan yang boleh diberi penekanan dalam memperkasakan industri herba ialah sepertti:

a. Penggunaan alat/mesin pembiakan bahan tanaman

Satu teknologi penggunaan alat rendaman sementara (*temporary immersion system*) di dalam bidang kultur tisu tanaman dapat memperbanyakkan bahan tanaman herba dalam masa yang singkat dan dalam kuantiti pukal. Penggunaan alat ini bersama media yang bersesuaian dapat meningkatkan hasil sebanyak 2-3 kali ganda berbanding kaedah konvensional yang memakan masa lebih lama.

b. Pembinaan sistem rumah hijau

Pengeluaran bahan tanaman herba di dalam rumah hijau boleh dipertingkatkan lagi melalui kejuruteraan pertanian seperti kawalan suhu, cahaya, kelembapan dan kuantiti baja serta air untuk menyediakan persekitaran bersesuaian mengikut jenis spesies tanaman. Kaedah ini dapat mengurangkan kadar kematian bahan tanaman herba yang dihasilkan dalam rumah hijau terutamanya semasa peringkat pengikliman (*acclimatization*).

c. Rekabentuk alat/jentera penuaian

Bahan mentah herba yang perlu dituai dari ladang boleh menggunakan alat/jentera penuaian yang mempunyai rekabentuk yang efisien. Gabungan teknologi semasa untuk tujuan automasi seperti sistem kedudukan global (GPS) dan sensor dapat memastikan hasil tuaian herba dapat dikutip semaksimum yang boleh tanpa pembaziran.

d. Sistem penyelenggaraan tanaman di ladang

Satu sistem penjagaan dan pemantauan tanaman di ladang menggunakan bidang kejuruteraan juga dapat dilaksanakan sebagai contoh dengan memasang sensor pengesan cuaca kering, sistem pengesan kekurangan bekalan air, sistem pengesan nutrien dan sebagainya. Kombinasi sistem ini akan memudahkan aktiviti penanaman herba di ladang menjadi lebih cepat, efisien dan juga meningkatkan pendapatan pengusaha ladang herba.

e. Kejuruteraan genetik tumbuhan

Kejuteraan genetik menggunakan teknik pengklonan dan pengubahsuaian molekular untuk mengubah struktur dan ciri gen bagi sesuatu tanaman mengikut trait yang diinginkan. Kejuteraan genetik tumbuhan telah berjaya dalam beberapa kegunaan termasuk dalam meningkatkan teknologi tanaman.

Kesimpulan

Kebanyakan herba yang ditanam pada hari ini adalah datangnya dari sumber tanaman secara liar dan bukannya dari bahan tanaman yang terpilih dan berkualiti tinggi. Selama ini aktiviti pembiakbakaan hanya bertumpu kepada spesis ladang dan hutan bagi tujuan mendapatkan hasil kayu yang baik. Tiada aktiviti pembiakbakaan dijalankan untuk spesis herba. Oleh itu, Cawangan Membaikbiak Herba dan Pokok, FRIM telah mengambil inisiatif dengan menjalankan penyelidikan ke atas herba-herba yang berpotensi untuk dibiakbaka selaras dengan objektif asalnya iaitu untuk menghasilkan baka tanaman yang berkualiti.

Dengan adanya bahan tanaman dari baka-baka terpilih ini, pengusaha industri herba dapatlah mengeluarkan produk yang berkualiti tinggi terhasil daripada bahan tanaman yang superior pada masa akan datang. Selain daripada itu, dengan kombinasi aplikasi bidang kejuruteraan juga perlu diselaraskan agar hasil bahan mentah herba yang dikeluarkan dapat dapat ditingkatkan. Ia merangkumi aspek-aspek pengeluaran bahan tanaman, pembinaan rumah hijau, penjagaan dan penuaian di ladang. Jika kedua-dua bidang ini dapat dijalankan secara bersama sudah pasti industri herba negara memperolehi manfaat dan maju.

Penghargaan

Penulis ingin mengucapkan terima kasih kepada semua yang terlibat dalam kajian-kajian berkaitan pembiakbakaan spesies herba terutamanya dari Bahagian Bioteknologi Perhutanan dan Bahagian Hasilan Semulajadi, FRIM. Begitu juga kepada pemberi dana penyelidikan bermula dari projek IRPA, E-Science, NRGS, MSI, Rancangan Malaysia dan lain-lain geran yang menyumbang kepada kejayaan kajian-kajian yang telah dijalankan.

Rujukan

Farah Fazwa, M.A. (2013). *Ex-situ* conservation of *Labisia pumila* for breeding purposes. Proceedings of the 13th Seminar on Medicinal and Aromatic Plants. Translating Natural Products R, D &C Initiatives in Line with Economic Transformation Programme. (Eds. Mastura M., Asiah, O., Adiana MA. & Hada Masayu ID). Pp. 43-47.

Farah Fazwa, M.A., Norhayati, S., Syafiqah Nabilah, S.B., Ling, S.K., Zunoliza, A., Mohd Zaki, A., Masitah, M.T. & Sharmizi, I. (2018). Evaluation of growth performances and reference markers of *Chromolaena odorata* at breeding stocks plot in Maran, Pahang. Proceedings of The 15th Medicinal and Aromatic Plants Seminar (MAPS 2018). Pp. 37-42. (ISBN 978-967-2149-32-3).

FAO. (1985). *Forest Tree Improvement.* FAO Forestry Paper No. 20. Rome: FAO

Latiff, A. (1994). Conservation of medicinal plants resources through in situ and ex methods. Report of the Second Regional meeting of Asian Region Countries on G-15 Gene Bank for Medicinal and Aromatic Plants Project. 20-21 September, Kuala Lumpur.

Latiff, A. (1997. Medicinal and aromatic plants of Malaysia: Approaches to exploitation and conservation. *Proceeding Medicinal and Aromatic Plants of Malaysia: Strategies and Technologies for Conservation*, 20-29

Norini, H. & Mohd Azmi, M.I. (2004). Market prospects of home-grown medicinal plants in Malaysia. Kertas kerja Seminar on Medicinal and Aromatic Plants 2004. Anjuran Forest Research Institute Malaysia. Kepong, 20-21 Julai.

Rohana, A.R., Siti Zubaidah, S., Ariff Fahmi, A.B., Nik Zanariah, N.M. & Lim, H.F. (Eds.).(2017). *Socio-economic Background of Herbal Industry in Peninsular Malaysia*. Forest Research Institute Malaysia, Kepong. 188pp.

Rohana, A.R., Ainu Shuhadah, B., Lim, H.F., & Ismariah, A. (2012). *Herbal Cultivation For Wealth Creation In Peninsular Malaysia.* Forest Research Institute Malaysia, Kepong. 157pp.

Shibli, R.A. (1994). In vitro conservation of plant genetic resources. *Proceeding of A National Seminar on Plant Genetic Resources of Jordan*, 207-215.

Towill, L. E. (1996). Germplasm preservation. Dlm. Trigiano, R.N. & Gray, D.J. (pnyt.). *Plant Tissue Culture, Concepts and Laboratory Exercises*, hlm. 291-296. Boca Raton: CRC Press.

Zobel, B.J. & Talbert, J. (1984). *Applied Forest Tree Improvement*. New York: John Wiley & Son.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya
MSAE2019-ARWM16

Serai Wangi : Minyak Pati dan Kawalan Kualiti

Mailina J.[1*], Nor Azah M.A.[1], Abd. Majid J. [1], Mohd Shafik Yuzman T. [1], Saidatul Husni S. [1], Mohammad Faridz Z.P.[1], Imin K.[2], Sharmizi I. [1], Syazwan A. [1], Hada Masayu I. [1], Mohd. Hafizi R. [1] & Menhat A.R.[3]
[1]Bahagian Hasilan Semula Jadi, Institut Penyelidikan Perhutanan Malaysia (FRIM), 52109 Kepong, Selangor
[2]Bahagian Biodiversiti, Institut Penyelidikan Perhutanan Malaysia (FRIM), 52109 Kepong, Selangor
[3]MARDI Kuala Linggi, Jalan Kuala Sungai Baru, 78200 Kuala Sungai Baru, Melaka
*Corresponding Author, Tel: +603- 62797349, E-mail: mailina@frim.gov.my

Abstrak
Serai wangi (Citronella) merupakan salah satu tumbuhan herba di Malaysia yang telah digunakan sejak dahulu di dalam perubatan tradisional terutamanya untuk rawatan ibu selepas bersalin. Ia adalah daripada genus Cymbopogon dan famili Gaminae. Terdapat dua spesies serai wangi yang biasa ditanam di kawasan Semenanjung Malaysia iaitu C. nardus (Jenis Sri-Lanka) dan C. winterianus (Jenis Java). Sekali imbas secara fizikal, kedua-dua spesies tumbuhan ini agak sukar dibezakan. Pengecaman daripada ahli botani adalah penting untuk proses autentikasi spesies. Namun begitu, jika ianya telah diproses menjadi minyak pati, kawalan kualiti (analisis kimia dan ciri kimia-fizik) memainkan peranan penting dalam membantu proses autentikasi spesies-spesies ini. Kandungan kimia penting bagi minyak pati daun C. nardus adalah kamfena, limonena, sitronelal, borneol, sitronelol, geraniol dan metil isoeugenol. Manakala, minyak pati daun C. winterianus terdiri daripada limonena, linalol, isopulegol, sitronelal, sitronelol, geraniol, geranial, sitronelil asetat, eugenol, geranil asetat, β-elemena, germakrena D, δ-kadinena dan elemol.

Kata kunci : Serai wangi, *citronella*, minyak pati, GCMS, COA

Pengenalan
Minyak pati biasanya aromatik dan berbentuk cecair yang diperolehi daripada tumbuhan seperti daun, bunga, batang, ranting dan rizom. Minyak pati terdiri daripada hidrokarbon dan derivatif oksigen yang terdiri daripada alkohol, asid, ester, aldehid, keton, amina dan sebatian sulfur. Monoterpena, seskuiterpena, malah diterpena merupakan komposisi sebahagian besar minyak pati. Sebatian lain yang menarik diperolehi daripada fenilpropanoid dan benzenoid. Kumpulan-kumpulan kimia ini yang memberikan aroma atau bau kepada tumbuhan aromatik (Handa et al., 2008). Minyak pati digunakan sebagai perisa dan wangian, perubatan, kosmeseutikal, kesihatan dan penjagaan diri serta aplikasi farmaseutikal. Kepentingan menggunakan minyak pati dalam pemeliharaan makanan telah diperkuat pada tahun-tahun kebelakangan ini oleh persepsi pengguna yang semakin negatif terhadap pengawet sintetik (Hyldgaard et al., 2012).
Industri herba tempatan sentiasa kompetitif dalam meneroka potensi tumbuhan ubatan dan beraroma yang bersesuaian untuk dibangunkan sebagai bahan aktif di dalam produk siap. Serai wangi atau *citronella* (*Cymbopogon* sp.) adalah salah satu herba popular yang biasa digunakan untuk penjagaan diri dan kesihatan. Dua spesies yang biasa terdapat di Malaysia adalah *C. nardus* (Jenis Sri-Lanka) dan *C. winterianus* (Jenis Java). Kedua-dua spesies ini biasanya hanya dikenali sebagai serai wangi. Minyak pati daripada dua spesies ini mempunyai perbezaan bau yang disumbang oleh kandungan kimia yang terdapat di dalamnya.
Genus *Cymbopogon* adalah milik famili Graminae dan terdiri daripada kira-kira 140 spesies aromatik (Ganjewala, 2009). Spesies *Cymbopogon* adalah tumbuhan yang sangat tahan tekanan yang mudah disesuaikan dengan keadaan iklim yang pelbagai (Wany et al. 2013). Mereka menghasilkan minyak pati serai wangi dengan peratus hasil yang tinggi. Minyak pati serai wangi digunakan secara tradisional untuk merawat demam, sakit perut, sakit dan reumatik (Nor Azah et al., 2002). Ia juga disenaraikan dalam Kamus dan Buku Panduan Bahan Kosmetik Antarabangsa (Ropien et al., 2012). Minyak pati serai wangi juga digunakan sebagai salah satu ramuan dalam produk herba dan sauna. Secara saintifik, minyak pati serai wangi mempunyai sifat larvisidal dan repelensi nyamuk (Zaridah et al., 2003; Zaridah et al., 2006), anti-radang dan antioksidan (Leite et al., 2010) dan antikanser (Ganjewala, 2009). Komponen utama minyak pati serai wangi ialah sitronelal, sitronelol dan geraniol (Nor Azah et al., 2002).

Kaedah adulterasi minyak pati mula berlaku apabila permintaan semakin meningkat. Ia berlaku disebabkan oleh faktor-faktor seperti penambahan bahan sintetik atau bahan daripada sumber semula jadi lain atau minyak sayuran yang lebih murah (Koenig & Hochmuth, 2004) untuk meningkatkan berat atau kuantiti sesuatu minyak pati (Do et. al., 2015). Adulterasi akan merendahkan kualiti minyak pati dan membawa kepada isu keselamatan atau ketidakpatuhan gred semula jadi. Pengesahan dan kawalan kualiti adalah penting bagi industri mahupun pengguna untuk memastikan perolehan minyak pati yang berkualiti.
Kajian ini bertujuan untuk mengenalpasti kandungan kimia minyak serai wangi terpilih, mengecam spesies bagi sampel yang tidak dikenalpasti (*Unknown*) dan melihat sama ada wujud proses adulterasi melalui perbandingan kandungan kimia mudah meruap yang utama.

Bahan dan Kaedah

Penghasilan dan Perolehan Minyak Pati

Daun serai wangi yang dikutip di lokasi terpilih, dikeringkan secara *air-dried* selama 2 hari. Contoh plot tanaman serai wangi adalah seperti di Foto 1. Kemudian ianya dipotong kecil dan disuling menggunakan peralatan penyulingan samada berskala besar (Foto 2) atau berskala makmal (Foto 3) selama 6 jam. Minyak pati yang terhasil diasingkan daripada hidrosol untuk ujian selanjutnya. Sebanyak 3 minyak pati daripada spesies yang telah dikenalpasti (CN, CW1 dan CW2), 3 sampel daripada spesies yang tidak dikenalpasti (*Unknown* 1-3) dan 4 minyak pati komersial (*Com* 1-4) telah diperolehi untuk ujian selanjutnya.

Ujian Kawalan Kualiti

a) Analisa GC Dan GC/MS Ke Atas Minyak Pati

Minyak pati serai wangi dianalisa menggunakan gas kromatografi (GC) dan gas kromatografi/jisim spektrometri (GCMS). Shimadzu GC 2010 Plus dan Agilent Technologies GC/MS 7890A/5975C masing-masing dilengkapi dengan kolum kapilari HP-5MS (30m x 0.25mm x 0.25mm). Program suhu disetkan bermula 60ºC (10min) dan dinaikkan ke 230ºC (1min) pada kadar 3ºC/min. Kandungan kimia minyak pati telah dikenalpasti dengan perbandingan spektra sampel dengan spektra yang terdapat di pangkalan data GCMS iaitu HPCH2205.L dan Wiley7Nist05.L, perbandingan dengan bahan kimia piawai dan juga nilai Indeks Kovats.

b) Ujian Penentuan Ciri Kimia-Fizik

Nilai indeks biasan dan putaran optik minyak pati masing-masing diukur menggunakan KRUSS refraktometer, dan S&H UniPol polarimeter.

Keputusan dan Perbincangan

Sebanyak 10 minyak pati telah digunakan di dalam kajian ini. Daripada jumlah tersebut, hanya 3 minyak pati diperolehi daripada spesies yang telah dikenalpasti, 3 sampel *unknown* dan 4 minyak pati yang dibeli daripada syarikat pembekal minyak pati/komersial. Pengenalpastian kandungan kimia mudah meruap telah dijalankan melalui analisis GC dan GCMS. Senarai kandungan kimia utama/penting bagi setiap sampel adalah seperti di Jadual 1.

Kandungan kimia utama/penting bagi minyak pati *C. nardus* adalah kamfena, limonena, sitronelal, borneol, sitronelol, geraniol dan metil isoeugenol. Manakala, minyak pati daun *C. winterianus* terdiri daripada limonena, linalol, isopulegol, sitronelal, sitronelol, geraniol, geranial, sitronelil asetat, eugenol, geranil asetat, β-elemena, germakrena D, δ-kadinena dan elemol. Berdasarkan senarai kandungan kimia di Jadual 1 dan profil kromatogram GC dan GCMS, dapat ditentukan bahawa ketiga-tiga sampel *unknown* adalah minyak pati daripada spesies *C. winterianus*. Ini termasuk 3 sampel komersial iaitu *Com 2, 3* dan *4* kecuali *Com 1* yang dikenalpasti sebagai spesies *C. nardus.*

Bagi sampel *Com 3*, didapati terdapat kandungan kimia yang ketara berbeza dengan sampel-sampel yang lain, walaupun dinyatakan semasa proses pembelian bahawa ianya adalah 100% tulen. Ini menunjukkan bahawa pihak syarikat telah melakukan proses adulterasi untuk memperoleh keuntungan yang lebih tinggi. Minyak *Com 3* berwarna hijau muda yang nyata berbeza dengan 9 minyak pati lain yang berwarna di antara kuning muda ke kuning keemasan.

Bagi sampel *Com 4* pula, terdapat kandungan kimia kumpulan monoterpena yang tinggi seperti α–pinena, kamfena, sabinena, β-pinena serta mirsena yang tinggi berbanding dengan sampel daripada spesies yang sama. Ia mungkin disebabkan oleh faktor-faktor seperti lokasi, usia pokok serta musim semasa kutipan sampel.

Penentuan nilai ciri kimia-fizik bagi setiap sampel disenaraikan di Jadual 2. Nilai-nilai ini penting bagi memastikan sesuatu minyak pati adalah berkualiti. Ia akan dijadikan rujukan untuk penilaian ke atas minyak pati daripada spesies-spesies yang diperolehi dari sumber yang sama untuk tujuan penyeragaman. Hasil analisis kimia dan ciri kimia-fizik diterjemahkan ke dalam bentuk *COA*. Contoh COA adalah seperti di Foto 4. Sijil ini diibaratkan sijil kelahiran yang menunjukkan maklumat-maklumat penting bagi sesuatu minyak pati yang dihasilkan. Setiap minyak pati mempunyai sijil yang berbeza.

Kesimpulan

Kandungan kimia mudah meruap yang terkandung di dalam minyak pati pelbagai spesies serai wangi mempunyai perbezaan dan ianya secara langsung dapat membantu dalam proses pengecaman spesies. Laporan ujian GC dan GC/MS amat bermanfaat bagi memastikan pengguna atau pengeluar produk memperoleh minyak daripada spesies yang betul dan tepat. Tanaman serai wangi adalah kekal relavan untuk ditanam oleh pengusaha herba sama ada sebagai tanaman utama atau sampingan kerana minyak yang diperolehi boleh digunakan untuk tujuan pembangunan produk secara komersil mahupun untuk kegunaan harian di rumah.

Jadual 1: Kandungan kimia utama bagi beberapa sampel minyak pati serai wangi

Bil	Nama sebatian kimia	%									
		CN	*CW 1*	*CW 2*	*Unknown 1*	*Unknown 2*	*Unknown 3*	*Com. 1*	*Com. 2*	*Com. 3*	*Com. 4*
1	α-Pinena	1.67	<0.01	<0.01	-	<0.01	-	2.96	0.18	<0.01	8.22
2	Kamfena	5.85	<0.01	<0.01	<0.01	-	-	10.11	0.15	-	4.29
3	Sabinena	0.10	-	<0.01	-	<0.01	-	0.19	-	-	11.87
4	β-Pinena	<0.01	-	<0.01	-	-	-	<0.01	-	-	3.65
5	Mirsena	0.44	<0.01	0.12	<0.01	<0.01	-	0.85	<0.01	<0.01	2.78
6	Limonena	6.52	0.18	4.89	<0.01	2.52	<0.01	9.00	4.01	0.34	4.32
7	Linalol	0.80	0.92	0.78	2.41	0.66	1.98	0.46	0.78	<0.01	0.42
8	Isopulegol	0.61	0.58	<0.01	0.52	2.28	-	0.41	0.76	<0.01	-
9	Kamfor	0.20	-	-	-	-	-	0.20	-	0.04	9.22
10	Sitronelal	4.71	20.69	41.49	26.31	37.35	18.92	3.56	33.58	1.08	15.97
11	Borneol	2.91	-	-	-	-	-	4.77	<0.01	-	-
12	Sitronelol	2.98	8.00	11.50	2.00	9.81	17.56	2.75	9.07	0.32	7.44
13	Neral	0.53	7.53	-	4.97	<0.01	-	0.32	0.61	0.12	-
14	Geraniol	17.64	44.04	16.39	0.95	15.83	41.20	13.10	20.29	0.64	9.45
15	Geranial	0.73	3.67	-	5.74	0.50	-	0.29	0.75	0.15	-
16	Sitronellil asetat	0.87	0.95	1.87	8.11	2.40	0.81	0.71	2.80	0.07	1.46
17	Eugenol	<0.01	1.28	0.92	-	0.69	1.07	<0.01	1.22	<0.01	0.89
18	Geranil asetat	3.27	2.61	2.12	43.24	3.56	1.86	3.92	4.27	0.11	1.63
19	δ-Kadinena	-	0.22	2.17	0.17	3.14	-	1.33	2.00	0.07	-
20	β-Elemena	0.78	0.31	2.88	-	3.31	0.49	0.97	1.57	<0.01	1.19
21	Germakrena D	0.64	0.66	2.95	0.16	1.14	1.27	1.52	2.89	0.05	1.71
22	Metil eugenol	10.71	<0.01	-	-	-	-	0.86	0.27	-	-
23	β-Kariofilena	0.16	1.68	0.11	0.14	0.23	2.33	2.70	0.85	-	0.36
24	(*E*)-Metil isoeugenol	11.31	<0.01	<0.01	-	-	-	12.02	1.78	-	-
25	γ-Kadinena	-	2.63	0.53	0.53	0.91	4.10	0.55	1.03	<0.01	0.56
26	Elemol	3.10	0.37	3.16	0.21	6.79	0.67	1.35	2.37	0.10	2.04
27	Dietil ftalet	-	-	-	-	-	-	-	-	47.71	-
28	Etil tetradekanoat	-	-	-	-	-	-	-	-	7.50	-
29	Isopropil tetradekanoat	-	-	-	-	-	-	-	-	46.50	-

Petunjuk: CN= *C. nardus*; CW= *C. winterianus*; *Unknown*= Spesies yang tidak dikenalpasti; *Com*= Minyak pati komersil

Jadual 2: Nilai indek biasan, graviti spesifik dan putaran optik minyak pati serai wangi

Sampel	Indek biasan	Putaran optik	
		Min	Max
CN1	1.4801-1.4803	-0.94°	-0.97°
CW1	1.4737-1.4744	0.12°	0.15°
CW2	1.4732-1.4734	-1.28°	-1.30°
Unknown 1	1.4582-1.4583	-0.15°	-0.17°
Unknown 2	1.4650-1.4654	0.03°	0.06°
Unknown 3	1.4692-1.4694	0.28°	0.30°
Com 1	1.4798-1.4806	-1.91°	-1.94°
Com 2	1.4659-1.4661	-0.43°	-0.44°
Com 3	1.4497-1.4498	0.03°	0.06°
Com 4	1.4667-1.4668	0.05°	0.06°

Petunjuk: CN= *C. nardus*; CW= *C. winterianus*; Unknown = Spesies yang tidak dikenalpasti; *Com* = Minyak pati komersil

Foto 1 : Salah satu tanaman serai wangi

Foto 2 : Alat penyulingan berskala besar

Foto 3 : Alat penyulingan berskala makmal

CERTIFICATE OF ANALYSIS (COA)

Foto 4 : Contoh *Certificate of Analysis (COA)*

Penghargaan

Projek ini adalah di bawah biayaan peruntukan dana FRGS/1/2018/WAB01/NRE/1 dan RMK11. Penulis ingin merakamkan setinggi-tinggi penghargaan kepada semua staf Bahagian Hasilan Semula Jadi yang terlibat secara langsung dalam membantu memproses sampel-sampel serai wangi.

Rujukan

Handa, S.S. 2008. An Overview of Extraction Techniques for Medicinal and Aromatic Plants in Extraction Technologies for Medicinal and Aromatic Plants. International Centre for Science and High Technology, ICS-UNIDO, pp. 21-52.

Hyldgaard, M., Mygind, T., Meyer, R.L. 2012. Essential Oils in Food Preservation: Mode of Action, Synergies and Interactions with Food Matrix Components. *Front. Microbiol* 3, 12.

Ganjewala, D. 2009. *Cymbopogon* essential oils: Chemical compositions and bioactivities. *International Journal of Essential Oil Therapeutics* 3: 56-65.

Wany, A., Jha, S., Nigam, V.K. & Pandey, D.M. 2013. Chemical Analysis and Therapeutic Uses of Citronella Oil from *Cymbopogon winterianus*: A short review. *International Journal of Advanced Research* 1(6): 504-521.

Nor Azah, M.A., Zaridah, M.Z., Abu Said, A., Mohd Faridz Z.P. & Siti Asha A.B. 2002. Chemical Constituents of Essential Oils of *Cymbopogon nardus* and Their Larvicidal Activities, Towards Moderisation of Research and Technology in Herbal Industries in Proceeding of Seminar Medicinal and Aromatic Plant, pp. 171-175.

Ropien, J., Zulaikha P., Puziah, H., Rozita, B., Noorulhamezan, M.N., Nor Azah M.A., Vimala, S., Mastura M., & Abu Said, A. Personal Care Products With Serai Wangi Oil. Towards Moderisation of Research and Technology in Herbal Industries in Proceeding of Seminar Medicinal and Aromatic Plant, pp. 81-91.

Zaridah M.Z., Nor Azah, M.A, Abu Said, A & Mohd Faridz Z.P. 2003. Larvicidal Properties of Citronella (*Cymbopogon nardus*) Essential Oils from Two Different Localities. *Tropical Biomedicine* 20(2): 169-174.

Zaridah, M.Z., Nor Azah M.A. & Rohani, A. 2006. Mosquitocidal Activities of Malaysia Plants. *Journal of Tropical Forest Science* 18(1): 74-80.

Leite, B.L.S., Bonfim, R.R., Antoniolli, A.R., Thomazzi, S.M., Araujo, A.A.S., Blank A.F., Estevam C.S., Cambui E.V.F., Bonjardim L.R., Albuquerque Junior, R.L.C. & Quintans-Junior, L.J. 2010. Assessment of Antinoceptive, anti-inflammatory and Antioxidant Properties of *Cymbopogon winterianus* Leaf Essential Oil. *Pharmaceutical Biology* 48(10): 1164-1169.

Koenig, W.A. & Hochmuth, D.H. 2004. Enantioselective Gas Chromatography in Flavor and Fragrance Analysis: Strategies for the Identification of Known and Unkown Plant Volatiles. *Journal of Chromatograhy Science* 42: 423-439.

Do. T.K.T., Hadji-Minaglou, F., Antoniotti, S. & Fernandez X. 2015. Authenticity of Essential Oils. *Trends in Analytical Chemistry* 66: 146-15.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE01

The Effect of Drying Temperatures on the Active Compound of *Vitex Negundo* Leaves

*Hada Masayu I, Fauziah A, Fadzureena J, Nor Azah M A, Sharmizi I, Fatin Fazliyana M L and Mohd Hafizi R

Natural Products Division, Forest Research Institute Malaysia (FRIM) 52109 Kepong, Selangor

*Corresponding author, Tel : 03-6279 7781 E-mail : hada@frim.gov.my

Abstract

The effect of drying temperature on the leaves of *Vitex negundo* was determined. Three levels of temperatures (40, 50 and 60°C) were used in the presented study. The initial moisture content of the leaves was 69.98%. Continuous drying at the above mentioned temperature levels was conducted to determine the drying time required to achieve equilibrium moisture content. The quality of dried leaves was evaluated based on the quantity of agnuside, major compound of *V. negundo* using High Performance Liquid Chromatography (HPLC) analysis. The fastest drying of the leaves was achieved at 60°C, followed by at 50°C, but HPLC results showed that dried *V. negundo* suffered at 40% reduction in agnuside content when drying at 60°C as compared to at 40°C. Slight reduction of agnuside was found in the sample dried at 50°C. Based on the findings of this work, the best convection oven drying condition for *V. negundo* leaves was at 50°C with 502.224 mg/L of agnuside concentration.

Keywords : *Vitex negundo*, agnuside, drying, phytochemical

Introduction

The genus *Vitex* (Verbenaceae) consists of trees and shrubs, found in tropical and subtropical regions. About 30 species occur in the Malesian region. The most important medicinal species, *V. negundo* and *V. trifolia*, are widely cultivated not only for their medicinal properties but also as ornamental and hedge plants, and have sometimes naturalized. The leaf extract of *V. negundo* has been reported to reveal a wide range of biological actions including mosquito repellent activity, anti-angiogenic, hepatoprotective, analgesic, antiinflammatory, anti-arthritic, antimicrobial, antihistaminic, CNS depressant, anti-filarial activities etc. These actions may be due to the various phytoconstituents present in the plant, which include iridoids, flavonoids, polyphenolic compounds, alkaloids, terpenoids etc. (Patil, 2018). Owing to these various phytochemicals, this plant has a crucial role in phytomedicine.

Drying is an important process of dehydrated material preparation because it reduces the moisture content of fresh materials for long storage and minimizes the costs of transportation and preservation. However, drying conditions have been shown to have significant influences on the quality and stability of bioactive compounds, and their bioactivity capacity. *V. negundo*, shows the presence of numerous iridoids like agnuside, negundoside and its responsible for the different pharmacological activities. Among these iridoids, agnuside is an important chemotaxonomic marker that can be used in quality control of *V. negundo* raw material. Importantly, there is no previous study reporting on the optimal drying conditions from convection oven drying of *V. negundo* leaves. Therefore, it is necessary to identify the optimal drying conditions for preparation of dried *V. negundo* leaves for further processing steps. In the present work, the optimum drying condition was studied to produce high quality dried material of *V. negundo* leaves. The quality of the dried materials will be evaluated based on agnuside content quantified by HPLC analysis.

Methods

Raw Material

Fresh plant of *V. negundo* was harvested from Maran Research Station, Forest Research Institute Malaysia (FRIM). The plant was sorted manually for its leaves to be used in the experiments. The leaves were cleaned from dirt using tap water, rinsed and then kept in polystyrene box while being transported to the laboratory. Initial moisture content of the leaves was 69.98 ± 5.42% (wet basis) measured via calibrated Halogen Moisture Analyser (Model AND MS-70, Japan).

Drying experiments

The drying experiments were done at three selected temperatures of 40, 50 and 60°C. Lab scale convection oven dryer (UFE 500 type, Memmert, Germany) was used in this study. For the experiments, an approximate weight of 5.00 g leaves of *Vitex negundo* was distributed uniformly on aluminium tray placed in the drying chamber. Sample mass was measured by weighing the tray outside the drying chamber periodically using an electronic balance. Weights were recorded every 10 minutes until the equilibrium moisture content was reached for the calculation of moisture content during experiment. Each drying experiment was triplicated. Final moisture content was determined using Halogen moisture analyser.

The free moisture versus drying time graphs was plotted for each of the experiments. Moisture content (dry basis) of the sample was described by the percentage equivalent of the ratio of the weight of water to the total weight of the dry material. It was calculated by using equation as below (Ramaswamy and Marcotte, 2006):

$$Moisture\ content = \left({}^{M}\!/_{S}\right) \times 100$$

Where M is the content of water and S is the content of solid.

Qualitative and Quantitative Determination of Phytochemical in Dried V. negundo

Instrumentation:
HPLC chromatograms are generated with Waters HPLC system composing of a quaternary pump (Waters 600E), an autosampler (Waters 717) and a PDA detector (Waters 2996 PDA) scanning from 190 nm to 400 nm using a reversed phase C-18 column (4.6 i.d. x 250 nm, 5µm). The Chromatograph are processed using Empower 2 software.

Sample preparation of V. negundo leaves for HPLC analysis:
The dried and ground sample (0.5 g) is extracted in 15 ml of HPLC grade methanol by sonication in a closed vial for 15 min. the solution is filtered using 0.45 µm filter before subjected to HPLC analysis. An aliquot of 10 µL is injected for the analysis.

Preparation of standard solutions for HPLC analysis:
Stock solutions of agnuside (1 mg/mL) was prepared separately in methanol. The prepared standard solutions were sonicated and filtered through a 0.45 µm membrane filter prior to analysis

HPLC analysis:
The analysis was carried out on a RP-18 column using 0.1% formic acid (solvent A) and acetonitrile (solvent B) as mobile phase in gradient mode. The gradient elution profile used was: 0 min, 10% B; 7 min, 30% B; 15 min, 40% B; 18 min, 100% B. The column was equilibrated with 10% B for 5 min before the next injection. 10 µL of standards and sample were injected into the HPLC at a flow rate of 1 mL/min. The agnuside was analyzed 285 nm.

Results and Discussion

Drying Kinetics of Vitex negundo Leaves from Convection Oven Drying
Figure 1 illustrates the change of free moisture over time for *V. negundo* leaves with initial moisture content in range of 3.730 - 3.970 % (db). It is clear that the moisture content decreased with increasing time during drying process. It took 500, 330 and 140 minutes to dry the leaves at respective temperature of 40, 50 and 60°C. Higher drying temperature resulted in shorter drying times. Drying at 50 and 60°C could reduce about 34 and 72%, respectively of drying time as compared to drying at 40°C. This might be due to larger driving force for heat transfer at temperature 60 and 50°C as compared with at temperature 40°C.

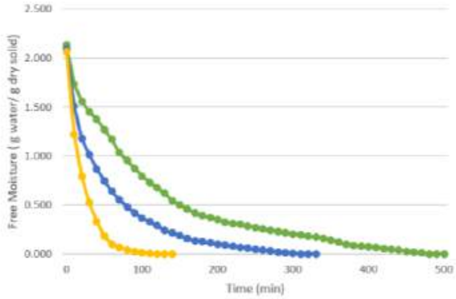


Figure 1: Drying curves of V. negundo leaves dried at 40, 50 and 60°C using convection oven

Phytochemical content of V. negundo leaves from Convection Oven Drying

Concentration of agnuside in convection oven dried leaves of *V. negundo* is illustrated in Figure 2. The figure shows that the concentration of agnuside was decreasing with increasing temperatures. *Vitex negundo* leaves dried at 40, 50 and 60°C contained remaining agnuside concentration of 535.377 mg/L, 502.224 mg/L and 320.574 mg/L, respectively. The slight reduction of agnuside was observed when the leaves were dried at 50°C as compared to at 40°C. The drop of concentration of agnuside was significant in the leaves dried at 60°C when compared to at 40 and 50°C indicates that it might be due to the destruction of agnuside during drying as a result of thermal damage.

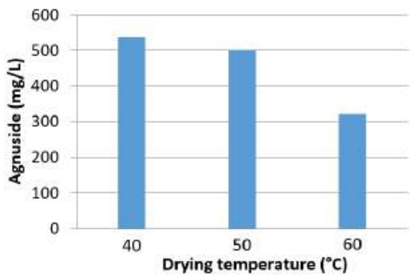


Figure 2: Concentration of V. negundo in dried leaves subjected to different drying temperatures

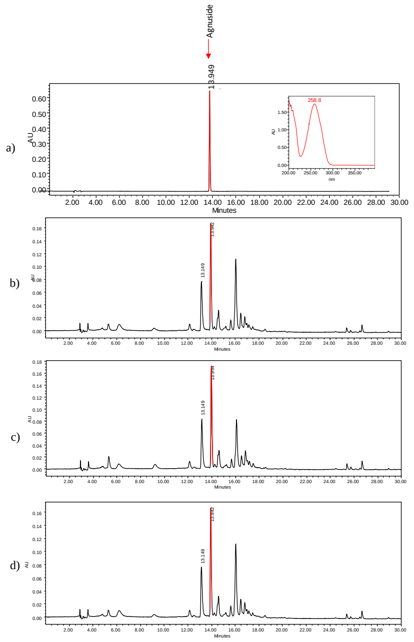


Figure 3: HPLC chromatograms of (a) standard; (b) leaves dried at 40°C; (c) leaves dried at 50°C; (d) leaves dried at 60°C

Conclusion

In term of quality with regards to drying time and phytochemical content, the best convection oven drying condition for *V. negundo* leaves was at 50°C with 502.224 mg/L of agnuside concentration.

Acknowledgements

The authors would like to thank all the staff of Natural Products Division of Forest Research Institute Malaysia (FRIM) for their support and technical assistance.

References

Ramaswamy Hosahalli & Marcotte Michéle. (2006). Food processing: Principles and applications. CRC press.

Vasisht K. (2008). Quality control of medicinal and aromatic plants and their extracted products by HPLC and high performance thin layer chromatography. In: *Extraction Technologies for Medicinal and Aromatic Plants* edited by Handa, S.S., Khanuja, S.P.S., Longo, G., & Rakesh, D.D., pp. 21-54. Trieste: International Center for Science and High Technology (ICS-UNIDO).

Patil S. P. & Laddha K.S. (2018). Extraction efficiency of agnuside from Vitex Negundo leaves using different techniques and its quantitative determination by HPLC. *International Journal of Health Science and Research*. Pp 129-135.

Sehgal C.K., Taneja S. C, Dhar K.L and Atal C.K. (1982). 2’-p-hydroxybenzoyl mussaenosidic acid. A new iridoid glucoside from Vitex negundo. Pp363 – 366.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE02

Drying Air Properties Investigation and Simulation Study of a Commercial Mixed-Flow Batch Type Paddy Seed Drying System

Azmi. M., Z.[1,*], Rukunudin. I., H.[2], Ismail. H., A.[2] and Dahuli. K.[1]
[1]Paddy Industry Division, Muda Agricultural Development Authority (MADA)
[2]School of Bioprocess Engineering, Universiti Malaysia Perlis (UNIMAP)
*Corresponding author. Tel.: +6012-4584978, Email:zaharan.arsenal@gmail.com

Abstract
In Malaysia, numerous extensive research to gauge the performance and efficiency of paddy dryers were conducted by past researchers. These studies gave valuable insights into paddy drying and promoted further research oppurtunities, especially in engineering and technical studies. However, the study of commercial grain dryers performance for paddy seed drying still lacks in Malaysia. The absence of fundamental information, such as the static pressure requirement, the right volume of air (volumetric flow rate) and the drying air temperature profile requisite in regard to paddy seeds drying leads to ill-informed judgements and poor decision-making which can be detrimental, especially in regars to the design and plant installation. This study was therefore undertaken to investigate the three pertinent parameters i.e. static pressure, volumetric flow rate and the temperature profile of the drying air of a commercial, mixed-flow, batch type seed dryer at Loji Pemprosesan Benih Padi Sah (A) at Telok Chengai, Kedah using both field experimentation and computational fluid dynamics (CFD) simulations. Results from experimentation investigation suggested that in current operating condition and configuration, the drying system is producing 460 Pa (46.90 mmH_2O) of static pressure per 300 mm of grain bed depth which is lower than the recommended value of 500 Pa (51.00 mmH_2O) and 4 times lower than the actual required value due to higher grain bed depth (1,200 mm) at the top of the dryer. The volumetric flow rate of 15,699 m³/h (9,240 cfm or 577 cfm/mt) produced by the blower fan also indicated that it lacks volume of air to facilitate efficient drying rate as recommended value are as high as 1,589 cfm/mt. Thermal imaging of the drying system revealed that 8.88% losses in temperature occured from the blower fan (45°C) to the drying plenum (41°C). Computational Fluid Dynamics (CFD) simulations was performed through ANSYS-Fluent commercial software indicated that these results were acceptable as the disparity between the actual experimentation results and the simulated results were 10.0% and 7.3% for the static pressure and temperature profile respectively.

Keywords: Paddy Seed Drying, Commercial, Static Pressure, Volumetric Flow Rate, Temperature, Computational Fluid Dynamics, ANSYS-Fluent

Introduction

Syarikat Perniagaan Peladang MADA Sdn. Bhd. (MADACorp), a subsidiary of the Muda Agricultural Development Authority (MADA) operates a commercial seed processing plant, namely the *Loji Pemprosesan Benih Padi Sah* at Telok Chengai, Kedah, to supply certified seeds to farmers within the MUDA area and its vicinity. Seed integrity is one of the ultimate goals of the processing plant. High quality certified paddy seeds which are guaranteed in terms of their physical and genetic purity, possess important attributes, such as good germination and vigor, are crucial to increase the production yield by between 5% and 20% (Mat et. al., 2002; IRRI, 2013). The most effective and economical way of preserving seed quality is through drying. However, lately most of the 13 units of plant batch dryers , which have a total holding capacity of 130 metric tons, showed a decline in their performance efficiency. Being a commercial entity that accounted for approximately 40% of the total annual income of MADACorp., a dip in the overall effeciency in the drying plant can have a significant impact on the overall profitability. Considering a plant of almost 40 years in operation, a comprehensive review of the drying system and structrural integrity must therefore be carried out for immediate improvement. Drying is defined as the removal of moisture to moisture content (MC) in equilibrium with normal atmospheric air or to such an MC that reduces in activity of molds, enzymatic action and insects (Henderson & Perry, 1976). Convective type of drying is used extensively in grain drying such as paddy seeds. It is one of the most effective and economical type of drying with regards to grain conditioning. The principles of air movement especially its relationship to the static pressure of the air and the volume of air per unit time is crucial to the rate of drying of the paddy seeds. Sufficient volume of air per unit time and pressure must therefore be provided to affect optimum drying process effectively and efficiently in order to produce high quality of dried grain and seeds.

Materials and methods

Seed dryer system

The experiments were conducted by using one of the commercial scale Louisiana State University (LSU) batch mixed-flow seed dryer systems (Figure 1), which was available at the *Loji Pemprosesan Benih Padi Sah* at Telok Chengai, Kedah. The seed dryer had a holding capacity of 15 metric tons. The cross-sectional area of the dryer was 3.65 m x 2.55 m and the height of dryer was 7.90 m. The dryer was connected to an 11.0 kW, 15.0 HP backward-curved centrifugal blower fan. The atmospheric air was heated through the use of a diesel-fired burner, with a burning capacity of 320,000 BTU or 80,000 kcal.

Measurement of air flow properties

Air properties, such as its velocity, volumetric flow rate and pressure components were measured by using a pitot tube anemometer/differential manometer (CEM 0001). The measurement was carried out by using log-Tchebycheff for a transverse circular duct method. The readings were recorded at 10 different points and the average value was calculated. These data were collected at the inlet for heated air and outlet for exhausted air and carried out at a specified time interval. The pitot-tube anemometer/differential manometer was calibrated before use.

Measurement of temperature

The drying air temperatures were measured on an hourly basis at two different locations by using a thermal hygrometer data logger (RIX 670). This data along with the air properties will be used in the simulations. An investigation of temperature distribution profile on the dryer plenum was also conducted using a thermal imaging scanner in order to validate the actual results with the CFD simulations.

ANSYS-Fluent Simulation

The temperature regime, static pressure distributions and the volumetric flow rate of the drying air in the drying plenum of the seed dryer at *Loji Pemprosesan Benih Padi Sah* at Telok Chengai, Kedah was simulated using commercial CFD software, ANSYS Fluent Ver. 15. The 3D geometry modelling of the drying plenum was done through another commercial software called Solidworks. The modelling of the drying plenum was "cut" into half, as analysing was done based on the concept of symmetrical model. Its dimension was given by 1,255 mm in length x 480 mm in width x 4,490 mm in height. An extension of the air outlet was done to the fluid domain to avoid fluid's "backflow" error. This method of extending and moving the outlet further away from its original location by modelling in an additional length of outlet surface is on one of the common tactics with CFD modelling to minimize backflow behavior (Wong, 2017). A total of 6,031,348 number of elements and 1,135,607 nodes were produced in the discretization of the drying plenum. The simulation was carried out for a steady-state condition. The k-ε was used to represent the turbulence model for this simulation. The turbulence specification method was based on the turbulence intensity and its hydraulic diameter. Two materials was defined for this analysis; the air for fluid and the steel for the solid walls. The thermo-physical properties for air was determined from the experimental analysis, while the properties for the steel was taken from the pre-set ANSYS-Fluent configuration. Three domain were defined in this simulation; the air inlet, the air outlet and the wall. For this simulation, the properties of the fluid (drying air) was used to define the air inlet. The bottom of the drying plenum was set as the air inlet, the outlet of the air was set to be the drying air channels out which was extended 500 mm to cater for backflow of air and the rest of the domain was set as walls. The walls were set as stationary and the condition of the solution was set to be in no-slip condition. The default SIMPLE scheme algorithms were used for the analysis of the problem. Hybrid Initialization was chosen as the solution initialization for this problem, due to the general in nature of the problem itself.

Results and discussion

Air flow properties

From the experimentation investigation, the centrifugal backward-curve blower fan produced a total of 15,699 m^3/h (9,240 cfm) of air. The corresponding volumetric flow rate per tonnage for the dryer system was approximately 933.35 m^3/h per mt (549.31 cfm/mt). The resultant static pressure which responsible for the "push" of the drying air across the drying bed depth was approximately 460 Pa (46.90 mmH_2O). According to Brooker, Bakker-Arkema & Hall (1992), mixed-flow types of dryers require an operating static pressure as high as 51.00 mmH_2O (500 Pa) and a minimum air delivery of 1,589 cfm/mt dried materials (45 m^3/min.mt). From the result of the experimentation investigation, it was noted that the fan does not produce enough static pressure to provide enough "push" for the drying air to penetrate and conversely does not produce enough volumetric flow rate to increase the drying rate.

Temperature distribution profiles

Temperature distribution profiles investigation revealed that the highest temperature distribution recorded was localized at the fan's casing which was the closest section to the heat source, the burner. The surface temperature of the fan metal housing registered a temperature ranged from 36 to 46°C. The average temperature was recorded at 45°C, as indicated in Figure 1.0 As the drying air moves farther from the heat source, its temperature began to drop. The temperature distribution at the ducting's wall ranged from 33 to 45°C with an average value of about 40°C as in Figure 2.0. The decreased in the drying air temperature can also be attributed to the presence of turbulence in this section of the duct. As the velocity of the drying air inside the ducting increased as a result of the change in the ducts cross sectional area, the fluctuations in the temperature gradient became higher thus causing the average temperature to drop. As the air moves into the drying plenum, which acts like a diffuser, the velocity of the air slowed, reducing the fluctuations of the temperature, in contrast with the ducting section. From Figure 3.0, the temperature at the dryer's wall suggested that the drying air temperature at this section ranged from 33 to 42°C and its average was approximately at 41°C. From the above observation, an approximately 8.88% of total temperature losses can be traced from the temperature difference from the fan's casing to the drying plenum.

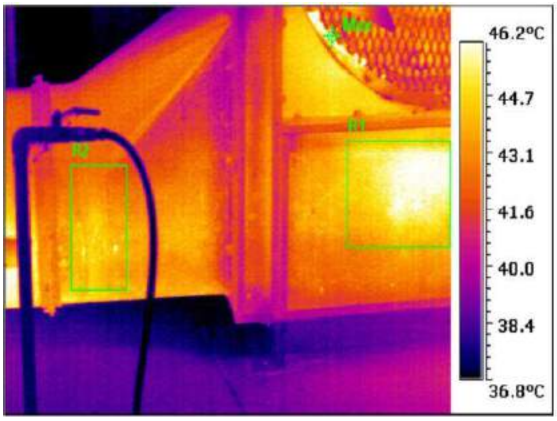


Figure 1.0: The thermo imaging of the temperature distribution at the fan's casing

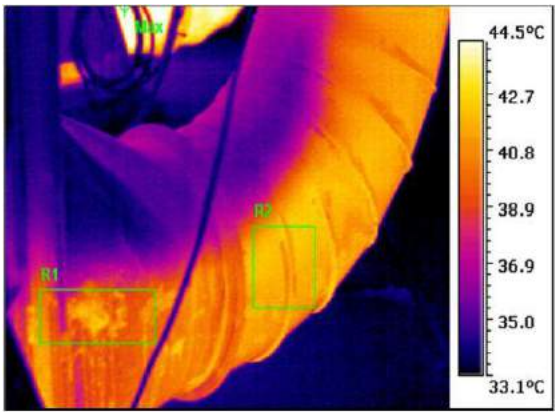


Figure 2.0: The thermo imaging of the temperature distribution at the ducting

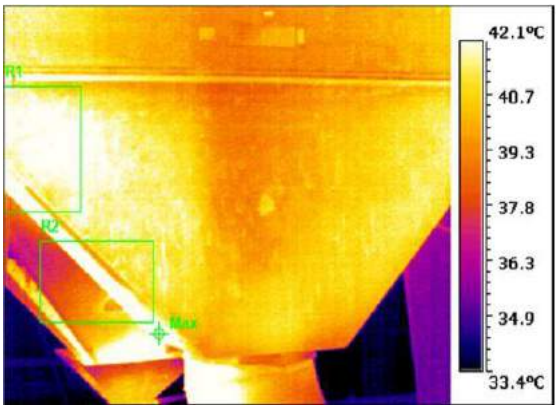


Figure 3.0: The thermo imaging of the temperature distribution at the entrance of drying plenum

ANSYS-Fluent Simulation Results

Static Pressure and Volumetric Flow Rate

ANSYS-Fluent simulated result showed the distribution of the static pressure ranged from as low as -734.5 Pa (-75.0 mmH_2O) to as high as 820.2 Pa (84.0 mmH_2O) as indicated in Figure 4.0. Based on the simulation, the static pressure distribution can generally be divided into 2 distinctive sections where the bottom section of the plenum's static pressure ranged from as low as 509.3 Pa (52.0 mmH_2O) to 664.7 Pa (68.0 mmH_2O) and the top section's static pressure ranged from 664.7 Pa (68.0 mmH_2O) to as high as 820.2 Pa (84.0 mmH_2O). Other sections such as the lower side of the entrance of the air channels and inside the air channels have a much lower range of static pressure. The accuracy of the simulated static pressure was confirmed through cross examination with the experimentation results. It was found that the average static pressure measured at the bottom section of the dryer was 46.90 mmH_2O (460 Pa); was relatively close (approximately 10% difference) to the average simulated static pressure of 52 mmH_2O (509 Pa) at the bottom of the dryer section (taken from the average of static pressure ranged from 36 mmH_2O (353.8 Pa) to 68 mmH_2O (664.7 Pa)). These regimes of static pressure distributions can be attributed to the drying air's velocity. As the bottom section of the dryer is closer to the air inlet of the drying plenum, it registered higher velocity of air thus possessed lower ranged of static pressure. As the drying air moves up the drying plenum, its velocity was reduced, therefore registered higher ranged of static pressure. The same correlation of static pressure-velocity of drying air was observed at the entrance and inside of the air channels; where lower static pressure was observed as a result of higher ranged of air velocity around those regions. In an ideal condition where the losses of the generated static pressure would be as minimum as possible, the simulated results predicts that the drying system (the blower fan) could generate as high as 820 Pa or 84.0 mmH_2O of static pressure, localized at the top section of the dryer, a region where the formation of relatively high static pressure was considered more critical compared to the lower sections of the dryer as the top section of the dryer required the largest "push" to overcome the high static-pressure drop due to thicker grain bed depth. The usual practice at the plant to over fill the top section to the brink of the drying chamber (heaping to an average of 1200 mm) can be counter-productive and adversely affect the overall drying performance.

From the findings, the static pressure requirement at the top of the dryer were at least 4 times the static pressure needed for the rest of the dryer's volume (that accounted almost 90% of the dryer's volume). Since the average static pressure measured during the experiment were 46.9 mmH_2O (460 Pa) and were sufficient for a standard 300 mm grain bed depth, then the theoretical static pressure requirement for the top part of the dryer that has a 1200 mm grain bed depth, would amount to an approximately 188 mmH_2O (1,844 Pa). Such a high static pressure requirement is impossible to achieve under current drying system configuration thus adversely affecting the dryer performance. However, positive outcomes could be anticipated if the current optimum fan speed configuration and the ideally simulated static pressure values be used as a guidelines to reduce the level of the filling to 1,000 mm and below, then the theoretical requirement for static pressure at the top of the dryer would be reasonably low (approximately 140 mmH_2O) and the disparity between the simulated static pressure of 84 mmH_2O (820 Pa) would be reduce from 55% (comparison between 188 mmH_2O) to 40%. The reduced from the theoretical static pressures of 188 mmH_2O to 140 mmH_2O would result in a reduction of approximately 48 mmH_2O (470 Pa) or is equivalent of reducing 1 layer on grain bed depth of static pressure. This could significantly boost the efficiency of the dryer system and hence reducing both the drying rate and as well as the drying period. The analysis of volumetric flow rate of the drying air is closely related to the characteristics of the air's velocity. Since the cross sectional area are constant, therefore the volumetric flow rate is directly proportional to the air's velocity. As the drying air moves upward towards the top section of the dryer, its velocity decreased thus reducing its volumetric flow rate. The opposite reactions could be viewed at the bottom sections of the dryer where the velocity is high hence a higher volumetric flow rate is expected at that section as in Figure 5.0.

Temperature Distribution Profiles

The simulated temperature readings from the analysis showed that as the hot drying air enters the plenum from the bottom and moves upwards before making a perpendicular turn into the drying bed, there exist a temperature gradient between the bottom and the top section of the plenum. It was found that the bottom plenum section to be the highest (45.01°C) and reduced as it moved upwards where the lowest was 41.3°C. The reduction in the drying air temperature seemed uniformly distributed across the longitudinal-section of the plenum. As in Figure 6.0, the average drying air temperature inside the drying plenum from the simulations was found to be 44°C. The existence of the temperature gradient of about 4°C showed a distinctive heat loss occurred in the drying air as it moved up the dryer chamber. The loss in the heat from the drying air is gained by the metal housings of the dryer system as indicated by the thermal image captured by a thermal camera as discussed earlier. Therefore, it can be inferred that the simulation gave a sound result of the ideal temperature of the drying air would be if the control system is efficient and accurate.

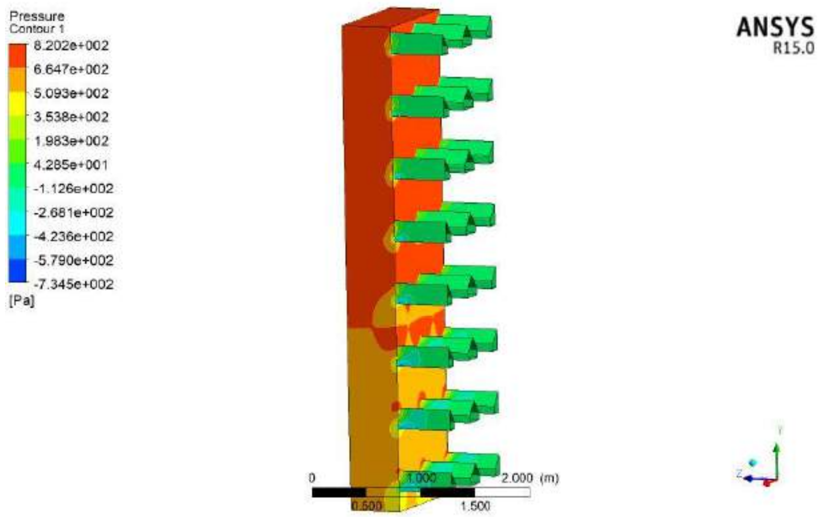


Figure 4.0: The pressure distribution inside the drying plenum

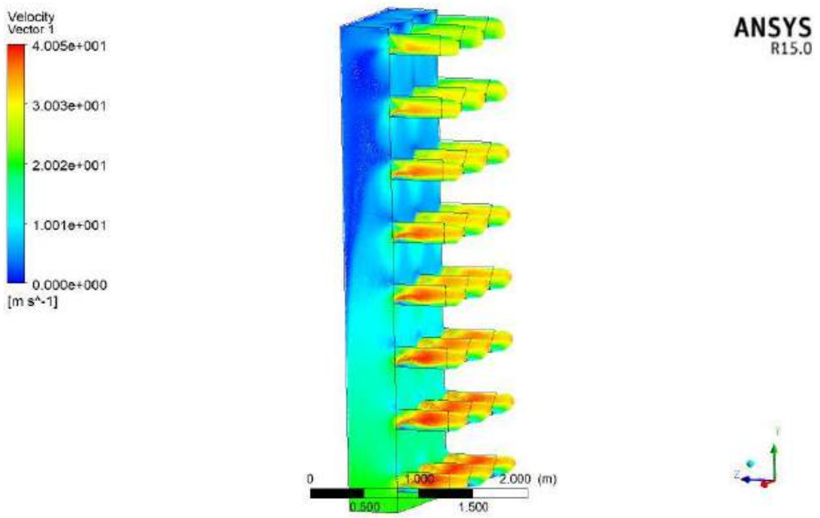


Figure 5.0: The velocity distributions inside the drying plenum

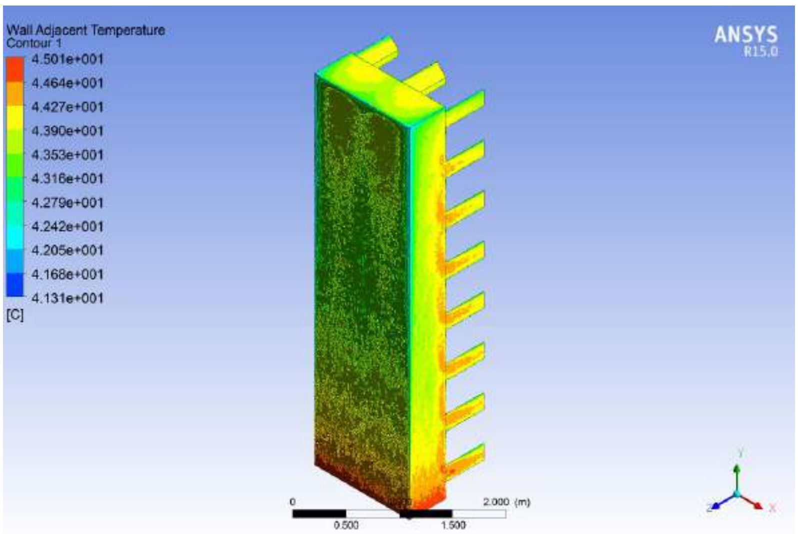


Figure 6.0: The temperature distribution inside the drying plenum

Conclusions

The performance of the LSU Batch Mixed-Flow Seed drying system *at Loji Pemprosesan Benih Padi Sah (A) Telok Chengai* was needed to be assessed and evaluated in order to determine its operating form and also to provide a basis for improvements and modifications in the future. Cross examination of the performance of the dryer system was done between experimentation investigation and CFD simulation using ANSYS-Fluent commercial software on three (3) drying air properties; static pressure, volumetric flow rate and temperature distribution profile. From the experimentation investigation, it was evidenced that the current blower fan produced a relatively low static pressure (460 Pa or 46.90 mmH_2O) and volume of air (15,699 m^3/h or 9,240 cfm or 577 cfm/mt) compared to the proposed which were 500 Pa (51.00 mmH_2O) for static pressure and 45 m^3/min.mt (1,589 cfm/mt) for the volume of air. These lack of drying air and the amount of "push" needed to overcome a greater grain bed depth at the top of the drying chamber has reduced the drying rate and consequently increased the drying period from 24h to approximately 30h. Validation for the static pressure generated using ANSYS-Fluent revealed a 10.0% disparity between the two results which indicates a very close approximation to the actual situation. From the simulation, under ideal condition, the drying system are producing as high as 820 Pa (84.00 mmH_2O) at the top of the dryer which are still insufficient to cater 4 times the normal requirement which are currently at 460 Pa (46.90 mmH_2O) per 300 mm of grain bed depth. Furthermore, validation on the drying air temperature distribution profile inside the drying plenum suggested a 7.3% disparity between the actual (41°C) and the simulated results (44°C). This result suggested that there was actual losses occurred in the drying system and one of the way to overcome this issue is to improve on the configuration of the drying system, such as to increase the effective length of the ducting and to maximize the pre-set temperature to 45°C, the maximum allowable safe drying temperature for seeds.

References

Brooker, D. B., Bakker-Arkema, F. W., & HALL, C. W. 1992. Drying and storage of grains and oilseeds, AVI Publ. Van Nostrand Reinhold, New York.

International Rice Research Institute (IRRI). 2013. Rice Seed Quality Reference Manual. Retrieved from http://www.knowledgebank.irri.org/images/docs/training-manual-seed-quality.pdf

Mat, N., Ho N. K., Ismail, S., Ali, A., Lum K. Y. & Mansor, M. (Eds.). 2002. Sustainable rice production in Malaysia beyond 2000. Malaysia

Ngu, T. N. W., Chu, C. M. and Janaun, J. A. 2016. Simulation of air velocity in a vertical perforated air distributor. International Conference on Chemical Engineering and Bioprocess Engineering. Universiti Malaysia Sabah. Malaysia.

Ng, P. P., Law, C. L., Tasirin, S. M., & Daud, W. R. W. (2005). Drying characteristics of Malaysian paddy: Kinetics & grain cracking quality. Drying Technology, 23(12), 2477–2489

Wong, A. J. 2017. CFD Study of force air cooling and windage losses in small gap region of high speed electric motors. Master's Thesis. California State Polytechnic Univeristy. California. USA

Yahya, M., Fudholi, A. and Sopian, K. 2017. Energy and exergy analyses of solar assisted fluidized bed drying integrated with biomass furnace. Renewable Energy. 105. 22-29

.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE03

Evaluation of lab scale Vitato flour processing and drying performance using cabinet dryer

Amir Syariffuddeen, M.A.[1], Faridah, H.[2], Shahrir, A.[1], Aida Hamimi, I.[2], Hazila Khairuunizah, K.[2], and Azman, H.[1]
Engineering Research Centre[1]
Food Science and Technology Research Centre[2]
Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
**Corresponding Author, Tel: +06 89536557, E-mail: asyariff.mardi@1govuc.gov.my*

Abstract
Vitato sweet potato has a bright orange colour with rich in carbohydrate as well as high content of β-carotene which functioning as Vitamin A in human body. With this high nutrients, Vitato has potential to become an alternative for health ingredient for processing flour and has used as one of the ingredient for premix flour for bakery purposes, such as for baking biscuits, muffins and cakes. An experiment has done to evaluate the processing flow of Vitato flour in the pilot scale. An amount of 25kg of fresh Vitato has used as feedstock and has through several processes of washing, peeling, sorting, slicing, drying and grinding. The performance of drying process on time consumption and moisture reduction profile has investigated. It has recorded time consumption to complete process for production of Vitato flour are 8 hours/ day with 20% recovery of flour, with 14.49kW electricity power, 560 litres of water used with 3 man power operation.

Keyword: Vitato, Flour, Drying, Moisture, Recovery

Introduction

Sweet potato (Ipomea batatas) is a cultivated tubers that come from tropical continent of America which appropriate to grow in sandy lush soils with containing many organic substances (Izalin, 2014). Sweet potato are rich in carbohydrates and known as among the dominant food crops which produce the highest amount of edible per hectar per day (Futega et. al., 2013). Sweet potato also is a food crop that is have play an important role in improving household and national security, health and livelihood of poor family in sub-Sahara African (SASHA/CIP, 2009). In Malaysia, sweet potato has considered as one of the staple food in Malaysia instead of rice, wheat, corn, barley, potato and cassava (Utusan Malaysia, 2016). Sweet potato has become an alternative crop to replace the plantation of tobacco since it has announce as a new revenue resource for farmer especially in Kelantan and Terengganu. Sweet potato has planted twice in a year in small area with estimation of 3000 hectar. A study conduct by MARDI related to the sweet potato has successfully produce new variety of sweet potato named “Vitato”. Sweet potato “Vitato” has belong to the family “Convolvulaceae” with its scientific named “Ipomea Batatus” (Senanayake et. al.,2013). It have characteristic as orange-fleshed in colour which particularly rich in β-carotene and most important contain of pro-vitamin A carotenoid (HarvestPlus, 2009). The orange-fleshed of “Vitato” has rich in antioxidant which converted into Vitamin A when reaction occur in human body. Moreover, “Vitato” also rich in Vitamin C and E together with Anthocyanin which can prevent cell and DNA damage, cancer prevention, fetal defects and delay aging. “Vitato” can processed into flour and used as one of the ingredients in a production premix flour for bakery products such as biscuits, muffins and cakes. “Vitato” processed flour can be stored for more than 1 year at room temperature. Commonly, sweet potato flour processing involved several processing such as reported by Hageninama and Owuri (2000) which it started with selection of sweet potato, then cleaning and trimming, washing, slicing, drying, milling and packaging. Ekinyu, (2010) reported that sweet potato flour processing step are choosing the sweet potato, then washing, draining, chipping and slicing, drying, milling, packaging and labelling and storage as final step. In this experiment, a Vitato flour processing has done in pilot scale for lab scale production which involve processes such as washing, peeling, sorting, slicing, drying and grinding. This paper will discussed on evaluation of whole process involve in Vitato flour processing in small scale in pilot plant including the investigation on drying performance, time and power consumption for each process step and also recovery of final products.

Materials and methods

The experiment for processing of Vitato Flour were implemented in the Pilot Plant in Food Science Research Centre, MARDI, Selangor. 25kg of raw Vitato samples has used and purchased from Pasar Borong Selangor, Seri Kembangan, Selangor. The detail of processing were described as below:

1)Selection of Vitato roots

25 kg of Vitato roots use should be undamaged and mature with 4 months for the early maturing varities and 5-6 months for the late maturing varities (Figure 1).

Figure 1: 25kg of matured Vitato

2)Washing process
The Vitato samples has washed using mechanical Nilma Thumbler Washer (Italy) as Figure 2, with specification of 230V, 1.45HP with water capacity used per batch washing process 328 litre. The time consumption for washing process was set for 15 minutes. The electrical energy consumption for the process is calculated and measured.

Figure 2: Washing process of Vitato using mechanical thumbler washer

3)Peeling process
After washing, the Vitato samples are taken to the peeling section and the samples has put in stone grinder for deskinning and peeling process as Figure 3. The water and time consumption along the process are recorded and measured.

Figure 3: Deskinning and peeling process of Vitato using stone grinder machine

4)Sorting and cutting defect of tuber
Then, the deskinning Vitato will be sorting and cutting the defect or damaged part of the Vitato samples (Figure 4). This process was done manually with assisted by the 3 manpower. Time taken along the discarded damage part of samples also has taken and recorded. The samples after sorting and cutting process were weighed also.

Figure 4: Sorting and cutting defect of Vitato manually by man power

5)Slicing to cut-strip
After weighing, the samples will be slicing into the cut-strip form using AB Hallde Maskiner slicer machine (Sweden) as Figure 5 with specification of 415V and 1.3HP. The time consumption, electricity along the slicing process are recorded and the final mass of sample after process also weighed.

Figure 5: Slicing Vitato into cut-strip form using slicer machine

6)Soaking and tossing process
The samples then are soaked in the solvent consist of water and sodium metabisulphate with ratio of 1:7 as Figure 6. This purpose is to preserve the orange-fleshed colour of Vitato. The soaking process are only 1 minutes and then the samples are tossed manually assisted by 2 manpower. Then, the samples are reweighed to get their mass before proceed to drying process.

Figure 6: Soaking and tossing process of cut-strip Vitato using sodium metabisulphate

7)Drying process

The samples then are arranged in the tray in the cabinet dryer with amount 1.5kg samples filled in each tray as shown as Figure 7. The thickness of sample in each tray has set at 1.5 cm and samples then put in hot air circulating cabinet dryer with profile of maximum capacity 150kg, power input 1.5kW/hour. The drying process are set at 70°C. Time consuming, electricity and moisture reduction profile was investigated along the drying process.

Figure 7: Drying process of cut-strip Vitato using cabinet dryer

8)Grinding process

The dried sample of Vitato are grinded using Hammer mill Model UM-50SS (Germany). It is necessary to pass twice the dried material in the mill to produce a finer flour. The residual moisture in the dried slices should be between 5-10%. Over drying of slices will contributed to the formation a lot of dust and loss of material during the milling process. It is recommended to grind dried Vitato immediately after drying to prevent the rehydration. Time consuming and power consumption was investigated along the drying process. Recovery of Vitato flour from initial feedstock also has calculated.

Figure 8: Grinding dried cut-strip Vitato into powder using Hammermill machine

Results and discussion

Table 1 has summarized the parameter involved and has recorded in each step of processing along the Vitato flour production. A 25kg of Vitato roots are selected and has washed using mechanical thumbler washer. All of Vitato was washed in one batch in 328 litre of water. Under processing of 15 minutes with one manpower, it takes 0.36kW of electrical energy for washing the tubers. For peeling process, a batch of 3.5kg of Vitato has subjected to stone grinder. So that, to complete the peeling for 25kg samples, 7 batch of process has been implemented which take 28 minutes with 420 litres of water consumption under operation of one manpower. Then, after peeling process, the samples has be sorted and discarded he damage part of Vitato. This process was done manually and took about 3.5kg sample for a batch with time consuming of 3 minutes per/batch processing. Thus, the process take about 21 minutes with assisting of 3 manpower. The mass after sorting and cutting process were 22.97kg. Thus it indicated about 9% waste has discarded from initial tubers used. The samples has been sliced into cut-strip form with a 2.1kg of samples can be used for a batch processing. This means for 23kg samples after sorting and cutting, it operate 11 batch of processing to complete the slicing process with time of consumption of 6 minutes. Using 2 manpower, the slicer machine has recorded using 130kW of electrical energy. The mass of sample after slicing also has taken and it recorded the mass of 22.60kg. The sliced cut-strip Vitato then are soaked in solution of sodium metabisulphate in order to preserve the orange-fleshed colour of Vitato. The mass after has recorded 24.99 kg and this increment of mass contribute due to the absorption of water during soaking process.

Table 1: Parameter recorded for each process in pilot plant production of Vitato flour

Process	Initial Mass (kg)	Final Mass (kg)	Power Consume (k/hr)	Water Consume (litres)	Duration (min)	Manpower	Remarks
Selection of Vitato	25.00	-	-	-	-	-	-
Washing	25.00	-	0.36	320	15	1	-
Peeling	25.00	22.97	-	420	28	1	i) 3.5kg/ batch in stone grinder (25kg = 7 batch) ii) Time consuming: 28 min (4 min per/batch) iii) Water consuming: 420 litre (60 litre/batch)
Sorting and cutting defect			-		21	2	i) 3.5kg/ batch sorting ii) Time consuming: 21 min (3 min/ batch
Slicing to cut strip	22.97	22.60	130	-	6	2	a) 2.1kg/ batch (23kg= 11 batch) b) Time consuming: 6 min (0.5 min/batch)
Soaking and tossing process	22.60	24.99			1	2	
Drying process	24.99	4.95	1.5	-	420	2	a) Thickness sample per/tray: 1.5 cm b) Tray thickness: 4.0 cm c) Dryer type: Hot Air Circulating Cabinet Dryer d) Capacity: 150kg/batch e) Power: 1.5+0.5kW/ hour f) Temperature: 70°C

Table 1 has summarized the parameter involved and has recorded in each step of processing along the Vitato flour production. A 25kg of Vitato roots are selected and has washed using mechanical thumbler washer. All of Vitato was washed in one batch in 328 litre of water. Under processing of 15 minutes with one manpower, it takes 0.36kW of electrical energy for washing the tubers. For peeling process, a batch of 3.5kg of Vitato has subjected to stone grinder. So that, to complete the peeling for 25kg samples, 7 batch of process has been implemented which take 28 minutes with 420 litres of water consumption under operation of one manpower. Then, after peeling process, the samples has be sorted and discarded he damage part of Vitato. This process was done manually and took about 3.5kg sample for a batch with time consuming of 3 minutes per/batch processing. Thus, the process take about 21 minutes with assisting of 3 manpower. The mass after sorting and cutting process were 22.97kg. Thus it indicated about 9% waste has discarded from initial tubers used. The samples has been sliced into cut-strip form with a 2.1kg of samples can be used for a batch processing. This means for 23kg samples after sorting and cutting, it operate 11 batch of processing to complete the slicing process with time of consumption of 6 minutes. Using 2 manpower, the slicer machine has recorded using 130kW of electrical energy. The mass of sample after slicing also has taken and it recorded the mass of 22.60kg. The sliced cut-strip Vitato then are soaked in solution of sodium metabisulphate in order to preserve the orange-fleshed colour of Vitato. The mass after has recorded 24.99 kg and this increment of mass contribute due to the absorption of water during soaking process.

Drying process for Vitato cut-strip has been done by using cabinet dryer and the arrangement of sample were by filling 1.5kg of sample in the 6 different location tray. The location of the tray are divided by two compartment which is 3 tray in the left compartment (upper, middle and bottom) and other 3 tray in the right compartment (upper, middle and bottom) as shown in previous Figure 7. From Figure 8, it displayed the moisture reduction distribution during drying process. It has summarize that the moisture reduction distribution in non-uniform and this suggested due to the different hot air velocity that has received by each tray. This phenomenon also contributed by the different location of the tray with the tray in the bottom left reached targeted moisture ≤10% after 3.5 hours faster than other tray. Moreover, this location are the closest to the hot blower so that it received highest speed hot air flow compared to the other tray location Then, it has followed by tray in middle right (4 hours), bottom right (4.5 hours), middle and upper left (5.5 hours) and lastly upper left (6.5 hours) to complete and reached moisture ≤10%. Since the targeted moisture to complete the drying process was ≤10%, it has shown that the optimum time to complete drying is close to 7 hours with each tray reached uniform moisture of ≤10%.

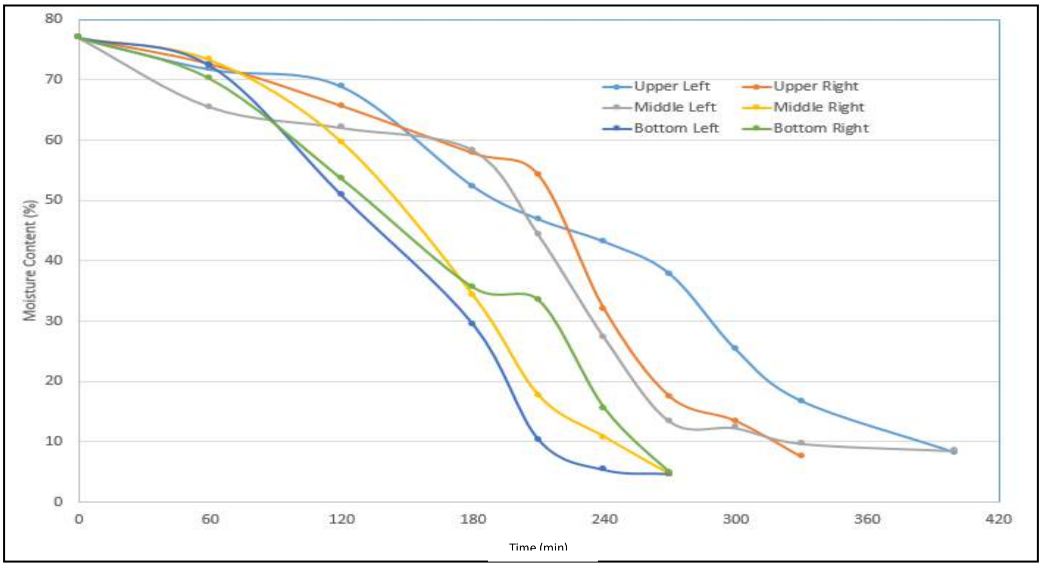


Figure 8: Profile of drying cut-strip Vitato

Instead of measuring moisture reduction, mass reduction also has recorded during drying process. This has been done by put 20 grams of sample in each tray and recorded the mass reduction until it reach the mass that represent moisture content of 10%. Based on Figure 9, it can be seen that each tray has reached the mass of 6.6 grams, which is represent for 10% targeted moisture after 5 hours with sample located in bottom and middle right exhibited 3.5 hours to reached 10% of moisture content. However, this result are contradicted with the moisture reduction profile and this suggested due to the small amount sample used and the location and container used for filling the sample were not represent entire sample in the each tray.

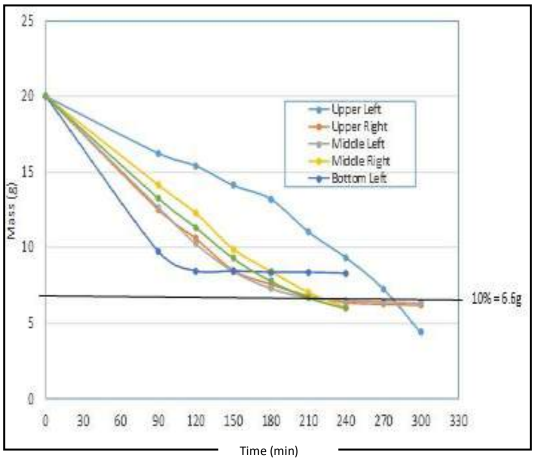


Figure 9: Mass reduction during drying of Vitato cut-strip

Table 2: Characterization of dried Vitato after drying and grinding process

Mass dried Vitato after drying process (kg)	4.95
Percentage Drying recovery (dried mass/ initial mass x100%)	20.00
Dried Vitato water activity, Aw	0.40
Mass flour after grinding (kg)	4.63
Percentage product recovery (flour/ initial mass x100%)	18.50
Vitato flour water activity, Aw	0.28

As refer to Table 2, after entire sample has reached targeted moisture of ≤10%, the mass of the dried Vitato sample are 4.95kg and this contributed to the 20% of drying recovery. The water activity of dried Vitato was 0.40Aw. Then, the dried sample has grinded and produced 4.625kg which is represent of 18.5% flour recovery with water activity of 0.28Aw. Summary for whole process flow, starting from selection of tubers until production of flour, it exhibited that the lab scale processing of Vitato flour managed to produce 18.5% of flour recovery with total time consumption 8 hours with maximum 3 man power, using 14.49kW of electricity with using 560 litres of water per/batch/day processing. Cost calculation for operation has found only RM 3.49 per/batch/day or RM 76.78 per/month as shown in Table 3.

Table 3: Parameter and cost calculation involve in production of Vitato flour using lab scale approach

Parameter	Unit	Monthly/ cost (22 days working day)	Cost operation per/day	Cost operation per/month
Time Operation	8 hours/ day	176 hours/ month	-	-
Man Power (trained worker/ MARDI staff)	3 person (maximum)	-	-	-
Electricity	14.49kW/ day	318.78kW/ month	RM 3.17	RM 69.76
Water	560 litres/ day	12, 320 litres/ month	RM 0.32	RM 7.02
	Total cost		RM 3.49	RM 76.78

Conclusion:

Production of Vitato flour via lab scale has been implemented using 25kg of fresh-harvested Vitato. All stage processes has been done using minimal facilities with assisted of minimum trained worker which is MARDI staff. Based on the results, it has found the product recovery are 18.5% with minimum cost operation of RM 3.49 per batch process that involve 8 hours one day operation. It has suggested the using of advance equipments such as semi or fully automated sorting and cutting machine, or improve the existed accomodations into larger capacities. Also using the advance dryer such as Fluidized Bed Dryer so that it will shorten the time operation, increase the production of product and also cut the operation cost.

References:

Eugene Ekinyu (2010), Multiplication of OFSP and non-OFSP varieties in NEU Uganda, Sweetpotato Platform Meeting, Namulonge,1 July 2010

Futega G. O., Tomlins K., Bechoff A., Henshaw F.O., Idowu M.A. and Westby A., (2013), A survey of traditional processing of sweet potato flour for amala, consumption pattern of sweet potato amala and awareness of orange-fleshed sweet potato (OFSP) in South West Nigeria, Journal of Food, Agriculture & Environment Vol.11 (3&4): 67-71.

Hagenimana V and C Owori (2000), Process of producing sweetpotato flour. Research for Development, Department for International Development, UKAID. http://r4d.dfid.gov.uk/PDF/Outputs/CropPost Harvest/R7036_sweetpotato_flour.pdf.

HarvestPlus 2009. Provitamin A sweet potato. http//ww.harvestplus_sweet_potato_strategy.pdf (accessed on August 30th, 2010).

Nur Izalin, M.Z., Siti Meriam, A., and Hasri H. (2014), Penghasilan tepung pracampuran hasilan bakeri berasaskan ubi keledek VitAto(Development of premix flour for VitAto sweet potato based bakery products), *Buletin Teknologi MARDI, Bil. 6(2014): 9 – 16*

SASHA/CIP 2009a. Sweet Potato for Health and Profit Initiative.http//www.cipotato.org/sasha/index.html (accessed on January 12th, 2010).

Senanayake SA, Ranaweera KKDS, Gunaratne A, Bamunuarachchi A (2013). Comparative analysis of nutritional quality of five different cultivars of sweet potatoes (Ipomoea batatas (L) Lam) in Sri Lanka. Food Sci Nutr; 1: 284-291.

Utusan Malaysia, article entitled “Nilai Ubi Keledek”, 29 December 2016

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE04

Kajian Kesan Pengawetan dan Tanpa Pengawetan Keatas Penyimpanan Persekitaran Pengudaraan Biasa Terhadap Kualiti Tekstur Ubi Keledek Unggu Varieti K6

Ishak, H[1]. Noor Ismawaty, N[2]. Zaulia,O[3]. Nur Syafini, G[4]. Nurul Afza, A. K[2].
[1]Pusat Penyelidikan Kejuruteraan, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
[2]Pusat Penyelidikan Tanaman & Sains Tanah, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia
[3]Pusat Bank Gen dan Biji Benih, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia
[4]Pusat Penyelidikan Hotikultur, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia
*Corresponding Author, Tel: +017 3957121, E-mail: ishak.mardi@1govuc.gov.my

Abstrak
Pegawetan merupakan satu proses penting dalam rantaian pengendalian lepas-tuai ubi keledek. Dalam proses pengawetan, ubi keledek akan di simpan selama 3 atau 4 hari bergantung kepada variety di bilik pengawetan dimana parameter suhu dan kelempan udara persekitaran dikawal. Melalui proses pengawetan, luka-luka kecil semasa penuaian dan pengendalian di peringkat ladang akan dirawat bagi mengelak kerosakkan yang lebih parah seperti pereputan pada sruktur isi akibat pembiakkan mikro organism. Objektif kajian ini ialah untuk menilai kualiti tekstur ubi keledek unggu variety K6 selepas pengawetan dan tanpa pengawetan keatas peyimpanan persekitaran pengudaraan biasa. Eksperiment telah dilaksanakan di Ibu Pejabat MARDI, Serdang. Ubi keledek unggu varieti K6 yang telah matang (selepas 16 minggu penanaman) di tuai dan dibawa dari Stesen MARDI Bachok, Kelantan. Sampel-sampel ubi keledek dengan masing-masing berat dalam julat 1 kilogram dibahagi ke dua iaitu rawatan pengawetan dan tanpa rawatan pengawetan (kawalan). Parameter suhu dan kelembapan bandingan bilik pengawetan ditetapkan masing-masing pada 27ºC ±1ºC dan 85%RH ± 5%. Tempoh masa rawatan pengawetan adalah 1,2 dan 3 hari yang dikira bermula hari ia dimasukkan ke dalam bilik pengawetan. Masa untuk penyimpanan persekitaran biasa, bagi sampel-sampel yang diawet dan tanpa diawet adalah 0,5,10 dan 15 hari yang dikira bermula hari disimpan. Tiga sampel bagi setiap ujian dikeluarkan dan satu ubi keledek akan diambil dari setiap sampel. Bacaan purata tekture yang diukur dari tiga lokasi diambil dan direkodkan serta dianalisis menggunakan perisian statistik. Keputusan menunjukkan bahawa rawatan pengawetan mainkan peranan dalam meningkatkan nilai tektur keledek unggu. Daripada plot kesan utama (main effect plot) menunjukkan bacaan tekstur lebih tinggi iaitu sekitar 21N selepas 3 hari pengawetan.

Keywords: Ubi keledek, pengawetan, tekstur

Pengenalan
Ubi keledek dianggap sebagai salah satu makanan ruji utama selain daripada gandum, beras, jagung, barli, ubi kentang dan ubi kayu. Bagi ubi keledek ungu atau dikenali sebagai Kedudut, ia biasanya digunakan untuk membuat kerepek sebagai makanan ringan dan dijadikan sebagai bahan asas dalam pembuatan kuih tradisiona.Disebabkan oleh perubahan dalam gaya hidup dan peningkatan pengetahuan mengenai manfaat nutrien yang terdapat dalam ubi keledek telah mendorong peningkatan terhadap permintaan dipasaran. Oleh itu, dalam Rancangan Malaysia Ke-8 (MP ke-8) MARDI telah mengambil inisiatif menjalankan penyelidikan dan pembangunan dalam memperbaiki dan mengembangkan ubi keledek unggu sehingga terhasilnya varieti baru iaitu K6 atau dikenali sebagai **Anggun** yang dikeluarkan pada tahun 2017. Dengan ciri khas yang kaya bahan antioksida dan antosianin yang dapat melindungi kerosakan DNA, membantu mengurangkan perkembangan sel kanser, menstabilkan penyakit kencing manis serta meningkatkan daya ingatan.

Bagi mengekalkan kualiti yang baik sepanjang proses penyimpanan dan penjualan ubi keledek Varieti K6, maka keperluan untuk memelihara agar keadaan fizikal luaran dan dalaman serta kandungan nutrien yang tinggi dalam ubi keledek Varieti K6 ini dapat dikekalkan setanding ketika awal proses penuaian. Ini kerana wujud permasalahan ketika penuaian dan pengendalian dari ladang hingga ke rumah/pusat pembungkusan yang tidak sesuai telah menyumbang kepada kehilangan lepas tuai iaitu menjejas kualiti dan fizikal ubi keledek Varieti K6. Sebagai contoh, semasa penuaian, ubi akan cedera secara mekanikal, lebam semasa pemindahan atau pengangkutan, pengecutan berlaku akibat pendedahan terlalu lama kepada sinaran matahari, percambahan . Kecederaan mekanikal pada kulit ubi dan lebam akan menarik kehadiran mikro organisma untuk membiak dan merosakkan struktur dalaman ubi. Keadaan ini mengakibatkan kualiti ubi keledek Varieti K6 merosot seperti penurunan kadar kandungan nutrien dan struktur fizikal yang rosak. Ia secara lansung akan memberikan keadaan penampilannya tidak menarik kepada penilaian pengguna atau pembeli dan tempoh jangka hayat penyimpanan yang singkat. Bagi megelakkan perkara ini berlaku pengawetan perlu dilaksanakan selepas proses pengasingan dan pengredan di tempat pengumpulan atau di rumah pengedalian lepastuai.

Pengawetan adalah proses menempatkan ubi keledek di dalam satu persekitaran terkawal untuk tempoh tertentu dimana suhu dan kelembapan udara dilaras agar bersesuaian untuk aktiviti rawatan secara semulajadi akan berlaku, menyembuh kecerderaan kecil dan pembinaan kulit baru. Telah banyak kajian telah dilakukan bagi menilai kelebihan proses pengawetan dalam rantaian aktiviti lepas-tuai ubi keledek (Thompson et al., 2002; Edmunds et al., 2008; Aranchibia, 2011). Kandungan biokimia seperti antosianin juga menunjukkan peningkatan selepas proses pengawetan keledek unggu atau kedudut (Rosaliazan et al., 2014).Suhu yang disyorkan adalah sekitar 30ºC dan kelembapan bandingan udara sekitar 90 - 95% untuk tempoh 4 hingga 7 hari (Aranchibia, 2011). Walaubagaimanapun, parameter suhu, kelembapan bandingan dan tempoh bagi proses pengawetan adalah bergantung kepada variety ubi keledek. Hasil dari beberapa siri kajian bagi memenentukan parameter proses pengawetan terhadap ubi keledek Varieti K6 menunjukkan gandigan suhu dan kelembapan bandigan 27ºC dan 85%RH untuk tempoh 3 hari adalah yang terbaik baik mengekalkan kandungan antosianin. Data kajian terdahulu hanya mengfokuskan kepada analisis bagi sampel tanpa melalui proses penyimpanan. Maka objektif kajian ini adalah menilai kembali kualiti tekstur ubi keledek unggu variety K6 selepas pengawetan dan tanpa pengawetan diikuti dengan peyimpanan persekitaran pengudaraan biasa.

Kaedah dan bahan

Untuk melaksanakan kajian ini, ubi keledek varieti K6 yang terlah mencapai tempoh matang iaitu 16 minggu selepas penanaman dituai dari ladang di Stesen MARDI Bachok, Kelantan dan dibawah ke Ibu Pejabat MARDI Serdang. Proses pengasingan dilakukan selepas penerimaan untuk mengasingkan ubi yang rosak dan dikuti dengan penyediaan sample. Ubi keledek Varieti K6 ini ditimbang dalam julat satu (1) kilogram sebelum dimasukkan ke dalam bakul-bakul plastik dan dilabel mengikut kod masing-masing. Untuk kawalan (tanpa pengawetan), sampel-sampel ditempatkan terus di ruangan persekitaran. pengudaraan biasa manakala untuk rawatan pengawetan ianya ditempatkan di dalam bilik sejuk yang dilengkapi dengan unit pelembapan jenis ultrasonic *(ultrasoanic humidifier*) (Gambar 1) berkuasa 300 Watt (Jadual 1). Suhu bilik sejuk dilaraskan pada 27ºC ±1ºC dan kelembapan udara dalam bilik ditetapkan pada unit pelembapan pada julat 85%RH ± 5%.

Gambar 1: Pelembapan jenis ultrasonic (ultrasoanic humidifier)

Jadual 1: Spesifikasi teknikal pelembapan untrasonic (ultrasoanic humidifier)

Ultrasonic humidifier with single hole	
Model	**JDH-G030Z**
Humidity capacity	**3kg/h**
Voltage/Cycle	**220VAC/50Hz**
Air Volume	**350m³/h**
Work Temperature	**-5 -40 Centigrade**
Power input(w)	**300w**
Dimension(mm)	**500*380*400**
Usable area	**50-80m²**

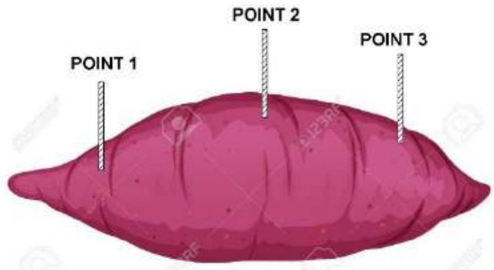
Sampel-sampel ubi keledek varieti K6 diawetkan untuk tempoh 1, 2 dan 3 hari dan selepas tamat tempoh pengawetan, ia dikeluarkan dan disimpan di ruangan pengudaraan biasa bersama sampel-sampel kawalan (Gambar 3 dan 4) . Tempoh penyimpanan untuk sampel-sampel kawalan dan sampel-sampel yang diawetkan adalah 0(tanpa simpanan),5 ,10 dan 15 hari. Pengiraan tempoh proses pengawetan dan peyimpanan ialah bermula tarikh ia ditempatkan pada tempat masing-masing .

Gambar 3: Sampel-sampel diletakkan bilik sejuk untuk proses pengawetan

Gambar 4: Sampel-sampel kawalan dan yang telah diawetkan disimpan dalam persekitaran pengudaraan biasa

Pengambilan data daya tekanan untuk penilaian tekstur dengan mengunakan alat pengukur tekstur model *TA.XTplusC* dari *Stable Micro Systems* bersama prob jarum bergarispusat 2 mm (Gambar 5) dari sampel-sampel yang telah ditentukan dilakukan dan direkodkan. Untuk setiap bakul, satu biji ubi keledek Varieti K6 dipilih secara rawak dan pengukuran daya tekanan maksmum diukur pada tiga (3) lokasi berbeza (Gambar 6).

Gambar 5: alat pengukur tekstur model TA.XTplusC dari Stable Micro System



Gambar 6: lokasi pengambilan pemgukuran pada ubi keledek

Keputusan

Jadual 2 hingga 5 menunjukkan bacaan purata daya tekanan dalam unit Newton (N) untuk penilaian tekstur yang diperolehi dari 3 lokasi untuk 3 sampel bagi tempoh penyimpanan selepas 0, 5, 10 dan 15 hari.

Jadual 2: Keputusan bacaan purata daya tekanan untuk sampel kawalan selepas 0,5,10 dan 15 hari penyimpanan

Purata Daya (N) 0 Hari	Purata Daya (N) 5 Hari	Purata Daya (N) 10 Hari	Purata Daya (N) 15 Hari
21.53367	18.747	20.746	18.188
17.504	14.517	18.140	20.635
20.00267	16.904	19.618	18.185

Jadual 3: Keputusan bacaan purata daya tekanan untuk sampel 1 hari pengawetan selepas 0,5,10 dan 15 penyimpanan persekitaran biasa

Purata Daya (N) 0 Hari	Purata Daya (N) 5 Hari	Purata Daya (N) 10 Hari	Purata Daya (N) 15 Hari
21.314	13.944	18.410	20.429
16.836	18.860	19.816	20.725
17.926	16.285	19.105	20.580

Jadual 4: Keputusan bacaan purata daya tekanan untuk sampel 2 hari pengawetan selepas 0,5,10 dan 15 hari penyimpanan persekitaran biasa

Purata Daya (N) 0 Hari	Purata Daya (N) 5 Hari	Purata Daya (N) 10 Hari	Purata Daya (N) 15 Hari
18.483	19.299	19.524	21.237
19.697	14.475	16.828	20.483
17.418	17.881	18.204	20.488

Jadual 5: Keputusan bacaan purata daya tekanan untuk sampel 3 hari pengawetan selepas 0,5,10 dan 15 hari penyimpanan persekitaran biasa

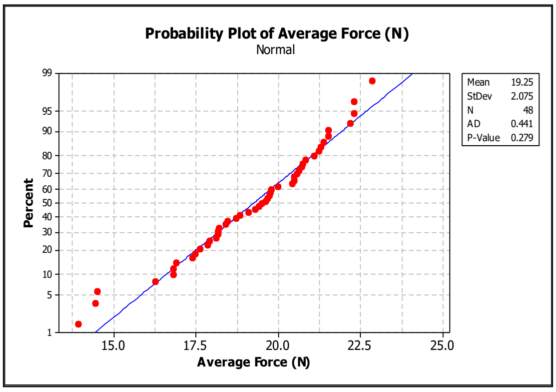
Purata Daya (N) 0 Hari	Purata Daya (N) 5 Hari	Purata Daya (N) 10 Hari	Purata Daya (N) 15 Hari
20.848	22.188	21.396	22.319
21.114	19.441	22.309	22.868
19.737	17.650	19.784	21.527

Perbincangan

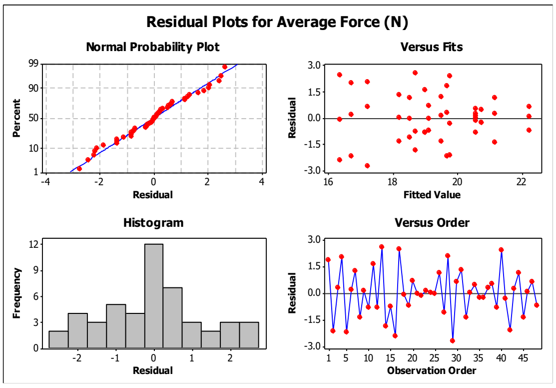
Bacaan purata daya tekanan maksimum dianalisis menggunakan perisian statistik MINITAB v16 dengan menggunakan method Two-way ANOVA dan dengan hipotesis-hipothesis berikut pada tahap keertian 0.05:

1. H_0 – Tempoh proses pengawetan tidak memberi kesan kepada bacaan tekstur
   H_A – Tempoh proses pengawetan memberi kesan kepada bacaan tekstur
2. H_0 – Penyimpanan persekitaran pengudaraan biasa tidak memberi kesan kepada bacaan tekstur
   H_A – Penyimpanan persekitaran pengudaraan biasa memberi kesan kepada bacaan tekstur
1. H_0 – Tiada interaksi antara proses pengawetan dan penyimpanan persekitaran pengudaraan biasa
   H_A –Terdapat interaksi mempengaruhi antara proses pengawetan dan penyimpanan persekitaran pengudaraan biasa

Hasil analisis adalah seperti dibawah :-



Graf 1: Pengujian taburan normal Normality



Graf 2: Analisis Residual

Berdasarkan nilai *p-value* ialah 0.279 (Graf 1) yang lebih besar daripada 0.05 dan bentuk taburan *residual* (Graf 2) yang berada dalam julat kawalan, maka ia menujukkan bawa taburan data tekstur mematuhi taburan normal.

```
Two-way ANOVA: Average Force (N) versus curing days; ambient storage days

Source               DF      SS       MS     F      P
Curing days           3   45.111  15.0369  5.78  0.003
ambient storage days  3   60.086  20.0286  7.69  0.001
Interaction           9   13.878   1.5421  0.59  0.794
Error                32   83.315   2.6036
Total                47  202.390

S = 1.614   R-Sq = 58.83%   R-Sq(adj) = 39.54%

                    Individual 95% CIs For Mean Based on
curing              Pooled StDev
days        Mean    --+---------+---------+---------+-------
0        18.7267    (-------*-------)
1        18.6858    (-------*-------)
2        18.6681    (-------*------)
3        20.9318                       (------*-------)
                    --+---------+---------+---------+-------
                    18.0      19.2      20.4      21.6
ambient
storage              Individual 95% CIs For Mean Based on Pooled StDev
days        Mean       +---------+---------+---------+---------
 0       19.3677                   (-----*-----)
 5       17.5159       (------*-----)
10       19.4900                    (-----*-----)
15       20.6388                          (------*-----)
                       +---------+---------+---------+---------
                    16.5      18.0      19.5      21.0
```

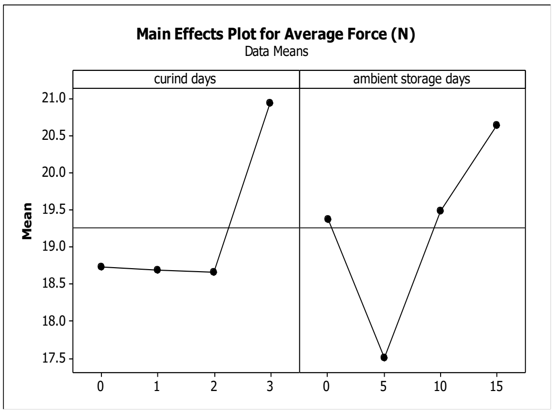
Analisis 1: Keputusan Two-way ANOVA

Daripada nilai *p-value* (Analisis 1) proses pengawetan dan penyimpanan persekitaran pengudaraan biasa masing-masing memberikan nilai 0,003 dan 0.001 adalah lebih kecil dari tahap keertian iaitu 0.05, maka kedua-duanya factor ini telah memberi kesan kepada bacaan tekstur. Bagi nilai *p-value* interaksi antara proses pengawetan dan penyimpanan persekitaran pengudaraan biasa, 0.794 adalah lebih besar dari dari tahap keertian iaitu 0.05 maka interaksi keduanya tiada memberikan sebarang kesan keatas bacaan tekstur.

```
Two-way ANOVA: Average Force (N) versus curing days; ambient storage day

Source               DF      SS       MS     F      P
curing days           3   45.111  15.0369  6.34  0.001
ambient storage days  3   60.086  20.0286  8.45  0.000
Error                41   97.193   2.3706
Total                47  202.390

S = 1.540   R-Sq = 51.98%   R-Sq(adj) = 44.95%

                    Individual 95% CIs For Mean Based on
curing              Pooled St Dev
days        Mean    --+---------+---------+---------+-------
0        18.7267     (------*-------)
1        18.6858    (-------*------)
2        18.6681    (-------*------)
3        20.9318                     (------*-------)
                    --+---------+---------+---------+-------
                    18.0      19.2      20.4      21.6

ambient              Individual 95% CIs For Mean Based on
storage              Pooled St Dev
days        Mean     ---------+---------+---------+---------+
 0       19.3677                (-----*-----)
 5       17.5159     (-----*-----)
10       19.4900                 (-----*-----)
15       20.6388                         (-----*-----)
                     ---------+---------+---------+---------+
                           18.0      19.5      21.0      22.5
```

Analisis 2: Keputusan Two-way ANOVA (Pooling)

Dari analisis (Analisis 2), keputusan membuktikan proses pengawetan dan peyimpanan persekitaran penguadaraan biasa memberi kesan keatas bacaan tekstur.



Graf 3: Plot kesan utama (main effect plot)

Daripada plot kesan utama (*main effect plot*) (Graf 3) menunjukkan bacaan purata daya tekanan untuk penilaian tekstur ubi keledek varieti K6 lebih tinggi iaitu sekitar 21 N selepas 3 hari pengawetan . Tempoh peyimpanan juga mempengaruhi nilai bacaan tekstur dimana pada hari ke 15 bacaannya telah melebihi 20.5 N.

Kesimpulan

Kesimpulan daripada kajian ini menunjukan bahawa bacaan tekstur ubi keledek varieti K6 meningkat seiring dengan tempoh proses pengawetan pada suhu dan kelembapan bandingan masing-masing 27^{O}C dan 85%. Begitu juga dengan tempoh penyimpanan yang memberi kesan kepada nilai tekstur ubi keledek varieti K6. Walaubagaimapun factor-faktor perubahan lain perlu diambil kira seperti kehilangan berat, perubahan biokimia. warna isi dan percambahan mata tunas dalam menentukan keberkesanan tempoh proses pengawaten.

Penghargaan

Penulis merakamkan ucapan terima kasih MARDI yang telah memberikan peruntukan kewangan di bawah geran di bawah projek utama Pengeluaran Sayur-sayuran dan Ubian Bernutrisi Tinggi, Selamat Dimakan dan Mesra Alam, nombor projek P-RH403 untuk tujuan penyelidikan ini. Penulis juga merakamkan penghargaan kepada kakitangan Pusa Penyelidikan Kejuruteraan, Pusat Penyelidkan Tanaman & Sains Tanah, Pusat Bank Gen dan Biji Benih dan Pusat Penyelidikan Hotikultur,MARDI yang telah membantu dalam menjayakan penyelidikan ini.

Rujukan

Edmunds, B., Boyette, M., Clark, C., Ferrin D., Smith, T. and Holmes, G. (2008). Postharvest handling of sweetpotatoes. North Carolina Cooperative Extension Service. 53 pp.

Aranchibia, R.A. (2011). Evaluating postharvest practices to improve sweetpotato storage and culinary characteristics in Mississippi. Final report of Mississippi State University, 14 pp.

Rosalizan, M.S, Erwan Shah, S. and Jeeven, K. (2014). Biochemical changes of purple flesh sweet potato during curing, Proceeding on International Agriculture Congress, 25-27 Nov 2014, Pullman Putrajaya Lakeside, Putrajaya, Malaysia.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya
MSAE2019-PFE05

Challenges in cleaning for frozen food SMEs: Current and suggested cleaning program

N.I. Khalid and N. Ab Aziz,*

Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia

*Corresponding author. Tel.: +603-8946 4302, Email: norashikin@upm.edu.my

Abstract

Cleaning can be costly and complex especially for SMEs. Food SMEs have a restricted budget and knowledge to implement an effective cleaning program. A study was conducted in a frozen food SME to investigate the current cleaning practice. Physically and microbiologically cleanliness was set as the cleaning target. Results show that the current cleaning program was unable to reach a physically clean condition. A new cleaning program was suggested for this frozen food industry. The new cleaning program was expected to help this factory to reach physically and microbiologically clean conditions. A clean environment can lead to better food product quality and appearances.

Keywords: Cleaning, cleaning program, fouling mitigation, frozen food industry

Introduction

An effective cleaning program is essential for every food factory. Many food manufacturer SMEs do not have adequate knowledge to design their own cleaning program (Noor Hasnan et al., 2014; Khalid et al., 2016; Köhler et al., 2015). Thus they tend to follow the cleaning program implemented by bigger and successful food factories. The cleaning program might not suitable as it is designed for bigger or different types of food production.

Cleaning process includes 1) removal of gross debris 2) pre-rinse, 3) detergent wash (usually alkaline wash), 4)intermediate rinse, 5) second detergent wash (usually acidic wash: optional) 6) intermediate rinse, 7) disinfection, 8) final rinse (optional) (Tamime, 2008). Each cleaning steps has different functionality with different cleaning parameters (temperature, fluid velocity, chemical concentration) are manipulated to generate an effective cleaning program (Tamime 2008; Etienne, 2006; Khalid et al., 2014, 2015, 2016).

However, food manufacturer SMEs tend to skip some of the cleaning steps which can be costly, for instance cleaning or rinsing with hot water. Hot water cleaning step can increase the cleaning performance and effectively reduced food borne pathogens to an acceptable level. In removing the invisible fat layer which is common in meat patty production, hot water rinsing is necessary. Moreover, hot water rinsing can replace disinfection detergent that is costly. Nevertheless, the boiler is essential for this process. SMEs try to avoid boiler utilization as it will increase the operating and maintenance cost.

Physical, chemical and microbiological cleanliness are most common cleanliness level associated in the development of a cleaning program (Khalid et al., 2014; Khalid et al., 2015; Khalid et al., 2016; Tamime, 2008). The food processing surfaces (equipment, floor and wall) are physically clean when all visible 'soil' or residues are removed by the cleaning operations. Surfaces are microbiologically clean when numbers and types of microorganisms are reduced to an acceptable level. Chemically clean condition when materials used in plant cleaning and/or sanitizing are removed completely. In this work, only indirect microbiological cleanliness is used as the cleaning target.

The objectives of this paper are to identify current cleaning practice and to redesign an efficient cleaning program for the frozen food industry.

Materials and methods

Identifying the current cleaning program

A frozen meat patty factory (factory X) at Sungai Chua, Selangor, Malaysia was used for the case study. The factory is a small andmedium (SME) factory with average capacity production 1000 kg to 1500 kg patty per day. This factory operated for 8 hours daily. Figure 1 shows the manufacturing process of a meat patty at factory X. Every process is a batch processing. The function of each equipment is also shown in Figure 1.

The current cleaning practice was expected not efficient due to cleaning was performed with tap water at room temperature, domestic tap water pressure, inappropriate cleaning tools and without a well-designed cleaning program.

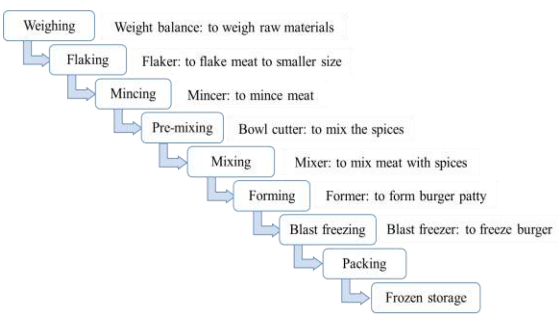


Figure 1. The manufacturing process of meat patty

Cleaning validation

The indirect microbiological cleanliness of the food processing equipment (flaker, mincer, bowl cutter, weigh balance, mixer and burger former) and areas (floors and walls) were tested using Path-Check Hygiene Protein (Microgen, United Kingdom). Path-Check Hygiene Protein was used to detect the presence of protein residue on food contact surfaces. The swab cotton colour will change from yellow to green when there was protein residue on the surfaces. This indicates the surface was not microbiologically cleaned. The presence of protein indicated the potential of microbe's growth. The physically clean condition was determined based on visual and touch inspection.

3 different areas were swabbed for each equipment and factory areas (walls and floor). For equipment, 3 areas which are difficult to clean such as blades and edge were swabbed. While for the wall and floor area which were near to the flaker and burger former were chosen as our study area as the area were the dirtiest area as during processing the meat splashed from the equipment.

If only one of the area was not cleaned, the equipment was considered not clean. Observation and protein swab test was performed for 3 days to get average data.

Designing a cleaning program

A new cleaning program was designed to clean different food processing equipment and areas. This new program incorporate a new cleaning apparatus such as industrial cleaning brushes (Hillbrush, United Kingdom) (Figure 2) and a portable cleaning unit. The portable cleaning unit produces the desired hot water without the need to assemble a boiler inside the factory area. The portable cleaning unit has two main parts; (1) storage tank, and (2) spray nozzle. This portable cleaning unit was designed and constructed at the Process and Food Engineering laboratory of the Faculty of Engineering, the Universiti Putra Malaysia, Malaysia. This cleaning unit has a stainless steel tank (100 L) containing a heating element which was used to store and heat the cleaning solution. The spray nozzle (even flat spray VNP series, 30° spray angle, spray capacity code 49, H. Ikeuchi & Co., Ltd., Japan) was used to generate high pressure fluid for cleaning. This cleaning unit can be operated at nozzle pressure varying from 5.2 bar to 7.0 bar and capable of withstanding contact with detergents and disinfectants at the cleaning temperatures (20 °C to 110 °C).

Results and discussion

Current cleaning program

The comparison between the current cleaning program and suggested the cleaning program is shown in Figure 3. The current cleaning program is shown in Figure 3(a). Cleaning equipment Part 1 was started after the mixing process (Figure 1) which mixer, flaker, mincer, weigh balance and bowl cutter were cleaned (Figure 3 (a)). During equipment cleaning, workers used water buckets, common pipe hoses and common brushes. The water pressure from the pipe hose cannot be controlled and limited. Thus, it is not enough to remove meat residues. As an alternative to adding mechanical action, they used water buckets during rinsing. However, the meat residues splashed all over surrounding areas including wall, floor and equipment near the cleaned equipment. Cleaning detergent was applied on the equipment surfaces and was brushed using common brushes. Then, the equipment was rinsed again with water.

Next, the walls near this equipment were cleaned. Workers used a water bucket to remove the meat residues attached on the walls. Then, they applied cleaning detergents and used a common sponge to brush the wall surfaces. From observation and interviews with the workers, it is difficult to clean areas such as edge and blades. There were hand injuries were reported due to the cleaning of sharp blades of mixer and mincer. Workers also suffer back pain as they have to bend to clean the mixer with a deep tank and to carry heavy water bucket.

After brushing with detergent, they rinsed the wall with a water bucket and pipe hose. Then, they cleaned the floor used a common floor broom to gather the meat residues and to swipe the remained water. At the same time, the burger former was operated to form the meat patty to the desired form. As the forming process ended, the former was cleaned. Then followed by cleaning at the wall and floor near the former respectively.

The cleaning effectiveness for the current cleaning program was validated using the protein swab test and the result is shown in Table 1. Visual and touch inspection were also performed to ensure physical cleanliness. The result shows that none of the equipment and areas were cleaned properly. There were still remaining meat residues remained on the surfaces. Moreover, there was still an invisible fat layer remained on the surfaces. The invisible fat layer act as a protective layer which prevents the microbes and other food compositions (ie. protein, carbohydrate) removal. Thus, it can be concluded that the current cleaning program was not sufficient enough and a new improved cleaning program is needed.

The suggested overall cleaning program

A new cleaning program with an additional cleaning apparatus (a portable cleaning unit and industrial cleaning brushes) was suggested for this factory. Suggested cleaning program is shown in Figure 3 (b). The cleaning sequence is different from the current cleaning program (Figure 3 (a)). After production, it is suggested to clean the wall first and then followed by equipment cleaning. Then eventually ended with floor cleaning. The purpose of this new sequence is to avoid cross contamination due to the splashing of meat residues when cleaning the walls. The portable cleaning unit is expected to replace the usage of common pipe hose and water bucket. The cleaning unit can generated water at the desired fluid velocity and temperature. It is important to know the suitable fluid velocity and temperature.

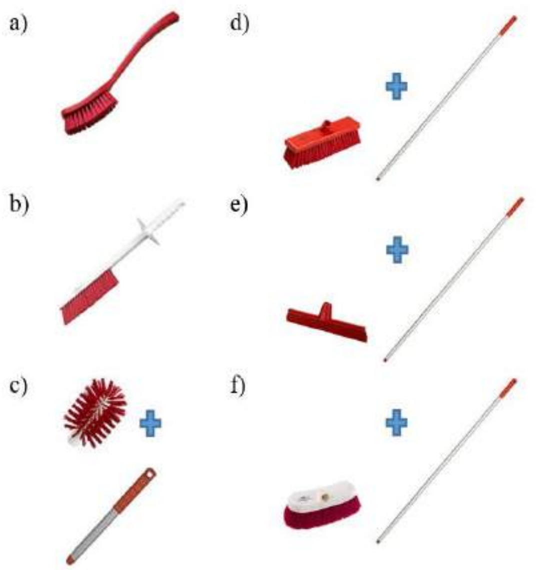


Figure 2. Industrial cleaning brushes: a) long handle brush, b) guarded machine brush, c) plastic core tube brush (with handle), d) flat sweeping broom (with handle), e) single Blade Ultra Hygienic Squeegee (with handle) and f) Soft Curved Wall Brush (with handle).

Suggested cleaning program: wall

A standardized cleaning method for wall cleaning is necessary to maintain the cleanliness of the walls (Etienne, 2006). The suggested method for wall cleaning is shown in Figure 4. First, the wall was rinsed with high pressure water generated using the portable cleaning unit. The industrial cleaning brushes were soaked in cleaning detergent at ±49°C. Then, the wall is brushed and the cleaning detergent was left stand for 5 minutes before water rinsing. Appropriate industrial cleaning brushes are also important as they can assist in easier cleaning for workers and also produce good cleaning performance. Figure 2 (f) shows a soft curved wall brush which is used to clean wall. Since it is curved, it is easier for workers to clean the walls.

Table 1: Level of cleanliness for each food processing equipment and area

Equipment	Level of cleanliness		
	Visual inspection	Touch inspection	Protein swab test
Weigh balance	****	×	NC
Flaker	***	×	NC
Mincer	***	×	NC
Bowl cutter	****	✓	NC
Mixer	****	×	NC
Burger former	**	×	NC
Wall (near flaker)	****	×	NC
Wall (near former)	***	×	NC
Floor (near flaker)	****	×	NC
Floor (near former)	***	×	NC

(Notes: ****** Highest physically clean, * Lowest physically clean, ✓ Physically clean from fat-based fouling deposit, × Fat-based fouling deposit remained, NC- not clean (protein residue detected), C- clean)

Suggested cleaning program: floor

The standard cleaning program for the floor was adapted from Etienne (2006) as shown in Figure 5. Hot and high pressure water jet was used to gather the meat residues to the drain or at the collector grates. The meat residues were collected. Then cleaning chemical was spread evenly on the floor and left stand for 5 minutes. Then, flat sweeping broom (Figure 2 (d)) was used to brush the floor. Water rinsing was performed and single blade ultra-hygienic squeegee (Figure 2 (e)) was used to remove the water residues from the floor. It is important to let the floor dry to avoid any microbial growth.

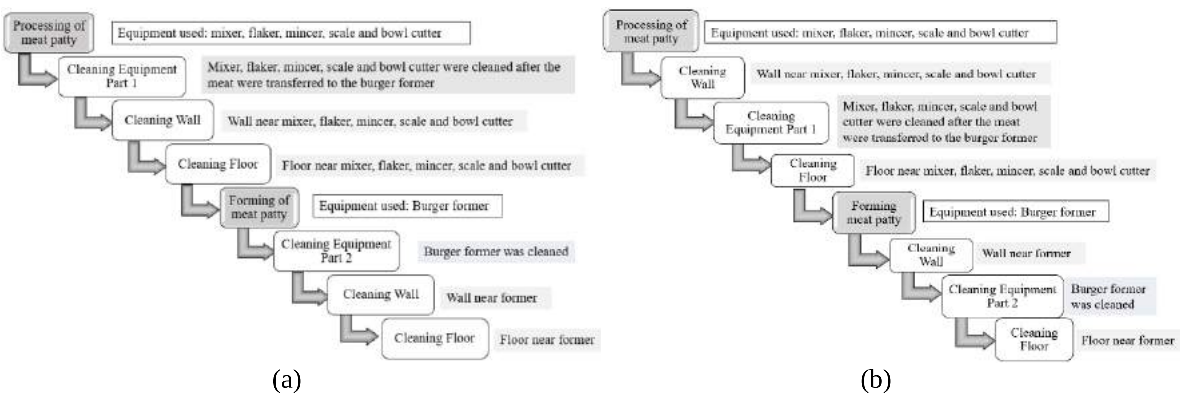


Figure 3. (a) Current cleaning program and (b) suggested cleaning program

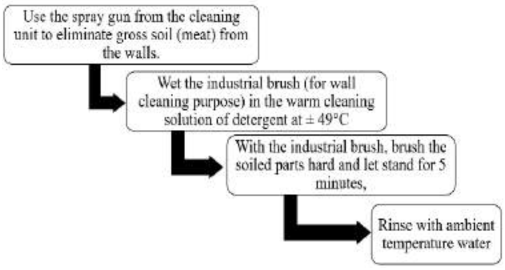


Figure 4. Wall cleaning

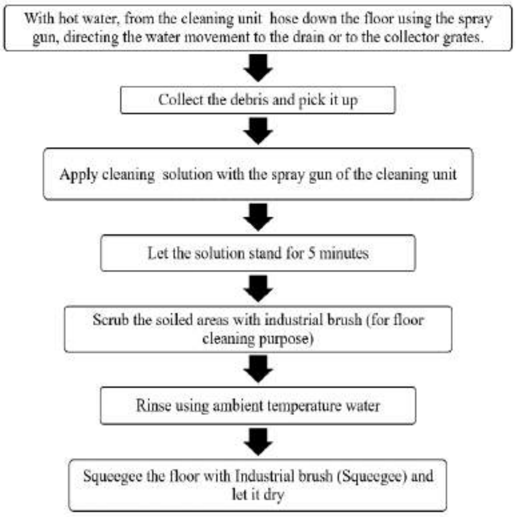


Figure 5. Floor cleaning

Suggested cleaning program: food processing equipment

The cleaning process for equipment was adjusted to overcome the problem with the invisible fat layer which remained on the equipment surfaces. First the meat residues were removed. Then, the equipment was water rinsed. Then by using the portable cleaning unit, hot water of 65°C were sprayed evenly on the surfaces. Cleaning detergent was applied and the surface was brushed using industrial cleaning brushes (Figure (a) to (c) depending on equipment geometry). Then the surfaces were water rinsed. Lastly the surface was sprayed with 75°C hot water as sanitization steps as to ensure that all the potentials foodborne pathogens on the equipment surfaces were eliminated (Heinz and Hautzinger, 2007; Tamime, 2008). Sanitization with hot water can reduce sanitiser usage and lead to a green environment. It can also reduce detergent cost.

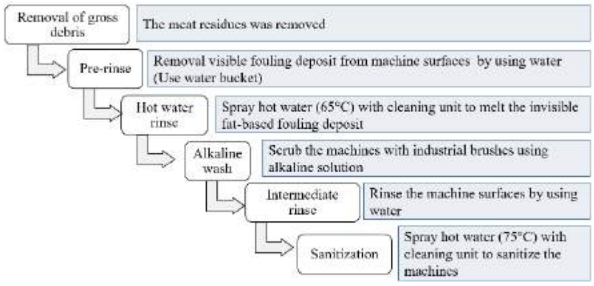


Figure 6. Equipment cleaning

Conclusions

The current cleaning program practice by the SMEs in frozen food industry was unable to reach required cleaning level. All of the food processing equipment (flaker, mincer, bowl cutter, weigh balance, mixer and burger former) and areas (floor and walls) were not physically and microbiologically clean. The invisible fat layer which remained on the equipment surfaces and areas can provide a barrier between microbes and the cleaning solutions. Therefore, a new cleaning program was proposed in this work which included cleaning for the floor, walls and equipment. The proposed cleaning program was assisted with the new cleaning apparatus (industrial cleaning brushes and a portable cleaning unit). The proposed cleaning program not only can produce a hygienic cleaning environment and safe food products but also a safe and healthy working environment for workers.

Acknowledgement

The support of the Ministry of Science, Technology and Innovation, Malaysia through High Impact Putra Grant (9658400) is acknowledged.

References

Etienne, G. (2006). Principles of Cleaning and Sanitation in the Food and Beverage Industry. USA: iUniverse.

Heinz, G. and Hautzinger, P. (2007). Heat Treatment of Meat Products, Meat Processing Technology for Small to Medium Scale Producers. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok, Thailand.

Khalid, N.I., Aziz, N.A., Nuraini, A.A., Taip, F.S., Anuar, M.S. (2014). Alkaline Cleaning-in-Place of Pink Guava Puree Fouling Deposit Using Lab-scale Cleaning Test Rig. Agric. Agric. Sci. Procedia 2, 280–288.

Khalid, N.I., Nordin, N., Abdul Aziz, N., Ab. Aziz, N., Taip, F.S., Anuar, M.S. (2015). Design of a Test Rig for Cleaning Studies and Evaluation of Laboratory-Scale Experiments Using Pink Guava Puree as a Fouling Deposit Model. J. Food Process Eng. 38, 583–593.

Khalid, N.I., Nordin, N., Chia, Z.Y., Ab Aziz, N., Nuraini, A.A., Taip, F.S., Ahmedov, A. (2016). A removal kinetics approach for evaluation of economic cleaning protocols for pink guava puree fouling deposit. J. Clean. Prod. 135, 1317–1326.

Köhler, H., Stoye, H., Mauermann, M., Weyrauch, T., Majschak, J.P. (2015). How to assess cleaning? Evaluating the cleaning performance of moving impinging jets. Food Bioprod. Process. 93, 327–332.

Noor Hasnan, N.Z., Ab. Aziz, N., Zulkifli, N., Taip, F.S., (2014). Food Factory Design: Reality and Challenges Faced by Malaysian SMEs. Agric. Agric. Sci. Procedia 2, 328–336.

Tamime, A. (2008). Cleaning-in-Place, Cleaning-in-Place: Dairy, Food and Beverage Operations: Third Edition.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE06

Characteristics of Powders Produced from Different Parts of Sweet Potato

Zakaria, N. Z. and Nor, M. M. Z.
Department of Process and Food Engineering,
Faculty of Engineering, University Putra Malaysia, 43400 Serdang, Selangor, Malaysia
**Corresponding author. Tel.: +603-89464303, Email: zuhair@upm.edu.my*

Abstract
Sweet potato or scientific name called (Ipomoea batatas (L.) Lam.) is one of the nutritious staple food crops that mostly planted in the tropical regions. Different parts of the sweet potato plant may offer various benefits, but there is a lack of understanding on the properties to link with its potential applications. The objective of this study is to determine the characteristics of powders produced from different parts of sweet potato including stem, leaves, tuber and skin. The analyses were done using powder flow analyser to perform the cohesion test, Powder Flow Speed Dependency test (PFSD test) and caking test. All samples were fixed at 70ml volume for each experiment. The finding showed that the powder of sweet potato stem, leaves, tuber and skin are categorized as free and stable powders and also prone to cake.

Keywords: sweet potato, flow ability, cohesion, caking, PFSD test

Introduction

Sweet potato (*Ipomoea batatas*) is a tropical staple fruit crop of *Convolvulaceae* family, identified by long trailing vines and leaves of different shapes (Sullivan, Asher, & Blarney, 1997). Sweet potato is a very vital crop in developing countries by considering its fast growing duration of 90-120 days. In Malaysia, among the tuber crops, sweet potato ranked second next to cassava and has been cultivated on a small scale since the 17th century (Mohd Hanim et al.,2014). Sweet potato contains high nutritional contents including vitamins A and C, fibers, carbohydrates, potassium, iron and high quality protein that can fulfil human nutritional needs (Mais and Brennan, 2008). This crop plays various roles in the human diets either for supplemental or a luxury food. Besides, sweet potato can also be applied to various products like drinks (wine, liquor, vinegar), sugar production, biscuits, flour, pasta, alcohol and many more (Ellong, Billard, & Adenet, 2014). For this reason, annual sweet potato-based edible food products are reported to be over 135 hundred million metric tons worldwide (Mohd Hanim, Chin, & Yusof, 2014). The benefits offered by sweet potato are not only exclusive to the tuber part, since other parts of this plant also have different amount of appreciable nutritional compounds. For example, sweet potato leaves are rich in ß carotene, calcium, iron, zinc, protein, vitamin B and the crop is highly tolerant of diseases, pests and have high moisture than other leafy vegetables in the tropics. The annual yield of sweet potato tops is much higher than many other green vegetables and can be harvested several times a year. The nutritional value of sweet potato leaves is being acknowledged, as the understanding between health and diet increase. Sweet potato leaves may become good leafy vegetables with their high nutritive value and also antioxidants (Islam, 2003). Other than leaves and tuber, parts such as stem and skin also have high potential in providing nutritional benefits, hence, further exploration in this avenue is required. One of the practical ways to utilize the sweet potato parts is by converting them into powders. It will give advantages in technological potential of food development. Thus, this study aimed to determine the characteristics of powder flow properties produced from different parts of sweet potato.

Materials and methods

Different parts of sweet potato samples were supplied by local farmers in Semenyih, Selangor, Malaysia.

Preparation of samples

The leaves and stem were separated and cut down to 2 to 3 cm to become small pieces and then placed onto the aluminium foil. The skin of tubers was peeled and the tubers were cut into small pieces and separated onto the aluminium foil. All the samples were dried at 60°C for 72 hours in a conventional oven (OF-G22W, Jejo Tech, Korea). The dried samples were ground using a Mill Grinder (Retsch, SM200 Rostfrei, Germany) prior to sieving using 250μm mesh. The produced powders of different sweet potato parts were kept in a chiller (4˚C) for further analysis.

Flowability analysis

The flow properties of different parts of sweet potato were analysed using probe Powder Flow Analyser attached to a texture analyser (TA-XT plus, Stable Micro Systems, Surrey, UK) (Benkovic and Bauman, 2009). The caking test, cohesion test and powder flow speed dependency test (PFSD test) were performed. All samples were fixed at 70 mL volume for each experiment. The caking test, cohesion test, and PFSD test were ran and triplicated except for caking test. A conditioning cycle was performed at the beginning of the test to remove user loading variation by moving the blade downward and upward through the powder column at a tip speed of 50 $mm.s^{-1}$.

Results and discussion

Flowability analysis

Flowability of powders is an important property since it will affect the behaviour of the powders during storage, handling and processing. This property may be depends on a few factors such as temperature, pressure and humidity (Teunou et al., 1999). Table 1 exhibits the flow characteristics of powders from different parts of the sweet potato plant. Based on the finding, all samples were categorized as free flowing powders with cohesion index below 11. This may be due to small particle size of the powders that has been sieved at 250 µm during the preparation stage. Smaller particle size of powder is more cohesive and the ability to flow is becoming more difficult. The reason for the flowability reduction for smaller particle sizes is due to the increase of surface area per unit mass of the powders. More surface contacts or surface area lead to high resist flow resistance.
Based on Table 1, the tuber powders have the highest cohesion index of 3.01, followed by leaves, skin and stem respectively. Meanwhile, all the samples were considered as stable powders since the flow stability values were closed to 1. Flow stability index near to 1 indicates that the powders will not easily change.

Figure 1, shows tin speed versus compaction coefficient of different parts of sweet potato powders. Stem powder has the highest compaction coefficient followed by leaves, tuber and skin powder respectively. Based on the finding, compaction coefficient of all samples decreased at high tin speed. This indicates that as the flow speed increases, the powders become freer to flow. The smaller the particles, the freer the powder to flow.
Caking is a phenomenon where food powders are transformed into a sticky unwanted material. It can cause deterioration in powders quality and functionality. Cake strength can be affected by a number of factors such as particle to particle interactions, packing efficiency and moisture content (Benkovic and Bauman, 2009). The tuber powder had the highest cake strength of 21336.52 g.mm and mean cake strength of 853.85 g compared to leaves, stem and skin powder as shown in Table 1. Figure 2 illustrates the cake height ratio of all the powders. The cake height ratio increased as the number of compaction cycle increased. High cake height ratio indicates a higher tendency for the powders to caking, which related to having high mean cake strength and high cake. Hence, the finding indicates that all the samples have a high tendency to caking.

Table 1: Flow characteristic properties of different parts of sweet potato powders.

Parameter	Stem	Leaves	Tuber	Skin
Cohesion index	1.63±0.03	2.9±0.07	3.01±0.05	2.1±0.07
Flow stability	0.95±0.01	0.92±0.01	1.01±0.06	0.86±0.10
Cohesion coefficient 50 mm/s	495.34±4.96	488.09±23.56	717.08±69.52	204.36±6.71
Cake strength (g.mm)	2272.25	8275.04	21336.52	9336.97
Mean cake strength (g)	307.25	344.82	853.85	577.27

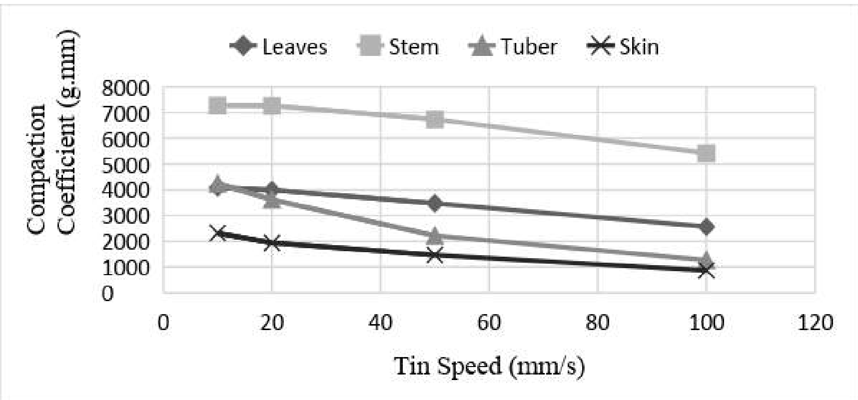


Figure 1: Tin Speed versus compaction coefficient of different parts of sweet potato powders

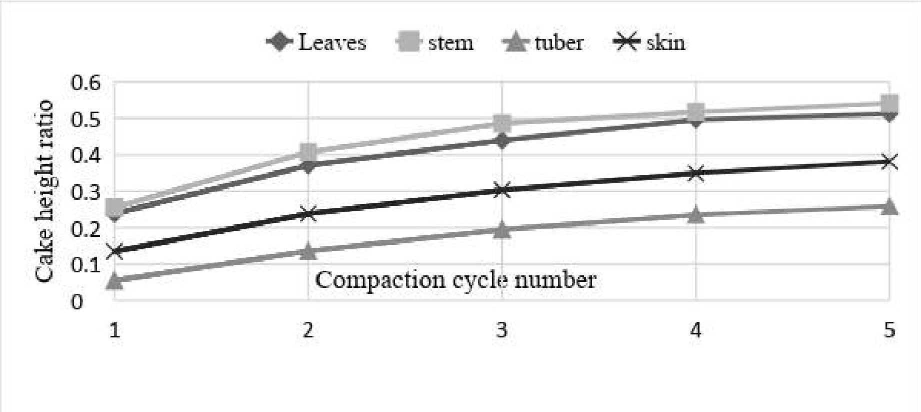


Figure 2: Caking height ratio versus compaction cycle number of different parts of sweet potato powders.

Conclusions

In flowability analysis, the powder of sweet potato stem, leaves, tuber and skin are classified as stable powders and free flowing. They were also becoming more likely to caking. Based on this study, different parts of sweet potato produce different powder properties value. Thus, further explorations are needed to apply the advantages as new applications.

References

Benkovic, M. and Bauman, I. 2009. Flow properties of commercial infant formula powders. World Academy of Science, Engineering and Technology 54: 495-499

Eleazu, C. O., & Eleazu, K. C. (2012). Determination of the Proximate Composition, Total Carotenoid, Reducing Sugars and Residual Cyanide Levels of Flours of 6 New Yellow and White Cassava (Manihot esculenta Crantz) Varieties. *American Journal of Food Technology*. https://doi.org/10.3923/ajft.2012.642.649

Ellong, E. N., Billard, C., & Adenet, S. (2014). Comparison of Physicochemical, Organoleptic and Nutritional Abilities of Eight Sweet Potato (Ipomoea batatas) Varieties. *Food and Nutrition Sciences*, *5*(January), 196–211. https://doi.org/http://dx.doi.org/10.4236/fns.2014.52025

Islam, S. (2003). Medicinal and Nutritional Qualities of Sweetpotato Tops and Leaves.

Janjatović, D., Benković, M., Srečec, S., Ježek, D., Špoljarić, I. and Bauman, I. 2011. Assessment of powder flow characteristics in incoherent soup concentrates. Advanced Powder Technology 23 (5): 620-631.

Mais, A. and Brennan, C. S. 2008. Characterisation of flour, starch and fibre obtained from sweet potato (kumara) tubers, and their utilisation in biscuit production. International Journal of Food Science & Technology 43(2): 373-379.

Mohd Hanim, A. B., Chin, N. L., & Yusof, Y. A. (2014). Physico-chemical and flowability characteristics of a new variety of Malaysian sweet potato, VitAto Flour. *International Food Research Journal*, *21*(5), 2099–2107.

Sanoussi, A. F., Dansi, A., Ahissou, H., Adebowale, A., Sanni, L. O., Orobiyi, A., … Sanni, A. (2016). Possibilities of sweet potato [Ipomoea batatas (L.) Lam] value chain upgrading as revealed by physico-chemical composition of ten elites landraces of Benin. *African Journal of Biotechnology*, *15*(13), 481–489. https://doi.org/10.5897/AJB2015.15107

Sullivan, J. N. O., Asher, C. J., & Blarney, F. P. C. (1997). Nutrient Disorders of Sweet Potato.

Teunou, E., Fitzpatrick, J. and Synnott, E. 1999. Characterisation of food powder flowability. Journal of Food Engineering 39 (1): 31-37.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE07

Clarification of Guava Juice Through Membrane-Based Process

J.M. Omar[1] and M.Z.M. Nor[1,*],
Department of Process and Food Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
*Corresponding author. Tel.: +603-97694303, Email: zuhair@upm.edu.my

Abstract
This study was aimed to explore the potential of using membrane-based process for the clarification of fresh guava juice. The study was done to determine the effect of the process on the permeate flux behavior as well as the guava juice quality attributes such as pH, turbidity and total soluble solids (TSS). The clarification of guava juice was performed using 100 kDa polymeric membrane in a dead-end module. The clarification process exhibited high productivities in terms of permeate flux (12.72 -60.94kg/m²/hr) at a processing pressure of 1 bar. The process has also resulted a high reduction of turbidity (95%) in the permeate with 5.67% reduction of TSS. No significant change was observed in terms of the pH of the feed, permeate and retentate. The findings indicate that ultrafiltration can be successfully used in guava juice clarification.

Keywords: Clarification, Guava, Membrane-based process, Ultrafiltration, Processing pressure, Fruit juice

Introduction

Guava (*Psidium guajava* L.) is a very popular fruit in many tropical and subtropical countries. It has been cultivated and distributed by man and bird where the place of origin is uncertain but it is believed to be an area extending from Southern Mexico into or through Central America. Guava is usually consumed fresh where it contains high vitamin C and lycopene as compared to orange fruit (Sciences, Akesowan, and Choonhahirun 2013). Besides, it is rich in vitamin A, omega-3 and -6 polyunsaturated fatty acids, dietary fibre, potassium, magnesium and antioxidant pigments such as carotenoid and polyphenols (Sciences, Akesowan, and Choonhahirun 2013).

Guava is also being processed and preserved into puree, canned slices in syrup and juice. Due to its high nutritional values, guava has high potentials to be promoted as a healthy fruit juice. However, similarly to other typical fruit juices, guava juice contains high concentration of pectin and other carbohydrates such as cellulose, hemicellulose and etc. resulting the juice to be high in turbidity and viscosity. This characteristic may affect the consumers acceptance as they prefer pleasant flavour, texture and colour of fruit juices. Besides, normal fruit juice processing undergoes pasteurization and concentration process by thermal treatment that cause colour changes and loss of nutritional values. Hence, a suitable processing approach is needed in order to improve the juice characteristics while maintaining its nutritional substances.

Membrane-based process offers an alternative to the conventional juice processing since it has many advantages such as the absence of phase transition, mild operating conditions and easy scaling up (Castro-mu, Fíla, and Barrag 2017). Membrane-based process is a method which selectively separate materials via pores and/or minute gaps in the molecular arrangement of continuous structure. It is classified by pore size and separation driving force which includes microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO) and nanofiltration (NF).

Membrane-based process, especially ultrafiltration (UF) has been widely used in many industrial applications such as recovery and concentration of protein from cheese whey for dairy application, recovery of electrodeposition paints in chemical and mechanical industries and also in the fruit juice industry (Jonsson and Tragbirdh 1990). There are many reports on the successfullness of using UF to clarify pear, kiwifruit and alfalfa juice (Rai, Majumdar, and Gupta 2007). The advantages of using membrane-based process is that it consumes lower energy which is able to reduce the operating cost while allows significant improvement on the process efficiency and juice quality attributes such as colour, turbidity and preservation of its natural bio-active compounds.

By considering its advantges, UF has a big potential in the guava juice processing. However, guava fruit has been minimally processed at industrial trial and up to date there is lack of information on the processing of guava juice by membrane technology. Hence, this study was aimed to explore the potential of applying the membrane-based process using ultrafiltration (UF) for guava juice clarification by observing its effect on the permeate flux behaviour and guava juice quality attributes.

Materials and methods

Material

Ripe seeded guavas (*Psidium guajava* L.) with 80-90% maturity and free from visual blemishes and bruises were purchased from a local market in Seri Kembangan, Malaysia.

Method

1) *Guava juice preparation*

Ripe guavas were washed with tap water, peeled off the skin and cut into small pieces. The peeled guavas were then processed using a juice extractor. The guava puree was filtered through a cheese cloth prior to centrifugation at 9000 rpm for 15 minutes in a centrifuge (Hettich Benchtop centrifuge Universal

320, Germany). The obtained supernatant was used as a feed for the ultrafiltration (UF) process.

2) Experimental set-up and procedures

This process was carried out using a laboratory scale membrane stirred cell unit (Milipore, USA) attached with a compressed air tank. The system was equipped with a polyethersulfon dead end disc membrane with a molecular weight cut-off (MWCO) of 100 kDa, which had been reported to be suitable for clarification of natural juices and agro-food by-products. Each UF experiment performed was executed with a capacity of 250 ml of juice at 1.0 bar processing pressure. The specifications of the membrane used for guava juice clarification are shown in Table 1.

Table 1: The specifications of the membrane-based process for the guava juice clarification

Membrane	Ultrafiltration (UF)
Manufacturer	EMD Millipore Corporation
MWCO (Da)	100,000
Filter diameter (mm)	63.5
Membrane material	Polyethersulfon (PES)
Configuration	Dead end
Processing pressure (bar)	1.0

Performance of the UF process was measured in terms of the permeate flux (*J*) and permeate recovery (PR) as described below:

$$J = \frac{1}{A_m} x \frac{\Delta W}{\Delta t} \qquad (1)$$

$$PR(\%) = \frac{V_p}{V_f} x100 \qquad (2)$$

where A_m is the effective membrane area (m^2) and ($\Delta W/\Delta t$) is the permeate weight ΔW collected over time Δt ($kg.h^{-1}$). While V_f and V_p are the volume (g) of the feed and permeate, respectively.

3) *Physicochemical properties*

The properties of the feed, permeate and retentate were analyzed in terms of pH, total soluble solids (TSS), and turbidity.

i) pH

The pH was determined using pH meter (PB-11, Sartorius, USA). It was calibrated with buffer solution of pH 4 and 7.

ii) Total soluble solid (TSS)

The TSS was measured in terms of ˚Brix using a handheld refractometer (PAL-3, Atago Co., Tokyo, Japan) with a scale of 0-50 ˚Brix.

iii) Turbidity

Turbidity in the samples was determined using microprocessor turbidity-meter (TN-100, Eutech Instrument, Singapore) and was calibrated with patron solution 0-1000 NTU.

Results and discussion

Permeate flux behaviour

Figure 1 shows the behavior of permeate flux as a function of time at the processing pressure of 1.0 bar. There are three obvious states to represent the flux behavior, where the first state was identified as an extreme reduction in permeate flux during the first 18 minutes. Then, the second state at time between 18-105 minutes was identified as a minor flux reduction, while the third state was identified after the 105 minutes which is known as steady-state that represents non-variation of permeate flux as a function of time.

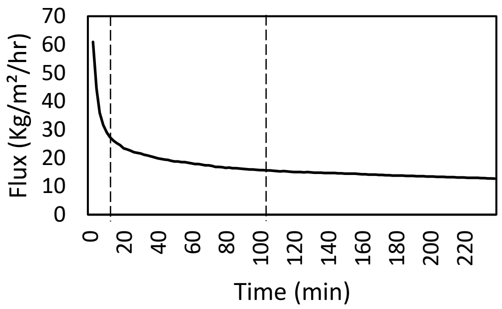


Figure 1: Permeate flux vs time

The initial productivity of the membrane in terms of permeate flux was 60.94 kg/m²/hr and a continuous decreasing trend was observed up to a final permeate flux of 12.72 kg/m²/hr. The result shows that the decreasing trend in permeate flux may be due to the fouling and polarization-concentration phenomena (Castro-mu, Fíla, and Barrag 2017). During the first state, it can be clearly seen that there was a drastic decrease in permeate flux and it started to decrease slowly in the second and third state. This is due to the gel polarization phenomenon where the feed pass through the membrane and the separation of suspended solid from the guava juice occurs. When the rejected particles (suspended solids) start to deposit on the membrane surfaces, the rate of flux decreases (Castro-mu, Fíla, and Barrag 2017).

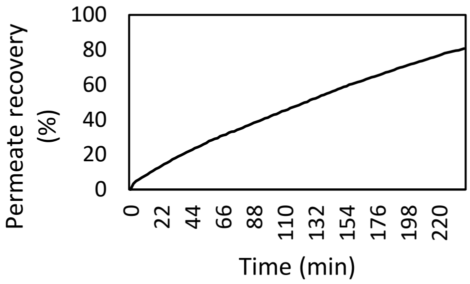


Figure 2: Permeate recovery (PR) vs time

Figure 2 shows the permeate recovery (PR) as a function of time. The clarification process was completed at 80% PR. At the end of the process, 160 g of permeate was recovered as clarified juice from 200 g of feed, with 40 g remaining as retentate in the system. The performance of the pressure-driven membrane process depends on many factors such as MWCO, configuration, membrane material, fouling phenomena and etc. Besides, operating conditions such as feed flow rate, processing pressure and temperature also play important roles in the separation process.

Effect of the membrane process on guava juice properties

Table 2 shows the properties of feed, permeate and retentate from the UF process. The original pH of the crude guava juice was 3.81, indicating the presence of organic acids such as ascorbic, malic and citric acid (Castro-mu, Fíla, and Barrag 2017) in the feed. The filtration process did not affect the pH of the sample since no obvious change of the value can be observed in the permeate and retentate compared to its initial value after the UF process was completed. This claim can be supported by similar research done by Castro-mu, Fíla, and Barrag (2017) where the findings have shown that there was a minimal changes in pH values observed in the fresh, clarified and retained juice.

Table 2: Physicochemical properties of guava juice during membrane separation process

	Feed	Permeate	Retentate
pH	3.81	3.78	3.79
Turbidity (NTU)	20.01	1.00	33.32
TSS (˚Brix)	5.29	4.99	5.20

Meanwhile, the turbidity value was greatly reduced from 20.01 NTU to only 1.00 NTU when the guava juice was filtered through UF membrane. This indicates a 95% reduction in turbidity in the clarified guava juice (permeate) through the UF process. Hence, the UF process is proven to be an effective mean to clarify the juice. Furthermore, in an observation-based study by Cassano, Donato, and Drioli (2007), the finding have found that the suspended solids in fresh kiwi fruit juice was fully removed by UF that cause the turbidity of clarified juice was negligible. The finding is further supported by the reduction of TSS from 5.29 ˚Brix in the feed, to only 4.99 ˚Brix in the permeate sample. According to Castro-mu, Fíla, and Barrag (2017), turbidity and TSS are related to each other. High turbidity indicates the presence of many soluble solids content in the sample such as fibers, suspended solids, high molecular weight compounds such as sugars (sucrose, glucose and fructose), mineral salts and organic acids. The membrane removed about 5.67% of TSS and therefore resulting a clear filtered guava juice in the permeate.

Conclusion

The clarification of guava juice was performed via ultrafiltration with a 100kDa PES membrane at 1.0 bar. 80% of the initial juice was recovered in the permeate as clarified juice. Permeate flux values ranging 12.72-60.94kg/m²/hr, reflecting a good filtration efficiency. The UF process managed to reduce the turbidity of the juice by 95%, 5.67% reduction of TSS and a stable pH, indicating the successfulness of the clarification process. The findings in this study show potential application of UF to clarify guava juice.

References

Cassano, A, L Donato, and E Drioli. 2007. “Ultrafiltration of Kiwifruit Juice : Operating Parameters , Juice Quality and Membrane Fouling.” 79: 613–21.

Castro-mu, Roberto, Vlastimil Fíla, and Blanca E Barrag. 2017. “Processing of Xoconostle Fruit (Opuntia Joconostle) Juice for Improving Its Commercialization Using Membrane Filtration" : 1–9.

Jonsson, Ann-sofi, and G U N Tragbirdh. 1990. “Ultrafiltration Applications.” 77: 135–79.

Rai, P, G C Majumdar, and S Das Gupta. 2007. “Effect of Various Pretreatment Methods on Permeate Flux and Quality during Ultrafiltration of Mosambi Juice.” 78: 561–68.

Sciences, Plant, A Akesowan, and A Choonhahirun. 2013. “Effect of Enzyme Treatment on Guava Juice Production Using Response Surface Methodology.” 23(1): 114–20.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE08

Determination of Pure and Adulterated Stingless Bee Honey Based on Dielectric Properties

Sapri, N.S. and Jamaludin, D.*
Department of Biological and Agricultural Engineering,
Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
**Corresponding Author, Tel: +603 89464325, E-mail: diyana_upm@upm.edu.my*

Abstract
Recently, honey has become the target of adulteration due to high consumers demand and its nutritional value. This study was carried out to quantify adulteration of stingless bee (kelulut) honey from Heterotrigona Itama sp. based on its dielectric properties by using Precision Impedance Analyzer at frequency range of 40kHz to 40MHz. Five treatments of honey were prepared: 1) pure honey,2) adulterated with 15% water, 3) adulterated with 30% water, 4) adulterated with 15% sucrose and 5) adulterated with 30% sucrose. Result shows that dielectric constant (ε ') decrease as frequency increase and the best frequency to distinguished between pure and adulterated honey is at the range of 10MHz to 40MHz. It was found that as percentage of sucrose added in pure honey increased, the dielectric constant is decreased while as the percentage of water added in pure honey increased, the dielectric constant is increased. Strong negative relationship was found between dielectric constant with viscosity (R^2= 0.94), moisture content (R^2= 0.98) and soluble solid content (R^2= 0.81) at frequency of 40 MHz. From this result, it concludes that the dielectric properties of stingless bee honey can be used to differentiate between pure and adulterated honey and to determine viscosity, moisture content and soluble solid content of stingless bee honey.

Keywords: dielectric, stingless bee honey, adulterated, viscosity, moisture content, soluble solid content

Introduction

Stingless bee are also known as *Lebah Kelulut* in Malaysia with more than 38 stingless bee species have been identified but only four species are commercially cultivated: *Geniotrigona thoracica, Heterotrigona itama, Lepidotrigona terminata and Tetragonula leviceps* (Mustafa et al., 2018). Stingless bee honey has been claimed to have high medicinal beneficial than other bee species (Biswa et al., 2017). According to Souza et al. (2006), honey from stingless bee is more valuable and it has been used for a long time to treat various diseases. The recent studies showed that the stingless bee honey has the potential to treat colorectal cancer (Yazan et al., 2016), anti-inflammatory (Borsato et al., 2014), antimicrobial (Medeiros et al., 2016) and has an antioxidant property (Almeida Da Silva et al., 2013; Duarte et al., 2012). According to Chuttong et al. (2016b), stingless bee produce about 1–5 kg of honey per year depending on the species compared to *Apis mellifera* bee, with an average of 20 kg of honey per hive. Due to limited source and high demand of honey, the retail price of stingless bee honey is higher than common honey bee. Average stingless bee honey retail price is between RM250-RM300/kg (57 – 70 USD/kg). This has encouraged the flourishing of stingless bee honey industry in Malaysia. Nevertheless, with abundance of stingless bee honey product in the market, the purity of these honey is somehow questioned. According to the definition of the Codex Alimentarius and other international honey standards, honey shall not be added with others ingredient. However, natural honey had become targets of adulteration for economic gains due to its high demand due to its high nutritional value and the unique flavour characteristics There are several types of adulteration of honey in the industry, which are indirect adulteration of honey and direct adulteration of honey. Indirect adulteration of honey happens by feeding stingless bee with industrial sugar at bee farm. This type of adulteration is extremely hard to detect. Direct adulteration is the addition of foreign substances directly to honey for example adulteration of honey with sucrose syrup and water.

Recently, guaranteeing honey quality is getting to be progressively vital for consumers, producers and regulatory authorities. Therefore, detection of honey adulteration is very important. Various analytical techniques, including: isotopic (Padovan et al., 2003), chromatographic (Cordella et al., 2003a), and thermal analysis have been implemented for the detection of honey adulteration. The strength of these methods in honey adulteration detection has been proven by numerous researchers, however, they are time-consuming, destructive, and some of them are expensive. Therefore, fast, non-destructive, and precise analytical methods are encouraged to complement the existing technique. One of possible method is by using dielectric spectroscopy. Dielectric properties determine the interaction of electromagnetic energy with materials. It represented by a complex number, the relative complex permittivity, $\varepsilon^o = \varepsilon' - j\varepsilon''$ where the real part ε' (dielectric constant) is associated with the capability of energy storage in the material, and the imaginary part ε'' (loss factor) associated with energy dissipation in the material in the form of heat (Guo et al., 2010). Extensive work has been done on a huge range of agricultural products and food which shows that the electromagnetic wave frequency and food compositions, particularly moisture content are the most vital factor influencing dielectric properties. In honey adulterations process, water is one of the common adulteration ingredients. Besides water, adulteration using additive sugars such as sucrose and fructose is also common and will change the composition of water content in the honey. Since water is the most important ingredient affecting the dielectric properties of a material, this has become the motivation to study the potential of dielectric properties to determine adulteration of stingless bee honey. Puranik *et al.* (1991) found that the addition of water to honey caused decreasing in relaxation time and increasing water content leads to the decreasing relaxation time. However, the correlations between the dielectric properties with other honey quality properties such as moisture content, soluble solid contents and viscosity is not yet discussed.

Materials and methods

Pure stingless bee honey from *Heterotrigona Itama sp.* was obtained at Ladang 10, Universiti Putra Malaysia (UPM). The pure samples have been harvested directly from the stingless bee hives that have been rear at farm to ensure only pure honey samples are used for this study.

1)Preparation of sample

There are five group of treatments for this study which are 1) pure honey, 2) adulterated with 15% water, 3) adulterated with 30% water, 4) adulterated with 15% sucrose and 5) adulterated with 30% sucrose (Figure 1). 5 samples with 50ml of pure honey were prepared for each group. Adulterated groups mixture was left in water bath at 45° C for about 3 hours to ensure that the sucrose and water added to the honey mixed well and to dissolve the presence of bubbles and crystal in the solution (Yanniotis *et al.,* 2006).

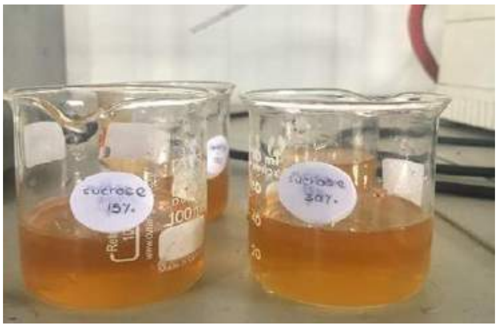


Figure 1: The honey sample inside viscometer cup

2) Dielectric properties measurement:

Dielectric properties measurement of each sample was performed by using a liquid test fixture Agilent 16452A, Agilent Technologies, Hyogo, Japan that connected to a Precision Impedance Analyzer Agilent 4294A, Agilent Technologies, Hyogo, Japan (Figure 2). Firstly, the dielectric test fixture was assembled and the shorting plate was inserted for fixture compensation. A 1.3mm spacer was used for the experiment. After the fixture compensation, the air capacitance (C_o) of the test fixture was measured at a room temperature of 25ºC. Five milliliters of stingless bee honey were poured in the inlet of the test fixture gently to avoid creating any air bubble. Then, the capacitance (C_p) and resistance (R_p) of the extracts were measured at frequency range between 40 kHz to 40 MHz. In between each sample measurements, the honey was drained, and the fixture was disassembled, cleaned and dried at room temperature. The test was replicated three times for each sample of extracts to determine the dielectric constant (ε').

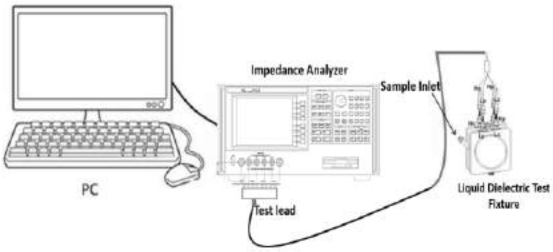


Figure 2: Dehydrator of stingless bee honey

3)Sucrose content and moisture content measurement

The sucrose content of all samples was measured using Digital Refractometer (D-22297, KRUeSS Optronic, Germany). Firstly, the switch button was turned on and one to two drops of sample was poured on the prism. Then, the sample prism was gently closed and the prism switch was rotate to lock it in place. The measurement knob was turn to set a boundary line to the intersection of the crosshairs while looking at eyepiece of the refractometer. The refractive index and temperature were displayed simultaneously on the LCD. The refractive index of honey is different from that of a sucrose solution at the same concentration, therefore the refractometer reading needs to be converted to percent moisture. Therefore, for honey, the water content is calculated from the refractive index measure, by applying the equation of Wedmore (1955).

$$W_{wed} = \frac{-0.2681 - \log\ (R.I - 1)}{0.002\ 243}$$

where

W_{wed} is the water content in g per 100 g honey; and

$R.I$ is the refractive index

Furthermore, to convert refractive index into brix reading, the table conversion according to 16th Session of ICUMSA 1974 was used. The brix reading was the value of soluble solid content or the sugar content of the samples. It defines the percentage by weight of sucrose in pure water solution.

4) Viscosity measurement

The viscosity testing was determined by using Sine-wave Vibro Viscometer (A&D SV-10, Tokyo,). It measures viscosity by detecting the driving electric current necessary to resonate the two sensor plates at constant frequency of 30Hz and amplitude of less than 1mm. A sample of 40 ml was poured into the cup until the surface reaches between the level gauges (Figure 3). Then the cup was attached to the table along the guides. Next, the protector was confirmed to in the position and the lever was raised to the sensor unit. Then, the knob was turned to adjust the sample surface to the center of sensor plate. Then, the viscometer was run to measure the viscosity of the samples. The viscosity reading was displayed on the unit of the viscometer in Pas or mPas.

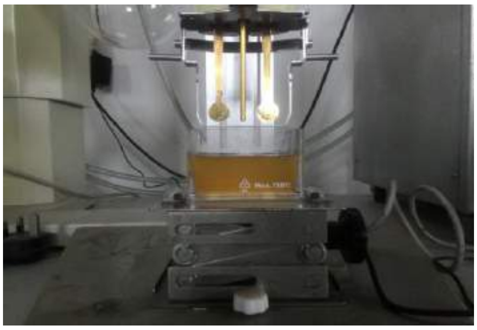


Figure 3: The honey sample inside viscometer cup

Results and discussion

Moisture content, soluble solid content and viscosity of pure and adulterated stingless bee honey

Moisture content, soluble solid content (SSC) and viscosity of pure and adulterated samples were measured and analyzed using statistical software SPSS. One way ANOVA with post-hoc Tukey HSD was used to determine difference between each group of treatment. Table 1 shows the average value of each honey properties with group of treatment.

Table 1: Average value for moisture content, soluble solid content (SSC) and viscosity of each treatment

Treatment	Average Moisture content (g/100g)	Average SSC (%)	Average Viscosity (pas)
Pure honey	26.76 ± 0.032 [a]	71.73 ± 0.029 [a]	0.38 ± 0.008 [a]
15% water	35.48 ± 0.427[b]	61.82 ± 0.845[b]	0.07 ± 0.004[b]
30% water	47.86 ± 0.516[c]	50.46 ± 0.585[c]	0.03 ± 0.001[c]
15% sucrose	26.25 ± 0.883 [a]	71.73 ± 0.357 [a]	0.42 ± 0.003[d]
30% sucrose	25.77 ± 0.563 [a]	72.6 ± 0.666 [a]	0.55 ± 0.001[e]

Table 1 shows that sucrose adulterated honey has higher viscosity compared to pure honey, while honey adulterated with water has lower value of viscosity. Honey adulterated with 30% of water have the highest moisture content value while honey adulterated with sucrose have slightly the same moisture content value with pure honey with no significant difference. This shows that moisture content increase with increasing water in honey. The result also shows that the SSC value has inverse relationship with moisture content. Honey adulterated with 30% of water have the lowest SSC value while honey adulterated with sucrose and pure honey have slightly the same SSC value with no significant difference using Tukey HSD mean comparison analysis. This shows that SSC value decreases with increasing water in honey and also proved that moisture content and soluble solid content analysis couldn't differentiate between pure honey and honey adulterated with 30% sucrose. The adulteration leads to reduced nutritional value of honey and could cause health concerns to the consumers with additive sugars. Honey adulterated with water has higher moisture contents which favours fermentation.

Variation of dielectric constant (ε') against frequency range of 40 kHz to 40 MHz

The dielectric constant for full sweep range frequency from 40 kHz to 40MHz is shown in Figure 4. From the graph, the pattern of dielectric constant for each group against frequency 40 kHz to 40MHz was difficult to differentiate and become constant as it reached to 10MHz. Furthermore, the slope between pure honey and adulterated honey is hard to distinguish since the line overlaps with each other. The value of dielectric constant at early frequency range from 40 kHz to 10MHz was not stable due to disturbances and noises

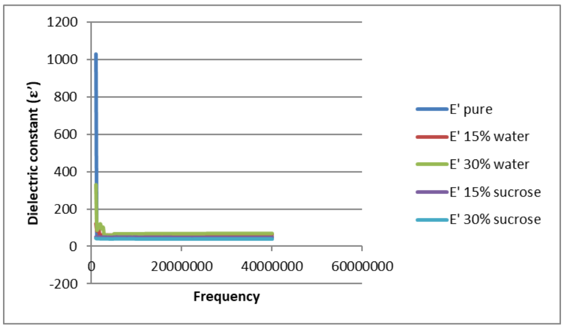


Figure 4: The dielectric properties of pure honey , honey adulterated with sucrose and water at frequency range from 40kHz to 40 MHz

Then, the range of frequency from 40 kHz to 40MHz was scale into two phase frequency range to form clearer pattern of dielectric constant for each group. The first range frequency analysed from 40 kHz to 10MHz and the second range frequency analysed from 10MHz to 40MHz. From Figure 5, the graph of first range frequency from 40 kHz to 10MHz is still difficult to analysed and quite similar with the graph of full range frequency. From Figure 6, the graph shows better pattern and dielectric constant for each group can be differentiate against the frequency of 10MHz to 40MHz. The pattern is clearer since less noise in between this frequency compared to the lower range frequency from 40kHz to 10MHz. This frequency range is then chosen to develop the regression graph and correlation.

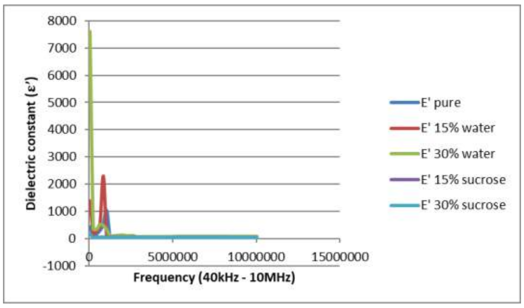


Figure 5: The dielectric properties of pure honey , honey adulterated with sucrose and water at frequency range from 40kHz to 10MHz

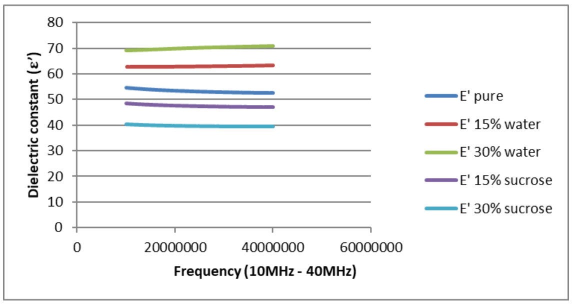


Figure 6: The dielectric properties of pure honey , honey adulterated with sucrose and water at frequency range from 10MHz to 40 MHz

The measured dielectric properties of five group treatments over the frequency range from 10MHz to 40MHz is shown in Figure 6. The result reveals that the dielectric constant of the five different treatments had the same frequency dependence. Honey adulterated with 30% water shows highest dielectric constant (70) compared to other treatment, and honey adulterated with 30% sucrose shows lowest dielectric constant (40). The graph also shows that pure (**ε**'=53***)*** and adulterated honey can be differentiate using dielectric constant value. Since dielectric constant has significant relationship with water content, it proved that honey adulterated with additional water has higher dielectric constant than others.

Relationship between dielectric constant (ε') with moisture content, SSC and viscosity.

The linear curve fit analysis was carried out on each quality parameters against dielectric constant model for each treatment in selected frequency value. All these frequencies were proceeded with regression analysis to generate the regression equation and selected the best linear regression model for quality parameter prediction. From the analysis, it was found that the best frequency that explained the relationship between dielectric constant and quality parameter is at 40MHz. Table 2 shows the regression equation for each quality parameter based on dielectric constant as functioning equation. It shows that each linear regression equation has high R^2.

Table 2: Regression equation for each parameter based on dielectric constant as functioning equation

Parameter	Regression equation	R^2
Viscosity	y = -0.018 **ε**' + 1.260	0.960
Moisture Content	y = 0.688 **ε**'-5.126	0.832
SSC	y = -0.699 **ε**'+ 103.85	0.844

Conclusion:

The dielectric properties on pure and adulterated honey has been measured between frequency of 40kHz to 40MHz using a liquid test fixture that connected to precision impedance analyser. From the results produce, dielectric properties of stingless bee honey shows promising result to be used as adulteration indicator and to develop a rapid, handheld sensor based on dielectric properties.

References:

Biswa, R., Sarkar, A. and Subba, S.K. (2017). Ethnomedicinal uses of honey of stingless bee by Nepali community of Darjeeling foothills of West Bengal, India, p. 648–653. India: NISCAIR-CSIR

Borsato, D. M., Prudente, A. S., Döll-Boscardin, P. M., Borsato, A. V., Luz, C. F., Maia, B. H., ... & Miguel, O.

G. (2014). Topical anti-inflammatory activity of a monofloral honey of Mimosa scabrella provided by Melipona marginata during winter in Southern Brazil. *Journal of medicinal food*, *17*(7), 817-825.

Chuttong, B., Chanbang, Y., Sringarm, K., & Burgett, M. (2016). Physicochemical profiles of stingless bee (Apidae: Meliponini) honey from South east Asia (Thailand). *Food chemistry*, *192*, 149-155.

Cordella, C., Faucon, J.P., Cabrol-Bass, D., Sbirrazzuoli, N. (2003a). Application of DSC as a tool for honey floral species characterization and adulteration detection. Journal of Thermal Analysis and Calorimetry, 71 (1), 279–290

Guo, W., Zhu, X., Liu, Y., Zhuang, H., (2010). Sugar and water contents of honey with dielectric property sensing. Journal of Food Engineering 97 (2), 275–281.

Mustafa, M. Z., Yaacob, N. S., & Sulaiman, S. A. (2018). Reinventing the Honey Industry: Opportunities of the Stingless Bee. *Malaysian Journal of Medical Sciences*, *25*(4), 1-5.

Padovan, G.J., De Jong, D., Rodrigues, L.P., Marchini, J.S. (2003). Detection of adulteration of commercial honey samples by the 13C/12C isotopic ratio. Food Chemistry, 82 (4), 633–636.

Puranik, S., Kumbharkhane, A., Mehrotra, S., (1991) Dielectric properties of honey–water mixtures between 10 MHz to 10 GHz using time domain technique. Journal of Microwave Power and Electromagnetic Energy 26 (4), 196–201

Saiful Yazan, L., Zali, M., Shyfiq, M. F., Mohd Ali, R., Zainal, N. A., Esa, N., ... & Voon, F. L. (2016). Chemopreventive properties and toxicity of Kelulut honey in sprague dawley rats induced with azoxymethane. *BioMed research international*, *2016*.

Souza., B., Roubik, D., Barth, O., Heard, T., Enríquez E., Carvalho, C., Villas-BôAs, J., Almeida-Muraidan, L., Bogdanov, S. and Vit, P. (2006). Composition of stingless bee honey: setting quality standards. Interciencia, 31, 867-875.

Wedmore E. (1955) The accurate determination of the water content of honeys, Bee World 36, 197–206.

Yanniotis, S., Skaltsi, S. and Karaburnioti, S. (2006). Effect of moisture content on the viscosity of honey at different temperatures. Journal of Food Engineering, 72(4), pp.372-377

Effect of Different Sugar Concentration on the Rheological and Textural Properties of Fish Mince

Rozzamri, A.[1,*]
[1]Food Technology Department, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia
*Corresponding author. Tel.: +603-89468390, Email:rozzamri@upm.edu.my

Abstract
Fish mince were prepared from Alaska Pollock where fish were headed, gutted, washed and minced. The fish mince were subjected to three formulations with different types of sugar which was sucrose, sorbitol and mannitol at 4%, 6% and 8% (w/w) concentration. Rheological properties and textural properties of the fish mince is determined using a rheometer and texture analyser. Rheological properties showed that as the sugar concentration increases, the fish mince displayed more elastic properties rather than viscous. Higher stress and force were needed for deformation of fish mince at higher sugar concentration. Fish mince added with mannitol at 8% (w/w) displayed the highest value of G' and G''. Textural properties also concur with rheological results as it shows that an increase in sugar concentration, increases the gelling strength of the fish mince especially with mannitol ($p<0.05$). An increase from 4% to 6% concentration of sugar showed a significant difference for all sample ($p<0.05$). However, sucrose and sorbitol does not display any significant difference with an increase from 6% to 8% ($p>0.05$). This indicates that a lower sugar concentration could be used to produce similar gelling strength of higher sugar concentration.

Keywords: fish, rheology, texture, gel strength, sugar

Introduction

Freezing is a preservation technique widely used during handling and transportation of surimi. However, denaturation occurs during frozen storage which promotes protein aggregation thus reducing gel forming ability (Zhou et al., 2006; Shenouda, 1980). Cryoprotectants were introduced as a solution to prevent and slower the rate of denaturation during frozen storage (MacDonald and Lanier, 1994). Cryoprotectants added has the ability to alter the surface hydrophobicity of surimi thus preventing oxidation and protein aggregation (Parvathy and George, 2014; Campo-Deaño, Tovar and Borderías, 2010; Zhou et al., 2006). The ability of cryoprotectants to increase the hydration of surimi also decreases the rate of protein denaturation (Nopianti et al., 2012: Yoon and Lee, 1990). Various low molecular sugars such as sucrose and sorbitol have been identified as cryoprotectants and have been added to surimi to prevent freezing damage (Campo-Deaño, et al., 2010; Carvajal, Lanier and MacDonald, 2005). These sugars are chosen because they are economical, easy to obtain and cause minimal Maillard browning reaction to surimi (Carvajal et al, 1999). However, due to its high calorie content and sweetness (sucrose), other sugars with lower calorie content and sweetness such as trehalose, polydextrose, maltodextrin have been researched to promote a much healthier product (Campo-Deaño et al., 2009; Zhou et al., 2006; Sych et al., 1991). Sych et al. (1991) reported that polydextrose, a branched polysaccharide with no sweetness could substitute sucrose/sorbitol mixture as cryoprotectant on cod. However, a high concentration of polydextrose causes the natural actomyosin to possess higher viscosity thus making it harder to be processed (Herrera and Mackie, 2004). This study was done to understand the rheological and textural properties of Alaska Pollock surimi when sucrose, sorbitol and mannitol were added as cryoprotectants. In addition, the feasibility of using mannitol as a cryoprotectant was also investigated. So far, only few reports on the use of mannitol as cryoprotectant exist. In conjunction to that, the effects of sugar concentrations on the rhelogical and textural properties of surimi paste and gel were also investigated. Lowering sugar concentrations might produce a less sweet surimi with low calorie content. Rheological properties and textural properties of surimi are used as an indicator of surimi quality. Understanding these properties will further assist seafood manufacturers to design their processing line efficiently and effectively.

Materials and methods

Fish paste preparation

Fresh Alaska Pollock fish obtained from the local market. The fish was beheaded, gutted, washed and cleaned to obtain fish meat. The fish was then minced using a food processor to attain uniformity and homogeneity. The fish mince underwent washing with water to mince ratio 3:1 (w/w). Washing was done using chilled distilled water at 4°C. The mixture was stirred gently for 5 minutes and filtered using cheesecloth. The paste was then mixed with different type of sugar and sugar concentration as presented in Table 1. The sample was then stored inside a freezer at -18°C overnight.

Fish gel preparation

For fish gel preparation, the frozen samples were thawed at room temperature for 1 hour. The samples were then blended using a food processor to produce a homogenized fish paste. The samples were inserted into an extruder and extruded into a polyvinilydine casing with a diameter of 25 mm. Both ends of the casing were tightly sealed. The samples were then boiled in water at 40°C for 30 min and 90°C for 20 min as described by Benjakul et al. (2002) two-step heating. The samples were cooled under running water and stored at -18°C overnight before analysis.

Table 1: Fish sample formulations with different types of sugars and sugars combination.

Sample	Formulation (w/w)
C	No additives
SU4	4% Sucrose
SU6	6% Sucrose
SU8	8% Sucrose
SO4	4% Sorbitol
SO6	6% Sorbitol
SO8	8% Sorbitol
MA4	4% Mannitol
MA6	6% Mannitol
MA8	8% Mannitol

Rheological tests

Small amplitude oscillatory shear (SAOS) tests were performed using a Discovery HR-2 Hybrid Rheometer using 40 mm 4° cone and plate geometry with 59 µm truncation gap. The sample was thawed at room temperature prior to analysis. Fish paste was spread evenly on the lower plate and any excess sample was carefully removed. The sample was covered using a moisture trap during measurement to prevent moisture evaporation.

Stress sweep test was done to determine the linear viscoelastic region (LVR). Stress values ranging from 0.1 Pa to 1500 Pa were implemented on the fish paste at 1 Hz and 20°C. The storage modulus (G') and loss modulus (G'') were observed and recorded.

Temperature sweep test was performed to analyse the variations in storage modulus (G') and loss modulus (G'') when the temperatures changed. The temperature sweep was done at 0.5% strain with 1°C per minute increase from 10°C to 90°C.

Textural properties

Puncture test was done using a TA-XT plus Texture Analyser (Stable Micro System Ltd., Surrey, UK). Samples with a diameter of 25 mm and a height of 25 mm were pierced to a breaking point using a round-ended cylindrical metal probe (P/0.25s). The crosshead speed was set at 1 mm/sec and a 5 kg load cell was used. The force required to cause deformation represents the breaking force (g) and the depth of penetration represents the breaking deformation (cm) as the gel loses its strength and ruptures. Gel strength was calculated using the equation by Huda, Leng and Nopianti (2011) as below:

Gel Strength (g/cm) = Breaking Force (g) x Breaking Deformation (cm)

Statistical Analysis

Statistical analysis was performed by using MINITAB 16 statistical software. Analysis of variance (ANOVA) was conducted to test the significant difference ($p < 0.05$) of the experimental results with Tukey test. Data are reported as mean values of triplicates ($n = 3$) ± standard deviation (SD). Data with significant difference between them ($p < 0.05$) will display difference letters (a,b,c and etc.).

Results and discussion

Rheological properties

Stress sweep tests were done to determine the effects of different concentration of sugar on its linear viscoelastic region (LVR). Figure 1 shows the effects of different types of sugar at 4%, 6% and 8% sugar concentrations (w/w) on the storage modulus (G'). All samples in Figure 1 displayed similar results in which as the stress increased to a certain level, G' value started to decrease. The point where G' value started to decrease is considered as the maximum value of stress that can be applied to the sample before it deforms. This indicates that all cryoprotectants display similar behaviour when subjected to a range of stress.

G' value of samples with different formulations also displayed similar result. This is shown when all sample displayed similar curve trend when subjected to stress. However, it was found that 4% (w/w) sugar concentration for all samples displayed the lowest value of G' and as concentration increased, the G' values also increased. Another observation that is apparent in Figure 1 is that as sugar concentration increased, the LVR became wider. Strong gels exhibit a much wider range of LVR compared to weak gels (Steffe, 1996) as evidenced when the sugar concentration increased, the gel strength of all samples increased.

Different types of sugar did not display any difference in trend and this implies that all types of sugars behaved similarly in which as concentration increased, the G' value for LVR increased. Results obtained also suggested that as sugar concentration increased, the structure of the fish paste became more intact and rigid which is represented by the G' value (Campo-Deaño Tovar and Borderías, 2010). As a result, the fish paste is predicted to have better gel strength when compared to others. As sugar concentration increased, the moisture content and water activity decreased (Chen *et al.*, 2002) thus, the cryoprotective quality was enhanced.

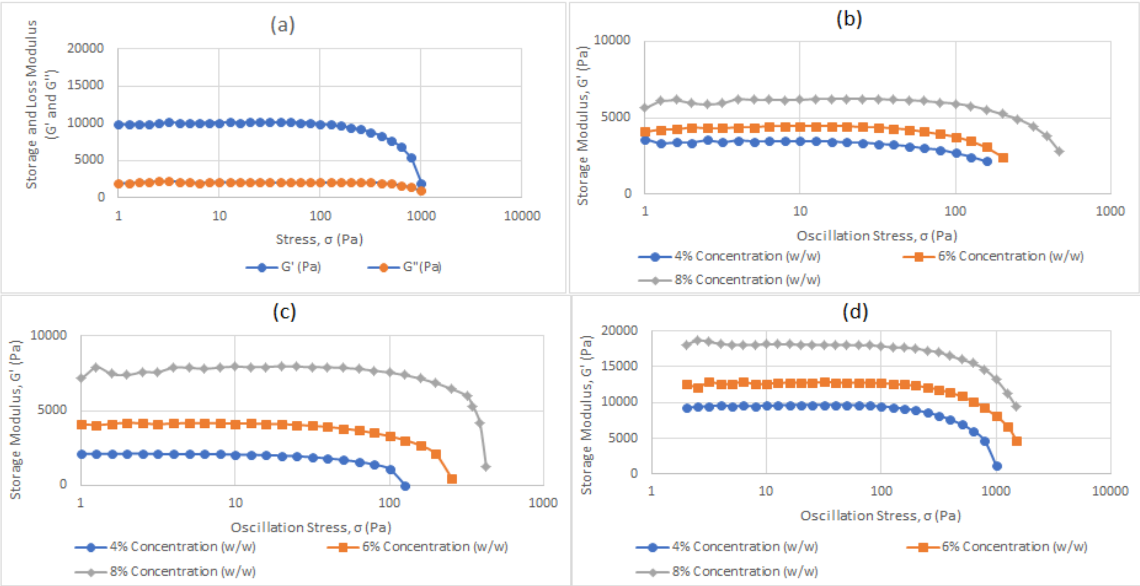


Figure 1: The storage modulus (G') for fish mince added with (a) control, (b) sucrose, (c) sorbitol, (d) mannitol at 4%, 6% and 8% (w/w) concentration subjected to stress sweep

Temperature sweep tests were done to determine the effects of sugar concentration on the gelation profile of fish paste. Figures 2 displays the effects of sugar concentration on the gelation profile of fish paste with different sugar combinations. All samples show the 4-stage gelation. However, 6% (w/w) sugar concentration showed a much more distinct peak between the first gelation point and second gelation point (between 40°C to 55°C) especially for sucrose and mannitol. This suggests that between these two points, the protein-protein interaction was more complex and requires more energy to dissociate (Poowakanjana, Mayer and Park, 2012). Lower energy consumption to induce gelation will display lower peak. These are represented by peaks with 4% and 8% sugar concentrations when compared with 6%. The final gelation point of each sample was found to decrease as concentration increased. These points are defined as the temperature where the second G' value started to increase (50°C to 60°C range). From this point onwards, gel strengthening phase took place. The protein (actin) started to form a much denser, complex and irreversible gel network with other proteins (Campo-Deaño, Tovar and Borderías., 2010). The amount of protein networking at this stage increased thus reinforcing the gel matrix to form irreversible gel (Campo-Deaño et al., 2009). Lower gelation temperature is beneficial for food manufacturers as less energy is required to induce gelation.

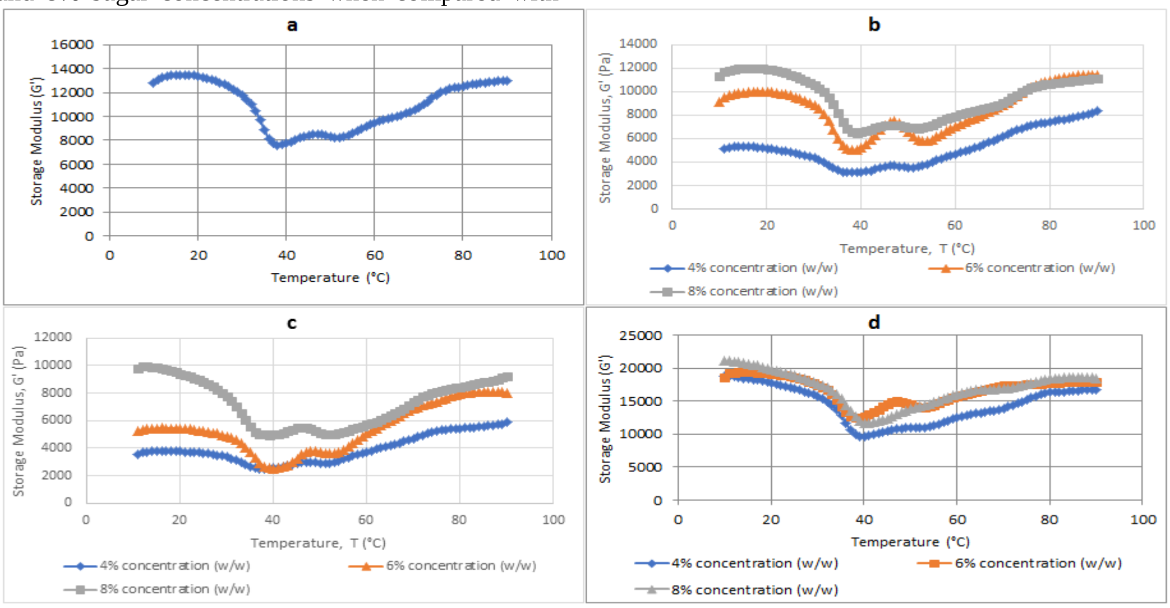


Figure 2: The storage modulus (G') for (a) control fish mince and fish mince added with (b) sucrose, (c) sorbitol, (d) mannitol at 4%, 6% and 8% (w/w) concentration subjected to temperature sweep

The G' value was found to be similar for samples at 6% at 8% at the end of the temperature profile (80°C to 90°C). This temperature range is when the final structure of surimi is shaped and becomes permanent (Belibagli et al., 2003). This suggests that the gelling strength of sugar concentration at 6% and 8% might have a similar value. However, this will be further discussed and proven with texture analysis.

Textural properties

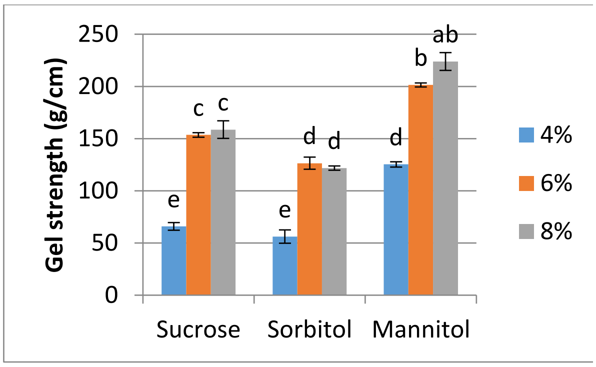


Figure 3: Effects of different sugar concentrations on the gel strength of fish gel. Values are means ± SD of triplicates (*n* = 3). Different letters indicate significant differences (*p* < 0.05).

Figure 3 shows that the gel strength of each sample increased almost twice from 4% to 6% sugar concentration. A higher value in gel strength can be related to the cryoprotective effect. As the concentration increases, protein deformation is better prevented thus producing better gel quality (Huda, Leng and Nopianti., 2011; Yoon and Lee, 1990). Even though all samples displayed similar trend, only mannitol displayed a significant difference at different mannitol concentrations ($p < 0.05$). However, 6% sugar concentration did not show any significant difference with 8% concentration ($p > 0.05$). Although initially the hypothesis was that 8% sugar concentration was to yield higher gel strength, the obtained data do not seem to support that hypothesis. Huda, Leng and Nopianti. (2011) also found that gel strength did not differ when cryoprotectant (polydextrose)'s concentration was increased from 6% to 9%. Another research on threadfin bream also showed a minimal increase of gel strength when concentration of sucrose:sorbitol (1:1 w/w) was increased from 6% to 8% (Parvathy and George, 2014). This indicates that the cryoprotective effect in this range (6% to 8%) might be similar.

Poowakanjana, Mayer and Park (2011) stated that certain sugar might inhibit gel formation. This might be true for the case of sugar at 4% concentration as all samples at this concentration appeared to display the lowest gel strength. Different types and concentrations of cryoprotectants differently affect the rate of protein denaturation, chemical structure and gelation properties of surimi (Huda, Leng and Nopianti., 2011; Belibagli et al., 2003; Sych et al., 1991). Overnight frozen storage was reported to induce protein (myosin) deformation which leads to lower gel strength (Nopianti et al., 2012). Without an effective cryoprotectant, the surimi gel quality decreases rapidly. However, when compared to the rheological tests done on the viscoelastic properties of samples, it was found that the results presented and recorded supported all the outcomes of texture analysis, thus, making rheology a feasible method to predict the gelling behaviour of fish paste.

Conclusions

In the present work, mannitol has showed promising results and could be considered as an alternative to sucrose and sorbitol which are commercially used in the surimi industry. Rheological tests and texture analysis showed similar trends for all sugar combinations. Sample with mannitol presented the highest value of gel strength which indicates high quality when compared with other fish gel and sugar combinations. Effects of sugar concentrations on gelling strength showed only significant difference from 2% (w/w) to 4% (w/w). Increment from 6% to 8% did not show any significant difference on gelling strength. Thus, using 6% sugar concentration would be better in achieving a healthier low calorie surimi. 6% (w/w) concentration could be used in the surimi industry whilst maintaining its quality similar to the commercial amount of 8% (w/w).

References

Belibagli, K.B., Speers, R.A., & Paulson, A.T. (2003). Thermophysical properties of silver hake and mackerel surimi at cooking temperatures. Journal of Food Engineering, 60, 439-448.

Benjakul, S., Visessanguan, W., Riebroy, S, Ishizaki, S., and Tanaka, M. (2002). Gel-forming properties of surimi produced from bigeye snapper, Pricanthus tayenus and P macracanthu, stored in ice. Journal of the Science of Food and Agriculture 82; 1442-1451

Campo-Deaño, L., Tovar, C.A., Pombo, M.J., Solas, M.T., and Borderías, A.J. (2009). Rheological study of giant squid surimi (Dosidicus gigas) made by two methods with different cryoprotectants added. Journal of Food Engineering 96 pg. 26-33

Campo-Deaño, L., Tovar, C.A., & Borderías, A.J. (2010). Effect of several cryoprotectants on the physicochemical and rheological properties of suwari gels from frozen squid surimi made by two methods. Journal of Food Engineering, 97, 457- 464.

Carvajal, P.A., Lanier, T.C., & Macdonald, G.A. (2005). Stabilization of proteins in surimi in J.W. Park (2nd Edition), 493-576 pp. CRC Press, Boca Raton.

Carvajal, P.A., MacDonald, G., & Lanier, T.C. (1999). Cryostabilization mechanism of fish muscle proteins by maltodextrins. Cryobiology, 38,(1), 16-26.

Chen, W.S., Liu, D.C., & Chen, M.T. (2002). Effects of high level of sucrose on the moisture content, water activity, protein denaturation and sensory properties in Chinese-style pork jerky. Asian-Australasian Journal of Animal Science, 15(4), 585-590.

Dileep, A.O., Shamasundar, B.A., Binsi, P.K., Badii, F., and Howell, N.K. (2011). Composition, physicochemical and rheological properties of fresh bigeye snapper fish (Pricanthus hamrur) mince. Journal of Food Biochemistry ISSN 1745-4514

Ferry, J.D. (1980). Viscoelastic properties of polymers (3rd ed.) New York: John Wiley and Sons, Inc.

Herrera, J.R., & Mackie, I.M. (2004). Cryoprotection of frozen-storage actomyosin of farmed rainbow trout (Oncorhynchus mykiss) by some sugars and polyols. Food Chemistry, 84, 91-97.

Huda, N., Leng, O.H., & Nopianti, R. (2011). Cryoprotective effects of different levels of polydextrose in Threadfin Bream surimi during frozen storage. Journal of Fisheries and Aquatic Sciences, 6(4), 404-416.

Karthikeyan, M. Dimeep, A.O, and Shamasundar, B.A. (2006). Effect of water washing on the functional and rheological properties of proteins from threadfin bream (Nemipterus japonicas) meat. International Journal of Food Sciencs and Technology, 41, 1002-1010

Macdonald, G.A., & Lanier, T.C. (1994). Actomyosin stabilization to freeze-thaw and heat denaturation by lactate salts. Journal of Food Science, 59, 101-105.

Nopianti, R., Huda, N., Fazilah, A., Ismail, N., and Easa, A.M.(2012). Effect of different types of low sweetness sugar on physicochemical properties of threadfin bream surimi (Nemipterus spp.) durinf frozen storage. International Food Research Journal 19 (3). Pg 1011-1021

Parvathy, U., & George, S. (2014). Influence of cryoprotectant levels on storage stability of surimi from Nemipterus japonicas and quality of surimi-based products. Journal of Food Science and Technology, 51(5), 982-987.

Poowakanjana, S., Mayer, S.G., Park, J.W. (2011). Optimum chopping condition for Alaska Pollock, Pacific Whiting and Threadfin Bream surimi paste and gel based on rheological and raman spectroscopic analysis. Journal of Food Science 77 (4), E88-E97

Ramírez, J.A., Uresti, R.M., Velazquez, G., and Vázquez, M. (2011). Food hydrocolloids as additives to improve the mechanical and functional properties of fish products: A review. Food Hydrocolloids 25 pg. 1842-1852

Shenouda, S.Y.K. (1980). Protein denaturation in frozen fish. Advances in Food Research, 26, 175-311.

Sych, J., Lacroix, C., & Carrier, M. (1991). Determination of optimal level of lactitol for surimi. Journal of Food Science, 56, 285-290

Yoon, K.S, & Lee, C.M. (1990) Cryoprotectant effects in surimi and surimi / mince-based extruded products. Journal of Food Science, 55, 1210-1216.

Zhou, A., Benjakul, S., Pan, K., Gong, J., & Liu, X. (2006). Cryoprotective effects of trehalose and sodium lactate on tilapia (Sarotherodon nilotica) surimi during frozen storage. Food Chemistry, 96, 96-103.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE10

Effect of Oat to Flour Ratio on Stickiness of the Cookie Dough

Jais, N.M. [1], Mohd Salahuddin, M.B. [1*]
[1]*Department of Process and Food Engineering,*
Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
**Corresponding author. Tel.: +603-97694312, Email: salahuddin@upm.edu.my*

Abstract
Texture attributes, such as stickiness of grain-based food is important to consumers and manufacturers (McManuis, 2001). Descriptive method such as Texture Profile Analysis (TPA) is used in order to describe the textural properties of the cookie dough. By using TPA, the structure of the food can be emphasize. Mixture formulation of cookie dough based on five different cup ratios of oat to flour which are 1:1, 1:1.25, 1:1.5, 1:1.75 and 1:75. The ratio of 1:1.5 is the basic mixture formulation provided by the SME's cookies company. The calculated weight was rounded off to the nearest whole number. Example, for 1.8 cups of oat at ratio 1:1.5, the total weight required was 1.8 cups times 94 grams which equal to 169.2 grams. After rounded off to the nearest whole number, the weight required was 169 grams. Similar calculation method was used to calculate the weight of flour. For each ratio of oat to flour, the total cup required for every mixing process was 4.5 cups. As results, different ratio of oat to flour had a significant effect on the dough stickiness where cookie dough with ratio 1:1.75 flour have the highest stickiness value while cookie dough with ratio 1:1.25 have the lowest stickiness value. This is because the higher flour content contains higher starch which contribute to higher moisture content. Hence, the dough with more flour is more sticky. The current study indicated a high potential in developing fiber-rich cookies with large inclusion with composition of 1:1.25 of oats and flour respectively which produced a less sticky dough. Thus, the increasing of oat and flour content in the formulation show a significant effect on dough stickiness.

Keywords: Stickiness, Oat to flour ratio, Resting time

Introduction

As studied by Norimah et al. (2008), in Malaysia, there is an expanding consumption patterns of ready-made or convenience food such as biscuits, bread and cake among Malaysian adults. According to Malaysian Adult Nutrition Survey, in particular, biscuit and bread appeared in the list of top ten daily consumed food. The survey also concluded that 16.3 percent of the local population consumed an average of five pieces of biscuits daily which showed that biscuits are one of many popular food in Malaysia. Biscuits are among the well-known and highest consumed baked food in the world. This is because of their ready to eat nature, affordable, good nutritional quality, available in different flavours and longer shelf life. Oat-based cookies is a cookie that contains basic ingredients including butter, sugar, salt and additional ingredients which are oat, either rolled or instant oat, and a large inclusion such as shown in Figure 1. Large inclusions are the additional ingredients added into the dough including chocolate chips, almonds, raisins, cashew, and other type of nuts. The purpose of adding the large inclusion into the cookie dough is to produce the oat cookies with various flavour following the consumer preferences. Due to addition of oat and large inclusions, the texture of the cookie dough is different as compared to that of the basic cookie dough which not has oat and large inclusions inside. As the texture differ, the dough properties such as stickiness and cohesiveness will significantly affect the production process of the cookie. Thus, study on parameters affecting the properties of the cookie dough including ratio of oat to flour and resting time of cookie dough is unduly important. By ensuring and determining the suitable oat-based cookie dough with suitable stickiness, problem such as dough sticks on the machine surfaces may potentially be hindered.

In biscuit making, the main ingredients are flour, sugar and fat. The quality of the biscuit is governed by the nature and quantity of the ingredients used. Nevertheless, several authors have attempted to describe the effect of ingredients in a dough and formula balance on the final structure of the product (Chen and Hoseney, 1995).

Texture attributes, such as stickiness of grain-based food is important to consumers and manufacturers (McManuis, 2001). Texture evaluation is an important step in developing a new product or optimizing process variables (Meullenet et al, 1998). Descriptive method such as Texture Profile Analysis (TPA) is used in order to describe the textural properties of the cookie dough. By using TPA, the structure of the food can be emphasize.

Dough stickiness or adhesion can be defined as the adhesion of dough to the contact surface (Dobraszczyk, 1996; Hoseney and Smewing, 1999; Adhikari et al., 2001; Yildiz et al., 2012). Some authors described dough stickiness or adhesion as the combination of cohesion which is the stickiness between particles, and adhesion which is defined as the stickiness between particle and wall or surface stickiness (Adhikari et al., 2001). Dough stickiness emerged as one of the major problems in bakery and confectionary industries since decades ago. Today, modern bakery and confectionary industries apply dusting flour or oil method to reduce the dough stickiness. However, it is

significantly help in eliminating the problem. The negative effect due to the dough stickiness has long be proven to interrupt the production schedule and subsequently caused losses due to low quality of the final products (Grausgruber et al., 2003).
Parameters resulted in dough stickiness and enhanced the dough stickiness had been reported in many journals. According to a research by Grausgruber et al. (2003), there are several parameters that influenced the dough stickiness such as overmixing of dough, over addition of water and uncontrollable intrinsic factors of the flour.

Materials and methods

a) Sample preparation

Basic mixture formulation used in this research are provided by one of the SME's cookies company who has experience for more than 10 years in producing oat-based cookies. The basic mixture formulation of the cookie dough in cup measurement and weight for one cup of ingredient is shown in Table 2. This mixture formulation is for one time mixing process. For example, by using ratio of 1:1.25 of oats to flour, two cups of oat and 2.5 cups of flour were required in mixing process which makes up a total weight for oat and flour of 188 and 285 grams, respectively.

Table 1: Basic mixture formulation of the cookie dough

Ingredients	Quantity	Weight percup (g)
Oat	2 cups	94
Flour	2.5 cups	114
Brown sugar	0.75 cup	164
Castor sugar	0.5 cup	232
Chocolate chip	0.75 cup	178
Cashew nut	0.25 cup	140
Almond slice	0.5 cup	96
Egg	1 piece	-
Butter	250 gram	-
Soda bicarbonate	3 gram	-
Baking powder	8 gram	-

Since the basic mixture formulation were provided in cup measurement (Table 1) for most of the important ingredients including oat and flour, the ratio of oat to flour were calculated based on the cup measurement throughout the research. Prior to the experiments, samples were prepared at different ratio of oat to flour, while other ingredients were remained constant.
Mixture formulation of cookie dough based on five different cup ratios are shown in Table 2. The ratio of 1:1.5 is the basic mixture formulation provided by the SME's cookies company. The calculated weight was rounded off to the nearest whole number. Example, for 1.8 cups of oat at ratio 1:1.5, the total weight required was 1.8 cups times 94 grams which equal to 169.2 grams. After rounded off to the nearest whole number, the weight required was 169 grams. Similar calculation method was used to calculate the weight of flour. For each ratio of oat to flour, the total cup required for every mixing process was 4.5 cups.

Table 2: Mixture formulation of cookie dough for different ratio of oat to flour

Measurement	Ratio Oat to Flour	Oat	Flour	Total
Cup	1 : 1	2.25	2.25	4.50
	1: 1.25	2.00	2.50	4.50
	1: 1.5	1.80	2.70	4.50
	1: 1.75	1.64	2.86	4.50
	1: 2	1.50	3.00	4.50
Weight (g)	1 : 1	212	257	469
	1: 1.25	188	285	471
	1: 1.5	169	308	477
	1: 1.75	154	326	480
	1: 2	141	342	483

The dough was prepared using a domestic mixer (Mixer HR 1565, Philips, Malaysia). First, butter, castor and brown sugars were placed inside the mixing bowl and mixed using the mixer. The mixing time and speed were kept constant at 11 minutes and 6 rpm, respectively. Then, egg was added into the mixture and was mixed for another 2 minutes at 6 rpm. The mixing product was a soft white-yellowish batter.
At the same time, the remaining ingredients were mixed manually by hand in other bowl following proper ratio as shown in Table 1. The batter was mixed with the remaining ingredients for 2 minutes until the mixture was well-mixed (Figure 1). The mixing process were repeated for all ratio of oat to flour.

Figure 1: Cookie dough

Prior to testing, the well-mixed cookie dough was divided into five equal parts. The dough were rested at five different resting times which were 10, 20, 30, 40 and 50 minutes. Samples were tested in different days. Therefore, the dough were rested inside incubator at controlled room temperature (approximately 27°C with 85 to 90 percent relative humidity. The mixing process and testing apparatus are located near to each other. This is important to minimize inaccuracy in data collection due to changes of temperature and relative humidity caused by distanced location.

b) Experimental design

Experiments were conducted in two phases. The first phase involved the determination of stickiness, cohesiveness, and moisture content properties of different cookie dough mixture formulation based on the oat to flour ratio and resting time. Texture and moisture analyzer were used in the first phase. The second phase focusing on the stickiness properties of cookie dough on different material surfaces including teflon, silicone, stainless steel, and parchment paper. For the second phase, only good and poor samples, obtained in the first phase based on the properties, were tested.

c) Experimental procedure (Texture Analyzer)

The value of adhesiveness and stickiness were studied by using the texture analyzer (TA.XT PLUS, Stable Micro Systems, Surrey, U.K.) with a 75 mm diameter cylinder probe (P/75P) under the following setting: Pre-Test Speed: 0.5 mm/s, Test Speed: 0.5 mm/s, Post-Test Speed: 10.0 mm/s, Return Distance: 5 mm, Applied Force: 5 g, Contact Time: 0.1s,Trigger Type: Auto – 5 g (Chen and Hoseney, 1995). The measurement was performed on triplicate samples from each condition and three measurements were performed on each replicate.

Figure 2: Texture Analyzer

Results and discussion

Stickiness value of the cookie dough

Stickiness value obtained by the Texture Analyzer for different ratio of oat to flour and resting time were tabulated in Table 3.

Table 3: Stickiness value on different oat to flour ratio

Resting time (min)	Ratio 1:1	Ratio 1:1.25	Ratio 1:1.5	Ratio 1:1.75	Ratio 1:2
10	-144.5	-146.1	-135.2	-129.3	-131.1
20	-125.3	-143.2	-114.6	-27.4	-46.6
30	-129.0	-169.5	-113.3	-17.5	-38.4
40	-142.2	-164.7	-114.4	-22.6	-63.3
50	-137.0	-186.3	-134.0	-54.2	-81.0

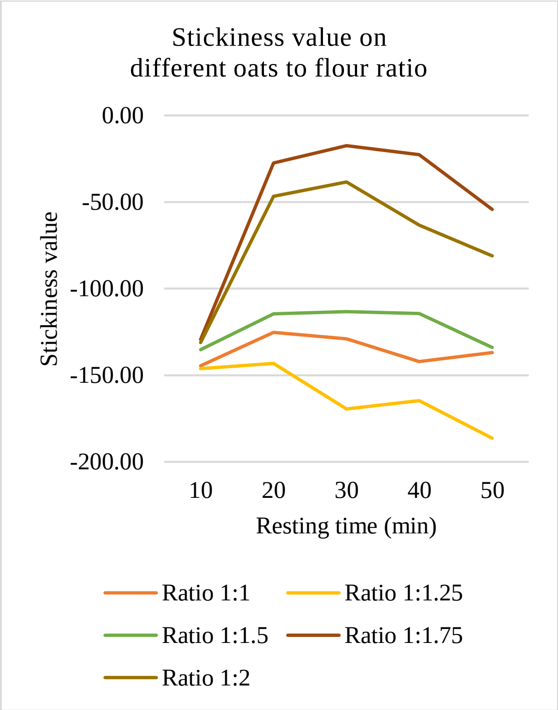


Figure 3: Graph stickiness value on different oat to flour ratio vs resting time

In order to enhace the cookie's quality, it is crucial to understand the function of the ingredients such as dietary fiber in the cookie. Based on Figure 3, it shows that the different ratio of oat to flour had a significant effect on the dough stickiness where cookie dough with ratio 1:1.75 have the highest stickiness value while cookie dough with ratio 1:1.25 have the lowest stickiness value.
Preliminary research using different ratio of oat to flour with different resting time showed that the best cookie dough with 2 and 2.5 cups of oat and flour, which indicated the lowest stickiness among the mixed cookies.
Based on Figure 3, the dough stickiness can be grouped into 3, where ratio 1:1.75 and 1:1.2 as high stickiness, ratio 1:1.15 as moderate stickiness and ratio 1:1 and 1:1.25 as less stickiness.
This is due to the starch content from the flour, where the higher flour used in the dough means that there are higher starch content. The starch is is hydrophilic which caused the dough to absorb moisture easily. Thus, the higher the flour content,

the higher the stickiness of the cookie dough due to the higher moisture content.

Dough stickiness value are evaluated to examine the adhesion force of the cookie dough. Dough with higher stickiness value indicates higher adhesive forces while the low stickiness value indicate lower adhesive value (Avramenko, 2017). Hence, the result as shown in Figure 3 shows that the formulation of different oat to flour ratio vs resting time.

Conclusion:

There are many parameters that influence the determination of stickiness value of the cookie dough with different composition. In food industry, one of the major issues in finding out the dough stickiness is that there is no standardized standard for measurement of the stickiness value. The current study indicated a high potential in developing fibre-rich cookies with large inclusion with composition of 1:1.25 of oats and flour respectively. The increasing of oat and flour content in the formulation show a significant effect on dough stickiness.

References:

Adhikari, B., Howes, T., Bhandari, B. R. and Truong, V. (2001). Stickiness in foods: A review of mechanisms and test methods. International Journal of Food Properties 4(1): 1–33.

Avramenko, N.A. (2017). Investigating structure-function relationships of dough stickiness within low sodium bread dough formations page 79-82.

Chen, W. Z. and Hoseney, R. C. 1995. Development of an objective method for dough stickiness. LWT - Food Science and Technology 28(5): 467–473.

Dobraszczyk, B. J. 1997. The rheological basis of dough stickiness. Journal of Texture Studies 28(2): 139–162.

Grausgruber, H., Hatzenbichler, E. and Ruckenbauer, P. (2003). Analysis of repeated stickiness measures of wheat dough using a Texture Analyzer. Journal of Texture Studies 34(1): 69–82.Salma, I. (2011). Durio of Malaysia, 166 p.Serdang: MARDI Press

Hoseney, R. C. and Smewing, J. (1999). Instrumental measurement of stickiness of doughs and other foods. Journal of Texture Studies 30(2): 123–136.

McManuis R. (2001). Using instrumental texture analysis to ensure product quality. Cereal Foods World 46:517-518.

Meullenet JFC, Carpenter JA, Lyon BG, Lyon CE. (1997). Bicyclical instrument for assessing texture profile parameters and its relationship to sensory evaluation of texture. J Texture Studies 28:101-118.

Norimah, A.K., Safiah, M., Jamal, K., Siti Haslinda, Zuhaida, H., Rohida, S., Fatimah, S., Siti Norazlin, Poh, B.K., Kandiah, M7, Zalilah, M.S., Wan Manan, W.M., Fatimah, S. & Azmi, M.Y. (2008). Food consumption patterns: Findings from the Malaysian adult nutrition survey (MANS). Mal. J. Nutr. 14(1): 25-39.

Yildiz, O., Meral, R. and Dogan, I. S. (2012). Determination of stickiness values of different flour combinations. International Journal of Food Engineering 8(3). Article 37.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE11

Effect Of Storage Duration On The Color Value Of Sweet Potatoes (*Ipomoea batatas*)

Nurfarhana, S.[1] , Rosnah, S.[1,2*],Mohd. Zuhair, M.N.[1], Norhashila, H. [3], Azman, H. [4]
[1] Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[2] Institute of Advanced Technology, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3] Department of Agriculture and Biology, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[4] Pusat Penyelidikan Kejuruteraan, Ibu Pejabat MARDI, Persiaran MARDI, UPM, 43400 UPM Serdang, Selangor, Malaysia
**Corresponding author, Tel.: +603-89466366, Email: rosnahs@upm.edu.my*

Abstract
Sweet potato (Ipomoea batatas) is a cultivar belongs to the family of Convolvulaceae, a herbacous and woody species. This cultivar is recommended as a superior source for the production of foods with health benefits.The quality of sweet potatoes must be maintained especially during postharvest storage to ensure its health benefits not affected. Colour is an important parameter which reflects the quality of sweet potato in terms of appearance and nutrients.Therefore, the effect of storage duration on the colour of sweet potato after exposure for ten days at room temperature were investigated. The colour parameters in terms of L-,a-,b-values, Hue and Chroma were determined using colour reader (CR-10,Conica Minolta, Japan). A significant ($p < 0.05$) decreased about 8% and 28.64% was observed in L-values and a-values respectivley after 10 days of storage. The b-values and hue increased significantly ($p < 0.05$) by 26.49% and 43.28% respectively. However, the chroma value shows no significant different during the storage. Therefore, this finding indicates that storage time significantly effects the color value of sweet potatoes. This knowledge will offer potential application in sweet potatoes industry especially in developing a system to maintain the freshness and quality of sweet potatoes during the storage.

Keywords: Sweet potatoes, storage, CIE Lab value, colour change

Introduction

The sweet potatoes (*Ipomoea batatas*) or locally known as "Ubi Keledek" is one of the most important staple food in the world that approximately 80-90% of the dry matter (DM) is composed of carbohydrates (Vincent, 2009). It can be in fusiform globular, round or ovate in shape, with a smooth, ridged or rough surface. Its skin colour varies from white to yellow, orange, red, purple or brown and flesh may be white, yellow, orange, reddish or purple (Vincent,2009). The weight usually about 150 to 250 g (Rosnani et.al, 2017).

In 2017, Malaysian Agriculture Research and Development Institute (MARDI) had reported that 2,799.85 ha of sweet potatoes's plantation area leads to the production of 43,211.8 metric tons per year. It is also been stated that the production value for this crop is equivalent to 70.867 million Ringgit Malaysia/17.1 million US$ with the average production yield of 16.7 tons/ha. In order to increase the production of sweet potatoes in Malaysia, MARDI had also developed three varieties of purple flesh sweet potatoes known as Anggun 1, Anggun 2 and Anggun 3. These varieties classified based on shape of leaves and roots. The advantages of these varieties are high in anthocyanin content (185 – 316 mg/L), ability to survive in low fertility soil and resist to disease (Rosnani et.al, 2017).

The first quality of food usually determines based on its visual appearance. Appearance analysis of foods (colour, taste, odour and texture) are used in maintenance the food quality throughout and at the end of processing (Medeni, 2001). Colour is one of the most important appearance contribute to the customer acceptability. CIE L*a*b* color space is a system defined by the Commision Internationale de I'Eclairage (CIE), used to evaluate the lightness (L), red/green (a) coordinates and yellow/blue (b) coordinates. The study shown that L values of peel colour of sweet potatoes ranged from 28.7 to 63.1, while a and b values ranging from 6 to 16.9 and 4 to 19.3 respectively (Adebisola et al., 2009). Picha(1985) reported that lighter colour chip of sweet potatoes have higher total carotenoid content. However, storage also has a substantial influence on the final quality of fruit, as it affects the appearance and induces colour change (Dobrzañski et al., 2001; Kader, 1999; Kameoka et al., 1994). Storage conditions such as duration, temperature and humidity influenced in keeping the food products in a good quality (Dobrzañski et. Al, 2002). Vincent stated that tubers can be stored at 30^{0}C and 90-98% relative humidity for 4-7 days with good ventilation. The storage duration for sweet potatoes can be up to to 3 months in ventilated village storage structures in which the relative humidity may be controlled at ambient temperature (Data et al., 1987). Temperature of storage can influence colour and texture, mainly through its effect on respiration (Alvarez et al., 2000; Laza et al.,2001 and Nourian et al.,2003a). Temperature below $5^{0}C$ inhibit respiration but continued hydrolysis of starch leads to the accumulation of reducing sugars, to the detriment of colour, flavour and texture (Blenkinsop et al.,2002;Chourasia et al.,2001;David et al.,2004). However, according to Uritani, Data and Tanaka (1984), the storage temperature lower than $8^{0}C$ may cause chilling injuries. While temperature above $21^{0}C$ increase respiration and prevent accumulation of reducing sugars but cause spoilage (Cheftel et al.,1992). Jenkin stated that when tubers are stored at $24\text{-}35^{0}C$, only 20-25% losses occured.

To the best of our knowledge, there is a limited number of research on the effect of storage duration on colour of sweet potatoes at room temperature. Therefore, as storage condition (duration and temperature) may affect the colour of sweet potato, the present study aims to appraise the effect of storage duration on color value of sweet potatoes at room temperature.

Materials and methods

Preparation of sample

Sweet potato was obtained from a farm at Semenyih, Selangor. Variability of the raw material were minimized by selecting the sweet potatoes from the same variety known as Anggun 1 and it was harvested once reached commercial maturity stage which normally 3 months after planting. Sample was completely washed with tap water immediately to remove soil adhesion and other extraneous material; then air-dried. Three fresh roots selected in weight of 150-250 g/root size and stored at room temperature for 10 days.

Colour measurement

The surface colour of fresh tubers were evaluated visually by using colour reader (CR-10,Conica Minolta, Japan) at room temperature. The color values were measured at three different locations on the surface of tubers as shown in Figure 1. The colour values were expressed as L* a* b*. The average values of three replications were reported. The tubers must be placed completely in contact with the light port of colour reader to avoid any light leakage hence affect the reading of the data. Chroma (C) and hue angle colour parameters were calculated as below (Pankaj et al., 2012):

$$C = \sqrt{a^2 + b^2} \quad (1)$$

$$H = Tan^{-1}\left({}^{b}/_{a}\right) \quad (2)$$

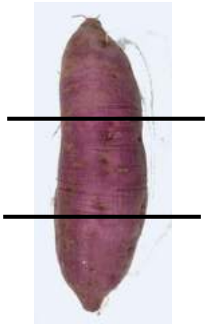


Figure 1: Longitudinal section of fresh Anggun 1 sweet potatoes

Statistical analysis

The data collected were analyzed using SPSS Statistics 21.0 edition whereby Duncan's test was tested to evaluate the significant difference between mean values.

Results and discussion

Colour is an important quality attributes in the food and bioprocess industries as it influences consumer's choice and preferences (Pankaj et al., 2012). CIELAB colour scales were opponent-type systems commonly used in the food industry in order to monitor and control product quality (Pereira et al., 2009; Yu et al., 2003). Colour parameters L, a, b, chroma and hue are the common quatitative values attribute to the colour analysis. These parameters were affected by the storage duration of the samples.

Colour parameters L, a, b

Table 1 shows the effects of different storage duration on the colour of Anggun 1 at room temperature. From Table 1, it shows that the original colour parameters L, a, b which is during 0 day were 44.40 ± 1.66, 12.90 ± 3.43 and 11.07 ± 3.43 respectively. These results are in line with the values reported by Adebisola et al. (2009).

L is used in colour coordinates to denote the psychometric index of lightness (Pankaj et al.,2012). The lightness of Anggun 1 during 10 days of storage ranged from 45.37 ± 0.83 to 41.73 ± 0.77 at room temperature. The L-values of the samples were decreased gradually as a function of storage time. The L-value of the samples after 10 days (41.73 ± 0.77) showed significantly ($p < 0.05$) lower than 0 day (45.37 ± 0.83). A decline trend also reported by Marti (2004), where the L-values of sweet potatoes decrease from 50.1 to 49.3 during the storage. Since the L-value is a measure of the colour in the light-dark axis, the decreasing value indicates that the samples were turning darker and conversely. This change might be due to the respiratory activity and browning reaction (Hernandez et al., 2014) which increase during the storage.

The parameter a-values used to indicate the reddish colour (positive values) and greenish colour (negative values). The reddish colour normally related to the water soluble anthocyanin while green colour showed the fat soluble chlorophyll (Jackson, 2016). In Table 1, the result shows the redness (a-value) with the decreasing trend during the storage from the 14.00 ± 1.32 to 9.99 ± 1.08. The a-values showed a significant decreased ($p < 0.05$). These decreasing values in redness of the samples can be linked with the degradation of red anthocyanin pigments (Carolien et al., 2017).

The b-value is a measurement for yellowish colour (positive values) and bluish colour (negative value). The yellowish colour related to carotenoids and flavonoids pigments while bluish colour linked to anthocyanin content. Table 1 shows that b-values ranged from 11.21 ± 0.66 to 14.18 ± 0.61 during 10 days of storage. The b-values increased by 26.49 % after 10 days of storage. Significant different ($p < 0.05$) was observed between 10 days and 0 day of storage. Due to this increment, it might be dependent on the concentration of the beta carotene pigment in the samples (Woolfe, 1992). Therefore, the increasing trend may due to the decomposition of carotenoid pigments in sweet potatoes (Kostaropoulus & Saravacos, 1995; Lee & Coates, 1999; Weemaes et. al., 1999).

Table 1: Colour value of Anggun 1 as affected by different storage duration.

Time (day)	L	a	b	Chroma	Hue
0	45.37 ± 0.83 ^{a}	14.00 ± 1.32 ^{a}	11.21 ± 0.66 ^{a}	17.94 ± 1.39 ^{a}	0.67 ± 0.03 ^{a}
2	44.15 ± 0.80 ^{a}	12.94 ± 1.12 ^{ab}	12.55 ± 0.79 ^{b}	18.05 ± 1.02 ^{a}	0.77 ± 0.05 ^{b}
4	42.84 ± 0.25 ^{b}	12.13 ± 1.39 ^{abc}	12.91 ± 0.37 ^{b}	17.73 ± 1.13 ^{a}	0.82 ± 0.05 ^{bc}
8	41.79 ± 0.76 ^{b}	11.09 ± 1.43 ^{bc}	13.02 ± 0.51 ^{b}	17.11 ± 1.22 ^{a}	0.87 ± 0.05 ^{c}
10	41.73 ± 0.77 ^{b}	9.99 ± 1.08 ^{c}	14.18 ± 0.61 ^{c}	17.63 ± 1.06 ^{a}	0.96 ± 0.03 ^{d}

Result were expressed as mean ± standard deviations (n = 3).
Values sharing different letters (a,b,c,d) within the column are expressed as significantly different ($p < 0.05$) during the storage time.
L* values indicates lightness of the samples; 100 = white, 0 = black
a* values designate redness when positive; greeness when negative.
b*values represent yellowness when postive, blueness when negative

Chroma and hue

Chroma and hue values were calculated using Eqs. (1)-(2) respectively and shown in Table 1. The chroma value attribute to the degree of difference of a hue in comparison to a grey colour with the same lightness. The higher the chroma values, the higher is the colour intensity of samples recognized by humans (Pankaj et al., 2012). The chroma values ranged from 17.94 ± 1.39 to 17.63 ± 1.06 during 10 days of storage at room temperature. Slightly changes about 0.61% was found in chroma values during 2 days of storage that indicates stability of yellow colour in Anggun 1 (Barreiro et al., 1997; Lee at al., 1999; Palou et al., 1999). However, the influence of storage time was not significant ($p > 0.05$) on the chroma values. The finding of chroma value in the current study was in contrast with a study done by Marti (2004), which reported chroma values decreased over storage time from 27.7 to 25.8. This might be due to the different types of cultivar, geographical location and storage condition.

Another colour parameter, hue angle is attributed to which colours have been traditionally defined as reddish, greenish and others. It used to determine the difference of a colour with reference to grey colour with the same lightness (Pankaj et al., 2012). Table 1 showed the hue ranged from 0.67 ± 0.03 to 0.96 ± 0.03 after 10 days of storage. Significant increased ($p < 0.05$) was observed in hue values during 10 days of storage. This increment was in linked with the b-values. These values suggested the stability colour in orange-red angle as stated by Maskan (2001), green colour (when Hue > 90^{o}C) and orange-red (when Hue < 90^{o}C). This result was parallel to that conveyed by Marti (2004), which revealed that the hue increased linearly over time of storage.

Conclusion

In this research, the effect of storage duration on changes in colour values of Anggun 1 at room temperature was systematically investigated. All colour parameters were influenced significantly from the storage duration except for chroma. The result suggested that after 10 days of storage, respiratory and browning reaction increased as the value of L decreased. The decreasing trend redness (a-values) also can be linked to the degradation of anthocyanin content. The yellowness (b values) of Anggun 1 increased during the storage as related to the decomposition of carotenoid pigments. Hue values were in line with b-values as both result showed that the stability of yellowness in Anggun 1.

Acknowledgement

The authors express their gratitude to the Universiti Putra Malaysia for providing financial and technical support under grant GP-IPB/2018/9660301 to conduct this research work.

References:

Adebisola J. Aina, Kolawole O. Falade, John O. Akingbala & Pathelene Titus. (2009). Physicochemical properties of twenty-one Caribbean sweet potato cultivars. International Journal of Food Science and Technology, 44, 1696 – 1704.

Alvarez, M.D. and Canet, W. 2000. Storage time effect on the rheology of refrigerated potato tissue (cv. Monalisa). European Food Research and Technology, 212: 48–56.

Barreiro, J. A., Milano, M., & Sandoval, A. J. (1997). Kinetics of colour change of double concentrated tomato paste during thermal treatment. Journal of Food Engineering, 33, 359±371.

Brands, C. M. J., and van Boekel, M. A. J. S. (2001). Reactions of monosaccharides during heating of sugar−casein systems: Building of a reaction network model. Journal of Agricultural and Food Chemistry 49(10), 4667–4675.

Blenkinsop, R.W., Copp, L.J., Yada, R.Y. and Marangoni, A.G. 2002. Changes in compositional parameters of tubers of potato (Solanum tuberosum) during low-temperature storage and their relationship to chip processing quality. Journal of Agricultural Food Chemistry, 50: 4545–4553.

Carolien Buv, Biniam T. Kebede , Cedric De Batselier , Celia Carrillo, Huong T.T. Pham , Marc Hendrickx , Tara Grauwet and Ann Van Loey. 2018. Kinetics of colour changes in pasteurised strawberry juice during Storage. Journal of Food Engineering, 216, 42 – 51.

Cheftel, J.C. and Cheftel, H. 1992. Introducción a la bioquímica y tecnología de los alimentos, Zaragoza, , Spain: Ed. Acribia.

Chourasia, M.K. and Goswami, T.K. 2001. Losses of potatoes in cold storage vis-à-vis types, mechanism and influential factors. Journal of Food Science and Technology—Mysore, 38: 301–313.

Data, E.S., Diamente, J.C., and Eronico, P.S. 1987. Postharvest handling and storability of sweet potato roots. International sweet potato workshop, Visayas State College of Agriculture, Philipines. 19p.

Davids, S.J., Varoujan, V.A., Yaylayan, A. and Turcotte, G. 2004. Use of unusual storage temperatures to improve the amino acid profile of potatoes for novel flavoring applications. Lebensmittel-Wissenschaft und-Technologie, 37: 619–626.

Dobrzañski, jr. B. and Rybczyñski R., 2001a. Physical description of the fruit colour in apple quality grading (in Polish). Acta Agrophysica, 37, 17–27.

Dobrzañski, jr. B. and Rybczyñski R., 2002. Colour change of apple as a result of storage, shelf-life, and bruising. Int. Agrophysics, 16, 261-268.

FAO., 2016. Statsitical databases. Food and Agriculture Organization of the United Nations, Rome, Italy.

H.R. Marti. 2004. Short communication. Effects of storage time and boiling on root tuber colour in two sweet potato [Ipomoea batatas L. (Lam.)] cultivars. Spanish Journal of Agricultural Research 2(4), 570-575.

Hernandez-Herrero, J. A., & Frutos, M. J. (2014). Colour and antioxidant capacity stability in grape, strawberry and plum peel model juices at different pHs and temperatures. Food Chemistry, 154, 199e204.

Kameoka T., Hashimoto A., and Motonaga Y., 1994. Surface color measurement of agricultural products during postripening. Color Forum Japan'94, Proc., 11–14.

Kostaropoulos, A. E., & Saravacos, G. D. (1995). Microwave pretreatment for sun-dried raisins. Journal of Food Science, 60, 344± 347.

Laza, M., Scanlon, M.G. and Mazza, G. 2001. The effect of tuber pre-heating, temperature and storage time on the mechanical properties of potatoes. Food Research International, 341: 659–667.

Lee, H. S., & Coates, G. A. (1999). Thermal pasteurization effects on color of red grapefruit juices. Journal of Food Science, 64, 663±666.

Medeni Maskan. (2001). Kinetics of colour change of kiwifruits during hot air and microwave drying. Journal of Food Engineering, 48 , 169 ± 175.

Nourian, F., Ramaswamy, H.S. and Kushalappa, A.C. 2003a. Kinetic changes in cooking quality of potatoes stored at different temperatures. Journal of Food Engineering, 60: 257–266.

Palou, E., Lopez-Malo, A., Barbosa-Canovas, G. V., Welti-Chanes, J., & Swanson, B. G. (1999). Polyphenoloxidase activity and color of blanched and high hydrostatic pressure treated banana puree. Journal of Food Science, 64, 42±45.

Pankaj B. Pathare , Umezuruike Linus Opara, Fahad Al-Julanda Al-Said. 2013. Colour Measurement and Analysis in Fresh and Processed Foods: A Review. Food Bioprocess Technol, 6, 36 – 60.

Pereira, A. C., Reis, M. S., & Saraiva, P. M. (2009). Quality control of food products using image analysis and multivariate statistical tools. Industrial and Engineering Chemistry Research, 48(2), 988–998.

Picha, D.H. 1985b. Crude protein, minerals and total carotenoids in sweet potatoes. J. Food Sci. 50: 1768.

Rosnani, A.G. 2017. Manual Teknologi Pengeluaran Ubi Keledek Ungu Anggun. Malaysia: MARDI

Uritani, I., Data, E.S., and Tanaka, Y. 1984. Biochemistry of postharvest deterioration of cassava and sweet potato roots. In: Uritani, I., and Reyes, E. D. ed. Tropical Roots Crops- Postharvest Physiology and Processing, Japan Scientific Societies Press, 61-75.

V.Lebot (2009). Tropical root and tuber crops Cassava, Sweet Potato, Yams and Aroids. UK: MPG Books Group

Weemaes, C., Ooms, V., Indrawati, , Ludikhuyze, L., Van den Broeck, I., Van Loey, A., & Hendrickx, M. (1999). Pressure±temperature degradation of green color in broccoli juice. Journal of Food Science, 64, 504±508.

Woolfe, J.A. (1992). Sweet Potato An Untapped Food Resource. Pp. 1–12. Cambridge: Cambridge University Press.

Yu, H., MacGregor, J. F., Haarsma, G., & Bourg, W. (2003). Digital imaging for online monitoring and control of industrial snack food processes. Industrial and Engineering Chemistry Research, 42(13), 3036–3044.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE13

Effects of Conventional Storage Method on *Geniotrigona thoracica* Stingless Bee Honey Properties

Nashratul Shera, M. G.[1], Yus Aniza, Y.[1,2]*, Hasanah, M. G.[3], Nyuk Ling, C.[1], Siti Hajar, O.[1], Lee Sin, C.[3] and Yanty Noorzianna, A. M.[2]
1Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
2Laboratory of Halal Services, Halal Products Research Institute, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
3Department of Food Science, Faculty of Food and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
**Corresponding author. Tel.:+60389464425, Email: yus.aniza@upm.edu.my*

Abstract

Most of stingless bee honey contains high moisture content that can easily lead to honey fermentation. This study aims to investigate the applicable of conventional storage method on stingless bee (Geniotrigona thoracica) honey and its effect on storage stability. The Geniotrigona thoracica honeys were stored in a glass bottle at 25˚C for 21 days. The samples were subjected to physicochemical analysis such as moisture content, water activity, viscosity, pH, free acidity, electrical conductivity, colour (L, a* and b*) and colour intensity. The results obtained indicated that the honey stored in glass bottle slowly reduced the moisture content. The moisture content of honey stored at 25˚C in a glass bottle was reduced from 28.03% to 27.25%. The free acidity of honey increase significantly from106.7 meq/kg to146.3 meq/kg. In conclusion, the amount of water content of honey stored in glass bottle was not largely reduced and consequently changes the physicochemical properties of honey.*

Keywords: Honey, stingless bee, *Geniotrigona thoracica*, moisture content, physicochemical analysis

Introduction

Geniotrigona thoracica (*G. thoracica*) is a species of stingless bees found in Malaysia that have commercial value. *G. thoracica* stingless bee produced honey that naturally acidic and varies according to the geographical and botanical origins (Abdul Aziz, Giribabu, & Rao, 2017)**.** Stingless bee honey chemically consist of carbohydrates, especially glucose and fructose, organic acids, amino acids, minerals, vitamins, enzymes, pollen and pigments (Carvalho, Fonseca, Souza, & Clarton, 2009). Some of the vitamins found in honey include ascorbic acid, pantothenic acid, niacin and riboflavin; along with minerals such as calcium, copper, iron, magnesium, manganese, phosphorus, potassium and zinc that are important for health and nutritional value (Ajibola, Chamunorwa, & Erlwanger, 2012). Stingless bee honey acts as wound healing agent and has a lot of similarities with other honeys in terms of its bioactive components (Abd Jalil, Kasmuri, & Hadi, 2017).

However, the moisture content of stingless bee honey is well-known to be higher that the moisture of other honeys such as *Apis mellifera* honey that can lead to unwanted fermentation (Oddo et al., 2008; Chuttong et al., 2016). Honey has the ability to absorb and hold moisture from surrounding which is known as hygroscopicity. The environmental factors during production such as weather and humidity inside the hives also plays important role to final moisture content of honey (Olaitan, Adeleke, & Ola, 2007). For good quality *Apis mellifera* honey, the International Honey Commission (IHC) has set the threshold in term of moisture which is 20 g/100 g but most of stingless bee honey exceeds the limit.

Therefore, this study is to investigate the effect of conventional storage method in Malaysia which the honey stored in glass bottle on physicochemical properties of *G. thoracica* stingless bee honey during storage time.

Materials and methods

1) Materials:

Geniotrogona thoracica stingless bee honey was obtained from Faculty of Forestry, Universiti Putra Malaysia. The clay pots are custom-made and obtained from Belipot Craft Sdn Bhd, Kota Bharu, Kelantan.

2) Sampling

1.05kg of *G. Thoracica* honey was divided in 21 identical glass bottles. Each bottle filled with 50g of *G. Thoracica* honey. Then, the glass bottles were divided to 7 testing days for storage period of 0, 1, 3, 5, 7, 14 and 21 days. The samples were stored at 25˚C.

3) Physicochemical Analysis

i) Moisture content and total soluble solid

Moisture content of honey was obtained with a digital refractometer (Digital ABBE Refractometer AR2008, A.Kruss, Germany) at 20°C determining the corresponding moisture percentage by means of equation 1 (Sesta et al., 2008):

Moisture content (%) =
[-0.2681 –log (RI-1)]/0.002243
(1)

Where RI is the refractive index. The total soluble solids content in the honey samples is expressed in °Brix (Amin, Safwat, & El-Iraki, 1999)

ii) pH and free acidity

pH and free acidity was determined according to the method described by Bogdanov, (2009). The pH is measured by using pH meter (Milwaukee, Mi 805, USA). The pH meter was calibrated with pH 4.00 and pH 7.00 buffer solutions. 10g of honey was dissolved in 75ml deionized water for the analysis. pH electrode was immersed in the solution and pH value was recorded. Then, the solution was titrated with 0.1M NaOH solution until the pH reach 8.3 (end-point of phenolphthalein) to determine the free acidity in the sample.

iii) Water activity

Water activity (aw) was measured by using water activity meter (Aqualab CX2, Decagon Devices Inc, WA, USA). 2g of honey was placed in the sample dishes and measured at room temperature (25˚C).

iv) Viscosity measurement using rheometer

Steady state measurements of honey was measured by using a rheometer (AR-G2, TA Instrument, New Castle, USA) and equipped with a software (TA Instrument Advantage TM software). 60mm diameter plate geometry and 1° steel cone angle was used to determine the viscosity of the honey. Steady state measurements was conducted at 1-1000 s-1 shear rate and plate gap of 1000µm at temperature 20°C. Circulated water system was used to control the temperature. 2g of honey was placed onto the sample plate. Data was obtained by calculating the average of 30 points. The experiment was measured twice for each sample and test was conducted at room temperature (25°C) (Chong, Chin, & Yusof, 2017).

v) Colour intensity

An UV-VIS spectrophotometer was used to determine the colour of honey according to the method described by Maria et al., (2016). Honey is diluted to 50 g/100 ml. About 2 ml of sample is placed in quartz cell and read at 636 nm and the white (or reference cell) was provided by ultrapure water. The colours were classified in the Pfund scale by using the formula:

mm Pfund = -38.7 + 371.39 x Abs

vi) Colour difference

Visual or optical colour was measured by using an Ultrascan PRO Spectrophotometer (Hunterlab, Reston, Virginia) in three aspects L* (lightness), a* (redness and greenness) and b* (yellowness or blueness). The instrument was calibrated with light trap and white tile prior to the measurement of the samples. Port plate of 0.780 inches was used. 30g of honey sample was poured into optically clear glass cell (20mm depth x 55 mm width x 57 mm height). Glass cell with samples was placed on the reflectance sample shelf and covered with light cover before being measured with EasyMatch QC software (Quek et al., 2012). Colour difference was measured using the formula as in equation 2:

$$\Delta E=\sqrt{\left(L^*-L_0^*\right)^2+(a^*-a_0^*)^2+\left(b^*-b_0^*\right)^2}$$
(2)

Where L*, a* and b* denoted as colour of the stingless bee honey after treatment and L_0*, a_0* and b_0* indicated the colour of honey before treatment.

Results and discussion

Physicochemical Properties

The moisture content of fresh honey on day 0 was 28.03%±0.18 and decreased to 27.25%±0.15 on day 21. There was only 0.77% of moisture loss during the storage of 21 days. This result showed that honey stored in glass bottle will maintain the moisture content and slowly reduced it in time. Glass bottle is a non-porous material that cause moisture cannot be evaporated or loss to environment. Total soluble solid of honey is related with moisture content so it also showed the same trend. The total soluble solid increased from 70.5%±0.1 on day 0 to 71.3%±0.1 on day 21.

The result for pH value of honey indicates its acidity which 3.43±0.01 on day 0 and 3.16±0.01 on day 21. The Malaysian Standard has set an acceptable pH range of 2.5 to 3.8 for stingless bee honey which shows that honey stored in glass bottle after 21 days was still in a good quality. The free acidity of honey increased rapidly from 106.7meq/kg ±0.6 on day 0 to 146.3meq/kg±1.5. This result indicates that honey undergo fermentation process which convert the sugar into organic acids. The water activity of honey showed to remain the same from 0.779±0.001 on day 0 to 0.774±0 on day 21.

The changes of colour parameters of *G. thoracica* honey during 21 days of storage time are shown in Figure 3. All parameters showed the decreasing value from day 0 to day 21 of storage period. The a* value decreased from 2.25±0.02 to 1.86±0.05 on day 0 and day 21, respectively. The b* value decreased from 2.93±0.08 on day 0 to 0.90±0.15 on day 21. The L value decreased from 26.48±0.03 to 24.98±0.07. This indicates that the *G. thoracica* honey was darker throughout the storage period. The colour difference, ΔE showed an increasing trend from day 0 to day 21. The colour intensity of stingless bee honey increased steadily during storage from 121.6±1.2 on day 0 to 146.3±1.0 on day 21. The viscosity of stingless bee honey increased slightly during the storage period.

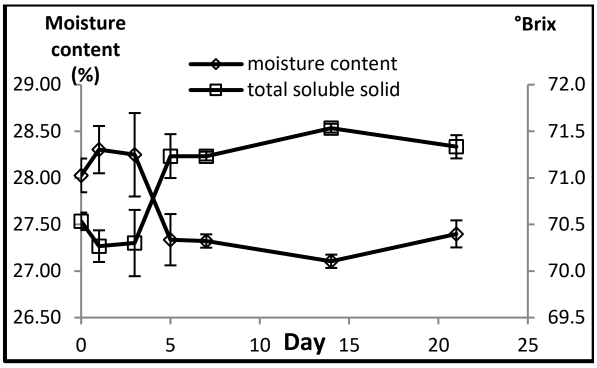


Figure 1: Profile of water reduction and total soluble solid during storage period

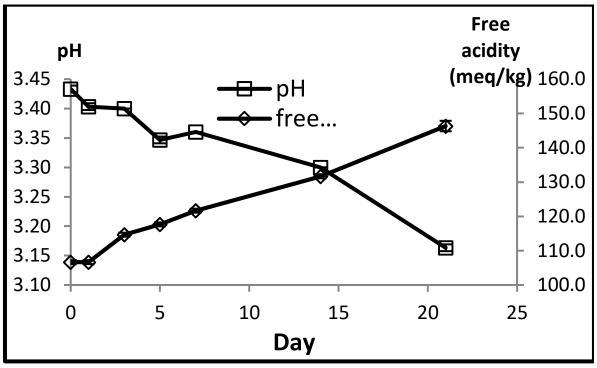


Figure 2: pH and free acidity during storage period

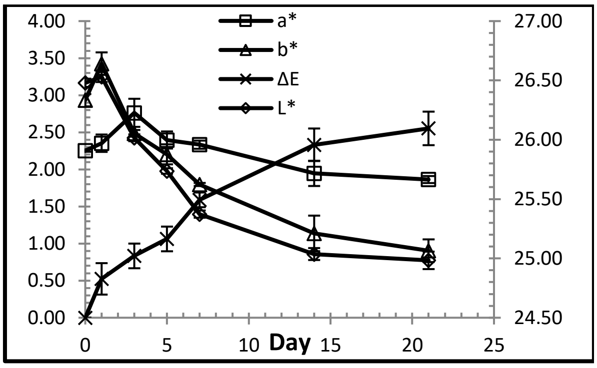


Figure 3: Colour parameter of stingless bee honey during storage period

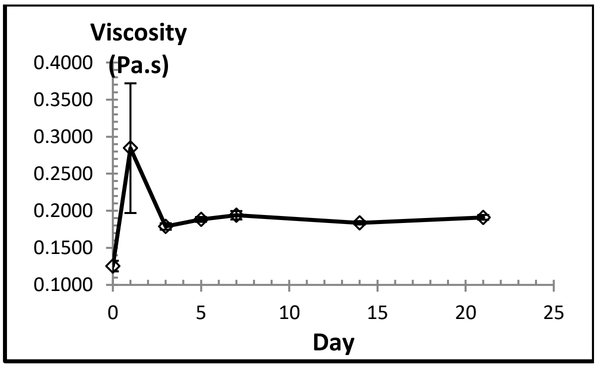


Figure 4: Viscosity of stingless bee honey during storage period

Conclusion:

Storage of stingless bee honey in glass bottle does not make any significant reduction of moisture content. Some physicochemical characteristic of *G. thoracica* changed; free acidity increases significantly during storage period that indicates fermentation of honey. For a better storage of honey, it is suggested to store at low humidity condition and the glass sealed tightly. Therefore, honey will not absorb the water at surrounding since it has the hydroscopic properties.

Acknowledgement:

The authors thank to Ministry of Education Malaysia for the Transdisciplinary Research Grant Scheme with Vote number: 5535708 for the research funding.

References:

Abd Jalil, M. A., Kasmuri, A. R., & Hadi, H. (2017). Stingless Bee Honey , the Natural Wound Healer : A Review, *25200*, 66–75. https://doi.org/10.1159/000458416

Abdul Aziz, M. S., Giribabu, N., & Rao, P. V. (2017). Pancreatoprotective effects of Geniotrigona thoracica stingless bee honey in streptozotocin-nicotinamide-induced male diabetic rats. *Biomedicine et Pharmacotherapy*, *89*, 135–145. https://doi.org/10.1016/j.biopha.2017.02.026

Ajibola, A., Chamunorwa, J. P., & Erlwanger, K. H. (2012). Nutraceutical values of natural honey and its contribution to human health and wealth, 1–12.

Carvalho, C. A. L., Fonseca, A. A. O., Souza, B. A., & Clarton, L. (2009). Physicochemical characteristics and sensory profile of honey samples from stingless bees (Apidae : Meliponinae) submitted to a dehumidification process, *81*, 143–149.

Chuttong, B., Chanbang, Y., & Sringarm, K. (2016). Effects of long term storage on stingless bee (Hymenoptera : Apidae : Meliponini) honey, *8839*(June). https://doi.org/10.1080/00218839.2016.1186404

Oddo, L. P., Heard, T. A., Rodríguez-malaver, A., Pérez, R. A., Fernández-muiño, M., Sancho, M. T., … Vit, P. (2008). Composition and Antioxidant Activity of Trigona carbonaria Honey from Australia. *Journal of Medicinal Food*, (June 2016). https://doi.org/10.1089/jmf.2007.0724

Olaitan, P. B., Adeleke, O. E., & Ola, I. O. (2007). Honey : a reservoir for microorganisms and an inhibitory, 159–165.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE14

Comparative proximate composition and cyanide contents of each parts of local cassava (*Manihot esculenta* Crantz)

Sarah, I.,[1], Rosnah, S[1,2*]., Mohd Noriznan, M. [2], Mohd Zuhair, M.N.[2], and Siti Salwa, A.G.[1]
[1]*Halal Products Research Institute, University Putra Malaysia, 43300 UPM Serdang, Selangor, Malaysia.*
[2]*Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.*
*Corresponding Author, Tel: +063 89466366, E-mail: rosnahs@upm.edu.my

Abstract
Each cassava parts, namely tuber, discarded tuber, leaves, stems, inner and outer peels of yellow cassava (Manihot esculenta Crantz) from Selangor, Malaysia were used in this study. The cassava plant portions such as the tubers, stems, peels, discarded tuber, and leaves were 50.06%,31.01%, 10.63%, 6.92 and 1.49% (w/w) respectively. Proximate analysis show that all the cassava parts had high dry matter content with stems had the highest dry matter (98.77±0.00) than other parts and the leaves had the least (93.89±0.06). There were significant differences (p<0.05) in crude protein, crude fat, crude fiber, ash, and carbohydrate. The leaves had the highest crude protein (28.02±0.10), crude fat (5.63± 0.12) and gross energy (4824.3 g/cal). Stems had the highest crude fiber (39.51±0.05), outer peels have the highest ash (14.59± 0.07) and tuber had the highest carbohydrates(92.66± 1.88) compared to other parts. All parts were observed to had no significant difference and have very low cyanide content (p>0.05).These results indicate that the leaves and the stems contained nutrients which can be included in the diet of animal after proper processing techniques that can lowering the cyanide content to the safe level.

Keywords: cassava parts, proximate analysis, cyanide, waste utilization

Introduction

Malaysia harvested 3400 ha of cassava in 2015, and the amount of wastes produced by the agricultural processing operations was 50%. Yearly, approximately 80000t of cassava wastes are discarded or burnt during post-harvesting at the factory site (Department of Agriculture Peninsular Malaysia, 2017). Most of the wastes is from the cassava chip factories which are given to the villagers as ruminant feed. However, without proper processing techniques, the livestock could die due to the high level of anti-nutrient contained in the various parts of cassava plant.

In the developing countries, cassava tuber serves as a major staple food and is a secured source of energy (Otache et al., 2017). Food is made up of different nutrients needed for growth and health, which include protein, carbohydrates, fat, water and minerals. Each nutrient has specific uses in the body. According to Thomas (2006), proper nutrient means that all nutrients are supplied and utilized in adequate amount to maintain optimal health and well-being.

Carbohydrates are consumed as a major source of energy. Carbohydrates are hydrolyzed in the body to produce glucose which can be used immediately, or stored as glycogen in the muscles and liver for future use (Okeke et al., 2008). When carbohydrates are consumed in excess of the body requirement, the excess is converted to fat and stored in the adipose tissues under the skin.

Protein is important in the body for the production of hormones, enzymes and blood plasma. They act as an immune booster and help in cell division and growth (Okeke et al., 2008). Fat yields more energy than carbohydrates. Dietary fat is important because of their high energy value and essential fatty acids contained in the fat of natural foods. Moisture or water content dissolves substances, carries nutrients and other materials throughout the body, making it possible for every organ to perform its function effectively (Ilodibia et al., 2014).

Fibers are parts of plants which cannot be digested nor absorbed by the human system (Agarwal and Rastogi, 1974). Dietary fibers role in the body to slow down the rate of sugar absorption into the bloodstream. They also reduce the levels of plasma cholesterol and prevent colon cancer and cardiovascular diseases (Davidson et al., 1975).

Ash content of plant-based food is the function of the mineral elements present. Dietary ash is proven to help in establishing and maintaining the acid-alkaline balance of the blood system and also in controlling hyperglycemia condition (Gokani et al., 1992). Nutritive value of cassava plant depends on the chemical composition and gross energy. One of the characteristics of cassava plants is the presence of natural nitrile ($^{-}$CN) compounds called cyanogens, which are in the form of linamarin (93%) and lotaustralin (7%). These precursors upon breakdown release the cyanide (HCN) which can be harmful to the consumer such as goiter, Tropical Ataxic Neuropathy, and kwashiorkor (Akintola et al., 1998). Various parts of cassava plants such as the tubers, stems, petioles, leaves, and peels are differentiated from one another by their chemical composition. Processing of cassava plants such as peeling, drying, soaking, and cooking is sufficient to eliminate all the toxicity.

Different parts of cassava plants have different nutrient and cyanide contents from one another. Evaluation of the nutrient compositions and cyanide contents of different parts of cassava plant thereby providing the nutritional data of some underutilized cassava wastes. The objective of this study was to determine the proximate analysis, gross energy, cyanide contents from every part of the cassava plant in Malaysia. The results are important in order to identify the edible parts of the cassava plant as the potential usage as ruminant feed. Furthermore, this will reduce the disposal of solid wastes of cassava plant in the field to minimize environmental pollution.

Materials and methods

Samples preparation

According to Steyn (1959), the samples were cleaned using tap water to remove soil. Then, the samples made up of tuber, discarded tuber, stem, peel, and leaf were cut using a sharp knive as in Figure 1. Each part was determined and reported as a percentage of the proportion of a cassava plant. After washing, the samples were hand-peeled and cut down to 2 to 3 cm. The samples were put into separately labelled clean trays, followed with oven-drying at 60 ℃ for 24 hr to preserve the nutritional content of the samples. All the samples were ground into powder and screen shived at 2mm and were stored in a desiccator until required. All the samples were used to analyze the proximate, gross energy and their cyanide content.

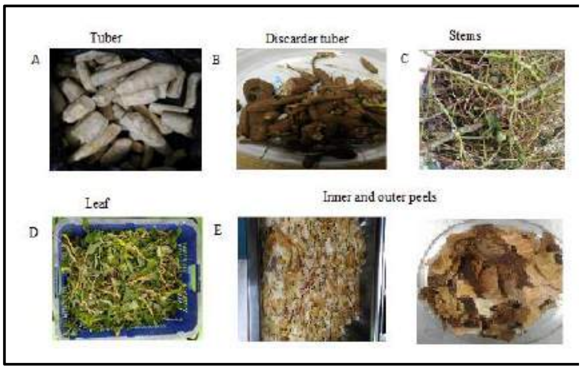


Figure 1: Morphology of cassava parts

Proximate Analysis

Dry matter content represents all the constituents in plant except water. In practice, dry matter is calculated from the formula 100−moisture content. Moisture content was determined according to AOAC (1990). Total ash was determined using a furnace at 525 °C for 6 hr. Crude fiber determined by using fibertec analysis (FibertecTM 2010, Foss Analytical; Denmark). Crude Protein is determined by Micro Kjeldahl method (N × 6.25). Crude Fat was obtained by using the Soxtec 2050 system, Hogan, Sweden apparatus. Carbohydrate content was determined by using the difference method. This method involves adding the total values of crude protein, fat, crude fiber, moisture, and ash constituents of the sample and subtracted it from 100.

Determination of gross energy

Gross energy of dried samples were determined using a Parr 1341 Oxygen Bomb Calorimeter. The samples were burnt in a closed container and heat produced from it was measured.

Cyanide analysis using picrate in solution method

The cyanide levels of each part of the samples was determined using picrate in solution method (Gervason et. al., 2017). 3.0 g of each part of the samples was dissolved in 5.0 mL distilled water. The samples were filtered and 0.04 mL of each extract was mixed with 2.0 mL alkaline picrate solution (obtained by dissolving 2.56 g moist picric acid and 5.0 g sodium carbonate in 100 ml of distilled water) and 1.96 mL distilled water. Then, the mixture was incubated in a water bath at 37°C for 15 min. Then, the mixture was added 15 µL of concentrated sulphuric acid. The mixture was read spectrophotometrically at 535 nm against a distilled water. The cyanide absorbance of the samples was extrapolated from a standard curve that was prepared by diluting potassium cyanide in water, with varies concentrations (0.0 to 0.05 µg/mL) as shown in Figure 2 using the equation of the standard graph Y = 0.0342x+ 0.0039 (R^2 = 0.9793) Where Y = Unknown concentration of the sample, 0.1528 = slope of the graph, x = absorbance.

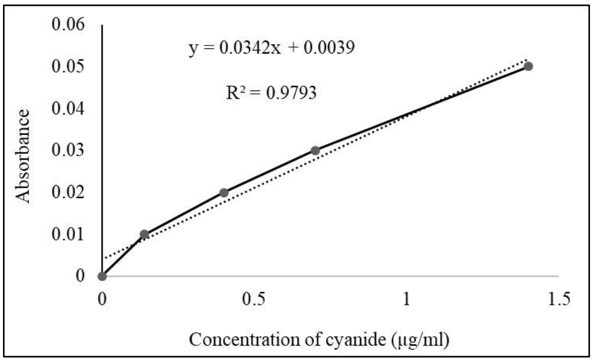


Figure 2: Cyanide standard curve

Amount of cyanide in the tested samples was calculated using the formula:

mg/Kg cyanide =

$$\frac{\mu g/mL \text{ of cyanide} \times \text{final volume (L)}}{\text{sample weight (Kg)}}$$

Where: ug/mL obtained from the KCN calibration curve; the final volume is the filtered extract; sample weight is the weight of the sample extracted.

Statistical analysis

The results were subjected to Analysis of Variance (ANOVA) using Minitab, version 17.0. Results are presented as Means±standard deviations. ANOVA was used for comparison of the means. Differences between means were considered to be significant at $p < 0.05$ using the Tukey test.

Results and discussion

The proportion of the cassava plant

Local cassava plant was divided into different parts as presented in Table 1. From the cassava wastes, the stems were the largest portion (31% w/w). Other proportions namely peels, discarded tuber and leaves were 5.14, 3.35 and 0.72 % (w/w), respectively. While cassava tuber was 50% (w/w). As a result, the cassava plant wastes (discarded tuber, stem, leaf and peel) accounted for 50% (w/w) of total cassava stems, 4701.55 Mt of peels, 30606.50 Mt of discarded tubers and 659.01 Mt of leaves are generated annually (Department of Agriculture Peninsular Malaysia, 2017).

Proximate analysis, gross energy, and cyanide content

Table 2 shows the results of the proximate analysis, gross energy and cyanide content of the cassava parts studied. The data show that the dry matter content is the highest component in all cassava parts, followed by total carbohydrate. Other components such as crude weight. In Malaysia, approximately 12711.01 Mt of stems, fiber, crude protein, ash, and crude fat were found to vary according to the different parts of plant.

Table 1: Proportion of local cassava parts

Cassava parts	Weight (Kg)	Percentage % (w/w)
Tuber	24.20	50.06
Stem	14.93	31.00
Peel	5.14	10.63
Discarded tuber	3.35	6.92
Leaf	0.72	1.49
Total	48.34	100

Table 2: Proximate analysis of different parts of local cassava plants

Cassava Parts	Dry matter (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	CHO (%)	Gross energy (cal/g)	HCN equivalent (mg/Kg)
Tuber	97.17 ±0.02[c]	1.75 ±0.01[d]	0.64 ±0.05[d]	2.11 ±0.03[f]	1.24 ±0.05[e]	92.66 ± 1.88[a]	4223.9 ±4.9[c]	0.00± 0.00[a]
Discarded tuber	95.97 ±0.02[d]	3.54 ±0.04[c]	0.75 ±0.05[c,d]	5.31 ±0.11[e]	2.94 ±0.00[d]	83.39 ±0.43[b]	3645.0 ±0.1[e]	5.99×10^{-3}± 0.00[a]
Stem	98.77 ±0.00[a]	5.24 ±0.19[b]	1.37 ±0.05[b,c]	39.51 ±0.05[a]	6.43 ±0.18[b,c]	42.99 ± 1.52[e]	4168.4 ±38.4[c]	5.71×10^{-3}±0.00[a]
Leaf	93.89 ±0.06[f]	28.02 ±0.10[a]	5.63± 0.12[a]	21.41 ±0.00[c]	7.28 ±0.39[b]	31.55 ±1.09[f]	4824.3 ±10.6[a]	5.68×10^{-3}± 0.00[a]
Inner peel	98.60 ±0.01[b]	0.023 ±0.03[e]	1.59 ±0.06[b]	12.41 ± 0.12[d]	5.58 ± 0.28[c]	78 .94 ± 0.05[c]	4069.2 ±26.8[d]	4.618×10^{-3}±0.00[a]
Outer peel	94.97 ±0.02[e]	4.08 ±0.16[c]	1.14 ±0.37[b]	24.49 ±0.11[b]	14.59 ± 0.07[a]	50.71 ±0.20[d]	4666.5 ±0.3[b]	5.64×10^{-3}±0.00[a]

Values are mean of duplicate determination expressed on dry weight basis±standard error.
Different alphabets indicate significant different at p<0.05 between samples

The dry matter content of cassava plant varied from 98.77% (stem) to 93.89% (leaf), which were significantly different from each other ($p<0.05$). Cassava leaf has been reported to have the highest moisture content than other parts. Siti Sarah and Aishah (2016) found that the local cassava leaf has quite similar dry matter content (92.6%). Sarkiyayi and Agar (2010) also reported tuber has 99.18% dry matter. Percentage of dry matter in peels are higher compared to the result of Otache et al. (2017). This

result shows that as the cassava parts have high dry matter content, it may have long storage lives if packaged properly and well stored (Eleazu and Eleazu, 2012).

Crude fiber represents that portion of carbohydrate that is not digestible by the body. It mainly consists of largely cellulose and lignin (97%) and other minerals (Eleazu and Eleazu, 2012). The fiber content of all parts of plant showed the significant differences in the fiber contents $p < 0.05$. Crude fiber contents were highest in the stem and tuber the lowest. The value for tuber is within a range of 1.5 to 3.5% (Charles et al., 2005).

Crude fat is important to the structure and biological functions and also giving high energy to the body (Eleazu and Eleazu, 2012). Crude fat contents in leaf (5.63%) was significantly higher than parts, while inner and outer peels, and stem did not show significantly different ($p<0.05$). The value obtained is comparable to the study by Siti Sarah and Aishah (2016).

The values of the carbohydrates content of the cassava parts ranged from 31.55% (leaf) to 92.66% (tuber). The result shows a significant difference ($p<0.05$) between each part. Tubers would be a good source of energy to the ruminant as animal feed.

The gross energy values presented based on the dry matter indicate their potentials as food or as feed for ruminant. From Table 2, it shows that the leaf has the highest in gross energy content (4824.3 cal/g). This result may be explained by the fact that the leaves has the highest crude fat and protein, but low in carbohydrate than other parts. This suggests that after harvesting of the tubers, cassava leaf wastes could used as animal feed because of its high protein, fat, and energy gross contents.

Due to concern about the cyanide content after cassava plants being dried, the limitation of recommended cyanide level in food is 10 mg HCN equivalent/Kg dry weight which means cassava cannot be eaten raw. All dried cassava parts showed the value that are below the cyanide content limit, which are 50mg/ kg of fresh forms (Delange et al., 1982).This indicating the efficiency of the processing method and safe for use.

From this study, it shows that almost all dried cassava parts contained high nutrient, high energy gross and low in cyanide. All the dried cassava wastes showed the potential as ruminant feed. According to Apata and Babalola (2012), cassava leaf has relatively same properties compared to maize (high protein), would be an alternative feed for non-ruminant and also for ruminant.

Conclusion:

In conclusion, the stem was the largest wastes portion of cassava plant followed by the peel, discarded tuber, and the leaf. According to the nutrient and cyanide composition of cassava wastes, the leaf has the highest protein with 28.02%, whereas other parts were around 1.75% to 5.24%. The stem seems to have the most potential for animal feed because it accounts for the highest waste proportion. It also has the second highest gross energy after the leaf. The proximate analysis indicates that all parts of cassava wastes were rich in nutrient, especially the carbohydrate. With these findings, cassava wastes can be formulated into animal feed. Clinical studies are recommended to determine at what level the nutrient becomes toxic to ruminant and ascertain the side effects if any.

References:

Achidi, A. U., Ajayi, O. A., Maziya-Dixon, B., and Bokanga, M. (2008). The Effect of Processing On the Nutrient Content of Cassava (Manihot Esculenta Crantz) Leaves. Journal of Food Processing and Preservation, 32(3): pp: 486-502.

Agarwal, S.K. and Rastogi, R.P. (1974). Triterpenoid saponins and their genius. Phytochemistry, 12: pp: 2623-2645.

Akintola, A.A, Grisson, S.E. Toramiro and Oke, O.L. (1998). Parameter of Thyroid function in the endemic goiter. Nutr. Health, 18: pp: 355-367.

Akpabio, U. D., Akpakpan, A.E., Udo, I. E., and Nwokocha, G.C. (2012). Comparative Study on the Physicochemical Properties of Two Varieties of Cassava Peels. International Journal of Environment and Bioenergy, 2(1): pp: 19-32.

AOAC. (1990). Official Methods of Analysis. Association of Official Analytical Chemists (AOAC), Washington, DC.

Charles, A., Sriroth, K., and Huang, T. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food Chemistry, 92(4): pp: 615-620.

Davidson, S., Brock, J.F. and Truswell, A.S., 1975. Human Nutrition and Dietetics. Churchill Livingstone, Edinburg, UK, pp: 107-119, 221-224.

Delange, F., Iteke, F.B. and Ermans, A.M. (1982). Nutritional Factors Involved in th Goitrogenic Action of Cassava. International Development, Research Centre, Ottawa, ON, Canada, pp: 100.

Department of Agriculture Peninsular Malaysia. (2017). Vegetable and Cash Crops Statistic Malaysia. Retrived from http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/booklet_statistik_tanaman_2017.pdf

Eleazu, C., and Eleazu, K. (2012). Determination of the Proximate Composition, Total Carotenoid, Reducing Sugars and Residual Cyanide Levels of Flours of 6 New Yellow and White Cassava (Manihot esculenta Crantz) Varieties. American Journal of Food Technology, 7(10): pp: 642-649.

F. Apata, D., and O. Babalola, T. (2012). The Use of Cassava, Sweet Potato and Cocoyam, and Their By-Products by Non – Ruminants. International Journal of Food Science and Nutrition Engineering, 2(4): pp: 54-62.

Gervason A, M., Ben O., O., Bibianne W., W., Edith W. T, W., and Jared M., O. (2017). Evaluation of Cyanide Levels in Two Cassava Varieties (Mariwa and Nyakatanegi) Grown in Bar-adult, Siaya County, Kenya. Journal of Food and Nutrition Research, 5(11): pp: 817-823.

Gokani, A., Ibrahim, G. and Shah, H. (1992). Alkaline-ash foods in the dietary management of diabetes mellitus. Int. J. Diabetes Dev. Countries, 12: pp: 85-89.

Ilodibia, C. V., Ugwu, R. U., Okeke, C., Ezeabara, C. A., Okeke, N. F., Akachukwu, E. E., and Aziagba, B. O. (2014). Determination of Proximate Composition of Various Parts of Two Dracaena Specie. International Journal of Botany, 10(1): pp: 37-41.

Okeke, C.U., A.I., Izundu and E. Uzoechinda. (2008). Phytochemical and proximate study of female pawpaw (Carica papaya L.) Caricaecae. J. Sci. Eng. Technol., 15: pp: 8207-8216.

Otache, M. A., Ubwa, S. T., and Godwin, A. K. (2017). Proximate Analysis and Mineral Composition of Peels of Three Sweet Cassava Cultivars. Asian Journal of Physical and Chemical Sciences, 3(4): pp: 1-10.

Sarkiyayi S., and Agar, T. M. (2010). Comparative Analysis of the Nutritional and Anti-Nutritional Contents of the Sweet and Bitter Cassava Varieties. Advance Journal of Food Science and Technology, 2(6): pp: 328-334.

Siti Sarah, J., and Aishah, B. (2016). Nutrient And Antinutrient Composition Of Different Variety Of Cassava (Manihot Esculenta Crantz) Leaves. Jurnal Teknologi, 78(6-6): pp: 59-63.

Steyn, W.J.A. (1959). Leaf Analysis: Errors involved in the preparatives phase. Agricultural and Food Chemistry, 7(5): pp: 344-348.

Thomas, M.D. (2006). Textbook of Biochemistry. 6th Edn. Wiley-Liss, U.S.A: pp: 1080-1084.

Zainuddin, M. F., Shamsudin, R., Mokhtar, M. N., and Ismail, D. (2014). Physicochemical Properties of Pineapple Plant Waste Fibers from the Leaves and Stems of Different Varieties. BioResources, 9(3).

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE15

Physical Properties of Matured Pepper Berries

Puteri Nurain, M.A.A.[1], Rosnah, S.[1,2,*], Hasfalina, C.M.[3], Mohammad Effendy, Y.[1]
[1]Department of Process and Food Engineering, Engineering Faculty, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[2]Institute of Advanced Technology, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
[3]Department of Biological and Agricultural Engineering, Engineering Faculty, Universiti Putra Malaysia, 43400 Serdang, Malaysia.
*Corresponding author. Email: rosnahs@upm.edu.my

Abstract
Pepper is known as the 'King of Spices' and its botanical name is Piper Nigrum which is one of the most popular and oldest spices in the world. There is a problem during manual sorting and grading of pepper such as the selected pepper berries for white pepper production are less fulfilled according to standard of properties (dimension, weight and colour) requirement that had been done by man power. This study is carried out to determine the physical properties (dimension, weight, and colour) of mature pepper berries because they are vital in sorting and grading to evaluate the food quality. The physical properties of food materials is essential for processing design and optimization. The preparation of the samples is starting to collect from the plantation. The spikes with mature pepper berries were threshed manually to obtain the pepper berries. The only full mature pepper berries were selected and prepared for further analysis. The physical properties of mature pepper berries such as dimension (5.42 mm), weight (0.12 g), and colour (value of 63.05 (a), 47.33 (b*), and 39.17 (L*)) were obtained after analysed. Hence, the results are based on the maturity period and can be applicable for the food processing.*

Keywords: physical properties, pepper berries, matured, sorting, applicable

Introduction

The botanical name of pepper is Piper Nigrum. Pepper is known as the 'King of Spices' and one of the most popular and oldest spices in the world. Its natural habitats are in Vietnam, Malaysia, Indonesia, Sri Lanka and others. The pepper maintains the highest standards among the spices for a little more than one fourth of the total world trade in spices (Taylor et al., 2009). It has a sharp, pungent aroma and flavour, light colour (Thankamani & Giridhar, 2004). There is an increasing demand for white pepper in the markets worldwide (Thankamani & Giridhar, 2004). The amount of production of pepper is 5 kg per year for one pepper vine. The largest of the national production of pepper in Malaysia is contributed by Sarawak which is 98% (Hong, 2015). The pepper is widely grown in several areas such as Kuching, Samarahan, Sri Aman, Betong and Sarikei (Rosli et al., 2013). The area of plantation in Sarawak is about 13,000 hectares. Pepper has various types which including green, yellow or red, black and white pepper. The green pepper berries are the immature berries meanwhile the yellow or red pepper berries are the fully matured berries. These both types of pepper have the same average diameter, which is 5 mm to 6 mm. According to Malaysian Pepper Board (MPB), there are few recommended varieties of pepper such as Kuching, Semongok Emas and Semongok Aman. The Kuching pepper is most widely grown cultivar in Sarawak and Johore when compared to other varieties. In order to produce either black or white pepper, the physical properties are very vital in food processing. Some components are inedible or have variable physical characteristics contained in most raw materials. Processing techniques such as sorting and grading are necessary to obtain the required uniformity of the raw materials for further processing. The manual techniques of sorting and grading is time consuming and inaccurate susceptible due to human judgements (Fauzi et al., 2015). Dimension, weight, and colour also known as main external criteria needed to sort agriculture products. The dimension sorting is essential to estimate the effectiveness of methods used to prevent blocking. Weight sorting is more accurate than other methods which completing measurement weight of raw materials before further processing and mostly used for more valuable foods. The matureness or ripeness of fruits and food can be specified by colour that has been widely used in agriculture application. Specification in colour range from yellowish or slight reddish to bright red which are a direct result of senescence and it is used in colour sorting of pepper (Shearer & Payne, 1990). Based on the physical properties, the lower grade pepper will be classified by sorting for any crushed, immature or undersized pepper. The aim of this study is to determine the physical properties (dimension, weight, and colour) of mature pepper berries as it is easier for sorting and grading techniques during white pepper production.

Materials and methods

Preparation of sample

The fully ripe pepper berries were selected and collected from the farm in Universiti Putra Malaysia. The spikes which have one or two reddish-orange berries were collected for the analysis. The pepper berries was separated from the leaves and others by manual. The sorted pepper berries were put in a plastic bag and stored in chiller with 10ºC before further analysis.

Dimension
100 samples of pepper berries were used. A digital Vernier calliper (Series 500, Mitutoyo, Japan) with accuracy of 0.01mm was used to measure the dimensions of the pepper berries(Rosnah & Chan, 2014; Sirisomboon et al., 2007; Terdwongworakul et al., 2009). The dimensions of sample were measured as major axis (a), medium axis (b) minor axis (c) and diameter as shown in Figure 1.

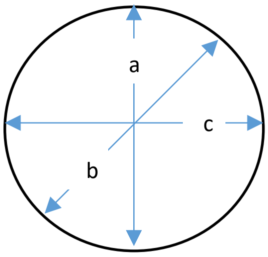


Figure 1: Dimensions of pepper berry

Weight
The mature pepper berries were weighed by using an electronic balance (ER-120A, AND, Japan) with accuracy of 0.0001 g (Terdwongworakul et al., 2009). 100 of pepper berries were used as samples and the weight obtained was divided by 100 to get the average weight for a pepper berry.

Colour
Colour of pepper berries were measured and the colour values of *L**, *a** and *b** were determined by using a colour meter (CR-10, Konica Minolta, Japan). They were recorded and used to determine the chroma and hue angle by using equation below (Mohsenin, 1986). The Commission Internationale de L'Eclairage (CIE) 'Lab' colour space coordinates indicates *L* represents the degree of lightness (the light to dark spectrum), *a* represents the green to red spectrum, and *b* represents the blue to yellow spectrum (Rosnah & Chan, 2014).

$$\text{Chroma, } c^* = [(a^*)\ 2 + (b^*)^2]\ ½$$

$$\text{Hue angle, } h^* = \tan^{-1}(b^*/a^*)$$

Results and discussion
Dimension
The properties of dimensions include diameter, major axis, medium axis, and minor axis of mature pepper berries are shown in Table 1. The values of dimensions are determined by using 100 mature pepper berries. According to Table 1, the average diameter of the mature pepper berries is 5.42 mm with standard deviation of 0.449. The mature pepper berries have the values of 5.22 mm, 5.50 mm, and 5.55 mm for the average major axis (a), medium axis (b), and minor axis (c). The average value of minor axis is larger among the others and then followed by the average value of medium and major axis. Based on the results in Table 1, it indicates the average diameter of mature pepper berries is higher value when compared to previous works on green pepper berries (Rosnah & Chan, 2014) and dried black pepper seeds (Murthy & Bhattacharya, 1998) which are 5.21 mm and 5.12 mm respectively. Thus, the mature pepper berries have the highest value of average diameter when compared previously published works.

Weight
The average weight of 100 pepper berries measured is 11. 52 g. After dividing the 100, the weight of a pepper berry is 0.12 g. Meanwhile, the previous work according to Rosnah & Chan (2014) indicates the weight of one green pepper berry is 0.11 g. This difference shows the mature pepper berry has the larger value of weight. One of the major parameters such as weight is important to determine density, quality and texture of pepper berries.

Colour
The colour measurements are used as quality parameters and indicator of some inner components of the material (Jha, 2010). An analysis of colour shows th determination of the a*, b*and L* values for fresh mature pepper berries. The colour values of mature pepper berries are shown in Table 2. The colour values are referred to the Commision Internationale de L'Eclairage (CIE) 'Lab' colour space coordinates. The value of *a** is representing as the green to red spectrum, *b** represents the blue to yellow spectrum, and *L** represents the degree of lightness which is the light to dark spectrum. Table 2 indicates a red colour of mature pepper berries with an average value of 63.05 (*a**), 47.33 (*b**), and 39.17 (*L**) with standard deviation. These values are in the range of red colour according to CIE 'Lab' colour space. The average *c** and *h** values of mature pepper berries are 48.64 and 36.90. These results are obtained and calculated by substituting the values of *a** and *b** into the equations. Meanwhile, the average value of -36.69 (*a**), 40.77 (*b**), 42.05 (*L**), 54.88 (*c**), and -47.89 (*h**) based on previous work of green pepper berries colour at soaking day 1,which are in colour range from mint green to turquoise green (Rosnah & Chan, 2014). The different values of colour among these results are caused by different maturity period of each fresh pepper berries on a spike. The different maturity that caused the red colour of pepper berries is due to the natural pigment such as carotenoids.

Table 1: Dimension of mature pepper berry

Properties	Average	Standard Deviation
Diameter (mm)	5.42	0.449
Major axis, a (mm)	5.22	0.429
Medium axis, b (mm)	5.50	0.497
Minor axis, c (mm)	5.55	0.511

Table 2: Colour values of mature pepper berries

Properties	Mean	Standard Deviation
a*	63.05	0.153
b*	47.33	0.361
L* - luminosity	39.17	0.231
c* - chroma	48.64	0.354
h* - hue angle	36.90	0.151

The mature pepper berries should be sorted by the properties, which were significantly different between immature pepper berries and mature pepper berries based on the Table 1 and 2.

Conclusions

In this study, all of the properties of mature pepper berries that have been analysed such as dimension, weight, and colour provide useful information for new design of food processing and application in future. The analysis of physical properties of mature pepper berries was conducted and results show that the diameter, major axis, medium axis, minor axis, weight, *a**, *b** and *L** are 5.42 mm 5.22 mm, 5.50 mm, 5.55 mm, 0.12 g, 63.05, 47.33, and 39.17 respectively. It can also be concluded that the physical properties of mature or red pepper berries are determined. According to these results, the diameter of mature pepper berries is different when compared to previous work on green pepper berries. This difference is due to the maturity period.

Acknowledgement

The authors express their gratitude to the Universiti Putra Malaysia for providing financial and technical support to conduct this research work.

References

Fauzi, A. H., Iskandar, D. N. F. A., & Suhaimi, M. A. A. (2015). Automated Machine for Sorting Sarawak Pepper Berries. *2015 9th International Conference on IT in Asia (CITA)*, 1–4. https://doi.org/10.1109/CITA.2015.7349840

Hong, W. K. (2015). SLUSE-M Sustainable Use and Science Natural and Resource Management Faculty Land of Resource Technology.

Jha, S. N. (2010). Nondestructive evaluation of food quality: Theory and practice. *Nondestructive Evaluation of Food Quality: Theory and Practice*, 1–288. https://doi.org/10.1007/978-3-642-15796-7

Mohsenin, N. N. (1986). Physical properties of plant and animal materials. Structure, physical characteristics and mechanical properties. *New York : Gordon and Breach Science Publishers*, *31*, 987. https://doi.org/10.1002/food.19870310724

Murthy, C. T., & Bhattacharya, S. (1998). Moisture dependant physical and uniaxial compression properties of black pepper. *Journal of Food Engineering*, *37*(2), 193–205. https://doi.org/10.1016/S0260-8774(98)00083-1

Rosli, A., Radam, A., & Rahim, K. A. (2013). Technology Adoption in Pepper Farming: a Case Study in Sarawak, Malaysia. *The Internacional Journal of Social Sciences*, *1*, 19–22. https://doi.org/10.1093/molbev/msv014

Rosnah, S., & Chan, S. . (2014). Enzymatic rettings of green pepper berries for white pepper production, *21*(1), 237–245.

Shearer, S. A., & Payne, F. A. (1990). Peppers Using Machine Vision, *33*(December), 2045–2050.

Sirisomboon, P., Pornchaloempong, P., & Romphophak, T. (2007). Physical properties of green soybean: Criteria for sorting. *Journal of Food Engineering*, *79*(1), 18–22. https://doi.org/10.1016/j.jfoodeng.2006.01.022

Taylor, P., Govindarajan, V. S., & Herbert, W. (2009). *C R C Critical Reviews in Food Science and Nutrition Pepper — chemistry , technology , and quality evaluation*.

Terdwongworakul, A., Chaiyapong, S., Jarimopas, B., & Meeklangsaen, W. (2009). Physical properties of fresh young Thai coconut for maturity sorting. *Biosystems Engineering*, *103*(2), 208–216. https://doi.org/10.1016/j.biosystemseng.2009.03.006

Thankamani, V. L., & Giridhar, R. N. (2004). Fermentative production of white pepper using indigenous bacterial isolates. *Biotechnology and Bioprocess Engineering*, *9*(6), 435–439. https://doi.org/10.1007/BF02933482

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE16

Physicochemical properties of pomelo (*Citrus grandis* L. Osbeck) byproducts

Nur Farhana, A. R.[1,2], Rosnah, S. [1,3,*], Amin, I. [3,4], Nor Nadiah, A. K.S.[1] Jaturapatr, V.[2]

[1]*Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia. 43400 UPM Serdang, Selangor, Malaysia*
[2]*Division of Food Engineering, Faculty of Engineering and Agro-Industry, Maejo University, Chiang Mai, Thailand*
[3]*Halal Science Research Laboratory, Halal Products Research Institutes, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[4]*Department of Nutrition and Dietician, Faculty of Medicine and Health Science, University Putra Malaysia. 43400 UPM Serdang, Selangor, Malaysia*
** Corresponding Author, Tel : +603-89466366, Email: rosnahs@upm.edu.my*

Abstract
Pomelo (Citrus grandis L. Osbeck) is known as the largest citrus fruit in the worlds. The fresh pulp often consumed directly meanwhile pomelo byproducts including peels; exocarp: flavedo and endocarp: albedo and lamella were discarded. A significant yield of waste was produced and may result in high cost of waste management. Therefore, the present study was carried out after freeze-drying (FD) to discover the physico-chemical properties (water activity (aw), total soluble solids (TSS), pH and vitamin C) of pomelo byproducts (flavedo, albedo and lamella). Results showed that the overall byproducts contain lower water activity (<0.7) value after dried, whereas for TSS albedo (2.43°Brix) and lamella (2.23°Brix) showed significantly (p <0.05) higher value compared to flavedo (1.77°Brix). Similar with pH analysis, significant lower value of flavedo (5.44) was observed in comparison with albedo (5.78) and lamella (5.70). Nevertheless, lower pH value indicates the presence of higher concentration of vitamin C in flavedo (30.52 mg AA/100g DW) more than albedo (25.83 mg AA/100g DW) and lamella (17.48 mg AA/100g DW). Noteworthy information of the byproducts could be further applied in nutraceutical approach and functional foods for commercial purposes.

Keywords: Physicochemical, pomelo byproduct, water activity, pH, vitamin C

Introduction

In South Eash Asia, pomelo (Citrus grandis (L.) Osbeck) fruits was categorized as a native citrus fruit. In Malaysia, famous pomelo varieties is known as Sha Ting, Tambun, Ledang and Melo Mas (Shah et al., 2013). The weight of pomelo fruit is around 1 - 2 kg per pieces; the largest size in citrus family. Significant yield (~50%) of peels per fruits was discarded every year. The peels comprised of different parts of peels which covers the flesh of the fruits. Flavedo is a greenish part where it is the outermost peels of the fruits, the endocarp containing the thickest peels and spongy texture in whitish color; albedo and the pinkish in color of the skin that covers the juice sacs directly known as lamella **(Figure 1)**.

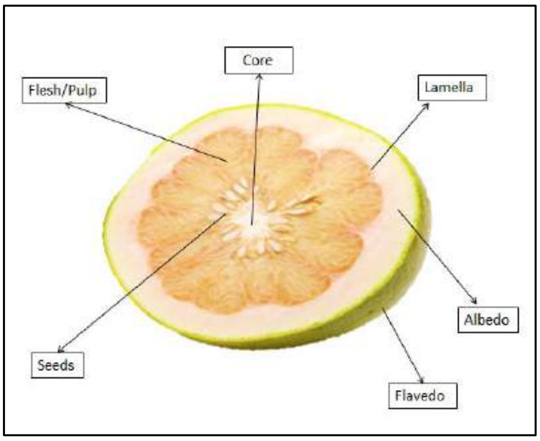


Figure1. Cross section of pomelo fruits (adapted from Rahman et al., 2018a)

Nowadays, high demand of waste valorization into beneficial compound was superior practices. Previously, most of the researchers focuses and elaborate on physicochemical properties of the pomelo pulp which involve different varieties such as Tambun (PO52) and Ledang (PO55) from Malaysia (Shah et al., 2014) properties of the flesh, effects of storage time on the texture of pomelo fruits (Sirisomboon and Lapchareonsuk, 2012), phenolic identification of the pomelo fruits using HPLC and the effects of enzyme pectinase on clarification of pomelo juice obtained using UV-C (Shah, et al. 2014). As for byproducts known as peels, most of the researchers focus potential source of pectin, optimum condition to extract pectin from albedo, potential source of carbon to treat waste water, potential source of antimicrobial, essential oil identification from flavedo part, effects of post-drying on pomelo peels and its phenolic content (Rahman et al. 2016, 2018b). However, limited information can be found for identification of physicochemical properties in different parts of pomelo peels known as flavedo, albedo and lamella generally. Therefore, the current study focuses on comparison of physicho-chemical properties of pomelo byproducts (flavedo, albedo and lamella).

Materials and methods

Plant materials

The pomelo (*Citrus grandis* (L.) Osbeck) fruit was obtained from P052 Tambun White variety at Department of Agriculture Kinta District, Ipoh, Perak. Then, the fruit was cleaned thoroughly and was separated physically into flesh and peels (flavedo, albedo and lamella) as shown in **Figure 1**. Overall parts was separated and undergone freeze drying process prior to further analysis

Drying process

Freeze drying process was conducted by freezing the flavedo, albedo and lamella (~100g) first in ultra-low freezer (MDF-U2086S; Sanyo, Japan) at -85°C overnight and undergoing lyophilized process using freeze-dryer (VirTis Benchtop K, PA, USA) (Rahman et al., 2016) for approximately 96 hr. The dried byproducts were grind into powder and was used for physicochemical analysis.

1) Physiocchemical analysis

i) Determination of water activity

Water activity is a measurement of the availability of water for biological reactions in the sample. The water activity (aw) was measured with a dew point hygrometer at 25 °C (Aqualab series 3TE. Decagon Devices Inc., Pullman) (Shamsudin, et al., 2015).

ii) Determination of pH

Determination of pH as an indicator of acidity or basicity of a solution. This is to indicate the limitation of the spoilage microorganism to be able to react during storage period. The samples were dip into a distilled water and filtered to obtain the filtrate solution. An electrode pH meter was dipped into the filtrate solution. It is an important parameter used to determine whether the potential food spoilage microorganisms are liable to grow during storage. The samples were squeezed to obtain their juice and the pH of the juice was measured using an electrode pH meter.

iii) Determination of total soluble solids (ºBrix)

The major soluble solids presence in fruits also known as sugar. Total soluble solids (TSS) indication can be used to determine the general estimation of sugar content. TSS was determine by using a digital refractometer (AR-2008, Kruss, Germany). A substantial amount of filtrate by-products was dropped onto the refractometer and measured as °Brix. Triplicate value were recorded and average value was obtained.

iv) Determination of Vitamin C (Ascorbic acid)

Vitamin C (ascorbic acid) is an essential dietary component which could not be synthesized by the body. Ascorbic acid was measured by using 2,6-dichlorophenol indophenol (DCPIP) as the titrant based on Ali, et al. (2015) and Toh, et al. (2013) with a slight modification. Dried samples (1 g) was homogenized with 3% metaphosphoric acid (20 mL) and was filtered using filter paper (Whatman No. 4) to obtain the filtrate. Briefly, standard ascorbic acid (AA) standard (1%) solution was prepared and was used to calculate vitamin C in the samples. The filtrate (5 mL) was titrated with DCPIP (0.1%) indicator using No. 967.21, AOAC method (AOAC, 2002). The final value of vitamin C was expressed as mg AA/100g of sample

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 21.0 version based on a Duncan's test in order to evaluate the significant difference (p <0.05) between the mean values. The confidence intervals were significant based on 95% and the final value were expressed as the average ± standard deviation.

Results and discussion

Physicochemical properties of pomelo byproducts

Table 1 showed the result of water activity (aw) and total soluble solids (TSS) from different parts of pomelo byproducts. Water activity is an indicator for stability of end products. Results showed that overall parts of pomelo peels are considered stable enough as it falls within the recommendation level (<0.7) (Geankoplis, 2003). Nevertheless, the flavedo (0.398) showed significantly higher (p<0.05) compared to albedo (0.372) and lamella (0.360). It could be due to the flavedo consist of parenchyma cell which are more compact (Thielen et al., 2015) and the space of the movement of moisture taking longer time during drying process. Therefore, the bound moisture could be trapped within the microstructure of the solid materials and leads to aw level higher than other parts. Consistent with the structure of albedo which most of it is porous (Thielen et al., 2015) and the size of the capillary cell is big enough to eases the removal of moisture from inside to outside during drying process. In addition, the thickness also plays an important role affecting the level of water activity. Lamella is the thinnest peels compared to flavedo and albedo due to the nature behavior that its cover juice sacs (flesh) directly. Nevertheless, it comprise strong structure and elastic enough to hold the juice sacs intact (Sirisomboon and Lapchareonsuk, 2012).

Table 1. Water activity and total soluble solids of pomelo byproducts

Parts of pomelo byproduct	Water activity (aw)	Total soluble solids (TSS) (°Brix)
Flavedo	0.398 ± 0.005[a]	1.77 ± 0.06[c]
Albedo	0.372 ±0.007[b]	2.43± 0.06[a]
Lamella	0.360 ±0.006[b]	2.23± 0.06[b]

Final value were expressed as the average ± standard deviation, Similar letter within column showed not significantly (p>0.05) different between different parts of pomelo by-products.

Total soluble solids (TSS) considered as the sugars available from the product. TSS value of different parts of pomelo byproducts can be observed in Table 1. As can be seen, the TSS value increases with increasing sugar content in the following order: [albedo (2.43°Brix) > lamella (2.23°Brix) > flavedo (1.77°Brix)]. This is thought to be a general indicator of carbohydrate content in albedo which consistent with result obtained by Rahman et al. (2018). The result reported on the carbohydrate content of albedo (71.42%), lamella (68.44%) and flavedo (56.34%). In addition, previous researcher had found that albedo remarkably containing multiple chain of carbohydrate content namely pectin (Gamonpilas et al. 2015; Methacanon, et al., 2014) which might contribute to the higher level of TSS compared to other parts.

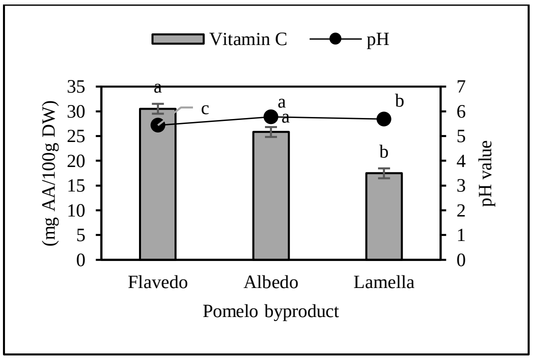


Figure 2. Vitamin C and pH of different parts of pomelo byproducts

The pH level can be considered as an indicator for acidity of end product. pH value and vitamin C of different parts of pomelo residues was compared (Figure 2). Significant different (p <0.05) of pH value was observed in flavedo compared to albedo and lamella. Flavedo (5.44) contain significant (p <0.05) low pH value which considers higher concentration of H+ ion was recorded compared to albedo (5.78) and lamella (5.69). This is believed to be occur due to the present of higher concentration of vitamin C in flavedo (30.52 mg AA/100g DW). Ascorbic acid (Vitamin C) is one of the essential nutrition that is beneficial to the health. The concentration of vitamin C is decreasing from flavedo (30.52 mg AA/100g DW) > albedo (25.83 mg AA/100g DW) > lamella (17.48 mg AA/100g DW). Low value of vitamin C in albedo and lamella was ~15% and ~43% respectively. Nevertheless, albedo did not differed (p >0.05) significantly to flavedo. Previous research found that the trend whereby the concentration of bioactive compound is lower/higher from outer peels towards the flesh (Abdullah et al., 2012).

Conclusion:

Physicochemical properties (water activity, total soluble solids, pH and vitamin C) of different part of pomelo peels namely flavedo, albedo and lamella was investigated. In general, different parts of freeze-dried pomelo byproducts possesses significantly differed properties. As for water activity (aw), overall parts showed within recommended level (<0.7) of dried product can be stored for longer period of time. Albedo showed higher TSS and pH value compared with other parts can be used for potential source of pectin or cosmetic application. Higher concentration of vitamin C of flavedo could be used as supplements or functional food for pharmaceutical company. Different aspects of physicochemical properties can be used as a reference for further application in food industry, cosmetic application, and Nutraceutical Company.

Acknowledgement

The authors gratefully thanks the Ministry of Education of Malaysia, for supporting financial scheme under the Fundamental Research Grants Scheme (FRGS) (Project Number: 03-01-14-1412FR), Research Grant of Universiti Putra Malaysia and Department of Agriculture Kinta District, Ipoh, Perak for the pomelo fruits of this study.

References:

Abdullah, N., Zulkifli, K. S., Abdullah, A., Aziman, N., and Kamarudin, W. S. S. W. (2012). Assessment on the antioxidant and antibacterial activities of selected fruit peels. International Journal of ChemTech Research, Vol: 4(4): pp: 1534–1542.

AOAC. (2002). AOAC Official Methods of Analysis. AOAC Official Methods of Analysis, Vol: 1(1).

Gamonpilas, C., Krongsin, J., Methacanon, P., and Goh, S. M. (2015). Gelation of pomelo (*Citrus maxima*) pectin as induced by divalent ions or acidification. Journal of Food Engineering, Vol: 152: pp: 17–23.

Geankoplis, C. J. (2003). Transport Processes and Separation Process Principles: Includes Unit Operations. Prentice Hall Professional Technical Reference.

Methacanon, P., Krongsin, J., and Gamonpilas, C. (2014). Pomelo (*Citrus maxima*) pectin: Effects of extraction parameters and its properties. Food Hydrocolloids, Vol: 35: pp: 383–391.

Rahman, N. F. A., Shamsudin, R., Ismail, A., and Karim Shah, N. N. A. (2016). Effects of post-drying methods on pomelo fruit peels. Food Science and Biotechnology, Vol: 25(S1): pp:85–90.

Rahman, N. F. A., Shamsudin, R., Ismail, A., Shah, N. N. A. K., and Varith, J. (2018a). Nutrisi kulit Limau Bali (*Citrus grandis* (L.) Osbeck). Proceedings of Conference in Malaysian Society of Agricultural Engineers, Faculty of Engineering, Universiti Putra Malaysia, 7-8 February 2018, pp:58-65

Rahman, N. F. A., Shamsudin, R., Ismail, A., Shah, N. N. A. K., and Varith, J. (2018b). Effects of drying methods on total phenolic contents and antioxidant capacity of the pomelo (*Citrus grandis* (L.) Osbeck) peels. Innovative Food Science and Emerging Technologies, Vol:50: pp: 217–225.

Shah, N. N. A. K., Rahman, R. A., Shamsuddin, R., and Adzahan, N. M. (2013). Identification of phenolic contents in malaysian variety of pummelo (*Citrus grandis* L. osbeck) fruit juice using HPLC-DAD. International Scholarly and Scientific Research and

Innovation, Vol: 7(6): 166–168.
Shah, N. N. A. K., Rahman, R. A., Shamsuddin, R., and Adzahan, N. M. (2014). Effects of pectinase clarification treatment on phenolic compounds of pummelo (Citrus grandis l. Osbeck) fruit juice. Journal of Food Science and Technology, Vol: 52(8): pp: 5057–5065.
Shah, N. N. A. K., Shamsuddin, R., Rahman, R. A., and Adzahan, N. M. (2014). Effects of physicochemical characteristics of pummelo fruit juice towards uv inactivation of salmonella typhimurium. Agriculture and Agricultural Science Procedia, Vol: 2: pp: 43–52.
Shamsudin, R., Buang, S., and Aziz, N. A. (2015). Effect of different extraction methods on the physico-chemical properties of pomelo juice. chemical engineering transactions, Vol: 44: pp: 265–270.
Sirisomboon, P., and Lapchareonsuk, R. (2012). Evaluation of the physicochemical and textural properties of pomelo fruit following storage. Fruits,Vol: 67(6): pp: 399–413.
Thielen, M., Speck, T., and Seidel, R. (2015). Impact behaviour of freeze-dried and fresh pomelo (*Citrus maxima*) peel : Influence of the hydration state. Royal Society Open Science, Vol: 2: pp: 140322
Toh, J.J., Khoo, H.E., Azrina, A. (2013). Comparison of antioxidant properties of pomelo (*Citrus grandis* (L.) Osbeck) varieties. International Food Research Journal, Vol: 20(4): pp: 1661–1668.
Yusof, Y. A., Ali, M. A., Chin, N. L., and Ibrahim, M. N. (2015). Effect of different drying treatments on colour quality and ascorbic acid concentration of guava fruit, pp: 1–7.

eISBN 978-967-16145-1-8

Some Physical Properties of Mature Green Nipah and Nangka Banana Fruit

[1]Farahana Nabilah Z.A, [1,2*]Rosnah S., [1]Mohd Salahuddin M.B., [1]Zanariah M.D.
1 Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia.
2 Halal Product Research Institute, Universiti Putra Malaysia, 43000 UPM, Serdang, Selangor, Malaysia
**Corresponding Author, Tel: +03-97696366, E-mail: rosnahs@upm.edu.my*

Abstract
Physical properties of fruits and vegetables are important as it is used as a grading measurement for packaging and safe transportation. The postharvest losses of fruits are mainly due to its mechanical damage during transport and handling. Banana for example, has various varieties with different shapes and sizes. Therefore this study was conducted to assess some physical properties of mature green Nipah and Nangka banana fruit. Properties obtained were weight of whole fruit, peel and pulp, dimensions, surface area and projected area. The average weight, length and diameter of Nangka is higher than that of Nipah ($p<0.05$). Peel thickness of Nipah is higher than Nangka. The volume (Vellip), projected area (Pellip) and surface area (Sellip), Nangka possess higher value than Nipah.

Keywords: Physical, banana, nangka, nipah

Introduction
Physical properties of fruits are important data for grading operation. Different countries have different standard grading specifications. Most of it are based on maturity, shape, size, colour, degree of blemishes and taste. Besides it can also be used in the design and operation of machines for fruits processing.
Many studies were made on the physical properties of fruits such as pomegranate (Radunić et al. 2015), apricot (Haciseferoğullari et al. 2007), okro (Owolarafe and Shotonde 2004) and mango (Wanitchang et al. 2011). Radunić et al. (2015) evaluated the physical and chemical properties of seven pomegranate cultivars. The physical dimension obtained shows high variability in fruit weight and size, calyx and peel properties. Haciseferoğullari et al. (2007) evaluated the physical and chemical characteristics apricot and attribute to the processing equipment. Wanitchang et al. (2011) measured the physical and mechanical properties and used it for classification of maturity of mango.
Among fruits, banana have the second largest production are in Malaysia and 5th in its export revenue (Department of Statistics 2011). Exportation of fruits requires proper handling and packaging as it is one of the main reason of postharvest losses (Wasala et al. 2015).
This paper aims to determine the physical properties of two varieties of mature green bananas which are Nipah and Nangka. The properties which will be measured are weight of peel, pulp and whole fruit as well as diameter. While, geometric mean diameter (Dg), sphericity (φ) and radius of curvature (R), estimated volume (Vellip), projected area (Pellip) and surface area (Sellip) will be obtained by using specific equations with the measured data.

Materials and methods
Banana fruits of Nipah and Nangka variety is harvested from a small farm in Kampung Sungai Lang, Banting. The banana fruits were transported and stored in a room temperature of 25oC. The samples were made sure to have a ripening index 1 and were randomly selected from the bunch.
The external and internal length of banana (Lo, Li) was measured by a flexible ruler as in Figure 1. The diameters were measured by a digital Vernier caliper as in Figure 2. The mass of both banana varieties was measured using an electronic weighing scale (Model SB12001, Switzerland). The measurement was replicated three times and is averaged out. For measurement of geometric mean diameter (Dg), sphericity (φ) and radius of curvature (R), estimated volume (Vellip), projected area (Pellip) and surface area (Sellip) the following equations are used (Sharifi et al. 2007).

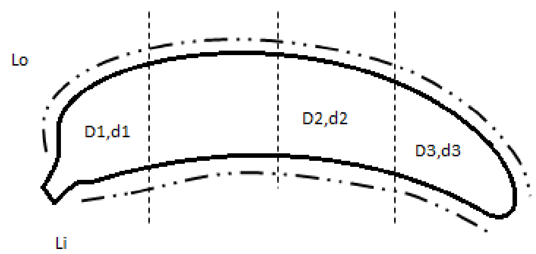


Figure 1: Longitudinal section of banana

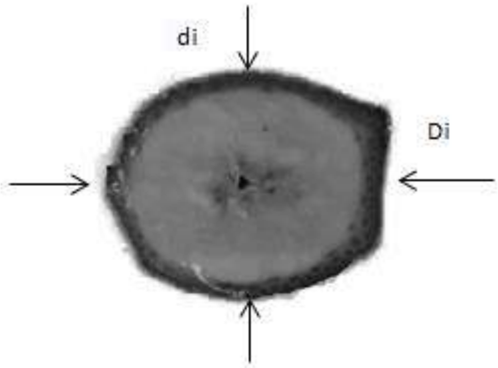


Figure 2: Cross sectional plane on longitudinal axis

Geometric Mean Diameter (D_g)

D_g = (L average x D average x d average) $^{0.333}$

where:

$$L_{average} = \frac{L_o + L_i}{2}$$

$$D_{average} = \frac{D2 + D3}{2}$$

$$d_{average} = = \frac{d2 + d3}{2}$$

Shpericity (φ)

$$(\varphi) = \frac{D_g}{L\ average}$$

The intermediate section of banana is estimated to be in circular shape thus the radius of curvature (R) was measured as

$$R = \frac{L_i}{\Delta L} D_{average}$$

where

$\Delta L = L_o - L_i$

The estimated volume (Vellip), projected area (P ellip) and surface area (S ellip) is treated as an ellipsoidal shape with following formula.

$$V_{ellip} = \frac{\pi}{6\ x\ 1000} L_{average}\ x\ D_{average}\ x\ d_{average}$$

$$S_{ellip} = \pi D_g{}^2$$

$$P_{ellip} = \frac{\pi}{600} L_{average}\ x\ D_{average}$$

Results and discussion

Weighting properties of both Nipah and Nangka banana fruits are presented in Table 1. The average weight of whole fruit for Nipah is seen lower than that of Nangka with 31% differences. While study by Kachru et al. (1995) obtained 89.69g for Dwarf Scavendish and 126.16g for Nendran variety. The average pulp to peel ratio for Nipah and Nangka banana variety was found to be 1.45±0.25 and 1.5+0.06 respectively. Which means that Nipah have thicker peel than Nangka variety.

Table 1: Weight properties of Mature Green Nipah and Nangka banana variety

Properties	Nipah	Nangka
Weight of Fruit (g)	85.67±1.25^a	124.67±1.70^b
Weight of peel (g)	49.33±3.30*	48.67±1.70*
Weight of pulp (g)	34.67±3.40*	73±0.82*
Pulp/peel ratio	1.45±0.25^a	1.5+0.06^b

In each row, means followed by same letter are not significantly different (P<0.05)

The dimensional properties of Nipah and Nangka banana fruits are presented in Table 2. Nangka banana is bigger compared to Nipah as it possesses higher average outer length with 209.00±0.22mm. This result may vary to other places as fruit size may fluctuate depends on climatic conditions and also the plantation practices (Lopez et al. 2007). As for the diameter, D1 to D3 and d1 to d3 shows range of average diameter at various planes of cut of banana fruit with peel for both varieties tested. It can be seen that the diameter of the fruit is lowest at the bottom and highest at its top due to its curvature structure. The changes were as function of their position on banana and varied as a linear form. The Daverage and daverage were obtained for Nipah and Nangka which are 37.83±0.96mm and 25.33±0.62mm, 40.50±0.41mm and 30.50±0.00mm respectively.

Table 2: Dimensional properties of Mature Green Nipah and Nangka banana variety

Properties (mm)	Nipah	Nangka
L_o	148.33±0.24^a	209.00±0.22^b
L_i	123.33±0.24^a	122.67±0.21^b
L	135.83±0.24^a	165.83±0.08^b
ΔL	25.00±0.00^a	86.33±3.90^a
D1	41.00±0.82^a	41.00±0.00^b
D2	40.50±0.71^a	40.00±0.82^b
D3	34.67±1.18^a	40.00±0.82^b
d1	22.50±1.08^a	29.83±0.62^b
d2	28.33±0.24^a	31.43±0.09^b
d3	28.17±0.24^a	31.17±0.62^a
$D_{average}$	37.83±0.96^a	40.50±0.41^b
$d_{average}$	25.33±0.62^a	30.50±0.00^b

In each row, means followed by same letter are not significantly different ($P<0.05$)

Results of other estimated and calculated properties are presented in Table 3. The radius of curvature for Nipah and Nangka was measured at 186.64±3.60mm and 57.54±3.44mm respectively. This means that Nangka have a more curvy shape compared to Nipah. Besides, for average value of geometric mean diameter for Nipah was obtained lower that of Nangka banana while Nipah possess higher sphericity value. While for estimated volume (Vellip), projected area (Pellip) and surface area (Sellip), Nangka possess higher value than Nipah with value of 107.26±0.57mm3, 35.17±0.19mm3 and 10828.29±38.56 mm3 respectively.

Table 3: Physical Properties of Mature Green Nipah and Nangka banana variety

Properties	Nipah	Nangka
R (mm)	186.64 ± 3.60^{a}	57.54 ± 3.44^{b}
D_g (mm)	50.48 ± 0.73^{a}	58.71 ± 0.10^{b}
φ	0.37 ± 0.01^{a}	0.35 ± 0.00^{b}
V_{ellip} (mm^3)	68.17 ± 2.96^{a}	107.26 ± 0.57^{b}
P_{ellip} (mm^2)	29.88 ± 26.91^{a}	35.17 ± 0.19^{b}
S_{ellip} (mm^2)	8006.74 ± 231.79^{a}	10828.29 ± 38.56^{b}

In each row, means followed by same letter are not significantly different ($P<0.05$)

Conclusion:

Some physical properties of mature green Nipah and Nangka banana were determined. From the result, it can be concluded that Nangka banana is larger and heavier than Nipah. Peel of Nangka is thinner than Nipah. The sphericity of Nangka is lower as it have higher radius of curvature which result to a more curvature shape. Thus it can be concluded that the physical properties of bananas are dependent of its varieties.

Acknowledgments

The authors acknowledge with thanks, the financial support (UPM/700-1/2/GPB/2017/9543400) and facility that University Putra Malaysia have provided to carry out research activities.

References:

Department of Statistics, Malaysia. 2011. "Supply and Utilization Accounts Selected Agricultural Commodities 2007-2011." : 2013–15.

Haciseferoğullari, Haydar, Ibrahim Gezer, Mehmet Musa Özcan, and Bayram MuratAsma. 2007. "Post-Harvest Chemical and Physical-Mechanical Properties of Some Apricot Varieties Cultivated in Turkey." *Journal of Food Engineering*.

Kachru, R P, Kotwaliwale Nachiket, and D Balasubramanian. 1995. "Physical and Mechanical Properties of Green Banana (Musa Paradisiaca) Fruit." *Journal of Food Engineering* 26(3): 369–78.

Lopez, Gerardo, R. Scott Johnson, and Theodore M. DeJong. 2007. "High Spring Temperatures Decrease Peach Fruit Size." *California Agriculture*.

Owolarafe, O. K., and H. O. Shotonde. 2004. "Some Physical Properties of Fresh Okro Fruit." *Journal of Food Engineering*.

Radunić, Mira et al. 2015. "Physical and Chemical Properties of Pomegranate Fruit Accessions from Croatia." *Food Chemistry* 177: 53–60.

Sharifi, M et al. 2007. "Some Physical Properties of Orange (Var. Tompson)." *Industrial Research*.

Wanitchang, Padungsak, Anupun Terdwongworakul, Jaitip Wanitchang, and Natrapee Nakawajana. 2011. "Non-Destructive Maturity Classification of Mango Based on Physical, Mechanical and Optical Properties." *Journal of Food Engineering*.

Wasala, W M C B, D A N Dharmasena, T M R Dissanayake, and B M K S Thilakarathne. 2015. "Physical and Mechanical Properties of Three Commercially Grown Banana (Musa Acuminata Colla) Cultivars in Sri Lanka." *Tropical Agricultural Research* 24(1): 42. https://tar.sljol.info/article/10.4038/tar.v24i1.7988/.

Strategies for Sustainable Production of Starch from Sweet Potato

Zulkifli, N.A, *Nor, M.Z.M., Mokhtar, M.N., and Sulaiman, A
Department of Process and Food Engineering,
Faculty of Engineering, Universiti Putra Malaysia (UPM), 43400 UPM Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +603- 89464303, Email: zuhair@upm.edu.my

Abstract
Sweet potato (Ipomoea batatas L. Lam) belongs to the Convolvulaceae family. It is originated from southern Central America and can be easily grown in the tropical climax. The sweet potato contains high nutritional values such as carbohydrate, protein, dietary fibre, amino acids, enzymes, minerals, and vitamins. The main component in sweet potato is starch, which can be used in many food applications. The main objective of this study is to propose some strategies in designing a sustainable starch production from sweet potato. This can be done with the consideration of efficient starch production steps as well as the production of its by-products in order to minimize the wastes as well as to maximize the net profitability. The implementation of the recommended strategies in this study will hopefully ensure sustainable and feasible production of starch from sweet potato which can benefit the farmers and producers of this crop.

Keywords: Ipomoea batatas (L.) Lam, sweet potato, starch production, value-added products, process scheduling, process costing

Introduction

Sweet potato (Ipomoea batatas) is a member of the family Convolvulaceae and it can be harvested about 3.5 to 4 months after planting in the tropics (Tan, 2015; Ray and Tomlins, 2010). It has a great advantage in growing well on marginal soils such as bris, tin-tailings, acid sulphate soils and drained peat (Tan, 2015; Ray and Tomlins, 2010). Marginal soils in Peninsular Malaysia alone cover some 1.67 million hectares, with 870,000 ha of peatland and muck soils, 433,000 ha of idle paddy land, 165,000 ha of bris, 110,000 ha of acid sulphate soils and 91,000 ha of sand tailings (Tan, 2015).

Worldwide, the sweet potato production that is traded on the world market is relatively small. It is cultivated in about 111 countries with a total of 110.75 million tons produced in 2013 (Akoetey et al., 2017). Many countries, mainly grow it for the domestic consumption. China currently accounts the sweet potato worldwide production of more than seventy million tonnes (Mulderij, 2016; Wee; Akoetey et al., 2017). Second is Nigeria at 3,478,270 metric tons. Third is Tanzania at 3,345,170 metric tons. Fourth is Ethiopia at 2,701,599 metric tons. Fifth is Indonesia at 2,382,658 metric tons. Sixth is Uganda at 1,863,000 metric tons. Seventh is Vietnam at 1,401,055 metric tons. Eighth is United States at 341,910 metric tons. Ninth is India at 1,087,880 metric tons. Tenth is Rwanda at 1,080,780 metric tons (Wee, 2017). In Malaysia, the sweet potato production involved in many areas in the states of Perak, Kelantan and Terengganu. The production is reaching 26, 688 tonnes (2,505 ha) in 2013 (Yusoff et al., 2018).

Sweet potato is a highly nutritious carbohydrate food in vitamins, protein, minerals and energy content. It is rich in β-carotene, vitamin A and vitamin E. The nutritional value of sweet potatoes was the highest among several other foods (Ukom et al., 2009; Tan, 2015; Marczak et al., 2014). β-carotene, a potent provitamin A which used for nutrition and health in the developing countries. The deficiency of Vitamin A will leads to the serious health problem like eczema, cystic fibrosis, chronic diarrhea and others. Those who are risk of deficiency are pregnant women, breastfeeding mothers, infants and children (Ukom et al., 2009; Streit, 2018). Aside all the nutritional elements present in sweet potato, the main component of sweet potato is starch. Starch represents 9.3% per 100g of the sweet potato composition (Englyst and Hudson, 1996). Sweet potato starch is the potential raw material and important role in applying in many foods and non-food products such as chemical, and pharmaceutical industries. In the food industry, it used as an ingredient in some bakery products such as bread, biscuits, cake, juice, and noodles (Soison et al., 2015). Thus also used in the manufacturing of vermicelli, jelly, and other consumable products. In addition, it used as a food additive. For example, used as a thickener, stabilizer, or tissue reinforcing agent to improve foods to retain water, control water flows, and maintain food storage quality (Mu et al., 2017). While in the non-food industry products the starch is used for textiles, paper, fuel, adhesives, plastics, and paints production (Mu et al., 2017).

By considering its wide applications, commercialization of the starch from sweet potato is a smart move. In order to commercialize the starch, a proper design of the production steps is required. Besides, to ensure a sustainable starch production, the producer may want to consider utilizing all the waste produced during the operation and convert

eISBN 978-967-16145-1-8

them into by-products. This strategy will indirectly assist in preserving the environment by reducing waste while making big profits. If these potential value-added products are considered in the milling and business model, it would benefit to the millers for their extra incomes. Indirectly, farmers also will get this benefit if the millers are affordable to buy their sweet potato at a higher price.

Hence, the aim of this study is to discuss two processing strategies in order to ensure sustainable starch processing from sweet potato with the consideration of the production of its by-products.

Strategy 1: Efficient starch processing steps
The sweet potato will be subjected to mechanical processes (washing, peeling, grinding and pressing). After that, it will be soaked to extract starch from the cell. Overall starch processing strategies can be illustrated in Figure 1. The resulted crude starch will be further subject to separation processes (centrifugation, sieving, and concentration, cleaning and drying) as shown in Figure 2.

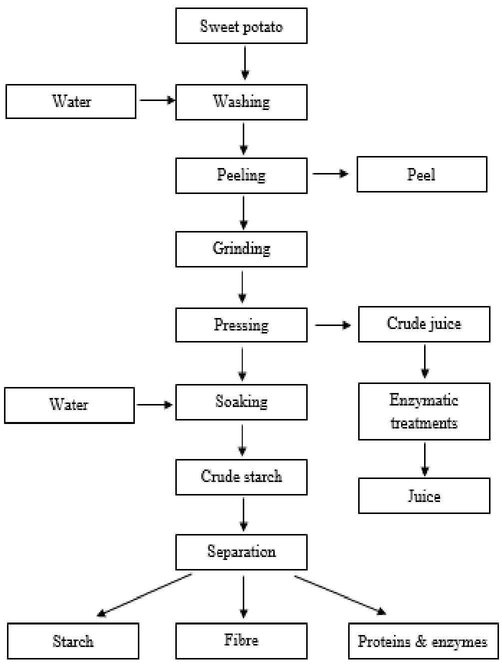


Figure 1: Overall process flow of sweet potato utilization for production of starch and value-added products.

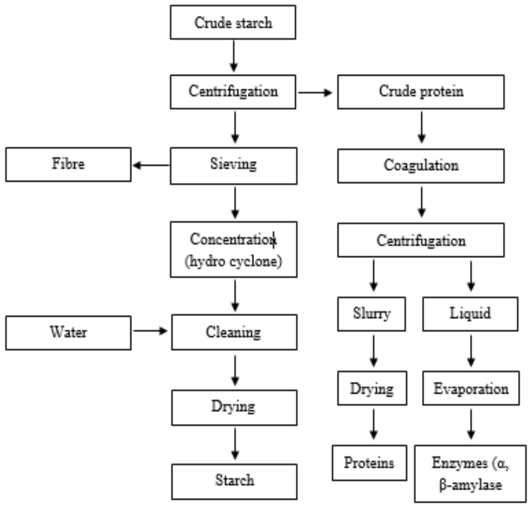


Figure 2: Flow of separation process of production of starch and value-added products.

To ensure efficient starch processing steps, a few considerations can be suggested. These may include the optimization of the whole processing steps using proper scientific procedures. Optimization of the whole processing steps may start by identifying some of the most important matters in the starch production, including the production rate and yield, critical processing steps, production cost and the outcomes of each processing step. These matters can be further re-adjust according to the producer needs such as faster processing time, higher production yield and reduction of the processing cost. These adjustments may be too costly to be implemented in a real-scale operation, hence the usage of simulation software to stimulate the real condition is recommended. This step may save some cost while ensuring the feasibility of the overall starch processing steps at different industrial scales. Some of the simulation softwares such as FlexSim, SuperPro and ProSimPlus that can be used for this purpose. For the examples, FlexSim Software has been used to study the processing of cream cheese manufacturing (Flexsim, 2012); SuperPro designer was used to model the production economics of the latest generation expression technologies on Nicotiana host plants by evaluating process unit operations and calculated bulk active and pre-dose or per-unit costs (Tusé et al., 2014); while ProSimPlus used to simulate the pasteurization process of the milk (Bon et al., 2010).

All mechanical units and operating units can be integrated and simulated. Energy and water consumption can also be considered in the design. Process sensitivity can be analyzed and process scheduling can also be developed in order to evaluate the process feasibility and its economical process design and operation.

Strategy 2: Production of by-products

Based on the conventional starch processing steps shown in Figure 1 and 2, there is no current commercial starch production that highly considers the recovery of some other valuable by-products that flow together in waste streams such as residual solid waste and waste water. It is expected the overall design would be different from conventional design and several additional unit operations will be needed. To design a sustainable process, by-products need to be considered in minimizing wastes as well as maximizing net profitability. Value-added products are the best strategy for farmers and millers to improve net profitability. Value-added products are highly possible to open new markets and therefore enhance the public's appreciation to the farmers. Due to sweet potato is naturally high nutritional values agricultural product, these nutritional values will accumulate in the form of by-products during the starch processing. Some of the waste generated during the starch production that can be converted to by-products as shown in Table 1.

Table 1: Potential by-products that can be obtained from the starch production of sweet potato

Stage in the processing steps	By-products	Applications
Centrifugation	-α-amylase -β-amylase	Baking, brewing, preparation of digestive aids, production of cakes, fruit juices, starch syrups and glucose syrup production (Hagenimana et al.,1992; Khan et al., 2011; Dehkordi and Javan, 2012).
Peeling	-High dietary fibre. -The peel extract as an antioxidant in food systems.	-Healthy and functional food ingredient. It's used in bakery production. -It can prevent lipid oxidation in oils and meat. (Sepelev and Galoburda, 2015; Gebrechristos and Chen, 2018)
Centrifugation	Proteins	Animal feeding (Machin and Nyvold, 1991).
Pressing	Pressed juice	Healthy fermented drink (Lacto-juice) (Oke and Workneh, 2013).

Beside rich of micronutrients, sweet potato is found to have endogenous α-amylase and β-amylase that would have potential to be used in related industrial purposes (e.g. Glucose syrup production) (Hagenimana et al.,1992). The β-amylase can be isolated from tuber by ammonium sulphate fractionation, indicating the specific enzyme activity could be increased as much as 24 folds (Oktiarni et al., 2015). Sweet potato consists also high dietary fibre, indicating that soluble and insoluble dietary fibre was 5.30 % and 5.43 %, respectively (Mullin et al., 1994). Dietary fibre is found to improve our digesting system and it is essential for a healthy diet. It can be also extracted and has the potential to be commercialized.

Many countries are facing problems with expensive growing demand for livestock. Alternatively, the used of rich-protein sweet potato as animal feeding has high potential (Machin and Nyvold, 1991). Besides, the juice of sweet potato can be formulated to become a healthy fermented drink (Lacto- juice) which is processed by lactic acid fermentation for their rich nutrition value, vitamins and minerals for human consumption (Oke and Workneh, 2013).

Conclusions

Two strategies have been proposed in this study in order to ensure a sustainable and feasible starch production from sweet potato. These include the considerations on starch processing efficiency and by-products production. With the consideration of both strategies, production of starch from sweet potato can be successfully commercialized at the industrial scale in order to help the farmers and manufacturers of sweet potato.

Acknowledgements

The financial support from the IPB Putra Grant (9660302), University Putra Malaysia (UPM) is gratefully acknowledged.

References

Tan, S.L. (2015). Sweetpotato-Ipomoea batatas- a great health food. *UTAR Agriculture Science Journal,* Vol. 1(3).

Ray, R.C & Tomlins, K.I. (2010). Sweet Potato: Post Harvest Aspects in Food, Feed and Industry. Nova Science Publishers. ISBN: 978-1-60876-343-6.

Lareo, C., Ferrari, M.D., Guigou, M., Fajardo, L., Larnaudie, V., Ramírez, M.B., & Garreiro, J. M. (2013). Evaluation of sweet potato for fuel bioethanol production: Hydrolysis and fermentation. *SpringerPlus*. 2: 493. 10.1186/2193-1801-2-493.

Marczak, B.K., Sawicka, B., Supski, J., Cebulak, T., & Paradowska, K. (2014). Nutrition value of the sweet potato (Ipomoea batatas (L.) Lam) cultivated in south – eastern Polish conditions. *International Journal of Agronomy and Agricultural Research (IJAAR).* ISSN: 2223-7054 (Print) 2225-3610 (Online). 4(4):169-178.

Hagenimana, V., Simard, R.E., & Vezina, L.P. (1992). Distribution of amylases within sweet potato (Ipomoea batatas L.) root tissue. *Journal of Agricultural and Food Chemistry.* Vol. 40(10):1777-1783.

Oktiarni, D., Lusiana, Simamora, F.Y., & Gaol, J.M.L. (2015). Isolation, purification and characterization of β-amylase from Dioscorea hispida Dennst. *AIP Conference Proceeding*. 1677(1).

Mullin, W.J., Rosa, N., & Reynolds, L.B. (1994). Dietary fibre in sweet potato. *Food Research International,* 27 (6):563-565.

Soison, B., Jangchud, K., Jangchud, A., Harnsilawat, T., and Piyachomkwan, K. (2015). Characterization of starch in relation to flesh colors of sweet potato varieties. *International Food Research Journal*, 22 (6) :2302-2308.

Mu, T., Sun, H., Zhang, M., & Wang, C. (2017). Sweet Potato Processing Technology. China Science Publishing & Media Ltd. Published by Elsevier Inc. ISBN: 978-0-12-812871-8.

Akoetey, W., Britain, W. M., and Morawicki, R.O. (2017). Potential use of byproducts from cultivation and processing of sweet potatoes. *Ciência Rural, Santa Maria*, 47: 05, 1-8. ISSNe 1678-4596.

Wee, R.Y. (2017). Top Sweet Potato Growing Countries. Article worldatlas.com. Retrieved on 12 February 2019. https://www.worldatlas.com/articles/top-sweet-potato-growing-countries.html

Mulderij, R. (2016). Overview Global Sweet Potato Market. Retrieved on 12 February 2019. https://www.freshplaza.com/article/2163603/overview-global-sweet-potato-market/

Yusoff, M.M., Abdullah, S.N., Halim, M.R.A., Shari, E.S., Ismail, N.A., and Yusoff, M.M. (2018). Growth and Yield Performance of Five Purple Sweet Potato (*Ipomoea batatas*) Accessions on Colluvium Soil. *Pertanika J. Trop. Agric. Sc*. 41 (3): 975 – 986.

Streit, L. (2018). 8 Signs and Symptoms of Vitamin A Deficiency. Retrieved on 15 February 2019. https://www.healthline.com/nutrition/vitamin-a-deficiency-symptoms

Ukom, A.N., Ojimelukwe, P.C., and Okpara, D.A. (2009). Nutrition Composition of Selected Sweet Potato [Ipomea batatas (L) Lam] varieties as influenced by different levels of nitrogen fertilizer application. *Pakistan Journal of Nutrition*. 8 (11): 1791-1795.

Englyst, H.N., and Hudson, G.J. (1996). The classification and measurement of dietary carbohydrates. *Food Chemistry*, 57 (1) :15-21.

Dehkordi, M.M, and Javan F.A. (2012). Application of alpha-amylase in biotechnology. *Journal of Biology and today's world*. 1(1):39-50.

Khan, M.J, Khan F.H, and Husain, Q. (2011). Application of Immobilized Ipomoea batata β Amylase in the Saccharification of Starch. *Journal of Applied Biological Sciences*. 5(2): 33-39.

Sepelev, I., and Galoburda, R. (2015). Industrial Potato Peel Waste Application in Food Production: A Review. *Research for Rural Development*. 1: 130-136.

Gebrechristos, H.Y., and Chen, W. (2018). Utilization of potato peel as eco-friendly products: A review. Food Science and Nutrition 6(6). Published by Wiley Periodicals, Inc.

Machin, D. and Nyvold, S. (1991). Roots, tubers, plantains and bananas in animal feeding. FAO Animal Production and Health Paper 95. M-23 ISBN 92-5-103138-X

Oke, M.O. and Workneh, T.S. (2013). A review on sweet potato postharvest processing and preservation technology. African Journal of Agricultural Research. 8(40): 4990-5003.

Bon, J., Clemente, G., Váquiro, H.A., and Mulet, A. (2010). Simulation and optimization of milk pasteurization processes using a general process simulator (ProSimPlus). Computers & Chemical Engineering 34(3):414-420.

FlexSim (2012). Cream Cheese Manufacturing Case Study. Retrieved on 15 February 2019. https://www.flexsim.com/cream-cheese-manufacturing-case-study/

Tusé, D., Tu, T., and McDonald, K.A. (2014). Manufacturing Economics of Plant-Made Biologics: Case Studies in Therapeutic and Industrial Enzymes. *BioMed Research International.* Hindawi Publishing Corporation. Pp 1-16.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE19

Production of spinach under variable water supply

F. F.W. Fazilah[1,*], N. S. Saroni[1] and C.Y. N. Norasma[1]
[1]Fakulti Pertanian, Universiti Putra Malaysia
*Corresponding author. Tel.: +6012-9558678, Email:wanfazilah@upm.edu.my

Abstract
The effects of a variable water supply on the growth and yield of spinach grown in cocopeat medium was examined in a field experiment. Three irrigation treatments; (T1) common practice (T2) crop water requirement; and (T3) time scheduling were monitored through the season from transplanting to harvest, 28 days (from January and February 2018) after planting located in a shade house. For T1, spinach was irrigated 2 times per day until the medium surface is wet. An estimated value of crop evapotranspiration (ETc) was determined for spinach during this period in T2, giving a water requirement of 3.72 mm/day (for January 2017) and 4.04 mm/day (for February 2017). The irrigation interval was three days and scheduled water was given based on the ETc value in T2 for T3. There were no significance response to the irrigation treatments for plant height, number of leaves, canopy diameter and leaf length despite differences in biomass production measured. Plant fresh weight and root length density was more sensitive in T3. The insignificant difference was hypothesized to be contributed by that cocopeat medium used in this study that had provided satisfactory available water for the spinach growth regardless different amount of irrigation water applied.

Keywords: spinach, variable water supply, irrigation, crop water requirement, irrigation time scheduling

Introduction

In agriculture, plant should be irrigated with the actual amount of water needed to ensure that the plant can grow well and save the cost for irrigation. Kumar and Sahu (2013) stated that proper irrigation management can reduce irrigation water requirement and increase the yield.

Over irrigation or excessive water can affect plant respiration as the roots cannot take in gases. Under irrigation or water deficit, caused the plants to a water stress. Flexas et al. (2006) and Chaves et al. (2009) reported that water stress can immediately affect the photosynthesis of the plant by reducing the carbon dioxide intake since the stomata is close. Therefore, by knowing the actual crop water requirement and time to irrigate, the plant damage can be reduced, increase irrigation cost efficiency and yield.

There are many leafy vegetables that are essential in our life for nutrient and vitamins. One of the leafy vegetables that is rich with vitamin, mineral and antioxidant is spinach. However, it is one of the leafy vegetable that is very sensitive to water. A small change of water application to the spinach can be detected through the observation within one growing period.

Thus, managing water requirement for spinach is very important because it can affect its production yield. Bennett and Harm (2011) stated that there are relationship between the crop yield and water supply in the field that depend on the sensitivity of the crops. The optimum or deficit water supply to the crop will affect the increasing or decreasing of the production yield. Therefore, managing water requirement to the crop is very important to the yield and also able to save the irrigation cost.

Materials and methods

Experimental site

The experiment was conducted at Faculty of Agriculture University Putra Malaysia facility, shade house Field 15 (coordinate: 2.984138, 101.732884). The west region of Malaysia is having a tropic climate with lots of rainfall and sunshine. The maximum and minimum average daily temperatures during the experimental period were 27 °C and 35 °C, respectively. The medium used in the shade house was cocopeat perlite mixture.

Planting material

Spinach (*Spinacia oleracea)* is a vegetable that is rich with chlorophyll that was selected as the plant material in this study. Spinach is an annual plant with short growth cycle between 25 – 30 days after transplanting and is commonly grown in the summer or rainy season. The leaves are round bowl shape, oily light green in colour and less fibrous, heat tolerant and diseases resistant. In this study, the seed of the spinach was sowed in the tray seedlings. The media for the spinach seedling in tray was peat moss media. For the purpose of transplanting, 120 polybags were prepared filled with cocopeat as the media. Spinach seedlings aged 2 weeks were transplanted into the growing medium at 29 January 2018.

Experimental design

The study was designed in a Random Completely Block Design (RCBD) with four replications. Each of the replication had three treatments and labelled as T1: common irrigation practice, T2: crop water requirement irrigation and T3: irrigation time scheduling. For one experimental plot, 10 spinach were grown. The arrangement design for this experiment is show in the Figure 1.

T2	T3	T2	T1
T3	T1	T3	T2
T1	T2	T1	T3

Figure 1: Arrangement of experimental design for spinach

Treatment 1 is for common practice where spinach was irrigated 2 times per day until the surface of cocopeat is wet. In treatment 2, the spinach was irrigated based on the spinach crop water requirement. Climatic data from CLIMWAT 2.0 software; daily temperature, relative humidity, wind speed, sunshine hours and solar radiation was obtained to calculate the monthly reference crop evapotranspiration (ET_o) in CROPWAT 8.0 software. Crop evapotranspiration (ET_c) can then be calculated with the crop coefficient (K_c) was equal to 1 as recommended by Allen et al (1998) . The crop water requirement calculation is shown in table 1. For treatment 3, the growth of spinach was observed as the effect of irrigation time scheduling. In this irrigation time scheduling, the time interval will be determined first. The irrigation time scheduling for spinach is shown in Table 2.

Data collection

Data were collected during 29 January until 1 March 2018. The effect of the treatments on the plant development of spinach was measured by taking the plant height, number of leaves, canopy diameter and leaf length. The plant height of the spinach was measured from the cocopeat medium surface until the top of the plant top while the number of leaves was counted each week. The canopy diameter was measured from one leaf tip to the other end and for the leaf length it was measured from the bottom to the tip of the leaves. The fresh weight and root length were measured at the end of this study. For each of the treatment, plants were removed from the medium and fresh weight of spinach was taken with using the electronic scale (Model OHAUS PA2202) and the root length was measured with a ruler.

Data analysis

The effect of each treatment on the growth parameter i.e, plant height, number of leaves, canopy diameter, leaf length, fresh weight and root length of the spinach were analysed using Statistical Analysis Software (SAS). Analysis of Variance (ANOVA) was performed to find significant effect of different growth parameters. Mean comparison using Least Significant Difference (LSD) test at P < (0.05) was employed for mean comparison. Differences were considered significant when the P value was < 0.05.

Results and discussion

Plant height, number of leaves, canopy diameter and leaf length

The result in plant growth of the spinach from day 14 until 28 after transplanting is shown in Table 3. In the second week there was a significant difference between treatment T1, T2 and T3 for plant height. The result for T1 (3.4 cm) was significantly difference with T2 and T3, while T2 (4.90 cm) had the highest height compared to T3 (4.31 cm) and T1 (3.4 cm). However, at 28 days after transplanting there were no significant difference between all treatments. , For number of leaves, canopy diameter and leaf length showed no significant difference between treatments in day 14 and 28.

The reason for significant difference in T1, T2 and T3 for plant height at day 14 after transplanting was because the cocopeat medium is known for high water holding capacity. Therefore at early stage, the medium did not receive enough water to reach the maximum water holding capacity which corresponded to the different respond of plant height in the treatments. However, at day 28 after transplanting (end growing season), the cocopeat medium had reached the maximum water holding capacity and could possibly had been in the saturated state. At this stage, the available water for plant roots to extract is sufficient regardless of the different amount of water given to the plants.

Table 1: Steps to calculate the volume of water based on crop water requirement.

Steps	Values
Crop Evapotranspiration	ET_c Jan = 3.72 mm/day ET_c Feb = 4.04 mm/day
Area of Polybag	16 800 mm^2
Volume of Water	Volume of water: Jan = 3.72 mm/day × 16 800 mm^2 = 62 496 mm^3= 60 ml Feb = 4.04 mm/day × 16 800 mm^2 = 67 872 mm^3 = 70 ml

Table 2: Steps to calculate the volume of water based on irrigation time scheduling.

Steps	Values
Available water (Sa) : obtained from water retention curve (Ilahi, W.F.F, 2017)	0.33 m3 / m3 = 330 mm/m
Effective root depth, D : spinach, root depth (Allen et al., 1998)	0.18 m
Permissible deficit, p (Allen et al., 1998)	0.25
Net irrigation application depth (d) : d = (Sa × p) D	= (Sa × P) D = (330 mm/m × 0.18 m) 0.25 = 11.88 mm
Crop water requirement	Jan = 3.72 mm/d Feb = 4.04 mm/d
Irrigation interval = d/ET_c Where ET_c is the crop evapotranspiration (mm/day) and d is the net irrigation application depth (mm).	Jan = 11.88/ 3.72 = 3.19 = 3 days Feb =11.88/ 4.04 = 2.94 = 3 days
Irrigation frequency The irrigation water need was calculated from the net irrigation application depth (mm) divided by the irrigation intervals (days). The value gives the amount of water need to irrigate each day for every irrigation interval.	Medium = cocopeat Irrigation water need (mm/d) = 11.88 mm/3 days = 3.96 mm/d Total volume (l/day) = 66 528 mm^3/day = 70 ml Frequency application per day = 2 Volume per application = 35 ml

Table 3: Plant height, number of leaves, canopy diameter, and leaf length of spinach with treatments, T1: common irrigation practice, T2: crop water requirement irrigation and T3: time scheduling irrigation at the early and end stage of spinach. Values are means ± Standard error (n = 10).

Days After Transplanting	Treatment	Plant Height (cm)	Number of leaves	Canopy Diameter (cm)	Leaf Length (cm)
14	T1	3.4±0.10b	5.7±0.12a	5.74±0.42a	2.23±0.24a
	T2	4.90±0.23a	5.8±0.22a	6.31±0.38a	2.53±0.25a
	T3	4.31±0.34ab	5.6±0.37a	5.28±0.48a	2.07±0.21a
28	T1	18.15±2.36a	18.15±2.36a	5.27±0.48a	7.84±0.52a
	T2	21.4±1.03a	22.38±0.58a	25.7±0.59a	8.71±0.40a
	T3	21.3±2.71a	21±4.54a	24.8±1.99a	7.84±0.52a

Values in each column with same letter did not differ significantly at $P < 0.05$ according to LSD.

Fresh weight and root length of the spinach

In this study, the fresh weight and root length (figure 2) of the spinach were collected at the end of the growing season. Based on table 4, the fresh weight was highest in T3 (26.43 g) followed by T2 (23.68 g) and T1 (18.82 g). Although there were some differences in fresh weight among the three treatments, there were no significant differences in the fresh weight and root length spinach between treatments when analysed with ANOVA. As cocopeat is a medium with high water holding capacity, different irrigation practice with different amount of water given to the plants did not affect the fresh weight and root length of spinach. Although spinach is a type of plant that are sensitive to water, the cocopeat medium had shown to provide sufficient water for the plants to grow and produce good yield at different irrigation water regime.

Figure 2: The spinach that was harvesting to get the fresh weight and root length

Table 4: Fresh weight and root length of the spinach in treatments likes T1: common irrigation practice, T2: crop water requirement irrigation and T3: time scheduling irrigation at the early and end stage of spinach. Values are means ± Standard error (n = 10).

Treatment	Fresh Weight (g)	Root Length (cm)
T1	18.82 ± 2.68a	11.37 ± 0.36a
T2	23.68 ± 2.42a	11.99 ± 0.45a
T3	26.43 ± 4.80a	12.45 ± 1.15a

Values in each column with same letter did not differ significantly at $P < 0.05$ according to LSD.

Comparison between the irrigation common practices with the irrigation crop water requirement and irrigation time scheduling on the spinach.

Results had shown that with the use of cocopeat as growing medium, there were no significant difference between the growth parameters, fresh weight and root length of the spinach. Significant difference was only observed for plant height after transplanting which was caused by the insignificant available water in the medium.

The study showed that regardless of different amount of watergiven to the spinach; similar yields can be obtained if the spinach is grown using cocopeat as a medium.Based on the three irrigation treatments results, the best practice is to accurately irrigate the water to spinach according to its crop water requirement and irrigation time scheduling.

Conclusions

The outcome of this study showed that spinach grown in cocopeat medium had no significant difference in growth when irrigated by common irrigation practices, irrigation based on crop water requirement and irrigation time scheduling. This was proven from the results of the plant height, number of leaves, canopy diameter, leaf length, fresh weight and root length of the spinach which had no significant difference between treatments.

The main factor that affected the irrigation of the spinach is the medium used to plant the spinach. Cocopeat is a fibrous material which absorb and holds water tight in the material. Cocopeat is also known for its high water holding capacity which can hold water in pores at higher rates and longer period. It can be concluded that the actual amount of water required for spinach growth in cocopeat based medium is according to its crop water requirement and can be scheduled to its irrigation time scheduling for better irrigation water management.

References

Allen, R.G., Pereira, L.S., Raes, D., Smith, M. (1998) *Crop evapotranspiration —guidelines for computing crop water requirements*. FAO Irrigation and drainage paper 56. Food and Agriculture Organization, Rome.Kumar, P., & Sahu, R. L. (2013). Effect of irrigation and fertigation levels on cabbage (Brassica oleracea var. Capitata L.). Progressive Horticulture, 45(2), 366-372.

Bennett, D. R., & Harms, T. E. (2011). Crop Yield and Water Requirement Relationships for Major Irrigated Crops in Southern Alberta. Canadian Water Resources Journal, 36(2), 159–170.

Chaves, M. M., Flexas, J., & Pinheiro, C. (2009). Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Annals of botany, 103(4), 551-560.

Flexas, J., Ribas-Carbó, M., Bota, J., Galmés, J., Henkle, M., Martínez-Cañellas, S., & Medrano, H. (2006). Decreased Rubisco activity during water stress is not induced by decreased relative water content but related to conditions of low stomatal conductance and chloroplast CO2 concentration. New Phytologist, 172(1), 73-82.

Ilahi, W. F. F., & Ahmad, D. (2017). A study on the physical and hydraulic characteristics of cocopeat perlite mixture as a growing media in containerized plant production. Sains Malaysiana, 46(6), 975–980..

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE21

Utilization of Banana Peel Flour As Fibre Ingredient in the Waffle Cones

Zanariah, M. D.*, Nur Zaleqha, M. H., and Lisnurjannah, M.
Dept. of Process and Food Engineering,
University Putra Malaysia, 43400 Serdang, Selangor, Malaysia
*Corresponding author, Tel.: +603-89466358, Fax: +603-8946 4440, Email: nana@upm.edu.my

Abstract
Banana fruits are the most eatable fruits in Malaysia. However, its beneficial skin mostly will be thrown away. The fibrous peels have slightly bitter taste with its good nutritional food attraction. They rich in starch and non-starch polysaccharides including food fiber, antioxidants, polyphenols, essential minerals such as potassium, provitamin A, carotenoids, B1, B2 and C that are acts as dietary roles in human health. In this study, Saba banana peel flour (BPF) sifted to 0.012 inch will convert into waffle cones. Preliminary study on the protein, moisture, crude fiber and fat were carried out for first stages of maturity. First stage BPF acts as water binding agent in food due to its high water holding capacity and have low oil holding capacity. BPF's pH (6.15-6.46) is in standard wheat flour acidity range. Then, the BPF was substituted for 5%, 10%, and 20% of the wheat flour in a batter mix to make waffle cones. The substitution of BPF will affect the physicochemical properties by the pH, colour, odour and tensile strength. As the results, waffle cones of BPF had lower value of L and b* which turned darker than controlled sample. The odour of banana smells in this waffle cones are sweet and fresh but only acceptable physical analysis for 5% and 10% substitution BPF. While for 20% substitution of BPF gave poor result in tensile strength and the sensory analysis but there also can be utiise for making dietary cookies.*

Keywords: Saba banana, banana peel powder, banana peel flour, waffle, banana peel waffle cones

Introduction

Saba banana (Musa balbisiana), is a triploid hybrid banana cultivar originating from the Philippines, primarily a cooking banana, it is usually boiled, steamed and fried. It is one of the most important banana in the Philippine Cuisine. The high demand for banana in the Filipino diet owing to its nutritive value and affordable price compared to mango and pineapple. It is commonly used in processing banana chips and catsup. With the growing awareness on healthy food consumption, substantial increase in value added products derived from banana encouraged the banana industry to augment the raw material production.(Food Development Center, National Food Authority) Banana (*Musa spp*.) is one of the tropical fruits that belongs to the Musaceae family (Chakraborty, Mukherjee, Banerjee, Mukkherjee, & Bandyopadhyay, 2017). Among many species of banana, 'Saba' is the name given in the Philippines to a cooking banana belonging to the Saba subgroup. Saba bananas are classified as *Musa acuminata* x *balbisiana* crossed species. Saba bananas are a popular cooking variety used and known around the world by different names such as *Pisang Nipah* and *Pisang Abu* in Malaysia, *Pisang Kepok* in Indonesia and Kluai Hin in Thailand.

In this study, Saba bananas have been used instead of Cavendish bananas in the making of banana peel waffle cone. Some parameters that need to study to define the acceptance of waffle cones based on its batter are including pH, colour, tensile strength and nutritional values. pH plays an important role in food as it measures the acidity or alkalinity of food and it also measured acid content [H+] directly. Besides, the colour of the food will determine its composition and can be an attraction factor for food consumptions. The strength of the food also needs to be considered because it will affect the handling and storage of the food. Depend on how the food is consumed, the strength will cause changes in shape and texture of foods. Eating a balanced diet is vital for good health and wellbeing. Thus, nutritional values of food will provide the information of energy, protein, essential fats, vitamins and minerals needed by humans to live, grow and function properly.

Materials and methods

Materials

Basic ingredients for banana peel waffle cone preparation were obtained from a local supermarket. The experiments was conducted in the Faculty of Engineering Lab in University Putra Malaysia, Selangor, Malaysia.

Preparation of Banana Peel Flour

The hands of Saba banana were randomly picked from banana bunch. The banana fingers were then separated from its hand and removed its stalk end and blossom end. Then, the banana was rinsed several times with tap water and last rinsed by distilled water. After that, the banana was then peeled and immersed in 0.5% citric acid solution. The peels were then cut and immersed back into citric acid solution and drained after 10 minutes. Next, the peels were dried in the oven (Noxxa Oven) about 72 hours at 60°C. Then, the banana peels were milled for about 30 minutes with interval. The milled powder was then sieved with 50 mesh sifter that gave 126-**250**$\boldsymbol{\mu}$m in size particles. The samples were then stored in ziplock bag in an airtight package at 5$\pm$2 °C for further analysis.

Preparation of Banana Peel Waffle Cones

Formulations for the waffle cones are shown in Table 1. The basic waffle formula consisted of 120 g of wheat flour, 80 g of sugar, 112 g of eggs white, 2 g of salt, and 3 g of essence vanilla. Three additional waffle samples were prepared by substituting wheat flour with 5%, 10% and 20% of banana peel flour. White eggs and essence vanilla were stirred first until bubbles formed. Then dry and wet ingredient were added one by one starting from wheat flour, banana peel flour, sugar, salt, and fresh milk were added and continuously. The parameters involved in the batter analysis are pH, density and viscosity. The analysis is done immediately after the mixing activity is done.

Table 1: Formulation of waffle samples.

Ingredients (g)	Types of waffle			
	Control	5% BPF	10% BPF	20% BPF
Wheat flour	120	114	108	96
Sugar	80	80	80	80
Egg white	112	112	112	112
Salt	2	2	2	2
Essence vanilla	3	3	3	3
Milk	109	109	109	109
Banana peel flour	0	6	12	24

Proximate Analysis

Moisture content was determine with A&D MX50 moisture analyser. Crude protein (AOAC 988.05)., fat (AOAC 963.15), and fibre (AOAC 978.10). The carbohydrate content was determined by using difference meaan. While, the ash was identified by inserting the sample of 5 g into muffle furnace at 600°C until grayish colour obtained.

Water holding and oil holding capacity

a)Water holding

The WHC determination was referred and modified from method applied by (Wachirasiri, Julakarangka, and Wanlapa 2009). The 2g of banana peel powder sample was weight on electronic balance. Then the sample was put into the centrifugal tube with 25 m distilled water. Then, the lid was closed and vortex for about 5 minutes until the water and banana peel powder was mix well. Then the centrifuge tube was heated at 40℃ of water bath. After that, the mixture was centrifuge for 25 minutes at 3000 rpm in room temperature (25℃). The supernatant was decanted carefully and the mass leave in the tube was measured by using electronic balance. Another test with similar method was carried out by replacing the heating temperature from 40℃ into 60℃ and 80℃.

b)Oil holding

The 2g of banana peel powder sample was weight on electronic balance. Then the sample was put into the centrifugal tube and with 25 m cooking palm oil (Seri Murni). Then, the lid was closed and vortex for about 5 minutes until the water and banana peel powder was homogenised. Then the centrifuge tube was heated at 40℃ of water bath. After that, the mixture was centrifuge for 25 minutes at 3000 rpm. The supernatant was decanted carefully and the mass leave in the tube was measured by using electronic balance. Another test with similar method was carried out by replacing the heating temperature from 40℃ into 60℃ and 80℃ . All analysis was done in triplicate.

pH

4% mass of banana peel powder was weight by using weighing balance. Then, the powder was poured into the centrifuge tube and added with 15 ml of distilled water. After that the mixture was vortex for 5 minutes and let it stand for another 30 minutes (Savlak, Türker, and Yes 2016). The acidity of the supernatant was measured by using pH meter. The measurement was done in triplicate.

Results and discussion

Proximate Analysis

Moisture content of banana peel flour is suitable for long time storage as it is in range of standard moisture content of flour.

Table 2: The proximate composition of moisture, crude protein, fat and crude fibre (%w/w)

Proximate component	Saba peels
Moisture (%w/w)	9.18
Crude protein (%w/w)	4.4
Fat (%w/w)	4.8
Crude fibre (%w/w)	1.3

The amount of crude fibre have close similarity as the finding by A et al., (2006) at 1.6±0.03 % at fresh state of mature green and 2.51 ± 0.01 % of ripe Saba banana peels. However, the crude fibre content in this study was lower than the report from Dibanda Romelle et al. (2016) that evaluate the crude fibre of banana peel of Cavendish and obtain value in the range of 11.81 ± 0.06 at 50 ℃ for 24 hours. B.A., Ugye, and Nyiaatagher (2009) also report the value of Musa Sapentium banana's fibre at 31.70 ± 0.25%. It is important to note that the method of preparation of dry banana peel do affect the crude fibre deterioration in banana peel (Wachirasiri, Julakarangka, and Wanlapa 2009).

The amount of protein in banana peel as in Table 2 was much lower compared to the 11.5% quantity of protein proposed by Salehifar, Ardebili, and Azizi (2010) to produce bread with better sensory characteristics and storage time. Although the quantity of protein in banana peel flour is low, Toufeili et al. (1999) asserted that the same bread quality produced is not necessarily due to the same amount of protein. Therefore, the development of banana peel powder in food products blend have good potential as we are rich with resources and able to reduce the dependency of wheat import. It also have potential in non-gluten product development. This is because the protein composition increases as the maturity stage increases. This is in agreement with (A et al. 2016) as the stage of ripeness increases, the protein contents in banana peel of Saba also increases. The effect of stage of fruit maturity on protein composition in banana peels is also reported by (Khawas and Deka 2016).

Contradictory, the amount of fat contents of *Saba* is not detected at premature and mature stage of banana as reported by A et al.(2016). The percentage of fat in this study was detected because the moisture content in sample was lower than their sample study. Longer heating time also influenced the removal of volatile fat from the sample.

The pH ranging from 6.16 to 6.46 in which was acidic. The acidity of green banana peel powder also can be supported by similar finding in Cavendish banana varieties with 8% powder suspension in water(Salih et al. 2017). Paliyath and P. Murr (2007) confirmed earlier by stating that the young fruit tend to be more acidic and it is reduced as the ripening process occur.

pH standard of wheat flour is in range 6 to 6.8 that put it as an acidic food (Pearson 2003). Since the banana peel powder's pH was in the same range as standard flour, it have good potential as wheat substitute of food products.

Conclusions

Utilization of banana peel powder on some food like waffle cones will need extra care on the formulation as it have small diameter. High water holding capacity will cause the banana peel powder volume to lower the tensile strength of wafer cone. The high water holding capacity characteristics is suitable for the food product that need to restore moisture such bread, waffle, cake, biscuit and cookies. The low oil holding capacity characteristic is also beneficial to reduce the absorption of oil during frying. Lastly, 5% and 10% substitution BPF are acceptable because of the sweet and fresh odour of banana smells and acceptable in physical analysis. While for 20% substitution of BPF gave poor result in tensile strength and the sensory analysis but there also can be utiise for making dietary cookies.

References

A, Ogbonna Obiageli, A I Izundu, Ikeyi Adachukwu Pauline, and Ohia Geraldine Ukamaka (2016).Proximate Compositions of Fruits of Three Musa Species at Three Stages of Development. *IOSR Journal of Dental and Medical Sciences* 15(6): 107–17.

Alkarkhi, Abbas F.M., Saifullah Bin Ramli, Yeoh Shin Yong, and Azhar Mat Easa. 2011. 'Comparing Physicochemical Properties of Banana Pulp and Peel Flours Prepared from Green and Ripe Fruits'. *Food Chemistry* 129(2): 312–18. http://dx.doi.org/10.1016/j.foodchem.2011.04.060.

Berk, Zeki. 2013. 'Physical Properties of Food Materials'. *Food Process Engineering and Technology*: 1–27. http://linkinghub.elsevier.com/retrieve/pii/B9780124159235000010.

Brannan, Robert G. et al. 2014. 'Influence of Ingredients That Reduce Oil Absorption during Immersion Frying of Battered and Breaded Foods'. *European Journal of Lipid Science and Technology* 116(3): 240–54.

Carr, R.L. 1965. 'Classifying Flow Properties of Solids'. In *Chemical Engineering Journal*, , 69–72.

Castelo-branco, Vanessa Naciuk et al. 2017. 'The Use of Green Banana (Musa Balbisiana) Pulp and Peel Flour as an Ingredient for Tagliatelle Pasta Uso Da Farinha de Polpa e de Casca de Banana Verde (Musa Balbisiana) Como Ingrediente Para a Elaboração de Massa Tipo Talharim'.

Castillo-Israel, K. A.T. et al. 2015. 'Extraction and Characterization of Pectin from Saba Banana [Musa 'Saba'(Musa Acuminata x Musa Balbisiana)] Peel Wastes: A Preliminary Study'. *International Food Research Journal* 22(1): 202–7.

Christina, Josephine, and Youngsoo Lee. 2016. 'Modification of Sodium Release Using Porous Corn Starch and Lipoproteic Matrix'. *Journal of Food Science* 81(4): E897–905.

Dibanda Romelle, Feumba et al. 2016. 'Chemical Composition of Some Selected Fruit Peels'. *European Journal of Food Science and Technology* 4(4): 12–21. www.eajournals.org.

Hausnerr, and H.H. 2003. 13 *Friction Conditions in a Mass of Metal Powder*. Amsterdam: Elsevier Science.

Khawas, Prerna, and Sankar Chandra Deka. 2016. 'Comparative Nutritional, Functional, Morphological, and Diffractogram Study on Culinary Banana (Musa ABB) Peel at Various Stages of Development'. *International Journal of Food Properties* 19(12): 2832–53. http://dx.doi.org/10.1080/10942912.2016.1141296.

Paliyath, Gopinadhan, and D. P. Murr. 2007. 'Biochemistry of Fruits'. In *Food Biochemistry and Food Processing*, ed. Y. H. Hui. Blackwell Publishing, 1–769.

Ramli, Saifullah, Abbas F. M. Alkarkhi, Yeoh Shin Yong, and Azhar Mat Easa. 2001. 'Utilization of Green and Ripe Banana Peel as a Functional Ingredient in Yellow Noodle'. 0: 9–10.

Salehifar, Mania, Mehdi Seyedein Ardebili, and Mohammad Hosein Azizi. 2010. 'Effect of Wheat Flour Protein Variations on Sensory Attributes, Texture and Staling of Taftoon Bread'. *Ciência e Tecnologia de Alimentos* 30(3): 833–37. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-20612010000300041&lng=en&nrm=iso&tlng=en.

Savlak, Nazlı, Burcu Türker, and Nazlıcan Yes. 2016. 'Effects of Particle Size Distribution on Some Physical , Chemical and Functional Properties of Unripe Banana Flour'. 213(October 2014): 180–86.

Toufeili, I. et al. 1999. 'The Role of Gluten Proteins in the Baking of Arabic Bread'. *Journal of Cereal Science* 30(3): 255–65. https://www.sciencedirect.com/science/article/pii/S0733521099902862 (May 19, 2018).

Wachirasiri, Phatcharaporn, Siripan Julakarangka, and Sorada Wanlapa. 2009. 'The Effects of Banana Peel Preparations on the Properties of Banana Peel Dietary Fibre Concentrate'. *Songklanakarin Journal of Science and Technology* 31(6): 605–11.

Widjaya, Cecillia. 2010. 'The Impact of Ingredient Formulation and Processing Parameters on Colour and Texture of Instant Noodles'. *School of Applied Sciences Science, Engineering and Technology Portfolio* PhD(July).

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE22

Performance Evaluation of Vertijack (Jackfruit Opener) for Commercial-scale Fresh-cut Fruit Industry

Z. Mohd Shafie[1,*], R. Abdul Wahid[1], A. Shahar[1], A. Hamzah[1], H.H. Hasbullah[1], W.M.F. Wan Azman[1], S.A. Azizan[1], , A.A. Rahim[1], S. Alwi[1], M.Z. Zainol Abidin[1], M.H. Mohd Amin Tawakkal[1], M.S. Johari[1], M.A. Sani[1], M.A. Jamaluddin[1] and F. Abdul Karim[3]

[1]Engineering Research Centre, Malaysian Agricultural Research and Development Institute (MARDI), MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor

*Corresponding author. Tel.: +603-8953 6544, Email: szainun@mardi.gov.my

Abstract

The market of fresh-cut jackfruit is increasingly popular, due to current lifestyle that prefer quality fresh fruit and ready to eat. The preparation of fresh-cut jackfruit is a time consuming, labour intensive and complicated due to the inherent nature of the fruit. Skilled operators are needed to avoid bulb damaged and tissue injury that subsequently leads to quality deterioration. For commercial or export markets the edible bulb needs to be presented in good shape. To overcome the problems mention above, Vertijack was developed to cater commercial scale processing of jackfruit. The machine functions is to aid the opening of the fruit whilst minimizing injury to the edible bulb by removing the core and then splitting open the fruit. The average damaged bulbs due to mechanical injuries during splitting of fruit manually compared to the machine is reduced by half i.e. 34% and 16% respectively. Furthermore, the processing time needed for Vertijack is about 73s per fruit, which is 3 times faster than manual operation. The core removing efficiency is only 49 to 70% depends on the fruit size and their core shape.

Keywords: Jackfruit, fresh-cut, jackfruit opener

Introduction

Jackfruit (Artocarpus heterophyllus) is the largest edible fruit in the world belongs to the family Moraceae. Jackfruit can be eaten fresh or process into chip, juice, jam, pickles and canned. There are about 5097 hectares of jackfruit was grown in Malaysia with annual production of 28,042 metric tons per year (Department of Agriculture Malaysia, 2017). Fresh jackfruit has the potential to penetrate the China and USA market.

Clone J33 also known as Tekam Yellow or Honey Jackfruit is the most popular variety for local and export market. J33 has the best quality value because of its sweetness, crispy, golden-yellow color, strong sweet and fruity aroma, and longer shelf life compare to other varieties (Norhashila & Bisant, 2013). Jackfruit usually market in the form of whole fruit or fresh-cut fruit as minimally processed fruit. The fresh-cut or ready to eat form has greater market compare with the whole fruit because of their large size, difficulty in peeling and risk in obtaining poor-quality bulbs.

The fruit has oval shape with spiny and thick rind and may weight from 5 to 50 kg. The fruit consists of 50 to 100 edible bulbs embedded between center core and inner skin. The bulbs are covered with thin strips of epidermal cells and cuticle layer (Latifah et al., 2016). The process of separating the edible bulbs is difficult and unpleasant as the fruit contain gummy latex that stick to the hands and knives. Skilled workers are needed to separate the bulbs from the fruit to avoid tissue injury during processing. Tissue injury will fasten the deterioration process due to the increase of respiration rate, ethylene synthesis, enzymatic browning and microbial growth (Latifah et al., 2016). Furthermore, the process of opening the fruit manually is time consuming.

Seeing the need by the industry, a jackfruit opener (Vertijack) was developed to aid large scale processing of fresh-cut jackfruit. The simplicity of the design would enable unskilled operator to operate it. The machine functions to aid the opening of the fruit whilst minimizing injury to the edible bulb by removing the core and then splitting open the fruit. The aim of this study is to evaluate the performance of jackfruit opener.

Materials and methods

Materials

Jackfruit of the variety Tekam Yellow (honey jackfruit J33), of weight in the range of 9 to 14 kg, was obtained from Pasar Borong Selangor, Seri Kembangan, Selangor and DRS Trading Sdn. Bhd. Jackfruits with maturity at index 3 were used for this study. Jackfruits at index 3 have the following characteristics: 1) Fruit color turns into green or greenish yellow; (2) the fruit spines become less sharp and widely spaced; (3) an aromatic adour develops (FAMA).

Vertijack prototype

The prototype consists of hollow shaft for removing the center core, two sets of blade for cutting the jackfruit rind, a pusher to split the jackfruit, a holder to hold the fruit and pneumatic system to provide compression force for coring and splitting action. The overall structure of the prototype is made of stainless-steel.

To operate the prototype, operator has to place jackfruit into the holder and push the start button. The hollow shaft would penetrate at the stem end of the jackfruit until required depth for coring operation. Simultaneously, the blades would moved downward and penetrate the rind for cutting process. After that, the pusher would pushed to split the jackfruit.

Figure 1: Vertijack

Figure 2: Cutting and splitting process by Vertijack

Prototype evaluation

The evaluation was conducted by comparing the performance of the jackfruit opener versus manual cutting on the basis of time taken to complete the cutting and removing the core. After each operation, the edible bulbs were sorted and the percentage of damaged bulbs will be calculated. The bulbs with visual cut and tear were considered as damaged. The percentage of damaged bulbs was calculated by the following equation (1):

$$\text{Damaged bulbs (\%)} = \frac{W_d}{W_t}\ x\ 100\% \qquad (1)$$

Where;

W_d = Weight of damaged bulb (kg)

W_t = Total weight of bulb separated (kg)

The efficiency of the prototype in term of percentage of core removing was determined using the following equation 2:

$$\text{Core removing efficiency (\%)} = \frac{W_{cr}}{W_{tc}}\ x\ 100\% \qquad (2)$$

Where;

W_d = Weight of core removed (kg)

W_t = Total weight of bulb separated (kg)

Figure 3: Splitting jackfruit and core from Vertijack

Results and discussion

Performance comparison between Vertijack and manual method

From the results presented in Table 1, it is very clear that jackfruit opener is capable for coring and splitting the jackfruit 3 times faster that manual. The time indicate for jackfruit opener is inclusive of the time needed to loading and unloading the jackfruit from the holder. Therefore, the actual coring and splitting process is very much less than that is recorded.

Table 1: Performance comparison between Vertijack and manual method

Performance parameter	Method	
	Jackfruit opener	Manual
Processing time (s)	72.7 ± 21.7	219 ± 34.9
Damaged bulbs (%)	16.2 ± 3.5	34.9 ± 4.1

Table 1 also shown that the percentage of damaged bulbs. The percentage of damaged bulbs for Vertijack and manual are 16% and 34% respectively. Thus, it is clearly shows that by using Vertijack, the damaged bulbs can be reduced by almost half compare to the manual method. The damage was due to mechanical injury from cutting (flesh cut) and splitting (flesh tear) process.

Core removing efficiency

The core removing efficiency of Vertijack was about 49 to 70%. From the observation, the core removing efficiency was higher for small size fruits compare with large size fruits. This probably because the large size fruits have bigger core diameter compare with small size fruits. Thus, a part of the core remained because the diameter of the hollow shaft was smaller than the fruit core diameter. If using hollow shaft with bigger diameter, it will cut some of the edible bulbs during coring action especially for small size and medium size fruits. Thus, will increase the percentage of bulb damage.

Furthermore, some of the fruits have uneven core shape, thus increase the possibility of incomplete core removing process, thereby reduce the core removing efficiency. The uneven core shape also cause the increase in percentage of damaged bulbs due to flesh cut during coring action.

Conclusions

The Vertijack manage to speed up the jackfruit coring and splitting process by about 3 times faster compare to manual. Furthermore, the percentage of bulb damage reduce from 34 to 16% when using Vertijack. This show that Vertijack can significantly reduce the processing time and losses due to mechanical injury. However, the core removing efficiency is low especially for large size fruits and fruits with uneven core shape. Therefore, further improvement is needed to increase the performance of Vertijack.

References

Anaya-Esparza, L. M., González-Aguilar, G. A., Domínguez-Ávila, J. A., Olmos-Cornejo, J. E., Pérez-Larios, A., & Montalvo-González, E. (2018). Effects of Minimal Processing Technologies on Jackfruit (Artocarpus heterophyllus Lam.) Quality Parameters. Food and Bioprocess Technology, 11(9), 1761–1774. doi:10.1007/s11947-018-2136-z

Ab Aziz, I., Zolkafli, A., Latifah, M.N., Ruwaida, A.W., and Shafie, A. A (2014). Application of devices during minimal processing of jackfruit. National Conference on Agricultural and Food Mechanization 2014(NCAFM 2014) (Kota Kinabalu, Sabah, Malaysia)

Department of Agriculture Malaysia. Fruit crop statistic Malaysia 2017. Retrieved from http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/perangkaan_buah_2017.pdf

FAMA. Kualiti Nangka Berpandukan Malaysian Standard (MS 1055:2012). Retrieved from http://www.fama.gov.my/documents/20143/0/nangka+baru.pdf/15ed0e57-336a-a099-f007-ab83d3cb5bef

Latifah M.N., Ab Aziz I., Ruwaida A.W., Nur Azlin G., Siti Aisyah A., Joanna C.L.Y., Nur Shafini G., Fauziah M., Zaulia O. and Razali M. (2016). Processing and handling of fresh-cut tropical fruits. Acta Hortic. 1141 Proc. III Int. Conf. on Fresh-Cut Produce: Maintaining Quality and Safety, 91-102.

Latifah, M.N., Abdullah, H., Ab Aziz, I., Nur Aida, M.P., Bizura Hasida, M.R., Fauziah, O., Azlan, O., Hairiyah, M., Talib,Y., Zainab, Y., and Ismail, M. (2013). New approaches in improving the quality and safety maintenance of selected minimally processed tropical fruit for market distribution. Acta Hortic. 1012, 1229–1234

Norhashila I., Bisant K. (2013). Consumer preference for jackfruit varieties in malaysia. Journal of Agribusiness Marketing, Vol. 6, 37-51.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE23

Mobile precooler for horticultural produces – a preliminary study

Sharifah Hafiza, M.R.,[1,*], Nur Azlin, R.[2], Jamaluddin. M. A.[1] and Zainol Abidin. M. Z[1]
[1]Engineering Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor
[2]Horticultural Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor
*Corresponding author. Tel.: +603-89536558, Email: shhafiza@mardi.gov.my

Abstract

Cooling is one of the critical unit operations in the horticultural supply chain. Cooling shortly after harvest is called precooling. A mobile forced-air-cooler has been developed to visualize these precooling techniques. The mobile forced-air-cooler with a dimension of 0.6x0.15x1.3 m was developed using an axial fan with five nylon blade impeller and a fan capacity of 1425 rpm. During experiments, five boxes of fruits were stacked in two columns in a cold room for the precooling experiments. The mobile forced-air-cooler was placed in front of the stacks to draw the cold air through the stacks via the ventilation holes. Another room cooling experiments were also executed concurrently as a comparison. The fruits were then stored in a cold room for four weeks. Durian reduced its temperature to 9 °C from its initial temperature of 20 °C, while pineapple reached 14 °C from initial temperature of 25 °C after 7 hours of precooling experiments. The trials did not able to reach the seventh-eight cooling time however the fruits had a similar quality of fruits with cold room cooling experiments. Nevertheless, the cooling profiles showed a lower curved than cold room cooling. Recommendations and improvements to reach the desired seventh-eight cooling time were discussed.

Keywords: precooling, forced-air-cooler, durian, pineapple

Introduction

Horticultural produce is a biological material, that is even after separated from the parent plant, is still respiring and transpiring. Therefore, precooling is employed to slow down the metabolism, minimizing the respiratory heat generation, hindering the ripening, prevent moisture loss and microbial spoilage. Precooling was done rightly after harvest, to remove the field heat from the fresh produce. Various methods of precooling are available, including natural convective cooling, evaporative cooling, vacuum cooling and hydrocooling. Nevertheless, the most flexible and cost effective cooling method is forced-air-cooling (Ambaw et al., 2018; Elansari & Mostafa, 2018).

Tropical fruits are usually susceptible to chilling injury therefore they need to be cool to individual temperature requirement rapidly (ASHRAE, 2010). Pineapple is amongst one of the tropical fruits that has a short postharvest life span in ambient temperature and tends to deteriorate easily (Mandal et al., 2015). While durian, which is known as “Malaysian King of fruit” has wide acceptance for commercial market therefore a proper temperature management during postharvest handling is required. For forced-air-cooling of banana, Kuan et al. (2015) reported that the forced-air-cooled banana had lower pH and showed less chilling injury symptoms than the untreated banana.

In this study, a mobile precooler is developed as a direct cooling using air as a refrigerant coolant in cold room (Ambaw et al., 2018). During forced-air-cooling (FAC), cold airs are pushed through pallets via the ventilation holes in the stacked or palletized cartons (Wu et al., 2018). This paper discusses the development of the mobile precooling and its efficiencies in lowering the field heat of pineapples and durian.

Materials and methods

Plant Materials

Musang King variety of Durian and MD2 variety of pineapple were used in this study. After receiving, the durian and pineapple was kept at 25°C overnight. Four pieces of fruits were placed in each box (53x40x20 cm).

Mobile forced-air-cooling apparatus

The mobile forced air cooling apparatus was developed based on the concept of drawing the cold air to the stacks of produces. This mobile forced-air-cooling has a dimension of 0.6x0.15x1.3 m, equipped with five blades nylon impeller axial fan (EPMB-4E-350, Massive Fan, Malaysia) with 1425 RPM fan capacity. The developed mobile forced air cooler was depicted as in Figure 1. Tarpaulin sheet was used to cover the stacks of the fruit.

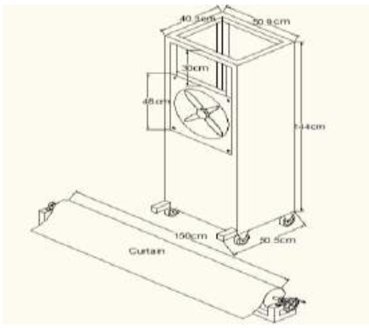


Figure 1. Mobile forced-air-cooler unit to precool horticultural produces

Experimental Setup

The developed mobile forced-air-cooler was placed inside a 20.6 m^3 cold room. The setting temperature of the cold room was predetermined (10 °C for durian and 7°C for pineapple). Five boxes of fruits were stacked on a pallet and placed in front of the forced-air-cooling unit. The arrangement of the stacked boxes was illustrated in the Figure 2. Tarpaulin sheet curtain was pulled to cover the whole stacks of boxes. The same configuration for cold room cooling was replicated at another cold room. The experiments were carried out concurrently. The forced-air-cooling was initiated by switching on the fan and stopped after seven hours of precooling trial.

Three temperature probes (HOBO, Massachusets) was drilled to the core of the fruits to log the core temperature of the fruits at every five minutes interval.

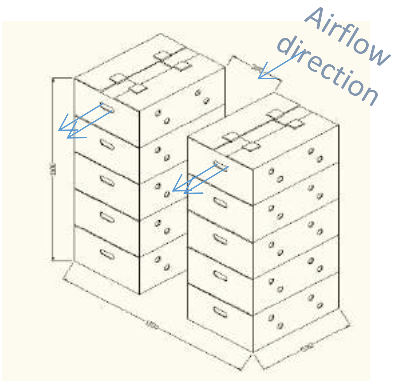


Figure 2. Fruits arrangement during forced-air-cooling experiments

Fruit quality assessment

After precooling experiments were carried out, the fruits were then stored for four weeks in the cold room. The fruit qualities were assessed subjectively by scoring in visual quality scoring indices for their visual appearances. The visual quality scoring indices used as described by Abdullah et al. in Mandal et al. (2015)

Results and discussion

Time-temperature response

The time-temperature response of the two different fruit commodities were showed in graph as in Figure 2. The cooling curves for both fruits did not significantly different when precooled with FAC techniques. The durian fruits reached 9.37 ° C after cold room cooling and 9.67° C after precooled using mobile FAC after seven hours. The pineapple reached 14.0 °C in cold room cooling and reached 13.6 °C after seven hours of precooled using mobile FAC. Linear regression was used to determine the line of best fit in the semilog graph in Figure 3, in which the slope of the regression line is the cooling coefficient, C (hr^-1). The steeper the slope of the graphs indicated the faster the cooling rate. The cooling coefficient was demonstrated as in Table 1. The highest cooling coefficient was from durian that was precooled using cold room cooling (-1.6625 hr^{-1}), while the pineapple that is precooled with mobile FAC unit has higher cooling coefficient (-1.3358 hr^{-1}) than the pineapple precooled using FAC unit (-1.292 hr^{-1}). Due to small difference in the cooling coefficient for both techniques of precooling, this might indicate that the mobile FAC did not significantly able to precool the fruits after seven hours.

Fruit Quality

The visual appearance of durian and pineapple after precooling treatment was demonstrated as in Figure 4 sample, after stored up to week 4. Durian also resulted in a comparable quality between the forced-air-cooling and cold room cooling samples after stored up to week 2.

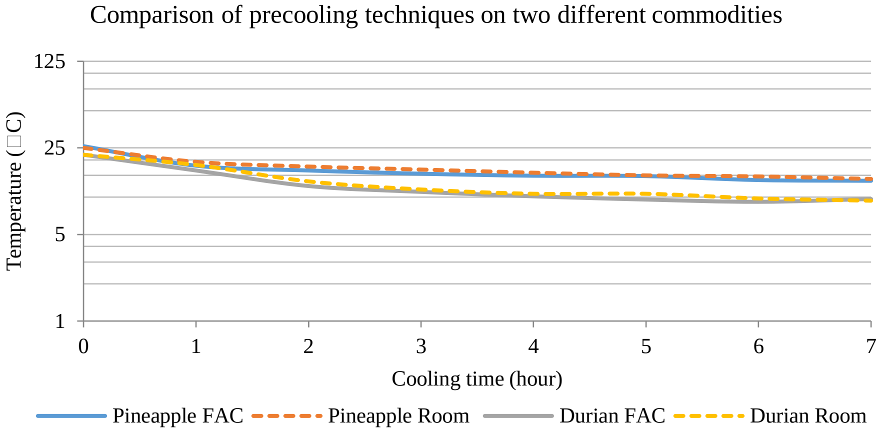


Figure 3. Time-temperature response of two different commodities on the forced-air-cooling techniques. Complete line (---) indicated the forced- air-cooling techniques, while the dash (- - -) indicated the room cooling techniques

Table 1: The cooling coefficient, C and R^2 of the fruit commodities at two different precooling treatments

Fruits	Treatment	Cooling Coefficient, C (hr^{-1})	R^2
Durian	RC	-1.6625	0.8031
	FAC	-1.5673	0.7320
Pineapple	RC	-1.2920	0.7906
	FAC	-1.3358	0.6275

*FAC is forced air cooling treatment
*RC is cold room cooling

Observations from the existing mobile precooler indicated that some improvement may be done to increase the efficiency of the precooler. Some recommendations for improvement are listed below for future references.

Fan type

The existing mobile precooler is using an axial fan with a 1425 m^3/h fan capacity. Axial fan moves the air parallel to the direction of inlet air. The air flow created by axial fan usually are low pressure but large in volume. It was recommended to use the centrifugal type fan. The prototype developed by Elansari and Mostafa (2018) and Mukama et al. (2017) used centrifugal fan. Centrifugal fan removes the air perpendicular to the direction of the inlet air. Differential pressure difference that created when the air flow is directed to the ducts resulted to higher pressure airflow.

Packaging type

In this experiment, a box was used as the packaging material for the fruits. The vent ratio of the box, at the front and the back is 3.3%, at the sides' 2.4 % and 29.8 % at the top. This vent ratio indicated that only 5% vent area to the total box area is provided to the fruits. Therefore, the increase of vent areas in the packaging is expected to improve the efficiency of the precooling.

Air flow distribution

The limitation or system boundary of this study is that the precooling experiment was carried out in the pre-existing facilities. The airflow distribution in the pre-existing cold room was found not uniform, and the largest air flow was at the point D in Figure 5 (A = 0.8 m^3/s, B = 0.4 m^3/s, C = 1.7 m^3/s, D = 2.4 m^3/s, E = 1.8 m^3/s, F = 0.3 m^3/s). As air flow also contributed to the effectiveness of the precooling method, the manipulation of this limitation should be considered in the future works.

Conclusions

The preliminary results from precooling using mobile forced-air-cooling unit showed that the cooling curve for forced air cooling was slightly lower than the cold room cooling curve when plotted linearly. When plotted in a semilog graph, the cooling coefficient showed a similar cooling rate, indicating that the forced-air-cooling efficiency was poor. The fruit quality also showed a comparable characteristic with cold room cooling.

Some recommendations are also discussed in this paper, such as fan type, packaging type and the airflow distribution. Further investigations on the forced-air-cooling with improvement on the observed parameters are needed to increase the efficiency of this precooling method.

Figure 4a. Pineapple fruits at week 0

Figure 4b. Cold room cooling pineapple at week 4

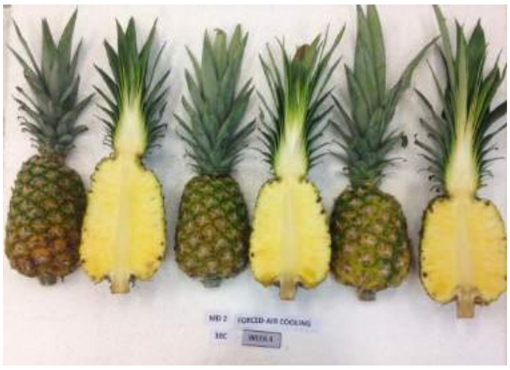


Figure 4c. Forced air cooling pineapple at week 4

Figure 4. The overall appearance of pineapples after storage up to week

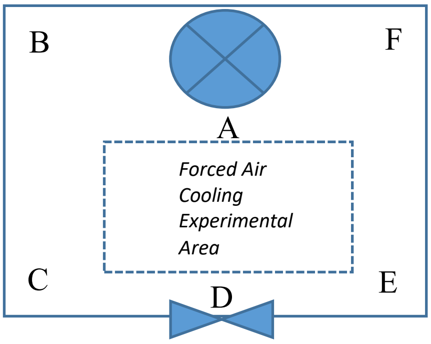


Figure 5. Air flow distribution in the pre-existing cold room


Figure 6a. Durian fruits at week 0


Figure 6b. Durian fruits at week 2 after cold room cooling


Figure 6c. Durian fruits at week 2after force air cooling

Figure 6. The overall appearance of durian fruits after storage up to week 2

References

Ambaw, A., Mukama, M., & Opara, U. L. (2018). Computational fluid dynamics (CFD) based analysis of the aerodynamic and thermodynamic performances of package designs during cooling of stacked pomegranates. *Acta Horticulturae*(1201), 205-212. doi:10.17660/ActaHortic.2018.1201.28

ASHRAE. (2010). Methods of precooling fruits, vegetables and flower *ASHRAE Handbook*.

Elansari, A. M., & Mostafa, Y. S. (2018). Vertical forced air pre-cooling of orange fruits on bin: Effect of fruit size, air direction, and air velocity. *Journal of the Saudi Society of Agricultural Sciences*. doi:10.1016/j.jssas.2018.06.006

Kuan, C. H., Ahmad, S. H., Son, R., Yap, E. S. P., Zamri, M. Z., Shukor, N. I. A., . . . Bunga Raya, K. (2015). Influence of forced-air precooling time on the changes in quality attributes and consumer acceptance of Musa AAA Berangan. *International Food Research Journal, 22*(5), 6.

Mandal, D., Lalremruata, Hazarika, T. K., & Nautiyal, B. P. (2015). Effect of Post-harvest Treatments on Quality and Shelf Life of Pineapple (Ananas comosus [L.] Merr. ‘Giant Kew’) Fruits at Ambient Storage Condition. *International Journal of Bio-resource and Stress Management, 6*(4), 490. doi:10.5958/0976-4038.2015.00072.x

Mukama, M., Ambaw, A., Berry, T. M., & Opara, U. L. (2017). Energy usage of forced air precooling of pomegranate fruit inside ventilated cartons. *Journal of Food Engineering, 215*, 126-133. doi:10.1016/j.jfoodeng.2017.07.024

Wu, W., Häller, P., Cronjé, P., & Defraeye, T. (2018). Full-scale experiments in forced-air precoolers for citrus fruit: Impact of packaging design and fruit size on cooling rate and heterogeneity. *Biosystems Engineering, 169*, 115-125. doi:10.1016/j.biosystemseng.2018.02.003

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya
MSAE2019-PFE25

Rice Quality Assessment Using Fluorescence Imaging Technique

MAHIRAH, J.*[1], Dimas, F.A.R.[2], WIDODO, S.[3], SUZUKI, T.[3], OGAWA, Y.[3], KONDO, N.[3]
[1]*Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.*
[2]*Graduate School of Agriculture, Kyoto University, Kitashirakawa-Oiwakecho, Sakyo-ku, Kyoto 606-8502, Japan*
[3]*Department of Mechanical and Biosystem Engineering, Bogor Agricultural University (IPB),Jawa Barat 16680 Indonesia*
**Corresponding Author, Tel: +603 89464330, E-mail: jmahirah@upm.edu.my*

Abstract
Grain rice quality is defined by various parameters including physical, biochemical and physiochemical properties. Most of the technology that have been developed only measure one quality characteristics at one time. More capability such as assessment of multiple quality parameters in one system is desirable. In this research, a machine vision with double lighting system has been developed to incorporate more features for the quality evaluation. The proposed machine vision system has the capability to obtain information related with morphological features and fluorescence color information of the rice simultaneously. Those features extracted from the image set were used to separate between non-white core, white core, chalky and dead sake rice with different freshness condition. This system shows promising result for separating difference type of rice with different freshness. These results provide an alternative way for quality grading technology for rice.

Keywords: Double Lighting, Freshness, Fluoresence, Rice Quality

Introduction

In Japan, the quality of rice as an ingredient of sake depends on several physicochemical properties, such as protein content, water absorbability of grain, the weight of 1000 grains (around 25 to 30 g), moisture content, and the most important characteristic for sake brewery the presence of the white core at the center of the rice grain. In addition, for all rice varieties, both table or sake rice, freshness is also an important factor of quality evaluation. Moreover, these physiochemical and physiological characteristics will change during storage (Hachiya et al., 2009). Chrastil et al. (1990) explains the changes in functional properties associated with aging on the rice.

In this study we will focus on two main qualities for sake rice: freshness and the occurrence of white core (type of sake rice). White core refers to an opaque region in the endorsperm of the rice grain, which is called Shinpaku in Japanese. Rice grains with white core can absorb water quickly and steam well; a desirable characteristic of sake rice grain. The white core is very important because it helps to increase the ability to gelatinize during steaming, has a softer center for Aspergillus Oryzae (koji), a filamentous fungus (a mold) (Aramaki et al., 2004; Kamara et al., 2009), to invade once it breaks through the firmer outer layer, and is more readily converted by the koji enzymes. It is used to saccharify the rice, breaking down the complex carbohydrates into monosaccharide components.

This structure scatters light and causes what is often seen as a white core at the center of large grains. But amongst the harvested sake rice grains, not all the rice will have the desired white core. Other rice grains can have a chalky appearance, which is associated with the development of numerous air space between the loosely packed starch granules; resulting in changes in light reflection (Tashiro and Wardlaw, 1991).

Recently, Ultraviolet (UV) imaging, including fluorescence imaging, has begun to be explored and used for some non-destructive applications. The fluorescence material absorbs the UV excitation, then reradiates at a longer wavelength (Richards, 2006). Non-destructive approaches have been proposed by Hachiya et al., (2009) to evaluate freshness of rice using fluorescence imaging with UV-Excitation (Hachiya et al., 2009). They found that the old rice has a higher fluorescence intensity compared to new rice in the emission wavelength region of 440 – 500 nm, which is related to the chemical oxidation of the rice. However, the color information their system obtains is restricted to the red region of visible spectrum, since they are applying a short pass filter to the camera. As a consequence, original RGB information that may also useful for freshness discrimination has not been explored thoroughly in previous research.

This study develops novel ideas for evaluating rice quality appearance using a unique machine vision system. A double lighting system is developed, which consists of frontlighting and backlighting and a RGB camera for image acquisition. In addition, UV LEDs with a specific narrow bandwidth for inducing visible fluorescence and a backlighting system with white LED were develop to acquire transmittance images of the rice. These two sets of images were then used to extract features related to morphological properties and the fluorescence properties of the rice. These extracted features were then used to discriminate between rice grain types and freshness levels.

Materials and methods

1. *Rice samples*

A total of 536 rice grains (Yamadanishiku) harvested in 2011 and 2016 in Hyogo Prefecture, Japan with a moisture content of 15.4% were used. In each year sampled the rice grains consisted of the 4 type of sake rice grain: non-white core (translucent) rice (67 samples), white core rice (67 samples), chalky rice (milky white rice) (67 samples) and dead rice (67 samples). Images of the different types of rice grains are shown in Figure 1.

(a) (b) (c) (d)

Figure 1: Images of (a) non-white core (translucent) rice (b) white core (c) chalky rice (milky white) (d) dead rice

In translucent rice the starch granules are tightly packed into the cell, which will allows the transmission of scattered light (Yamada et al. 2002). Whereas in the white core rice there is space between the starch granules in the cell, which are small and disorganized thus preventing the transmission of scattered light (Yamada et al., 2002). Moreover these white core rice normally have an opaque region in the central region of endosperm, while in the chalky (milky white) rice the opaque region is in the ventral part or entire endosperm (Yoshizawa and Kishi, 1994), but both the white core and milky white rice grains are larger in length, width and thickness, but lower in length/width ratio than the non-white core rice.

2. *Machine vision system setup*

The machine vision system consisted of a camera, two lighting arrangements: frontlighting and backlighting, and a glass plate for placing the samples on. The images were captured using a Digital Single Lens (DSLR) camera (Canon EOS Kiss X7, Canon, Japan) with PL filter. For the frontlighting, we constructed a UV LED lighting system (365 nm) with PL filter (Y-49, Japan). Then, for the backlighting, we used square type white LED (CCS Co., Ltd., type:LFX2-75SW) as backlight and a power unit (PD2-3024-2, CCS Co., Ltd., Japan.) to control brightness for both lighting devices. At the time of measurement the grain sample was placed on the smooth surface of the glass plate. This system is a modification of the double lighting system previously reported in detail elsewhere (Jahari et al., 2015; Mahirah et al., 2017). The schematic layout of the developed machine vision system is shown in Figure 4.

Before acquiring the images, the camera operation parameters were optimized for high quality image capture. EOS Utility Software（Canon Inc.）was used for acquiring the images and setting the parameters of the camera. Appropriate combinations of shutter speed, ISO, focal length and F-number were adjusted to ensure objects could be easily distinguished from the background. After the white balance setting, both lighting systems were two set-up optimal lighting.

The sample was then subsequently sub-sampled for ease of image acquisition. The image acquisition device is compact necessitating the sample be of small size to avoid problems with overlapping of grains and other material in this experiment, the sample was placed manually on the object plate.

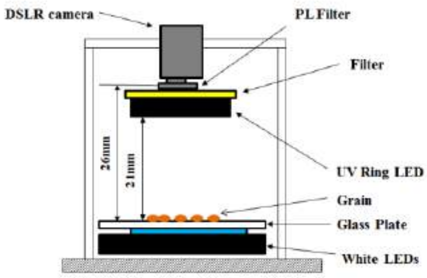


Figure2: Double lighting machine vision setup

3. *Image processing and analysis*

Images captured by the UV LED frontlighting were then processed by extracting the color features, such as Red, Green, Blue (RGB) of the rice grains using Matlab R2013a (MathWorks, Natick, USA). For the images from the backlighting system, the morphological properties of the grains were extracted using ImageJ2 (ImageJ developers). In this study, we used 3 features parameters as below:

$$\boldsymbol{Ratio\ (Perimeter\ with\ area) = \frac{Perimeter\ of\ opaque}{Area}} \quad (1)$$

$$\boldsymbol{Ratio\ (Opaque\ area\ with\ full\ area) = \frac{Area\ of\ opaque}{Area\ of\ full\ grain}} \quad (2)$$

$$\boldsymbol{Distance\ of\ centroid\ (opaque\ and\ full) = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}} \quad (3)$$

where

(i) perimeter is defined as the distance around the boundary of the region

(ii) area is defined as the actual number of pixels in the region

(iii) centroid is defined as the center point of the region which is the average of the x and y coordinates of all of the pixels.

Figure 3 shows the flowchart of the image processing and feature extraction for the backlighting image.

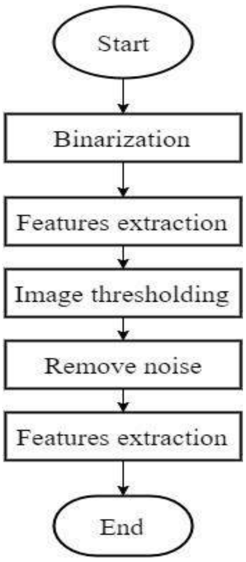


Figure 3 Flowchart of backlighting image processing

4. Classification of sake rice

A two-way ANOVA was used to compare the mean differences between groups. The primary purpose of the two-way ANOVA was to understand if there was any interaction between the two independent variables on the dependent variables. In this study, we observed interactions between color and morphological overview of the similarities and differences among the samples.

Results and discussion

Images of sample grains for the different sake rice grain types and different year of harvest (2011 & 2016) obtained by the double lighting system (frontlight and backlight) with the same orientation are shown in Figure 4.

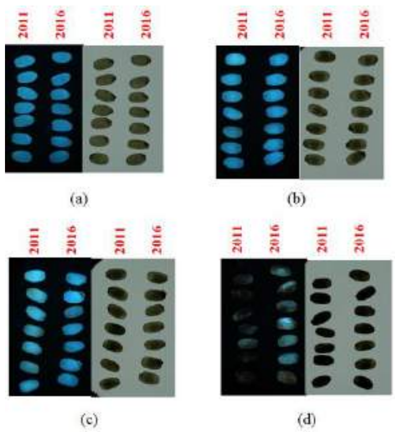


Figure 4 : Image of samples harvested in different years taken using double lighting image system (the left side is the frontlight image taken using UV LEDs and the right side is the backlight image taken using white LEDs (a) non-white core (translucent) rice (b) white core (c) chalky rice (milky white) (d) dead rice

The old rice (2011) has a higher intensity of RGB compared to the new rice.

Table 1 shows average and variance for each type of rice in different years followed by the two-way ANOVA results for the RGB. This result confirms that the color information from the UV-imaging is promising for separating the rice with difference of the year. Even though it also gives a difference for different type of the rice, but it doesn't shows a same pattern for all type of rice.

Table 1 The average, variance and two way ANOVA results for RGB color channel

		Non-white core		White core		Chalky		Dead	
		2011	2016	2011	2016	2011	2016	2011	2016
R	Average	26.37	18.40	27.79	20.76	41.90	22.50	41.09	23.04
	Variance	15.60	7.07	22.75	7.66	37.29	10.65	79.74	23.92
G	Average	110.51	95.64	115.12	108.88	126.24	102.21	86.61	38.55
	Variance	123.80	109.93	129.01	107.76	248.76	204.03	683.08	143.63
B	Average	145.94	135.43	151.08	153.09	152.83	141.33	93.54	42.74
	Variance	183.21	223.84	191.01	192.51	420.37	446.51	1109.52	273.94

Two way ANOVA

Source of Variance	SS[1]	df[2]	MS[3]	F[4]	P-value	$F_{critical}$
Type of rice	700521.2	7	100074.5	480.7818	0.0001	2.01535
RGB	2792623.0	2	1396312	6708.218	0.0001	3.001405
Interaction	398343.7	14	26453.12	136.6957	3.2E-260	1.698016
Within	329708.6	1584	208.1494			
Total	4221197	1607				

[1]Sum of squares [2]Degree of freedom [3]Mean squares [4]The test statistics

The results in Table 1 show that the F value is greater than the F critical and the P value is less than 0.05. The within rice type p value was 0.001 ($p<0.05$), while for the RGB colors the P value was also 0.001 and the P value for the interaction between these < 0.005. Therefore, the results obtained show a significant difference between rice types in different year, and also between the RGB colors (Table 1). Next the potential of backlighting images to separate rice types is examined. The morphology characteristics were extracted from the binary and the threshold images. Table 2 shows the two way ANOVA results. These three physical properties were chosen based on a preliminary. A T-test shows that these three parameters are significantly different between each type of rice.

Table 2: The two way ANOVA

Two way ANOVA

Source of Variance	SS	df	MS	F	P-value	F crit
Type of rice	109928.6	7	15704.08	49.08295	2.18E-63	2.01535
Morphology	332256	2	166128	519.2312	3.9E-174	3.001405
Interaction	226648.4	14	16189.17	50.59908	2.2E-116	1.698016
Within	506800.6	1584	319.9499			
Total	1175634	1607				
Total	5299566					

[1]Sum of squares [2]Degree of freedom [3]Mean squares [4]The test statistics

From the two way ANOVA, it shows that the F value is greater than the F critical value (F > Fcritical) for the different types of rice and also between the morphological factor with the P value being less than 0.05. for both conditions. Therefore we can say that the morphological factors are significantly different between these types of rice grain harvested in different years. As a result, we conclude that the morphological information can distinguish between the different types of rice, but cannot differentiate freshness levels of the rice.

Conclusions

From this research, it can be concluded that the double lighting machine vision system provides the most promising results for multiple quality evaluation of sake rice grains. The results show frontlighting based on UV LEDs provides fluorescence information useful for detection of freshness. These promising results provides an alternative way to grade rice using two features of quality evaluation: freshness and chalkiness.

Acknowledgement

Thanks are extended to Associate Professor Garry Piller, Kyoto University for his editing and proof reading of the manuscript. Also thank you very much for Dr. Takuma Sugimoto and Dr. Masaru Ikegami from Department of Agriculture and Horticulture, Hyogo Prefectural Institute for Agriculture, Forestry and Fisheries for providing the sake rice sample
.

References

Aramaki, I., Kikunaga, Y., Yoshii, M., Okuda, M., Koseki, T., Ogawa, M., Kumamaru, T., Sato, H., Hashizume, K., 2004. Observation of the Endorsperm-mutant Rice GGrains having a White Core (Shinpaku) and Analysis of Their Physical and Chemical properties for Sake Brewing. J. Brew Soc Jpn. 99, 134–145.

Chrastil, J., 1990. Chemical and physicochemical changes of rice during storage at different temperatures. J. Cereal Sci. 11, 71–85.

Hachiya, M., Asanome, N., Goto, T., Noda, T., 2009. Fluoresence Imaging with UV-Excitation for Evaluating Freshness of Rice. Jpn. Int. Res. Q. 43, 193–198.

Kamara, J.S., Hoshino, M., Satoh, Y., Nayar, N., Takaoka, M., Sasanuma, T., Abe, T., 2009. Japanese Sake-Brewing Rice Cultivars Show High Levels of Globulin-like Protein and a Chloroplast Stromal HSP70. Crop Sci. 49, 2198. doi:10.2135/cropsci2008.12.0719

Mahirah, J., Yamamoto, K., Miyamoto, M., Kondo, N., Ogawa, Y., Suzuki, T., Habaragamuwa, H., Ahmad, U., 2017. Monitoring harvested paddy during combine harvesting using a machine vision-Double lighting system. Eng. Agric. Environ. Food 10, 140–149. doi:10.1016/j.eaef.2016.12.001

Richards, A., 2006. UV Imaging Opens New Applications. Vis. Syst. Des.

Tashiro, T. (Nagoya U., Wardlaw, I.F. (Commonwealth S. and I.R.O., 1991. The effect of high temperature on kernel dimensions and the type and occurrence of kernel damage in rice. Aust. J. Agric. Res. Aust.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE26

Ultrasonic Pretreatment Prior to Soxhlet Extraction for Essential Oil from Basil Leaves (*Ocimum Basilicum L.*)

M. Nuramanina[1], H. Muhammad Hazwan[2,*] and C.M. Hasfalina[3]
[1]Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +603-89466422, Email: hazwanhamzah@upm.edu.my

Abstract
The extraction of oil from basil leaves was investigated by using conventional Soxhlet extraction method and ultrasonic as a pre-treatment prior to Soxhlet extraction. The effects of two operating parameters on the oil extraction namely solvent to solid ratio and reaction time were investigated to optimize the processing conditions of conventional Soxhlet extraction for achieving maximum oil yield using Response Surface Methodology (RSM). The optimum conditions were found at 5 hours, and a solvent to solid ratio of 1:33. The oil recovery from ultrasonic pretreatment prior to Soxhlet extraction under the same optimum parameters was compared. The yield of oil from samples underwent ultrasonic as a pretreatment was 4.14% while the conventional Soxhlet method yielded 6.24%. This finding is consistent with the evidence of Scanning Electron Microscopy (SEM) images showed that the treated samples were flakier and porous than untreated samples. Overall, this study has shown that treated samples via ultrasonic is incapable to increase the oil yield percentage compared to the conventional Soxhlet extraction method.

Keywords: basil, ultrasonic, Soxhlet, essential oil, optimization

Introduction

Basil, one of the most popular herbs over 150 different species growing in the world can be observed growing in tropical regions of Asia, Africa, Central and South America (Zaree et al., 2014). The most common species grown *O. africanum* Lour. (syn. *O.* x *citriodorum* Vis.), O. *americanum* L. (syn. *O. canum* Sims.), *O. basilicum* L., O. *gratissimum* L., *O. minimum* L., and *O. tenuiflorum* L. (syn. *O. sanctum* L.) (Carović-Stanko et al., 2010). Sweet basil (*O. basilicum L.*) is an aromatic herb belonging to the *Lamiaceae* family (Ladwani et al., 2018). The essential oil from *O. basilicum* L. is shown to have an economic value for cosmetic, cookery, and pharmaceutical purposes (Srivastava et al., 2014).

Essential oils are obtained by various extraction methods depending on the nature of the plant, the stability of the chemical components and the specification of the targeted product. Conventional extraction technologies such as cold expression, solvent extraction and distillation have been used. Various promising or green extraction technologies such as supercritical fluids and microwave-assisted extraction also available and capable of producing products with the same or improved characteristics (Stratakos and Koidis, 2016). All extraction techniques have limitations and understanding the advantages or disadvantages are crucial in order to help in selection of proper methods (NN, 2015).

Pre-treatments have become a great interest for enhancing and accelerating the extraction process. Other than manipulating the extraction parameters and conditions, treatment can be applied to increase the extraction yield and improve the parameters condition. One of the pretreatment is indirect ultrasonic. The sample for indirect ultrasonic treatment process is carried out first before being extracted and not simultaneously in between the two processes.

Dharmendra and Pandey (2010) defined ultrasonic as the acoustics wave above the human hearing range (the audio frequency limit) of 20 kHz whereby the wavelength of wave induced particle vibrations in elastic medium such as a liquid or a solid. The suitability of ultrasonic pre-treatment on essential oil extraction has been described by Nora and Borges, (2017), that the cavitation bubbles in relation to structural rupture facilitates the mass transfer of solvent from the continuous phase into plant cells, thus enhance the essential oil yield.

Soxhlet extraction, an example of solid-liquid extraction transfers the target analytes from the solid to appropriate organic solvents to ensure that the extraction solvent maintains continual contact with the sample during the extraction process (Daso and Okonkwo, 2015). In this study, indirect ultrasonic treatment is used prior to Soxhlet extraction. The aim of this work is to study on ultrasonic pretreatment prior to Soxhlet extraction as an improved method for basil essential oil. The objectives of this work are summarized as follows: (i) To verify the optimize extraction conditions of basil essential oil using Response Surface Methodology (RSM); (ii) To compare the amount of oil yield extracted between with and without pretreatment prior to Soxhlet extraction; and (iii) To identify the morphological structure differences between with and without pretreatment prior to Soxhlet extraction.

Materials and methods

Sample preparation

Basil leaves was purchased from Tesco IOI City Mall Putrajaya. The basil leaves sample was grown and packed by Monoluxury Sdn. Bhd., Hydroponic Unit, Genting Highlands, 69000 Pahang, Malaysia. The leaves are dried in oven for 2 hours until constant weight was achieved. The dried leaves were crushed to powder by using pestle and mortar and stored in resealable bag at room temperature. The flowchart of methodology was presented in Figure 1.

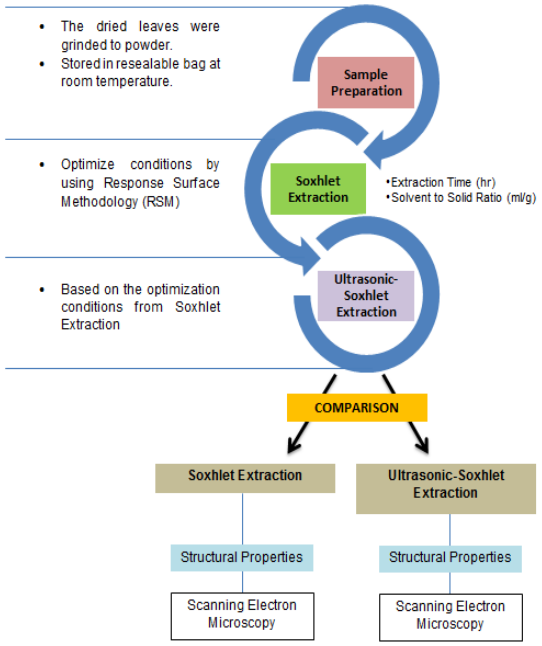


Figure 1: Flow chart of methodology.

Experimental design of Soxhlet extraction

Extraction parameters i.e. solvent to solid ratio and extraction time influencing extraction yield were investigated at three levels (-1, 0 and 1) using randomized central composite design as expressed in Table 1.

Table 1: Selected variables and coded level

Variables	Symbol	Coded levels		
		-1	0	1
Time	A	4	5	6
Solvent to solid ratio	B	10:1	20:1	30:1

A second degree polynomial equation derived from RSM was used. Data were analyzed by Analysis of Variance (ANOVA) to determine the lack of fit and the effects of quadratic and interaction variables on basil oil extraction. Data analyses and RSM were performed with Design Expert software program (Version 10.0.6.0; Stat-Ease, Inc., Minneapolis, MN, USA).

Extraction of basil essential oil

The effect of two parameters which are reaction time and solvent to solid ratio were investigated on the extraction operating conditions for basil essential oil. Five grams (5g) of basil leaves were extracted by using hexane as solvent. The reaction time was varied between 4, 5, and 6 hours. 100, 150 and 200 ml of solvent volume were used to determine the extraction yield giving out the solvent to solid ratio of 10:1, 20:1 and 30:1 respectively. The extraction process was carried out by using Soxhlet apparatus. Finally, the solvent was separated from the oil using Rotavapor EYELA running at 60°C temperature and speed of 4. The oil which was remained in the sample flask was weighed after the process was completed.

Ultrasonic

The ultrasonication of crushed basil leaves sample was conducted using Ultrasonic Cleaner Elmasonic S30H. Before the sample was sonicated, the water in the bath was first sonicated for five minutes for degassing purpose. After that, the sample was immersed with hexane inside a 250ml beaker and covered with aluminium coil. The beaker with its content was then suspended in the water bath of the ultrasonic cleaner. The sample was sonicated for 30 minutes with constant frequency at 37kHz, 280W. After ultrasonication, the samples underwent Soxhlet extraction using optimized conditions. The result was then compared to the oil yield obtained from basil sample extracted at the same optimized parameters without ultrasonic pretreatment.

Scanning Electron Microspcopy (SEM)

SEM Hitachi S-3400N was used at operating voltage of 15 kV. Two types of basil leaves sample namely treated and untreated sample images were digitally recorded in high resolution topograhic images at 1000x magnification.

Results and discussion

RSM of Soxhlet Extraction

The detail of the outcome of experimental design is shown in Table 2. The response ranges from 0.02 g to 0.28 g depending on the condition of experiments. These results can be fitted into a second order polymonial equation of coded units as given in Equation 1.

$$\text{Oil yield (Y)} = 0.30 + (-0.01A) + 0.07B + 0.03AB + (-0.04A^2) + (-0.09B^2) \quad (1)$$

ANOVA is carried out for the response in order to test the significant of the suitability as presented in Table 3.

Table 2: Central composite design for optimization of basil essential oil using Soxhlet extraction.

Run	Time (Hour)	Solvent to solid ratio (ml/g)	Response: Oil yield (g)
1	6	40	0.24
2	5	44.1	0.20
3	5	15.9	0.02
4	5	30	0.33
5	6.4	30	0.22
6	3.6	30	0.23
7	6	20	0.05
8	5	30	0.26
9	5	30	0.31
10	4	40	0.22
11	4	20	0.14
12	5	30	0.29
13	5	30	0.28

Table 3: ANOVA for model.

Source	Sum of squares	df	Mean square	F value	p-value Prob>F
Model	0.10	5	0.02	42.12	<0.0001
A	1.09 x10^{-3}	1	1.09 x10^{-3}	2.22	0.18
B	0.03	1	0.03	69.68	<0.0001
AB	2.60 x10^{-3}	1	2.60 x10^{-3}	5.28	0.06
A^2	9.80 x10^{-3}	1	9.80 x10^{-3}	19.90	0.003
Residual	3.45 x10^{-3}	7	4.93 x10^{-4}		
Lack of fit	7.06 x10^{-4}	3	2.35 x10^{-4}	0.34	0.80
Cor total	0.11	12			
R-squared	0.97				
Adj R-squared	0.95				

A= Time, B = Solvent to solid ratio

The model p-value (<0.0001) indicates that the model was statistically significant as the probability >F is less than 0.05. The smaller the p-value, the higher significance the results (Zareen et al., 2014). Based on ANOVA, the results were obtained, the effects of experimental factors on oil yield, time and solvent to solid ratio; corresponding three dimensional responses surface plot was shown in Figure 2. The values of the axis in Figure 2 are real values. Overall, the model terms suggested variables with significance influence on oil yield was solvent to solid ratio (B). However, the time effect had lesser effect on the oil yield. The model was significant at 95% confidence level. The coefficient of determination (R^2) of the model was 0.97, indicating that 97% of the experimental oil yield values matched the model predicted values. The lack of fit also measures the significant of the model. The lack of fit *F*-value of 0.34 is not significant as the *p*-value is >0.05. The non-significance lack-of-fit proved that the model was valid for the present work (Mourabet et al., 2017).

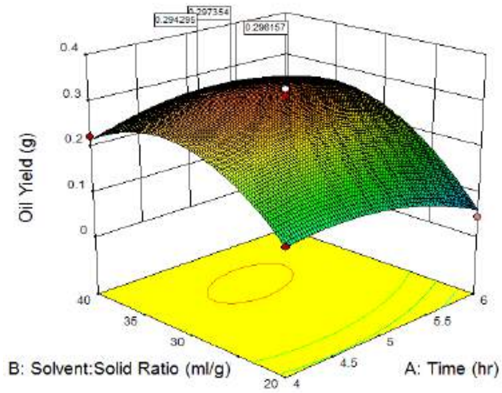


Figure 2. Combined effect of solvent to solid ratio and time on oil yield.

Figure 3 showed the contour plot of solvent to solid ratio and time on oil yield at optimum condition. The optimum conditions for oil yield were 4 hours 54 minutes extraction time and a solvent to solid ratio of 1:33.44. The predicted and experimental values for oil yield were obtained as 0.307 g and 0.312 g, respectively. A comparison between the experimental and predicted results indicates that the error was less than 1.6%. From the results, it was concluded that the developed model could accurately predict the oil yield. For convenience purposes, the optimum conditions were slightly modified to an extraction time of 5 hours, and a solvent to solid ratio of 1:33.

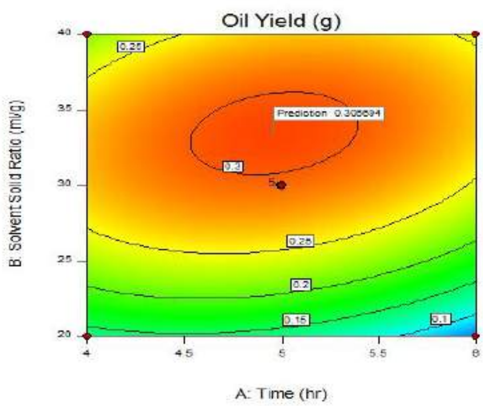


Figure 3. Contour plot of solvent to solid ratio and time on oil yield at optimum condition.

Comparison of Soxhlet extraction and ultrasonic as pretreatment prior to Soxhlet extraction

The comparison of extracted oil yield between Soxhlet extraction (untreated sample-SE) and ultrasonic as pretreatment prior to Soxhlet extraction (treated sample-USE) at optimum extraction time and solvent to solid ratio is shown in Figure 4.

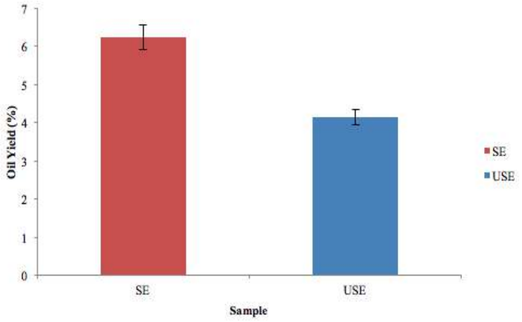
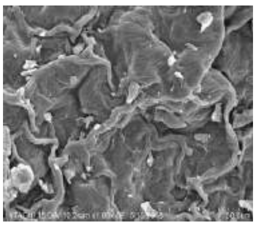
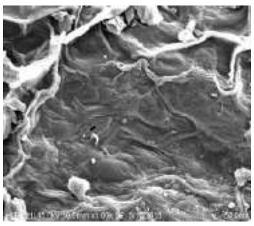


Figure 4. Comparison of treated (SE) and untreated samples (USE) on oil yield.

The maximum yield from untreated sample (6.24%) was obtained at 5 hours extraction time with 1:33 solvent to solid ratio meanwhile the treated sample producing minimum yield (4.14%) at the same condition. In this study, there was no evidence that ultrasonication has an influence on oil extraction for basil leaves. This result is somewhat counterintuitive. Overall, these results indicated that the ultrasonic pre-treatment did not increase the oil yield. Lou et al. (2010) stated that when the ultrasonic power was too high, the oil might be degraded by free radicals, thus the oil yield decreased. An extreme or longer exposure of sonication time on crushed basil leaves in this study had negative impact on degradation of phenolic compounds, therefore reduced the cavitation and decreased the extraction efficiency (Giacometti et al., 2018).

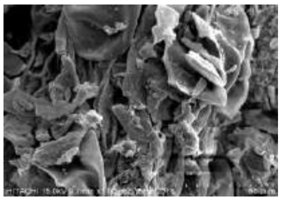
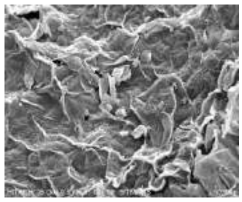
Figure 5 (a) and (b) showed the SEM images that indicated the morphological differences before and after ultrasonic was carried out, respectively. No evidence was found for structural changes between the samples before and after ultrasonic pretreatment.

(a) (b)

Figure 5. Scanning electron microscope (SEM) images of basil leaves cells: (a) before extraction (b) after sonication at 30 minutes, 37 kHz.

When comparison was made between samples after Soxhlet extraction for treated and untreated samples, the cell wall disruption made the untreated sample (Figure 6 (a)) became more porous and flaky compared to treated sample (Figure 6 (b)) after Soxhlet extraction. Overall, the results of SEM images correlated with the oil yield.

(a) (b)

Figure 6. SEM images of basil leaves: (a) treated (b) untreated samples after Soxhlet extraction.

Conclusion

This study has identified ultrasonic as a pretreatment prior to Soxhlet extraction made no significant difference to oil extraction. A greater focus on power or exposure time for ultrasonic as a pretreatment could produce interesting findings that account more for extraction efficiency.

Conclusion

The authors would like to thank staff of Department of Biological and Agricultural Engineering for administrative and technical support.

References

Carović-Stanko, K., Liber, Z., Besendorfer, V., Javornik, B., Bohanec, B., Kolak, I., and Satovic, Z. (2010). Genetic relations among basil taxa (*Ocimum* L.) based on molecular markers, nuclear DNA content, and chromosome number. *Plant Systematics and Evolution*, *285*(1), 13–22.

Daso, A. P., and Okonkwo, O. J. (2015). Conventional Extraction Techniques: Soxhlet and Liquid-liquid Extractions and Evaporation. In Jared Anderson, A. Berthod, V. Pino, and A. M. Stalcup (Eds.), *Analytical Separation Science* (1st ed., pp. 1437–1468). Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA.

Dharmendra, and Pandey, S. (2010). Ultrasonics: A Technique of Material Characterization. In D. Dissanayake (Ed.), *Acoustic Waves* (pp. 397–420). London, United Kingdom: InTechOpen.

Giacometti, J., Žauhar, G., and Žuvić, M. (2018). Optimization of ultrasonic-assisted extraction of major phenolic compounds from olive leaves (*Olea europaea* L.) using Response Surface Methodology. *Foods*, *7*(9), 149.

Ladwani, A. M., Hameed, A. E., and Amal ALadwani, C. M. (2018). Chemical composition of *Ocimum basilicum* L. essential oil from different regions in the Kingdom of Saudi Arabia by using Gas chromatography mass spectrometer. *Journal of Medicinal Plants Studies*, *6*(1), 14–19.

Lou, Z., Wang, H., Zhang, M., and Wang, Z. (2010).

Improved extraction of oil from chickpea under ultrasound in a dynamic system. *Journal of Food Engineering*, *98*(1), 13–18.

Mourabet, M., El Rhilassi, A., El Boujaady, H., Bennani-Ziatni, M., and Taitai, A. (2017). Use of response surface methodology for optimization of fluoride adsorption in an aqueous solution by Brushite. *Arabian Journal of Chemistry*, *10*, S3292–S3302.

NN, A. (2015). A review on the extraction methods use in medicinal plants, principle, strength and limitation. *Medicinal & Aromatic Plants*, *4*(3), 3–8.

Nora, F. M. D., and Borges, C. D. (2017). Ultrasound pretreatment as an alternative to improve essential oils extraction. *Food Technology*, *47*(9), 1–9.

Srivastava, H. C., Shukla, P., Tripathi, S., and Shanker, B. (2014). Antioxidant and antimicrobial activities of sweet basil oils. *International Journal of Pharmaceutical Sciences and Research*, *5*(1), 279-285.

Stratakos, A. C., and Koidis, A. (2016). Methods for Extracting Essential Oils. In V. R. Preedy (Ed.), *Essential Oils in Food Preservation, Flavor and Safety* (pp. 31–38). Oxford, United Kingdom: Academic Press.

Zareen, A., Gardezi, D. A., Naeemullah, M., Masood, M. S., and Tahira, R. (2014). Studies screening of antibacterial potential of Siam queen , Holy basil and Italian basil essential oils. *Journal of Medicinal Plants Studies*, *2*(2), 63–68.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE27

RiSe-IViS: Rice Seed Inspection Vision System

R. Ruslan[1,2,3*], S. K. Bejo[2], I. H Rukunudin[3], M. F. Ibrahim[2,3], A. A. Aznan[3]
[1]*Department of Biological and Agricultural Engineering, Universiti Putra Malaysia, UPM 43400 Serdang, Selangor Malaysia*
[2]*School of Bioprocess Engineering, Universiti Malaysia Perlis, UniMAP 02600 Arau, Perlis Malaysia*
[3]*Center of Excellence for Advanced Sensor Technology (CEASTech) Universiti Malaysia Perlis, UniMAP 02600 Arau, Perlis Malaysia*
**Corresponding author. Tel.: +6017-2933885, Email:ruslanrashidah@gmail.com*

Abstract
Rice seed production in Malaysia is greatly dependent on the purity of the cultivated paddy seed produced through the government certified paddy seed program. Under the program, the seeds to be marketed by the seed processors must undergo quality control protocol where the seed lots are sampled from the seed farms and seed processing plants for purity analysis by the Seed Testing Laboratory of the Department of Agriculture (DoA), the enforcing agency. The current inspection conducted by the laboratory is based on manual process which is laborious, time consuming (max 40 min for newbie while skilled operator takes about 15-20 min.). The process is also very subjective and error prone as it is influenced by the skills and experience of laboratory workers especially those involving segregating vague and indistinct special morphological or even textural and color features. A prototype (Patent ID: PI2018500018) of a machine vision-based paddy seed inspection system (RiSe-IViS) was developed to explore the possibility of replacing the existing manual method in distinguishing the weedy rice and cultivated rice seeds under the SJPM standard protocol with a modern, effective and efficient technique. The RiSe-IViS prototype developed consists of two parts i) hardware configuration ii) software protocol development. A user friendly graphical user interface (GUI) was developed to assist user for image acquisition and analysis. Analysis protocol was first developed based on the morphological features of the paddy seed and was tested for MR297 against weedy rice. The classification accuracy was achieved up to 99%. Validation of the protocol is to be carried out with local seed plant in Kedah to enhance the system. The RiSe-IViS is expected to classify major rice seed varieties available in Malaysia against the weedy rice variants with superior accuracy.

Keywords: Machine vision, weedy rice, paddy seed, MR297, prototype, image processing, classification

Introduction
Weedy rice is a serious threat to the rice industry in Malaysia. The term weedy rice or locally known as *padi angin* refers to populations of the weedy types of rice that are identified through its characteristic of easy-shattering grains during harvest (Azmi et al., 1998). Weedy rice in Malaysia was reported to be an evolution from the cultivated rice due to dry seeding and volunteer seeding practiced by the farmers in the late 1984 - 1988 according to Abdullah et al. (1996). The morphological form of the Malaysian weedy rice seeds found in Peninsular as classified by Sudianto et al. (2016) are based on hull coloration and awn presence into eight morphotypes. Hull color were classified into strawhulled, intermediate strawhulled, brownhulled or blackhulled. The seeds either have awn or no awn. The pericarp could be either brown, red or white grain. Table 1 shows the eight morphotypes of weedy rice found in Peninsular Malaysia.
The long term paddy seed production program in Malaysia is addressed under the Enhancement of Paddy and Rice Industry of the National Agro Food Policy (Dasar AgroMakanan) – with strategy to enhance the productivity and quality of paddy and rice through the use of high quality produced paddy seed. The paddy seed producers are appointed by the government and supply certified seeds to the farmers.

Table 1: Morphotypes of weedy rice in Peninsular Malaysia

No.	Hull Color	Awn Presence
1.	Strawhull	Awn
		No awn
2.	Intermediate strawhull	Awn No awn
3.	Brownhull	Awn
		No awn
4.	Blackhull	Awn
		No awn

Source: Sudianto et al. (2016)

The paddy seed produced must achieve high quality standard in accordance to Standard Jabatan Pertanian Malaysia (SJPM 2011) through a Seed Testing Laboratory, a certification body under the Department of Agriculture (DOA). DOA, also an authorised new certified paddy seeds marketing, is continuously besieged with a problem in identifying and distinguishing weedy rice seed and existing and new true paddy seed variety every year. The current manual inspection under SJPM protocol involves the field inspection, seed plant premises auditing, record and testing on the paddy seed samplings before certified seed can be released (Ismail & Said 2012). Seed testing requires laboratory workers to count and identify paddy seed samples and distinguish between the cultivated paddy seed and weedy rice/unwanted seed or off-type seed. The maximum allowable unwanted or dangerous weed seeds are 10 seeds/kg. If the producers did not comply with the standard, the seed lot will be rejected, thus give losses to the producers. Hence, the purpose of this invention is to explore possibilities in minimizing the workload of seed laboratories during quality inspection. The invention is expected to reduce the time taken and human error due to tiredness and eye sore of looking at small seeds.

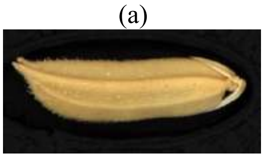
Materials and methods

The development of RiSe- IviS was done in CEASTech Laboratory, Universiti Malaysia Perlis. The weedy rice seeds were collected around granary area near Pendang, Kedah. The cultivated rice seed were supplied from Rice Seed Bank of Rice Research Station, Malaysian Agricultural and ResearchInstitute (MARDI) Seberang Perai, Malaysia. Four rice seed varieties mainly the MR297, MR263, MR284 and MR219 were used to test the protoype accuracy in distinguishing the weedy rice and cultivate drice.

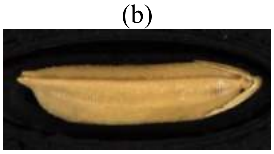
Figure 1 displays sample images of the cultivated rice seed and weedy rice variants. The shape of the rice seed varieties is almost similar to each other while weedy rice variants used in this project is slightly smaller than cultivated rice seed varieties and have an awn.

(a)

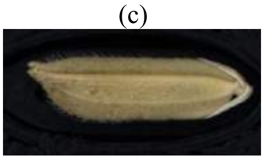
(b)



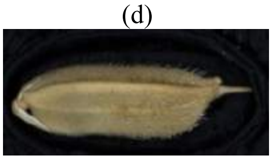
(c)



(d)



(e)



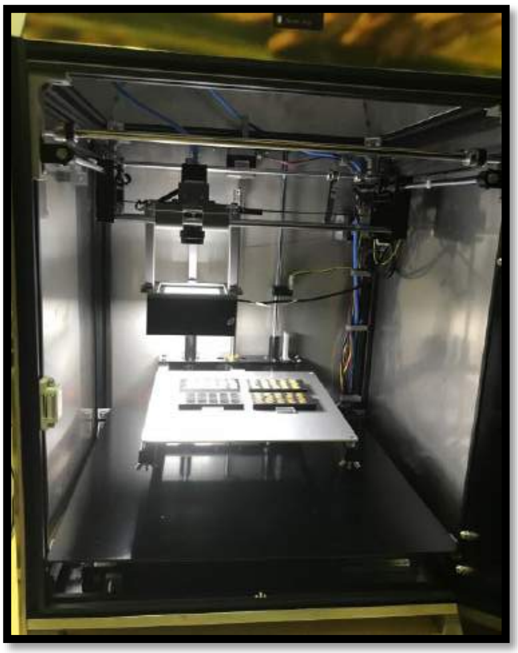
(f)

Figure 1: Rice seed variety and weedy rice variants (a) MR219 (b) MR284 (c) MR297 (d) MR263 (e) WRA (f) WRB

Hardware Configuration

RiSe-IVis is equipped with a CMOS 6MP 1/1.8" GigE area scan camera (MVCA060-10GC, HIK Vision) and 6MP 16mm focal length lens (MVL-HF2528M-6MP, HIK Vision). The camera has a resolution of 3072 x 2048 and sensor size of 2.4 µm x 2.4 µm per pixel. The prototype was arranged as in Figure 2. A low angled LED lighting (TMS Lite) was used to provide uniform illumination on the seed samples. The seed sample was kept at a distance of 14.1 cm from the lens and camera. The prototype allow the camera to move in X-Y-Z direction to cover seed images on the platform. The acquired images were saved and later analysed in LabVIEW programmed developed for classification of the seeds.

(a)



(b)

Figure 2: RiSe-IviS prototype machine vision (a) Overall view (b) Inside view

Software Development

Feature extraction was programmed in LabVIEW environment and IMAQ Particle Analysis VI was used. Image processing technique was employed to analyse the seed kernel images and extract morphological features of the individual seed. Image analyses were performed using discriminant functional analysis (DFA). Number of dominant morphological features to distinguish the weedy rice and cultivated paddy seed ranging from five to eight depending on the seed variety. Lower number of features reduced the time taken for analysis.

Results and discussion

The prototype works exceptionally well in identifying and distinguishing the weedy rice and cultivated rice seed in one seed plate. The accuracy of the machine is presented in Table 2.

Table 2: Classification accuracy of the RiSe - IViS

Seed Variety	MR297	MR263	MR284	MR219
Weedy Rice	99.1%	98.1%	93.7%	98.3%

Discriminatory ability of rice seeds depends on the variety as different seed have different inherent seed features. The most significant features selected in DFA were convex hull perimeter, minor axis length and area ratio. The developed system is fast, accurate and reliable. The maintenance for the hardware is minimal. The system's software need to be updated periodically and to be tested with new varieties of paddy seed.

Conclusion

RiSe-IVIs has met the requirement to distinguish between weedy rice and cultivated paddy seed. More paddy seed variety could be added in the software in future to cover wide range of seed variety produced by the seed producer.

References:

Abdullah, M. Z., Vaughan, D.A., Watanabe, H., and Okuno, K. (1996).The Origin of Weedy Rice in Peninsular Malaysia. MARDI Res. J. Vol:24(2): pp: 169-174.

Azmi, M. and Abdullah, M. (1998). A manual fortheidentificationandcontrolof padi angin (weedyrice) in Malaysia. p. 18. Serdang: MARDI

Ismail A.T., and Said A. R., (2012), Certified Paddy seeds and Processing, Internasional Conference on Agricultural and Food Engineering for Life CAFEi2012-179 : pp:1-5

Jabatan Pertanian Malaysia (2009), Standard Jabatan Pertanian Malaysia Spesifikasi Pengeluaran Benih Padi (OryzaSativa). Putrajaya pp:1-10

Sudianto, E., Neik, T. X., Tam, S. M., Chuah, T.S., Idris A. A., Olsen, K.M., and Song, B.K. (2016). Morphology of Malaysian Weedy Rice (OryzaSativa): Diverity, Origin and implications for Weed Management. Weed Science, Vol: 64(3): pp: 501-512.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE28

Effect of Polyvinyl Alcohol/Chitosan Hydrogel Loaded with NPK Compound Fertilizer on *Capsicum sp.* Growth and Fruiting Yield Analysis

N.H.M. Nayan[1,2*], M.S.A. Hamzah[1], A. Austad[1], E.F. Muslih[1] and S.I.A. Razak[3]
[1]Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, KM1 Jalan Panchor, 84600 Pagoh, Johor, Malaysia
[2]Microelectronics and Nanotechnology – Shamsuddin Research Centre, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia
[3]Centre for Advanced Composite Materials, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
*Corresponding author. Tel.: +606-9742032, Email: nadirul@uthm.edu.my

Abstract
This paper reported on the reinforcement of superabsorbent (SA) fertilizer based from polyvinyl alcohol (PVA) using chitosan via superficial freeze-thawing method. The obtained SAP beads are well developed with excellent mechanical properties and high NPK compound fertilizer loading at 6 wt% chitosan loading. The effect of PVA/chitosan hydrogel on plant growth and fruiting yield was observed using Capsium sp.by comparing with conventional fertilizer. The studies showed plant samples with PVA/chitosan hydrogel growth exceptionally in term of its number of fruits(43±1), total mass fruit yield (1654±1.3g), fresh and dry weight of plant (139.5±1.2%), leaf number (130.6±0.2%) and width (19.8±0.6%) as well as chlorophyll content (0.036659) compared to conventional fertilizer method. Overall, these give good indication of the modified SAP fertilizer as a new technology to be used in future agriculture.

Keywords: hydrogel, superabsorbent fertilizer, agriculture, plant growth, fruiting yield

Introduction

Capsicum sp. was consumed in a wide range, as fresh produce and products for ingredients and medicine. Therefore, as the demand for fresh chili fruits and products increases both in domestic and foreign trades, there is a need to increase the crop production (Meghavansi *et al.,* 2010). Thus, attempts to increase fruit and seed yield have been introduced such as variety improvement, cultural practice and application of some chemicals to induce growth and development. However, the large problem faced in agriculture recently is the loss of nutrient elements. It causes the insufficient of plant nutrients, increases process cost and pollutes the environment (Dbe, 2011). With the use of controlled-released systems, nutrients are released at a slower rate throughout the seasons, plants are able to take up most of the nutrients without waste by leaching (Kanjana, 2017; Nayan *et al.,* 2018).

Superabsorbent polymers (SAP), a new functional polymer material, can absorb a large amount of water, swell to many times their original size and weight and the water is hardly removed even under pressure, and so it has been widely used in agriculture as controlled-release fertilizer (Liu *et al.*, 2006). Hydrogel is a loosely cross-linked three dimensional networks of hydrophilic monomer with the ability to absorb great amount of water. Hence, the combination of hydrogel and fertilizer has become one of the promising materials to overcome the shortcomings of conventional fertilizer by greatly improving the nutrition of plants, decreasing fertilizer loss rate, alleviating environmental impact from water-soluble fertilizer, supplying nutrients sustainably and lowering frequency of irrigation (Guo *et al.,* 2005).

In our previous study, showed that the potential of polyvinyl alcohol (PVA) hydrogel reinforced with chitosan as SAP hydrogel fertilizer using freeze-thawing method (Nayan *et al.,* 2018). The SAP hydrogel have excellent crystal like structure distribution swelling properties which suitable for controlled release fertilzer application. Therefore, in this study the SAP hydrogel was analyzed to determine its effect on Capsicum sp. growth in term of number and total weight of fruits produce, fresh and dry weight of plant, physical characteristic of leaf and chlorophyl content.

Materials and methods

Preparation of PVA/Chitosan hydrogel loaded with fertilizer compound

The PVA/6%Chi hydrogel loaded with NPK compound (SAP hydrogel) was prepared using freeze-thawing method as describe in previous study (Nayan *et al.*, 2018).

Preparation of Capsicum sp. for growth analysis

The growth analysis of Capsicum sp. were done using purcahsed 20 plants per plot at age 4 weeks and re-planted in 10x12 inches polybags. Each plots were planted with SAP hydrogel, chemical fertilizer (CF), organic fertilizer (OF) and without any fertilizer as control. The watering was done at alternate day for each plot and monitored within 1 week interval period. The growth analysis were measured at 1, 2, 3 and 4 week’s interval period.

Total yield and the number of fruits

To measure total yield of each of the plant after fruits harvest, by a digital scale, the weights of fruits were registered in consecutive harvest. To calculate the number of fruits in the plant, the total number of harvested fruits of each plant was recorded after weighing session.

Fresh and dry weight of plant, number of leafs and width of meatured leaves

The measurements of dry and fresh weight of plants were done at the end of harvest. The fresh weight was recorded after the complete cut of plants from the soil surface by digital scale. To measure fresh weight of the root, it was weighed after washing. The shoots and roots were put in the oven at 70 ºC for 24 h and after weighing, their dry weight were recorded. Plant width of matured leaves were measured by ruler, respectively. For width of leaves measurement, few matured leaves from each pots were measured and the average were obtained.

Photosynthetic pigments

Photosynthetic pigments content was determined by taking fresh leaf samples (0.1 g) from young and fully developed leaves. The samples were homogenized with 5ml of acetone (80% v/v) using pestle and mortar and centrifuged at 3,000 rpm. The absorbance was measured with a UV/visible spectrophotometer at 663 and 645nm and chlorophyll contents were calculated using the equations proposed by Strain and Svec (1966).

Results and discussion

Total yield and number of fruits

The fruits produced were harvested and counted for 4 weeks and weighted at 2nd and 4th weeks of experiment duration. Figure 1 shows the numbers of chilly fruits produced using different types of fertlizer. The samples with PVA/6%Chi NPK hydrogel produced highest number of fruits followed by chemical fertilizer, organic fertilizer and control sample. It was expected the control produced low number of fruits due to lack of nutrients and minerals for plant growth. Besides, the total yield is higher at SAP hydrogel sample compared to chemical, organic and control fertilizer as indicated in Figure 2. This contributes by the chitosan monomer in the SAP hydrogel that act as plant growth promoter (PGP) that important in enhancing plants growth as well as has elicitor effect against plant disease (Karanatsidis and Berova, 2009).

On the other hand, other study also reported that the application of chitosan in agricultural system help to control the release of NPK due to its hydrophobicity charactheristic (Kuo, 2015). Control release strategy do help to keep consistance nutrrient supply for plant growth unlike burst release fertilizer such as chemical/organic fertilizer that tend to leach out before plants able to absorb as food supply. Appart from that, the application of to much chemical/organic fertilizer could lead to ‘burn’ foliage and damage to the plants due to excessive nutrient at soil that lead to toxic condition (Jamir *et al.*, 2017).

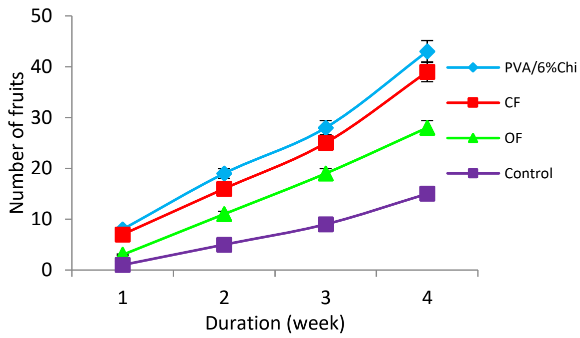
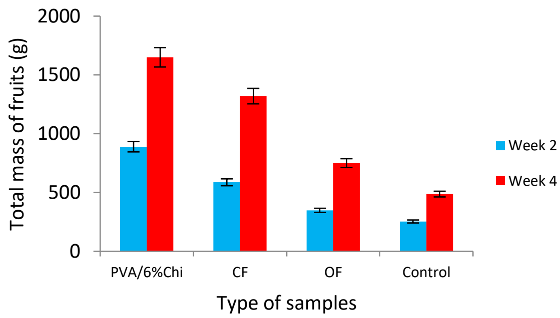


Figure 1: Total production of Capsicum sp. fruits by using different types of fertilizer



.*Figure 2: Total mass of Capsicum sp. fruit yield using different types of fertilizer*

Fresh and dry weight of Capsicum sp. plant

Figure 3 showed the percentage increase on fresh and dry weight of chilly plants from week 1 until 4. Plants with chemical fertilizer result in the highest fresh weight and dry weight was due to its minerals component content was formulate to give quick boost for the plants growth (Jamir *et al.*, 2017). Unlike the longer time-period taken by organic fertilizer to work on the growth of the plants, chemical fertilizer work in a hastened manner and work their appropriate actions on the plants in the required time-frame. However, SAP hydrogel have better potential on future agricultural application due its controlled release mechanism that more economical advantages. Although it might work slower but it will gave everlasting impact on the soil texture, improves the water holding capacity of the soil, regains its fertility and prevents soil erosion which help better plant growth (Zayed *et al.*, 2013).

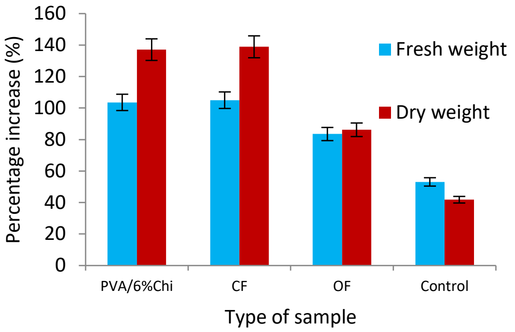


Figure 3: Average percentage increase of fresh and dry weight of Capscum sp.

Number and width of matured leaves

The number of leaves increased almost 130.6±0.2% for SAP hydrogel compared chemical fertilizer (124.5±0.4%), organic fertilizer (59.5±0.3%) and control (31.13±0.7%) respectively as showed in Figure 4. Although chemical fertilizer gave a quick boost in early stage, due to uncontrolled release resulting for lower nutrient in soil after certain period. This will reduced soil texture and soil's long-term fertility condition for plant growth (Jamir *et al.*, 2017). The same trend also showed by width of leaves in Figure 5, where the control showed lowest increase of width leaves and the highest was SAP hydrogel fertilizer. Previous study, showed that SAP hydrogel fertilizer have tendency to hold more water in soil that allowed control release of nutrient for plant uptake. This advantages will help to keep the moisture of the soil and act as nutrient reservoir for the soil plant system that helps in utilizing water and nutrient uptake effectively (Nayan *et al.*, 2018).

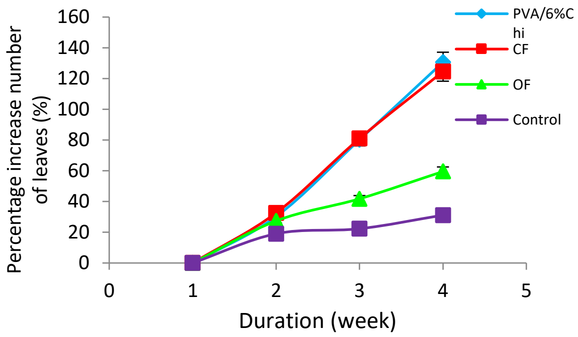


Figure 4: Percentage number of Capsicum sp. leaves

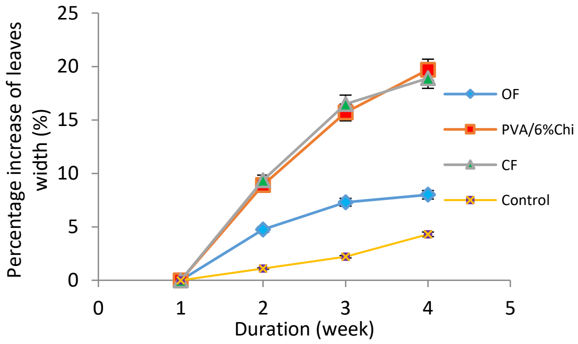


Figure 5: Width leaves trend for 4 weeks

Photosynthetic pigments

Chlorophylls are greenish pigments which contain a porphyrin ring where surrounded free moving electron that make the ring potentially to gain or lose electrons easily, and thus also able to provide energized electrons to other molecules. This is the fundamental process by which chlorophyll "captures" the energy of sunlight or known as photosynthesis that will manufacture sugars as food for plant growth (Humphrey, 2004; Baker, 2008). Figure 5 showed the chlorophyl content of Capsicum *sp*. leaves in different fertilizer, which overall indicates that the SAP hydrogel not only improve physical characteristic of the plant but at the same time enhanced the leaf chlorophyll content. This also give early indication that the plant have consumed adequate amount of N mineral as N is a component of the chlorophyl where the deficiency of this element will be reflected as chlorosis in leaf (Dutta et al., 2004; Ayala-Silva and Beyl, 2005; Soetan et al., 2010). Therefore, this give indirect good indication on food production by the plant to ensure continous growth.

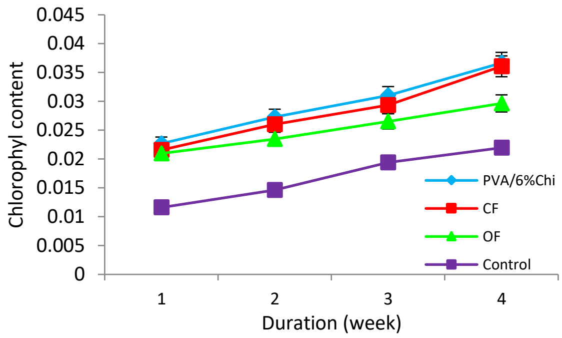


Figure 6: Chlorophyll content of Capsicum sp. leaves

Conclusions

PVA/6%Chi hydrogel loaded with NPK (SAP hydrogel) shown highest results for plant growth parameters compared to chemical fertilizer, organic fertilizer and control sample. The application of SAP hydrogel showed positive results in term of fruit number and total weight, fresh and dry mass of plant, number and width of leaf as well as the chlorophyll content. Although through works have been done, further investigation is needed to study the kinetic mechanism of the fertilizer, the effect of SAP hydrogel onto plant tissue and effect on *Capsicum sp.* mass production.

Acknowledgement

The authors would like to express the deepest appreciation to the Universiti Tun Hussein Onn Malaysia (UTHM), for funding this project through (Geran Kontrak-Vote number U526 and Geran Penyelidikan Pascasiswazah-Vote number U993).

References

Ayala-Silva, T., & Beyl, C. A. (2005). Changes in spectral reflectance of wheat leaves in response to specific macronutrient deficiency. Advances in Space Research, 35(2), 305-317.

Baker, N. R. (2008). Chlorophyll fluorescence: a probe of photosynthesis in vivo. Annu. Rev. Plant Biol., 59, 89-113.

DBE, S. (2011). Curriculum and Assessment Policy Statement: Grades 10–12, Mathematical Literacy. Pretoria: Department of Basic Education.

Dutta, P. K., Dutta, J., & Tripathi, V. S. (2004). Chitin and chitosan: Chemistry, properties and applications.

Guo, M., Liu, M., Zhan, F., & Wu, L. (2005). Preparation and properties of a slow-release membrane-encapsulated urea fertilizer with superabsorbent and moisture preservation. Industrial & engineering chemistry research, 44(12), 4206-4211.

Humphrey, A. M. (2004). Chlorophyll as a color and functional ingredient. Journal of Food Science, 69(5), C422-C425.

Jamir, T., Rajwade, V. B., Prasad, V. M., & Lyngdoh, C. (2017). Effect of Organic Manures and Chemical Fertilizers on Growth and Yield of Sweet Pepper (Capsicum annuum L.) Hybrid Indam Bharath in Shade Net Condition. Int. J. Curr. Microbiol. App. Sci, 6(8), 1010-1019.

Kanjana, D. (2017). Advancement of Nanotechnology Applications on Plant Nutrients Management and Soil Improvement. In Nanotechnology, Springer, Singapore, 209-234.

Karanatsidis, G., & Berova, M. (2009). Effect of organic-N fertilizer on growth and some physiological parameters in pepper plants (Capsicum Annum L.). Biotechnology & Biotechnological Equipment, 23(sup1), 254-257.

Kuo, Y. J. (2015). Effects of fertilizer type on chlorophyll content and plant biomass in common Bermuda grass. African Journal of Agricultural Research, 10(42), 3997-4000.

Liu, M., Liang, R., Zhan, F., Liu, Z., & Niu, A. (2006). Synthesis of a slow-release and superabsorbent nitrogen fertilizer and its properties. Polymers for advanced technologies, 17(6), 430-438.

Meghvansi, M. K., Siddiqui, S., Khan, M. H., Gupta, V. K., Vairale, M. G., Gogoi, H. K., & Singh, L. (2010). Naga chilli: a potential source of capsaicinoids with broad-spectrum ethnopharmacological applications. Journal of ethnopharmacology, 132(1), 1-14.

Nayan, N. H. M., Hamzah, M. S. A., Tahir, A. A. H. M., Rajali, A. A. A., Muslih, E. F., & Mazlan, R. (2018). Development of Polyvinyl Alcohol/Chitosan Hydrogel Loaded with Fertilizer Compound: Preparation, Properties and Effect on Seed Germination. Journal of Science and Technology, 10(4).

Soetan, K. O., Olaiya, C. O., & Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants-A review. African journal of food science, 4(5), 200-222.

Strain, H. H., & Svec, W. A. (1966). Extraction, separation, estimation, and isolation of the chlorophylls. In The chlorophylls (pp. 21-66).

Zayed, M. S., Hassanein, M. K. K., Esa, N. H., & Abdallah, M. M. F. (2013). Productivity of pepper crop (Capsicum annuum L.) as affected by organic fertilizer, soil solarization, and endomycorrhizae. Annals of Agricultural Sciences, 58(2), 131-137.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA01

Application of electrical resistivity method to identify suitable location of shallow tube well for irrigation

Muhammad Haniff,A[1]., Chan,C.S[1]., Teoh,C.C[2]., Eddy Herman,S[2]., Mohd Zubir,M.I[2]., Mohamed Fauzi,M.I[1]., Mohd Khusairy,K[1]., Mohd Shahril Shah,M.G[1]., Mohammad Aufa,M.B[1]
[1]Engineering Research Centre, MARDI, Seberang Perai, Pulau Pinang
[2]Engineering Research Centre, Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
**Corresponding Author, Tel: +04-5758402, E-mail: mhaniff@mardi.gov.my*

ABSTRACT

Agricultural drought becomes more appearance due to climate change and uncertain weather pattern. The current and continuing drought in many parts of the world, combined with ever increasing demands from both traditional and new water users, including municipal, industrial, agricultural and environmental needs, has impacted groundwater resources. Supplementary irrigation becomes important to overcome short term drought ensuring successful cultivation. Apart from obtaining the irrigation water from the traditional water sources (surface run off and rainfall) for irrigation, other alternative water source needs to be explored. The most feasible water source and relatively abundance is the ground water.Identify suitable location for shallow tube well development using electrical resistivity method has been extensively used. This method once of the surface geophysical methods can reduce risk and unnecessary costs by assisting in the siting of wells location. Technique based on resistivity can be used to interpret the characteristics of aquifer and thus to identify suitable location for tube well. The surveys were conducted at three different locations in Perak and Kelantan situated in Peninsular Malaysia which was mainly aluvial deposits lithology.The shallow tube well in quartenary aquifer into the ground will consider for groundwater identification.The resistivity values of highly discharge of groundwater approximately in ranges of 4.4Ωm to 20 Ωm with flowrate at range 45 m^3/h to 47 m^3/h.The depths of tube well were in between 9 to 24 m. The groundwater aquifers are found in saturated sand, coarse sand with some gravelly sand**.**

Keywords: Geophisical method, tube well, irrigation

Introduction

Studies indicate that farms irrigated by groundwater have higher crop yields than farms irrigated by surface water (Bardhan, 2012). Usage of groundwater for irrigation has been used by farmers around the Southeast Asian region. Countries like Thailand, Indonesia, Philippines, and Malaysia itself makes groundwater as a source of additional water for irrigation (Mohd Fauzie et al., 2013). In 1994, an 8% utilize groundwater for irrigation system in Malaysia. It is because most of the geological conditions of the land covered by alluvial deposits (Mohd Fauzie et al., 2013].

Groundwater basin can be defined as a hydro geological unit containing one large or several aquifers which are interconnected and interrelated (Antholt and Wennergren, 1982). In the valley between mountain ranges groundwater basins may sit in the middle of the river basin. In addition, in areas of limestone and sand dunes, the drainage basin and groundwater basin may have a whole different configuration. Groundwater basin concept is important because the hydraulic continuity that exists for groundwater resources. To ensure the availability of groundwater continues, ground water exploration is necessary to know the location and the amount of groundwater (Hasbrouck, 2003).

Furthermore, groundwater can't be seen above the earth surface, a scope of techniques can be supply in sequence of concerning its happening with certain conditions even its properties. Surface investigations allow us in deciding the information about type, porosity, water content and the density of subsurface creation. It is usually done with the help of electrical and seismic characteristics of the earth and without any drilling on the ground. The data supplied by this technique are partly reliable and it is less expensive (Hasbrouck, 2003). It gives only indirect sign of groundwater so that the underground hydrologic records must be inferred from the surface investigations. Right interpretation requires additional data from the sub surface investigations to confirm surface findings. It is generally achieve by geophysical method like electrical resistivity & seismic refraction method.

An electrical resistivity of rock formations limit the amount of current flowing through the formation when an electrical potential is applied. The resistivity can be defined as the resistance in ohms of a cubic meter unit (Ωm). The resistivity of rock formations vary over a wide range, depending on the material, density, porosity, size, and shape of the pores, the content and quality of water, and also the temperature(Hago, 2000). There is no fixed limit to the resistivity of various kinds of rocks. Igneous and metamorphic produce a resistivity in the range between 10² to $\mathbf{10^8}$ Ωm, while the sediments and non-consolidated rocks which are electrical resistivity ranging between $\mathbf{10^0}$ to $\mathbf{10^4}$ Ωm (Ashvin, 2011). Groundwater contains various dissolved salts Geophysical exploration is a scientific measurement of the physical properties of the Earth's crust to survey mineral deposits or geological structures. Geophysics methods can detect differences or anomalies, physical properties found in the earth's crust.

Materials and methods

Area of the study

In Malaysia, there are a number of states that are actively engaged in agricultural activities, such as kedah, Perak, and Kelantan. crops such as vegetables, fruits,and grains were . Water resources are important for the sustainability of agricultural activities. Areas lacking in water require suplementary irrigation besides rain as a major source. There are not many areas that provide water supply for agriculture. Especially smallholders who carry out small farming activities. Many places, when the rainy season passes, it will face a a short drought. water shortage happen suddenly. Shallow well to get additional water supply at that time.This studies were located at the west Malaysia. Three locations were selected shown in table 1.

The Site lithology based on a map established by the Department of Mineral and Geoscience Malaysia.

Table 1: Site information

Places	Coordinate	Lithology	Crops
Seberang Perak,Perak	100°56'27.085"E 4°5'24.335"N	Clay, silt, sand and gravel - undifferentiated (Continental)	Paddy, corn
Bachok, Kelantan	102°25'34.36"E 5°58'40.314"N	sand (mainly marine)	Tapioca & sweet potato

Electrical Resistivity Method (ERM)

The electrical resistivity imaging was conducted using ABEM Terrameter LS2 and Lund electrode selector system ES464. For data collection, 41 electrodes were arranged in a straight line with constant spacing and connected to a multicore cable. The data were processed by using inversion software

and it is ironically conductive, this enables electric currents to flow into ground. As a result, by calculating the ground resistivity it gives the possibility to the availability of water (Ashvin, 2011).

RES2DINV (Asry et al., 2012). In data acquisition, there are various types of array that suitable to be applied which depends on several factors. Gradient, Schlumberger, and Pole-dipole were the common array used in investigates the underground layer. The array configuration has a substantial influence on the resolution, sensitivity and depth of investigation

Figure 1: Terrameter LS 2

During data acquisition, Schlumberger array was used as this array is capable in imaging deeper profile data and suitable for areas with homogeneous layer Schlumberger array with 5 m equal electrode spacing and two cables with total layout length of 200 m was used in interpret the potential shallow aquifer in this study.

The factor influence the ERM based on the principle that the earth material is being tested acts as a resistor in a circuit. Inducing electric current to the ground could be differentiating the ability of material to exhibit characteristics of resistivity value. The images of ERM could be presenting the material exist in the ground. Interpreters should analyze the image to identify the existing of groundwater.

The location of groundwater obtained from the layer of shallow groundwater based on the image of resistivity. The parameters of interest include location and depth of initial groundwater positions.

In order to verify the availability of water in existing subsurface conditions, tube well drilling was implemented. Tube well depth was measured and pumping test was conducted to validate the availability of water obtained from images from electrical resistivity methods.

Method of pumping test

The pumping test conducted in order to identify the type of aquifer.
Pumping test also to verify the optimum discharge of tubewell can be extracted in m3/hr. Pumping test was conducted to verify the electrical resistivity result, carried out immediately after the completion of the well construction. Submersible pumps were used to pump the water from the tube wells, and the discharge rates were measured with a weir tank. The valve was installed to control and vary the discharge rates. The method weir tank based on the standard of procedure from Hudson(1993).

Results and discussion

In Perak the studies was to explore the shallow groundwater resources for the aerobic rice plantation. The potential of groundwater are very high due to topography and lithalogy information. The ERM was tested in this area to searching perfect location and estimate the depth of tubewell for the development of infrastructure. After a few lines of ERM was implement in this area, the 2D Image from the ERM was selected for the tubewell location. Figure 2 show the image of the shallow groundwater in quarternary aquifer. The resistivity data ranges in between 0-400 Ωm. The potential of saturated shallow groundwater was detected around 10-30 m depth which are resistivity index are from 0-30 ohm m.
The tubewell 1 drilled until the layer of coarse sand with gravel founded. Drilling stopped at 11 m depth . The pumping test was conducted. The flowrate was 45 m^3/hr.

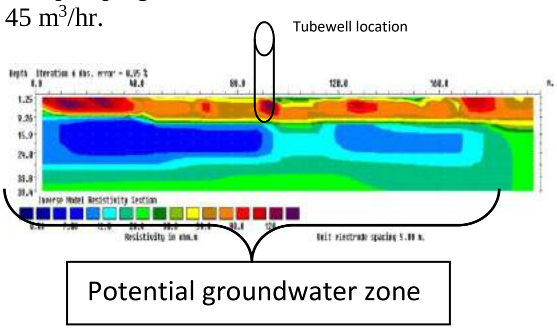


Figure 2: Electrical resistivity imaging at the survey site for Seberang Perak 1

Another resistivity conducted at different location in Seberang Perak 2 showed resulted in between range 0-150 Ωm. 30 m depth was boring to extracted the groundwater resources. The aquifer showed the thickness of sand to gravel layer was very thick and suitable to development of tubewell at specific location. From the image, it is hard to find the hard layer or rock appear in the diagram. Groundwater discharged was measuered in between 43 m^3/h-49 m^3/h. average discharge 44 m^3/h. it slightly lower than tubewell 1. This two(2) tubewell was succesfully detected and tested with the ERM .

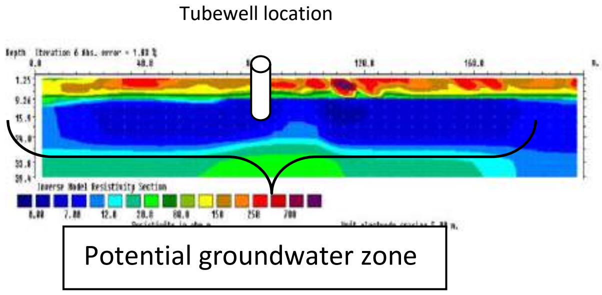


Figure 3: Electrical resistivity imaging at the survey site for Seberang Perak 2

ERM studies also implement in Kelantan which located at east coast Peninsular Malaysia. The lithology at this area are marine sand. Bachok famous with tapioca and sweet potato plantation. Almost small farm in this area were used tubewell as water sources for suplementary irrigation. From the figure 4 showed that the saturated confined aquifer were located at depth 8-10 m from the ground level. Besides that, other alluvial deposition still covered up surrounding the aquifer layer. The resistivity data in ranges 0 – 500Ωm. the first 5 m of the layer slightly high value due to the embankment or road which is different compared to original ground level. Below the road layer probably sand and gravel layer which show the resistivity value 0-10 Ωm. it located from the ground level. To verify the depth of an aquifer, well boring were conducted at proposed location. The resulted show the depth of tubewell was 8.5 m from the ground level to the coarse sand layer where the value of resistivity was 8-9 Ωm . This resulted also proofed ERM could use as a surveying grondwater especially for exploration shallow groundwater for agricultural purposes.

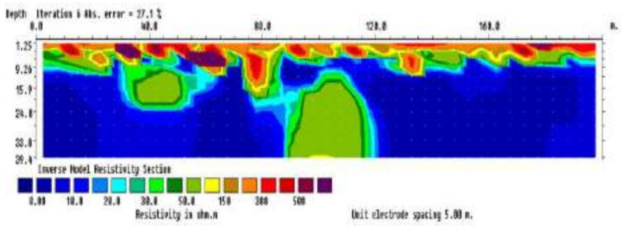


Figure 4: Resistivity imaging at the survey site for Bachok, Kelantan

Conclusion

Geophysical method more reliable than most conventional method in groundwater exploration. Conventional method based on the experience of boring contractor to located the location of tubewell sometime it take risk and difficult to define the specification of tubewell . Try and error well drilling is one of the conventional method which applied a direct way in exploring subsurface groundwater, however the cost is very expensive.Since the cost of development in agriculture sector slightly increase nowadays, geophysical method can be tools to assist in groundwater exploration especially in agriculture industry to reduce the cost of farm infrastructure This technique was also helped to improved the understanding of groundwater aquefers. Groundwater in the form of unconfined aquifer is obtainable between a depth of 9-24 m. In summary ,the resistivity of the aquifer layer is in between 0-20 Ωm at marine sand area potentially shallow groundwater.

Table 2: Result of Tubewell exploration

Tube well	Depth (m)	Resistivity (Ωm)	Discharge (m^3/hr)
Seberang Perak 1	24	15	45
Seberang Perak 2	11	4.45	47
Bachok 1	9	8-9	N/A

References

Antholt, C. H., & Wennergren, E. B. (1982). Crop Output and Utilization Labor Input Input Availability Boro 1983 Intentions Drying Processing Storage Rice Hulling Mills Conclusion, (December).

Ashvin Kumar, M. (2011). Exploration of Ground Water Using Electrical Resistivity Method, 39.

Asry, Z., Samsudin, A. R., Yaacob, W. Z., & Yaakub, J. (2012). Groundwater investigation using electrical resistivity imaging technique at Sg. Udang, Melaka, Malaysia. *Bulletin of the Geological Society of Malaysia*, *58*(58), 55–58.

Bardhan, P. (2012). Shallow Tubewell Irrigation in Nepal: Impacts of the Community Groundwater Irrigation Sector Project.

Hago, H. A. (200). Application of Electrical Resistivity Method in Quantitative Assessment of Groundwater Reserve of Unconfined Aquifer Hago Ali Hago.

Hasbrouck, J(2003) Deep Groundwater Exploration Using Geophysics, (August), 6–10.

Jusoh, M. F., Moamed Zawawi, M. A., Man, H. C., & Kamaruddin, S. (213). Performance of shallow tube well on groundwater irrigation in tropical lowland rice cultivation area. *Sains Malaysiana*, *42*(8), 1101–1108.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA02

Design and Development of a Control System for Automated Rotary Planting

Hafidha[1*], Mohd Shukry H.B [1] and Mahidzal D.[2]
[1]Engineering Research Centre, Malaysian Agricultural Research and Development Institute, Malaysia
[2]Department of electrical Engineering, Faculty of Engineering, University of Malaya, Malaysia
*Hafidha Azmon Tel.: +603-89536562, Email: hafidha@mardi.gov.my

Abstract
This research has been done to design and develop a planting system as a need to improve an urban farming technology. This planting system is targeted to cultivate edible crops on urban house or building which can produce food plants within a decorative landscape. The design was inspired by a Ferris wheel which the rotation mechanism is intended to allow enough sunlight and good air flow to each crop in the planter box. This rotation gives chance to each crop in each planter box to sunbathe during sunny day. The rotational mechanism is also aimed to assist all range of consumers to run agricultural activities at convenient height. The system is equipped with sensors and a motor for an automation control. Arduino Uno was used as a microcontroller to control irrigation system and relocation of planter boxes to the various positions. The irrigation system starts it operation at 8.00am and 12.00pm. The rotation of planting system will stop at every 45 degrees until it complete the full rotation for 2 times. The relocation of planter boxes happens at 9.00 am, 10.00am, 11.00am, 1.00pm, 2.00pm and 3.00pm. Each planter box is positioned at the new location to expose to the sunlight for an hour long. Results obtained from the functioning test showed a good and promising performance of the rotary planting system as it can be automatically operated to grow crops in an urban residential.

Keywords: rotary planting system, irrigation, control system, urban farming, microcontroller, arduino, automation

Introduction

The limited space for agriculture activity has boosted an idea to grow plant on stackable pot which is known as vertical farming. This type of farming cultivates crops on the multitier pots which can be installed on the wall or placing them on the floor with numbers of pots stacked on top of other layer (Blatter, 2013; Fell, 2011). In a few recent years, vertical farming becomes one of the most preferred and popular designed of planting system because it can expand the production of fresh food on a very minimal space. One acre for growing plants using vertical type system can be the same as many of ten to twenty on conventional open field-based acres (Despommier, 2011). Instead of planting crops on the spacious land, technology of vertical farming can be adapted in the city since it is less dependent to land, easy to maintain, require minimal distance to travel and at the same time can secure food to the resident (Mustafa Koc et. al, 1999). Limited and expensive water resources in urban area had contributed to an efficient use of water in this type of farming (Smit et. al, 2001). There are many advantages of urban farming to the city communities. It helps every household to grow their own food, educate people for consuming healthy food, create jobs, increase local economic for neighbourhood, and improve communities revitalization (Hagey et. al, 2012;Besthorna, 2013).

Research shows that urban farming is favourable among females and old folks compare to young and adults male (Carola et al, 2017). Thus, the design of the new planting system must takes into account the need of the consumers. The vertical farming itself require a “grow up planting system” where crops are cultivated from bottom to top. For short consumer, the vertical system is often a challenge for them to manage the crops. This is why the rotary planting system is introduced. It is to cater the most targeted consumer of urban agriculture.

The development of rotary planting automation system is planned to offer an ergonomic way to the user for planting crops. It is also give the best solutions to the space constraint. It is targeted for houses or buildings with limited space to cultivate edible crops which can produce food plants within a decorative landscape setting view.

Material and Method

Rotary Planting Structure

The concept of the rotary planting automation system is based on the design of the Ferris wheel as shown in Figure 1. The purpose of rotating mechanism is to ensure all crops in each planter box are exposed to enough sunlight for photosynthesis process. Besides, the rotating system allows the planter box to stop at desired height for easy maintenance and allow user to do planting activities.

The body of planting structure consisted of a couple of four arms to hold four pieces of planter boxes. The planter box holder was designed for easy maintenance and to remain the top of the box facing up. This is to ensure the crops and soil face upward even when the system is rotating 360^{O}.

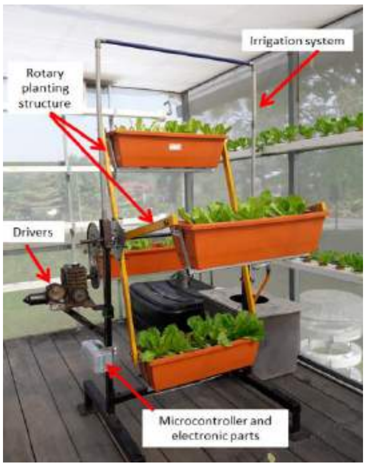


Figure 1: Rotary planting system

Actuator

The system uses DC motor to actuate the rotating arms. The most important criteria in choosing the motor was to estimate the torque required to rotate the planting system. Torque (τ) is an amount of force acting on an object that results in the object rotating. In rotational motion, torque can be described as the multiplication of moment of inertia (I) and angular acceleration (α). The moment of inertia is known as a quantity expressing a body's tendency to resist angular acceleration, which is the total product of the mass of each particle in the body with the square of its distance from the axis of rotation. The torque required by the motor to actuate the system was estimated.

Irrigation system

The rotary planting structure was installed with the irrigation system in order to supply water to the crops. The system comprised of perforated pipe, 100L water tank, water pump, and piping act as water conveyance canal. The 3/4in pipe which is placed on top of the system is fabricated with 9 tiny holes with the diameter of 1mm as shown in Figure 2. The perforated pipe is used to water the crops at a specified time.

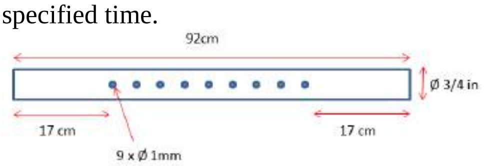


Figure 2: Perforated pipe dimension

Microcontroller

Arduino was chosen as a microcontroller for this project because of it worthy price to run a simple automation instruction. Arduino was preferable over other microcontrollers due to it easy to create program based on open source platform and suitable for many type of sensor's integration.

Rotary Planting Mechanism

In general the operation of rotary planting system can be divided into 2 ways of handling.

i. Manual handling
ii. Automatic handling

i) Manual handling

Manual handling is needed when it is the time of harvesting crops or during crops maintenance. The push button is connected to the circuit as an alternative to bypass the instruction of microcontroller. This is an important feature for the user since every user has different height. They requires different working height to harvest crops thus, the manual button offers a solution for height variety level when operating the system.

ii) Automatic handling

Automatic handling involved two processes
i. Irrigation
ii. Reposition planter box for sunbathing

The design for rotary planting automation system is shown in Figure 3.

Automatic handling requires a Real Time Clock (RTC) to start the process. In this project, RTC is controlled by Arduino Uno microcontroller.

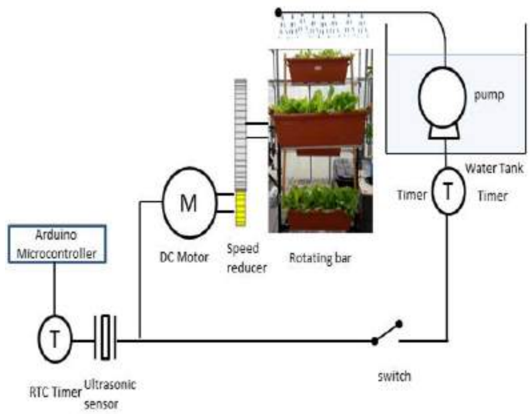


Figure3: Design for Rotary Planting Automation System

Figure 4 shows the flow of rotary planting automation system to operate the system in manual or automatic mode

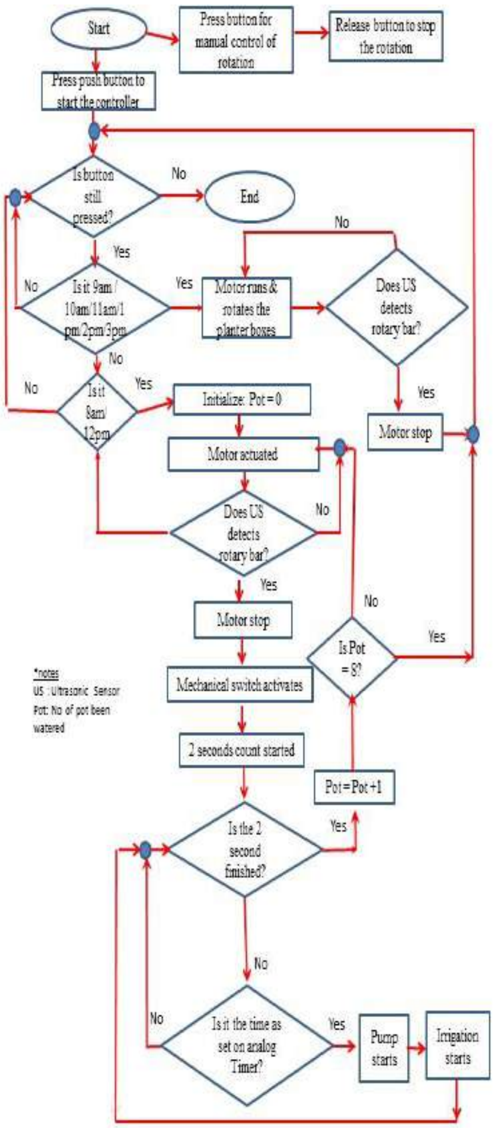


Figure 4: Flow of Rotary Planting Automation System

Results and discussion

Control System Design

i)Irrigation Process

The irrigation system starts it operation at 8.00am and 12.00pm. When the time reached, the system starts and the motor rotates the rotating bar. The rotation will stop at every 45 degrees until it complete the full rotation for 2 times. Ultrasonic sensor is used to stop the motor rotation for 2 seconds at every 45 degrees rotation. During each stop, the pump start and irrigation process run for 2 seconds.

ii) Reposition planter box for sunbathing

The second process of the system is to reposition the planter box. It happens at 9.00 am, 10.00am, 11.00am, 1.00pm, 2.00pm and 3.00pm every day. This process is required in order to expose crops in each planter box to sunlight and to allow good air flowing through the stacking boxes. The reposition of planter box is occurred at every hour where each planter box is positioned at the new location for an hour long.

Sequence of Rotary Planting System

The sequence of Rotary Planting System can be divided into two processes

i. Process flow for Irrigation (RTC timer is set to 8.00am and 12.00pm):

ii. Process flow for reposition planter box (RTC timer is set to 9.00am, 10.00am, 11.00am, 1.00pm, 2.00pm and 3.00pm)

<u>Process Flow for Irrigation (RTC timer is set to 8.00am and 12.00pm):</u>

(1) As the start button is switched on, Arduino microcontroller starts to operate the system

(2) The RTC timer starts the motor when the time set (8.00am & 12.00pm) is reached. The count of variable ‘Pot’ is initialized to 0

(3) DC Motor rotates in counter clockwise direction to move the rotary bar. It is rotates until the ultrasonic sensor detect the object (rotary bar)

(4) When the ultrasonic sensor triggered, the motor stop, and counting of ‘Pot’ is started. This means that the first pot is start to given water. The program is coded so that the motor stop for 2 second. When the motor stop, the rotary bar is momentarily presses the mechanical switch which is connected to the pump.

(5) If the time set for the pump set is reached, the pump starts to irrigate the crops when the switch is turned on.

(6) The Arduino controller starts the motor after 2 second and the process start again until the count of variable Pot = 8

<u>Process flow for reposition planter box (RTC timer is set to 9.00am, 10.00am, 11.00am, 1.00pm, 2.00pm and 3.00pm)</u>

(1) As a start button is switched on, Arduino microcontroller starts to operate the system

(2) The RTC timer starts the motor when the time set is reached (9.00am / 10.00am / 11.00am / 1.00pm / 2.00pm / 3.00pm).

(3) DC Motor rotates in counter clockwise direction to move the rotating bar. It is rotates until the ultrasonic sensor detect the object (rotary bar)

(4) When the ultrasonic sensor triggered, the motor stop and the rotary bar presses the mechanical switch.

(5) The timer for the pump is not set at these hour, thus no irrigation happened at this time although the switch to the pump is connected. The off timer cut the connection of the switch and the water pump.

(6) The Arduino controller stops the motor and the process will start again to reposition next planter box after 1 hour.

Conclusion

Results in the field testing shows a good and promising performance of the rotary planting system as it can be automatically operated to grow crops in an urban residential. The planting system is aimed for the constraint space, and natural resources. This system is inspired by a Ferris wheel where the rotation mechanism is intended to allow enough sunlight and air flow to each crops in the planter box. The rotational mechanism is also aimed to assist all range of consumer to run agricultural activities at a convenient height.

Reference

Besthorna, F. H. (2013). *Vertical Farming: Social Work and Sustainable Urban Agriculture in an Age of Global Food Crises.* Australian Social Work, 66(2)

Blatter, K. (2013). *Farming Up: Using vertical farming to grow local produce.* CountrySpirit.

Carola., G., Iryna., P. & Antonios., P. (2017). *Relationship between Consumer Behavior and Success of Urban Agriculture*. Ecological Economics, *136*, 189-200.

Despommier, D. (2011). *The Vertical Farm: Feeding the World in the 21st Century*: Picador.

Fell, D. (2011). *Vertical Gardening: Grow Up, Not Out, for More Vegetables and Flowers in much less space*. New York: Rodale.

Hagey, A., Rice, S., & Flournoy, R. (2012). *Growing Urban Agriculture: Equitable Strategies and Policies for Improving Access to Healthy Food and Revitalizing* Communities: PolicyLink.

Mohanraj, I., Ashokumar, K., & Naren, J. (2016). *Field Monitoring and Automation using IOT in Agriculture Domain.* International Conference On Advances In Computing & Communications, India.

Mustafa Koc, R. M., Luc J.A Mougeot, Jennifer Welsh. (1999). *For hunger-proof cities : sustainable urban food systems*. Canada: Ottawa, Ont. .

Smit, J., Nasr, J., & Ratta, A. (2001 (edited)). *Urban Agriculture: Food, Jobs and Sustainable Cities*. New York: The Urban Agriculture Network, Inc.

Development of Mobile Traction Aid for Farm Machinery (Mo-Traid)

Mohd Khusairy, K.[1*], Fauzi, M. I.[1], Mohd Taufik, A[2]., Mohd Shahril Shah, M.G.[1], Muhammad Aufa, M.B.[1], Muhammad Fakhrulzaman, O.[3],Muhammad Haniff, A.[1] , Azlan, O.[1], Mohd Hashim, A.[1], Ibrahim E.[1], Saifulizan, M. N.[1]
[1] Pusat Penyelidikan Kejuruteraan, MARDI Seberang Perai, Kepala Batas, Pulau Pinang.
[2]Malaysia.Mechanisation and Automation Research Center, MARDI Headquarter, P.O. Box 12301, 50774 Kuala Lumpur
[3]Malaysia Agricultural Research And Development Institute, Alor Setar, Kedah, Malaysia.
*Corresponding author. Tel.: +6013-4195701, Email:mkhusairy@mardi.gov.my

Abstract
High moisture content of wetland soil makes wheeled farm vehicles have to struggle with severe loss of their mobility. Farm machinery are prone to being bogged down and traffic-ability of the soil surface layer is very poor, when working on problematic soil or soft soil area with low load-bearing capacity. This is due to hard pan damage or zero hard pan to support the machines, resulting in the machines not having sufficient traction and ability to float. A traction aid fitted to the wheels of a prime mover is needed to improve ground traction and its ability to maneuver on soft soil. Farm vehicles that are operated in these conditions require a traction aid fitted to the wheel or in place of wheel is needed to improve ground traction and its ability to maneuver on soft soil. The main purposes of this study are to examine soil behavior under traction aid device attached on the farm machinery wheel. As per the studies conducted earlier, Mobile Traction Aid for Farm Machinery (Mo-Traid) that have been develop are found to be the most effective device for wet rice fields to support and help the farm machinery when it encounter soft soil area. Mo-Traid made by mild-steel with size 30cm x 10cm x 7cm. This equipment can be adjustable with maximum length is 45cm. The weight of this equipment is 5kg and it practical to be carry to the field. From the research it was revealed that the Mo-Traid exert more pull in comparison with tires in flooded soil conditions.

Keywords: Trafficability, soft soil, mobility, traction, Mo-Traid

Introduction

High moisture content of wetland soil makes the machinery unsuitable for use with pneumatic tyre. Trafficability of the surface soil layer is very poor, being extremely soft with low load-bearing capacity when cone index are generally less than 0.3MPa at depth 30cm [1][2]. Performance of conventional rubber-tyred wheel is not acceptable because of high slippage and adhesion of sticky soil. Farm tractors and other farm vehicles that are operated in these conditions often require special devices used with tires or in place of tires. To increase the grip between machine wheels and the ground surface and to spread load weight, traction aids are needed to fit on farm machinery. The area of the wheel in contact with the ground is called the ‘footprint’ area [3]. If traction aids have a greater area in contact with the ground than wheels alone the footprint size increases and ground pressure exerted by the machine is reduced. Traction aids can also increase machine stability, improves flotation and protect tyres. Inappropriate selection of traction aids can have a negative impact on soil, water, the standing crop, and on machine and operator ergonomics [4]. Appropriate traction aid selection for use with a machine in a given situation is therefore very important.

Types of Traction Aid

Tyres

Traction is created where a machine makes contact with the ground; therefore the first consideration for increasing machine traction is the tyre specification. Different tread patterns impart different flotation, grip, load distribution and self-cleaning properties to the wheel; changing tyre specification can result in gains in traction. Rice production calendar generally includes the period of soil puddling and transplanting of rice seedling processes in which rice field soils are in flooded or slurry-like condition [5]. At this point of time, the wheeled farm vehicles have to struggle with severe loss of their mobility even in the field with appropriate hardpan.

Mobile Traction Aid for Farm Machinery (Mo-Traid)

Mo-Traid made by mild-steel with size 30cm x 10cm x 7cm. The weight of this equipment is 5kg a robust, easy to transport, quick to fit means of gaining additional traction (Table 1, Figure 1). Correct fit of adjustable strake to tyre is important to obtain maximum benefit and avoid damage to the tyre through slippage. The incorporation of expandable strake fit on the tyre rim provides increased grip although this may cause greater ground disturbance and operator discomfort due to a rougher ride. Mo-

Traid follow a curved profile around the wheel to reduce stress on the machine transmission. Mo-Traid plates wider than the machine wheels have flotation benefits. Anti-skid 'spikes' or 'lugs' give lateral grip to the track, helping to prevent lateral movement on side slopes. Flotation is increased as the footprint area is greater than that of the wheels. The broader the expandable plates are open, the greater the increase in flotation. Mo-Traid designed with broad plates and the smallest gap possible between plates to maximize the machine's footprint area.

Table 1:Advantages and disadvantages of traction aids.

Advantages	Disadvantages
Increased ability to work on slopes coupled with increased safety.	Can increase width of the machine and some aggressive characteristics can cause damage to standing trees and root systems.
Increased traction.	On hard surfaces increased vibration may have negative consequences for operator ergonomics.
Prevent tyre wear and damage.	Potential for site disturbance if used inappropriately.
Increased manoeuvrabilit y of the machine due to traction gain.	Poor fit can cause tyre wear and damage to the machine.
Reduced downtime as the machine will become bogged less often.	Additional weight and rolling resistance may lead to higher fuel consumption and reduced manoeuvrability.

Conclusion

Tread patterns may prove incompatible with some traction aids as widely spaced lugs have reduced surface area for track plate grip and support. Mo-Traid provides traction and flotation advantages under a diverse range of operating conditions. It is important to appreciate that gaining the best results in terms of traction and flotation during farm operations is achieved through a combination of appropriate traction aids and operating methods. Inappropriate use of traction aids can be detrimental to the site. Correctly fitted aids should prolong the useful life of machine tyres with no wear.

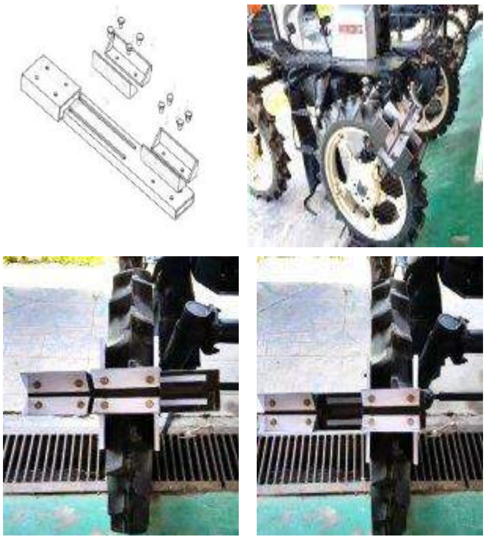


Fig.1. Mobile Traction Aid for Farm Machinery (Mo-Traid) fitted to High Clerance tyre

References

Hendriadi, A., & Salokhe, V.M. Improvement of a power tiller cage wheel for use in swampy peat soils. Journal of Terramechanics,39; 55-70, 2002.

Liljedahal, J.B., et al. Tractors and their power units, CBS Publishers and Distributers, New Delhi, 1997.

Mohd Khusairy, K., et al Soft Soil : Effects of Tractor With Rubber Tyres and Steel Half Track on Soil Compaction , Journal of Science and Engineering Technology (JSET), Malaysia, 2017.

MORGAN, S. (2000).Review of tyres and traction aids. Forestry Commission Technical Development Internal Report. Forest Research, Ae, Dumfriesshire. Reference to a chapter in an edited book:

Sirohi, NPS. Tractive performance of power tiller with traction aids in unsaturated soil conditions. Indian J Rural Technology, 3; 33-38, 1991.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA04

Mesin Merumpai Satu Baris Antara Batas Bagi Penanaman Nanas

Mohamad Fakhrul Z.O.[1,*], Hartinee A.[2], Mohamed Fauzi M.I.[3] and Mohd Khusairy K.[3]
[1]*Pusat Penyelidikan Kejuruteraan, Institut Penyelidikan dan Kemajuan Pertanian Malaysia, MARDI Sintok, Kedah*
[2]*Pusat Penyelidikan Hortikultur, Institut Penyelidikan dan Kemajuan Pertanian Malaysia, MARDI Sintok, Kedah*
[3]*Pusat Penyelidikan Kejuruteraan, Institut Penyelidikan dan Kemajuan Pertanian Malaysia, MARDI Seberang Perai, Pulau Pinang*
Corresponding author. Tel.: +604-9222601, Email:fakhrulz@mardi.gov.my

Abstrak
Masalah rumpai bagi tanaman nanas adalah sangat ketara terutamanya bagi jenis tanah mineral. Kebiasaannya rumpai menjadi masalah besar pada peringkat enam bulan awal pertumbuhan pokok dan mampu menjejaskan hasil pengeluaran nanas. Bagi mengawal masalah ini, terdapat beberapa kaedah boleh diaplikasikan antaranya adalah kawalan mekanikal atau mesin seperti yang kajian ini lakukan. Walau bagaimanapun, mesin itu perlu memenuhi kriteria utama iaitu jarak antara batas bagi kegunaan merumpai antara batas iaitu 90cm. Manakala, mekanisma yang digunakan untuk adalah jenis membajak. Oleh itu, terdapat dua jenis mesin telah dikenalpasti dan diubahsuai bagi kegunaan dalam kajian ini. Kajian ini telah dijalankan di plot nanas MARDI Sintok, Kedah dalam dua keadaan iaitu pada permukaan tanah rata dan bercerun. Data kekuatan tegasan tanah diambil sebelum dan selepas ujian dilakukan pada permukaan dan kedalaman 15cm daripada permukaan tanah. Selain itu, jarak dan masa yang digunakan direkodkan. Keputusan kajian menunjukkan keupayaan kerja bagi mesin merumpai traktor mini dan traktor dua roda masing-masing bagi tanah rata adalah 0.12 hektar perjam dan 0.115 hektar perjam. Manakala bagi tanah bercerun adalah 0.099 hektar perjam dan 0.077 hektar perjam masing-masing bagi jenis traktor mini dan traktor dua roda. Selain itu, hasil bajakkan menunjukkan kedua-dua mesin mampu untuk memotong permukaan tanah dan memusnahkan rumpai. Kajian menunjukkan bahawa mesin merumpai taktor mini lebih baik berbanding traktor dua roda dari segi keupayaan kerja dan keselesaan operator untuk menjalankan kerja merumpai di ladang.

Keywords: Nanas, Merumpai, MARDI

Pengenalan

Nanas *(Ananas comosus)* merupakan tanaman tropika yang dipercayai berasal daripada bahagian timur Amerika Selatan (Priya Devi et al. 2013). Buah nanas juga adalah salah satu daripada tanaman buah-buahan utama di Malaysia. Keluasan penanaman nanas di Malaysia ialah 13,148.9 hektar dengan hasil pengeluaran 391,714.4 tan metrik (Anon, 2016). Pokok nanas tergolong dalam kategori xerofit, maka tanaman ini memerlukan keperluan air yang sedikit. Oleh itu, nanas boleh ditanam dikebanyakkan kawasan. Johor merupakan pengeluar terbesar nanas negara dengan keluasan 5,295 hektar dan hasil pengeluarannya ialah 147,109 tan metrik (Anon, 2014).

Kaedah penanaman nanas yang biasa diamalkan oleh petani melalui kaedah tanam sulur dan berbatas. Dimana jarak antara batas ialah 90 cm dengan sistem penanaman nanas berkembar. Jarak tanam antara baris adalah 60cm manakala jarak tanam dalam baris adalah 30cm. Lebih kurang 40 ribu sehektar sulur nanas dapat ditanam dengan menggunakan kaedah ini.

Dalam aktiviti penanaman nanas, antara masalah yang sering dihadapi oleh petani adalah kawalan rumpai. Dianggarkan kerosakkan dan kehilangan nanas sehingga 80% disebabkan oleh masalah rumpai (Hussein et al. 2016). Manakala Reinhardt (2002), menyatakan bahawa nanas menunjukkan pertumbesaran buah dan sistem akar yang perlahan kerana faktor terdedah kepada persaingan yang sengit dengan rumpai, seterusnya menyebabkan kelewatan perkembangan buah dan mengurangkan hasil dan kualiti. Ia menyarankan agar keadaan ladang bersih dari rumpai semasa peringkat awal lima ke enam bulan selepas tanam.

Oleh itu masalah ini perlu ditangani bagi mengurangkan kehilangan hasil nanas. Kaedah kawalan rumpai yang amalkan adalah seperti amalan kultur, mekanikal dan racun kimia (Abd Rahim et al. 2012). Amalan kultur yang biasa digunakan adalah seperti kaedah merumput dengan tangan, memotong, menajak dan sungkupan. Kaedah sungkupan plastik mampu mengurangkan masalah ini tetapi ia boleh meningkatkan kos operasi. Manakala kaedah racun kimia mudah diamalkan dan penggunaan kos yang rendah, walau bagaimanapun kaedah ini mampu memberikan kesan terhadap pokok seperti melecur dan merencatkan tumbesaran pokok nanas (Edoh Adabe et al. 2016).

Oleh itu, kaedah kawalan rumpai secara mekanikal dengan menggunakan mesin yang sesuai boleh digunakan berbanding penggunaan tangan atau manual yang meningkatkan kos operasi dan masa kerja. Objektif kajian ini adalah bagi menentukan fungsi dan keupayaan kerja dua buah mesin yang telah dikenalpasti untuk merumpai antara batas bagi tanaman nanas.

Bahan dan Kaedah

Kajian telah dijalankan di plot kajian nanas MARDI Sintok, Kedah dengan berkeluasan 2 hektar. Terdapat dua keadaan permukaan tanah yang bertanam di plot ini iaitu tanah rata dan bercerun. Manakala, varieti nanas yang ditanam dalam plot kajian ini ialah varieti MD2 dan Yankee atau *Selangor Sweet*. Pokok nanas plot ini ditanam secara berbatas dengan sungkupan plastik. Rekabentuk batas yang dibangunkan adalah 60cm lebar, 30cm tinggi dan jarak antara batas adalah 90cm. Manakala pokok nanas ditanam 2 baris pada setiap batas. Pokok nanas berusia 4 bulan semasa kajian ini dilaksanakan.

Peralatan

Mesin dan peralatan yang digunakan dalam kajian ini ialah traktor dua roda (rajah 1) dan traktor mini empat roda (rajah 2) dengan masing-masing dilengkapi dengan peralatan bajak putar yang telah diubahsuai. Dimana, lebar bahagian pembajak telah dikurangkan kepada 82cm agar dapat beroperasi di antara batas yang berkelegaan lebih kurang 90cm. Mata bajak yang digunakan adalah jenis 'C' bagi kedua-dua jenis pembajak ini.

Jenis traktor dua roda yang digunakan ialah Kubota RT125 yang dipacu oleh enjin diesel yang berkuasa 12.5hp dan operator perlu berjalan kaki semasa menggunakan traktor ini. Manakala traktor mini empat roda yang digunakan ialah YANMAR A-10 berenjin diesel dengan kuasa 9.0hp. Operator boleh duduk menunggang traktor ini semasa menggunakannya.

Peralatan lain yang turut digunakan dalam kajian ini ialah ram ricih (*shear vane*), pita pengukur dan jam randek. Ram ricih digunakan bagi menentukan kekuatan ricih tanah sebelum dan selepas pengujian mesin dilaksanakan.

Rajah 1: Traktor dua roda (jenis berjalan).

Rajah 2: Traktor mini empat roda (jenis menunggang)

Kaedah

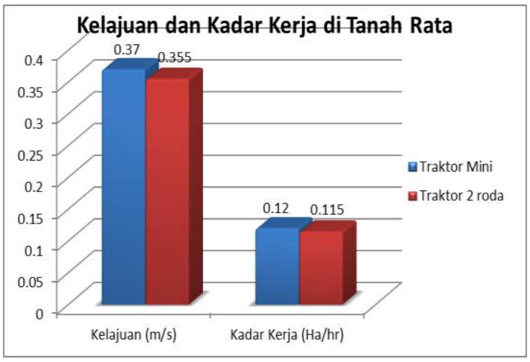
Pengujian ram ricih dijalankan terlebih dahulu, dimana data diambil sebanyak dua kali iaitu sebelum dan selepas pengujian mesin dilaksanakan. Kekuatan ricih tanah diambil pada permukaan tanah dan kedalaman 15cm daripada permukaan. Oleh itu, rod pada jarak 15cm daripada bahagian atas ram ricih perlu ditandakan bagi memudahkan pengendali alat ram ricih mengetahui had paras kedalaman 15cm bagi pengambilan data. Tiga titik data ram ricih diambil secara rawak pada setiap baris laluan mesin dan tiga ulangan data diambil bagi setiap titik.

Pengujian mesin dimulakan dengan mengukur jarak bagi setiap laluan mesin dengan menggunakan pita pengukur. Masa bermula dan tamat bagi operasi mesin bagi setiap baris laluan direkodkan dengan menggunakan jam randik, bagi pengiraan kelajuan mesin.

Bagi keadaan permukaan tanah bercerun, dua keadaan pengujian dilakukan bagi membezakan situasi mendaki dan menuruni cerun. Manakala, satu situasi saja bagi keadaan tanah rata untuk pengujian dilakukan. Traktor mini empat roda menggunakan gear 3 tinggi bagi pengujian di kedua-dua keadaan permukaan tanah rata dan bercerun. Manakala traktor dua roda menggunakan gear 2 tinggi bagi kedua-dua keadaan tanah bagi setiap pengujian.

Keputusan dan Perbincangan

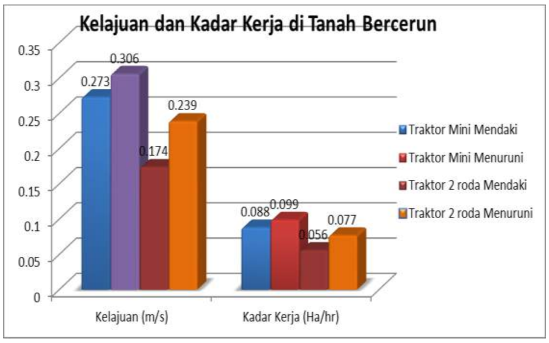
Keputusan kekuatan ricih tanah dengan menggunakan alat ram ricih menunjukkan purata kekuatan sebelum kajian adalah masing-masing 15kPa dan 64kPa di permukaan tanah dan pada kedalaman 15cm dari permukaan tanah. Manakala purata kekuatan ricih tanah selepas bagi traktor mini dan traktor dua roda masing-masing adalah 0kPa dan 54kPa bagi permukaan tanah dan pada kedalaman 15cm. Kekuatan ricih selepas kajian di permukaan tanah menunjukkan bahawa tanah telah diganggu sepenuhnya dan menjadi poros setelah dibajak, manakala pada kedalaman 15cm menunjukkan struktur tanah berlaku sedikit penurunan kekuatan ricih tanah.



Rajah 3: Kelajuan dan kadar kerja bagi traktor mini dan traktor dua roda di tanah rata.

Keputusan pengujian operasi di tanah rata (rajah 3) bagi kedua-dua jenis traktor menunjukkan bahawa kelajuan traktor mini empat roda adalah sedikit tinggi dengan 0.37m/s berbanding traktor dua roda dengan kelajuan 0.355m/s. Manakala perbezaan kadar kerja bagi kedua mesin ini hanyalah 0.005ha/jam.

Keputusan bagi pengujian di tanah bercerun (rajah 4) pula menunjukkan bahawa kelajuan bagi traktor mini empat roda menuruni cerun adalah tertinggi dengan 0.306m/s, diikuti oleh traktor mini mendaki cerun dengan 0.273m/s, seterusnya ketiga adalah traktor dua roda menuruni cerun dan yang akhir adalah traktor dua roda dengan 0.174m/s. Begitu juga dengan kadar kerja bagi operasi merumpai antara batas yang tertinggi adalah traktor mini empat roda menuruni cerun, diikuti oleh traktor empat roda mendaki, traktor dua roda menuruni dan terakhir adalah traktor dua roda mendaki dengan kadar kerja masing-masing 0.099ha/jam, 0.088ha/jam, 0.077ha/jam dan 0.056ha/jam.



Rajah 4: Kelajuan dan kadar kerja bagi traktor mini dan traktor dua roda pada keadaan mendaki dan menuruni cerun

Jika dibandingkan kelajuan operasi kedua-dua buah traktor di tanah rata dan cerun, kelajuan operasi di tanah rata lebih tinggi berbanding di tanah cerun bagi traktor mini beroda empat. Seterusnya menunjukkan bahawa traktor mini empat roda mempunyai kadar kerja yang paling tinggi.

Jika dilihat dari segi kesan dan fungsi kedua-dua mesin ini untuk merumpai, ia boleh dikatakan mencapai objektifnya untuk memusnahkan rumpai antara batas seperti yang ditunjukkan dalam rajah 5. Rajah 5 menunjukkan kesan terhadap pelbagai jenis rumpai ada di plot kajian yang telah berjaya dikeluarkan dan dipotong oleh mata bajak. Walau bagaimanapun, kesan sebenar terhadap rumpai ini dapat dipastikan selepas beberapa hari dengan rumpai ini benar-benar kering dan tidak hidup kembali. Pembajakkan kali kedua juga boleh dilakukan bagi meningkatkan lagi kadar kemusnahan terhadap rumpai ini. Namun begitu, ia akan meningkatkan kos dan masa operasi merumpai.

Selain itu, hasil pengalaman bagi operator terhadap mengendalikan kedua-kedua mesin ini memaklumkan bahawa traktor mini empat roda lebih mudah dikawal dan dikendalikan. Selain itu, operator juga selesa untuk memandu kerana perlu duduk berbanding traktor dua roda yang memerlukan operator terpaksa berjalan kaki untuk menggunakannya.

Rajah 5: Keadaan rumpai selepas dibajak

Kesimpulan

Sebagai kesimpulannya, kedua-dua jenis traktor dua roda dan traktor mini empat roda yang disertakan dengan peralatan membajak boleh berfungsi dan dijadikan sebagai mesin merumpai antara batas bagi tanaman nanas. Manakala, perbandingan kedua-dua mesin ini, menunjukkan bahawa traktor mini empat roda mempunyai kelebihan dari segi keupayaan kerja dan keselesaan terhadap operator semasa menjalankan kerja merumpai di ladang.

Penghargaan

Pengarang ingin merakamkan setinggi-tinggi penghargaan kepada pihak Pusat Hortikultur MARDI kerana memberikan peruntukkan bagi perlaksanaan projek ini. Selain itu, penghargaan juga kepada Pusat Hortikultur dan MARDI Sintok kerana menyediakan dan membenarkan kajian ini dilaksanakan di plot kajian nanas MARDI Sintok disamping bantuan yang bersungguh daripada kakitangan Pusat Hortikultur bagi menjayakan kajian ini. Seterunya juga jutaan terima kasih diucapkan kepada semua kakitangan sokongan Pusat Kejuruteraan MARDI yang membantu bagi melancarkan aktiviti kajian ini.

Rujukan

Abd Rahim H., Rohazrin A.R., Khairul Fithri A.R. and Miswan J. (2012). *Manual Teknologi Penanaman Nanas Berjentera.* MARDI

Anon, (2014). Perangkaan Agromakanan Malaysia, DOA, 2014

Anon, (2016). Statistik Tanaman Buah-buahan Malaysia, DOA, 2016

Hussein F. Abouziena, Wafaa M. Haggag, Hamed M. El-saeid and Eman A Abd El-Moniem (2016). Safe Methods for Weed Control in Fruit Crops: Challenges, and Opportunities: Review. *Der Pharmacia Lettre*, 8 (5):325-339

K. Edoh Adabe, Salama Hind and Adbou Maiga (2016). Production and proceesing of pineapple. *The Pro-Agro Collection*, ISF Cameroun.

S. Priya Devi, M. Thangam, M.S. Ladaniya, N.P.Singh (2013). Pineapple-a profitable fruit for Goa, *Technical Bulletin* No.35, ICAR (RC), Goa.

Reinhardt D.H., Cabral J.R.S., Souza L.F.S., Sanches N.F., Matos A.P. (2002). Pérola and Smooth Cayene pineapple cultivars in the state of Bahia, Brazil:growth, flowering, pests and diseases, yield and fruit quality aspects. *Fruits*, Paris, v.57, p.43-5

Pengujian Traktor Kubota L3800 bertrek sebagai penggerak utama mekanisasi nanas di tanah gambut

A.R Rohazrin,*, and A.S. Adli Fikri
Pusat Penyelidikan Kejuruteraan
Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +603-89536554, Email:rohazrin@mardi.gov.my

Abstrak
Nanas merupakan salah satu komoditi yang diberi perhatian sebagai sumber penjana ekonomi kepada petani di Malaysia. Nanas banyak ditanam di kawasan tanah gambut dan tanah mineral. Di kawasan tanah gambut, penggunaan mekanisasi adalah terhad kerana keupayaan galasnya rendah. Ini menyebabkan kurangnya mekanisasi ladang diguna pakai di dalam aktiviti pengeluaran nanas di tanah gambut. Kesesuaian penggerak utama atau traktor di tanah gambut dilihat sebagai faktor utama yang membataskan penggunaan mekanisasi. Traktor Kubota L3800 berkuasa 38 kuasa kuda atau 28 kW ,dengan sistem 4 separa rantai diuji sebagai penggerak utama yang berpotensi untuk menjalankan aktiviti ladang pengeluaran nanas di tanah gambut seperti aktiviti penyediaan tanah, penanaman, penjagaan tanaman, penuaian dan pengangkutan. Hasil dari ujian tusukan di ladang nanas bertanah gambut menunjuk keupayaan galas adalah di dalam lingkungan 0.1 ~ 0.2 Mpa, yang diketegori sebagai tanah bermasalah untuk mekanisasi. Keupayaan galas yang tertinggi didapati pada kedalaman 10 cm pertama. Secara teori, tekanan sentuh permukaan trek bagi traktor L3800 pada berat tanpa beban ialah 0.01 Mpa. Ketergelinciran pergerakan traktor adalah di antara 4.2 hingga 8.8%. Pemadatan tanah didapati berlaku sehingga kedalaman 15 cm pertama dari permukaan. Kelegaan traktor 55 cm adalah kurang mencukupi untuk kerja di dalam ladang. Kajian menunjukan mekanikasi pengeluaran nanas di tanah gambut adalah sesuatu yang boleh dilaksanakan dengan penggunaan traktor bertrek dan peralatan yang kecil serta ringan.

Kata kunci: Mekanisasi nanas, tanah gambut, penggerak utama, trek,

Pengenalan

Nanas merupakan salah satu komoditi yang diberi perhatian sebagai sumber penjana ekonomi kepada petani di Malaysia. Nanas banyak ditanam di tanah gambut dan di tanah mineral. Kehadiran varieti MD2 di industri pengeluaran nanas tempatan telah membuka pasaran eskport yang baik kepada Malaysia kerana varieti tersebut mendapat tempat dan penerimaan di peringkat antarabangsa.

Pengeluaran sumber makanan berasaskan tanaman tidak terlepas daripada masalah kekurangan tenaga buruh dan kadar produktiviti yang rendah. Masalah ini juga melanda dalam industri pengeluaran nanas tempatan. Kaedah mekanisasi dilihat salah satu jalan alternatif untuk menyelesaikan permasalahan ini. Tetapi, tidak semua pengeluaran tanaman boleh dimekanisasikan, terutama di kawasan pengeluaran yang mempunyai tanah bermasalah seperti di tanah gambut.

Pengeluaran nanas di tanah gambut kebanyakannya bergantung kepada operasi manual. Kekangan utama penggunaan mekanisasi di tanah gambut adalah keupayaan galasnya yang rendah, bersifat lembut dan banyak terdapat kayu-kayu yang tidak mereput di dalam tanah (H S. Ooi, 1996). Kebanyakan kawasan tanaman yang bermasalah dengan penggunaan mekanisasi umum adalah yang mempunyai keupayaan menampung beban di bawah daripada 0.3 MPa (Mohd Nadzim N, 2014). Mekanisasi umum di sini bermaksud kejenteraan yang biasa digunakan dalam mana-mana aktiviti pertanian di kawasan yang tidak bermasalah seperti penggunaan traktor beroda.

Pemadatan tanah yang terjadi di sesuatu kawasan tanaman boleh dikaitkan dengan kesan daripada operasi mekanisasi di lapangan terutama yang dijalankan ketika tanah berkelembapan tinggi. Struktur tanah yang baik adalah penting kerana ia menentukan keupayaan tanah untuk memegang dan mengalirkan air, nutrien, dan udara yang diperlukan untuk aktiviti pertumbuhan akar tumbuhan (DeJong-Hughes, 2107).

Teknologi sedia ada bagi pengeluaran nanas di tanah gambut kelihatan mencukupi walaupun ketidakmampuan untuk menjalankan kaedah mekanisasi, dan kekurangan ini akan menyukarkan dalam menghadapi kekurangan buruh dan peningkatan kos pengeluaran. Pengunaan mekanisasi boleh direalitikan dalam sistem pengeluaran nanas di tanah gambut jika terdapat penggerak utama yang sesuai diguna pakai.

Objektif kajian ini adalah untuk menilai traktor bertrek getah sebagai penggerak utama yang berpotensi untuk pengeluaran nanas di tanah gambut.

Bahan dan kaedah

Spesifikasi traktor dan rekabentuk sistem trek

Traktor Kubota L3800 berkuasa 28kW atau 38 kuasa kuda @ 2200 p.s.m dengan sistem pacuan empat roda dipilih dan dinilai sebagai salah satu penggerak utama yang berpotensi untuk memacu penggunaan mekanisasi bagi pengeluaran nanas di tanah gambut. Traktor tersebut menggunakan sistem 4-separa trek getah yang menggantikan roda getah berangin. Sistem trek ini dipasang di setiap gandar traktor seperti yang ditunjukan di dalam gambar rajah 1.0. Kelebihan reka bentuk sistem trek ini adalah mempunyai gandar yang berpangsi hidup yang dapat bergerak dengan lebih cekap di pelbagai keadaan permukaan tanah berbanding sistem trek penuh. Rekabentuk dan komponen sistem 4-separa trek ini adalah dikomersialkan oleh Syarikat *Soucy Track* di bawah model ST-300. Berat keseluruhan sistem trek ini ialah lebih kurang 582 kg dengan permukaan sentuhannya seluas 1.72 m^2. Daripada luas permukaan tersebut, sistem trek ini memberi tekanan sentuhan permukaan serendah 0.010 MPa dengan keberatan keseluruhan traktor bersamaan 1805 kg. Nilai tekanan sentuh ini adalah lebih rendah berbanding tekanan yang terjadi dari traktor yang sama dengan penggunaan roda iaitu dalam lingkungan 0.02 hingga 0.08 MPa yang bergantung kepada tekanan angin tayar (DeJong-Hughes et. al, 2017). Kelegaan gandar traktor tersebut ke permukaan tanah ialah lebih kurang 55 cm iaitu lebih tinggi daripada traktor yang sama menggunakan roda. Sistem 4-separa trek ini direka bentuk supaya mudah untuk dibuka dan dipasang pada traktor.

Gambar 1: Traktor Kubota L3800 dengan sistem 4-separa trek getah

Tempat kajian

Kajian telah dijalankan di Stesen MARDI Klang, Selangor dan Stesen MARDI Pontian, Johor. Kedua-dua plot kajian ini bertanah gambut keseluruhannya ,yang dirancang untuk penanaman nanas. Beberapa ladang pengeluaran nanas bertanah gambut di Johor juga dilawati dan diambil bacaan keupayaan galasnya. Graf bagi bacaan purata rintangan tusukan bagi kesemua ladang nanas bertanah gambut yang dilawati diplot untuk mendapat gambaran awal mengenai keupayaan galas yang dimiliki.

Untuk memastikan tiada kerosakan berlaku pada sistem trek terutama trek getah yang diguna pakai yang boleh mengganggu perjalanan kajian, plot kajian dibersihkan terlebih dahulu daripada semak samun dan tunggul-tunggul kayu yang tertanam. Kerja pembersihan dijalankan dengan menggunakan jenkaut berantai atau *excavator*.

Ujian rintangan tusukan tanah

Ujian rintangan tusukan tanah dijalankan di plot kajian dan di beberapa ladang nanas bertanah gambut di sekitar johor. Bacaan rintangan tusukan tanah diambil sehingga kedalaman 80 cm. Rintangan tusukan adalah cara untuk mendapatkan keupayaan galas tanah. Di kawasan penanaman baru, maklumat ini berguna sebagai langkah berjaga-jaga untuk menentukan kebolehgunaan traktor di kawasan tersebut. Jika ini tidak diberikan perhatian, traktor akan berisiko untuk terjelus ke dalam tanah.

Peralatan yang diguna untuk pengukuran rintangan tusukan tersebut adalah dari syarikat Eijkelkamp. Kon penucuk dengan luas permukaan kon 5cm² dengan sudut 60 ° diguna pakai. Terdapat beberapa saiz muncung kon yang lain boleh diguna pakai iaitu, 1cm², 2cm² dan 3.3cm² tetapi saiz 5cm ² dipilih kerana struktur tanah gambut yang terlalu longgar untuk muncung kon yang lebih kecil yang menyebabkan penderia peralatan tersebut kurang sensitif untuk mengesan daya tusukan. Ujian rintangan tusukan ini dijalankan secara rawak di dalam plot bersaiz 50 m x 9 m untuk 27 titik tusukan. Setiap titik diambil 3 bacaan di lokasi berdekatan dalam jejari 100 cm. Semua bacaan direkod di dalam sistem ingatan peralatan tersebut. Graf bacaan rintangan tusukan melawan kedalaman tanah diplot untuk melihat corak keupayaan balas tanah gambut.

Ujian ketergelinciran

Ketergelinciran adalah faktor yang berkait dengan kecekapan tarikan yang diukur dalam peratusan, dan ini merupakan salah satu kehilangan kuasa traktif. Ketergelinciran juga boleh diertikan sebagai sejumlah tanah yang tertolak secara mendatar selepas dilewati oleh roda. Untuk mendapatkan ketergelinciran pergerakan traktor dengan sistem 4 separa trek, dua pengukuran jarak perjalanan diambil iaitu jarak teori dan jarak sebenar (jarak yang diukur). Jarak perjalanan teori ditentukan dengan mengambil bilangan putaran penuh pergerakan trek dan didarab dengan panjang trek yang diguna pakai manakala jarak sebenar diukur dari titik permulaan trek bergerak sehingga ia kembali ke kedudukan pertama dalam beberapa putaran tertentu. Di bawah adalah persamaan yang digunakan untuk menentukan peratus ketergelinciran yang berlaku.

$$\text{Ketergelinciran}(\%) = \frac{S_{\text{teori}} - S_{\text{sebenar}}}{S_{\text{sebenar}}} \times 100$$

Dimana:
S_{teori} : Jarak Teori
$S_{sebenar}$:Jarak Sebenar (diukur)

Ujian pemadatan tanah

Pemadatan tanah adalah satu fenomena berlaku pada tanah apabila sesuatu yang berat bergerak di atasnya. Kepentingan untuk menentukan pemadatan pada tanah adalah untuk mengenalpasti tekanan yang dikenakan oleh sistem roda traktor terhadap tanah, dan ini mempengaruhi kesuburan tanah tersebut. Pemadatan yang terlalu tinggi akan menggangu perkembangan akar tanaman.
Untuk menentukan sama ada berlakunya pemadatan terhadap tanah dengan penggunaan traktor bertrek ini,bacaan rintangan tusukan sebelum dan selepas di kawasan yang dilalui oleh traktor diambil. Graf bagi kedua-dua bacaan tersebut diplot bersama-sama untuk mendapatkan corak perbezaan yang terhasil.

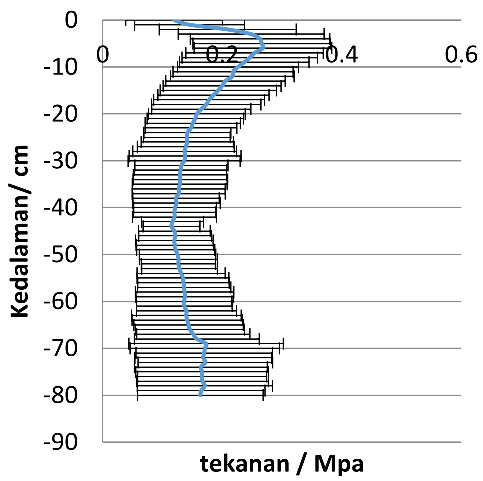
Ujian kebolehlaluan

Ketinggian kelegaan sesebuah traktor mempengaruhi kebolehannya melalui sesuatu kawasan tanaman. Traktor ini telah diuji menjalankan beberapa operasi dalam aktiviti penjagaan tanaman seperti operasi semburan racun perosak,kerja mengangkut baja semasa pembajaan dan aktiviti aruhan pembungaan. Prestasi traktor dilihat dari kebolehaan laluan dan keadaan tanaman yang dilalui. Kerosakan tanaman selepas pergerakan traktor diperhatikan untuk menilai kebolehgunaannya di dalam ladang nanas bertanah gambut.

Ujian tarikan

Tanah gambut terkenal dengan struktur pemukaan yang longgar. Ini akan menyebabkan daya tarikan traktor menjadi kurang. Untuk membuktikan kekurangan ini, satu kajian tarikan dijalankan dengan memasang traktor dengan trailer yang berisi sebanyak 1,500 kg baja. Pemerhatian ditumpukan kepada kemampuan traktor dan kemampunan tanah untuk menahan daya tarikan oleh traktor.

Keputusan dan Perbincangan



Rajah 1: Graf purata bacaan rintangan tusukan tanah gambut di ladang nanas

Ladang nanas bertanah gambut mempunyai keupayaan galas dalam purata 0.2 MPa dan keupayaan yang tetinggi adalah di lapisan 10 cm pertama dari permukaan tanah seperti yang ditunjukan di dalam Rajah 1.

Traktor Kubota 28kW (38 kuasa kuda) dengan sistem 4-separa trek getah boleh diguna pakai dengan baik di ladang nanas bertanah gambut. Traktor boleh bergerak di tanah gambut yang lembut tanpa sebarang masalah tetapi kelihatan terjadinya kesan tolakan tanah semasa traktor membuat pusingan seperti yang ditunjukkan dalam gambar 2.0. Ini merupakan keadaan yang biasa dimana kesan tolak akan berlaku di mana-mana kawasan yang bertanah lembut. Tekanan sentuh pemukaan yang lebih rendah daripada 0.1 MPa adalah salah satu faktor yang membolehkan untuk traktor dapat bergerak di tanah gambut tanpa masalah.

Gambar 2: Kesan tolakan tanah

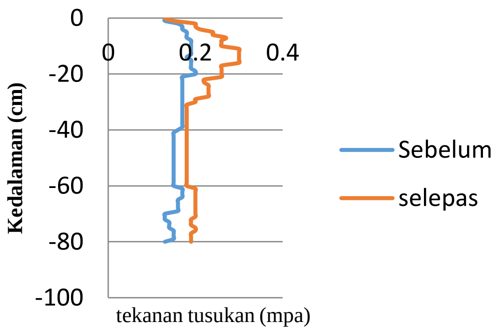
Jadual 1: Ujian ketergelincaran traktor dengan sistem 4-separa trek

Ujian	Bilangan pusingan	S_{teori}	$S_{sebenar}$	Ketergelinciran (%)
1	3	11.2	10.7	4.7
2	4	14.8	13.9	6.5
3	3	11.2	10.4	7.7
4	4	14.8	13.6	8.8
5	4	14.8	14.3	3.5
6	4	14.8	14.2	4.2

Ketergelinciran berlaku antara 4.2% hingga 8.8% seperti di Jadual 1. Terdapat perbezaan di dalam peratus ketergelinciran yangvmungkin disebabkan oleh struktur tanah yang berbeza di tempat yang berlainan.

Terdapat kesan pemadatan yang ketara dikesan dengan merujuk kepada graf kedalaman tanah melawan rintangan tusukan tanah yang membandingkan bacaan sebelum dan selepas pergerakan traktor seperti dalam Rajah 2.0. Pemadatan maksimum berlaku pada kedalaman 15 cm .

Tinggi kelegaan dari permukaan tanah traktor berukuran 55 cm adalah tidak mencukupi untuk menjalankan kesemua aktiviti mekanisasi pengeluaran nanas. Dengan ketinggian ini, traktor hanya boleh diguna pakai sehingga tanaman nanas berumur 9 bulan selepas tanam. Untuk meningkatkan potensi traktor dalam pengeluaran nanas di tanah gambut, ketinggian kelegaan traktor ke permukaan tanah haruslah sekurang-kurangnya 100 cm untuk memastikan kebolehlaluannya ke kawasan tanaman dengan tanpa sebarang kerosakan pada tanaman.



Rajah 2: Bacaan rintangan tusukan sebelum dan selepas pergerakan traktor bersistem 4-separa trek getah

Daripada ujian tarikan yang dijalankan, didapati traktor bertrek tersebut menunjukan tanda-tanda untuk terjelus ke dalam tanah. Kesukaran untuk menarik beban menyebabkan trek tergelincir dan mengorek tanah. Pengerokan yang berterusan menyebabkan trek lama-kelamaan masuk ke dalam tanah.

Kesimpulan

Traktor Kubota L3800 dengan sistem 4-separa trek getah telah dinilai prestasi di kawasan tanah gambut dari segi ketergelinciran, kesan pemadatan tanah, dan fungsi. Kajian awal ini menunjukkan bahawa:

- Kegelinciran berlaku antara 4.2 hingga 8.8%.
- Terdapat kesan pemadatan, dan bacaan maksimum adalah pada kedalaman 15 cm.
- Kesan tolakan tanah diperhatik belaku semasa traktor membuat pusingan
- Ketinggian kelegaan traktor perlu ditambah untuk meningkatan potensinya di dalam aktiviti mekanisasi pengeluaran nanas di tanah gambut.

Penghargaan

Penghargaan diberikan kepada semua yang terlibat secara langsung dan tidak langsung dalam menjayakan kajian ini terutama kepada En Noor Al-Anuar Bin Maskor, En. Ramlan Bin Ismail, En. Mohd Khairil Izani Bin Ishak En. Roslan Bin Razak dan En Mohd Humaizi Bin Jamin.

Rujukan

Ooi. H.S. (1996) Design and developement of a peat tractor prototypes, MARDI Report No.184. MARDI

Mohd Nadzim, Ayob H, Eddy Herman. S. Ahmad Syafik Suraidi, Mohd Fauzi. I, (2014). Kaedah Penggantian tanah untuk meningkatka n kekuatan struktur tanah di kawasan tanah jerlus, Jurnal Teknologi, Universiti Teknologi Malaysia

DeJong-Hughes, J. F. Moncrief, W. B. Voorhees, and J. B. Swan (2017), Soil compaction: Causes, effects and control, University of Minnesota Extension, Internet, https://www.extension.umn.edu/ agriculture/soils/tillage/soil-compaction/ reviewed on 31 Jan 2017.

DeJong-Hughes, J. F. Moncrief (2017), Tires, traction and compaction, University of Minnesota Extension, Internet, https://www.extension.umn.edu/agriculture/soils/tillage /tires-traction-and-compaction, reviewed on 31 Jan 2017

Disc Ridger Cum Inter-row Cultivator and Fertilizer Applicator for Sweet Potato Production

Anuar A.[1], Nurul Afza K.[1], Shahmihaizan M. J.[2], Mohd Fazly M.[2], Khairul Idzwan. A.[1], Norahshekin A.R.[2], Zawayi M.[2],

[1]Engineering Research Centre, MARDI Bachok, 16310, Bachok, Kelantan
[2]Engineering Research Centre, MARDI Headquarters, 43300, Serdang, Selangor
Tel: +609-7787900, Email: anuarabd@mardi.gov.my

Abstract

Mechanization has been the solution to counter issue such as labor shortage and low production rate on field in the agricultural sector. Adaptation of mechanization system have shown to lower the cost of production, improve quality and also reduce the tedious work of labor. Current practice, which seems to contribute high cost in labor since the job requires a lot of man power. MARDI has developed a complete machinery package for sweet potato production from land preparation until harvesting. One of the important activities that require an implementation of machinery aspect is ridge forming. This activity is essential due to the height of the ridge which is one of the important factors that influences the yield. It is believed that the higher the ridge will contribute, to more aeration and thus, produce higher yields. In this manuscript, the authors report on the development and evaluation of the disc ridger. It is believed that this implement is capable to be used as ridge forming as well as inter-row cultivator. This tractor-mounted implement is designed with two units of high quality steel discs which is attached to the frame with disc diameter and thickness of 720 mm and 6 mm respectively. This disc ridger is able to form either a single row or double row planting ridges to suit with the desired planting system for sweet potato. This is due to the location of the discs at the frame which is adjustable. Furthermore, this implement also can be employed as an inter-row cultivator for weeding control of sweet potato planting in the early stages. In addition, this implement also equipped with granular based fertilizer applicator in which 2 application can be performed together which are inter row cutltivation and fertilizer application.The recorded average working rate of this implement is 0.27 ha/hr for bed forming and 0.25 ha/hr for inter-row cultivation with fertilizer application. In terms of fertilizer application performance, the average amount of fertilizer to be withdrawn for 50m bed is 1.52kg, which is complied to the agronomist recommendation.

Keywords: Sweet potato, disc ridger, bed forming, inter-row cultivator, fertilizer applicator

Introduction

Nowadays, sweet potato has become one of the major crop planted in Bris soil especially in Kelantan and Terengganu because it has been recommended as an alternative industrial crop to replace the tobacco plantation (Zaharah, 2010). Thus, MARDI has announced quite a lot of sweet potato variety such as Gendut, Telong and Jalomas and VitAto (Zaharah, 2010). As a result, sweet potato plantation in Malaysia is increasing rapidly year by year. Moreover, Vitato plantation is one of the flagship projects of Ministry of Agriculture with collaboration among government agencies such as MARDI, LPP and FAMA. So, the mechanization aspect is essential in order to facilitate the field operation for sweet potato cultivation in Malaysia.

Usually, there are two planting season in a year for sweet potato cultivation especially in Kelantan and Terengganu. The first and second season starts during January until May and July until November respectively. However, the second season is quite troublesome for the farmers due to heavy rainfalls (Tan S.L, 2006). From the experiment, it is verified that the total yield from the second season is reduced with high percentage of low quality yield (<150g/sweet potato) (Tan S.L, 2006). It is believed that during the heavily rainfall season, the water table is increasing. This situation has led to the growth of roots and tuber development becomes limited.

In order to solve the problems, the raised bed planting system is recommended by the agronomist from MARDI. Furthermore, the use of raised bed planting system is thought to increase the yield and it also helps to prevent the crops from being flooded during monsoon season. Therefore, in mechanization aspect, the use of disc ridger is fit to fulfil the requirement instead of rotor-ridger.

Materials & Methods

The experiment was carried out at a research plot in MARDI Bachok Research Station. The site is characterized by Bris soil with annual precipitation and temperature between 2500-2800 mm and 24ºC – 32ºC respectively.

The plot was ploughed to a depth of 30cm using rotorvator after decomposed manure was broadcasted at a rate of 8-10 tonne per hectare. Fifteen ridges of 1.2m x 50m x 0.5m (width x length x height) for raised bed and 15 ridges of 1.2m x 50m x 0.3m (width x length x height) for normal bed were made by using disc ridger and rotor-ridger respectively. The arrangement of ridges on field is randomized.

The vine of sweet potato, Anggun variety (Anggun 1, Anggun 2 and Anggun 3) was cut into 0.3m in length as planting materials and mechanically planted using sweet potato transplanter for both ridges type; raised bed and normal bed with single row planting system. Cuttings were spaced 0.25m of intervals between plants. Plants were maintained until harvesting stage at $3^{1/2}$ months for data collection.

During the data collection, the evaluations recorded were; 1) performance of disc ridger during bed forming, 2) performance of disc ridger during crop management (inter-row cultivation) and 4) effect of ridges system (raised bed and normal bed) to the yield production.

Table 1: Machine parameter and performance evaluation during bed forming

Item	Data	
	Machine Parameters	
Prime Mover	FIAT, 70Hp	FIAT, 70Hp
Implements	Locally fabricated disc ridger	Rotor-ridger
RPM	-	540 (PTO)
Height of bed	0.5-0.6 m	0.3 - 0.35 m
	Performance Evaluation	
Average bed forming time per bed (1.2m x 50m)	1.32 min	1.25 min
Total bed forming time for the whole plot (30 beds)	39.6 min	37.5 min
Field work rate	0.27 ha/hr	0.29 ha/hr

Results & Discussions

The performance evaluation test during bed forming by using locally fabricated disc ridger and existing rotor-ridger were recorded as shown in Table 1. The machine's working rate was calculated based on working area and average time taken for the bed forming per bed. From the data collected, it shows that the time taken for the bed forming activity for both implements do not show a significant difference. Generally, it takes about 3-4 hours of operation per hectare for both implements. However, the working rate of bed forming by using disc ridger is slightly higher because of the factor of traction. It is because; more power of tractor is needed to pull the soils in order to make the raised bed.

In order to make a good quality of bed by using disc ridger, the best soils moisture content at Bris soil is at 20-30 %. At this moisture content, the quality of the beds is neat and firm, thus the risk of the soils at the bed to collapse is low. Therefore, the irrigation system to irrigate the required area is needed to increase the soils moisture content during the dry season.

Table 2: Performance evaluation of disc ridger during inter-row cultivation for sweet potato

Item	Performance Evaluation
Average time per bed	1.46 min
Total inter-row cultivation time for the whole plot (30 beds)	43.8 min
Field work rate	0.25 ha/hr

The weeding control is essential for many crops in the early stages of planting. In sweet potato planting, the weeding control especially at the furrow is important especially during 1st week until 4th week after planting. Hence, the employment of mechanical weeding is needed since the price of weedicide is high. As a versatile implement, the disc ridger also can be used as an inter-row cultivator for weeding control of sweet potato planting in the early stages. Through the experiment, the machine's working rate during inter-row cultivation is recorded at 0.25 ha/hr.

Table 3: Effect of bed system on the total yield of sweet potato

Item	Data					
	Sweet Potato Variety					
	Anggun 1		Anggun 2		Anggun 3	
Type of bed	Raised Bed	Normal Bed	Raised Bed	Normal Bed	Raised Bed	Normal Bed
Average yield per bed	161.25 Kg	79.3 Kg	126.2 Kg	105 Kg	159.2 Kg	148 Kg
Total yield per hectare	26.87 MT	13.22 MT	21.03 MT	17.5 MT	26.53 MT	24.67 MT

In terms of yield, the overall yield of sweet potato shows that the raised bed planting system gives a higher yield compared to normal bed for all sweet potatoes, (*Anggun 1*, *Anggun 2 and Anggun 3*) variety. As stated in the literature, it is proven that the height of the ridge is one of the important factors that influence the yield. Table 3 shows that the yield is increased by using raised bed planting system as the other factor that affecting the total yield such as crop management is constant.

Table 4: Performance evaluation of NPK fertilizer applicator for sweet potato

Item	Performance Evaluation
Average time per bed	1.46 min
Average of NPK fertilizer amount per bed (50m)	1.53 kg
Total inter-row cultivation time for the whole plot (30 beds)	43.8 min
Field work rate	0.25 ha/hr

As for fertilizer application during first fertilization stage (NPK) at week 3, this implement shows a promising performance as the rate of total fertilizer per bed can be adjustable. As recommended by the agronomist, the total fertilizer applied for each plant is 0.0075g or 1.5kg for each sweet potato bed (50m long). Table 4 shows the performance of implement during fertilizer application. In terms of tractor speed and working rate, the tuning is similar with bed forming. But the power take off (PTO) speed is set at 1200 rpm to control the amount of NPK fertilizer to be withdrawn according to the agronomist recommendation.

Conclusion

The performance evaluation of disc ridger for raised bed forming, and combined operation which are inter-row cultivation and fertilizer application had showed the general work rate at 0.27 ha/hr and 0.25 ha/hr respectively. Since MARDI had recommended the single row with raised bed planting system for sweet potato planting, the use of disc ridger plays an important part especially during bed forming, inter-row cultivation and fertilizer application operation.

References

Zaharah, A., Md. Akhir, H., Yahaya, H., Anuar, A., Abdul Rahim, M., Hasan, S., (2010). Prosedur Operasi Piawaian (SOP) Penanaman Ubi Keledek Berjentera di Tanah Bris. MARDI.

Tan, S.L, Abdul Aziz, A.M., Zaharah, A., Sukra, A.B., Md.Akhir, H. dan Mohsin,Y. (2006). Manual Penanaman Ubi Keledek. MARDI: Serdang

Gomes G (1999). Sweet Potato Growth Characteristics, (First Edition), Academic Press, New York, pp. 4-7. Onwuene IC (1999). The Tropical Tuber Crops, John Wiley and Sons Ltd, London, p. 43

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA07

Assessment of Electric Farm Vehicle as Motive Power for Oil Palm Mechanisation Operation in Malaysia

M., Azwan, B.*, A., Rahim, S., Salmah, J., M., Ikmal, H., M., Ramdhan, K., M. Rizal and Norman, K.
Farm Mechanisation Unit,
Malaysian Palm Oil Board (MPOB), 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
**Corresponding Author, Tel: +03 89201504, E-mail: azwan.bakri@mpob.gov.my*

Abstract
A comparative study on suitability of electric farm vehicle deployment in oil palm mechanisation operations was carried out. Two research methodologies were pursued, the assessment of battery's state of charge and the load carrying test. The test was conducted in a 70-ha actual oil palm planted area with mild undulating topography and inland type soil. The first results of the test suggested that the farm electric vehicle is suitable to be deployed for the field maintenance activity as compared to the fresh fruit bunch and loose fruit evacuation activity. The second methodologies indicated that the electric vehicle could reduce up to 48% of energy as compared to a common sizeable internal combustion engine vehicle in oil palm plantation operation. In term of the environment, it was anticipated that a saving of almost 5.2 tonnes of $CO_{2\text{-}eq}$ per year could be realised from the electric vehicle deployment for farm maintenance activity in Malaysia. Besides environmental benefits, the electric vehicle also incurs lower purchase and maintaining cost compared to the common utility type diesel engine vehicle. The benefit obtained shows that the electric vehicle could reduce dependency on fossil fuel energy for a sustainable agriculture development in Malaysia.

Keywords: Electric Vehicle, Oil Palm Mechanisation, Energy, Sustainable Development

Introduction

Farm mechanization is important due to the scarcity of labours in the oil palm plantation industry (Azwan *et al.*, 2016). Besides that, various other factors militate in favour of the shift to mechanization as a way to increase labour productivity in oil palm plantation (Mohd Ramdhan and Abd Rahim, 2014) The quantity of produce harvested by unit area and all other related services can be increased by improving the timeliness of operations and the efficiency on tasks' execution, thus improving the overall productivity. Mechanization appears to be the most suitable alternative to the intensive use of manpower despite its cost and the need for equipment and machinery, with an attractive long-term return to investment, along with the additional values from the alternative cropping system or livestock integration.

Malaysian oil palm cultivation areas had reached 5.6 million hectares in 2014 of which only 60% of the total is suitable for mechanisation, mainly due to topographic limitations (Jelani *et al.*, 2008; Hashim *et al.*, 2014). Thus, more than 3 million hectares of cultivated areas with oil palm are suitable for mechanization and requires engineering of the most appropriate and efficient schemes and technologies. Furthermore, even with only 3 million hectares mechanised land, a reduction of 33% to 46% of manpower could still be achieved (Abd Rahim, Mohd Ramdhan and Mohd Solah, 2011).

Oil palm farm machinery is typically powered by diesel fuel since the powertrain could provide higher torque compared to a gasoline engine. Besides, the ease of storage within the field office and its high evaporative temperature make it more favourable for farm application since a nearby filling station will ensure steady operation. However, one of the disadvantages of relying on diesel fuel consumption is the GHG emissions.

Oil palm plantation industries in Malaysia consume approximately 200 million litres of diesel fuel annually mainly for the farm machinery consumption (Ludin *et al.*, 2014). This consumption will soon increase because of efforts to improve worker productivities. Oil palm plantation industries will require more diesel to fuel their machinery if the current scenario prolongs. An increase in petroleum fuel consumption definitely will lead to a rise in GHG emissions.

One of the technologies that have been extensively researched is the electric farm vehicle as a prime mover for the field operations. There are several benefits that could be obtained from economic and ecological perspectives. The electric motor drive is far more efficient compared to the combustion engines and emits less GHG to the atmosphere. This technology appears to be more suitable and efficient for sustainable development of agriculture. Furthermore, some other known advantages of the electric vehicle's utilisation are ascertained. Thus, there is no need for maintenance of the vehicle power plant such as replacing worn and torn parts of the systems or lubricating of components. The vehicle will not run idle or set in an unused condition, thus reducing energy requirement.

Many farm duties would not require large amounts of power, and it could be undertaken by an electric vehicle, making the industry more self-sufficient. The electric vehicles have proven its efficacy in other industries such as the aircraft maintenance industry, and food and beverage handling industry. The system could easily deliver works such as pulling 1 to 5 tonnes of weight from one point to another point. Renewable source of energy such as photovoltaic system and wind turbine could provide power to charge the battery packs. The application could benefit sustainable development in any economic sectors for energy self-reliance in their operations.

An electric vehicle as motive power for oil palm mechanisation practice could reduce the diesel fuel utilisation in the oil palm field activity. However, capability analysis of the electric vehicle application in oil palm mechanisation and an energy density comparison with a comparable size of an internal combustion engine vehicle could further justify the benefit. Thus, this study is aim to provide scientific justification of an electric vehicle application in oil palm plantation operation and a comparative assessment of suitable farm duty for an electric vehicle deployment.

Materials and methods

The research was conducted in an oil palm plantation area with mild undulating topography and mineral type soil in Malaysia. About 70 ha of the plantation area was allocated for this study. The electric vehicle (EV) used for this study was a battery powered electric off-road buggy which is widely available and commonly used for the recreational activity.

There were two main research methods undertaken to measure the capability of an EV as a motive power for oil palm plantation operation. The two tests were the state of charge comparison and load carrying tests. A simple economic analysis is also incorporated for further justification.

State of Charge Comparison

The core question investigated within the state of the charge comparison methodology was the following: what are the suitable farm activities for deployment of an EV as one of the mechanisation fleets for oil palm plantation operation? Thus, a few real simulation tests were conducted in the field by measuring the state of charge (SoC) of the battery, which was one of the indicators that could be used for comparison purposes. The SoC is dimensionless, and this indicator mimics the function of fuel gauge indicator and always shows the percentage level of the battery. This voltage method is the fastest measurement technique to determine energy used from a battery (Nanaki and Koroneos, 2013). The aim of the state of charge comparison test was to analyse farm activities suitable for the EV based on the SoC comparison.

The SoC can be measured by five techniques such as chemical, voltage, current integration, Kalman filtering and pressure method (Doerffel and Sharkh, 2006). This study utilised battery voltage method to determine the SoC by installing the gauge to the EV's battery pack of 48 V in total. However, the battery temperature significantly affected the SoC reading. Thus, SoC reading was more accurate after a few minutes the EV had stopped.

The EV's operators recorded the SoC before the work started and after the work completed. The EV was required to be charged once a day after its usage. If the battery was depleted or the SoC indicated a low percentage, the EV was expected to stop working and put for charging event if the farm activity was not completed for a designated area. Thus, the SoC of the battery for each day of the test, machine daily coverage area and productivity of the farm work was recorded so that comparisons of each farm-work tested could be analysed and a statistical software was used in this study to evaluate the comparison.

Among the typical farm works in oil palm plantation are fresh fruit bunch (FFB) evacuation, loose fruit collection and herbicide spraying operation. These works were simulated in this test using the EV and conducted according to the test procedure elaborated below rather than the actual farm operation manner. The tests were replicated for a few days each at the selected area in the farm.

The first activity, FFB evacuation, required two workers. One worker was as a machine operator, and another was as FFB loader. Their task was to evacuate the FFB from the palm-based to the designated roadside platform in an area of 10 ha per day. It was an equivalent to almost 2 to 3 blocks of test area (about 3 ha in average per block). The machine must be fully charged before the daily activity conducted.

The collection of loose fruit was undertaken to gather the fruits scattered around the palm trunk. The loose fruits were detached from the main bunches during the harvesting process. The loose fruits had higher oil extraction rate than the main bunch and a proper care should be given to their collection to avoid opportunity lost. Normally, the loose fruits collection is carried out together with the FFB evacuation. However, in this test, they were conducted separately. During the test, the loose fruits were required to be filled into the EV's trailer bin before they were inserted into a few gunny bags to ease the external transportation to the mill and as productivity indicator in the test too. In this study, 10 ha of the area per day were assigned for the operators and replicated for five days.

Weedicide operation was conducted to remove unwanted weeds especially within the circle palm base to ensure ease of FFB and loose fruits picking, conducted by applying the chemical herbicide mix to the targeted palm-based area using the spraying equipment attached to the EV, which was equipped with a 200 L water tank, a 12 V electric pump and its auxiliaries. A power sprayer is more effective than a manual knapsack sprayer in the particular area, especially in flat and undulated areas, thus reducing the number of workers required.

The circle spraying activity (herbicide sprayed around the palm-based) was conducted in this test at the designated area within the farm. There were two spraying nozzles connected to a low-pressure pump operated by two sprayer operators. In this test, a 12 V 'Shurflo" pump was powered by a portable generator set. However, the generator set could be replaced by a dedicated battery or from the EV's battery pack through a step-down transformer. However, the test was conducted to estimates the SoC level for the EV as a motive power for this activity and not included to power other application. The area covered for the daily test was made consistent throughout the 5-days replication process.

The Load Carrying Test

For the second methodology in this technical evaluation, a load carrying test was conducted to determine the energy and power consumption of the EV. To compare, the load test was also made with a commercial ten horsepower; three-wheeler diesel type utility machine that is commonly available and also known as mechanical buffalo (MB).

The weight carrying test was undertaken to simulate the energy consumed by the EV and MB based on weight carried at certain distance and area. Known loads of 250 kg, 300 kg and 350 kg had been placed in the trailer bin for both EV and MB as variables in the test, thus reflecting the energy requirement for the electric vehicle and the internal combustion engine (ICE) vehicle to undertake the similar task for comparison.

The voltage method aimed to determine the state of charge of the battery and to predict the remaining capacity of a battery. Meanwhile, techniques for predicting the remaining capacity of a battery discharged were based on Peukert's Law (Doerffel and Sharkh, 2006). The law expresses the capacity of a battery in terms of the rate of discharge. The Peukert's law is written as in Equation 1.

$$\mathbf{C_p = I^k t} \qquad \textbf{………………} \quad \textbf{(Eqn. 1)}$$

Where,

C_p is the capacity at a one-ampere discharge rate, which must be expressed in A·h.

I is the actual discharge current relative to 1 ampere, which is then dimensionless.

t is the actual time to discharge the battery, which must be expressed in h.

k is the Peukert constant

The law expresses the capacity of the battery remaining as it discharges at a certain rate of current over a certain period of time (Doerffel and Sharkh, 2006). However, it was hard to predict the remaining capacity of a battery pack while the EV was moving since the loads varied over the driving pattern and road conditions. Thus, the solution was made by measuring the energy required to charge the battery pack to its initial state for every time it was used at a constant current value.

This concept enabled the prediction or measurement of the energy consumption for an EV during the charging period. The energy for charging is equivalent to the energy consumption during its working time. a similar concept to determine the energy requirement based on the voltage method where a constant load of battery charging process could be measured.

Fuel consumption for the MB had been measured with a conventional method by gauging the fuel level in the fuel tank before and after each test. Diesel fuel was set at a certain height in the fuel tank before the trial started. Once each of the replication completed, the amount of diesel fuel to be refilled in a temporary reservoir were measured before it was poured into the tank. The amount of fuel that was refilled indicated the amount of fuel consumed (F_c) in the test for each replication. Even though the measurement error was high, but this technique had been suggested by Grisso (Grisso, Kocher and Vaughan, 2004) in predicting the fuel utilisation for their study. The energy density (E_a) was obtained by dividing the fuel usage (F_c) with the area (A) covered by the machine as depicted in Equation 2.

$$\mathbf{E_a = F_c / A} \qquad ……………… \quad \text{(Eqn. 2)}$$

Results and discussion

State of Charge Comparison

The results of this study are given in Figure 1 which indicates the depth of discharge (DoD) of the battery, obtained by subtracting initial SoC level with the final SoC level for each day the test was performed. An analysis of variant was performed by using the Minitab software to analyse the comparison between all of the data obtained. It was found that the probability value is greater than 5% ($P>0.05$), which rejected the initial hypothesis of all means are equals. Thus, the means of the data are significantly different except for the loose fruit collection and herbicide spraying, as they indicate low energy consumed in the allocated field especially for the loose fruit collection activity. It was a strong evidence, on average, the FFB evacuation was consuming higher energy as compared to other simulated activities.

The result of this study was consistent with previous findings that stated lighter EV consumed less energy and has a higher working range compared to the heavier EV (Abdelhamid, Singh and Haque, 2015). The study measured the range extension technology for a few types of EV with a different mass in the United States which indicates that a lighter type EV could be extended up to 50% of distance compared to heavier type EV, thus reflecting that a similar EV with a different load weight could consume a different level of energy.

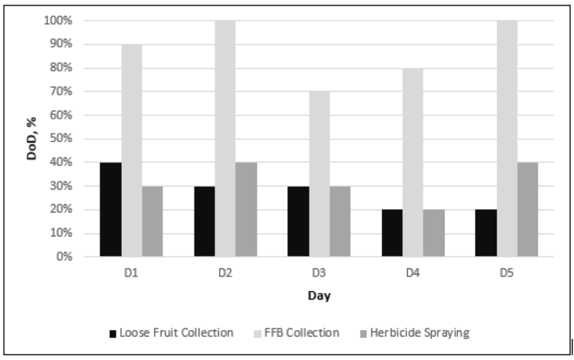


Figure 1: Comparison of depth of discharge for the EV's battery pack after each application or activities

The EV was also observed to have the similar capability with diesel machine in performing routine light duties. Besides that, the EV has excellent manoeuvrability and minimum daily maintenance requirements. These characteristics is beneficial to the user.

The EV is not practical for FFB evacuation since it needs to carry FFB from palm to palm at each palm rows until a designated roadside platform. In the test area, each row has at least 20 to 30 palms. If each palm bears 20 to30 kg of FFB, thus the EV needs to carry almost 300 to 400 kg of FFB in each trip, which is a high energy requirement. During the test, the EV could only work from morning to afternoon before the power depleted, and therefore could not complete its daily tasks efficiently. FFB that were not evacuated would cause a penalty to the workers since free fatty acid accumulation in the FFB would reduce its quality.

An electric vehicle (EV) is suitable to undertake load haul, and utility task since power requirement for those jobs are low and work even better in partial load condition (Cignini *et al.*, 2015). Distance covered by a 48V, 200 Ah EV usually in the range of 80 - 90 km. A mean agriculture road density in oil palm plantation is about 40 m per hectare, and for 1,000 ha of farming land, road length is about 40 km (Abd Rahim, Mohd Ramdhan and Mohd Solah, 2011). For herbicide spraying practice, coverage for a unit of typical machine used in plantation is about 10 hectare per day (Pebrian *et al.*, 2012) or less than 15 km a day of distance travels in the mechanisation paths if the planting distance is about 9 m (Soon, 2011). Thus, this total distance could be covered by an EV as a prime mover for the herbicide spraying activity.

The Load Carrying Test

An electric vehicle (EV) as a motive power for agriculture could reduce the diesel fuel consumption, and it had been investigated in term of its technical and economic point of views (Redpath *et al.*, 2011), which found that the EV utilised 80% of the energy obtained from any source of power to the wheel, meanwhile only 18% of the diesel fuel energy transmitted to the flywheel for tractors (Mousazadeh *et al.*, 2009).

The energy consumed by an EV varied based on certain conditions such as the weight of the load carried, topography, soil type, driving pattern and event climatic condition. Therefore, this study was carried out to investigate the energy consumed by the EV as a prime mover in the oil palm plantation. Energy to charge the battery pack for the EV was obtained from the national electricity grid and had been measured using a digital ammeter that was connected to the main charger.

Figure 2 shows the results of both trials, the EV and the Mechanical Buffalo (MB) for each replication and at the selected study site marked with area A, B, C, D and E. The energy consumption pattern of the MB or the internal combustion engine vehicle (ICEV) was almost consistent for all the test replications, with only slight differences, perhaps due to the ICEV carrying the load below its optimum carrying load of 500 kg. Thus, the energy was wasted for ICEV if it does not carry the optimal load. The previous study by Dyer & Desjardin (2003) had concluded that the fuel use per unit of work by ICEV rose significantly once the load was below about 60–70% of its maximum capacity. It was contradicted on the EV where the energy consumption reflected much on the weight carried.

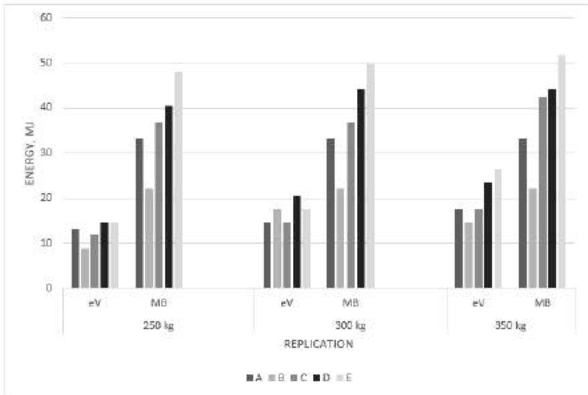


Figure 2: Energy consumption for the EV and internal combustion engine vehicle for the load carrying test.

Figure 3 summarises the cumulative energy for the EV and the ICEV to complete the task. Weights of 250 kg, 300 kg and 350 kg were the load or replication of the test that the machines carried into the paths at the test site area of A, B, C, D and E. Analysis of varians was conducted for the data obtained. It was assumed that all the data means for both sets of trial, EV and MB were different and with equal variances. The P-Value obtained for both sets of data were less than 5% significat levels. Thus, the alternative hypothesis indicated that at least one mean of difference is acceptable. Thus, it is strongly agreed that the two set of means are differed for EV and MB.

It was also found that the EV utilized lower energy if it hauled the load weight lower than 200 kg compared to carrying the load more than 300 kg. It was reflected that the EV was more efficient under partial load conditions. As a contrast, the ICEV had utilized almost equivalent energy for all the test replications. This analysis was in agreement with the previous finding (Dyer and Desjardins, 2003) on the ICEV, which concluded that energy was not utilized efficiently in ICEV for the weight of the load lower than its optimal requirement of power.

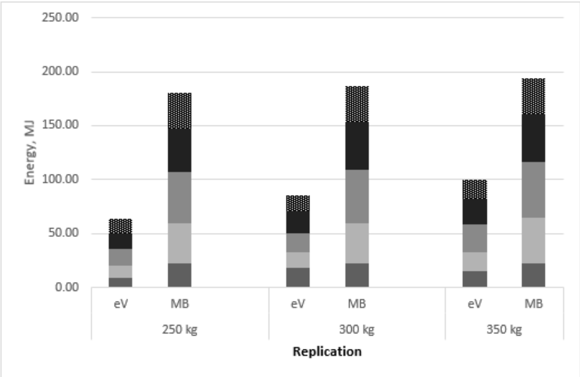


Figure 3: Cumulative energy consumption on the load carrying test.

Table 1 shows a simple analysis of energy density in terms of energy per distance travel of the EV and ICEV calculated based on Equations 2. The average distance per area was used to obtain the energy density. The distance was logged based on the distance meter attached to one of the machines. The result obtained shows that the energy density requirement for the EV was between 0.50 to 0.80 Wh/m. Meanwhile, the energy density for the ICEV was between 1.44 to 1.54 Wh/m. The result also indicated that difference in energy density requirement for both the EV and the ICEV was between 32% to 48% where the higher the load carried, the difference was reduced.

The result obtained in Table 1 was also consistent with Abdelhamid (2016) on the energy density for the EV and ICEV, that reported the energy consumed by a few US mid-sized EV was between 0.05 Wh/m and 0.22 Wh/m. A study conducted in the UK for their Brighton to London Future Car Challenge (BLFCC) estimated that the energy density for the EV was 0.17 Wh/m and that for ICEV was 0.47 Wh/ (Howey *et al.*, 2011). However, both studies by Abdelhamid (2016) and Howey (2011) measured the energy density for the EV and ICEV that drove on the asphalt road conditions.

This study indicates that the EV could reduce diesel consumption up to 0.3 L/ha (from the ICEV consumption) based on energy reduction between 30% and 50% which has been found throughout the test, in which ICEV consumed about 0.8 to 1 L/ha. The saving in terms of diesel fuel consumption reduction based on the total area covered by oil palm plantation area in Malaysia of 5.6 million ha is almost 1.68 million L, which makes up to a saving of almost 5.2 tonnes of $CO_{2\text{-eq}}$ based on GHG emission factor of 3.1 kg $CO_{2\text{-eq}}$ per L of diesel (Nikander, 2008).

Based on the experience of utilising the EV for oil palm plantation activities, maintenance was only carried out on the batteries for a cost estimated to less than RM 50 per year (Azwan *et al.*, 2017). It was also anticipated that the total cost of purchasing and operating the EV for five years including its maintenance is approximately RM 28,000. The comparison of owning and maintaining cost with the three-wheel utility type vehicles is shown in Table 2. It was found that the owning and maintenance cost is almost similar in between the EV and the commonly used three-wheeled type utility farm vehicle but the EV could provide the lowest operational cost for herbicide spraying activity in oil palm plantation. It was anticipated that the operational cost of the EV for the operation was in between RM 3 and RM 7 cheaper compared to the manual knapsack practice and a dedicated 20 horsepower herbicide spraying vehicle (Azwan *et al.*, 2017).

Table 1: Analysis of the energy density based on the load carrying test.

Loads	250 kg		300 kg		350 kg	
AREA - SIZE (ha)	**EV (Wh / ha)**	**MB (Wh / ha)**	**EV (Wh / ha)**	**MB (Wh / ha)**	**EV (Wh / ha)**	**MB (Wh / ha)**
A - 17 ha	222.19	558.12	246.88	558.12	296.25	558.12
B - 9 ha	285.04	716.01	570.09	716.01	475.07	716.01
C - 11 ha	293.32	921.01	366.66	921.01	439.99	1059.16
D - 16 ha	248.83	687.56	348.37	750.06	398.13	750.06
E - 14 ha	292.96	956.65	351.55	993.44	527.32	1030.23
Average (Wh/ha)	268.47	767.87	376.71	787.73	427.35	822.72
Average (Wh/m)	0.50	1.44	0.71	1.48	0.80	1.54
Difference (%)	**48%**		**35%**		**32%**	

Table 2: Comparison of owning and maintaining cost

	Electric Vehicle	**Three-Wheel ICEV**
Capital cost	RM 28,000	RM 22,000
5 years maintenance cost	Negligible	RM 8,000*
Total	RM 28,000	RM 30,000

*Input provided by a local supplier.

Conclusions

The electric vehicle for a motive power in the oil palm plantation operation could provide numerous benefits in terms of economic and environment. The study established that a few low power requirement operations could be undertaken by the electric vehicle to replace a diesel combustion vehicle such as a three-wheeled 10 horsepower utility vehicle, commonly used in oil palm plantations. The benefit is that a reduction of the energy density of up to 48% could be achieved in utilising the EV.

The study also found that inefficient energy utilisation occurred for the under-utilised diesel engine vehicle with a specific horsepower for certain low power requirement activities in oil palm plantation operations. A minimum load should be recommended for a diesel engine vehicle to avoid inefficient fuel utilisation. Thus, more energy efficient utilisation could be promoted in the sector.

In terms of economic, it was established that the EV ensures low cost of maintenance which is a very important aspect in operating a vehicle especially for agriculture operations. The study compared the preventive maintenance cost between a small utility vehicle and the EV. If bigger utility vehicle or a medium size tractor were to be compared, then more saving in terms of preventive maintenance could be realised from the EV utilisation. Therefore, based on the economic and environmental gained in utilisation the EV in oil palm plantation operations, more energy efficient practices should be emphasised to promote a sustainable development goal for the industry.

References

Abd Rahim, S., Mohd Ramdhan, K. and Mohd Solah, D. (2011) 'Innovation and technologies for oil palm mechanization', *Further advances in oil reserach (2000-2010)*, (April), pp. 570–597.

Abdelhamid, M. *et al.* (2016) 'Impacts of adding photovoltaic solar system on-board to internal combustion engine vehicles towards meeting 2025 fuel economy CAFE standards', *SAE International Journal of Alternative Powertrains*, 5(2), p. 12. doi: 10.1121/1.4929899.

Abdelhamid, M., Singh, R. and Haque, I. (2015) 'Role of PV generated DC power in transport sector: Case study of plug-in EV', *2015 IEEE 1st International Conference on Direct Current Microgrids, ICDCM 2015*, pp. 299–304. doi: 10.1109/ICDCM.2015.7152058.

Azwan, M. B. *et al.* (2016) 'Analysis of Energy Utilisation in Malaysian Oil Palm Mechanisation Operation', *Journal of Oil Pam Research*, 28(December), pp. 485–495.

Azwan, M. B. *et al.* (2017) 'Assessment of electric vehicle and photovoltaic integration for oil palm mechanisation practise', *Journal of Cleaner Production*. Elsevier Ltd, 140, pp. 1365–1375. doi: 10.1016/j.jclepro.2016.10.016.

Cignini, F. *et al.* (2015) 'Spazia-HPP: Hybrid plug-in for small vehicle', *Energy Procedia*, 81(January 2016), pp. 108–116. doi: 10.1016/j.egypro.2015.12.065.

Doerffel, D. and Sharkh, S. A. (2006) 'A critical review of using the Peukert equation for determining the remaining capacity of lead-acid and lithium-ion batteries', *Journal of Power Sources*, 155(2), pp. 395–400. doi: 10.1016/j.jpowsour.2005.04.030.

Dyer, J. A. and Desjardins, R. L. (2003) 'Simulated farm fieldwork, energy consumption and related greenhouse gas emissions in Canada', *Biosystems Engineering*, 85(4), pp. 503–513. doi: 10.1016/S1537-5110(03)00072-2.

Grisso, R. D., Kocher, M. F. and Vaughan, D. H. (2004) 'Predicting Tractor Diesel Fuel Consumption', *Applied Engineering in Agriculture*, 20(5), pp. 553–561.

Hashim, Z. *et al.* (2014) 'Water footprint: Part 2 - FFB production for oil palm planted In Malaysia', *Journal of Oil Palm Research*, 26(4), pp. 282–291.

Howey, D. A. *et al.* (2011) 'Comparative measurements of the energy consumption of 51 electric, hybrid and internal combustion engine vehicles', *Transportation Research Part D: Transport and Environment*, 16(6), pp. 459–464. doi: 10.1016/j.trd.2011.04.001.

Jelani, A. R. *et al.* (2008) 'Cantas ™ - A tool for the efficient harvesting of oil palm fresh fruit bunches', *Journal of Oil Palm Research*, 20(DECEMBER), pp. 548–558.

Ludin, N. A. *et al.* (2014) 'Malaysian oil palm plantation sector: Exploiting renewable energy toward sustainability production', *Journal of Cleaner Production*. Elsevier Ltd, 65, pp. 9–15. doi: 10.1016/j.jclepro.2013.11.063.

Mohd Ramdhan, K. and Abd Rahim, S. (2014) 'Field evaluation of harvesting machines for tall oil palms', *Journal of Oil Palm Research*, 26(JUNE), pp. 125–132.

Mousazadeh, H. *et al.* (2009) 'Technical and economical assessment of a multipurpose electric vehicle for farmers', *Journal of Cleaner Production*. Elsevier Ltd, 17(17), pp. 1556–1562. doi: 10.1016/j.jclepro.2009.05.009.

Nanaki, E. A. and Koroneos, C. J. (2013) 'Comparative economic and environmental analysis of conventional, hybrid and electric vehicles - The case study of Greece', *Journal of Cleaner Production*. Elsevier Ltd, 53, pp. 261–266. doi: 10.1016/j.jclepro.2013.04.010.

Nikander, S. (2008) *Greenhouse gas and energy intensity of product chain: case transport biofuel*, *Master Thesis, Helsinki University of Technology*.

Pebrian, D. El *et al.* (2012) 'Oil Palm Plantation Mechanisation in Totality', in *International Conference on Agriculture and Food Engineering for Life (Cafei 2012)*, pp. 739–751.

Redpath, D. A. G. *et al.* (2011) 'Battery powered electric vehicles charged via solar photovoltaic arrays developed for light agricultural duties in remote hilly areas in the Southern Mediterranean region', *Journal of Cleaner Production*. Elsevier Ltd, 19(17–18), pp. 2034–2048. doi: 10.1016/j.jclepro.2011.07.015.

Soon, P. C. W. N. B. C. Y. M. and L. W. (2011) 'Malaysian Oil Palm Industry: Responding to the Sustainability Criteria of Greenhouse Gas Emission Savings under the European Union Renewable Energy Directive', *Palm Oil Development*, 54, pp. 5–7.

Determination of Minimum Suction Level for Collecting Oil Palm Loose Fruits

Mohd Ramdhan, K., Abd Rahim, S. and Norman, K.
Biological Research Division, Malaysian Palm Oil Board
No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000, Kajang, Selangor, Malaysia
**Corresponding author. Tel.: +603- 8920 1504, Email:ramdhan@mpob.gov.my*

Abstract
Loose fruits (LF) can be found at almost every stage of oil palm fresh fruit bunch (FFB) collection whether in the field or at the mill. LF contain the optimum amount of oil, which is why they need to be collected to ensure maximum Oil Extraction Rate (OER) at the mill. Various methods of LF collection were introduced for the oil palm industry, mostly comprising a simple mechanical type or the suction type. Based on systems developed in the past, the suction type was found to be more practical for collecting scattered LF around the palm base. This study seek to determine some suction parameters such as airflow and air velocity, relationships between engine and fan speeds with various fruit capacities. Results of the study showed that the minimum air velocity that is required to lift up a single LF is approximately 22.4 m/s or an airflow of 0.21 m^3/s. Results also indicated that the effective airflow to collect oil palm LF is between 0.28 m^3/s to 0.33 m^3/s (air velocity of 30 m/s to 35 m/s). It was found that engine speed will not be affected by the number of LF in the barrel; except the speed of fan, which was affected especially at lower speed. Higher air velocity was produced at the end of the suction nozzle at 80% fruits capacity in the barrel as compared to the empty barrel. The findings are expected to help in designing an effective suction machine for collecting oil palm LF.

Keywords: Oil palm, Loose fruits, Suction, Airflow, Air velocity

Introduction

Oil palm planted area in Malaysia in 2018 has reached 5.85 million hectares since it was first planted as a commercial crop in 1917 (MPOB, 2019). Upon reaching its ideal maturity stage, oil palm fresh fruit bunches (FFB) need to be harvested to enhance the quality of palm oil. Harvesting involves cutting off the ripe bunches and evacuate them immediately to the mill for oil extraction. During harvesting, handling and transportation operations, ripe fruits become easily detachable from the bunch (Mohd Ramdhan et al., 2013). The presence of 1 to 10 loose fruits (LF) on the ground are used as a visual indication that a bunch is ready for harvesting. Besides that, high number of LF are scattered due to the impact of bunches falling to the ground during the harvesting activity. Therefore, the LF must be collected and gathered together with other bunches. Currently, conventional methods of collecting LF are being widely practiced in plantations, with a productivity of between 200 to 250 kg LF/worker/day. A practical and cost-effective mechanised LF collection system is still one of the primary targets of the oil palm industry. There is a need to increase the efficiency of the LF collection but at the same time, the cost of LF is to be kept at a minimal rate. Generally, there are two approaches that have been developed to assist LF collection activity i.e. mechanical and suction methods. Several suction type loose fruit collecting machines were developed by Malaysian Palm Oil Board (MPOB) (Ahmad Hitam et al., 1995; Ahmad Zamri and Ahmad Hitam, 1999 and Rahim et al., 2012). In addition, there were also studied by Universiti Putra Malaysia, where they have developed and tested different suction methods to collect LF (Ja'afar, 1999; Rimfiel and Abadanjumi, 2007). Based on the outcomes from the systems developed by the industry in the past, it was demonstrated that suction type system was more practical for collecting scattered LF around the palm base. Currently, there is no determination on the minimum and effective air velocity or airflow that is required to lift up or to collect a single or several oil palm LF. A study by Ahmad Zamri and Ahmad Hitam (1999) gave a range of air speeds between 20 m/s to 35 m/s while Taner (2016) in his study for picking up hazelnuts from the ground (average size around 2 g to 3 g), used a backpack hazelnut harvesting machine with a specification of 100 m/s of air velocity. There is also a challenge to ensure that the fruits capacity would not affect the performance of the suction capability as the fruits are constantly being accumulated in the tank.

Materials and methods

The Machine

The oil palm LF collecting machine (MK III) was used in the study (Figure 1) with the specifications as shown in Table 1. The collection process of oil palm LF is done via vacuum (closed system) using a suction nozzle. The vacuum is created by a radial blower fan which is powered by a diesel engine. The mixture of fruits and trash, when entering the barrel, will be at a tangential angle and subjected to a cyclone atmosphere. This is to ensure that the fruits are not only able to be sucked in but also separated from trash. As the fruits circulate in the barrel, the heavier fruits will fall to the bottom of the barrel (as it loses energy) while the lighter materials, such as dried leaves or trash, will be blown into another compartment**.**

Minimum airflow to lift up oil palm loose fruit.

The end of the nozzle was put at 2 cm height from the ground. A single LF (average weight of 10 g) was then put on the ground directly under the nozzle. The engine was then ignited and the throttle for blower fan was engaged gradually until the LF lifted slightly from the ground. The position of the throttle was then maintained and air velocity at the nozzle was measured. These steps were then repeated for nine replicates. For measuring the airflow, digital anemometer (Model HH-30 by Omega Pro) with an accuracy of ±1% was used.

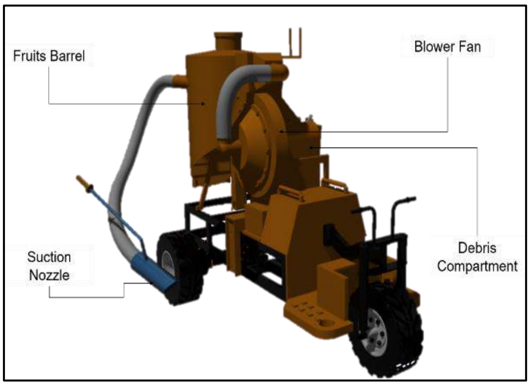


Figure 1: The isometric view of the machine.

Table 1: General specifications of the machine

Engine	**10 hp. diesel - air cooled**
Tank size, m^3 (est.)	0.15
Blower fan	
Type	Aluminium radial fan with 30^0 inclination
No. of blades:	12
Size (L x W x T), cm:	19 x 9 x 0.3
Suction nozzle	
Material:	PVC pipe
Diameter, cm:	10
Inlet area, A (Oval shape), m^2:	9.42×10^{-3}
Hose length, m:	5.5

Air velocity at the end of nozzle, engine and blower fan rpm at 0% and 80% fruit capacity.

0% capacity is referring to an empty barrel (no LF in the barrel) and 80% capacity is referring to approximately of 80% capacity of the barrel being filled up with LF (approximately 62.5 kg). A 100% capacity is not recommended for this experiment due to the possibility of fruits entering debris compartment or being hit by the blower fan. It is recommended that the operator should empty the LF from the barrel at 80% of the capacity before continuing the operation. Digital tachometer **(Model:** RM1500) by Prova Instrument Inc. with an accuracy of 0.04% ± 2 digits ±0.06 rpm was used to measure the speed (revolution per minute, rpm) of the fan and engine at their rotating shaft. Measurements were taken to determine the speed at different throttle positions (No.1 – No.4) for nine replicates. For measuring the airflow, the anemometer was put at approximately 2 cm from the suction nozzle and the airflow was then calculated using the airflow equation.

Calculation of Air Flow.

Airflow is the volume of air necessary for sucking the LF in the suction area. Airflow in the suction area can be calculated by the formula:

$$Q = V \times A$$

Note:
Q = Airflow of Suction Area (m^3/s)
V = Air Velocity (m/s)
A = Suction Area (m^2)

Data Analysis.

For statistical analysis, a comparison of means was performed using t-tests, where appropriate.

Results and discussion

Minimum airflow.

From the study, it was found that the minimum mean air velocity of 22.4 ±1.8 m/s or calculated of an airflow around 0.21 m^3/s is required to lift up and hovered a single LF with an average weight of 9.7 ± 0.4 g. From the observations, it was found that this airflow rate is not sufficient to lift up a group of LF (3 to 5 LF) simultaneously. These findings are crucial in order to design a mechanism to collect a number of LF simultaneously and channel them through a hose into a barrel or fruit compartment. Hence, extra air velocity is required for effective loose fruits collection in the field. The results, which were obtained in a lab environment, should also consider other factors such as ground surface condition, the material of nozzle and hoses, air temperature, turbulence in the hose etc. when operating in the field. The hose length plays an important role in determining the effective air velocity required. A longer hose will normally cause higher loss (David V. H. and Dan W., 2006). The oil palm LF collecting machine is equipped with 5.5 m hose length which was found to be sufficient and practical to be used in field operation. With this length, the machine is having better coverage to collect the scattered LF around palm circle and able to cover both sides of palm rows.

Effect of fruits capacity

Figure 2 shows that although there were a slight drop of engine revolution per minute (rpm) between empty (0%) and 80% fruit capacity of the barrel, however the difference were not significant ($p>0.05$). Thus, engine rpm was not affected by the number of LF in the barrel. Figure 3 indicates that there was a significant difference ($p<0.05$) of the fan's rpm between empty and 80% fruit capacity of the barrel at lower throttle positions (No. 1 & No. 2). It was believed that it was caused by the lower energy build-up and the fan was not at its peak performance at lower rpm. Once the fan had achieved its peak performance, the barrel capacity will not affect the fan's rpm. Higher air velocity is produced at the end of the suction nozzle during 80% of fruits capacity in the barrel as compared with the empty barrel as shown in Figure 4. As the fruits are being accumulated in the barrel, the volume of empty space is getting smaller thus reducing the air loss in the barrel. In another words, the suction generated by the fan is now being transferred directly to the hoses or suction nozzle without the need to build up its vacuum in a larger sized barrel. From the study, it was also found that the air velocity between 30 m/s to 35 m/s (airflow of 0.28 m^3/s to 0.33 m^3/s) and blower fan's between 3000 rpm to 3500 rpm are sufficient to collect several oil palm LF effectively.

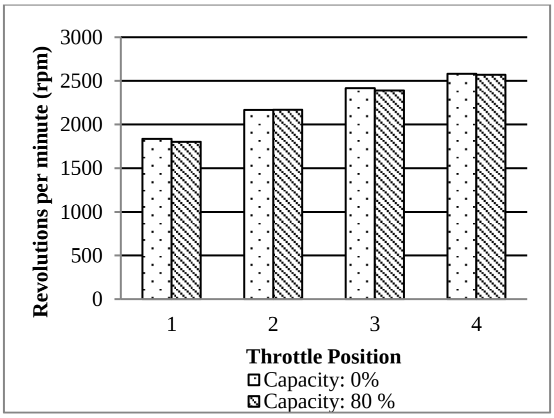


Figure 2: Comparison of engine speed at 0% and 80% fruits capacity.

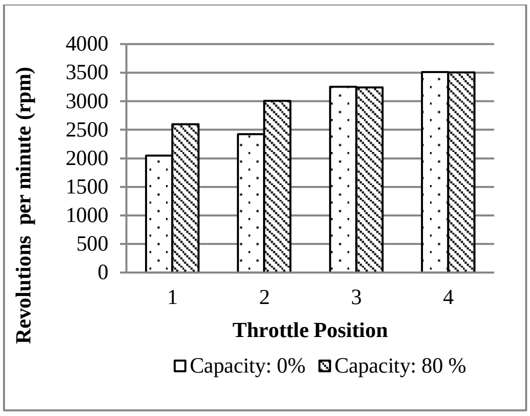


Figure 3: Comparison of blower fan speed at 0% and 80% of fruits capacity.

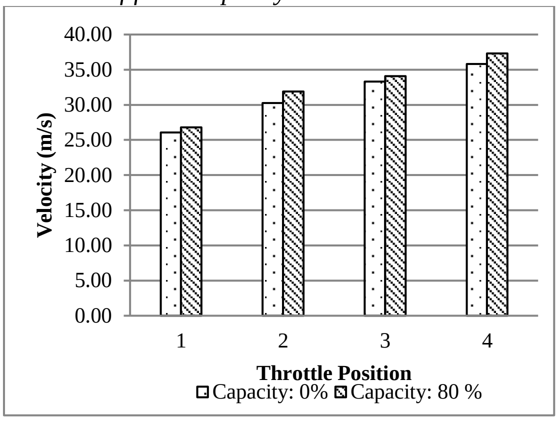


Figure 4: Air velocity at nozzle for different fruit capacities

Some recommendations that should be considered when designing the vacuum type collecting machine:

1. Minimising installation of fittings such as an elbow or bends along the system the fan discharge, which may cause non-uniform flow and increase the system's resistance.
2. Blower fan should be made from light materials but should be able to resist high sudden impact from small objects at high velocities. There are some cases where the fruits were accidently hit, which damaged the fan blades or wear and tear occurs due to impact from particulate matters that is constantly hitting the fan blades.

Regular checking on the machine should be conducted before and during the operation such as ensuring that the fan impeller is rotating in the appropriate direction i.e. clockwise or counter-clockwise. For belt-driven fans, a motor and fan sheave should be aligned properly with proper belt tension. Last but not least, the passages in the hoses and inlets, need to be regularly checked to ensure fan blades and its compartment, are in good conditions and no build-up of dirt or obstructions such as dried mud other foreign matters inside the fruit barrel.

Conclusions

The minimum airflow required to lift up a single LF and effective airflow to collect several LF were determined. Furthermore, the amount of LF in the barrel is not a major issue that could affect the suction capability. With these findings, it is hoped that more improvements can be made to the loose fruits collecting machine.

References

Abd Rahim, S., Mohd Ramdhan, K., Mohd Solah, D. and Aminulrashid, M. (2012). Oil palm loose fruits collecting machine (MK III). MPOB Information Series No. 592. palmolis.mpob.gov.my/ publication/TOT/TT-505.pdf.

Ahmad, H., Ahmad Zamri, Y. and Mohd Salih, J. (1995). Loose fruit collector. PORIM Information Series No.19. palmoilis.mpob.gov.my/publications/TOT/TT-19.pdf.

Ahmad Zamri, Y. and Ahmad, H. (1999). Mechanical loose fruit collector (MKII). PORIM Information Series No. 57. palmoilis.mpob.gov.my/publications/TOT/TT-57.pdf.

David, V. H. and Dan, W. M. (2006). Friction Loss in Wildland Hose Lays. Fire Management Tech Tips. United States Department of Agriculture Forest Service, Technology & Development Program: 1-12

Ja'afar, M. S. (1999). Teknik pemungutan buah kelapa sawit terlerai: cabaran dan pendekatan baru. National Conference on Engineering Smart Farming for the Next Millennium, 14-16 Mac 1999, UPM, Serdang, Selangor. (Unpublished)

MPOB (2019). Oil palm planted area as at December 2018 (hectares). http:// http://bepi.mpob.gov.my/images/area/2018/Area_summary.pdf, accessed on 1 Feb. 2019.

Mohd Ramdhan, K., Abd Rahim, S. and Mohd Solah, (2013). Mechanization: From field to mill. The Planter, Vol. 89 No. 1052, Nov. 2013: 827-838.

Rimfiel, J and Abadanjumi, E (2007). Performance evaluation of a terrain accommodating oil palm loose fruit collector. Pertanika Journal Science & Technology Vol. 15 No.1: 15-23.

Taner, Y. (2016). Labor Requirements and Work Efficiencies of Hazelnut Harvesting Using Traditional and Mechanical Pick-Up Methods. Turkish Journal of Agriculture and Forestry (2016). 40: 301-310.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA09

Technologies for ground vehicle operating on peat and soft ground area.

Abd Rahim S. Mohd Ramdhan, K and Norman, K.
Malaysian Palm Oil Board (MPOB),
No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia.
**Corresponding Author, Tel: +06 8926 1831, E-mail: rahim@mpob.gov.my*

ABSTRACT
The Malaysian plantation sector is dominated by the oil palm industry, and this sector needs innovative in-house technologies to improve the productivity as well as reducing costs. The current oil palm area stands at 5.85 million ha, which are planted on various ground soil conditions. This wide range of topography will definitely require diverse technical specifications of capabilities of machines to accommodate it. A tracked machine is known for its ability to work under wet and soggy ground conditions but it is costly to maintain. MPOB has developed a new transporter where it can be run either with all four (4) wheels or a combination of front axle with conventional tyre while rear axle mounted with track. With this innovation the durability of track can be extended as it only be fitted to the machine when the ground condition is demanding it. The triangular track system fitted standard 4 x 4 transporter works well in areas that inaccessible to the conventional wheel type transporter and reduces the problem of uncollected bunches. With this machine it is envisaged that the recovery of fresh fruit bunches will be greatly improved.

INTRODUCTION

The oil palm planted area as in 2018 is 5.85 million ha with 2.73 million ha (50.1%) in Peninsular Malaysia, 1.56 million ha (24.95 %) in Sabah and 1.56 million ha (24.95%) in Sarawak. Out of this area about 666 038 ha are on peat (mainly in Sarawak). Oil palm planted on peat or swampy area is facing challenging task when it comes to crop evacuation. This is due to the 'very loose' and 'very soft' nature of peat where the machines do not have sufficient traction and ability to float that restricts the machine to move efficiently. Apart from bearing capacity of the peat, the present of undecomposed or semi-decomposed log along the harvesting path required a special design vehicle to tackle this problem. The new concept of transporter/vehicle is specifically built for infield collection of FFB on peat and soft condition where a reliable transporter is considered crucial as it is the key activity to ensure harvested crop can be taken out from the field.

MPOB has recently redesigned the standard articulated tractor to get the optimum mobility on soft textured soils and peat area. With the blend concepts of articulated - halftrack and a cage wheeled, this transporter prototype is showing some potential to operate on the soft and peat area. For full track transporters/machines, since 1980 many fabricators/importers have tested/evaluated their units and among comments that are gathered from this exercise the maintenance cost particularly on the track and transmission system are high. With that in mind, MPOB has developed a new track transporter where compactness of the transporter design and material selection has been emphasized during fabrication with the intention of getting a reliable transporter for peat area.

TRIANGULAR TRACK SYSTEM.

The standard articulated tractor (*Figure 2*) comes with four standard tyres. The specifications of the tractor are shown below:

Table 1: Specification of the articulated tractor

Dimension (mm)	4540 (L) x 2200 (W) x 1915 (H)
Engine	JD diesel, 24.5 HP, 2-Cylinder, Water Cooled
Gross Weight	850 kg
Transmission	5 speeds, 4 forward and 1 reverse
Fuel Tank Capacity	15 Litre
Max. Carrying Load	500 kg
Tyre Size	7.5 x 16
Maximum Speed	18 km/hr.

Figure 2 : The Hunan 124Y articulated tractor

Advantages:

- Improved tractive performance compared with wheeled tractor.
- Lower ground pressure than with wheeled tractor.
- Lower weight than conventional crawler.
- Can be retrofitted to conventional 2 WD or 4 WD tractors.
- Can be attached to other implements such as pesticide spraying, fertilizer application etc.

To further utilize this interchangeable 4WD system, a larger size of front wheels (12.4 x 16) were fitted on and triangular tracks system (*Figure 3*) were installed at the rear axles. The rubber tracks were mounted to rear axle hub and anti-torque bar were installed to secure the track to the axle. The track is allowed to rotate 15 degree with respect to the chassis to ensure the machine can travel smoothly on uneven ground.

Figure 3 : Triangular track system

DESCRIPTION OF INVENTION

The present invention relates to an application – This invention relates to a method of collecting bunches in area where wheel type transporter having difficulty to traverse on this area. The vehicle which has been developed can be run with standard four wheels or a combination wheels mounted on front axle while rear axle fitted with triangular track (in placed of conventional wheels) enabling the vehicle to encounter less problematic whenever it traverse onto soft structured soil or peat.

For full track transporters/machines, since 1980 many fabricators/importers have tested/evaluated their units and among comments that are gathered from this exercise was the maintenance cost particularly on the track and transmission system were high. With that in mind, MPOB has developed new wheel/track transporter where compactness of the transporter design and material selection has been emphasized during fabrication with the intention of getting a reliable transporter for peat area and soft textured soil. This invention relates to a machine with a single chassis, powered by a 38hp water cooled diesel engine, coupled to a gear shift type transmission gearbox. The front bay of the chassis house the engine and transmission gearbox while the rear chassis carry a bin with a full capacity of 750 kg. The front axle is hinged to chassis and is able to swing 15 degrees, providing excellent ground contact when traveling over rough terrain. The additional mechanism that has been improved in this new innovation is the inclusion of dual mode gearbox which is placed between front and rear axle. The input shaft from gearbox will be connected to front axle while the output shaft from the gearbox will be connected to the rear axle. Both of these connections are done through propeller shaft. The selection to run with all wheels or a combination tyre and track can be executed by positioning the control lever to the designated point. The machine can be run either with all four (4) wheels or a combination of front axle with conventional tyre while rear axle mounted with track. With this innovation the durability of track can be extended as it only be fitted to the machine when the ground condition is demanding it.

Figure 4 : The schematic drawing of the complete assemble prototype

FIELD TRIAL

A function test was conducted once the track has been installed to the machine (*Figure 4*). It was found that after installing the track, the ratio movement between front wheel and rear track is not synchronized causing the track to slip out of the sprocket. To solve this problem a new gearbox has been constructed in order to get the suitable ratio. A gearbox provides speed and torque conversion from a rotating power source using different gear ratio. The final drive of gear ratio will allow the rear axle with sprocket to rotate 2.47 faster than front axle which is installed with tyre to have the same travelling speed.

The prototype later on was tested at the matured peat area at Penor, Pahang (*Figure 5*). From the observation, it was found that this transporter is able to function effectively in this area. However it was noticed that, the articulated tractor need to be fully engaged with the 4WD system especially for infield operation or otherwise it will tend to bog down. This prototype should have no problem to travel under 2WD mode on the main road.

Figure 5: Field test conducted at peat area with load

CONCLUSION

In general, the triangular track system fitted standard 4 x 4 transporter works well in areas that inaccessible to the conventional wheel type transporter and reduces the problem of uncollected bunches. With this machine it is envisaged that the recovery of fresh fruit bunches will be greatly improved. The triangular track transporter has the advantages of better traveling speed compared to full track transporter. Besides for infield transportation of FFB, the transporter can also be used for other field activities such as fertilizer application, weed control, maintenance etc. The machine is able to reduce manual requirement as well as improve the productivity and income of the worker.

REFERENCES

Arvidsson, J., Westlin, H., Keller, T., Gilbertsson, M. 'Rubber Track Systems for Conventional Tractors – Effects on Soil Compaction and Traction'. *Soil and Tillage Research* 117 (2011): 103-109.

Bekker, M.G. 1965. A proposed system of physical and geometrical terrain values for the determination of vehicle performance and soil trafficability. Volume 2, Interservice Vehicle Mobility Symposium, Hoboken, N. J., Stevens Institute of Technology.

Marshek, Kurt M. 'On the Analyses of Sprocket Load Distribution'. *Mechanism and Machine Theory* 14.2 (1979): 135-139. Web.

Nakanishi, Toshikazu, and A. A. Shabana. 'Contact Forces in the Non-Linear Dynamic Analysis of Tracked Vehicles'. *International Journal for Numerical Methods in Engineering* 37.8 (1994): 1251-1275.

Pinard, M.A, M.G Barker, and J Tay. 'Soil Disturbance and Post-Logging Forest Recovery on Bulldozer Paths in Sabah, Malaysia'. *Forest Ecology and Management* 130.1-3 (2000): 213-225.

U.S. Department of the Army. Corps of Engineers. 1962 Operation Swamp Fox I: terrain and soil trafficability observations. Washington, D.C. Technical Report No. 3-609

Wallin, Michael et al. 'A Comparative Study of Joint Formulations: Application to Multibody System Tracked Vehicles'. *Nonlinear Dynamics* 74.3 (2013): 783-800.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

VIBRATION ISOLATOR FOR THE OIL PALM MOTORISED CUTTER

Mohd Ikmal H., Abdul Razak J., Mohd Rizal A., and Abd Rahim S.
Malaysian Palm Oil Board (MPOB), 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
E-mail: ikmalhafizi@mpob.gov.my

Abstract
*MPOB has introduced an oil palm motorised cutter called '**CANTAS**' that works effectively for palms with harvesting height of below 5-metres. CANTAS which is powered by a small petrol engine has been proven to double up harvesting output compared to manual harvesting. However, the existing CANTAS design generates vibration that may lead to Hand Arm Vibration Syndrome (HAVS) under prolonged exposure. It is necessary that the level of vibration to be managed and controlled. A vibration isolator has been designed and developed which functions to collect and isolate vibration of the motorized cutter. The isolator comprises of a pair of bearing and a spring which the spring functions to reduce the vibration while the bearings dispose the vibration from the motorized cutter. The study showed that the use of isolator reduced the magnitude of HAV at holding points (P1 and P2) by 54 and 45%, respectively. Minimum HAV was obtained when the vibration isolator was fixed at 70cm from the engine. The isolator was tested by a harvester in Banting Selangor who experienced that the isolator helped to reduce vibration effect thus giving him much more comfortable during handling the machine. This invention has further application that can also be extended to other vibration tools such as grass cutter machine, mist blower, pruning machine and so on.*

Keywords: *oil palm motorised cutter, CANTAS, vibration reduction, damper system, vibration isolator*

Introduction

The efficiency of harvesting of fresh fruit bunches (FFB) is important to ensure the FFBs are harvested follow the recommended of harvesting rounds of 10 to 12 days interval. The manual method of harvesting (using a sickle or chisel) can produce about an average of 1 t FFB man-1 day-1 (Azman *et al.,* 2015). Estates are now looking forward to efficient harvesting tools that could increase productivity and ultimately reduce the number of workers. The harvesting productivity needs to be increased to 4 t FFB man-1 day-1roughfly if the country wishes to reduce the labour requirement significantly (Abdul Razak *et al.,* 2013). One of the technologies that have been well accepted by the oil palm industry is the oil palm motorised cutter (called CANTAS) that was introduced in 2007 (Abdul Razak *et al*., 2013). CANTAS is powered by a small petrol engine and utilises either a specially designed C-sickle or chisel as the cutting knife. CANTAS has been categorised as a type of machine that generates vibration which could cause HAVS when overexposure of daily usage. Therefore, it is necessary that the risks from vibration generated by CANTAS should be managed and controlled. The objective of this paper is to design, develop and test the vibration isolator on the magnitude of vibration on CANTAS.

METHODOLOGY

Vibration isolator designs

Sources of vibration of the oil palm motorised cutter fundamentally come from both rotational and linear motions of the moving components such as engine, transmission shaft, shaft guiders and gear-box (*Figure 1*). Rotational motions basically come from the engine, transmission shaft and bearings, while linear motions come mainly from the gearbox, pole, and sickle. The vibration, therefore, is developed throughout the length of the machine during operation with the magnitude which may differ from point to point. Vibrations arise when a body oscillates due to external and internal forces. Vibration may be transmitted to the human body through the part in contact with the vibrating surface such as the handle and the pole of the machine.

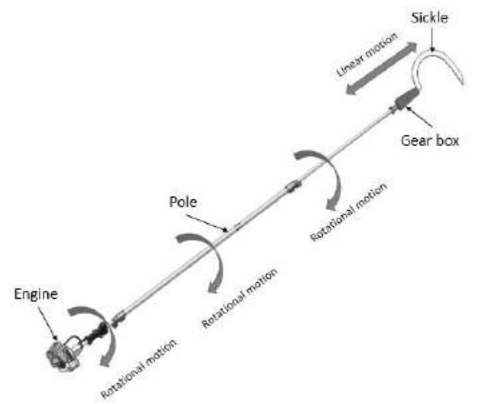


Figure 1: Sources of vibration of the motorised cutter

In this study, the vibration isolator was designed and developed. The vibration isolator is to be placed on the pole of the motorized cutter which its best position would be determined from this study. Theoretically, the vibration generated by the machine would be collected and stabilized by the vibration isolator (*Figure 2*).

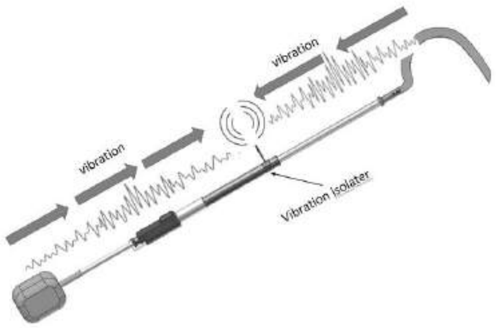


Figure 2: Vibration reduction of the motorized cutter by the vibration isolator system

The vibration isolator comprises of two basic components i.e. a compression spring and a pair of bearings. The spring with its nature of being elastic is functioning to isolate the vibration, while the bearings which are placed at both ends of the spring is functioning to stabilize the vibration collected by the spring.

The arrangements of bearings were fixed in line with the spring axis and the dimension of vibration isolator is shown in *Figure 3*.

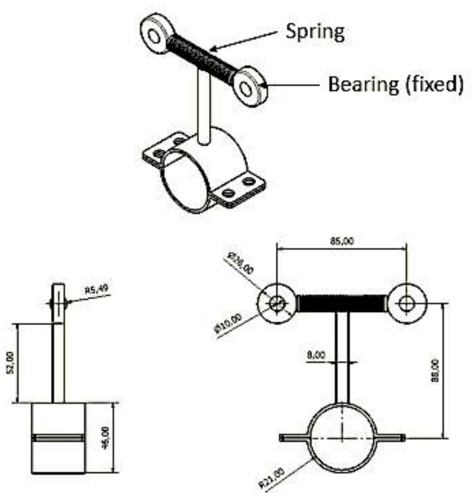


Figure 3: Schematic drawing of the Vibration isolator

The Experiment

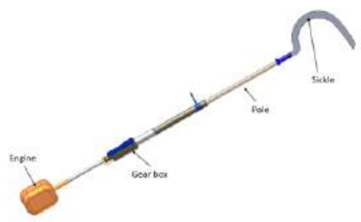
In the experiment, the vibration isolators will be fixed to CANTAS. The effect of vibration isolator designs and its position on the magnitude of hand-arm vibration (HAV) were studied using a 2x3 factorial experiment. Details of the vibration isolator experiment are as follows:

Subject: CANTAS

Vibration isolator position (L) - a distance of vibration isolator from the engine:

• For CANTAS: L1 (70) and L2 (120) cm from the engine

Table 1: Specification Of Motorised Cutter

Subject	CANTAS
Drawing	
Concept	The rotational motion generated by the engine is converted into linear motion by the gearbox which a pole is fixed to it. This allows the sickle which is fixed at the end of the pole to move linearly for cutting action. The gearbox is placed near the engine to reduce the point of the center of gravity as to ease the handling of the machine. The source of vibration comes from one rotational motion and two linear motion, i.e. • Rotational motion : engine • Linear motion :gear box and pole/sickle
Length (m)	2.90
Weight (kg)	7.40
Specific weight (kg/m)	2.55
Centre of gravity (cofg), m	1.07
Deflection at the point of cofg (cm)	3.00

Holding Points (P1 and P2)

Figure 4 shows the two holding points (denoted as P1 and P2) for CANTAS, the positions where the magnitude of HAV will be measured during the experiment. P1 is located at the engine’s throttle, the point where the harvester controls the speed of cutting, while P2 is the point where the harvester holds the machine during the cutting operation. The distance of P1 and P2 were fixed at 30 cm and 80 cm from the engine.

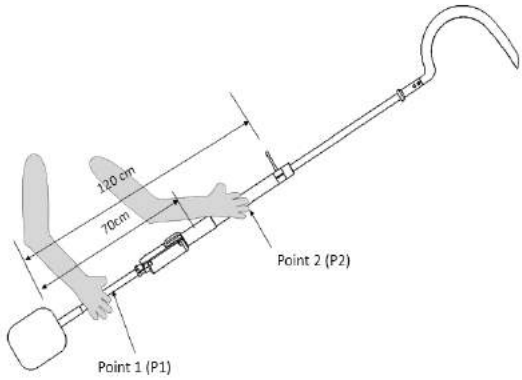


Figure 4: Vibration points (P1 and P2) and two distances of vibration isolator from the engine of CANTAS

Measurement of Vibration

The study was conducted at MPOB Keratong Research Station in Pahang. The palms where the experiment was conducted were about 10 years old with the height range from 2.5 m to 3.5 m. The field topography was flat.

A tri-axial accelerometer was used to measure the magnitude of vibration generated by the machine. The measurement complied with the standard ISO5349, the same standard used by other reports (Salihatun *et al*., 2013 and 2014; Amitkumar *et al*., 2015). In the experiment, the vibration sensor was placed at the holding points (P1 and P2) with the machine's pole angle was set at 60^o as shown in *Figure 5*. The data was recorded when the worker started cutting the frond until the finish.

Figure 5: Vibration measurement during cutting of frond

The HAV of the motorised cutter fixed with the vibration isolators were compared against the HAV of the motorized cutter without vibration isolator.

Results and discussion

Effect of Vibration Isolator on HAV of CANTAS

Table 3 and *Figure 6* show the average data of HAV generated by CANTAS from the experiment conducted. The highest HAV was obtained at P2L1 (1.8 m/s^2) and the lowest HAV was obtained at P1L1 (1 m/s^2). As for comparison, the HAV of CANTAS without vibration isolator was 2.7 m/s^2 and 3.2 m/s^2 for P1 and P2, respectively.

Table 3: Hav Of Cantas (With And Without Vibration Isolator)

Holding point	Control **(without vibration isolator)**	With vibration isolator	
		D	
		70	**120**
P1 (m/s^2)	2.7 n=6 σ = 1.29	1 n=6 σ = 0.50	1.5 n=6 σ = 0.68
P2 (m/s^2)	3.2 n=6 σ = 0.61	1.8 n=6 σ = 0.92	1.7 n=6 σ = 0.69

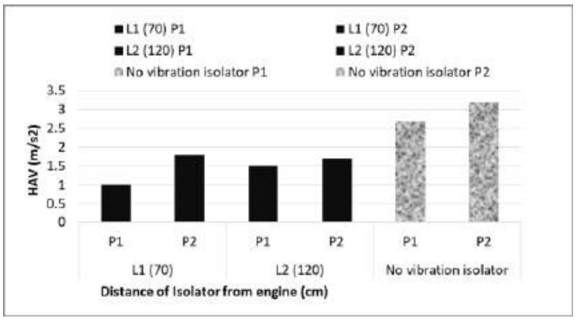


Figure 6: Results of hand-arm vibration (HAV) of CANTAS

Referring to *Table 4*, generally fixing a vibration isolator on CANTAS have given significant effects on the reduction of HAV. The isolators were found to reduce HAV significantly. The isolator had given a better effect where the HAV were reduced by 54% and 45%, respectively at P1 and P2, compared to HAV without vibration isolator. The experiment disclosed that the isolator is with overall HAV reduction of 49.5%.

Table 4: Average Of Hav Of Cantas With Vibration Isolators Vs Without Vibration Isolator

Holding Point	Without vibration isolator (m/s^2)	With vibration isolator (m/s^2)
P1	2.7	1.25 (-54%)
P2	3.2	1.75 (-45%)
	Overall	-49.5%

Comparison of minimum and maximum HAV of CANTAS

Table 5 shows the summary of the results of the minimum and maximum HAV of the motorised cutter fixed with vibration isolators. The minimum HAV at P1 and P2 occurred at the combination of L1P1 (1.0 m/s^2) when using an isolator.

Table 5: Result Summary - Minimum And Maximum Of Hav For The Motorised Cutter

	CANTAS		
	No vibration isolator	**Isolator**	
	Mag*	**Mag***	**Com****
Minimum HAV	1.2	1.0	L1P1
Maximum HAV	4.7	1.8	L1P2

Remark:
*Mag – magnitude
**Com – combination

Table 6: Result Summary – The Effect Of Vibration Isolator On Cantas At Holding Points (P1 And P2)

	CANTAS	
	No vibration isolator	**Isolator**
P1	2.7	1.25 (-54%)
P2	3.2	1.75 (-45%)

Conclusion:

The introduction of this technology is expected to give experience to the users' for comfortable handling. Initial tests as shown here indicated that the vibration level had been reduced when vibration isolator was installed to the CANTAS. Feedback from harvester using the vibration isolator that it reduces vibration of CANTAS which make the handling of CANTAS is more comfortable. The use of vibration isolator will give more comfortable handling for harvesting that ultimately will increase productivity and reduces HAVS issues. The invention is not only for CANTAS but can also be used in other vibrating tools such as grasscutter machine, mist blower, pruning machine and so on.

References:

Abdul Razak Jelani; Rizal, A; Ikmal, H; Salihatun, M S and Abd Rahim, S (2013). Oil Palm Motorized Cutter (*Cantas*) : A Tool For Improving Workers Productivity. *Proc. Of The Pipoc 2013 International Palm Oil Congress – Agriculture Conference*. Mpob, Bangi.

Abdul Razak Jelani; Ahmad, H; Johari, J And Malik, M N (2008). Patent No. My-136496-A : A Mechanised Harvesting Device Utilising A Rapid Chopping Method.

Amitkumar, K And Tayde, M M (2015). Design And Analysis Of Jigsaw And Damper For Effect Of Vibration Reduction In Hand Held Power Tool. *International Journal Of Emerging Technology And Advanced Engineering. Vol. 5(7): 65 – 73.*

Azman Ismail; Siti Mashani, A And Zuraihan, S (2015). Labour Productivity In The Malaysian Oil Palm Plantation Sector. *Oil Palm Industry Economic Journal. Vol. 15 (2).*

Health And Safety Executive (Hse). Hand-Arm Vibration. Advice For Employees.. Indg175(Rev1).

Health And Safety Executive (Hse). Hand-Arm Vibration At Work. A Brief Guide. Indg175(Rev3).

Haruhiko, K; Yoshinori, M; Toshikazu, Y And Jun, T (2004). High Performance Passive Hydraulic Damper With Semi Active Characteristics. *Proc. Of The13th World Conference On Earthquake Engineering, Canada*.

Klembczyk, A R (2009). Introduction To Shock And Vibration Isolation And Damping Systems, Imac-Xxvii: Conference & Exposition On Structural Dynamics, P. 58 – 66.

Ladgaonkar, A H (2016). Reducing Vibrations Of Hand Operated Power Tools With Vibration Isolation And Reduction Mechanism. *International Journal Of Research Publications In Engineering And Technology Vol. 2 (5).*

Lee, D And Taylor, D P (2001). Viscous Damper Development And Future Trends. Taylor Devices Inc, North Tonawanda, Ny North Tonawanda, Usa.

Rao, J And Gupta, K (2014), Theory And Practice Of Mechanical Vibrations. New Age International (P) Limited, Publishers.

Sallihatun, M S; Erween, A R; Roslan, M N; Ismon, M; Madlan, M A; Masrol, S R; Abdul Razak, J And Ahmad, M R (2013). Hand Arm Vibration Of Unskilled Oil Palm Motorised Cutter Operator. *Applied Mechanic And Materials Vol. 315: 695 – 699.*

Salihatun, M S; Ramlee M P; Abd Kadir, M S And Kasron, Z (2014). The Effect Carbon Fiber Pole On Hand-Arm Vibration Of Palm Fruit Motorised Cutter. *Applied Mechanics And Materials Vol 660: 521-525.*

Skogsberg, L (2012).Vibration Control On Hand-Held Industrial Power Tools. Product Ergonomics, Atlas Copco Tools & Assembly Systems, Stockholm, Sweden, P. 108-109.

Toshisuke, M; Yoshiharu, Y; Atsushi, N; Kazuo, K And Koichi, B (1979). Vibration Isolator For Portable Vibrating Tool Part 1. A Grinder. *Industrial Health Vol. 17: 85 -99.*

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Straight-Line Accuracy of an Autopilot Tractor at Various Speeds: A Preliminary Assessment on Malaysia's Flat Terrain

Muhammad Hairie, H. and Darius, E. P.*)
Faculty of Plantation and Agrotechnology
Universiti Teknologi MARA Melaka
77300 Kampus Jasin, Merlimau
Melaka, Malaysia
*Corresponding author. Tel.: +606-264-5297, Email:darius@melaka.uitm.edu.my

Abstract

Nowadays autopilot mode become one of the alternative modes in driving tractor besides manual and unmanned or autonomous. Although the system has been successfully introduced in its country of origin, however, specialized assessments of this system on the areas which are different from its country of origin are prime interest to be investigated whether it suits a local terrain condition of any country. Thus, a preliminary assessment of the straight-line accuracy of autopilot tractor running at various specified levels of speed was conducted in order to understand its suitability with Malaysia's terrain conditions. In this study, a New Holland TD5.75 tractor equipped with Trimble® EZ-Pilot® Steering System and Trimble® FmX® Plus Application was trialed on flat terrains that were overgrown with grasses at the UiTM farm in Jasin, Melaka, Malaysia. Three levels of autopilot tractor forward speeds, i.e. 1000 rpm, 1500 rpm, 2000 rpm were selected as the parameters in measuring straight-line accuracy of the tractor. The SPSS ver. 25 and spreadsheet software were used to analyze the collected data. This study found that there is a significant different between straight-line accuracy of each the tested speeds. It also showed that there is a relationship between the tested speeds and straight-line accuracy.

Keywords: Farm machinery, Autopilot tractor, Auto-guidance, Auto-steering, Mechanization

Introduction

The use of tractor in agriculture operations have been increasing drastically in Malaysia since past decades. This situation can be seen through increasing the import value of tractor for the country since five decades from2,685,000 USD in 1968 to 90,324,000 USD in 2008 (FAOSTAT, 2016). With the broadly usage of tractors in Malaysia today, the machines also contribute in solving the labor shortage in agriculture sector in the country. Besides, tractors also play roles in improving the advancement of mechanization in most of agricultural operations in the country through lightening workload and reducing human energy expenditure in the operations.

In line with the advancement of technology, various driving modes of tractors have been introduced and sold in the market. The autopilot tractors have been widely not only have been used in the country of its origin, but also in several developing countries. Several studies have been revealed in the literatures such as Santos et al. (2018), who reported the position errors in sowing of peanut in curved and rectilinear routes using autopilot tractor in Brazil. Another study reported by Jahns (1997), who introduced a concept which makes use of auto guidance components to minimize the costs of implementation. Easterly et al. (2010) tested the performance of satellite-based tractor auto-guidance using a vision sensor system. Lipinski et al. (2016) compared the tractor implement unit that was operated in conventional method when the tractor was operated manually and autopilot modes, which relied on satellite navigation.

Being a new technology, the performance of autopilot tractor is still unknown in Malaysia. Thus, assessments of this tractor driving mode on its suitability with local terrain conditions is prime interest to be investigated as no one to the best of our knowledge has studied this aspect. This paper is a preliminary attempt to assess the straight-line accuracy of an autopilot tractor at various speeds on Malaysia's flat terrain. Straight-line accuracy of tractor when operating in the field is crucial to be retained in order to minimize overlapping of works width for each trip. Higher overlapping trips could reduce field efficiency of an operation. Three levels of tractor engine speeds i.e. 1000 rpm, 1500 rpm, 2000 rpm were selected as the parameters in measuring straight-line accuracy of the tractor. In this paper, the error of accuracy at each level of speeds were presented. Besides, the relationship between the speeds and the error of accuracy of autopilot were also discussed.

Materials and methods

This preliminary study was carried out at university farm in UiTM Melaka, Jasin campus, Melaka, Malaysia. The selected area has a slope ranging from 0% to 0.5%, and it is considered as flat terrain (Weiss, 2001). During the field observation, the ground surface was overgrown with grasses. The weather was considered as heavy cloudy, thus, it might affect the signal of GPS. A New Holland tractor model TD5.75 at 75 horse power sizes that equipped with autopilot system, consisting of Trimble® EZ-Pilot® Steering System and Trimble® FmX® Plus Application was used as main subject of the study. Details specifications of tractor and autopilot system were shown in Tables 1 and 2. In this study, the tractor was operated on an area of 30 m x 30 m size. Three straight lines ropes were lied down on the ground to be tracked by outer right side of front and rear tires. Outer right side of front and rear tires of tractor was set to overlay the ropes during the test. Any strip along the straight movement of the outer side of tractor tires on the ropes was considered as an error. Thus, the ropes were also as references measurements for detecting the error of straight forward movement of the tractor when moving alongside the straight lines. The levels of tractor speeds were set at three different rates i.e. 1000 rpm, 1500 rpm, and 2000 rpm. The autopilot tractor mode GPS system was activated with five time replications at each of speed. Figure 1 shows the GPS setup for tracking the straight-line routes in the field. The movement of tractor tires then was followed closely a person to observe the error in straight-line accuracy. Any error in straight-line movement was then marked using spray paint. Once completed, the marked paints were perpendicularly measured. They were recorded as error in straight-line accuracy of autopilot. The SPSS ver. 25 and spreadsheet software were used in data analysis.

Table 1. Specifications of New Holland TD5.75Tractor

Engine	*Number of cylinder/aspiration/valve*	*4/TI/2*
	Emission level	*Tier 3*
	Capacity	*3908 cm^3*
	Rated horsepower-ISO TR 14396-ECE R120	*56/75*
	Rated engine speed	*2300 rpm*
	Max. Torque – ISO TR14396	*298@1400*
	Fuel tank capacity	*110 litres*
	Service intervals	*300 hours*
Hydraulic	*Main pump flow*	*36 l/min*
	MegaFlow™ pump flow	*48 l/min*
	Steering and services pump flow (Mechanical shuttle/Hydraulic shuttle)	*29 l/min*
Remote valves	*Type*	*Deluxe*
	Max. no. rear valves	*3*
	Max. no. mid mount valves	*2*
Linkage	*Max. lift capacity at ball end*	*3565kg*
	Max. lift capacity through the range (610 mm behind ball ends)	*2700 kg*

Table 2. Specifications of Autopilot Unit

Brand	*Trimble*	*Trimble® EZ-Pilot® Steering System and Trimble® FmX® Plus Application*
System	*DC power*	*Supplied by TM-200, 27 volts, 3.5 Amps*
	Processor	*1 GHz quad core*
	Storage	*Primary embedded memory – 32GB*
Mechanical	*Dimension*	*312 x 214 x 45 millimetres (plus connectors)*
	Weight	*2.5 kg (5.5lb)*
	Mount	*4 M6 screws on 75 mm centres*
Housing	*Material*	*Magnesium*
	Environmental rating	*IP55*
Connections	*USB (1 side facing, 1 rear facing)*	*USB 2.0*
	Ethernet (Via TM-200)	*RJ45 connector*
	CAN (sources 5VDC)	*RJ11 connector*
	Port Expander (optional)	*1 port for CAN bus, I/O, and serial*
	HDMI output	*DVI connector*
Temperature	*Operation*	*0◦C to 65◦C*
	Storage	*-40◦C to 85◦C*
LCD display	*Size*	*307 mm*
	Touchscreen	*Protective capacitive touch*
	Resolution	*1280 x 800*
	Brightness (adjustable)	*1000 candela/m^3*
Front facing camera	*Type*	*Low light level, colour*
	Resolution	*1.3 Megapixel*

Figure 1. The GPS system of autopilot mode has been setup for tracking the straight-lines routes in the field

Results and discussion

Table 3 shows the errors of autopilot mode during testing. The lowest error in straight-line accuracy of 6.462 cm was found at the highest speeds level of 2000 rpm, while at the highest error of 38.318 cm was recorded at the lowest speed of 1000 rpm (Figure 2). Generally, within the three levels of tested speeds, it is concluded that that the higher speed, the lower error in straight-line accuracy. This agree with Lipinski et al. (2016), who reported the actual operating width of the tractor-implement under three travels speeds i.e. 3 km/hr, 6 km/hr and 12 km/hr. They found out that increasing of the autopilot tractor speed has increased the actual operating width of the tractor-implement, or reduced overlaps of tractor-implement routes in the field. It cannot also be denied that the GPS is not always accurate and can affect the straight-line accuracy of tractor movement in the field. This is consistent with Morgan and Ess (1997), who said that the accuracy of GPS depends on several factors such as satellite clocks, atmospheric conditions, or the GPS receiver quality.

Table 3 Error in Straight-Line Accuracy at Various Speeds of Atutopilot Mode

Speed	Error (cm)					Mean error (cm)
(rpm)	1	2	3	4	5	
1000	21.57	49.02	0	77.25	43.75	38.318
1500	10.13	15.25	25.17	28.6	10.8	17.99
2000	9.14	10.17	2.5	5	5.5	6.462

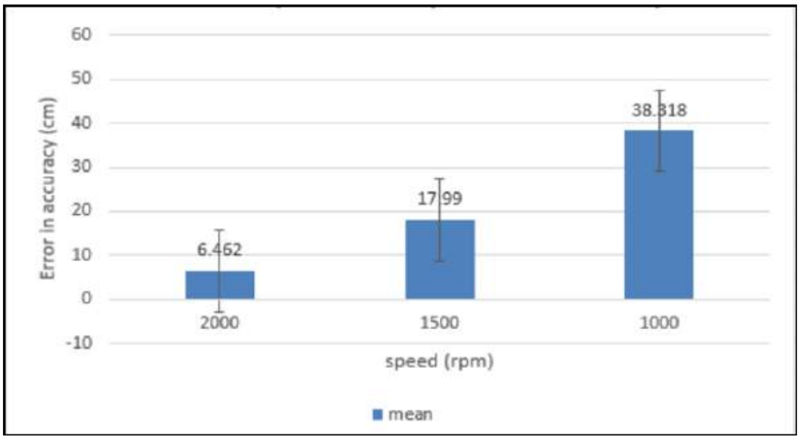


Figure 2. Relationship between speeds and error in straight-line accracy of autopilot in the field.

Conclusions

A preliminary evaluation of straight-line movement of autopilot tractor at various speeds i.e. 1000 rpm, 1500 rpm, and 2000 rpm on Malaysia's flat terrain has been successfully conducted. The findings of this study simply concluded that the level of speed and accuracy have a strong relationship. As it is in a preliminary stage, generally, this study has successfully initiated to discover another factor that may contribute to the error in straight-line accuracy of autopilot tractor, besides the GPS accuracy factors. Overall, the autopilot mode has potential to be used to overcome the problem regarding inadequate workers in Malaysian agriculture sector, and also reduce the time usage and operator fatigue while doing the agricultural activity. Comprehensive and complete study of this driving mode on various terrains conditions in Malaysia was recommended for further studies.

References

Easterly, D.R., Adamchuk, V.I., Kocher, M.F and Hoy,R.M (2010). Using a vision sensor system for performance testing of satellite-based tractor auto-guidance. Comp. and Electr. in Agric. 72 (2010) 107–118.

FAOSTAT(2018).Machinery.http://www.fao.org/faostat/en/#data/RM.

Jahns, G. (1997). Automatic guidance of agricultural field machinery. Proceedings of the Joint International Conference on Agricultural Engineering & Technology exhibition, Dec. 15–18, Bangladesh, 70–79. http://www.fal.de/∼jahns/papers.html.

Morgan, M and Ess, D (1997). The Precision-Farming Guide for Agriculturist. Deere &Company, Moline.IL.USA.

Murphy, D (2012). agricultural vehicle autopilot rolloverriskassessment system. United States Patent .Patent No.: US 8,275,516 B2.

Lipinski, A. J., Markowski P. , Seweryn, L and Pyra, P (2016). Precision of tractor operations with soil cultivation implements using manual and automatic steering modes. Biosystem Eng. 145(2016):22-28.

Santos, A.F. D, Correa, L.N., Gírio, L.A.S, Paixão, C.C.S and da Silva, R.P (2018). Position errors in sowing in curved and rectilinear routesusing autopilot. Engenharia Agrícola, Jaboticabal, 38 (4):568-576.

Weiss, A. (2001). Topographic Positions and Landforms Analysis (Conference Poster). ESRI International User Conference. San Diego, CA, pp. 9-13.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA12

The Effect of Tillage on Soil Compaction and Soil Moisture Content: A Preliminary Study on Paddy Soil in Merlimau, Melaka

Tengku Mohamad Khushaire, T.M.Z. and Samihah, M.*
Faculti of Plantation and Agroteknologi,
Universiti Teknologi Mara, Melaka Branch Jasin Campus, 77300 Merlimau Melaka
**Corresponding Author, E-mail: samihah096@melaka.uitm.edu.my*

Abstract

Soil tillage is an important step before cultivating rice by using equipment to prepare the soil for crop growth. It has many procedures to follow in order to avoid future problem such as lower growth rate and fewer yield, as it affects the nutrients intake. This study was conducted to investigate the effect of soil tillage on the soil compaction and soil moisture before and after ploughing process at paddy field. Hence, this study was to identify the change of soil compaction and soil moisture content in each session of ploughing process and the relationship between soil compaction and soil moisture content after first and second ploughing. A tractor model WM1104 with 110hp did the soil preparation. Both ploughing sessions were using rotary tiller. The penetrometer was used for reading the resistance to penetration and measurement data can be read from the display meter .The average values of soil compaction before and after first and second tillage are 186.94 psi, 162.22 psi and 137.78 psi respectively. There is also show a positive relationship between soil compaction and soil moisture content. The higher soil compaction the lower soil moisture content and vice versa.

Keywords: Paddy soil, Soil tillage, Soil compaction, Soil moisture

Introduction

Rice is cultivated on 688,770 hactares land on Malaysia land (FOASTAT, 2018) which produce approximateky 4107 kilograms per hectare in 2016 (STATISTA, 2019). Normally, rice cultivation involves ploughing before transplanting rice seedlings (Hobbs et al. 2007).

Soil tillage process is an important part of land preparation before cultivation and it gives more benefit to farmer. It can affect the soil compaction as the soil bulk density changed and inluences soil porosity, soil water content and soil air permeability (Badalikova, 2010). Hobbs et al (2017) has listed a few reasons why tillage is favoured before planting such as land preparation for seed to grow since the soil soften and eased the nutrient intake, weed and insect control. Furthermore, this process gives impact to soil which can change soil condition. According to Verma and Dewangan (2006), tillage process before cultivating paddy can cause soil compaction which can reduce water losses. Hence, this study was conducted to see whether tillage process has affected the soil compaction and soil moisture on paddy soil.

Materials and methods

Study site and test parameters

The study was taken place at Merlimau paddy field in Melaka. The selected field was a two acre area with four plots and predominantly clay soil. There were two parameters taken during the study which are soil compaction value and soil moisture content.

Test procedure

1) Data collection preparation:

The data was taken trice which were before tillage taken place, after first ploughing and after second ploughing process. Each plot was divided into nine square and the readings and samples were taken in the middle of each square. Figure 1 shows the design of study plot.

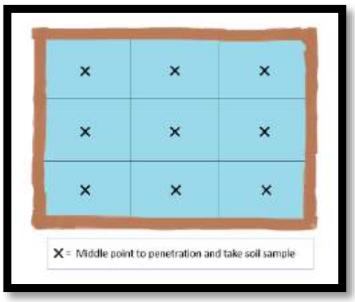


Figure 1: Design of study plot

2) Soil preparation in field

Tillage process was done by using a tractor model of WM1104 from China with 110hp. In normal practice, the first plough should use disc plough blade, while second and third plough are using rotary tiller. Unfortunately, due to bad weather condition with heavy rain, high labour cost and time contraint, the first plough using disc plough was waived. The tillage process was done using rotary tiller in wet condition paddy soil twice, hence became the first and second plough. Soil compaction reading was taken after each ploughing process.

3) Soil compaction reading

After study plot was designed, measuring process was taken place in the field. Soil compaction reading was taken using penetrometer. It is a soil compaction tester that used to measure soil compaction in pounds per square inch (Psi) unit. It has two cones to identify soil compaction which are ½ inch and ¾ inch base diameter. In this study, the latter base diameter was used since it is suitable for soft soil. There are six levels for depth marks which are at 3, 6, 9, 12, 15, and 18 inches. For this study, the 3-9 inch mark was used because it is a level for root development area and level for disc depth ploughing. The penetrometer was used for reading the resistance to penetration and measurement data can be read from the meter as shown in Fig. 2.

Figure 2: The reading meter of penetrometer

4) *Soil sampling analysis*

The soil samples were taken in the same place of penetrometer readings were done. The samples were taken at depth of 5-7 inch from the surface level of the soil. Then, the soil samples were put in a plastic containers and marked manually. The samples later were taken to laboratory to undergo a standard laboratory procedures to measure its moisture content. The wet soil was weighted and then put in the laboratory oven with temperature of 110ºC for 24 hours. After that, the soil was weighted once again to measure the dry soil. Then the moisture content was identified using the below formula and then is expressed as a percentage;

$$MC = \frac{W - D}{W} \times 100$$

where ;
MC = moisture content
W = wet soil weight
D = dry soil weight

Results and discussion

The data taken were analyzed to see the relationship of soil tillage on soil compaction and soil moisture content. Generally, there are two or three times of ploughing process which depend on farmers. But three times is better than two times plough in order to get fine clay soil and more nutrient can be taken up from soil. The first ploughing should be done in dry condition. For the second and third ploughing the soil should be in wet condition. However, in this study the data was taken during rainy season. Therefore, for the first plough, the soil was in wet condition and the paddy field was filled by water. The ploughing process undergo two times only due to weather condition.

Figure 3 exhibits the results of average soil compaction for four plots in two acres paddy field. Each plot have different value of compaction where Area B has the highest value of 273.33 psi while Area C has the lowest reading of 187.78 psi before tillage. Beside the different readings of compaction value, all plots show reduction from before tillage to the second plough session. It shows that, every ploughing session will loosen the soil further. Area B has shown a higher reduction of compaction reading compared to the other three where the total reduction is 32.22 psi.

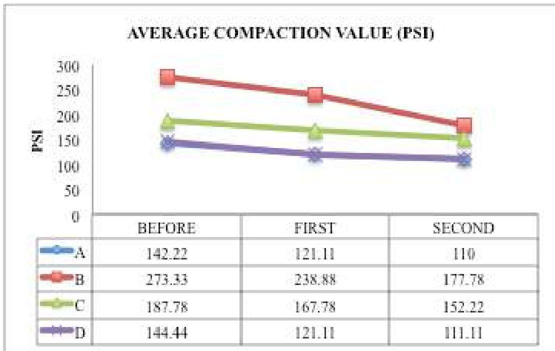


Figure 3: Average compaction reading for four paddy plots

The soil samples that were taken from the same plot of soil compaction readings have undergone drying process. The reason is to reduce the water content in the soil by heating so the value before and after drying process can be used to determine moisture content. As can be seen in Fig. 4, the hardest soil which is Area B contains the lowest percentage of moisture (22%). Moisture content are slightly lower in soil before tillage compared to after first and second plough. The graph shows an increment in moisture content percentage in all plots. As for moisture content, Area B shows an increment from before tillage to after tillage and slightly higher than other plot areas.

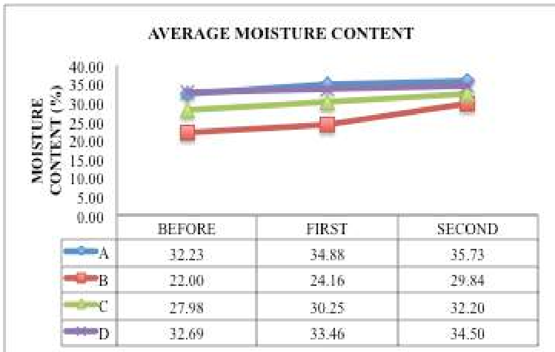


Figure 4: Average soil moisture content from four paddy plots

The results show that measurement of soil compaction has correlation with the moisture content. Referring to Fig. 3 and Fig. 4, the lower soil compaction, the higher percentage of soil moisture content. the highest compaction value after second round of ploghing is 177.78 psi with moisture content 29.84% while the lowest is 110 psi with moisture content of 35.73%. The average values of soil compaction before and after first and second tillage are 186.94 psi, 162.22 psi and 137.78 psi with average moisture content 28.73%, 30.69% and 33.07% respectively

Conclusion:

The change of soil condition can be identified by compaction and moisture content. The results show that the more ploughing process, the lower soil compaction and the higher percentage of moisture content in wet soil condition. Furthermore, the compaction process does not only occur during ploughing but the movement of heavy vehicle and traffic-related activities on soil as well. The higher the compaction, the lower the soil pores and the lower the moisture content. From this study, it was found that tillage can affect the soil compaction and soil moisture.

References:

Badalíková, B. (2010). Influence of soil tillage on soil compaction. In *Soil Engineering* (pp. 19-30). Springer, Berlin, Heidelberg.

FAOSTAT. 2019. Food and Agricultural Organization Annual report. Rome, Italy: F.A.O.

Hobbs, P. R., Sayre, K., & Gupta, R. (2007). The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 543-555.

STATISTA (2019). Average yield of paddy in Malaysia from 2012 to 2016. Retrieved from https://www.statista.com/statistics/795760/yield-of-paddy-malaysia/

Verma, A. K., & Dewangan, M. L. (2006). Efficiency and energy use in puddling of lowland rice grown on Vertisols in Central India. *Soil and Tillage Research*, *90*(1-2), 100-107.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA13

Effect of Field Speeds of Rice Combine Harvester on Grain Loss: A Preliminary Evaluation in Malaysian Paddy Fields

Shamilah, A. M., Darius, E. P. *
Faculty of Plantation and Agrotechnology
Universiti Teknologi MARA Melaka
77300 Kampus Jasin, Merlimau
Melaka, Malaysia
*Corresponding author. Tel.: +606-264-5297, Email: darius@melaka.uitm.edu.my

Abstract
Combine harvester is one of the important farm machinery that universally used in rice harvesting to overcome the labor shortage problem in Malaysian paddy fields. The machine is generally used in the harvesting of rice in the rice granaries of the country. However, the excessive grain loss during rice harvesting in Malaysia is still problematic. Among the factors of causing the significant grain loss is the field speed of the combine harvester. A preliminary study was conducted to investigate the effect of combine field speeds on grain loss in Malaysia paddy fields. This study was able to determine the most suitable combine field speed in rice harvesting with minimum the grain losses. The field speeds have a linear relationship with grain loss. The best speed with was found to be 3.87 km/hr, which contributes only 0.67 % grain loss or equal to RM8.04/ha of profit losses. Conclusively, the results can encourage the improvement of mechanization quality in rice harvesting and help in reducing rice farmer's profits losses.

Keywords: combine harvester, grain loss, mechanization, paddy cultivation, harvesting

Introduction

Utilization of combine harvester is becoming a success solution to overcome shortage of labor for harvesting paddy in Malaysia. To date, the machines are commonly being operated to harvest almost all rice fields throughout rice granaries in the country. However, the persistent issue in mechanized paddy harvesting using combine harvester is that how to minimize the grain loss.

Consequently, in order to reduce grain loss, the factors that cause extreme grain loss should be identified. One of the factors that have been studied that give excessive of grain loss during harvesting is the field speed of combine harvester. For minimizing grain loss, Mansouri and Minaei (2003) suggested the field speed of combine harvester should be in-between 1.25 km/hr to 1.50 km/hr. They said field speed affects the grain loss. The grain loss increased with increasing field speed of combine harvester during harvesting. Hunt and Wilson (2016) admitted that the most significant factor to maximize the combine harvester performance is field speed. When the field speed of combine harvester is too fast, it increased the field efficiency, but decreased the material capacity as there is grain spill out on the ground. Therefore, proper combine field speed can minimize the grain loss.

Nowadays it is believed that many operators of combine harvesters in Malaysia do not yet give great attention on the effect of field speed of combine harvester on grain loss. Even it is not yet known the current field speed of combine harvester applied by the operators in the fields and how its effects on the grain loss because no the suitable standard field speed for combine harvester operation in Malaysia revealed in the research literatures. The available field speed of self-propelled combine harvester provided by the American Society of Agricultural and Biological Engineers (ASABE) suggests the typical field speed should be 5.0 km/hr, and within the ranges of 3.0 km/hr to 6.5 km/hr (ASABE Standards, 2011).

Thus, there is a need to investigate the effect of current field speed of combine harvester on grain loss in Malaysian paddy fields. This paper is a preliminary attempt to evaluate current field speed of combine harvester and its effect to the grain loss. Current field speeds practiced by the operators in paddy fields were measured and evaluated. This study would hopefully lead to the findings of the best field speed of combine harvester with lowest grain loss during the harvesting of paddy under Malaysian conditions.

Materials and methods

This preliminary study was conducted through direct field measurements on daily harvesting operations at Bagan Serai, Perak state of Malaysia from July to September 2017. The fields were planted with certified paddy variety MR 220 and were divided into three plots. A New Holland Clayson 1545 combine harvester was operated in the study area. Details of specifications of the combine harvester used in the study are in Table 1. The paddy age was 110 days old, and average ambient temperature was 32 ˚C. Grain moisture was in the ranges of 5 to 10%, while mean soil moisture content was 3.45%. The perpendicularly position of planted paddy to ground was averaged at 88˚ tilt angle. The field speed of combine harvester was measured based on the time taken by the combine harvester at 30 m travel distance. The travel distance was measured with a measuring tape and the time spent was counted with a stop watch. Such operation was replicated in three times for each plot in order to obtain the average field speed of combine harvester for three days duration. The effective field speed was calculated by dividing the travel distance by time required to travel within that distance. As for the measured the grain loss, five quadrats with an area size of 1m x 1m were placed randomly inside each plot. The average loss per plot was measured and calculated. Spreadsheet software was used to analyze the collected data. Correlation analysis was made to explain the relationship between fields speed and grain loss.

Table 1. Specifications of the Combine Harvester

Brand	*New Holland*
Model	*Clayson 1545*
Engine type (model/version)	*2715E*
Engine capacity	*6220 cm3*
Power	*96 kW*
Engine fuel tank	*250 L*
Header width (working)	*457 cm*
Reel diameter	*107 cm*
Diameter of cylinder threshing mechanism	*60 cm*
Width of cylinder threshing mechanism	*127.5 cm*
Maximum speed	*21.4 km/hr*

Results and discussion

Table 2 shows the highest loss related to maximum field speed and vice versa. Generally, the grain loss in the study area ranged from 0.83% to 2.50%.The highest value of grain losses is 2.50 %, 2.20 %, and 1.80 % were recorded at field speeds of 6.11 km/hr and 5.81 km/hr. These losses caused profit losses amounting to RM30/ha, RM26.40/ha and RM21.60, respectively. The field speeds of 3.87 km/hr and 3.97 km/hr resulted in the lowest grain losses of 0.83 % and also the lowest profit losses, which accounted for RM8.04/ha. In spite of this, generally all the replications showed an increasing trend in the grain loss with respect to the increase in forward speed from 3.87 km/hr to 6.11 km/hr. It is obvious that more vibration occurred in the header unit of the combine harvester as the field speed increased. Moreover, the incompatibility between the reel speed and field speed of the combine harvester also increased the amount of grain scattered from the spikes.

As found by Stephen (1981), who informed that grain loss in the cutting, threshing, separation, and cleaning units would be increased by increasing field speed of combine harvester. The extreme field speed of combine harvester could lead to push out dry spikes forward, breaking grain, and also spill out some of grain to the ground which may increases the losses (Ramadan, 2010). The current findings agree with the pervious findings of many researchers, such as Ali et al., (1990) who studied about a self-propelled rice combine harvester. They reported that rising travel speed from 0.80 to 2.90 km/h may also increase grain loss. The same thing also has been reported by Qarnar-uz-Zaman (1992), who proved that losses increased as increasing field speed. Junsiri & Chinsuwan (2009) also indicated that head grain loss increased with increase in reel rotational speed. While Mansoori & Minaee (2003) said that there is the effect of field speed on header loss, and it indicated that header loss increased thru increasing field speed.

Figure 1 shows the relationship between field speed and grain loss. The regression data in the graph was almost certainly defined as a straight line. It means that the effect of field speed as dependent variable on grain loss was very strong positive, where the higher field speed of combine harvester, the higher grain loss. To predict the grain loss, a simple mathematical model was also successfully developed from the regression analysis as shown in Equation (1):

$$GL=0.6873FS-1.966 \qquad r^2 = 0.9402 \qquad (1)$$

Where:
GL = estimated grain loss (%)
FS = field speed of combine harvester (km/hr)

Having r^2= 0.9402, this model proves a strong relationship between variables and it can be considered as highly acceptable model.

Table 2. Field Speeds of Combine Harvester and Grain Loss

Day	Field speed (km/hr)	Grain loss (%)
	6.11	2.50
	6.11	2.20
1	5.81	1.80
	4.25	1.00
	4.25	1.20
Average	5.31	1.74
	4.51	1.20
	4.51	1.00
2	3.97	0.83
	5.22	1.50
	5.22	1.70
Average	4.67	1.25
	4.41	1.00
	4.41	1.00
3	3.87	0.67
	4.14	0.83
	4.14	0.83
Average	4.19	0.87

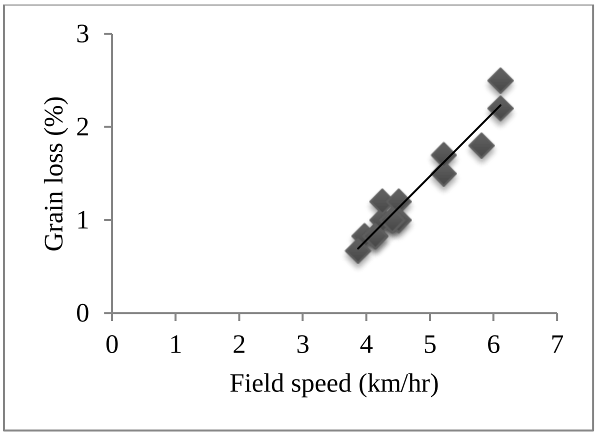


Figure 1. Relationship between field speeds of combine harvester with grain loss

Conclusions

A study to investigate the current effect of field speed of combine harvester on grain loss in rice harvesting in Malaysian paddy fields has been successfully conducted. This study proved that the field speeds of combine harvester affect the grain loss during harvesting. The best field speed was found to be 3.87 km/hr, which significantly gave the lowest grain loss around 0.67%, which also contribute to the profits losses of RM8.04/ha. The field speeds were suggested to be not more than 6.11 km/hr since it can give 2.50% of grain loss or equal to the highest profit losses of RM30.00/ha.

As the results revealed the grain losses increased with increasing of combine harvester's field speed. Therefore, important to educate the operators about the field speeds range in order to increase the farmers' profits. In order to minimize grain loss with mechanized harvesting, the relevant government agency was suggested to improve the extension services such as regular training to the combine harvesters' operators. It was also advocated to enhance the operators' awareness in regards to the importance of grain loss on the economic viability among farmers. The findings of this current study enriched knowledge in management of grain loss with mechanized rice harvesting. In fact, the results can also encourage the improvement of mechanization quality in rice harvesting and help in reducing rice farmer's profits losses.

References

Ali, A., Majid, A., Rehman, H., and Sagar, M. A. (1990). Milling recovery of Basmati as affected by threshing methods and crop harvesting time. Pakistan J. Agric. Res. 11, 7-12.

ASABE Standards. (2011). Agricultural Machinery Management Data. American Society Of Agricultural and Biological Engineers.www.asabe.org.

Hunt, D. and Wilson, D.(2016). Farm Power and Machinery Management. John Wiley and Sons.

Junsiri, C. and Chinsuwan, W. (2009). Operating parameters affecting header losses of combine harvesters for Chainat 1 rice variety. KKU Research journal 14 (3), 314-321.

Mansouri, H. and Minaei, S.(2003). Assessment of Machine Parameters Effect on Wheat Loss in Combine JD 955. Abstract of Paper on First National Conference of Assessing Agricultural Crops Wastes. Agricultural Faculty of Tarbiat Modaress University. Tehran, Iran.

Qarnar-uz-Zaman, A., Chaudhry, D., and Asgharrana, M (1992). Wheat harvesting losses in combining as effected by machine and crop parameters. Pakistan Journal of Agricultural Science, 29(1), 1-4.

Stephen, D. H. (1981). Combine losses compared. Power Farming Magazine. 60 (9), 28-29.

Ramadan, G. M. (2010). Effect of forward speeds for two types of combines on quantity loss of wheat. Journal of Tikrit University for Agriculture Sciences (JTUAS). 10(1), 247-254.

Comparetive Field Performances and Quality of Conventional Combine and Mid-Size Combine in Wetland Rice Cultivation in Malaysia

S. Elsoragaby[1,*], A. Yahya[1,*], M. Mairghany[1], N. Adam[2], M. Mahadi[1], N. Nawi[1], A. Su[3]
[1]Dept. of Biological and Agricultural Engineering Faculty of Engineering University Putra Malaysia 43400 Serdang, Selangor D.E.
[2]Dept. of Mechanical Engineering Faculty of Engineering University Putra Malaysia 43400 Serdang, Selangor D.E.
[3]Dept. of Agricultural Technology Faculty of Agriculture University Putra Malaysia 43400 Serdang, Selangor D.E.
*Corresponding author. Tel.: +601-176607071, Email: *suha.star.mees@gmail.com*
*Corresponding author. Tel.: +601-92168335, Email: *azmiy@upm.edu.my*

Abstract
In paddy cultivation, harvesting is the most important operation, which needs suitable machinery. Thus, this study was carried out to compare and evaluate field performances, grain quality and harvesting grain losses of conventional 5 m cutting width NEW HOLLAND CLAYSON 8080, combine running on a total net area of 42.78 hectares and the new mid-size 2.7 m cutting width WORLD STAR WS7.0, combine running on a total net area of 16.95 hectares of plots for two rice (Oryza sativa L.) cultivation seasons. The conventional combine as compared to mid-size combine showed 14.4% greater mean fuel consumptions, 31.1% greater mean effective field capacity, 20.90% lesser mean operational speed and 10.8% lesser mean field efficiency. In terms of quality of harvested grain the conventional combine showed 9.48% lesser mean whole and healthy grain and 2.29 times greater mean broken grain and 85.78% greater mean foreign materials and 8.97 times greater mean empty grain than the mid-size combine. In terms of grain losses, the conventional combine showed 2.06 times greater mean total losses, 2.94 times greater mean cleaning losses, 1.03 times greater mean unthreshed losses than the mid-size combine. The results revealed that the mid-size combine is more suitable in conducting the harvesting operation in rice cultivation in Malaysia than the conventional combine.

Keywords: Wetland Rice Cultivation, Rice Combine, Field Machinery Performances, Grain Quality, Harvesting Losses.

Introduction

Maintaining working conditions and optimal performance of combine harvesters is a vital importance in agricultural and rice production due to the timeliness factor. The planning and selection of equipment for the harvest of crops can greatly impact the performance and profitability of a farm. The type and size of equipment used to affect the harvested yield and nutritive value of the crop as well as production costs (Rotz, 2001). The performance of combine harvester should work in trend for reduced grain losses in order to produce the highest quality and quantity of rice. Grain losses during harvest represent a direct loss of income for the farmer. In some countries, it is perceived that the reasonable small grain loss should reach a maximum of 3 % of the total crop yield (Wiersma and Allrich, 2005). Adam & Pebrian, (2017) reported in their survey about harvesters in Malaysia that the farmer complained about the amount of harvested grain losses and quality of harvested grain of the conventional combine harvester. Broken grain is reducing the quality of grain as it leads to a reduction in the percentage of germination (R.Bawatharani et al., 2016). Broken grain means that organisms can easily penetrate the broken grains so that breakage can lead to difficulties in the storage of the grain, a factor affecting grain quality. Rice crop is too sensitive to harvesting operation due to the high percentage of grain losses affecting total yield. Hence, efficient harvesting and its quality of work are the main concern for the farmers and first customer to reduce grain losses and increase the grain quality.

It has been for decades in Malaysia that harvesting of rice is done using a 5 m cutting width and 5 ton capacity self-propelled rice combine harvester. This combine has been used because of its good effective field capacity to justify the short time slot that is available for the farmers in the harvesting of the crop. In the most occasion, the field harvesting operations have to be completed as soon as possible to minimize the yield losses of the overripe crops due to the incoming weather storm. However, the used of these combines have been reported to give several operational problems. Among the problems includes, bogging of the combine during operation especially on soft and watery terrain, slightly high grain losses during the harvesting operations, higgh percentage of broken grain and substantial damage to the terrain surface. Thus, with mid-size combine, there might be a possibility of less destruction to the field surface terrain and perhaps to the extent of reducing the grain losses, reducing broken grain and increasing the field effeciency. The quality of work in the harvesting operations with such combine could be much easier to achieve than the currently used combine.

An initiative was taken up here to compare the field performance of conventional combine harvester NEW HOLLAND CLAYSON 8080, 82 kW@2500 rpm and the newly introduced mid-size combine harvester WORLD STAR WS7.0 PLUS WS7.0, 76 kW@2600 rpm under the actual field harvesting operation in the real field conditions for two rice cultivation seasons in Malaysia. Specific objectives of this study to compare and evaluate working performance, grain quality and harvesting grain losses of these two combines.

Materials and methods

Study area

The chosen study area was located at (3º29´47´´N and 101º09´56´´E) in Sungei Burong, Kuala Selangor. Table 1 compares the technical specifications between the two combines. The involved field tests on the two combines were conducted in two cropping seasons; June to November 2017 for the first season and January to June 2018 for the second season. The paddy area is located within the total area that is under the management of North West Integrated Agricultural Development Authority (IADA) Rice Scheme. In the first season, 30 farms were involved in the data collection. While in the second season, 32 farms were involved, where 43 farms were harvested by using the 5 m cutting width conventional combine and 19 farms were harvested with the 2.7 m cutting width mid-size combine harvester. The farms that were harvested by the conventional combine in the two seasons involved a total area of 44.72 ha with average size area of 1.04±0.07 ha while the farms that were harvested by the mid-size combine involved a total area of 16.95 ha with average size area of 0.89±0.13 ha. Harvestings of the crop in the first season were conducted from 14 to 30 November 2017 while harvestings of the crop in the second season were conducted from 25 May to 18 June 2018. The recorded average crop yield in the first season was 6.7 ± 0.05 ton/ha and in the second season was 7.04 ± 0.05 ton/ha.

Table 1: Technical specifications of conventional combine and mid-size combine

Parameters	Conventional Combine	Mid-size Combine
Name	NEW HOLLAND combine	WORLD STAR combine
Model	CLAYSON 8080	WS7.0 PLUS
Max power	82 kW	75KW
Rated speed	2500 rpm	2600 rpm
Total weight	10000 kg	3400 kg
Tracking tire	Half-track	Full track
Fuel type	Diesel	Diesel
Fuel tank capacity	350 l	130 l
Grain tank capacity	3.5 ton	0.80 ton
Unloading discharge	8.70 kg/s	1.68 kg/s
Working width	5m	2.2m
Worker	1-2 Person	1 Person

Field performances

The measured combine field performance parameters include speed of operation, theoretical field capacity, actual field capacity, field efficiency, labor hour and fuel consumption. Field efficiency is the ratio between the harvester's productivity under actual working conditions and the theoretical maximum possible productivity and it calculated as shown in equations 1, 2 and 3 as defined by ASAE standards S495.1. (ASAE Standards, 2005 & Amponsah et al., 2017a)

$$\text{Field efficiency } \% = \frac{Effective\ field\ capacity}{Theoretical\ field\ capacity} \times 100 \quad (1)$$

$$\text{Effective field capacity, ha/h} = \frac{Total\ area,\ ha}{Total\ operation\ time,\ h} \quad (2)$$

$$\text{Theoretical field capacity} = \frac{Total\ area\ harvested, ha}{Effective\ operation\ time, h} \quad (3)$$

The fuel consumed by the conventional combine was determined by refilling the combine fuel tank back to its full capacity after the harvesting operation using a measuring cylinder as defined by ASABE standards D497.7, 2011 (ASABE Standards, 2011 & Amponsah et al., 2017b). While the fuel consumed by the mid-size combine was determined by directly reading of the difference in the fuel level gauge of the combine fuel tank after the harvesting operation.

Harvesting losses

Pre-harvest losses were determined by placing the wooden frame of 0.5m×0.5m mentioned above, randomly through standing crop in twelves different locations in each farm before the combine harvester entered the plots. Loose grains and panicles fell on the ground were collected within the quadrate and weighed as in (Bawatharani, 2013), and the percentage of pre-harvest losses was calculated by using the following equation,

$$\text{Preharvest losses } \% = \frac{Mass\ of\ collected\ grains, kg}{Total\ mass\ of\ grains, kg} \quad (4)$$

The harvesting losses (threshing and cleaning losses) were determined, at twelve different places randomly selected within the harvested area.
The area from where the sample was collected was 0.5 m in the direction of combine travel using metal frame 0.5m×0.5m. threshed and unthreshed grain fallen in the metal frame after the machine has run over it was picked up manually, all grains and panicles inside it gathered and weighted (Alizadeh & Allameh, 2013).

Grain qualty
To determine percentage the of whole healthy grain, broken, cracked, husked grains, and the impurities, randomly ten samples of 100g rice was taken from the tank of rice combine harvester from each farm and then broken and husked grains and any material other than grain were collected and separated manually and weighted, then the whole healthy grains were determined (Srivastava et al., 1998; Alizadeh & Allameh, 2013). The broken grains, husked grains were determined for quality losses, weed seed, straw or any other material were taken out manually and weighed employing an electric digital balance.

Statistical analysis
Data were subjected to analysis of variance T test using the statistical software of MINITAB. Variable means found to be significant were compared using 5% level of probability.

Results and discussion
Field performances
Table 2 and Figure 2 indicate that conventional combine shows 31.1% greater mean effective field capacity (0.69 versus 0.53 ha/h), 10.8% lesser mean field efficiency (0.64 versus 0.72), 14.4% greater mean fuel consumptions (21.13 versus 18.46 l/ha), 1.43 times greater mean effective working width (4.40 versus 1.81 m) and 20.9% lesser mean operation speed (3.24 versus 4.1 km/h) than the mid-size combine. The operating speed of conventional and mid-size was within the recommended operating speed of 3 to 6.5 km/h range for harvesting operation with a self-propelled combine by ASABE (ASAE, 2000). The advantage of having large working width makes the conventional combine to have greater field capacity even though with a field operating speed that is much lower than the mid-size combine. Alizadeh et al. (2013) found that the theoretical and effective field capacities of whole-crop and head-feed combines were 0.495 and 0.361 ha/h, respectively.

Table 2: Comparison of field performances between conventional and mid-size combines

Performance	Conventional	Mid-size	p value	Difference
Operating Speed, km/h	3.24±0.19§	4.10±0.28	2.26E-08***	-20.9%
Effective Field Capacity, ha/h	0.69±0.05	0.53±0.071	0.00262**	+31.1%
Field efficiency	0.64±0.04	0.72±0.12	0.00431**	-10.8%
Fuel Consumption, l/ha	21.13±0.95	18.46±0.91	0.0035**	+14.4%
Effective cutting width, m	4.40±0.08	1.81±0.05	1.91E-23***	+1.43

***Significant at α = 0.001 and **Significant at α = 0.01
§ At 95% confidence interval

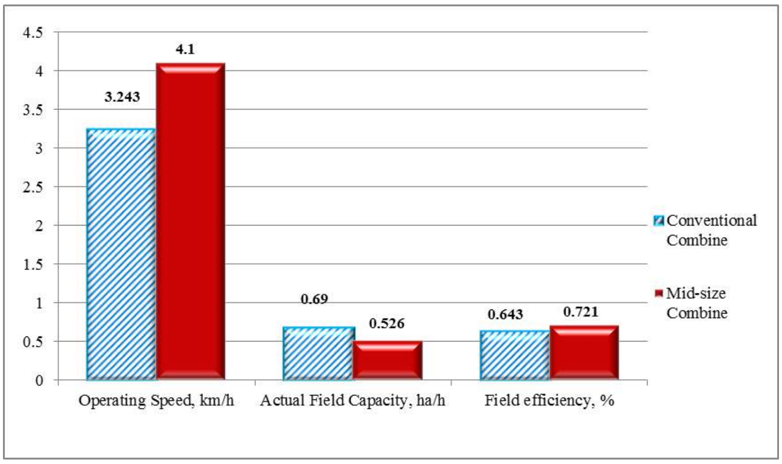


Figure 2: Comparison of field performances between Conventional and mid-size combines

Harvesting quality
The conventional combine harvester showed 9.48% lesser mean whole and healthy grain (87.32% versus 96.47%), 2.29 times greater mean visible broken grain (2.37% versus 0.72%), 85.78% greater mean empty grain of rice (4.05% versus 2.18%) and 8.97 times greater mean foreign materials (dockage and rubbish) (6.28% versus 0.63%) than the mid-size combine harvester (Table 3, Figure 3 & Figure 4).

This result agreed with the findings of Ahuja, (2016); Masek et al. (2016) and Sinha et al. (2014) they found that the grain breakage in axial flow cylinder was lesser than tangential threshing system cylinder. Bansal & Lahan, (2009) reported that the axial flow machines result in minimum seed damage with higher output and threshing efficiency. They found that the lesser grain damage in using the axial thresher than in using the conventional thresher.

Table 3. Quality of collected grains in grain tank of combines

Parameter	Conventional Combine		Mid-size Combine		p-value	Differences
	Weight, gm	% Total	Weight, gm	% Total		
Whole grain	87.32±1.168§	87.32	96.470±0.771	96.47	1.22E-19***	-9.48%
Broken grain	2.37±0.358	2.37	0.720±0.168	0.72	3.38E-11***	+2.29
Empty grain	4.05±0.569	4.05	2.183±0.542	2.18	1.08E-06***	+85.78%
Foreign materials	6.28±0.619	6.28	0.631±0.110	0.63	1.01E-20***	+8.97

***Significant at α = 0.001
§ At 95% confidence interval

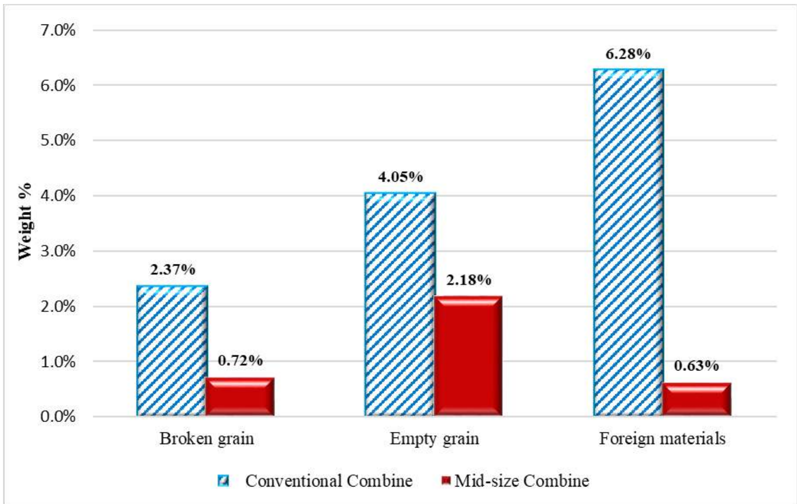


Figure 3. Quality of output grain for conventional and mid-size combine harvesters

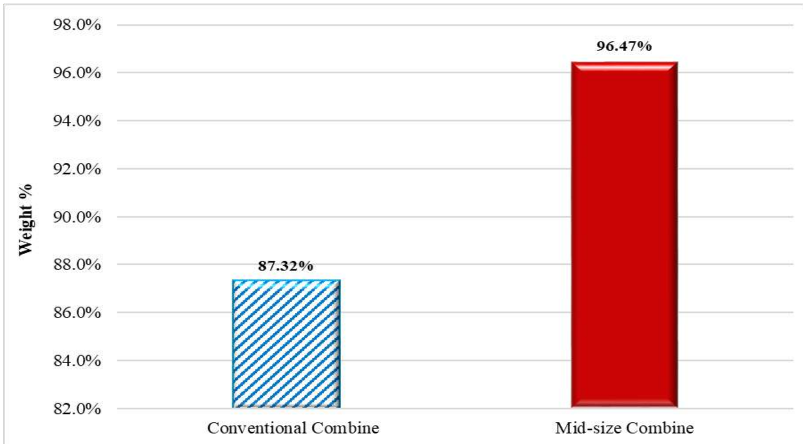


Figure 4. Whole and healthy grain of the conventional and mid-size combine harvesters

Grain losses

From Table 4 the conventional combine showed 2.06 times greater mean total grain losses (52.29 and 17.10 g/m^2), 31.04% greater mean pre-harvesting loss (3.25 and 2.48 g/m^2), 1.03 times greater mean threshing loss (16.15 and 7.94 g/m^2) and 2.94 times greater mean cleaning grain losses (36.14 versus 9.08 g/m^2) than the mid-size combine harvester (Figure 5). This result was similar to (Ahmad et al., 2005; Sinha et al., 2014) Our result revealed that the mid-size combine harvester has a lower percentage of grain losses which supported with the finding of Khan, (1986) he reported that use of axial-flow threshers in tropical producing countries have substantially reduced crop losses an estimated 2 to 5% grain has been saved. Miu, (2014) reported that in his study that the axial units have lower grain losses than the tangential threshing units. He reported that the conventional combine harvester has lower separation efficiency than the mid-size combine (92.79 and 97.72%) this led to limit grain separation and throughput of straw walkers in conventional combines and this one of the main reasons that led to the integral transfer of their function to the axial threshing units.

Table 4. Harvesting losses of combine harvesters

Parameter	Conventional Combine		Mid-size Combine		P value	Differences
	Weight, g/m^2	% total	Weight, g/m^2	% total		
Pre-harvesting loss	3.25±0.38	0.44	2.48±0.06	0.34	0.002**	+31.04%
Threshing loss	16.15±0.68	2.40	7.94±0.77	1.08	1.49E-29***	+1.03
Cleaning loss	36.14±0.94	5.38	9.16±0.22	1.25	1.26E-40***	+2.94
Total loss	52.29±1.18	7.78	17.10±0.81	2.37	3.49E-49***	+2.06

***Significant at α = 0.001 and **Significant at α = 0.01

§ At 95% confidence interval

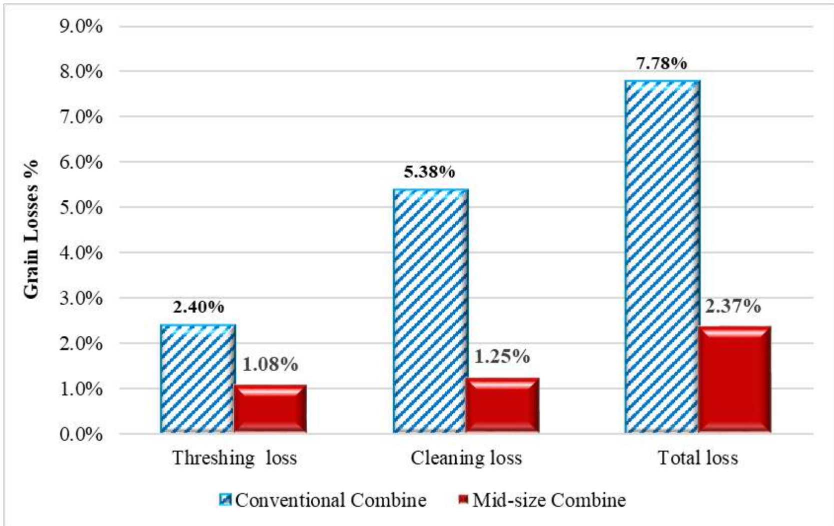


Figure 5. Total, threshing and cleaning losses of the conventional and mid-size combine harvesters

Conclusions

This study presents a comparison of the working performance, the grain qualty and harvesting losses of two combines (one conventional combine and one newly introduced mid-size combine harvester) under the actual field harvesting operation in the real field conditions for two rice cultivation seasons in wetland rice cultivation in Malaysia. From the results of the study the following conclusions are drawn:

- Although, the effective working width of the conventional combine was 1.43 times greater than the working width of mid-size combine but the conventional combine shows 10.8% lesser mean field efficiency than the mid-size-combine harvester (64% versus 72%).
- Based on the results, we can see that the mid-size combine separation devices doing better compared to the conventional combine harvester. The highest average content of whole grain weight was recorded in the harvested mass of mid-size combines.
- In contrast to conventional combine, the mid-size combine has the ideal threshing unit which produces a perfect threshing of maximum crop throughput, with optimum grain separation and preserving the natural shape and quality of grains and minimizing grain loss.
- Based on these results, we concluded that the mid-size combine harvester worked better than the conventional combine harvester, with lesser losses of rice grain, greater whole grain with a significantly lower share of impurities and less damage to the grain in relation to conventional combine harvester. It is concluded that the mid-size combine harvester is more suitable for rice harvesting than the conventional combine harvester.

References

Adam, N. S., & El Pebrian, D. (2017). Factors affecting farmers' satisfactions with mechanized rice harvesting in Malaysian paddy fields: A case study of hiring custom operators. Agricultural Engineering International: CIGR Journal, 19(2), 120-128.

Bawatharani, R., Bandara, M. H. M. A., & Senevirathne, D. I. E.). (2016). Influence of Cutting Height and Forward Speed on Header Losses in Rice Harvesting. International Journal of Agriculture, Forestry and Plantation, Vol. 4.

Bawatharani, R., Jayatissa, D. N., Dharmasena, D. A. N., & Bandara, M. H. M. A. (2015). Impact of reel index on header losses of paddy and performance of combine harvesters. Tropical Agricultural Research, 25(1), 1. doi:10.4038/tar.v25i1.8025.

Alizadeh, M. R., & Allameh, A. (2013). Evaluating rice losses in various harvesting practices. Int. Res. J. Appl. Basic Sci, 4, 894-901. Srivastava, A. K., Goering, C. E., & Rohrbach, R. P. (1993). Engineering principles of agricultural machines. American society of agricultural engineers.

Ahuja, M. (2016). Studies on axial flow paddy thresher equipped with modified mechanical feeding systems (Doctoral dissertation, Punjab Agricultural University, Ludhiana).

Masek, J., Kumhala, F., Novak, P., & Fic, T. (2016). Influence of different threshing system design on grain damage. In proceedings of the international scientific conference. Latvia University of Agriculture.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA15

Development of Aqua-loader for Fish Farming

T.S. Marliza[1,*], A.D. Kupo[1], S. Rimba[1], L.Rameli[1], N.U. Arang[1], A.A. Habari[1] and W.N.Z.Z. Abdullah[1]
[1]Department of Basic Science and Engineering, Faculty of Agriculture and Food Science, Universiti Putra Malaysia, Bintulu Campus, 97008 Bintulu, Sarawak, Malaysia
*Corresponding author. Tel.: +6086-855430, Email:t_marliza@upm.edu.my

Abstract
Aqua-loader is a multifunction machine that use for harvesting, grading, weighing, and packing the fish. This prototype has been developed in order to conduct a better management in aqua farming that consume cost and time. The objectives of this project are to reduce the time taken in the management of fish farming, to save cost in handling of the fish farming and to suggest a better management to the whole fish farming that can reduce a lot of management errors. Aqua-loader offer valuable benefits to the farmers, which is reducing the cost of labour, to enhance the quality of the product and increase productivity. Aqua-loader also offer a proper and good management for aquaculture and fish industry.

Keywords: aqua, fish farming, multifunction machine, cost, management

Introduction

The industry of aquaculture is growing nowadays since it is one of the main sources of food. Therefore, the development of technology for aquaculture industry purposes was also increased. However, the aquaculture industry still needs more advance technology to fit the capacity and also to make the management more organized with the usage of more efficient technology or machinery (Jena et al., 2017). Therefore, Aqua-loader was developed to fulfil the industry needs.

Major type of aquaculture yield cultivated including fish, crab and prawn. Those species required a very proper management that sometimes cannot be fulfilled by using current methods and technologies to control the quality (Kelleher and Weber, 2006). This is because some of the process of harvesting are supposed to be done quickly within a very short period of time to maintain the freshness (Summerfelt et al., 2009). For example, in order to control the freshness of barramundi species, those fishes must be located inside the ice tank before they die off (Towers, 2010). So, a machine that can perform many tasks at the same time is needed to shorten the period of harvesting process.

The Aqua-loader has been developed by combining a few functions that supposed to be done in a short period of time to maintain the quality and freshness of the aquaculture yield. The Aqua-loader has been designed to perform harvesting, grading, weighing, and packing the fish.

Methodology of the prototype

The aqua-loader was designed by hand drawing. The design sketched included the component of the aqua-loader. After the designed was released, the materials that will be used to make the prototype were determined and process for the making of the prototype begin.

Materials

The main materials used to make the prototype is Styrofoam board. The real net was used as a fish net and the bamboo stick skewer was used in the hydraulic system on the aqua-loader. The basic requirement such as hot glue gun, scissors, cutter, glue stick was needed. All the requirement materials used to make the aqua-loader prototype were purchased from nearby local suppliers.

Method

After all the basic requirements and the design was ready, the Styrofoam board was cut into a piece base on the part of the aqua-loader designed. After that, the piece of the Styrofoam board was combined using a hot glue gun to form the body of aqua-loader. When the body was ready, each compartments were combined to the body such as the netting, platform and the driving area. The prototype of aqua-loader is shown in Figure 1.

Figure 1: Aqua-loader

Functions

The first function of Aqua-loader is to harvest the fishes collectively. Aqua-loader has been design with a giant net at the front side. The net's radius was adjustable so that the opening can be adjust according to the size of pond and the routes. The front net was connected to the main body using a hydraulic connections to make it movable.

Aqua-loader was also designed to perform grading process. After the fishes trapped inside the net, the net will be lifted then the fishes will go inside a tunnel-like part which is located underneath the body of the machine. At the end of the this part, a few grates with different hole sizes will sort the fish according to their size. Inside the vertical grading tank, the grates will separate and create some spaces in between. The grate placed from the smallest at the bottom and biggest at the top. Small fishes will go down first then followed by the bigger one. Hence, the size of the fishes will be graded according to the different size of grates. Aqua-loader also designed to perform packing process. After the fish was graded inside the grading tank, the fishes will be taken out through a conveyer to be placed into fish boxes that located on top of the weighing scale. , this process make the fishes stored in box in a short time after it was harvested.

Besides that, Aqua-loader also perform weighing process. When the fishes enter the fish boxes, the weight of the box will be recorder by the weighing scale under the boxes. After the weight has been recorded, ice will be added and the conveyor bring the box to the storage area. The boxes are arranged properly in order to control the stability of the machine.

Advantages

Tractors have traditionally been used on farms to mechanise several agricultural tasks. These modern aqua-loader tractors are used for harvesting, grading, weighing and packaging the fish. Aqua-loader tractors offer benefits for large scale fish farming and provide proper and good management. This article discusses the various benefits of using aqua-loader tractors to mechanise aquaculture activity.

Wide range

Aqua-loader tractors are available in a wide range of options to suit specific tasks and requirements. Subcompact or compact tractors available in a horsepower range from 15hp to 40hp are ideal for heavy duty. Aqua-loader are designed to carry a task not only at the water, but also can move on the ground to ease the movement from one pond to another pond.

Aqua-loader also known as diesel tractors, utility tractors are recommended for mechanising complex farming tasks and come in different models with a horsepower range from 45 hp to 110 hp. A wide range of fish farming implements can be attached to utility tractors to help accomplish various jobs.

Versatility

Modern tractors are designed and manufactured to offer versatility in performing a wide range of tasks in fish farming. Compact tractors can accomplish tasks ranging from harvesting, grading the fish, weighing until the packaging automatically, with the ability to do more by attaching various implements such as front loaders or buoy to add their buoyant force.

Power and durability

Aqua-loader tractors are typically designed with powerful engines to run over in a pond and pull extremely heavy loads, making them effective in fish farming tasks. Aqua-loader tractors also come with cast iron front axles for extra strength and durability. It has been designed with a giant net at the front side.

Ease of transmission and operation

Modern tractors feature powershift transmission and hydraulic transmission to simplify the operation. These tractors are also equipped with power steering to make turning much easier, oil immersed brakes and high-speed gearbox**.** Advanced models help reduce operator fatigue with exclusive shift controls and an automatically responsive transmission.

Proper Management

During the process of harvesting the fish from the pond, problems may occur during harvesting until the packaging. Grading process usually done manually and always have an error. Aqua-loader will ease the process and the grading process can be done more accurate.

Specification

The development of this aqua-loader comes with a certain specification that needed to be considered for it to be well-function. One of the main specifications that needed to be considered in developing this machinery is the type of engine. For it to function as how it is designed to be, this Aqua-loader need to be supported by a four-stroke engine. This is because, a four-stroke engine is very suitable for a long life term condition so it can reduce the operating costs. Moreover, it is more reliable and faster in terms of speed and power and that make it stronger due to the bigger torque produce. Last but not least, a four-stroke engine needs a very little amount of lubricant consumption.

The other specifications that need to be considered in developing this machine is the size of the machine. This machine takes about 700 square feet for its sizing. This will affect the size of the pond that needed this machine to be well function as the pond has to be suitably sized for this aqua- loader. Last but not least, the horsepower of this machine also needed to be consider. For this Aqua-loader, the most suitable horsepower that can be used is from 70 to 90 horsepower to work properly at the pond. This Aqua-loader has to produce a bigger power because it need to be used on the land or on the water.

Conclusion

To summarise, this Aqua-loader is very handy and useful in aquaculture industry. It can do four main functions which is harvesting, grading, weighing and packaging the aqua products. It is much recommended for the farmers to have this machine as it gives a very proper management to the whole aquaculture process that will be a lot easier and helpful for them. It is undeniably that this aqua-loader consume costs and time saving that can satisfy its management.

References:

Jena, A.K., Biswas, P. and Saha, H (2017). Advance farming system in aquaculture: Strategies to enhance the production. Innovative Farming, Vol: 1(1): pp: 84 - 89.

Kelleher, K. and Weber, M. L. (2006). Toward sustainable management of world fisheries and aquaculture. In Bhargava, V. K. (Eds), Global Issues for Global Citizens. Washington D.C.: The World Bank, pp: 285 - 304.

Summerfelt, S. T, Davidson, J., Wilson, G. and Waldrop, T. (2009). Advances in fish harvest technologies for circular tanks. Aquacultural Engineering, Vol: 4(2): pp: 62 - 71.

Towers, L. (2010). How to farm barramundi. www.thefishsite.com (Access on 15th February 2019)

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya ***MSAE2019-AMA16***

Development of Dabai Nutcracker

Mohamad Ghazali, A.N[1], Shamsudin, R[1*], Amir Jalil, M.S[1]
[1]Department of Process and Food Engineering, Engineering Faculty, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
*Corresponding author. Tel.: +603-89466366, Email: rosnahs@upm.edu.my

Abstract
Dabai fruit is one of the underutilized fruit originated from Sarawak which rich with nutritional values. The flesh can be eaten raw after soaking it in warm water. The nuts from the seeds can also be consumed as it tastes like peanuts. There are also recent findings indicates that the nutritional quality of Dabai oil or canarium oil is most likely to be similar to the composition of palm oil such as the palmitic acid, linoleic acid, and linolenic acid. Dabai nutcracker is designed to separate the kernel from the nut. The design is to help in solving the difficulties in cracking the nuts of Dabai fruits, difficulties in accessing the whole kernel when using ready stock nutcracker because the uniqueness of the shape and the shell is very hard to rupture. The main objective of this research is to design, develop and evaluate the performance of the device. The dimension of the tool is 351 mm (upper part length) x 250 mm (bottom part length) x 144.09 mm (height) x 100 mm (width). The performance capacity of this tool is 1.64 kg/hr and gives 97.27 % in overall efficiency.

Keywords: Dabai, Nutcracker, kernel

Introduction

Figure 1: Dabai fruit and nuts

Dabai fruit or *Canarium Odontophyllum Miq.* (Figure 1) is one of the mainstream underutilized products of Sarawak, Malaysia. Numerous research of Dabai fruits nutritional values has been carried out, in different region of Sarawak where a significant finding shows the existence of cancer agent properties lies in the fruit (Lim, 2012). Dabai is a seasonal organic product that is accessible just amid the periods of October to December.

Dabai is an organic product which belongs to *Burseraceae* family which comprises of 100 species conveyed all through tropical Africa, Asia, and the Pacific island. The organic product is oval fit as a fiddle, rich wellspring of protein, fat, sugars, and minerals (sodium, calcium, and iron). Dabai seed paste is used as cocoa butter substitute to produce dark chocolate. A study reported that the best formulation was selected after a few hedonic tests. The formulation consisted of 50% chocolate, 45% Dabai seed paste, 35.25% sugar, 17% water, 2.5% butter and 0.25% citric acid. Besides, chocolate truffle with Dabai ganache can also be produced using Dabai puree. In future, the use Dabai or other local fruit as an additional ingredient in developing chocolate-based products can increase the variety of chocolate products in Malaysian market (Azlan, 2017).

Dabai fruit is a potential fruit with double set of benefits, which its lipids tend to produce a better blood lipid profile while the high content of phenolic compounds gives antioxidant effects. There are several products (mayonnaise, sauces, chips, pickles and soap) have been developed from this fruit for local markets. This fruit has also been used by local restaurants as ingredient in their dishes (Lim, 2012).Some industrialist and farmers take this issue as a small issue because they did not realize the potential of the nut's nutritional value that could possibly give their business or company a major profit. Therefore growing knowledge sharing has been done to the community of Dabai fruit producers and consumers to make them realize the importance of utilizing the Dabai fruit.

However, in order to retrieve the nut kernel from the shell they will stumble across the difficulty of cracking the shel. It is a challenge to crack the nut shell and access the nut kernel or the kernel without harming the nut kernel. The commercialized nutcrackers in the market are not suitable to be used in the small & medium industries as it is only designed for kitchen used. Other than that, past design of nutcrackers have complexity and do not provide good cracks and often damages the nut kernel or the kernel of the nut. Therefore, a specially designed nutcracker is needed for processing of dabai nut.

The invention of nutcracker has been evolving through times. Sticking to the same principal and concept of cracking nuts however, there are many design of nutcracker that available nowadays. There are also ways to crack a nut using magnetic methods where iron powder and magnetic fluids are used to separate the shells and kernel of a walnut (Berlage, 1984) . However in Malaysia, we can only find general nut cracker, walnut's nutcracker and several other nutcracker designs specifically for certain type of nuts. There is no significant designed nutcracker for Dabai fruit nut. This is because Dabai fruit is not a major fruit consumed by people around the world compared to other type of nuts. Although this fruit is not known to most of the malaysians, it has potential nutritional contents that would open the eyes of public. Therefore, this invention will help in obtaining the nut from its kernel as a whole for future development on its nutritional factor.

Materials and methods

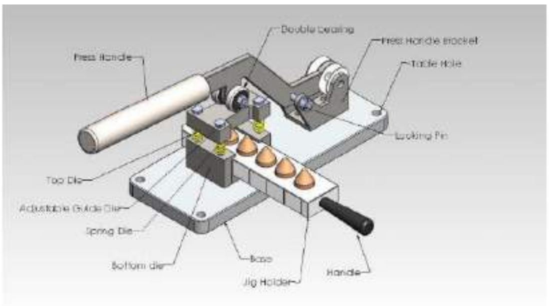


Figure 2: Dabai nutcracker

Figure 2 shows the Dabai Nutcracker that had been developed by using SOLIDWORKS software. The dimension of the tool is 250 mm (bottom part length) / 351 mm (top part length) x 100 mm (width) x 144.09 mm (height). The operation of the tool is carried manually with the use of a single manpower. The nutcracker is invented with a Jig holder with five mould spaces design to hold nuts vertically to ease cracking process and produce greater results. The mould is designed to hold nuts at 90 degrees angle. It comes in three different sizes based on the diameter of the dabai nuts. It is designed with a plastic handle to ensure user friendly. Double bearing is used to avoid the friction to the top die as it can cause damage to the operator. It also is being used to improve the accuracy of cracking when the top die is pushed down. The press handles acts as the pusher of the top die during cracking process. The base of the tool acts as the main holder for the entire component. The material of this part is made from lightweight hard material.The nuts are load to the jig holder accordingly to its size, and then the mention jig holder is slotted in through the bottom die, where the bottom die acts as the path for the jig holder. After the jig is slotted in, the first nuts is cracked when it reach under the top die. To ensure the cracking process to run smoothly and give greater result, the adjustable guide die is adjusted according to the nut height. After adjusting, then the press handle is pushes down, where it slowly touches the top die. When the press handle touch the top die, the force will moves the top die in downward direction until it reach the nut on the jig. The nut is then cracked open with good opening so that the kernel inside can be retrieve easily because the shell of the nut is not scattered or crush and mix with the kernel.

Performance test of the tools

Performance test is done to identify the defects of the tools for further improvement based on the production capacity and/or other related parameters. Before the performance test is done, the tools need to be fabricated and assembles completely. The loading orientation of the nuts is set to be longitudinal as it produces more effective cracks and easier access to the kernel without crushing the kernel. The loading orientation is decided. to be longitudinal based on preliminary studies which shows the best set of orientation of the nuts to be cracked. The samples of Dabai nuts are selected randomly and 3 experimental replications were carried out with time recorded using a stopwatch. An average production capacity for each category of size of Dabai nuts is calculated. The production capacity can be determined by using the equation (1) below:

$$\text{Product capacity} = \frac{\text{number of dabai nuts fully cracked (kg)}}{\text{time taken to fully cracked nuts (hr)}}$$

(1)

The performance efficiency of the Dabai Nutcracker is evaluated based on the capability of the tools to fully cracked open nuts. The justification of the cracking process is based on the circumstances of the kernel from the shell. The efficiency of the tools also is determined. The efficiency of the Dabai Nutcracker can be calculated using the equation below. Three samples weight of 100 g of nuts is used for each sampling. Fully cracked nuts are weigh after cracking process is done. Not fully nuts also is weigh after cracking process is done. All the results is tabulated in Table 4.14. Calculation of Tools Efficiency is based on equation (2) below:

$$\text{Efficiency} = \frac{\text{weight of nuts fully cracked}}{\text{total of sample weight}} \text{ x } 100\%$$

(2)

Results and discussion

Table 1: Performance Capacity of Dabai nutcracker

	Number of Dabai nuts fully cracked (g)	Time required (s)	Rate (g/s)	Rate (kg/hr)
Manual	100	385	0.26	0.94
Dabai nutcracker	100	220	0.45	1.64

From the data obtained and calculation using equation (1) the capacity of the tool is 1.64 kg/hr. There is 1.75 times increase in production capacity by using Dabai Nutcracker. This shows that this tool helps in increasing the productivity.

Table 2: Efficiency of Dabai nutcracker

Sample	Sample weight (g)	Weight (g)		Efficiency (%)
		Fully cracked open nuts	Not fully cracked	
1	100	96.4	3.6	96.4
2	100	100	0.0	100
3	100	95.4	4.6	95.4
Average				97.27

Three sets of 100 g samples are being used in the test of determining the efficiency of the Dabai Nutcracker. From the result obtained above, the efficiency for the Dabai Nutcracker is 97.27 % which is consider being high and successfully meets the requirements of the project design.

Conclusions

The aim of this project has been accomplished with the fabrication of the Dabai Nutcracker. This tool will helps in the cracking Dabai nuts by removing the shell more delicately and retrieving the kernel in a whole without crushing it into mixture of shell and kernel where it will make the separation process more difficult.

Aknowledgement

The authors express their gratitude to the Universiti Putra Malaysia for providing financial and technical support to conduct this research work.

References

Abd Manaf, A. (2011). No Title. Retrieved October 24, 2017, from http://ww1.utusan.com.my/pix/2011/1020/Utusan_Malaysia/Sabah_&_Sarawak/wb _01.1.jpg

Azlan, A. (2017). Dabai (Canarium odontophyllum), Fruit with Functional Oil. In A. Azlan & A. Ismail (Eds.), *Functional Foods Wonder Of The World Evidence-Based Functional Foods In Health & Disease* (p. 380). UPM Press.

Azlan, A., Prasad, K. N., Khoo, H. E., Abdul-Aziz, N., Mohamad, A., Ismail, A., & Amom, Z. (2010). Comparison of fatty acids, vitamin E and physicochemical properties of Canarium odontophyllum Miq. (dabai), olive and palm oils. *Journal of Food Composition and Analysis*, *23*(8), 772–776. https://doi.org/10.1016/j.jfca.2010.03.026

Berlage, A. G. (1984). Using Magnetic Methods, *1*, 1–3.

Brooke, P. (n.d.). The dabai story: experience in commercializing an underutilized fruit.

Brooke, P., & Yuon, L. C. (1980). Dabai Planting Material and Propagation Technique Pearlycia Brooke and Lau Cheng Yuon.

Burge, D. S. (2009). Pugh Matrix (PM). *The Systems Engineering Tool Box*, 1–15.

Gallegos, R. K. B., Suministrado, D. C., Amongo, R. M. C., & Madlangbayan, M. S. (2013). Some physical and mechanical properties of pili (Canarium ovatum Engl. cv. Katutubo) nut as a function of nut moisture content. *Philippine Agricultural Scientist*, *96*(1), 66–74.

Hun, C., Dan, P., & Daniel, N. (2014). Pembangunan produk berasaskan buah dabai (Product development from dabai fruit), *5*(5), 51–61.

Lim, T. K. (2012). Canarium odontophyllum, 624–629. https://doi.org/10.1007/978-90- 481-8661-7_86

Shakirin, F. H., Azlan, A., Ismail, A., Amom, Z., & Yuon, L. C. (2012). Antiatherosclerotic effect of canarium odontophyllum Miq. Fruit parts in rabbits fed high cholesterol diet. *Evidence-Based Complementary and Alternative Medicine*, *2012*. https://doi.org/10.1155/2012/838604

Shakirin, F. H., Prasad, K. N., Ismail, A., Yuon, L. C., & Azlan, A. (2010). Antioxidant capacity of underutilized Malaysian Canarium odontophyllum (dabai) Miq. fruit. *Journal of Food Composition and Analysis*,*23*(8),777–781. https://doi.org/10.1016/j.jfca.2010.04.008

Tan, C. X., & Azrina, A. (2016). Nutritional, Phytochemical and Pharmacological Properties of Canarium odontophyllum Miq. (Dabai) Fruit. *PJSRR Pertanika Journal o f Scholarly Research Reviews*, *2*(1), 80–94

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA17

Evaluation of Pesticide Spraying Quality in Wetland Rice Cultivation in Malaysia

Modather, M.[1], Azmi, Y.[1], Nor Maria, A.[2], Ahmad Suhaizi, M. S.[3] and Suha, E.[1]
1Dept. of Biological and Agricultural Engineering Faculty of Engineering Universiti Putra Malaysia1Institution
2Dept. of Mechanical Engineering Faculty of Engineering 43400 Serdang, Selangor D.E.
3Dept. of Agricultural Technology Faculty of Agriculture Universiti Putra Malaysia 43400 Serdang, Selangor D.E
*Corresponding author. Tel.:, Email:fayoomy1974@gmail.com)

ABSTRACT

The uniformity spray distributions, and labour quality of work were analysed for various operating conditions for two real field operations in wetland rice cultivation in Malaysia. Water sensitive papers used as positioned targets closed to the plant and were compared against known and standard coverage, droplet size spectra and class size distribution verified through manual counting. The results indicate that commonly used nozzle, swath width, nozzle heights, nozzle direction, pressures and labour performance often affect the operation quality and spraying distribution. The result showed that the spraying penetration index of 32.13%, which is 67.87% lesser than the desired penetration ratio. Spray applications distribution showed droplet density between 14 and 108 drops cm2 and a wide range of droplet size spectra. The study shows significant difference in distribution in the field. The higher distribution of very fine droplet (75 -108 droplet/cm^2) was mainly in the area of 0 to 1 metre from 4 edges of the field and 1m left and right the 8 working line, then (61- 73 droplets cm^2) and this in the location 1 to 2 m right and left the working line, the other areas ranges from (14 – 60 droplets cm2). The result shows there are 3.3% is uncovered horizontal area due to labour performance. Most of the operator 71.43% have speed higher than the ideal speed while 28.57% of the operator have speed lower than the idea. 34% of farmers have applied medium sprays, 66% of them have applied finer sprays.

Keywords: Coverage, Penetration, Droplet, Distribution, Swath width

INTRODUCTION

The world rice crop is attacked by more than 100 species of insects; 20 of them can cause economic damage. Insect pests that can cause significant yield losses are stem borers; leafhoppers and planthoppers (which cause direct damage by feeding as well as by transmitting viruses); gall midges, a group of defoliating species (main1y lepidopterans); and a grain-sucking bug complex that feeds on developing grains. Any decrease in pest damage means a corresponding increase in needed rice production.

It is critical that farm managers carefully monitor pest conditions and take action to keep pest levels and damage below economic thresholds. With the selective and timing of applications of new pesticide formulations becoming increasingly important, it is imperative that pesticides to be applied as efficientt as possible when needed. The situation is made more difficult because of the variety of pests and diseases and techniques found in this field (Derksen et al., 2006).

Ensuring a uniform placement of the applied materials (pesticide) to the target (pest) is an important task for the sprayer operator which required careful setting for the sprayer. This factor (spray distribution) which is expressed by the coefficient of variation (CV, %) could influence obtaining the required (maximum) efficiency of chemical crop protection with minimum costs and environmental contamination (Subr et al., 2017).

This paper aims to evaluate the quality of spraying in terms of uniformity of distribution, uncovered area, labor performance and suitability of equipments.

METHODOLOGY

The area of the paddy fields is at Sungai Burung located in the district of Tanjung Karang in the State of Selangor (Latitude: 3°29'0.47 N "Longitude: 101°9'0.56"). Data were collected for two seasons All the spray distribution tests were done during the sprayer was working in the paddy field by measuring the nozzle height, nozzle direction angle, swath width, amount of mixed chemical, operator forward speed, the actual working length, with the weather status, wind direction with or against working direction, wind speed in km/hr., relative humidity (%) , temperature degree (C^o). The spray distribution was evaluated by analyzing three parameters: (1) spray deposit on sensitive paper expressed by count the numbers of droplets per unit area (ng/cm^2); (2) spray coverage, which represents the percentage of water sensitive surface covered by the droplets; (3) Penetration index (PI), which enables the spray deposit measured in the whole parts of the plant to be compared with that uncovered part of the plant; (4) uncovered horizontal area. PI (%) was defined in order to analyses the relative deposition between the upper and lower parts of the canopy according to the equation:

$$PI = U/L \times 100$$

Where:

U is the average coverages length at the upper parts of the canopy.

L is the uncovered length at the upper and lower parts of the canopy.

PI was defined and calculated with the aim of evaluating the coverage and distribution of the product that arrives the whole part of the plant and the relation of the distribution uniformity of product deposited in the upper and the lower zones of the crop.

The sampling strategy was designed to enable deposits on water sensitive paper strips in the top, middle and lower parts of the plant canopy and quantified separately. Particular attention was directed at quantifying the ratio between upper and lower leaf-surfaces. Spray deposits on the water sensitive paper strips were quantified by recovering the target horizontally and vertically.

Swath width (working nozzle spacing (m)) was measured by measuring the effective spraying area left and right the operator in every working row. The distance between the operator and the edge of effective area during the operation was taken by using measuring tape. Nozzle type used was record, the height of the nozzle from the ground was measured during the operation by stopping the operator with hold their hand at the working height and measured the distance from the ground and the plant height was measured at ten different locations and the average was calculated, also the nozzle orientation and nozzle working angle and was measured from the horizontal level. The nozzle flow rate was measured by calibration and calculated during the operation which is depending on the volume of used liquid and the time needed to finish of whole volume. Spray volume per hectare was recorded.

RESULT

Distribution & Losses

Selecting Suitable Equipment

For evenly and completed covering distribution farmers should use a suitable nozzle. 63.33% of the farmers use a suitable nozzle for their spraying for the three first applications and 36.67% of them do not use the suitable nozzle. 63.33% of farmers use one type of nozzle (hollow cone nozzle) for spray the plant at all growth stage, this nozzle is suitable for spraying the plant at the early growing stage from emergence till tillering stage because the plant still not too high and the density is medium, but after this stage the nozzle is not suitable the farmers should use standard high pressure flat fan nozzle to achieve 100% of spray penetration ratio. Hollow cone nozzles are generally used where complete coverage of the leaf surface is important, and where a fine spray pattern is needed for thorough coverage. Spray drift is higher with hollow cone nozzles than with other nozzles as small droplets are produced. Full cone nozzles produce large, evenly distributed drops and high flow rates. 100% of the farmer use the smaller tank (200 *l*) than the standard tank (360 *l*) because the local manufacturers made it (200 *l*) and the carrying car cannot hold bigger than this tank. There a lot of pesticides should solute in 300 *l*/ha, and for 1.2 hectares the farmers should use a tank with at least 360 *l*.

Droplet Pattern

From first to the third application (plant age from 9-10 days to 30 -35 days) 34% of farmers have applied medium sprays, 66% of them have applied finer sprays. To minimize drift and contamination of water, the spraying was performed with fine droplet size while it should be done by very fine droplet size because the plant is still short in height (60 -70 cm) and the plant remains in medium density (350 - 370 stem/m^2) and this led to less efficient use of some pesticides. The farmers adjust the nozzle angle to small angle of 40^o, while it is better to wide angle to 90^o for wide range distribution and more fine spray pattern. Larger droplets in coarse or fine sprays may provide inadequate coverage to control pests. As much as 32% of the spray applied to a crop to be lost to the soil during the application.

100% of the droplets pattern at all operation are fixed, the operators do not fit low-drift nozzles to produce larger droplets. From the fourth to the sixth applications ((plant age from 60 days to 84 -90 days) the spraying droplet pattern remains as mentioned above 34% coarse and 66% fine, it should be done by coarser droplet size because the plant is high as (100 -105 cm) and the plant density remains (450 - 550 stem/m^2) in transplanted paddy and (650 - 750 stem/m^2) for directly seeded paddy, and this prevents the fine droplet from penetrating the plant and this lead to less efficient use of pesticides. And as a result of this 23% of the yield was lost due to the plant infection by stem borers which live in the bottom part of the plant and the lack of spraying to reach the target and uses the unsuitable nozzle with low height of spraying with the fine droplet.

Penetration Index

100% of farmers used hollow cone nozzles in spraying their fields. Mean droplet velocities from hollow cone nozzles are lower than those from flat fan designs. As consequence deposits on higher leaves of the paddy canopy were higher than on the bottom leaf and stem. The result shows that the spraying penetration index of 32.13%, which is 67.87% lesser than the desired penetration ratio, and this led to huge losses in the yield calculated to be 23% of the rice yield due to this lack of spraying penetration inside the plant for fighting Stem Borer which live in the bottom part of the plat and damage 23% of the crop. For improved penetration into the crop canopy 80º flat fan nozzles are recommended. (Al-Gaadi, 2010)The tested flat fan nozzles exhibited a better spray distribution and lower error in application rate at all nozzle heights compared to the hollow cone nozzles. Stem borer and brown plant -hoper are more efficientt controlled with a drop-pendant boom at high pressures to penetrate and cover the foliage while borers require a drench using large water volumes at low Pressures applied to the soil. The drenches would generally be applied with flat spray nozzles.

For the late spray, the nozzle height was ranging from 20 cm to 30 cm over the target (plant) 63.3% of spray operation the nozzle height was 20 cm and 37% of spray the nozzle height was 30 cm depending on the labor height. Azimi et al., (1985) found that 66 cm nozzle height above the plant is more effective and efficient than 32 cm. The nozzle height and tilt angle forms the effective nozzle-to-target distance. Greater nozzle-to target distances allow the spray droplets to spread more and create wider individual spray patterns. Also, higher pressures increase the initial spray droplet velocity which causes them to form a wider spray pattern. So the amount of overlap for a certain nozzle is influenced by spacing, height, and tilt angle of the nozzle and pressure at the nozzle. (Azimi et al., 1985).
Unless the pesticide is applied properly it will not produce the good results. Therefore, the quality of the application of pesticides is very important in pest control operations. Adherence to the following points can ensure it: Proper dosage should be applied evenly, the toxicant should reach the target, proper droplet size and proper density of droplet on the target. 23% of the rice yield was lost due to lack of spraying penetration inside the plant canopy for fighting Stem Borers which live in the bottom part of the plant.

Evaluation of Spray Distribution

Water-sensitive papers (WSP) manually counted droplet density (droplets/cm2). The WSP were grouped according the coverage (droplets/cm2): poor (1-19%) Medium (20-39% and excellent (40-100%). The result showed distribution coverage ranging from Poor to Excellent (Table 3). Spray parameters related with droplet density/cm2 spectra showed an overall ranged from Fair to Moderate. There was a great difference between droplet densities measured. The result showed highest droplet density coverage equal 100% and 94%. There are excellent coverage equal to 55.35, 47.06, 44.06 and 42.26%, low coverage from 15% to 1%. The water sensitive papers showed uncovered area especially at the vertical level where more than two-thirds of the plant height is not covered (67.87%). Spray applications distribution showed droplet density between 14 and 108 drops cm2 and a wide range of droplet size spectra. The study shows significant difference distribution in field. The higher distribution very fine (75 -108 droplet/cm2) was mainly in the area 0 - 1 metre from 4 edges of the field and 1m left and right the 8 working line, then (61- 73 droplets cm2) and this in the location 1 to 2 m right and left the working line, the other areas ranges from (14 – 60 droplets cm2). In overall, there are 31.19 % very high and excellent covered, 30.51% covered with good and satisfy distribution, 25% sprayed with insufficient amount of chemical and 3.3% of plant considered as uncovered are.

Control Drift

Reducing pesticide spray drift and maximizing efficacy are the paramount considerations when selecting technologies and operating parameters prior to making an application. Spray drift increases with the wind, in low humidity and when small droplets comprise the majority of the spray (Bouse et al. 1990), making nozzle selection of the utmost importance to any spray drift management procedure. Droplet size can also influence the rate of on-target deposition as well as canopy penetration (Spillman 1984) with smaller droplets providing better deposition and canopy penetration than larger ones, also influenced by plant structure (Miller et al. 2000). 100% of the operator do not avoid spraying on still warm days so convection currents cause drift in unpredictable directions. 79% of the operators spray the chemical within allowable range and 50% of this percentage work within the optimum wind speeds which are between. 44.71% of the operators do not cancel the operation or delay it because the wind speed is high and they do not avoid spraying on a windy day, while 55.29% of them avoid spraying on a windy day. 65.8% of the farmers follow the standard and do not spray in still warm days, as 34.24% of them do not delay the operation on still warm days.
51.84% of the operators reduced the nozzle height when they see that there is much drift, while 48.20% do not care and continue spraying anyway spray the crop at the same nozzle height and do not reduce nozzle height if they work against wind direction. 100% of the farmers do not delay the operation due to the high humidity weather they just do that if the rain is falling Table 1.
Every operation 50% of spraying performed in the same direction of the wind while the other 50% of the spraying is done against wind direction and that because the operator work in rounded pattern.
100% of the operator spray the crop using the same nozzles during all operation and do not use drift nozzles to avoid drift. 63.33% of farmer's controls limit drift of sprays outside treated areas by the introduction of no-spray zones (water canal) by spraying from the edge to inside the field, while 36.67% of the farmers tend to spray from inside the field to edge of the field which leaded to outside drift.

Timing, amount and type

Accurate spray timing of the adequate amount of the effective and suitable active ingredient with perfect and even distribution avoiding drift and the uncovered area will ensure that the product is applied with optimum effect. There are many factors and practices that negatively affected the spraying operation quality; when the decision to use the pesticide is made there is no considering of the effect of the selected pesticide product on the target and environment; The farmers do not make a pre-spray field survey to highlight surrounding areas of infected plant, the pest type, the infected plant area they do not located and map these objects.

Sprayer Ground Speed

Knowing the travel speed and maintaining a constant rate are crucial to good calibration and application. Speed of operators varies from one to another. Some labor has very fast speed during the application while other has a wise speed.

Compares the operator speed with ideal speed that calculated from calibrated Power Sprayer, most of the operator 71.43% has speed higher than the ideal speed which leaded to spray amount less than the whole solute chemical and remain amount average between 10 liter and 8 liter in the chemical container and that effect the efficiency of pesticides operation and the quality of work because the whole amount of chemical in the container was calculated to depend on the label and should be sprayed all in the farm evenly, beside, the remaining amount stays in the container till nearest application or poured on the land which harms the environment. On the other hand, 28.57% of the operator have speed lower than the ideal speed which always made the operator finished spraying the overall chemical before covering all the field what forced the farmer to add water to the remain chemical to cover unsprayed area in the field and that also leaded to deficiency of pesticide application and lack of work quality due to the concentration of the extra amount of chemical has not the same amount of ingredient concentration that most of the field had and the label included.

Table 1. Farmer Practices to Control Spraying Drift

Factor	Follow	Not follow
Avoid spraying on still warm days	65.8±0.84 %	34.24±0.69%
Avoid spraying on windy days	55.29±0.89%	44.71±0.44%
Reducing nozzle height	51.84±0.42%	48.20±0.38%
Reducing pressure and using larger nozzles	43.44±0.54%	56.57±0.55%
Fit low-drift nozzles.	33.51±0.55%	66.49±0.76%
Change current nozzle by drift nozzle	Zero%	100%
Using of no-spray zones	63.33%	36.67%

Table 2. Field and Climate Condition During Operations

Factor	Follow Standard	Not Follow
Wind speed km/hr.	63.33%	36.67%
Air speed at outlet km/hr.	63.33%	36.67%
Wind direction	50%	50%
Temperature C0	0%	100%
Humidity %	0%	100%
Water depth (cm)	64%	36%
Irrigation Water Closure	75%	25%
Irrigation water leakage	64%	36%
Operation day time	33.33%	66.67%

Table 3. Effect of pesticide operations on crop condition

Factor	Before Operation	After operation
The plant damage by pest/m2 %	9.34±0.43 %	8.94±0.15%
Weedy rice plant in rice field/m2 %	11.19±0.31 %	6.16±0.08 %
Weed extent in rice field	3.22±0.06 %	2.06±0.07%

Table 4. Statistics of coverage and droplet size spectra obtained by manual counting for the WSPs grouped according the coverage density

Spray parameters	Poor		Medium		Dense	
	Min	Max	Min	Max	Min	Max
Area Coverage %	3.9	19	20	40	41	100
Drop Density(droplets/cm^2)	15.8	22.5	26.4	47.8	63.1	109.2

4. Conclusions

Poor distribution uniformity may be caused by improper nozzle mounting geometry and insufficient overlap of the spray from the individual nozzles. Spray uniformity is also dependent upon the individual spray pattern profiles. The shape of the spray pattern profile of an individual nozzle depends partly on the type and capacity of the nozzle utilized which in turn is influenced by the pressure at the nozzle, the height of the nozzle from the spray surface, and the angle at which the nozzle is oriented. Ensuring a uniform placement of the applied materials (pesticide) to the target (pest) is an important task for the sprayer operator which requests careful setting for the sprayer.

Reference

Al-Gaadi, K. A. (2010). Effect of nozzle height and type on spray density and distribution for a ground field sprayer. Journal Saudi Soc. for Agric. Sci, 9(1), 1–12.

Azimi, A. H., Carpenter, T. G., & Reichard, D. L. (1985). Nozzle spray distribution for pesticide application. Transactions of the ASAE, 28(5), 1410–1414.

Derksen, R. C., Krause, C. R., Fox, R. D., Brazee, R. D., & Zondag, R. (2006). Effect of application variables on spray deposition, coverage, and ground losses in nursery tree applications. Journal of Environmental Horticulture, 24(1), 45–52.

SUBR, A., MILANOWSKI, M., PARAFINIUK, S., & SAWA, J. (2017). TESTING THE UNIFORMITY OF SPRAY DISTRIBUTION UNDER DIFFERENT APPLICATION PARAMETERS. Farm Machinery and Processes Management in Sustainable Agriculture, IX International Scientific Symposium. doi:10.24326/fmpmsa.2017.64

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA18

Oil Palm Motorised Cutter Evo 2

Mohd Rizal, A., Abdul Razak, J., Mohd Ikmal Hafizi and Abd Rahim, S.
Malaysian Palm Oil Board (MPOB), 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
**Corresponding author. Tel.: +603-89201504, Email: rizal.ahmad@mpob.gov.my*

Abstract
MPOB has introduced an oil palm motorised cutter called 'Cantas Evo' that works effectively for palms with harvesting height of below 7-metres. Cantas which is powered by a small petrol engine has been proven to double up harvesting output compared to manual harvesting. Even though Cantas Evo has shown very positive results in-terms of productivity and quality, but the R&D has never stopped as to improve its performance and cost-effectiveness. Over the past two years, a new generation motorized cutter has been designed, developed and tested. The prototype employs gear-box at the bottom of the machine which brings down the point centre of gravity that helps the handling become more convenient. Almost 50% of the components have been cut-off which brings to the saving on components of about RM306.06/machine. Results of the laboratory tests showed that the prototype passed all the required tests, i.e. functional, fatigue and vibration test.. A field trial conducted in Banting Selangor for 4-5-metres palms' height revealed that the machine was able to harvest about 3 t day-1(4 working hours). As for the economics, based on the estimated machine price of RM3100 per unit plus its operational, repair and maintenance costs, the cost effectiveness is calculated to be RM1.72 t-1 FFB.

Keywords: new generation oil palm motorised cutter, oil palm cutter

Introduction

The total oil palm planted area in Malaysia was about 5.85 million hectares, contributing the gross income of about RM67.58 billion to the country (MPOB, 2019). It was reported on December 2016 the statistics foreign workers that about 340,283 in this industry which accounts for about 77.8% of the total field workers in the plantation sector (MPOB website, 2016). The problem is become more serious as 90% of the harvesting operations in the oil palm industry are performed by the foreign workers. The alternative way to address that issue is through mechanisation.

Harvesting is one of the main activities in plantations. Harvesting history begins with the use of bamboo as a pole mounted on top of a sickle. Bamboo was the first harvesting pole used for harvesting FFB for tall palms. However, due to its low productivity and scarcity of getting it, other options have to be identified. Later PORIM (now MPOB) had developed a harvesting pole made of aluminum alloy that gave better strength and durability, and lightweight (Razak et al., 1998). In 2007, MPOB has moved a step forward with the introduction of oil palm motorised cutter known as the Cantas.

Difficulty in getting skilled harvesters has been a real issue, and ways on how to improve harvesting productivity has become a necessity. Manual harvesting (using a sickle or chisel) can only produce about 1t of FFB-man-1day-1 (Azman et al., 2015). Estates are now looking for more efficient harvesting tools which can double up this productivity in order to increase individual daily harvesting productivity and ultimately reducing the number of workers. The harvesting productivity needs to be increased to about 4 t/man-day if the country wishes to reduce labour requirement significantly.

Efficient harvesting can be achieved by at least two means; i.e. efficient harvesting tool and sufficient harvesters to cater to harvesting rounds of the recommended 10 to 12 days' interval. Harvesting activities required about 60% of the workforce for the whole plantation area in Malaysia. In order to reduce labour dependent and increase productivity, labour saving approach has to be introduced such as mechanisation. This could be achieved through the introduction of efficient and economical harvesting technology.

The current mechanical harvesting of oil palm fresh fruit bunches (FFB) or popularly known as 'Cantas Evo' employs a small 2-stroke petrol engine and transmission shaft to activate the sickle. Cantas consists of four main components i.e. 2-stroke petrol engine, extendable aluminium pole, pole gripper and the cutting head. The current Cantas Evo can reach up to 7m palms. Usage in plantations proving that Cantas Evo could improve workers' productivity by 70 – 80% and reducing labour requirement by 40 – 60% compared to manual sickle (Razak et al., 2008). Cantas Evo increases harvesting productivity which improves harvesters' earning besides reducing workers on the payroll, currently dominated by foreign workers (Razak et al., 2013).

Cantas (*Figure* 1) is a motorised cutter specifically designed for harvesting FFB and cutting fronds. It is powered by a small petrol engine and utilises either a specially designed C-sickle or chisel as the cutting knife. MPOB is the owner of the technology with patents filed in Malaysia, Indonesia, Thailand, Brazil, Costa Rica and Columbia. Cantas helps workers to speed up harvesting operation thus increasing harvesting productivity. This paper is aim to describe development process a new generation oil palm motorized cutter. The cutter should be able to carry out harvesting FFB and pruning efficiently and effectively.

Figure 1 : Oil palm motorised cutter (Cantas) (current version)

Materials and methods

The development of Oil Palm Motorised Cutter Evo 2 was carried out at Research Station MPOB/UKM and time motion study and field trial was conducted in Banting, Selangor.

The novelty of the technology can be described as follows:

- This design reduces the number of parts used which is only seven parts instead of 17 parts for previous version.
- The gear-box is placed at the bottom of the pole instead of at the top (as in the engine powered Cantas). This can bring down the point of centre of gravity of the pole which makes the handling of the tool is much easier and convenient for the operator. The gear box is used to convert rotational motion from the engine into a linear motion for the purpose of cutting.
- Higher reach as the pole length can easily extended.

The Prototype

Specifications:

Total length	: 4.00 m
Total weight	: 7.1 kg
Specific weight	: 2.56 kg/m
Cutting Knife	: C-sickle

Table 1 dan Figure 2 shows the technical comparison between Oil Palm Motorised Cutter Evo 2 and the prior art (Cantas).

Table 1: Technical Comparison
New Generation Oil Palm Motorized Cutter Vs Cantas

Description	Oil Palm Motorised Cutter Evo 2	Prior art (Cantas)
Activator	Petrol engine	Petrol engine
Power source	Fuel (petrol)	Fuel (petrol)
Gear box placement	At the bottom of pole	At the top of pole
Transmission	Nil	Mechanical – shaft & bearings
Cutting knife	Chisel / sickle	Chisel / sickle
Length (m)	4	4
Weight (kg)	7.1	7.4

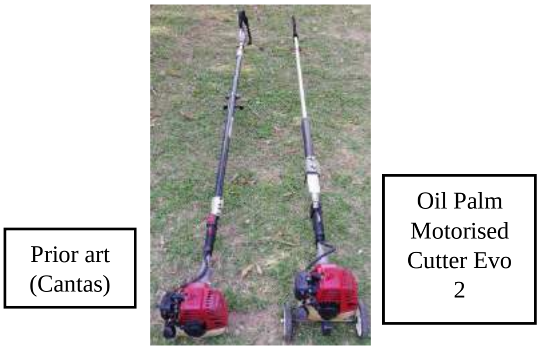


Figure 2 : Technical Comparison Oil Palm Motorised Cutter Evo 2 Vs Cantas

Figure 3: Prototype Oil Palm Motorised Cutter Evo 2

Results and discussion

Time and Motion Study (TMS)

Time and motion study was conducted in two different operations, *viz.* (i) harvesting FFB and (ii) pruning fronds. The purpose of TMS was to determine the performance of the prototype in the harvesting and pruning activities. For harvesting, the total time taken was the time required to cut fronds, cutting FFBs and walking. While for pruning, the total time was the time required to cut fronds and walking only. The number of palms, fronds and FFB were counted. The results are tabulated in *Table 2* and *3*.

Table 2 : Time And Motion Study For Harvesting Ffb

	Palm/ hour	Frond/ hour	FFB/ hour
Test 1	37	86	55
Test 2	31	62	65
Test 3	30	60	33
Average	**33**	**69**	**51**

Table 3 : Time And Motion Study For Pruning Frond

	Palm/hour	Frond/hour
Test 1	64	356
Test 2	65	286
Test 3	64	348
Average	**64**	**330**

Results of the performances of the machine are as follows:

<u>Harvesting FFB</u>

- 51 FFB/hr

<u>Pruning Frond</u>

- 64 palms/hr
- 330 fronds/hr

The overall performances of the machine for harvesting FFB and pruning fronds are 51 FFB/hour and 330 fronds/hour, respectively.

Field Trial

The field trial of the prototype was carried out by a smallholder plot at Banting, Selangor. The total area was about 50 ha with two rounds harvesting per month. The palms were about 3 to 5 metres height with flat topography.

Trial conducted showed that the average harvesting productivity was about 3 t FFB/day (4-hrs working a day).

Table 4: Field Trial Results From July 2017 To December 2017

Month	Total days	Total hours	FFB	
			Bunches	Tonnage
July 2017	15	60	2989	45
August 2017	16	64	3187	48
September 2017	15	60	2937	47
October 2017	14	56	2866	43
November 2017	15	60	2933	44
December 2017	13	52	2821	42
Total	**88**	**352**	**17733**	**269**

Average performance:

Bunches	:201 FFB/day @ 50 FFB/hour
Tonnage	: 3 t/day
Harvesting performance	: 3 to 4 ha/day

ECONOMIC ANALYSIS

User Perspective

From the user perspective, the fixed cost is the cost to own the machine while variable costs are labour and repair and maintenance. The operational cost per tonne FFB was calculated using a straight-line depreciation method. The details of the calculation are shown in *Table 5*.

Assumption	
Machine selling price	: RM3100/unit
Life span	: 2 years
Performance	: 3 tonne/day
Labour cost	: RM50/day

Table 5: Cost Analysis Of New Generation Mototrised Cutter Using Straight Line Depreciation Method

Description	Calculation	Cost (RM/day)
Depreciation (price/(life span x 300 days)	3,100/(2 yrs x 300d)	5.17
Fuel Cost	0.0625 l/hr x RM2.30/l x 4 hr	0.575
R&M cost @ 10% per year of purchase price	10% x 3,100 / (300d)	1.03
Total		**6.775**
Cost per tonne = total cost/productivity	(RM6.775/day) / (3 tonne/day)	RM2.26/t FFB

Therefore the operational cost per tonne FFB comes to about RM2.26/t (harvest only).

In term of cost-effectiveness (CE) of the technology the lower the CE, the more the technology will likely to be adopted by the industry. The cost-effectiveness is calculated by the following formulae (Stanners, 1992):

$$\text{Cost effectiveness (CE)} = \frac{\text{Tool or machine price (RM)}}{\text{Total bunches harvested (tonne FFB)}} \quad \ldots \quad (1)$$

=RM3100/(3t FFB/day x 300day/yr x 2yrs)

=**RM1.72/t FFB**

Therefore, the cost effectiveness of new generation mototrised cutter tool is RM1.72/t FFB

Conclusion:

The introduction of this technology is expected to increase take up rate as it offer a better performance, better quality, user friendliness and low repair cost. This will increase profit margin to the harvester or the owner of the machine. The cost-effectiveness has been increased significantly as a result of high productivity and low repair cost. Based on the estimated machine price of RM3100 plus its operational, repair and maintenance costs, the cost effectiveness is calculated to be RM1.72 t-1 FFB.

References:

Abdul Razak Jelani, Rahim S and Ahmad H. (1998). The Effects of Physical Characteristics of Aluminum Pole on the Harvesting Productivity of Toll Palms. Porim Bulletin, No. 36.

Abdul Razak Jelani, A. Desa, H. Ahmad, Y. Azmi and J. Jamak (1998). Force and Energy Requirements for Cutting oil Palm frond. Journal of Oil Palm Research. Vol. 10 No. 2 Dec 1998

Abdul Razak Jelani, Ahmad Hitam, Johari Jamak, Malik Noor, Yosri Gono and Omar Arifin (2008). CantasTM : A Tool for the Efficient for Harvesting Oil Palm Fruit Bunches. Journal of Oil Palm Research Vol. 20 December 2008 p 548 – 558.

Abdul Razak Jelani, Rizal Ahmad, Ikmal Hafizi, Salihatun Mohd Salleh and Abd Rahim Shuib (2013). Oil Palm Motorized Cutter (Cantas) : A tool for improving workers productivity. Proceedings of Malaysian International Palm Oil Congress (PIPOC) 2013, 19-21 Nov 2013, Kuala Lumpur

Economic Transformation Programme (ETP) Annual Report 2012.

MPOB website. Economic and Industry Development Division.

Stanner GH (1992). Investigating the True Cost of Conventional Harvesting Tools. Paper presented at the Eastern Plantation Agency Bhd. Seminar.

Stanners GH (1992). Field Trials of an Improved Oil Palm Harvesting Tool. Planters Vol. 68, 485-497.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA20

Smart Oil Palm Multi-purpose Tractor (Prototype)

Wan Nor Zanariah, Z. A.,[1,*] and Zainul Ariffin, M. I.[1]
[1]Department of Basic Science and Engineering, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus, P.O Box 396, Nyabau Road, 97008, Bintulu, Sarawak, Malaysia.
*Corresponding author. Tel.: +6086-855425, Email: wnzz@upm.edu.my

Abstract
Advancements in field mechanization for the oil palm industry have improved year by year and urged to the introduction of machines which could be adapted to local usage. A suitable choice of machines is depend on the land size, terrain condition, management practice and economic returns. Recently, mechanization approaches vary from one crop to another crop with the major aim of overcoming labour shortage and to increase the quality of agriculture production. Thus, "Smart Oil Palm Multi-purpose Tractor (SOPMT)" is a multipurpose vehicle designed to perform in all types of terrain, while dutiful of the environment. An articulate 4x4 all-terrain vehicle (prototype) developed with a smart hydraulic system that could work in peat, wet soils and hilly conditions. This tractor offer versatility in performing wide range of tasks which is suitable for harvesting and transporting the fresh fruit bunch (FFB) of oil palm to the implement as well as useful for spraying and applying fertiliser, herbicide, pesticide or insecticide. SOPMT also developed to remove the damaged frond from it trunk and could extremely pull heavy loads. It is also equipped with control chamber that has adjustable sit and digital screen to autonomously control the required tasks. This tractor is of a high standard to solve the harvesting, collection and transportation of FFB. Thus, by using this tractor, it could significantly enhance the quality of labour works as well as the quality of oil palm production.

Keywords: oil palm, fresh fruit bunch (FFB), multi-purpose tractor, SOPMT, terrain vehicle (prototype)

Introduction

The production of our primary commodity crop and industry; oil plam is very labour intensive. The industry requires many labours for its operations, ranging from the planting to processing. Labour problem is highlighted to be one of the main factor for the higher production cost. Foreign labours are usually employed in Malaysian palm oil plantations. Faizah (2010) had figured out that there are four main tasks in the oil palm plantation which are totally dependent of foreign workers who are employed as harvester, fresh fruit bunch (FFB) collector, loose fruit collector and field worker for general maintenance works. Currently, the problem of labour shortage is very critical (Azman 2012). Thus, to overcome this issue, the industry has to focus on the adoption of mechanization at oil palm plantation. Mechanization could increse the labour productivity and at the same time decrease the dependency on human resources. Numerous advance machines have been introduced into the oil palm industry in the last 30 years such as motorized cutter, mechanical harvester, mechanical grabber, compact transporter and many more (Abd Halim et al. 1988; Ahmad et al. 2008; Guturu et al. 2015).

The application of mechanization in oil palm industry is increasingly being used. There are a lot of research for oil palm harvesting, evacuation, loose fruit collection and the application of fertilizer and pesticide have been conducted to enhance the production of FFB and to speed up the field work. Thus, the "Smart Oil Palm Multi-purpose Tractor (SOPMT)" is a prototype of multipurpose vehicle that has been designed to fulfil those objective by designing its hydraulic robotic arm. This arm can automatically perform the harvesting of FFB and the design of crane grapple could bring the harvested FFB into a trailer which requires less workers as compared by using chisel or motorized cutter. In addition, this SOPMT not just limited for harvesting purposes but also useful for spreading the fertilizer as well as pesticide or herbicide on its own. Thus, it was named as "Smart Oil Palm Multi-Purpose Tractor (SOPMT)" since it can do multi-purpose works.

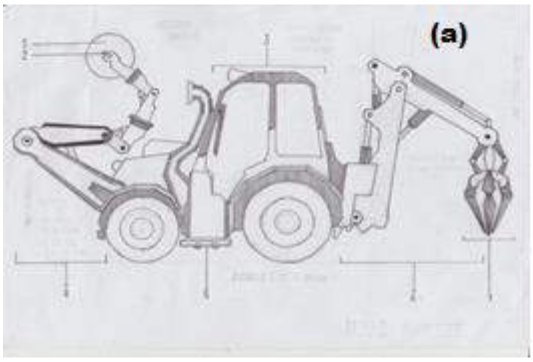
Materials and methods

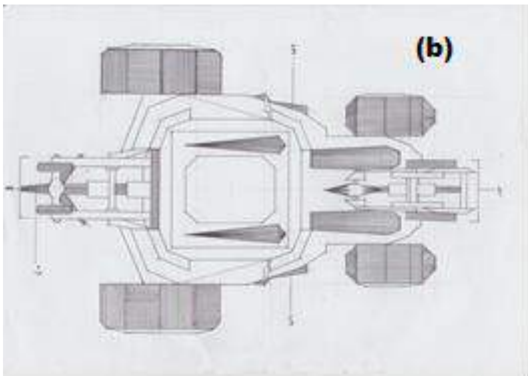
The design of the prototype's body is based on the structure of '*construction'* tractor type which is an articulated dual wheel four wheels drive. Firstly, the sketch of the tractor body was developed into three stages which are the front, side and top views. Secondly, an accurate measurement of length on a recycle paper box for each part was measured and cut accordingly. Geometry method was used in order to confirm the accurate measurement and produced the symmetry shape for each component. Thirdly, those cut components were attached together using glue or glue gun as per sketch. Fourthly, the wheel part also was established according to the desired size which is the front wheel is relatively small as compared to the back wheel. This is due to the stability purposes especially when the tractor will be attached with the hydraulic components. Fifth, hydraulic components at the front and back sides of the tractor were attached to the tractor body which applied a simple hydraulic concept such as using syringe and silicone tube together. The design of those hydraulic components were as same as to those attached to the real tractor in order to maintain the real concept of hydraulic. Sixth, fluid that has high viscosity like cooking oil was used as a medium for hydraulic system for efficiency of prototype's movement.

Results and discussion

Design Consideration

SOPMT was designed to be able to perform several specific functions, i.e. a) ability to harvest FFB automatically by hydraulic robotic arm's component; b) ability to scan and determine the ripe or unripe fruit and determine the precise position to cut the ripe fruit by using a scanner and camera located at both side of an adjustable chainsaw; c) able to hold and bring the harvested fruit into the trailer by using crane grapple; d) ability to depositing fertilizer and pesticide on both sides of SOPMT automatically by using an automatic spreader located under SOPMT's body; e) easy to operate; f) good manoeuvrability on uneven surface; g) durability insulator material protect the control chamber from an unexpected electric shock event. The schematic views of SOPMT is presented in Figure 1 while Figure 2 shows the prototype view of SOMPT.





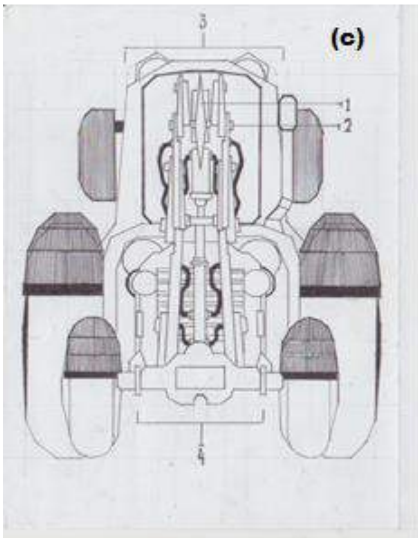


Figure 1. Schematic of (a) side, (b) top, and (c) top views of SOMPT (Prototype).

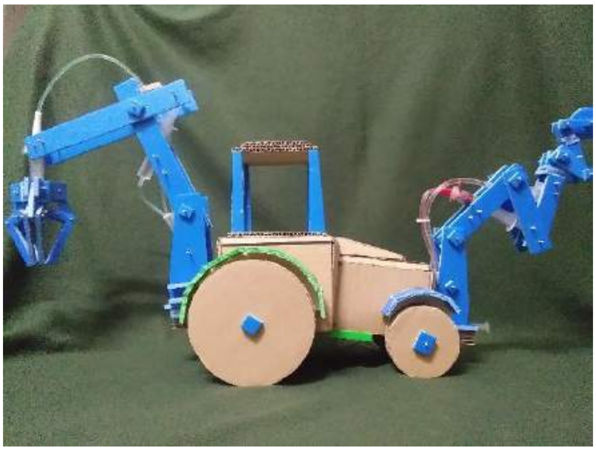
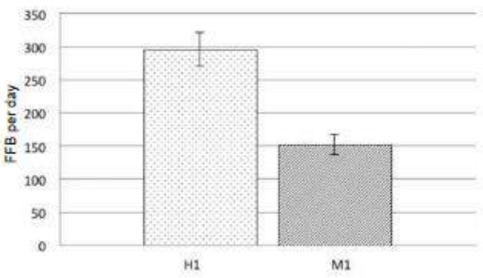


Figure 2. Prototype view of SOMPT.

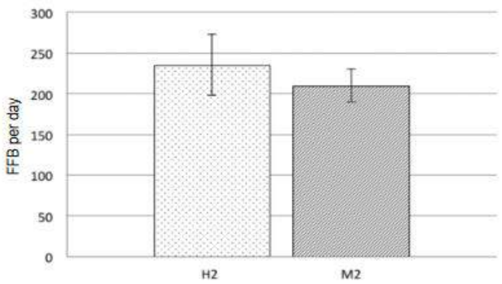
Advantages of SOMPT

The design and functions of SOMPT will speed up the harvesting activity and reduce the time for evacuating the FFB to the factory within or less than 24 hours which could maintain the quality of the FFB. According to Khalid and Shuib (2014), statistic has shown the comparison of detached fruits between the mechanical and manual harvesting methods which can be used to show the benefit of the application of mechanization in this industry. This have been reflected in Figures 3 and 4.



Note: FFB – fresh fruit bunch.

Figure 3. Average productivity per day for a complete harvesting machine with bucket (H1) and manual harvesting with a transportation-buffalo cart (M1).



Note: FFB – fresh fruit bunch.

Figure 4. Average productivity per day for the cutting only harvesting machine without a bucket (H2) and manual harvesting without transportation (M2).

Many of the oil palm farmers and labours neglect to follow the safety rules such as wear the safety helmet, safety boot and glove during harvesting activity with an excuse that all those things will affect work's concentration. Considering that, SOMPT also has been design to prevent injured when unexpected event happen and provide more safety and comfortable work environment to the workers.

Disadvantages of SOMPT

SOMPT has disadvantages too. Firstly, SOMPT can be very expensive to purchase by the small oil palm companies and farmers. To solve this problem, the government or related authorities should help with approving the loan or help them to make an investment. Secondly, it can be very dangerous if operated by unskilled operators. Therefore, the companies have to make sure that operators are well trained and hold the certification to operate the SOMPT.

Conclusions

The oil palm's researcher and authorities need to help and assure that the palm oil industries could sustain, go further and could bring maximum profits to the country. One of practical measured could be taken is through the improvement of efficiency at the field work, productivity and management system involving such as by enhancing the mechanization in fertilizing, weeding and replanting. SOMPT provide great potential to replace the conventional harvesting techniques that have a lot of flows and loose. Operational competency and management costs are factors that need to emphasize and not just depend on the market price to maximize profits in the production of FFB. The important role of hydraulic robotic arm's component that located at the front of SOMPT is suitable to harvest FFB automatically without using of human workload which will minimize the time required in harvesting FFB and improve processing of FBB less than 24 hours which also will enhance producing of oil extraction rate. Furthermore, it also could reduce the cost of hiring extra labours.

References

Abdul Halim, H; Rahim, S and Ahmad, H (1988). An improved FFB harvesting pole with special reference to PORIM's aluminum pole.Paper presented at the National Oil Palm/Palm Oil Conference – Current Developments. 11-15 October 1988, Kuala Lumpur.

Ahmad H, Jelani AR, Jamak J, Noor M, Gono Y, Ariffin O, Cantas TM. A tool for the efficient harvesting of oil palm fresh fruit bunches. Journal of Oil Palm Research. 2008; 20(3):548–58.

Azman, I (2012). An update on current labour situation in oil palm plantation sector. Proc. of the Palm Industry Labour: Issues, Performance and Sustainability Seminar 2012 (PILIPS 2012). 14-15 May 2012, Kuala Lumpur.

Faizah, S (2010). Status of labour force in the oil palm industry. Paper presented at the Palm Industry Labour: Issues, Performance,& Sustainability (PILIPS) Workshop. 8-9 February 2010, Sabah.

Guturu K, Sahitya K, Komali VN, Kiran BR, Satyanarayana VV. Design and fabrication of prototype telescopic raising platform for harvesting oil palm fresh fruit bunches. Indian Journal of Science and Technology. 2015 Aug; 8(17):1–6.

Khalid MR and Shuib AR, (2014). Field Evaluation of Harvesting Machines For Tall Oil Palms. Journal of Oil Palm Research Vol. 26 (2) June 2014 p. 125-132.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA21

Teknologi Baharu: Menuai Padi & Mengumpul Jerami Pada Mesin Jentuai

L., Lee Ban.*, and K., Lee Wei.
Syarikat Kejuruteraan Jentera Pertanian Worldstar Agriculture Machinery, 2268 & 2269, Pulau Nyior, Jalan Kodiang, 06000, Jitra, Kedah
**Corresponding author. Tel.: +604-929 1075, Email:worldstaram@hotmail.com*

Abstract
Jerami yang dibakar selepas aktiviti menuai selama ini amat merugikan, malah mendatangkan permasalahan lain seperti pencemaran alam sekitar. Para petani memilih untuk membakar timbunan jerami yang banyak dan tunggul daripada melakukan aktiviti pereputan. Proses pereputan jerami secara organik memerlukan masa yang agak panjang kerana sisa jerami yang dihasilkan oleh kebanyakan jentuai sedia ada bersaiz panjang dan dalam bentuk longgokkan besar. Proses pengumpulan sisa jerami selama ini dilakukan dengan menggunakan mesin penebas dan mesin baler yang dipasang pada traktor dan dilakukan secara berasingan dan ternyata melibatkan penambahan kos yang terpaksa ditanggung oleh para petani. Melalui pedekatan teknologi baharu pada mesin jentuai ini, sisa tunggul pokok padi menjadi lebih pendek dan akan memudahkan proses pereputan secara organik dilakukan. Sisa jerami dikeluarkan dalam bentuk yang mudah untuk dikumpulkan. Teknologi ini amat membantu banyak pihak terutama kepada para petani, mempunyai kesan ekonomi, dan dapat mengurangkan aktiviti pembakaran terbuka seraya dapat memelihara alam sekitar iaitu udara daripada tercemar.

Kata Kunci: Mesin Pengumpul Jerami, Baja Organik, Makanan Ternakan, Kesan Ekonomi, Pemeliharaan Alam Sekitar

Pengenalan

Mengikut rujukan daripada Wikipedia Bahasa Indonesia, Ensiklopedia Bebas maksud jerami merupakan hasil sampingan usaha pertanian iaitu batang dan tangkai tanaman *serealia* iaitu tanaman *biji-bijian* yang telah kering seperti jerami padi. Pengurusan jerami padi dilakukan secara berperingkat bermula daripada menebas baki tangkai tanaman dan melakukan proses pengumpulan menggunakan jentera yang dipasang mesin *baler* untuk mengumpul jerami. Lazimnya pengumpulan jerami padi dalam bentuk gulungan, diikat mahupun ditekan. Sisa jerami padi mempunyai banyak fungsi dan kebaikan sama ada secara langsung dan tidak langsung. Namun, pengurusan untuk mengeluarkan sisa jerami tersebut memerlukan kos tambahan yang tinggi dan perlu ditanggung oleh para petani sendiri. Kekangan tersebut mendorong para petani menguruskan sisa jerami padi dengan membakar sahaja kerana lebih mudah dan menjimatkan kos. Pendapat para petani yang memilih pembakaran adalah untuk menghapuskan perumah serangga perosak, patogen tanah, dan merencatkan percambahan benih rumpai serta padi angin. Namun dengan aktiviti berikut juga secara tidak langsung akan menjejaskan kadar percambahan benih padi kerana kandungan unsur K yang tinggi akibat daripada pembakaran jerami tersebut. Aktiviti pereputan jerami yang dilakukan secara semula jadi iaitu membiarkan sisa jerami mereput dan terlerai dengan enzim, organisma kecil, unsur dan bakteria yang ada semula jadi mengambil masa yang agak panjang. Saiz yang panjang dan longgokkan jerami yang banyak memerlukan tempoh pereputan keseluruhan jerami yang lama. Selang masa penanaman dan faktor cuaca turut memainkan peranan untuk membantu proses tersebut berjalan dengan baik. Aktiviti pembakaran dipilih kerana lebih cepat dan mudah oleh para petani banyak mendatangkan kesan tidak sihat kepada ekosistem dan alam sekitar khususnya. Oleh itu, teknologi baharu daripada mesin pengumpul jerami yang dipasang pada mesin jentuai ini dapat memberi kemudahan dan menjadi faktor penyelesaian masalah kepada kekangan yang dihadapi oleh para petani di Malaysia. Mesin pengumpul akan beroperasi bersama mesin jentuai pada masa yang sama. Padi akan dituai seperti kebiasaan manakala sisa jerami dikumpulkan secara lebih efisyen dalam bentuk empat segi tepat bersaiz sederhana kecil dan siap diikat. Objektif utama berperanan untuk melancarkan dan memudahkan sistem pengurusan mengeluarkan sisa jerami dengan satu unit jentera sahaja iaitu mesin jentuai dan melibatkan sekali kos kerja sahaja. Proses pereputan boleh dilakukan dalam tempoh masa yang sesuai oleh para petani. Sisa jerami yang dikumpulkan boleh dimanfaatkan untuk kegunaan lain seperti penghasilan baja organik, makanan haiwan ternakan, penghasilan sumber makanan ketiga, kegunaan domestik, dan lain-lain lagi. Para petani dapat menjana keuntungan daripada penjualan sisa jerami kepada pihak memerlukan selain menuai hasil padi setiap musim atau menyimpan sendiri untuk tujuan komsersial lain. Kebaikan kepada tanah sawah juga turut terkesan. Penglibatan jentera pertanian yang minima dapat mengurangkan impak tekanan ke atas lapisan keras tanah sawah. Hanya jentuai bersaiz kecil dan ringan digunakan. Operasi penuaian hasil padi dilakukan serentak bersama operasi pengumpulan jerami oleh jentuai tersebut. Kos, masa, dan tenaga dapat dijimatkan. Tanah lebih terjaga menghasilkan hasil yang luar biasa. Corak pertanian negara akan lebih maju, moden dan lebih proaktif di masa akan datang.

Bahan dan Kaedah

Kajian terperinci untuk penambahbaikkan bagi penggunaan mesin ini telah dilakukan oleh syarikat pengeluaran jentera pertanian yang beroperasi di China. Ujian lapangan turut dilakukan beberapa kali sebelum pihak syarikat pengeluaran mengesahkan mesin tersebut boleh beroperasi sepenuhnya bersama jentuai tersebut.

Mesin Pengumpul Jerami

Mesin pengumpul jerami yang dipasang pada jentuai mini Worldstar 7.0 Plus melibatkan penyambungan antara tali sawat (*belting*) dan beberapa *technical part* yang lain di bahagian akhir kilang dimana sisa jerami dikeluarkan. Mesin ini akan memproses jerami bermula dengan proses penghancuran menjadikan sisa jerami lebih pendek terlebih dahulu dan dimampatkan, kemudian akan diikat kemas dan dikeluarkan dalam bentuk kiub kecilan ke atas tanah semula. Semua proses tersebut dilakukan seiring proses menuai padi di lapangan seperti Gambar 1.

Gambar 1: Mesin jentuai Worldstar 7.0 Plus yang dilengkapi mesin pengumpul jerami.

Keputusan dan diskusi

Berdasarkan kepada permasalahan yang dihadapai oleh para petani sekian lama dalam hal pengurusan sisa jerami setiap musim, dengan bantuan teknologi ini, didapati dapat memberi manfaat dan beberapa kebaikan yang lebih memihak kepada para petani khususnya dan pihak lain amnya. Berikut merupakan antara kebaikan dan perbezaan antara kemudahan daripada teknologi mesin ini dengan yang sedia ada.

Kebaikan kepada tanah sawah.

Sisa jerami tidak sepatutnya dibakar tetapi perlu diuruskan dengan lebih baik melalui proses kitar semula seterusnya diguna balik untuk manfaat padi. Melalui teknologi mesin pengumpul jerami yang dipasang pada jentuai dapat menguruskan kerja-kerja dan proses kitar semula tersebut dengan lebih lancar. Pengurangan sisa jerami dan tunggul pokok padi dapat memberi kelebihan untuk para petani melakukan rawatan tanah dengan lebih baik. Sisa jerami yang dikeluarkan dapat diurai menjadi baja organik dan diguna semula untuk membantu menyuburkan dan menguatkan struktur tanah. Proses penguraian jerami padi dikawal pada kelembapan 55% hingga 65% dengan suhu antara 65°C hingga 75°C dalam tempoh 21 hari. Hasil penguraian akan menjadi kompos dan diguna pada kadar 2 Tan/ Hektar untuk mengembalikan sebahagian nutrien yang penting pada tanaman padi seperti N, P, K, Ca, Mg, S dan Si. Penggunaan baja kompos atau organik ini dapat mengatasi masalah padi angin iaitu kandungan mikrob dalam hasil penguraian mampu merangsang percambahan biji benih rumpai dan padi angin yang terdapat dalam tanah. Rumpai dan padi angin yang bercambah seterusnya akan dibuang melalui pembajakan atau meracun sebelum proses penanaman dimulakan.

Jana sektor dan pemacu ekonomi .

Para petani khususnya dapat meraih pendapatan berlipat kali ganda dengan menuai hasil tuaian padi dan sisa jerami untuk tujuan komersial lain. Para petani tidak lagi bergantung harap pada satu sumber sahaja setiap musim. Penggunaan sumber asli secara menyeluruh amat digalakkan untuk amalan sistem pertanian baik di negara ini. Negara maju seperti Amerika Syarikat, China, dan Jepun, serta beberapa negara lain seperti Thailand, Filiphina, India, Bangladesh dan Indonesia mempunyai teknologi, kaedah, dan kempen pro-aktif ke arah pengurusan jerami secara berkesan. Hasilan jerami berpotensi tinggi diaplikasikan dalam bidang pertanian seperti hortikultur dan penternakan; sektor industri; sektor pembinaan dan pembangunan sumber tenaga alternatif (Jadual 1) (Rosmiza et.al., 2014).

Jadual 1: Potensi jerami padi dalam rantaian industri (huluan dan hiliran)antara sektor pertanian dengan sektor ekonomi lain.

Sektor Pertanian	Sektor Pembuatan	Sektor Pembinaan	Sumber Tenaga
Baja Kompos	Hasilan Kerta Pembungkus Makanan	Bahan Binaan	Bahan Bakar (Ethanol)
Makanan Ternakan	Bahan Karbo Teraktif	Penebat Haba	Tenaga Elektrik
Medium Semaian Tika	Asid Pirolignus	Penahan Hakisan Tanah	Biogas (bahan bakar domestik)
Medium Pertumbuhan Cendawan		Tebus guna Tana	

Lantai Ternakan *(Animal Bedding)*
Bahan Sungkupan
Tempat Pembiakan (Sarang)

Sumber: Rosmiza et. al., 2014

Negara-negara tersebut juga berjaya mewujudkan petani berdaya maju dan berkesedaran tinggi terhadap pemeliharaan alam sekitar dalam pengurusan ladang. Usahawan daripada industri hiliran juga turut dilahirkan lebih ramai hanya berasaskan sisa jerami padi (Rosmiza et. al., 2014).

Pengiraan anggaran pendapatan hasil jualan jerami.

Menurut kajian Indonesia, berat jerami adalah lebih kurang 1.4 kali daripada hasil tuaian biji padi. Maka daripada 5 Tan/Hektar hasil tuaian, sebanyak 7.5 Tan jerami dihasilkan. Keterangan pengiraan seperti (Jadual 2).

Jadual 2: Pengiraan Pendapatan Hasil Jualan Jerami.

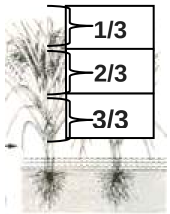
1 Hektar	7.5 Tan (7500Kg) Jerami
1 Kg	RM0.25
Kiraan	*7500Kg Jerami X RM0.25*
Pendapatan	*RM1,875.00*

Jika 1 Hektar sebanyak 7.5 Tan jerami diperoleh, maka petani bakal memperoleh jumlah pendapatan sebanyak **RM1,875.00** semusim hasil jualan jerami sahaja.

Perbandingan Pengurusan Jerami Sedia Ada (Baler) Berbanding Mesin Pengumpul Pada Jentuai Worldstar 7.0 Plus.

Keterangan perbandingan antara penggunaan mesin *baler* pemungut jerami dan mesin pengumpul jerami pada jentuai seperti (Jadual 3).

Jadual 3: Keterangan Perbandingan.

Mesin	Mesin Penggulung Jerami (*Baler*) Yang Ditarik Oleh Traktor	Mesin Penggulung Jerami (*Baler)* Yang Dipasang Di Jentuai
Gambar Mesin		
Kaedah	Mengumpul jerami yang berada di atas tanah yang dituai oleh jentuai besar .	Jerami dikumpulkan langsung terus daripada jentuai mini - tidak membazir sumber jerami yang diproses.
Skala Kerat Pokok Pad oleh Jentuai	Jerami yang dikumpulkan hanya 1/3 sahaja kerana jentuai besar hanya boleh menuai 1/3 daripada pokok padi – jika melebihi akan mengganggu sistem kilang pemprosesan jentuai besar. 	Pokok padi boleh dituai pada skala potongan 3/3 batang padi – jerami boleh banyak – memudahkan kerja pembajakan seterusnya. 
Pilihan	Petani tidak dikenakan bayaran ketika pemungutan sisa dilakukan dan jerami tidak boleh disimpan oleh petani.	Petani dikenakan upah penuaian yang lebih sedikit – petani boleh memilih untuk menjual atau menyimpan sisa jerami untuk kegunaan sendiri.
Manfaat	Memberikan kelebihan kepada pengusaha.	Memberi banyak kelebihan kepada tanah sawah dan petani.
Jentera Lain	Perlu menggunakan traktor untuk menarik mesin *baler* – perlu banyak kos dan tenaga	Tidak perlu menggunakan traktor – jimat kos bahan bakar – jimat kos operator
Tempoh	Perlu menunggu jerami kering untuk memudahkan kerja-kerja pengumpulan.	Jerami boleh terus dikumpulkan tanpa perlu menunggu kering.

Kesimpulan

Kehadiran teknologi terbaharu ini berperanan membantu dalam memudahkan urusan yang telah dijalankan oleh mesin sedia ada. Namun, peranan institusi sangat penting dalam melestarikan permintaan dan tawaran bagi pembangunan produk jerami. Penglibatan dan sokongan serta kerjasama pegawai, promosi, bantuan kepakaran, dan kecekapan pengurusan amat perlu digerakkan bersama-sama. Sokongan dan bentuk bantuan perlu disandarkan kepada beberapa polisi berkaitan pembangunan industri jerami yang dilaksanakan di Malaysia. Kebaikan daripada teknologi ini amat memberi ruang dan peluang yang lebih besar serta memudahkan banyak pihak namun promosi dan sokongan teguh dari pihak atasan perlu berterusan. Promosi berperanan penting dalam memberi maklumat kepada masyarakat khususnya para petani berkaitan kepentingan dan kelebihan penggunaan produk jerami terhadap pembangunan ekonomi dan alam sekitar. Sebagai contoh, pengguna terutama petani tidak mempunyai maklumat berkenaan keperluan tanaman kepada input organik dalam peningkatan kesuburan tanah dan tanaman serta penghasilan output yang lebih tinggi dalam jangka masa panjang. Perancanaan dasar di peringkat nasional dan pelaksanaannya di peringkat institusi secara menyeluruh dilihat mampu menjamin pembangunan industri jerami dengan lebih berkesan. Hasrat perundangan alam sekitar dan pemasaran produk berasaskan jerami merupakan cabaran utama yang perlu diberi perhatian. Corak penggunaan barangan mesra alam harus diterapkan dalam
.

kalangan masyarakat Malaysia khususnya untuk membantu memajukan usahawan-usawahan yang terlibat dengan industri jerami ini. Pihak kerajaan diharapkan dapat mengetengahkan kajian pasaran yang lebih luas dan kukuh untuk menaik taraf produk berasaskan jerami padi atau produk bersifat “produk hijau” ini. Permintaan yang tinggi akan mengurangkan tanggungan perundangan kerajaan dalam menguruskan alam sekitar yang tercemar akibat daripada pembakaran yang dilakukan setiap musim selepas aktiviti menuai.

Rujukan

Rosmiza MZ, Davies WP, Rosniza Aznie CR, Mazdi M, Jabil MJ (2014) Farmers’ knowledge on potential uses of rice straw: An assessment in MADA and Sekinchan, Malaysia. Geografia Malaysian Journal of Society and Space 5, 30-43.

Ida Nurlinda (t. th.) Konsep Ekonomi hijau (green economic) dalam pengelolaan dan pemanfaatan sumber daya alam di Indonesia untuk mendukung pembangunan berkelanjutan. [Cited 15 Mac 2015]. Available from: http://www. academia.edu.

Lembaga Kemajuan Pertanian Muda (MADA) (2004) Business plan: Projek jerami dan kompos di kawasan Muda. Alor Setar, Kedah.

Zhang R, Jenkins BM (2004) Commercial uses of straw. Agricultural mechanization and automation, Vol II. California, United States of America.

Ahmad Zakaria Mohamed Sidek, Jabatan Pertanian Malaysia (2017) Kaedah Betul Kitar Semula Jerami

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA22

Preliminary Study of existing Pineapple Transplanter

A.S. Adli Fikri[1], A. R. Rohazrin[1] and A. Mohd Taufik[1]
[1]Dept. of Engineering Research
Malaysia Agriculture Research and Development Institute (MARDI)
Ibu pejabat MARDI Persiaran MARDI-UPM
43000 Serdang, Selangor
Tel.: +6016-3214922, Email:adlifikri@mardi.gov.my

Abstract

Problems getting labor and increasing in labor wage with the large farm size will be directing the pineapple farmers towards to the use of farm mechanization. Manual pineapple planting required 15 workers to plant one hectare of pineapple, which involve planting of 43500 suckers. A Manual/semi-automatic mechanical pineapple transplanting machine, might helpful to be used for facilitating pineapple planting activity but a lot of issues regarding safety and standardization of works are need to be an-countered.This machine is able to plant pineapple in 13 hours/ha. Therefore a gripper type mechanical transplanter was proposed and developed to be used as a reference to improve the design of the pineapple transplanter.It is more smaller compared to the existing pineapple transplanter. The objective of the study was to evaluate and compare the performance of the machine in terms of ease of handling, reliability, stability, safety and maintainability.Preliminary tests showed that the changes done have improved the workability of the machine for mechanical transplanting of pineapple suckers.

Keywords: Manual/gripper transplanter, Gripper type, Pineapple, Transplanter,

Introduction

Pineapple is one of the tropical fruits that has a bright future in supporting the Malaysian economy. Currently, 95% of the domestic canned pinepapple production is used for the export market while the rest is for domestic market. Fresh pineapple contributes only 30% of the export market and 70% for domestic market. (MPIB, 2012) It is listed under NKEA for agriculture to increase production targeting the export market especially in the Middle East and Europe. It is forecasted that farmers would be enable to earn a monthly income of RM4500 per hectare and at the same time contributing RM1.6 billion to Gross National Income (GNI). (PEMANDU, 2011).To support the increase in production rate would mean that the planting density should be increased. A hectare of pineapple would require 43,500 plants. A standard worker is only able to plant 3000 suckers/day. This means that 15 workers are required to plant one hectare of pineapple in one day. In addition, domestic labor is difficult to obtain. As a result, domestic agriculture is highly dependent on foreign labor.

It is expected that mechanization would be the main enabling factor to support the increase in pineapple cultivation. MARDI has taken measures to handle this issue by developing a complete mechanized pineapple production package, which includes a mechanical transplanter. This machine is able to plant pineapple in 13 hours/ha. However it would still require two operators at the rear to release the suckers from the transplanter bin and place them in the soil. (Rahim et al.,2007)

The existing transplanter know as manual/semi-auto pineapple transplanter raised issues such as planting losses in the field and safety concerns. Therefore a gripper type mechanical transplanter was proposed and develop to be used as a reference to improve the design of the pineapple transplanter. It is more smaller compared to the existing pineapple transplanter. This machine requires one operator to transfer the seedlings or cuttings from the loading tray to the grippers.The objective of this study was to study and improved mechanicaltransplanter for pineapple suckers transplantingon operation work. A preliminary experiment based on the design study and operation process for current transplanter and the gripper type mechanical transplanter was done. There are major need to be Improve were suggested based on these two activities.

Materials and methods

Pineapple Transplaner

The manual/semi-auto pineapple transplanter (Figure 1) were been develop in 2007 by Mr. Rahim Abdul Rahman The machine is a tractor-mounted transplanter and requires 3 operators, where one of them works as a tractor driver and the remaining 2 operators seat at the rear of the machine and place the sucker manually into the holes that made by the machine. Manual pineapple planting required 15 workers to plant one hectare of pineapple, which required 43500 suckers. Previous tests showed that

using a minimum forward travel speed of 0.8 km/h, the operator had difficulty in loading the suckers onto the clippers.

Figure 1. Previous Existing manual/semi-auto operation transplanter

Therefore, Gripper type mechanical transplanter was developed (Figure 2).

Figure 2 gripper type mechanical transplanter

Design concept that been taken is from previous vegetable planting machine that where been custom to able to plant pineapple suckers (Figure 3).

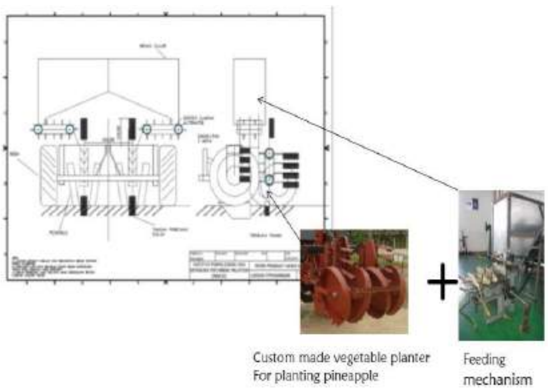


Figure 3. Design Concept for gripper type pineapple transplanter

This machine was ground wheel driven, which meant that the mechanisms of the machine were generated by the rotation of the ground press wheel. This ground wheel would move the three roller chain systems that would move the grippers. These grippers 4 hold the seeds, or in this case, the pineapple suckers, before transferring them to the soil. A furrow opener is located at the front of the machine to open up the soil to ease transplanting. An operator seat and a seed tray are available for the operator to sit on and to load seeds to transfer to the grippers. The planting distance can be pre-determined by changing the sprocket near the loading tray.

Field test

A preliminary study for the The manual/semi-auto pineapple transplater was done at Tampin. Negeri Sembilan, this machine or implement was attached to a 90 hp New Holland tractor (model 7740) and Josapine varieties were been tested during this test and for the the gripper type transplanter field test was done at Engineering Research Center (ER) research plot, using but with modification done on the furrow opener depth. This machine or implement was attached to a 90 hp New Holland tractor (model 7740). MD2 varieties were tested during this test to observe suitability of this transplanter to transplant pineapple suckers. The quality of the transplanting was observed in terms of actual planting distance and the condition of the pineapple suckers after transplanting.

Result and Discussion

Pineapple Transplanert

The manual/semi-auto pineapple transplanter

The transplanter were mounted at the rear of a New Holland tractor (model 7740) using a minimum forward travel speed of 0.8 km/h, the operator had difficulty in loading the suckers onto the clippers. Different chain pitches were used for the three roller chain system used for the planting mechanism. The clippers also needed improvement to properly hold pineapple suckers. The furrow opener was too small, thus required widening. The ground press wheel, which also drives the planting mechanism, is considered too big. Design improvements done were changing the roller chain system configuration to reduce the sucker loading while maintaining planting distance. The existing mechanical transplated raised issues such as planting losses in the field and safety concerns (Figure 4). The current transplanter has a huge loading bin, and two operators would sit at a low position near to the ground to grab pineapple suckers from the loading bin and positioned it in front of a mechanical soil puncher. This low position has created some safety concerns because the tractor driver cannot see the two planting operators (Figure 5). This puncher would create a soil opening and a set of soil compacter wheels will compact the soil after transplanting. During the transplanting process, unsuccessful planting occurred due to mis-planting or suckers not planted in a vertical position (Figure 3). The tractor drive had difficulties in seeingthe transplanting operators from the tractor cabin because they were sitting at a very low position.

Figure 4: The manual/semi-auto pineapple transplater(1)operator seat at the lower back of the machine- safety Issue (2) Speed of the feeding machnism missing point

Figure 5: Low position of planting

Figure 6: Show (1)the gripper mechanism was too fast because been diven from the wheels depend on the travel speed of the tractor. (2) show that the pineapple sucker is a bit bigger than the gripper

Gripper type Transplanter

Gripper type transplater was mounted at the rear of a New Holland tractor (model 7740) .The forward travel speed was initially set at 0.8 km/h, which was the slowest travel speed that can be adjusted for the tractor. It was observed that at this speed, the operator had difficulty in placing the pineapple suckers from the loading tray to the grippers, because the gripper mechanism was too fast (Figure 6). The transplanter could easily transplant all grades of the MD2 variety without any complications. However, the diameter of the suckers was too big for the machine. Improved design needed for the griper by increasing the length of diameter of the gripper (Figure 6). The modified furrow opener succeeded in creating a furrow about 5 to 8 cm deep, to allow the pineapple suckers positioned vertically. However the design of furrow need to be study to improved the effiesiecy of the opener because some of the suckers fall down during the planting(Figure 7). The furrow depth could be adjusted by controlling the three-point hitch of the tractor**.**

Figure 7: Show the pineapple suckers fall down during the planting

Conclusions

By comparing 2 type of conceptual design as a resultant, this gripper type transplanter can improve the work efficiency of pineapple transplanting to about 70-80% compared with manual/semi-auto operation and more friendly use and safety compare to previous machine.The machine is very effective in reducing labour workload especially during transplanting operation for making holes and carrying suckers.

References

Abd Rahim Hassan, A.R. Rohazrin, M.Noor Al-Anuar. 2007. Development and performance of pineapple transplanter for commercial scale production

Malaysian Pineapple Industry Board). 2012.http://www.mpib.gov.my. (Accessed 7 June 2012).–

PEMANDU (Performance Management Delivery Unit) 2011. Chapter 15: Transitioning from Agriculture to Agribusiness.Economic Transformation Programme: A Roadmap for Malaysia. pp 513-550.

JP-RM-0352 - Development of a planting mechanism for automated pineapple transplanting

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA23

Minimum Energy Performance Standards of Hydroponic Root Zone Cooling System For Lettuce Cultivation on Roof Top Garden

Ahmad Syafik, S.[1], Mohd Syaifudin, A. R.[2], Mohd Shukri, H. B., Mohd Latiman, Y.
Precision Agricultural Programme, Engineering Research Centre, MARDI Headquarters,
Jalan Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia.
Phone no: 0123651940 E-mail: syafik@mardi.gov.my

Abstract
Hydroponic cultivation techniques usually apply for growing leafy vegetables and sometimes fruit vegetables. Problems commonly associated with hydroponic system are water temperature can easily increase under direct sunlight in the tropics region especially under crop protection structure thus can affects the quality of fertilizer given. A study to develop a cooling system for hydroponic technique which can control the water-dissolved nutrient temperatures that suits the crop growth needs have been conducted to overcome the problem. This paper highlights the development and minimum energy performance determination of the hydroponics root zone cooling (HRZC) system for lettuce cultivation on (6.06 m x 2.35 m) roof top garden. It was found that with the using of only 0.5 hp water pump, the HRZC system was able to distribute and control the hydroponic water-dissolved nutrient temperatures flow to the hydroponic growing container which has a length of 10m long at different height levels of the structure wall. By using only 1.0 hp chiller water system, the ranges of temperatures that can be controlled using the HRZC system were between 15 ºC to 25 ºC which meets the crop-root zone temperature needs.

Keywords: energy performance, hydroponic, root zone cooling, roof top garden

Introduction

Malaysia Agriculture Research and Development Institute (MARDI) have developed several cooling techniques in greenhouse to increase the production of temperate crop in lowland. Research have been done to explore the alternative technology of cooling such as root zone cooling system, misting fan, evaporative pad and ventilation fan which can reduce the production cost (Ahmad Syafik et al, 2010). This root zone cooling system can be adapted to the hydroponics cultivation method which enables the water-dissolved nutrient temperature to be controlled. By manipulating the root zone temperatures with adequate lighting system, it would increase the crop productivity (Gosselin & Trudel, 1984). It was reported that the effect of root zone temperature is greater on root growth especially in early stage of crop development (Mohammud et al., 2012). Studies have shown that crop roots are more sensitive to fluctuation in temperature than crop shoots However, extreme root zone temperature manipulation can cause excessive vegetative growth, flower abscission and poor fruit set. Thus, it is important to consider the crop requirements before planning for cooling technique (Mat Sharif, 2006). In this study, hydroponic root zone cooling (HRZC) system was developed to cultivate high value vegetables in tropics and to determine the effects of HRZC on crops growth and yields. Among the many varieties of high valuable vegetables in Malaysia, Lettuce of *Lactuca Sativa* varieties have been chosen as selected vegetable in this study due its affordable price in Malaysia markets which is between RM 6/kg and RM 8/kg. Moreover, *Lactuca Sativa* also known and popular because it can be grown easily with the hydroponics system besides having simple maintenance procedure. The hydroponic root zone cooling system includes the chiller, cooling water pump, and hydroponic growing container. Among these devices, the chiller consumes most power of the HRZC system. The consumed energy is related to the loading of the system and it is necessary to determine the precise minimum power of the chiller to be used in order to reduce the production cost. The were several literatures discussing how to optimize the chiller loading. Braun et al. (1989) proposed the equal loading distribution (ELD) method. This method was established under the same operating characteristic of the chiller. Due to the different operating characteristic of the chiller, Braun et al. suggested that the power consumption of the chiller was correlated with load of air conditioner, cooling water return temperature, and chiller water supply temperature. This correlation may explain the optimal chiller loading (OCL) method. The objectives of the study were: (1) to determine minimum energy performance standards of hydroponic root zone cooling system for lettuce cultivation on (6.06 m x 2.35 m) roof top garden, (2) to evaluate the HRZC system performance in distributing and controlling water-dissolved nutrient temperatures to meet crop-root requirement needs.

Materials and methods

The study was conducted at Engineering Research Centre, Malaysian Agricultural Research and Development Institute (MARDI) in Serdang, Selangor Malaysia with latitude 20 59, N, longitude1010 42, E and 37.8m above sea level (Diyana, 2009).

Hydroponics root zone cooling systems development

HRZC was developed by the integration of 1 hp chiller system that can control the water-dissolved nutrient temperature inside the hydroponic water tank (Figure 1 and 2). The water-dissolved nutrient will be chilled till 10 ^{0}C and flowed using a 0.5 hp water pump to the hydroponic growing container which was 10 m long and vertically arranged at 4m long each level at the wall of the crop protection structure (figure 1). The water-dissolved nutrient temperature inside the 10 m length of hydroponics growing container at different levels will be controlled between 15-25 ^{o}C using a pipe valve and water with velocities between 5-10 m^3/s. The chiller will be on for 12 hours from 7.00 am in the morning till 7.00 pm in the evening.

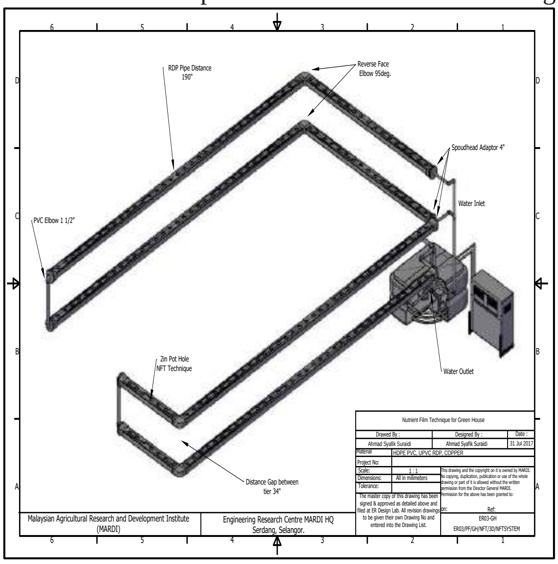


Figure 1: Systems schematic drawing

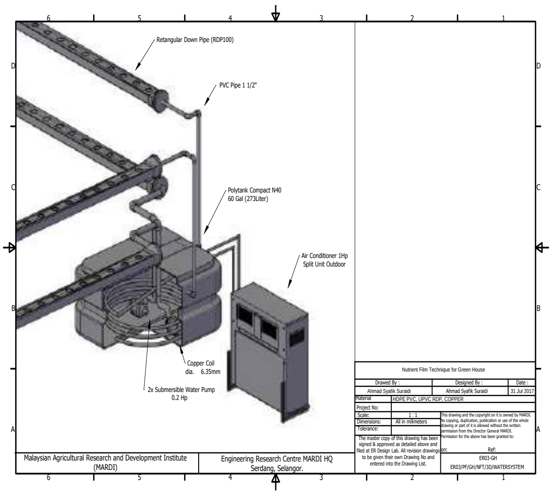


Figure 2: Cooling System

***Lactuca Sativa* cultivations**

Lactuca Sativa were planted in a Nutrient Film Technique (NFT) hydroponics plot of 20 cm wide, 10 cm thick and 4 m long (4m long at each level) that vertically arranged inside a crop protection structure (figure 3). The water level inside the growing container was 8cm which can reach by the crop roots. The crop spacing was 10 cm, and for 8m long of growing container it can accommodate near 300 crops. *Lactuca Sativa* was transplanted under the crop protection structure after 3 weeks of seeding in nursery. The crops were transplanted and grow inside the structure for 3 weeks (Figure 4) before harvested.

Figure 3: Cultivation inside crop protection

Figure 4: Lactuca Sativa after 2 weeks

Data collection

The data of average water-dissolved nutrient temperature for 10 points i.e. from H1.1 to H1.10 along the growing container (10 m long) were collected for 4 weeks started from 2 April to 23 April 2018 between 8.00 am and 5.00 pm in order to evaluate the water-dissolved nutrient temperature distribution along the pipe line. The ambient temperature was also collected at the same interval and time to study the correlation between the ambient temperature, conservative hydroponic water-dissolved nutrient temperature without cooling systems and hydroponic water-dissolved nutrient temperature with cooling systems (HRZC).

Results and discussion

Determination of chiller cooling capacity

The water chilling cooling capacity was estimated based on the heat required to reduce the water temperature from the ambient water temperature of about 30 ^{o}C to the target chilled water temperature of 10 ^{o}C. The cooling capacity was calculated using the following heat transfer formulas (ref. used from Accurate Heating and Cooling Load Calculation, Arthur Burlick 2010). The water flow rate of chilled water into the 60 gallon hydroponic tank is 0.0995 m3/s, the inlet temperature is 25 ^{o}C and the outlet temperature is 10 ^{o}C. This means the average temperature is 17.5 ^{o}C so we lookup the water properties at this temperature to find the density of the specific heat capacity of 4.19 kJ/kg/K.
Using the energy equation of $Q = \dot{m} \times Cp \times \Delta T$ we can calculate the cooling capacity.

^{0}C= celcius P= density of water kg/m^{3}

Cp= specific heat kJ/kg/K Q= heat transfer kW

K= kelvin temperatures V= volume flow rate m^{3}/s

Q= cooling capacity kW m= P x V

ΔT= temperatures difference

The hydroponic tank volume capacity is 60 gallons, so P= 60 gallon = 227.12 liter or kg, Volume = 70cm x 36 cm x 100 cm = 252000 cm^{3} = 2520 m^{3}. Density, P = m/v = 227.12/2520 = 0.1079 kg/m^{3} of water density. Q = (0.1079 kg/m3 x 0.0995 m^{3}/s) x 4.19 kJ/kg/K x ((25^{0}C +273.15K) – (10 ^{0}C +273.15K))

Q= 0.0107 x 4.19 x 15

This gives us a final answer of Q = 0.672 kW of cooling.

Equal to **0.905** hp #

We add 273.15K to the celcius to convert it to units of Kelvin. The Specific heat capacity (Cp) is measured in units of kJ per kg per Kelvin.

Determination of water pump capacity

Water and Pump Horsepower
To fully understand water horsepower, it is important to understand the terminology involved in deriving such a unit. The term "energy" is defined as the capacity to do work. "Power" is the rate at which energy flows or at which energy is used per unit of time; it is also the rate at which work is performed. In other words, power is the amount of energy that is used to do work or how quickly work can be done. Water horsepower is the minimum power that is required to move the water (Figure 6). In other words, it is the power that the pump would require if the pump were 100% efficient. The water horsepower can be determined if the flow rate of the water and the force (pressure) required to produce that flow are known.

The following formula can be used to calculate water horsepower (WHP).

WHP = HQ / 3960

Where H is the change in pressure measured in height of water in feet and Q is the water flow rate in gallons per minute.

This equation was derived knowing that one horsepower is equal to 550 ft-lb/s.

For example, if an irrigation pump located at water tank is pumping 60 gallons of water per minute from a water tank whose water needs to travels along 10 meter or 32.81 feet long of NFT hydroponic growing container, the water horsepower that the pump is delivering is:

WHP = (32.81 x 60) / 3960 = 0.497 #

So the pump is providing 0.497 WHP when it lifts water 32.81 feet at a rate of 60 gallons per minute.

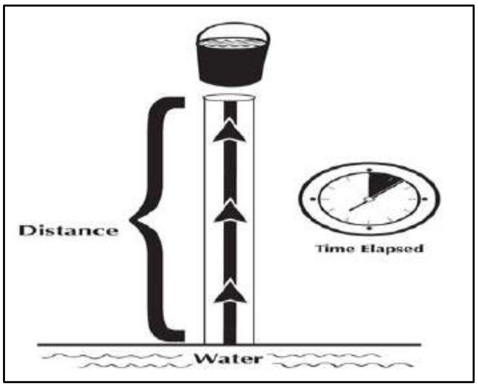


Figure 5: Diagram illustrating water horsepower by moving a volume of water a specified distance per period of time.

Pump Efficiency

No pump can convert all of its mechanical power into water power. Mechanical power is lost in the pumping process due to friction and other physical losses. It is because of these losses that the horsepower going into the pump must be greater than the water horsepower leaving the pump. The efficiency of any given pump (η) is a ratio defined as the water horsepower out divided by the mechanical horsepower into the pump.

η = water hp out / hp into pump 0 < η < 1

If the pump in the last example uses 17.0 HP to provide 13.0 WHP, the pump efficiency is:

η = 13 / 17 = 0.76 or 76%

The pump is 76% efficient, and 24% of the input energy is lost to friction and other losses. Most modern pumps have an efficiency of 50 to 85%.

When choosing a pump, it is important to consider the relationship between efficiency and overall cost. More efficient pumps tend to be more expensive. However, with better efficiency comes lower fuel costs to run the pump. Although more efficient pumps usually come with an increase in capital cost, the overall fuel consumption will be lower, resulting in lower annual fuel or electricity costs.
It should also be noted that the discussion in the previous paragraphs was for a pump properly sized for the application. If the pump does not match the application, it may have to operate in an inefficient range, and fuel or electricity will be wasted. Consult with a Professional Engineer or a pump supplier if you have questions about a specific pump or application.

Hydroponic root zone cooling system performance

Average water- dissolved nutrient temperature distribution profile of HRZC system for 4 weeks from 8.00 am to 5.00 pm daily at different 10 points and levels were as illustrated in Figure 6. Based on the graph, there was no significant difference between 10 points data along 4m of hydroponics growing container at different levels. In average, the HRZC system was found to be able to maintain the root zone temperature at different length and height of hydroponics growing container. The minimum water-dissolved nutrient temperature was 12.33 ^{o}C at 10.00 am, located at the early entrance of the flowing water from the water tank at 4 points which were H1.1, H1.2, H1.3, and H1.4. The heat loss was very minimum at these points due to length, water velocity, water level and ambient temperature factors. The maximum water-dissolved nutrient temperature was 23.5 ^{o}C at 3.00 pm which located at points H1.7 and H1.8. This was due to that points were located at the end of the growing container which having accumulated heat loss along the pipe length. Moreover, at 3.00 pm, ambient temperature was at the maximum conditions which can increase the heat loss of water-dissolved-nutrient temperature that flows inside the growing container.

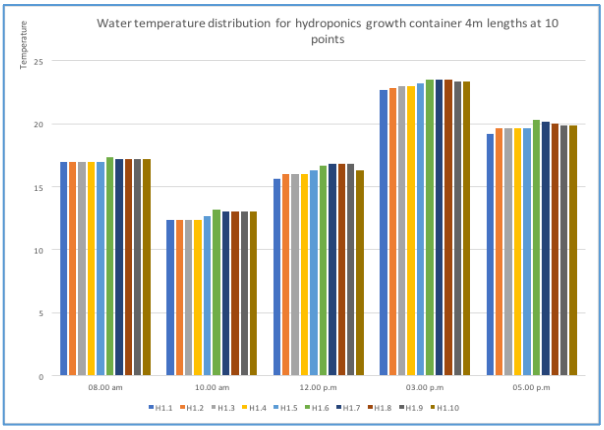


Figure 6: Average water-nutrient temperature distribution profile of HRZC

Conclusions

As a conclusion, it was found that the HRZC system using 0.5 hp water pump was able to distribute and control the hydroponic water-dissolved nutrient temperatures flow to the hydroponic growing container at different height levels of crop protection structure wall. The ranges of temperatures that can be controlled by HRZC using 1.0 hp chiller system were between 15 ^{o}C to 25 ^{o}C which meets the crop-root zone temperature needs. The ambient temperatures have a significant effect to the water-dissolved nutrient temperatures, in which the increase of ambient temperature can increase the water-dissolved nutrient temperatures inside both of the hydroponic cultivation methods.

References

Diyana, J., Rezuwan, K., Ahmad, D., Illias, M.K., Hawa, J., and Amin, M.S. 2009. Evaporative pads and exaust fans cooling system for temperate crop production in tropical greenhouse. In National Conference on Agricultural and Food Mechanization, Malaca.

Mohammud, C.H., Illias, M.K., Zaulia, O., Ahmad Syafik, S.S., and Angelina, H.M.Y. 2012. Effect of Rhizosphere cooling on tomato crop performance under controlled environment structure. In Malaysia International Conference on Trend Bioprocess Engineering (MICOTRIBE) 2012 (pp. 1-8).

Gosselin, A., and Trudel, M.J. 1984. Interaction between root-zone temperature and light levels on growth, development and photosynthesis of Lycopersicon esculentum Mill. Cultivar "Vendor". Scientia Horticuturae, 23(4), 313-321. Doi: 10.1016/0304-4238(84)90027-X.

Mat Sharif, I. (2006). Design and development of fully controlled environment greenhouse for the production of selected temperate crops in lowland tropics. In International Symposium on Greenhouse, Environmental Controls and In-house Mechanization for Crop Production in Tropics and Sub-tropics (pp.

127–134). Cameron Highlands: Acta Horticulturae (ISHS) 710.

Ahmad Syafik, S.S., Mohd Faisal, H., and Mohd Hafiz, H. 2010. Effect of growth media cooling using chilled water system for tomato growth to the temperature and humidity under controlled environment structures in lowland. In Malaysia Science and Technology Conference. Petaling Jaya, Selangor Malaysia.

Dickinson, H.W. 1936. James Watt: Craftsman and engineer. Cambridge: Cambridge University Press.

Hart, I. 1949. James Watt and the history of steam power. New York: Henry Schuman, Inc.

Pritchard, P. 2011. Fox and McDonald's introduction to fluid mechanics, 8th ed. New York: Wiley.

J.E Braun, S.A. Klein, J.W Mitcell, and W.A. Beckman. "Application of optimal control to chilled water systems without storage". ASHRAE transaction vol 95, no 1, pp. 663-675, 1989.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA24

Misai Kucing plotting arrangement under solar PV panel and harvester machine efficiency – A comparative study

Muhamad Nurjafni, J.[1], Mohd Salahuddin, M.B.[1,*]
[1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
*Corresponding author. Tel.: +603-97694312, Email: salahuddin@upm.edu.my

Abstract
Orthosiphon stamineus, a member of the Lamiaceae, is a native plant to tropical Asia. Misai Kucing can be harvest four cycles per year after planting. In Malaysia, this plant has been planted under solar photovoltaic (PV) arrays in large scale area. Until today, the harvesting process of the shoot is done manually using regular hand cutters such as knife and scissors. It is difficult to harvest the shoots since there is limited space between the plant and the solar panels. By using machinery, the labor worker and overall cost can be reduced, and productivity and profitability can be increased. Prior to the harvesting machine development, a study on the plot arrangement of the Misai Kucing under PV panel is required. The objective of this study is to determine the best plot arrangement based on three parameters which are total polybag harvested, harvesting time required and distance covered by the machine under one PV panel. The results will be discussed in consideration with the efficiency aspect of the harvester machine. The result shows that the plot arrangement E which provide 4 polybags per row to be harvested at one time has the highest total polybag to time and distance ratio. This result provides efficiency for the harvester machine to be designed and developed.

Keywords: misai kucing, solar PV panel, harvester machine, plot arrangement, efficiency, time, polybag

Introduction

Orthosiphon stamineus (Figure 1), a member of the Lamiaceae, is a native plant to tropical Asia. Although it was first introduced to the European consumers as an herbal tea in the 20th century, this species only became popular, particularly in Indonesia and Malaysia in the last few decades It is commonly known as "Misai Kucing" in Malaysia and Singapore, "Kumis Kucing" in Indonesia or Java Tea in. Misai Kucing can be harvest four cycles per year after planting. O. stamineus is used for treating diseases such as rheumatism, diabetes, hypertension, tonsillitis, epilepsy, menstrual disorder, gonorrhea, syphilis, renal calculus, gallstone, urinary lithiasis, edema, eruptive fever, influenza, hepatitis, jaundice and biliary lithiasis(Awale *et al*., 2002).

Figure 1: Orthosiphon Stamineus

Hybrid Agric Voltaic (Figure 2) evokes the green ecological economy concept through inculcating herbal plots under solar photovoltaic (PV) arrays in large scale. This approach optimally utilizes the unused space under solar PV arrays despite the issues of radiation effect and extensive heat discharge through inculcating Misai Kucing as the sustainable high-value herbal plant (Othman *et al*., 2017).

Figure 2: Hybrid Agric Voltaic

Until today, the harvesting process of the shoot is done manually using regular hand cutters such as knife and scissors. It is difficult to harvest the shoots since there is limited space between the plant and the solar panels. By using a tool like a machine as shown in Figure 3, the labor worker can be reduced, productivity can be increased, the cost can be reduced, and the profit can be increased.

Prior to the harvesting machine development, a study on the plot arrangement of the Misai Kucing under PV panel is required to determine the most optimized parameter that will be considered for the machine development. The objective of this study is to determine the best plot arrangement of Misai Kucing based on three parameters which are total polybag harvested, harvesting time required and distance covered by the machine under one PV panel. The results will be discussed in consideration with the efficiency aspect of the harvester machine.

Figure 3 Misai Kucing Harvester

Materials and methods

A twelve-series configured with 95WCEEG monocrystalline PV array has been installed in Universiti Putra Malaysia, Serdang, Malaysia at GPS coordinate of 2_5902000N: 101_4303000E as illustrated in Figure 2. The build-up area covers 8.64m^2 with a practical conversion efficiency of 17.05 percent at slanted tilt-angle of 7.60 facing 1600 south. The herbal plots are arranged with a few arrangement under PV foundation. The Java Tea plant growth process which covers pre and post herbal preparation is with flow segregation in 3 stages based on plant condition. Initially, the seedlings use fresh branches with small nodes from a mature plant at the herbal nursery. The polybags size is 12 cm x 12 cm and 80 percent filled with mix soils of top-soil, organic fertilizer, ash, sand and granulated stones. The mature period for Java Tea is approximately 2 months after deposition at PV site. Figure 1 shows the raw material in wet condition after washing and rinse before the oven drying and semi-fine grinding process. The operational costs and profits are achieved at a different sequence of harvesting period with specific increasing interest rates (Othman *et al*., 2014).

Results and discussion

Six plot arrangements of Misai Kucing under solar PV have been studied which comprised of three different plot arrangement layouts; 2-2 polybag (Figure 4 and 5), 3-3 polybag (Figure 6 and 7) and 3-3 polybag as shown in Figure 8 and 9. Each arrangement layout is plotted either in vertical and horizontal form. Space at the very left or right side of the polybags is left empty to allow the machine (Figure 3) with a motor, attached at the side of the machine, to pass through all polybags at the first cut.

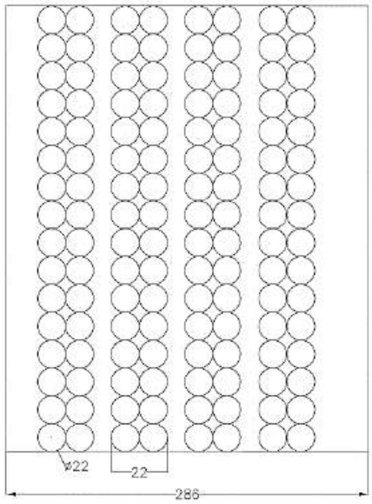


Figure 4 Plot arrangement A (2-2 polybag)

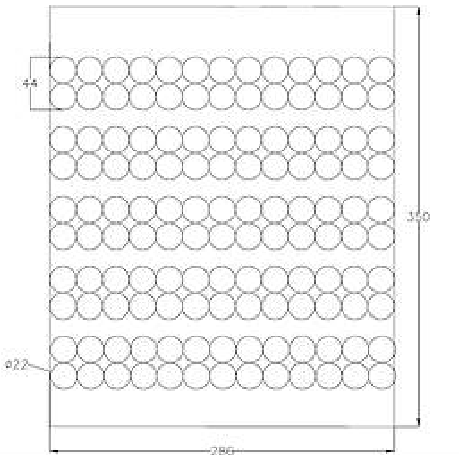


Figure 5 Plot arrangement B (2-2 polybag)

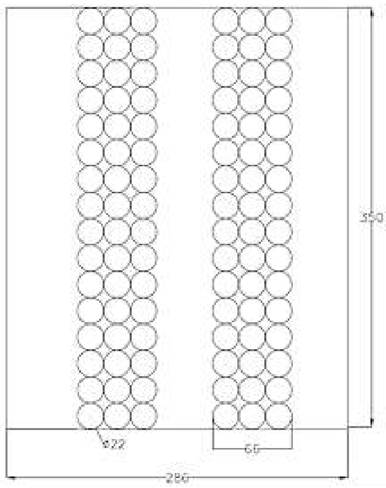


Figure 6 Plot arrangement C (3-3 polybag)

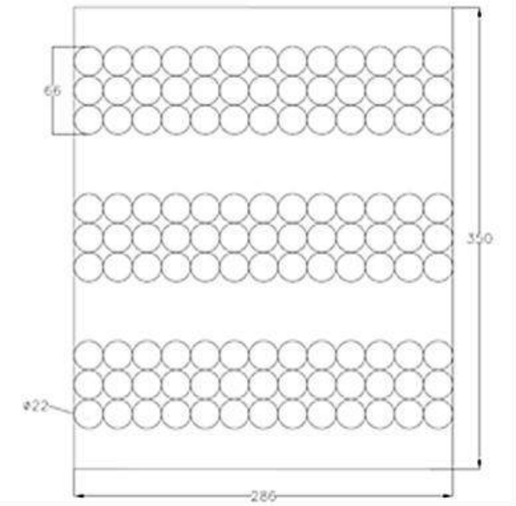


Figure 7: Plot arrangement D (3-3 polybag)

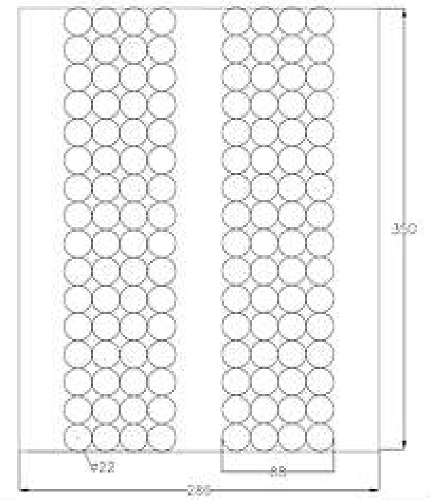


Figure 8: Plot arrangement E (4-4 polybag)

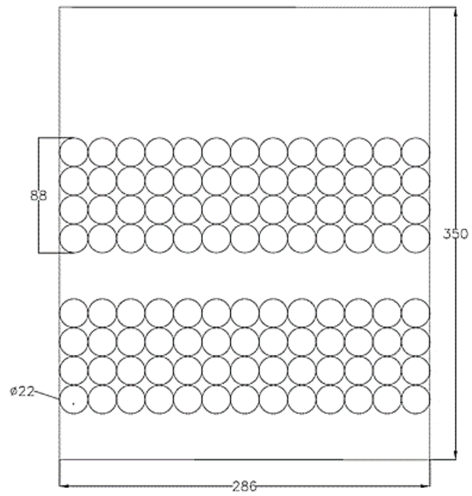


Figure 9: Plot arrangement F (4-4 polybag)

Table 1 shows results for three parameters including total polybag harvest, time requires, and distance cover for all plot arrangements. Plot arrangement B (2-2 polybag) offer the highest number of polybag that can be harvested, however, this arrangement requires the longest time and largest distance covered during harvesting. Plot arrangement E (4-4 polybag) shows a relatively high number of polybag can be harvested at the shortest amount of time and the distance covered by the machine is small. However, it is difficult to identify the optimum plot arrangement which provides the highest efficiency aspect.

Therefore, the ratio of total polybag to time and distance were calculated as shown in Table 2. The ratio of total polybag to time for plot arrangement E (4-4 polybag) is the highest which is 6.4. It means that such plot arrangement is able to allow the harvesting machine to harvest 6.4 polybags in a second. As compared to plot arrangement B, it can only offer 2.6 polybags to be harvested in one second.

Plot arrangement E (4-4 polybag) shows the highest number of total polybag to distance ratio which is 18.3. It means that for every meter that the machine covered, it can harvest a total of 18.3 polybags. From the result, it shows that plot arrangement E provide the most efficient arrangement as a guideline to design and develop the harvesting machine for Misai Kucing.

Table 1 : Different plot arrangements and their parameters

Parameter	**Plot arrangement**					
	A	**B**	**C**	**D**	**E**	**F**
Total polybag harvest	128	130	96	117	128	104
Time require (s)	40	50	30	20	20	20
Distance cover (m)	14	14.3	7	8.58	7	5.72

Table 2 : Ratio of total polybag to time and distance

Parameter	**Plot arrangement**					
	A	**B**	**C**	**D**	**E**	**F**
Total polybag to time ratio	3.2	2.6	3.2	5.85	6.4	5.2
Total polybag to distance ratio	9.1	9.1	13.7	13.6	18.3	18.2

Conclusions

Based on the results, it shows that plot arrangement E which provide 4 polybags per row to be harvested at one time has the highest total polybag to time and distance ratio. This result provides efficiency for the harvester machine to be designed and developed. Although plot arrangement E was found to be the most efficient arrangement, other parameters such as fabrication cost and handling effectiveness should be taken into consideration before going further with the machine development.

References

Awale, S., Tezuka, Y., Banskota, A. H., & Shimoji, S. (2002). Norstaminane- and isopimarane-type diterpenes of Orthosiphon stamineus from Okinawa, *58*, 0–9.

Othman, N. F., Ya, M. E., Abdul-rahim, A. S., Shahwahid, M., Radzi, M. A. M., Hizam, H., … Jaafar, H. Z. E. (2020). Embracing new agriculture commodity through integration of Java Tea as high Value Herbal crops in solar PV farms. *Journal of Cleaner Production*, *91*(2015), 71–77. https://doi.org/10.1016/j.jclepro.2014.12.044

Othman, N. F., Ya, M. E., Hizam, H., Farid, M. M., & Aziz, S. A. (2017). Inculcating herbal plots as effective cooling mechanism in urban planning, 235–242. https://doi.org/10.17660/ActaHortic.2017.1152.32

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AMA24

Soil Compaction Effects of Rubber -Wheel Tractors and Half -Track Tractors in Rice Cultivation

R. Mat Nasir[2], A. S. Mat Su[1,4,*], A. Yahya[2, 4], N. Mat Nawi[1,2,4], N. A. Wagiman[2]

[1]*Department. of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Selangor, Malaysia*
[2]*Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Selangor, Malaysia*
[3]*Institute of Plantation Studies, Universiti Putra Malaysia, 43400 Selangor, Malaysia*
[4]*Smart Farming Technology Research Centre, Faculty of Engineering, Universiti Putra Malaysia, 43400 Selangor, Malaysia*
**Corresponding Author, Tel: +06 019 6439149, E-mail : asuhaizi@upm.edu.my*

Abstract

As the machinery being operated in the field, the damage to the soil is obvious, which common damages appears mainly to the top soil layer such as increase in soil compaction and may create the 'soft soil' spot. However, the magnitude and the level of the damaged soil layer is challenging to quantify over the spatial distribution of the area. The study is focusing on comparing the level of soil compaction between rubber-wheeled tractor (RWT) and half-track tractor (HTT) during tillage operation using a rotovator implement in rice production. The widely used of HTT feared to cause damage to the soil hardpan as compared to common RWT type. A field study was conducted at Tunjang, Wilayah II – Jitra, Kedah with total area of 3.4 ha. More than 4000 data set of the soil pressured was measured using the soil penetrologger throughout two main growing seasons; wet and dry. The statistical analysis using T-test across all stages and operations revealed no significant different between the RTT and HTT on the soil compaction at the top soil layer (0-20 cm). However, the overall pressure from HTT is slightly higher than RWT, but below than threshold values of 1.4 MPa, thus may not limiting the root growth of the rice plant.

Keywords: tillage, soil compaction, paddy, hardpan

Introduction

Intensive and fully mechanized application across the rice production timelines have been proven as an effective machinery toolset to conduct most critical operation such as land preparation, planting, crop care and harvesting. In one hand, utilization of proper machinery type and selection is important for cost effective and most efficient farming operation (Robert et al., 2005). On other hand, from agronomic point of view the utilization of heavy machinery and continuous application over the years may damage the soil structure (Angers and Caron, 1998; Horn and Smucker, 2005) by introducing the compaction layer or introduce a 'soft soil' spot or a pothole, thus may damage the machinery during the operation (Bill Cotching, 2009) or limit the crop growth. Although some farmers claim that the damage from HTT is more severe than RWT, the scale and the magnitude is not well documented. HTT may provide a better alternative since during typical operation it would produce higher field capacity than RWT (Mohd Shahabudin Ismail, 2011).

Soil penetration resistance is highly depending upon to the soil moisture content (Ayers and Perumpral, 1982; Henderson et al., 1988). In some cases, the soil penetration resistance would increase during the drought season in rice production (Samson et al., 2002). In contrast, the resistance will be less during wet season. However, the level of the soil compaction might be different due to different soil type and structure (Soil Compaction Handbook, 2011). To apply heavy machinery usage in rice field, hardpan layer force should exceed reading 0.3 Mpa (Mohd Nadzim Nordin et al., 2014). In addition, according to the Cairns et al. (2011), the soil penetration resistance of 1.4 MPa is sufficient to inhibit root system expansion for rice plant. However, the ability of soils to withstand compaction is related to soil properties such as soil moisture, texture, organic matter content and clay mineral type (Hamza and Anderson, 2005; Tekeste et al., 2008). Compaction influences soil strength, aeration and water flow, creating inter-related stresses which may act simultaneously to influence root growth and distribution (Chen et al, 2014).

This study was therefore undertaken in order to evaluate the impact of the soil pressure due to implementation of two type of tractors during tillage operation in rice cultivation. The results was expected to help the local authorities to provide a guideline of RWT and HTT operation to avoid more soil damage that might affect soft soil in long term.

Materials and Methods

Study Area

This study has been carried out at Wilayah II – Jitra, Kedah, at three different locations with a combined area of 3.4 ha (Table 1). Each site location was divided by two sub plots equally. One subplot designated for HTT and the other is for RWT tractor. The site coordinates, the tractor path and speed, the soil sampling locations and compaction measurement points were recorded manually and using the GPS unit (Trimble Juno 3b) with 3-5 m accuracy. All sites received water from the open canal irrigation system, gravity flow. The soil textures were classified as clay and silty clay soil.

Tillage Operation and Test Procedure

The field tests were carried out using two tractors with the similar specification, however, fitted with different types of running gear. The main technical specification of these tractors and their running gear are given in Table 2. The soil was previously tilled up to 0.40 m and second tillage up to 0.20 m depth using rotorvator implement on both tractors. The field tests were carried out on soil previously tilled to compare the effect of two types of tractors HTT and RWT. This land preparation involved two operations which were primary tillage (PT) and second tillage (ST). This data collection for land preparation held on 23 September 2016 until 19 October 2016. There were three locations observed and each location was divided by two plots for side-by-side comparison and operation. Data collection of the soil had collected before, after and during tillage operation. Data collection for the soil before tillage was collected as a control. After the tillage operation, the hardpan of the soil was measured from time to time and table in this paper.

Penetration resistance measurement

The penetration resistances of the soil were measured using digital penetrologger (Model: Eijkelkamp), with on 30° cone and base area 3.3 cm^3 driven into the soil at constant rate about 3 cm/s speed. The soil penetration resistance was measured in the tracks left by each tractor in operation PT, ST and before tillage (BT: before tillage, which had no traffic). For each plot, including the control area, 20 point for penetrometer reading with 3 replications for each point were taken in increments of 1 cm at depth of 0.0-0.40 m. As a result 4320 datasets were collected (3 locations x 2 subplots per location x 20 sampling points per subplot x 3 measurements per sampling points x 3 stages (before and after every tillage operation) x 2 seasons (wet and dry) x 2 different tractor). The measured dataset from the data logger then were transferred in the text file (ASCII format). Then the datasets were further analysed using the Microsoft Excel software for graphical comparison, descriptive statistics and statistical T-test at 95% confidence interval.

Results and Discussion

The mean values of soil resistance of BT, PT and ST were compared as shown in Figure 3. Soil compaction induced by agricultural practices is caused by external forces shearing and compressing the soil particles together to reduce porosity, increase strength and restrict root growth. Overall, the analysis of the T-test comparison across tillage practices and test plots shows that no significant difference of the soil compaction level between HTT and RWT (p-value = 0.0583, t-stat =1.8944, T-Critical = 2.57). If the hardpan of the soil at shallow depth, the machinery difficult to get into the field as it potentially stuck deep in the soil.

Overall, the hardpan layer was found to be in between 0.25-0.30 cm (Figure 4). The compaction pressure increases with the increase of the soil depths (0-0.9 MPa) as in Figure 4, regardless the tractor's operation stages. However, the pressure values were reduced after second tillage operations at both depths 0-10 and 10-20 cm of the soil profiles, and either with HTT or RWT operations. This is very important from an agronomic perspective as softer soil structure is needed to facilitate the root growth of the rice plant. The pressure measurement before tillage for both types of tractor is almost similar, thus shows that the site shared similar soil characteristics. Over the tillage operation, the resistances were reduced drastically, especially on RWT sites. In contrast, HTT introduced slightly high soil compaction to the soil after first and second tillage operations. The compaction level may not severe effect as at 1.4 MPa is the threshold value limiting the root growth (Cairns et al, 2011). HTT type may provide better solutions for problematic area where the traction is superior to the RWT and better farm efficiency. For long run effect it might build fake soil hardpan (hardpan at shallow depth) or soft soil.

Conclusions

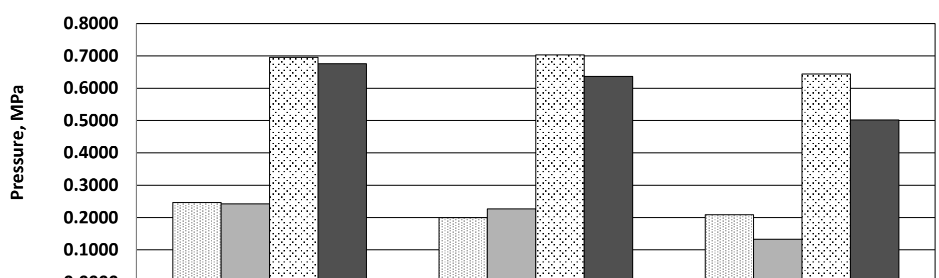
Overall, there is no significant difference on the level of soil pressure introduced by two different tractor types; HHT vs. RWT. However, HTT pressure reading was slightly higher than RWT. A long term monitoring for spatially distributed of the soil compaction is recommended since the compaction layer could be differ from one season to another due to different management practice, climatic condition, soil moisture content and irrigation schedule over the growing season.

Table 1: Site location information

Location	Coordinate	Area (ha)	Water Irrigation Type
1	N 6.3184 to N 6.3191 E 100.3616 to E 100.3639	1.1560	Open canal
2	N 6.2811 to N6.2816 E 100.3295 to E 100.3315	0.7836	Open canal
3	N 6.2729 to N 6.2732 E 100.3451 to E 100.3472	1.4881	Open canal

Table 2: Tractor specification.

Specification/Tractor type	Rubber-Wheeled Tractor	Half –Track Tractor
Brand	Massey Ferguson	
Model	Massey Ferguson 185	
Maximum engine power (HP / kW)	75 HP (55.9 kW)	
Engine RPM	1701	1143
Implement width, m	2.2	
PTO rpm	540 rpm	
Gear Selection	Low, 4	High, 1
Total weight	2510	4130
Total contact area pressure (kPa)	**272**	**111**



	Before Tillage	Primary Tillage	Second Tillage
HTT (0.00-0.10 m) Average	0.2467	0.1994	0.2083
RWT (0.00-0.10 m) Average	0.2422	0.2267	0.1328
HTT(0.10-0.20 m) Average	0.6950	0.7028	0.6439
RWT (0.10-0.20 m) Average	0.6756	0.6361	0.5017

Figure 3. Compare of mean value before tillage (BT), primary tillage (PT), second tillage (ST) for depth 0.0m -10m and 0.10-0.20m

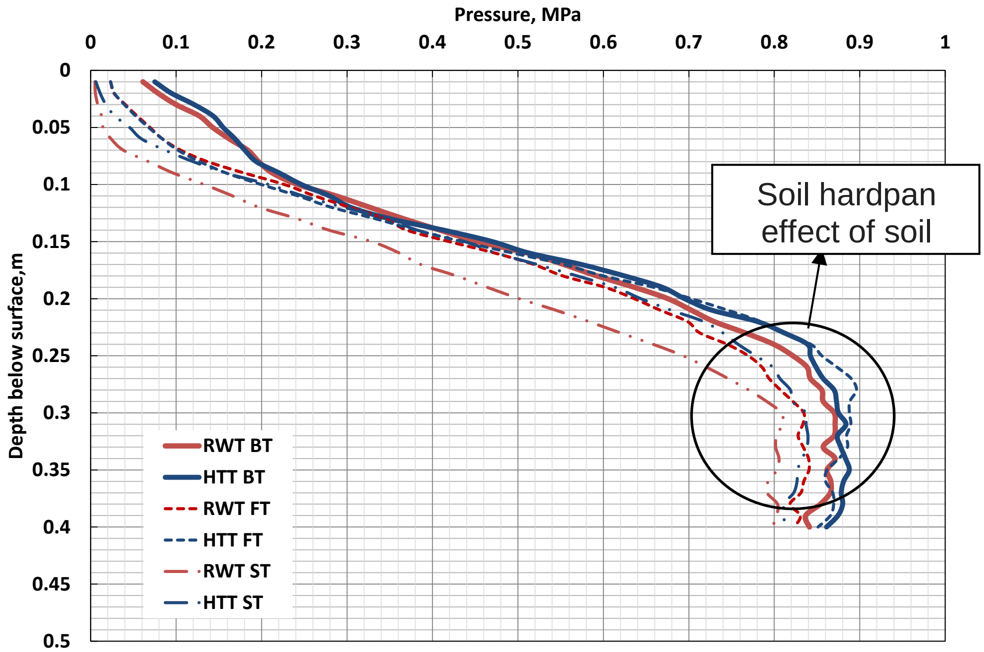


Figure 4. Compare of mean value RWT and HTT at operation before tillage (BT), first tillage (FT) and second tillage (ST) for depth 0-40cm. In the side-by-side comparison test, all three penetrometers were reasonably consistent.

Acknowledgements

The authors gratefully acknowledge the support and funding from Ministry of Higher Education through Fundamental Research Grant Scheme (FRGS) (Vote: 5540087), Muda Agricultural Development Authority (MADA) (Ref. #: MADA(C5)303105(43)), and the contributions and help from Mr. Ahmad Shukri Saad and his team from MADA, and Nurul Azimah Wagiman during data collection.

References

Ayers P, Perumpral J (1982). Moisture and density effect on cone index. Transactions of the ASAE 1982(5):1169-1972.

Bill Cotching (2009). Soil Health for Farming in Tasmania. Bill Cotching

Cairns, J. E., Impa, S. M., O'Toole, J. C., Jagadish, S. V. K., & Price, A. H. (2011). Influence of the soil physical environment on rice (Oryza sativa L.) response to drought stress and its implications for drought research. Field Crops Research, 121(3), 303-310.

Chen, Y. L., Palta, J., Clements, J., Buirchell, B., Siddique, K. H., & Rengel, Z. (2014). Root architecture alteration of narrow-leafed lupin and wheat in response to soil compaction. Field Crops Research, 165, 61-70.

Hamza, M. A., & Anderson, W. K. (2005). Soil compaction in cropping systems: a review of the nature, causes and possible solutions. Soil and tillage research, 82(2), 121-145.

Henderson C, Levett A, Lisle D. (1988). The effects of soil water content and bulk density on the compatibility and soil penetration resistance of some Western Australian sandy soils. Soil Research. 26:391-400.

Mohd Nadzim Nordin, Ayob Abd Hamid, Eddy Herman Sharu, Ahmad Syafik Suraidi Sulaiman, Mohamed Fauzi Isa (2014). *Kaedah Penggantian Tanah untuk Meningkatkan Kekuatan Struktur Tanah di Kawasan Tanah Jerlus. Jurnal Teknologi* (Sciences & Engineering) 70:6 (2014), 45–47.

Mohd. Shahabudin bin Ismail (2011). *Keberkesanan Penggunaan Traktor Separa Rantai. Lembaga Pertubuhan Peladang*

Robert M. Peart, W. David Shoup (2005). Agricultural Systems Management: Optimizing Efficiency and Performance. Taylor & Francis e-Library

Samson, B. K., Hasan, M., & Wade, L. J. (2002). Penetration of hardpans by rice lines in the rainfed lowlands. Field Crops Research, 76(2), 175-188.

Soil Compaction Handbook (2011). Available online: http://www.multiquip.com/multiquip/pdfs/Soil_Compaction_Handbook_low_res_0212_DataId_59525_Version_1.pdf. Accessed on 19 Feb 2019.

Wade, L. J., Fukai, S., Samson, B. K., Ali, A., & Mazid, M. A. (1999). Rainfed lowland rice: physical environment and cultivar requirements. Field Crops Research, 64(1), 3-12.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT01

Farm Security System: An Internet of Thing (IoT) Approach in Monitoring Farm Perimeter

Muhammad Aliuddin, B.[1], Nur Shahira, M. A. N.[2], Lilywati, B.[2]
[1]Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA, Kampus Jasin,77300, Melaka, Malaysia
[2]Faculty of Engineering Technology, Department of Electrical Engineering Technology Universiti Tun Hussein Onn Malaysia, 86400 Pagoh, Johor
*Corresponding author. Tel.: +60133015200, Email: aliuddin@melaka.uitm.edu.my

Abstract
Nowadays, security either related to human physical or things is really important as the level of crime occurs that involves murderer or thief was very frequently and become increases from time to time. Normally, stealing or burgle always heard to be occurs at residential area but recently this crime also takes place at the farm. As we know, farm located in an opened area which there were a lot of crops and sometimes farmers also left their farming equipment and chemical substances at the farm. Therefore, it becomes targeted place to steal instead of houses because there were large tendency and opportunity not to be seen by peoples when the farmer was not around. Although plants production and farming tools it is not jewel or money but it could be valuables for thieves to steal and make profits illegally. In order to overcome this problem, a security system for a farm is invented to helps the farmers from having losses and as well as to reduce the rate of stealing cases in our country. This security farm system project was implement to be useful in protecting the crops and farm area during the absence of its owner and its specialization was connected with technological features like Global System Multimedia (GSM) and Internet of Things (IoT). Thus, it can be controlled by the farmers from any places and at any time

Keywords: Internet of Thing (IoT) , Electric Fence, Mobile Applications,

Introduction
Agriculture plays an essential part in an economy. Their important cannot be nullified because these crops provide food and raw materials that making employment for a man in this country. Many farmers are today inserting the new technology for their farm that used the machine to replace the human labour in order to improve business in agriculture and increases the quantity and quality of the product. Due to the value of agriculture are towards human society, some untrusted people usually take advantages to the farmer crops like stealing the product. Therefore, security becomes a significant matter where despite that the threat of violence on the farm is not too often, but still can leads liability causes by criminal deeds for example robbery of farm product and equipment (Genever. 2015). Karl-Heinz Erb, through his journal it is stated about good security farming system unauthorised access to farm chemicals and application equipment, are most significant losses to the farms, and greenhouses where plants developed (K. Erb, 2012). This system will help to keep the farm secured, and monitor the highlighted area of farm to reduce the exhaust time to when leaving that area and effort of farmers. The project of the smart farm security system is an advanced technology concept farm that focused on several smart divisions which are electric fencing system, wireless camera and GSM alarm motion detector. It is also included with the lighting system on the electrical fence which only activates whenever it detects the absence of a human. The system was combine on one place and instructed by Arduino Uno and controlled through Global System Multimedia which is also known as GSM or IoT applications. The project intention is to help the farmers to protect their crops, livestock and equipment from getting damaged by animals and theft.

Materials and methods
The general block diagram of overall security system for this project is shown as figure 1.

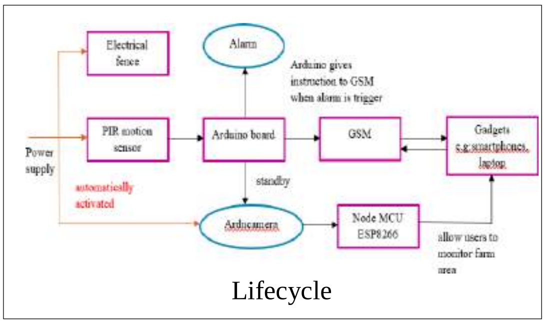


Figure 1: The Mobile Application Development

Figure 2 shows the research on sensing process flow of communication which is significant in order to make the applications went well through several types of modern gadgets nowadays such as smartphone or laptop. In this system, the GSM function as sender tools that sends the information to the user gadgets and need the user to reply an instruction either to continue or stop the triggering alarm while IoT will attach with Arduino camera for monitoring purposes by applications. This project not only trigger an alarm as security steps but also involves electrical fence and camera to monitor the farm area which can be referred to Figure 3 stands for research on how the process of information being transfer by gadgets to the users is required as below helps to improve the understanding of what will the applications do to make sure that the information fully received by the users.

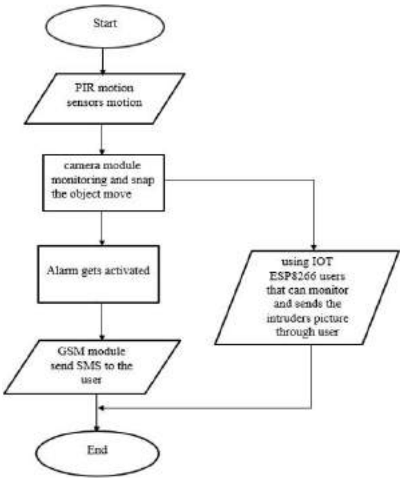


Figure 2: Flowchart Sensing

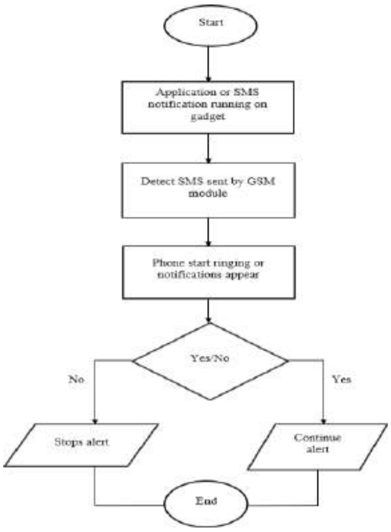


Figure 3: Flowchart for User

Results and discussion

The power supply is the most significant things on any electric and electronics project. In this part, the voltage and current used for circuits are measured to achieve the best voltage and current need to be used for the whole circuit to function which consists of an electrical gate, GSM alarm detection circuit and camera. Table 1 shows the amount of voltage and current used for each part of the farm security system.

Table 1: Amount of Voltage and Current Measurement Record

Type of circuit	Measurement	
	Voltage	Current
Electrical fence	6V	1.92 X 10^7a
GSM alarm motion detection circuit	16V	3.209a
Arducamera	3.3V	0.007a

For this project prototype, written coding set the distance can be measured from two until eighty cm far from the sensor itself, but in a real situation, this alarm motion detection circuit can detect up to 7m long. Since the sensitivity of PIR motion sensor is very high as it can detect any motion in front of it, therefore, this system is attached or together with a camera which can capture picture and do a video to look the real things disturb the crops or enter the farm without permission. The distance measurement helps the owner to know how far the danger on his farm through the short message system by GSM after the alarm is triggered by a motion sensor. Figure 3 below shows the constructed circuit of GSM alarm motion detection while Figure 4 shows the production output form (GSM send message and make a phone call to designated number).

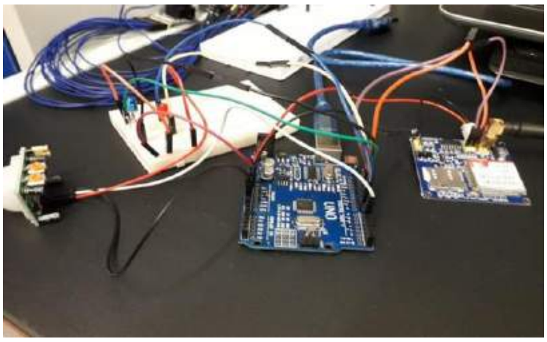


Figure 3: The constructed circuit of GSM alarm motion detection

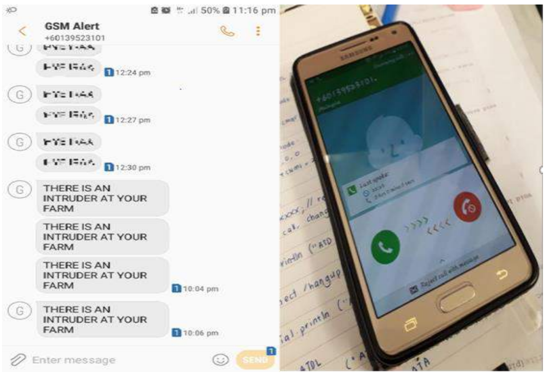
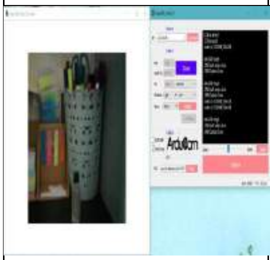
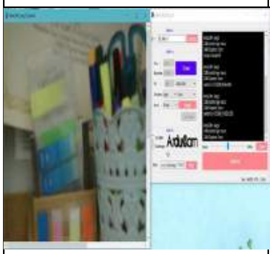


Figure 4: The production output form (GSM send message and make a phone call to designated number)

The camera in this farm security system helps to detect and identify the image of someone or animals that try to bring harm towards owner farm. It also makes the owner easy to trace and takes action to save the unwanted incident to happen on their farm. Thus, the clear resolution of the image is necessary (Mendoza, 2016). In this project, a type of OV2460 Arducam mini 2MP camera is set up on the prototype for monitoring the condition of farm manually. NodEMCU ESP8266 is used to instruct for the camera to capture and record the picture of the thief. Observation can be seen in Table 2 on how the pixels of camera lens influence the manifesting of picture capture and recorded.

Table 2: Observation effect of pixel of camera with picture captured quality.

Sample picture	**Observation**
	Camera Resolution setting for the condition is 160x240 which indicates the size of picture obtain. The small size of pictures appeared on the monitored screen.
	Camera resolution was then set to the condition is 640x480 pixels as the image become much clear and better. The size appeared on the screen increased from the previous picture.
	The camera is focused more on the items when the pixels is set to 1600x1200. The larger size of the image appeared

For this project, the Arduino Software IDE is used to write the coding because the language was closed to human language (high-level language) and easy for error detection compare to Micro C which it is heavy towards assembly machine language (low-level language). Figure 5 below shows a coding to make the alarm triggered (ON) when the input, PIR motion sensors trace a motion subject move in front of it

Figure 5: A part of source programming in Android mobile programming application.

Conclusions

The farm security system as in information was design and built with the intention to help the farmers that have farm protecting their belongings and crops revenue from being a steal and destroyed by wild animals. It can ease the burden of farmers out there in protecting their farm crops and equipment. It is suitable to be controlled and observed from any place whenever it was built attach to GSM and IoT camera which can ease the human energy and efforts requirement in protecting their land and belongings in 24 hours per day.

References

K. Erb, A. Mayer, T. Kastner, K. Sallet, and H. Haberl, "The Impact of Industrial Grain Fed Livestock Production on Food Security : an extended literature review Final report Main Messages," pp. 1–82, 2012

L. Genever, "Electric fencing for livestock Key messages," pp. 1–21,2015.

R. K. A. Mendoza, B. J. S. Malijan, and R. B. Caldo, "Development of Smart Farm Security System with Alarm Mechanism using Image Processing," vol. 3, no. 3, pp. 73–84, 2016.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Genetically Modified (GM) Rice : Exploring University Students' Awareness and Acceptance in Malaysia

N. Saripudin[1,*], A. Sulaiman[1], A. Awal[1] and N. Mat Nor[2]
[1]Centre of Postgraduate Studies, Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, 40450 Shah Alam Selangor.
[2]Arshad Ayub Graduate Business School1Universiti Teknologi MARA, Universiti Teknologi MARA, 40450 Shah Alam Selangor.
*Corresponding author. Tel.: +60168300487, Email:noraini.saripudin@gmail.com

Abstract
The adoption of genetic engineering in agriculture has made a strong impact. It not only resulted in positive implications but also raised controversies across the continents leading to further research on consumers' awareness, acceptance and perception on GM food. This study was conducted to explore the awareness and the acceptance of GM rice among students in Universiti Teknologi MARA (UiTM) Selangor as there has been no similar study on students in Malaysia. A qualitative approach was adopted in this study; focus group discussions among UiTM students from two campuses and semi structured interviews with representatives from different fields. Findings from data collected revealed that a majority of the students in UiTM Selangor were neutral regarding GM rice and the public in general have low awareness and negative acceptance towards GM food in Malaysia. Educational background have made an impact on awareness; science students showed higher level of awareness compared to non-science students. Several recommendations could be made to the relevant government bodies to enhance the current scenario. These include exposure of genetic engineering technology to students from primary to tertiary level in Malaysia, formulating strategic agricultural policies and plans to benefit the farmers and engagement of appropriate GM awareness programmes for the public.

Keywords: GM rice, Students, Acceptance, Awareness

Introduction

Genetic engineering has gained recognition among the scientific community as a powerful tool to offer better quality traits in crops such as having enhanced resistance against certain diseases (Pandey et. al, 2013). This state-of-the-art technology allows the modification or exchange of genetic components from one organism to another. It aims to improve certain traits in that organism to benefit the entire population. The application of genetic engineering in agriculture has resulted in the emergence of genetically modified (GM) crops or food. GM crops varieties were first commercialized in mid 1990s in US and had since experienced steady growth as farmers were gradually introduced to and became ready to adopt to this new technology due to its significance in increasing their crop yield while reducing the production costs at the same time (Cowan, 2011). Among the first commercialized GM crops were potato, cotton, maize, soybean and canola (Basu et. al, 2010)

The emergence of genetic engineering technology in agriculture have been a heated topic of discussion amongst scientists, politicians and the public, and this have given rise to a variety of different perceptions. The perceptions of these group of people have been the focal point of numerous studies by researchers in several countries around the world for the past decades since GM crops had been introduced. The majority of people from most countries in the world have different perceptions about GM crops as well as GM food. Numerous studies have been conducted in several countries across different continents to determine the acceptance of students on genetically modified food and the factors which influence their awareness and attitudes. Students are an interesting cohort to study because they are the younger generation who will become the primary consumers in the future, and they will become the future leaders and policy makers. Results from a study done in Tennessee State University revealed that students in the biological sciences had better knowledge and hence less fear of biotechnology. In addition to that, respondents with backgrounds in agriculture seemed to favour biotechnology products compared to others (Tegegne et al, 2013). Data from Higher Learning Institutions in Kenya demonstrated that GM foods purchasing decisions, moral values and awareness are factors which have correlation with consumer choices of GM food (Bett et al, 2014). One theory of awareness and acceptance is that the more people know about a biotechnology, the more intense their support or opposition will be for this topic (Fischoff, 1995).

Previous studies have been done among the public in Klang Valley as well as in Johor regarding the awareness and acceptance of GM foods. However, study on similar matters on different cohorts, particularly students, are absent. As such, there is a gap in the recent studies concerning GM foods in Malaysia. There is a need to understand the level of students' acceptance on genetic engineering technology specifically towards GM crops which will be used to produce GM foods and if knowledge in genetic engineering and modification technology would influence their perception. By knowing their acceptance and awareness level, it will greatly help to gain a better understanding on the readiness and the intention of future Malaysian generations to purchase GM rice as well as providing a clearer picture to the relevant parties to formulate a better strategy to commercialize GM rice as well as providing some input to the policy makers on the regulations for GM food. Rice has been chosen in this study because it is the staple food of the people in the country and GM rice might be one of the options available in the future to accommodate the increasing population.

Materials and methods

For this study, two focus group discussions were organized in two UiTM campuses in Selangor and two semi-structured interviews were done with two individuals representing different field. Quoting Halcomb et al. 2007, Cleary et al. (2014) reported that if the number of focus group discussion is fewer than two, this may lead to questionable true representation especially when the representativeness is the core element in the study. In this study, each session of the focus group discussion comprised of eight students, male and female, from various faculties. The campuses involved are UiTM Shah Alam and UiTM Sungai Buloh. Respondents in UiTM Shah Alam were recruited by direct approach at the campus library as well as at the faculty while respondents from UiTM Sungai Buloh campus were recruited by direct approach at the Institute of Medical Molecular Biotechnology and Faculty of Dentistry. All sixteen respondents were mixture of male and female students. The sessions were recorded for data analysis.

The sampling method was based on purposive sampling in which it allows selection of respondent based on the characteristics of each individual and therefore the sample size was not the fundamental matter in the study (Wilmot, 2005). For interviews, one person was invited from one of the agricultural research institutes in the country and another from the academic field. A set of questions with three sections were discussed among the respondents during the sessions. The first section includes the engagement questions, the second section consist of exploration questions and the third section are the exit questions. Below were the questions discussed during the focus group discussion.

Engagement questions:

1. What does the term GM evoke?
   a) What do you understand about GM?
   b) How do we feel about GM food
2. From where have you obtained information regarding GM food and GM rice?
   a) Do you trust the current information available?

Exploration questions:

1. Do we read food labels, and why do you do so?
   a) What do we read on labels.
2. What is your opinion or impression on GM labelled rice if you come across with one?
3. When you decide to purchase GM rice, what do you look for?
4. What are the risk and benefits do you think you gain from GM rice.
5. How would you describe your attitude towards GM food, particularly GM rice.
   a) Can you explain further why is your attitude towards GM rice is like that?

Exit questions:

1. What do you think about the future of GM rice in the country?
2. How do you prefer the information about GM food, particularly GM rice to be disseminated to the public?

These were the questions asked during the focused interview.

1. What is your opinion on the awareness and acceptance of GM food among our general public?
2. What is your opinion on the study of awareness and acceptance of GM food among students in Malaysia?
3. What do you think are the contributing factors to the current situation?
4. How do you see the future of GM food and GM rice in Malaysia?
5. Do you think it is necessary to inform and educate the general public, and why? What do you think is the best way to educate the public?
6. What do you think of early education exposure?

In this study, the recorded data for both focus group discussions and semi-structured interviews were transcribed using the Nvivo12 software. Data coding is a very fundamental stage in data analysis. Generally, it is carried out in two phases. According to Charmaz (2006), the first phase is known as initial coding in which a list of all arising ideas, diagrams or mind maps is prepared by the researcher as well as running query over the data to find any words that commonly raised by the respondents. The second phase is known as focused coding giving emphasis on removal, merging or subdivides all the coding groups generated in the first phase. It is also very crucial to identify the recurring themes which link all the codes (Charmaz, 2006; Krueger, 1994; Ritchie and Spencer, 1994) in Nyumba et al., (20170. The transcripts from the two focus group discussions were saved in the Nvivo12 software to ensure the data is systematically stored and easier to retrieve for processing. Initial coding was initiated by highlighting all the emerging ideas from all the transcripts followed by grouping these ideas into several categories. In the second phase, comparison among these categories was done to establish the links between all groups and individual, resulting in the emergence of the themes for the discussions. Themes were the main issues, or the key points that were being discussed frequently among the respondents during the discussions and was classified as the findings of the study.

Results and discussion

There were two interview sessions and two focus group discussions that were carried out in this study. The focus group discussions were conducted at two UiTM campuses in Selangor, namely Shah Alam and Sungai Buloh. Eight respondents were recruited for each of the sessions, comprising of both males and females, undergraduates and postgraduates from a variety of faculties. Each respondent in the focus group discussions was tagged as R1 up to R16, while the individuals being interviewed were labelled as individual 1 and individual 2. Three different sections of questions were asked; the engagement questions, exploration and the exit questions. All questions were open ended, and the respondents were encouraged to express their opinions and feedbacks freely. All sessions had visual and auditory recording in place. Below are the respondents' profiles for the study.

Table 1: Respondents' profiles in the interview

Profession	**Gender**	**Industry**
Individual 1: Professor	Male	Academic
Individual 2 : Senior research officer	Female	Biotechnology and agriculture research

Table 2: Respondents from UiTM Shah Alam

Respondent	Gender	Faculty	Age
R1	Female	Applied Science	21
R2	Female	Applied Science	21
R3	Female	Applied Science	21
R4	Male	Chemical Engineering	25
R5	Male	Plantation and Agrotech	32
R6	Male	Plantation and Agrotech	24
R7	Female	Plantation and Agrotech	24
R8	Female	Arshad Ayub Graduate Business School	23

Table 3: Respondents from UiTM Sg. Buloh

Respondent	Gender	Faculty	Age
R9	Female	Dentistry	20
R10	Female	Dentistry	20
R11	Female	Institute of Medical Molecular Biotechnology (IMMB)	22
R12	Female	IMMB	22
R13	Female	IMMB	23
R14	Female	IMMB	23
R15	Female	IMMB	22
R16	Female	IMMB	22

Table 4: Awareness towards GM rice among students

Awareness on GM rice	Group 1	Group 2
Modify gene/DNA	12.5%	37.5%
Genes transfer	25.0%	-
Change the gene	25.0%	-
Improved rice quality	25.0	12.5%
Better crops	-	12.5%
Something new, unfamiliar	12.5%	-
Secondary school exposure	-	25.05%
Tertiary education exposure	50.0%	75.0%
No exposure	12.5%	-

Table 5: Acceptance towards GM rice

Acceptance towards GM rice (%)		Determinants
Indifferent	50%	Concerned on safety.
		Concerned on trade monopoly Increased rice yield. Improved rice quality.
Positive	31.25%	Increased food supply.
Negative	18.75%	Unknown health risk. Not natural, not original rice.

Response from the respondents in this study reflected that students from science background have a higher awareness towards GM food compared to non-science student. They were able to describe gene modification technology and what genetically modified food is all about in general. The table presented the results relating to the awareness towards GM rice based on what the students understand about GM rice. It was demonstrated that 25% of respondents in UiTM Shah Alam group mentioned the word "gene transfer", 25% mentioned "change the gene" and another 25% mentioned "improved rice quality" when asked about their understanding regarding GM food and GM rice. One (12.5%) mentioned "modify gene or DNA". This showed that the respondents have certain extent of awareness towards GM food and GM rice. One respondent who was a non-science student (12.5%) mentioned that the term genetically was something new and was not familiar with it. This was the statement of the respondent.

"From my opinion, it is new to me. First time I heard about GM rice so from my perspective GM rice is not original rice." *[R8, Business School student]*

The study also revealed that most of the students gained their knowledge on genetically modified food during their tertiary education. While some have heard of GM food during their secondary school education, there was a respond stating that GM was unheard of. This might be due to the abscence of genetic modification subject in the learning syllabus. When asked regarding their perceptions towards GM rice, mixed response were given by the respondents.

Results showed that most of them have a neutral stance towards GM rice, while some felt positive and few were having negative perceptions. Eight from sixteen respondents were neutral, five were positive and another three rejected the idea of GM rice. The majority of students in the study were neutral because they have the impression that GM rice have valuable traits but the technology itself might pose unknown risks to consumers and to the environment in the long run. The fact that they are from science background indicates that knowledge per se is not a key factor in shaping a positive attitude towards GM rice. However, it does help to stimulate a fair and receptive perception, giving an indication that the GM rice acceptance might be possible in the future. Respondents who perceived GM rice negatively are from both science and non-science background. Their reason for being sceptical towards GM rice was that this rice is not natural, not from the land and will not have equivalent characteristics as compared to the normal rice. It is human nature to feel unsafe or sceptical or to doubt something new or "alien" to them. This has been highlighted in some studies previously pertaining to consumer perception and attitude towards GM food. In the case of golden rice perception in Malaysia, a previous study revealed that Muslim respondents in Klang Valley did not reject the idea of transgenic rice entirely because it was basically a plant to plant gene transfer and the health benefits carry some weights (L. Amin et al., 2010). Similar perception is also shared with the public as suggested by the respondents during the in depth interview sessions. A study among academicians regarding their perceptions and attitude towards GM food revealed that they are sceptical due to unknown risks especially towards human health, ecological risk and safety (Kaya et al., 2013).

These were some of the responds from the students about their perceptions.

"I will eat it if they can prove on the safety" *[R5, Agrotech student]*

"As for me, it goes both the consumer and producer, The positive thing is nutritional Aspect of it there's a lot of increase in nutrition that we can get from GM rice and the price is cheaper because the production can be increased and as for the negative effect, the concern is also on environmental, since Malaysia is a biodiverse country we have a lot of rice species we have to protect so what happen if cross pollination happen

between the GM and we going to lose a lot of the native species and that is why I feel neutral about GM" *[R15, Female science student]*

"…I will be scared to purchase the GM rice too because it is modified. My impression is that it is not natural and I don't feel it is safe."[*R13, Female science student]*

Several issues were discussed during the focus group discussions relating to their acceptance towards GM rice. According to the students, there are few benefits GM rice could offer to consumers which significantly influenced their perceptions and attitude towards GM rice. Perceived benefits have been reported in many studies previously to be influential in people's attitude and willingness to consume or to purchase certain food. The present study has demonstrated similar tendency among the respondents.

Findings during the interviews have pointed out some notable remarks regarding the acceptance of GM food among the members of public in Malaysia. The acceptance level of GM food among the public is still very low and the perception is negative. One factor that contribute to this is the lack of knowledge about the science behind GM food. As such, people always have sceptical thinking towards GM food. One of the individual interviewed has shared his view on this as below.

"The situation is always exacerbated make things more difficult because of lack of knowledge, lack of awareness, lack of proper information like a proper understanding and of course well we have to accept that media maybe not the official media but the social media they tend to blow things out of proportion and come out with stories like myth or even Frankenstein related stories like this is Frankenstein like food. These are all uproars which are not true reflection of the actual findings."

Conclusion:

Formal education plays an important role in acquisition of knowledge. Introducing genetic engineering technology in the syllabus of secondary educations could also help to give better understanding to the students about the science behind genetically modified food. Knowledge has been emphasized in a number of previous studies before relating to better understanding, better perception and increased of positive acceptance towards GM food. Engagement of GM awareness program to improve current awareness level among student populations as well as the public is very important. Lack of awareness have been reported to be one of the key factors for negative perceptions and rejection of GM food in other places.

In Malaysia, organizations like Malaysian Biotechnology Information Centre has play a very important role in promoting biotechnology to the general population. It aims at providing correct information regarding biotechnology to the society. This organization has carried out awareness programs such as roadshow as well as workshop to increase awareness and to help educate people about biotechnology. Similarly, education institutions or research institutions should come up with similar effort. Studies revealed that students and the public trust the educators and university scientists in disseminating correct information. Therefore, any GM awareness programs organized by universities and research institutions can strengthen the trust among the lay people and promote better understanding and perceptions about GM rice.

References:

Bett, E. K., Nyairo, N., Ayieko, D. M. O., and Amolo, J. O. (2014). Determinants of Consumer Perception towards Genetically Modified (GM) Foods in Higher Learning Institutions in Kenya, *5*(24), 35–45.

Cleary, M. , Horsfall, J. and Hayter, M. (2014), Data collection and sampling in qualitative research: does size matter?. J Adv. Nurs, 70: 473-475.

Cowan, T. (2011). Agricultural biotechnology: background and recent issues. CRS Report for the Congress, 7–5700, 46.

Fischhoff, B. (1995), Risk Perception and Communication Unplugged: Twenty Years of Process1. Risk Analysis, 15: 137-145.

Kaya, I. H., Poyrazoglu, E. S., Artik, N., and Konar, N. (2013). Academicans ' Perceptions and Attitudes toward GM-Organisms and – Foods. International Journal of Biological, Ecological and Environmental Sciences, *2*(2), 2–6.

L. Amin, N.A.A. Azlan, J. Ahmad, A.L. Samian and M.S. Haron (2010). Ethical Perception of Golden Rice in Malaysia, 11(2), 71–78.

Ochieng NT, Wilson K, Derrick CJ and Mukherjee N. The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods Ecol Evol. 2018;9:20–32

Pandey, P., Singh, A., Yadav, P., Kumar, P., and Deepti, B. (2013). Role of biotechnology in plant diseases management : An overview, *1*(3), 215–221.

S. K. Basu, M. Dutta, A. Goyal, P. K.Bhowmik, J. Kumar, S. Nandy, S. M.Scagliusi and R. Prasad (2010) Is genetically modified crop the answer for the next green revolution?, GM Crops, 1:2, 68-79

Tegegne, F., Aziz, A. N., Bhavsar, H., and Wiemers, R. (2013). Awareness of and Attitudes towards Biotechnology by Tennessee State University

Students with Different Backgrounds and Majors, (January), 16–23.
Wilmot, A. (2005). Designing sampling strategies for qualitative social research: with particular reference to the Office for National Statistics' Qualitative Respondent Register. Survey Methodology Bulletin-Office for National Statistics, 1–14.
Wunderlich, S., and Gatto, K. A. (2015). Consumer Perception of Genetically Modified Orgnanisms and Sources of Information. Advances in Nutrition, 6(February), 842–851Zhu, X., & Xie, X. (2015). Effects of knowledge on attitude formation and change toward genetically modified foods. Risk Analysis, 35(5), 790–810.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT03

Internet of Thing (IoT) Application for Planning the Routes Collection of Fresh Fruit Bunch (FFB) in Oil Palm Plantation.

Saiful Shahrin, K.[1], Muhammad Hudzari, H. R.[1,*], Mohamad Asrol, A.[2], and Mohamad Noorman, M.[3]
[1]Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA, Kampus Jasin,77300, Melaka, Malaysia
[2]Faculty of Science, Computer and Mathematic, Universiti Teknologi MARA, Kampus Jasin,77300, Melaka, Malaysia
[3]Faculty of Information Management, Universiti Teknologi MARA , Campus Puncak Perdana, 40150 Shah Alam, Selangor, Malaysia
*Corresponding author.. Tel.: +6019-220 8486, Email: hudzari@uitm.edu.my

Abstract
Oil palm industry is one of the major industry in Malaysia. There are many new technology and mechanization introduced for the oil palm industry. It is because to reduce the much dependent on manual labour to carry out the operations in the plantations. Harvesting and the evacuation of FFB is the most important operation in the plantations and must be done efficiently to maintain the quality and gain more profit to the company. The normal ways that use in the plantation to collect the FFB and loosen fruit by the collector is they need to stop at each palm through the harvesting path to find it before transfer to the platform and then send to the mill. It is become difficult to the collector and take a time to find FFB and collect the loosen fruit. The FFB Detector applications can ease the process of evacuation FFB to the platform because the collector can find it from the coordinate that they get after harvesting process. In a conclusion the mobile applications can give benefit for the evacuation FFB operation in the oil palm industry.

Keywords: Internet of Thing (IoT) , Remote Sensing (RS), FFB Route Planning, Mobile Applications, Oil Palm Plantation

Introduction
Oil palm is an important crop in Malaysia because the income and activities related to the crop contributes significantly to the country's Gross National Income. Malaysia is known as the world's second largest producer of oil palm behind Indonesia and this is a big gifted form Allah Subhanahuwataala. The oil palm industry is very dependent on labour. The industry requires many workers for its operation, ranging from planting to processing (Shuib, et al., 2010). It also reveals that four categories of work in the oil palm plantation are totally dependent on foreign worker, namely those employed as harvester or cutter, FFB collector, loose fruit collector and field worker.
A mobile application is a type of application software designed to run on a mobile device, such as smartphone or tablet computer. It frequently serves to provide users with similar services to those accessed on PCs. Mobile application is a new and fast developing Segment of the global Information and Communication Technology. Mobile device and their applications provide several of advantages to their users, in term of portability, location awareness and accessibility (Wan Ishak et al, 2011 and 2012). The improvements in the hardware and software capabilities and lower price point of smartphones in particular, the so-called handhelds have led to advancement expansion of the mobile and related markets (Nayebi F. et al, 2012 and Rashedul et al, 2010).
This study will develop the mobile application that can increase the efficiency of collecting the FFB and loosen fruit and the productivity per man day can be increase. This is the other alternative that can be used to solve the problem of labour shortage in the oil palm plantation industry. It also can give more income and revenue to the company and can reduce the cost.

Materials and methods
The Mobile Application Development Lifecycle (MADLC) is used for this project. As a requirement for build the mobile applications, it is important to have dedicated framework lifecycle for mobile application. The lifecycle consists of identification phase, design phase, development phase, prototyping phase, testing phase, deployment phase and maintenance phase as in figure 1.

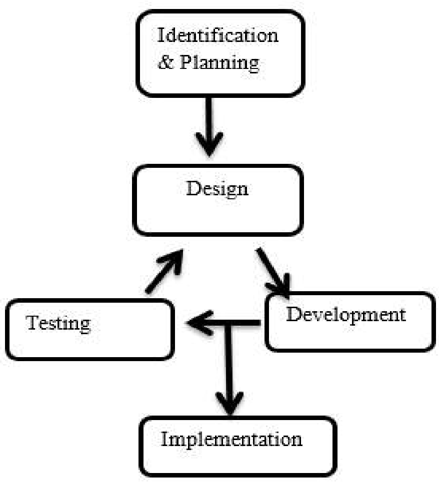


Figure 1: The Mobile Application Development Lifecycle
There is several hardware and software that needed for develop the application in this project. It is

important to have hardware like as personal laptop and software like Android Studio Software in order to help the user interact with the application.

Results and discussion

A design of Graphical User Interface (GUI) must have been sketched at first and make a prediction to make sure the interface used is easy for the target user and of course a design should be in a high quality conditions. The final design that be used in this applications which refer idea from this stage. There are three interface that needed in this applications which is Home, Harvester and Collector Interface. For the Home Interface, there is two button and have the Title of the applications. Through the Title, it can know the function of this applications. For the Harvester Interface, there is three button that have different function which is to get the location, save, and send the coordinate. There is a space in this interface for display the coordinate. Lastly, for the Collector Interface, only have two button which is send, and navigate the coordinate as shown in figure 2.

The results obtained shows the Interface of the Fresh Fruit Bunch (FFB) Detector applications that can be functioning.

recognize what process are done. Each button in this applications arranged systematically. In Home Interface, the Harvester and Collector button allowing it to navigate to the Harvester or Collector Interface just by click the button. So, the time to handle this applications is less in the field. Besides, the usability of the applications such as the easiness on how to use the applications and how it is manageable by the user allow the user to use the application without much complicated (Mohammad et al, 2018). In addition, this applications benefits in the process of evacuate the Fresh Fruit Bunch (FFB) from harvesting path to the platform because can get the coordinate of the harvested palm and save the coordinate for the collector. The collector can retrieve the coordinate that save by the harvester and find the FFB from the coordinate. The applications can be used in the plantation as long as the plantation area get coverage by the internet connection.

Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development especiaaly for detection of coordinate on such related projects (Sahar et al., 2017 and Yousefi et al., 2015). It is available for download on Windows, macOS and Linux based operating systems. In this project Android Studio version 3.2.1 for windows 64-bit is use. Figure 3 shows a part of source code Android programming in order for calling real position of coordinates.

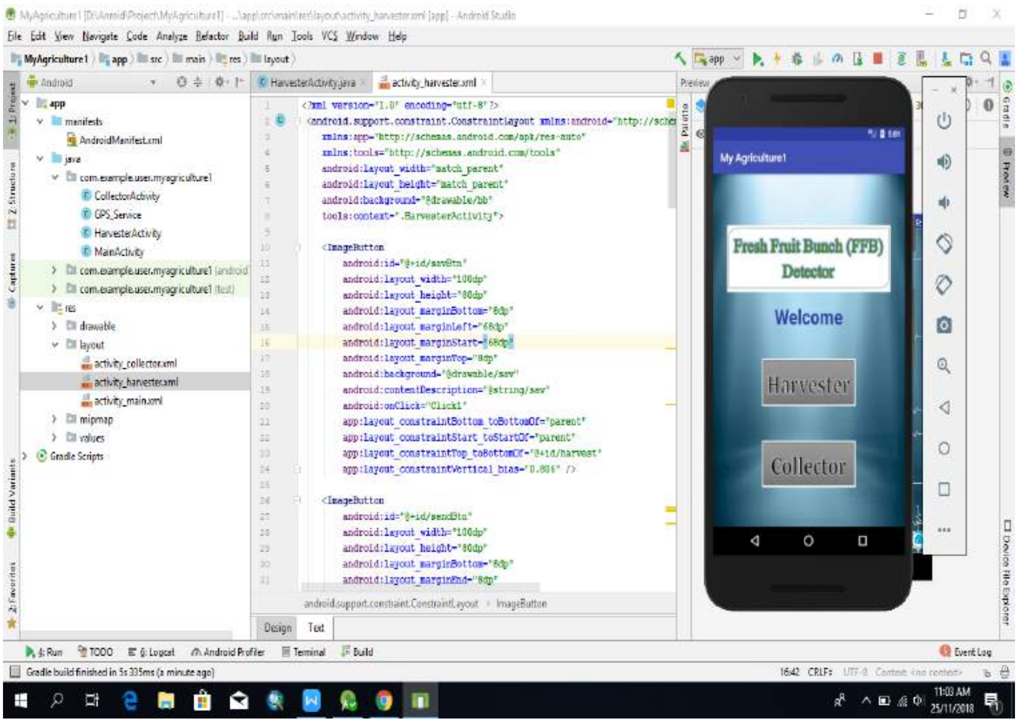


Figure 2: Test run the developed applications using emulator that available in the android studio software.

```
@Override
protected void onResume() {
    super.onResume();
    if (broadcastReceiver == null){
        broadcastReceiver = new
BroadcastReceiver() {
            @Override
            public void onReceive(Context
context, Intent intent) {
                textView1.append("\n"
+intent.getExtras().get("Longitude"));
                textView2.append("\n"
+intent.getExtras().get("Latitude"));
            }
        };
    }

registerReceiver(broadcastReceiver,new
IntentFilter("location_update"));
```

Conclusions

FFB detector application is the mobile application that can be used in plantation as an innovation and technology and using to detect and then evacuate the Fresh Fruit Bunch from harvesting path to platform before transport to the mill for the further process. By using this application, the process to evacuate FFB will be ease because can get the location or coordinate of the harvested palm tree. As a conclusion, the main idea of this project or research to design and develop the mobile applications that can be use in the plantation sector which is to evacuate the Fresh Fruit Bunch (FFB) from harvesting path to the platform.

It is important to develop an applications that can benefit the user either for company, harvester or collector from various aspects including cost, usability, efficiency and user interfaces which is to develop applications. Research which includes study of the journals that is related to the topic and ask to the supervisor to achieve the best technique and technology that suitable to be use in the project, thus help in completing the project objective.

Acknowledgement

Thankful to management unit and staff in Faculty of Plantation and Agrotechnology for supporting research project in farm filed in UiTM, Jasin , Melaka, Malaysia.

References

Mohammad Hudzari Haji Razali, Mohamad Noorman Masrek and Mohamad Fauzi Md Said, Internet of Thing (IoT) for Agriculture Technology Development, The 2018 Annual Conference of Malaysia Society Of Agricultural Engineers, 6-7 Februari 2018, Serdang, Selangor

Nayebi F., Desharnais J. M., & Abran, A., (2012). The state of the art of mobile application usability evaluation, CCECE, pp. 1–4.

Rashedul M. I., Rofiqul M. I., & Mazumder T. A., (2010). Mobile Application and Its Global Impact. International Journal of Engineering & Technology IJET-IJENS Vol:10 No:6.

Sahar Z. R., Maysem N. A., & Enteha G. M., (2017). Object Tracking based on GPS Technology. International Journal of Advanced Research in Science, Engineering and Technology; Vol 4 (5).

Shuib, A. R., Khalid, M. R. & Deraman M. S., (2010). Enhancing Field Mechanization in Oil Palm Management. Oil Palm Bulletin 61, p.1-10.

Wan Ishak Wan Ismail, Muhammad Razif Mahadi,Muhamad Saufi Mohd Kassim, Zakiria Ismail, Ramin Shamshiri, Mohd Hudzari Razali, Nader Kavandi (2012). Handphone Application for Oil Palm Fruit Maturity Prediction (*in Malay*), Malaysian Agriculture , *Horticulture and Agrotourism International Show* (MAHA2012) 'Agricultural Transformation Through Innovation', 23 – 30 Nov. 2012, Serdang, Selangor, Malaysia

Wan Ishak Wan Ismail, Nader Kavandi and Mohd. Hudzari Hj Razali (2011)." Technology Transfer: PDA handphone for agriculture sector application", *ICEE2011*, 25-27 December 2011, Medina, Saudi Arabia

Yousefi M. R., & Razdari A. M., (2015). Application of GIS and GPS in Precision Agriculture. International Journal of Advanced Biological and Biomedical Research; Vol 3(1), 7-9

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT04

Challenges of Smart Farming in Oil Palm Plantation in Malaysia: An Overview

Ahmad Safwan, A. B.[1,], Zareen, Z.[2]*
[1,2] Faculty of Plantation and Agrotechnology, UiTM Melaka Jasin Campus, 77300 Merlimau Melaka
*Corresponding author. Tel.: +606-2645300, Email:zareen88@melaka.uitm.edu.my

Abstract
Smart farming refers to the efficiency in agriculture management. One of the component of smart farming includes the usage of wireless internet and Global Positioning System (GPS) which connected with drone, machinery and equipment without visiting the farm. In some research, smart farming is stated to become the future of agriculture sector in which helps to overcome several problems nowadays for example, labour shortage. Oil palm production has been one of the primary economic sector in Malaysia. At present, Malaysia accounts for an overwhelming contribution to world's palm oil production and export which is 39% and 44%, respectively. Recently there has been a big drop in oil palm price. Nonetheless, smart farming is still very relevant in oil palm plantation in order to reduce production cost. However the implementation of smart farming is not fully implemented and restricted on several factors such as cost, weak imperatives for change, interoperability of different standards, connectivity in rural areas, and lack of knowledge on several technologies.

Keywords: Oil palm, smart farming, limitation, barriers

Introduction

Oil palm (*Elaeis guineensis*) is one of the major commodities for Malaysia. The oil palm industry continues to be an important foreign exchange earner for the country, with export earnings amounting to RM 64.8 billion in 2008 (Ministry of Plantation Industries and Commodities, 2009). The oil palm total acreage has reach 5.77 million acres in which represented a total of 2.23% from the total of 258.9 million of available land in this country (Bernama, 2017). This shows that the oil palm is the leading commodities in Malaysia. The increasing supply and demand of oil palm plantation product causes several problems to occur and one of it is declining labour (Alam et al., 2015). In order to come out with solution is by initiating smart farming or precision farming.

According to Kevan Reval, (2016), the next few decades smart farming will becoming far more important than it is nowadays and farming look smarter by indulging new technology.

Smart Farming

Smart farming refers to the application of information and communications technology in agriculture. The integration can help to increase production efficiency and the quality of produce. The practices include the use of drones for monitoring, field analysis and spraying, Internet of Things (IoT), sensors and actuators, geo-positioning systems and big data.

Smart Farming Technologies

According to Balafoutis et al, (2017), smart farming technologies can be divided into three major categories. The first technology is data acquisition technologies. This category contains all surveying, mapping, navigation and sensing technologies. The second category is data analysis and evaluation technologies, consist of a simple computer-based decision models until complex farm management and systems of information including many different options and data. The third technology is about precision application a technology which contains all application technologies, focusing on variables-rates applicators and guidance technology.

Smart Farming in Malaysia

Smart farming in Malaysia is still not applied thoroughly. However there are some research and applications that have been reported. One of it was a pilot projects (2001-2007) initiated by Malaysian Remote Sensing Agency (MACRES) together with agriculture-related agencies and Universiti Putra Malaysia (UPM) which conducted at Sawah Sempadan. This research focused on the development of Spatial Decision Support System for efficient management of paddy farms. It includes yield mapping, soil variability mapping, water management, variable rate treatment and GIS modelling (Malaysian National Paddy Precision Farming Project).

Another example is by using image processing. Norazlida Jamil (2014) has reported that thermal image can be used to detect husk and separate it with the seed. In addition, Mehdi Saberioon et al., (2013) have used digital camera image for determining nitrogen status in rice plants, Siti Sharifah et al.,(2014) also used image processing to determine physical rice composition.

Next is the application of drones and sensors to help in daily operations. Drones and sensors help to minimalize works and also decrease human labours in daily field operation. One the major company that used the drone technology is Braintree technologies

Sdn Bhd. which provides services about drone services to helps farmers in the field. According to Directors of Braintree technologies Sdn Bhd, Mr Arif, this company aims on using drones, geographic information systems, artificial intelligence and Internet of Things plans to help Malaysian plantation develop furthers (NST, 2018). In particular, the usage of drones allow farmers to get an overall survey and view of the area and make efficient used of farmers time (Tripicchio et al, 2015).
Besides that, the usage of LiDAR sensors also being used in oil palm plantation to obtain geographic information and also the soil elevation map (Helmi Z.M et al., 2014). This is another alternatives that can be used to substitutes the usage of satellite that will incurred more cost and needed specific to be carried out in that particular area (Balafoutis et al, 2017). Other than that, soil EC mapping also used in plantation area to obtain soil characteristics and properties including chemical and physical properties (Amirun et al., 2007). The example of chemical properties such as nutrient level, pH level and also site yield mapping by using soil Electrical Conductivity or else known as the soil EC mapping.

Challenges of Smart Farming in Oil Palm

There are several challenges that limiting the application of smart farming in Malaysia.

Weak Imperative for Changes

In Malaysia, the farmers and producers still using conventional technology and method. In well develop country the need for spatial is greater because of the principal of stronger imperatives for change and lack of conventional support (Cook et al, 2003). Contrast with what happen in Malaysia, they feel uncertainty with the result come from the smart farming. The unviability of many services and uncertain towards the benefit leads to this weak imperatives for change (Daberkow and McBride, 2003). Moreover, they are still using traditional method due to structural problems as well. These include small farm size and remote locations with limited access to the latest technology and knowledge.

Interoperability of Differents Standards

According to CEO of Tecknoledge software, Hussain Fakhruddin, the innovative technology comes from Original Equipment Manufacturer (OEM) cause several of available tools and technology often not following the same technology standards and platforms. The challenges lies in transforming the smart devices and gateway to become more holistic, hence becoming more farmer-friendly platforms (H. Fakhruddin, 2017).

The Learning Curves

Smart farming involving the implementation of new technology towards day to day field operations, they want more cost-effectives, easy to use and and integrated smart farming systems (Blackmore et al, 2004). Thus the lack of knowledge on several technology and equipment will eventually become disastrous, most important things is to getting the farmers thoroughly understand about the concept of smart farming and every tools involved in this particular.

Connectivity in Rural Areas

Most of the farming and plantations area involves in rural areas, which the implementation of cloud computing technology needs good network perfomance and bandwidth speed (H.Fakhruddin, 2017). Unless this network problem is not solved, then the implementation of several smart farming technology will become problematic. Since most of the sensors and cloud based computing is depends on cloud services, the services and networks needs to be strong enough to be implemented in rural areas (Balafoutis, 2017).

Conclusion

Smart farming is the new era in agricultural sector towards modernizing the agricultural sector in Malaysia and also the world. These include usage of drones or known as unmanned aerial vehicle (UAV) which help in crop maintenance activity such as oil palm census and also other maintenance activity such as circle spraying and selective spraying in the future.
There are several factors that limiting the usage of smart in oil palm plantation in Malaysia which includes the connectivity in rural areas, the learning curves, interoperability of difference standards and weak imperatives for change. All of this particular limitation can be overcome by educating and give more information on smart farming to the farmers. This is because the advantages of smart farming, precision agriculture and also internet of things in agriculture are far outweighing its liabilities and all the limiting factors.
Hence the smart farming is the new era and also will become future farming in plantations sectors. This will open up new job opportunities for the youngster that eager with technological advancement towards working in plantations sectors and will overcome the labour shortage problem

References:

Alam, A S A Ferdous & Er, Ah Choy & Begum, Halima. (2015). Malaysian oil palm industry:Prospect and problem. Journal of Food, Agriculture and Environment. 1313.

143-148.
A. T. Balafoutis, B. Beck, S. Fountas, & S. M. Pederson. (november 2017). Smart Farming Technologies - Description, Taxanomy and Economic Impact. 21-77. doi:10.1007/978-3-319-68715-5_2
Aimrun W., M. S. M. Amin, Desa Ahmad, M. M. Hanafi, C. S. Chan. (2007). Spatial Variability of Bulk Soil Electrical Conductivity in a Malaysian Paddy Field: Key to Soil Management. Paddy and Water Environment.
Ainun Jaabi (2017). Smart Farming is the Way to Go. Retrieved on 9 October 2018 from https://www.nst.com.my/opinion/columnists/2017/09/276234/smart-farming-way-go
Bernama Media Relations and Event Management (MREM). (2017, October 2). Retrieved from http://mrem.bernama.com/viewsm.php?idm=30196
Blackmore B., Fountas Spyros, Søren Marcus and Pedersen. (2004). ICT in Precision Agriculture – diffusion of technology an overview of Precision Agriculture. 10.13140/2.1.1586.5606.
Cook S., Dobermann A., Blackmore, B., Adamchuk Vi. (2004). Precision farming: Challenges and future directions. Published on CDROM. Web site.
Daberkow G. S., McBride D. and William. (2003). Information and the adoption of precision farming technologies. Journal of Agribusiness. 21.
Helmi Z.M. Shafri, Mohd Hasmadi Ismail, Mohd Khairil Mohd Razi, Mohd Izzuddin Anuar and Abdul Rahman Ahmad, (2014). Application of LiDAR and Optical Data for Oil Palm Plantation Management in Malaysia. Article in Proceeding of SPIE Vol. 852608-11– The International Society for Optical Engineering. DOI: 1117/12.979631.
Tripicchio P., Satler M., Dabisias G., Ruffaldi E., & Avizzano C. A. (2015). Towards Smart Farming and Sustainable Agriculture with Drones. 2015 International Conference on Intelligent Environments. doi:10.1109/ie.2015.29
Kevan Reval. (n.d.). What IoT means for Agriculture. Retrieved from http://www.iotamy.com/SmartAgric ulture
Ministry of Plantation industries and commodities. (2009).Retrieved from http://www.Palmoilworld.org/sustainability.html
Malaysian National Paddy Precision Farming Project. Retrieved on 13 February 2019 from https://apan.net/meetings/kualalumpur2009/proposals/Agriculture/APAN%20Eb%20Edit.pdf
Mohammad Mehdi Saberioon, Mohd. Soom Mohd. Amin, Wayayok Aimrun, Asa Gholizadeh and Anuar Abd. Rahim Anuar. (2013). Assessment of colour indices derived from conventional digital camera for determining nitrogen status in rice plants. Journal of Food, Agriculture & Environment Vol.11 (2), 655-662. WFL Publisher. ISSN: 1459-0255
Norazlida Jamil, Siti Khairunniza Bejo, (2014). Husk Detection Using Thermal Imaging Technology. 2nd International Conference on Agriculture and Food Engineering, CAFEi2014. Agriculture and Agricultural Science Procedia 2(2014) 128-135
NST. (2017, September 1). Ecological agriculture: Farming the smart way. Retrieved from https://www.google.com/amp/s/www.nst.com.my/node/275265/amp
International Conference on Agriculture and Food Engineering, CAFEi2014. Agriculture and Agricultural Science Procedia 2(2014) 128-135.
Tripicchio P., Unetti M., Giordani N., Avizzano C. A., and Satler M., (2014). "A lightweight slam algorithm for indoor autonomous navigation," Australasian Conference on Robotics and Automation, ACRA , 2014.
Pedersen, S. M. (2018). Precision agriculture: Technology and economic perspectives. Cham: Springer International Publishing.
Siti Sharifah Bibi Hanibah, Siti Khairunniza-Bejo , Wan Ishak Wan Ismail and Aimrun Wayayok. (2014). Determination of Physical Rice Composition using Image Processing Technique. Journal of Food, Agriculture & EnvironmentVol.12 (1): 205-209.WFL Publisher. ISSN: 1459-0255
V. Puri. (2016). Smart Farming: IoT based smart sensors agriculture stick for live tempreture and moisture monitoring using Arduino, cloud computing and solar technology. 673-680. 10.1201/ 9781315364094-121
Wolfert S., Ge L., Verdouw C., & Bogaardt M. (2017). Big Data in Smart Farming – A review. Agricultural Systems,153, 69-80. doi:10.1016 /j.agsy.2017.01.02

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT05

Pendidikan STEM@STREAM di dalam bidang Perladangan dan Agroteknologi

Muhammad Hudzari, H. R.*, Mohammad Mu'az, H., Samihah, M., Zareen, Z. dan Muhammad Nuruddin, M. N.
Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA, Kampus Jasin,77300, Melaka, Malaysia
*Perhubungan penulis. Tel.: +6019-220 8486, Email: hud47@hotmail.com

Abstrak
Dalam apa bidang sekalipun manusia menceburi didalam kehidupannya, syarat tersebut sebagaimana termaktub di dalam Al-Quran pada surah At-Tin , pastinya manuysia akan beroleh kejayaan di dunia mahupun ukhrawi. Justeru di dalam bidang pertanian malahan bagi manusia pertama yang telah diciptakanNYA, Adam Alaihissalam dikatakan telah dibekalkan dengan kemahiran didalam bidang pertanian bagi meneruskan survivalnya di alam yang fana ini sejurus diturunkan dari syurga. Malahan bercucuk tanam pastinya beroleh hasilnya di dunia mahupun pahala di akhirat sebagaimana mafhum sabdaan Nabi Muhammad S.A.W. Sehubungan itu kertas kerja ini membentangkan kaedah-kaedah yang digunakan dalam menerangkan kepentingan bidang pertanian terutamanya di dalam industri perladangan serta penggunaan teknologi bagi menarik minat serta meningkatkan pemahaman para pelajar terhadap kemahiran didalam modul program STEM (Science, Technology, Engineering , Mathematic) dan STREAM (Science, Technology, Reading, Engineering, Arts, Mathematic). Beberapa jenis modul STEM telah di kongsikan dan dibentangkan kepada para pelajar dari beberapa sekolah menengah kebangsaan di negeri Selangor. Modul ini merupakan sebahagian modul-modul STEM yang dijalani oleh rakan STEM@UiTM untuk sekolah-sekolah pilihan oleh Jabatan Pendidkan Negeri Selangor (JPS). Ianya ini telah dikategorikan di dalam bidang Sains dan terbahagi pula kepada dua bahagian iaitu tiga jenis modul bagi dijalani aktivitinya bersama para pelajar menerusi kakitangan dari Fakulti Perladangan dan Agroteknologi UiTM, manakala satu jenis modul lagi, boleh dijalani oleh rakan staf UiTM walaupun dari Fakulti yang berlainan. Melalui kaedah-kaedah yang diterapkan di dalam modul-modul ini, pastinya InshaAllah dapat menarik minat serta menjelaskan kepada para pelajar akan kepentingan pendidikan dan pertanian untuk di ceburi yang ianya menjadi bahan asas untuk kehidupun disamping membentuk dorongan jiwa bagi memperoleh keredhaan Ilahi.

Kata Kunci: Manusia, Pertanian, Perladangan dan Agroteknologi, STEM dan STREAM

Pengenalan

Pelan Pembangunan Pendidikan Malaysia 2013-2025(PPPM2013-2025) telah meletakkan pendidikan Science,Technology,Engineering dan Mathematics (STEM) sebagai satu agenda yang penting dalam transformasi pendidikan bagi menyediakan generasi muda untuk menghadapi cabaran abad ke-21. Pendidikan STEM dalam PPPM dilaksanakan dalam beberapa fasa seterusnya.

Bahan dan Kaedah

Bagi merealisasikan fasa-fasa ini,perancangan rapi dan kerjasama daripada semua pihak yang berkaitan amat diperlukan.Selain itu, kemunculan Revolusi Industri4.0 (Industrial Revolution4.0) juga telah memberi impak kepada keperluan pelajar sekolah dalam menguasai ilmu digital malah turut melibatkan transformasi yang komprehensif melalui penggabungan teknologi digital dan internet dengan industri pendidikan Negara. Tambahan lagi,ilmu berkaitan STEM merupakan keperluan kepada pelajar sekolah dalam memastikan mereka menjadi pelajar yang berdayasaing seiring dengan agenda STEM Negara. Berikut merupakan tiga jenis modul yang diterapkan sewaktu implementasi aktiviti STEM untuk para pelajar sekolah di Negeri Selangor**.**

1) Tajuk 1
Hubungan Manusia dan Pertanian

i) Penulis
Muhammad Hudzari Bin Haji Razali, Mohammad Mu'az Hashim, Zareen Binti Zulkifli, Samihah Binti Mustaffha dan Muhammad Nuruddin Mohd Nor

ii) Tujuan Pembelajaran
Para pelajar akan dapat memahami akan kepentingan bidang pertanian bagi diceburi untuk memenuhi keperluan kehidupan manusia.

iii) ***Masa Diperlukan***
45 minit

iv) Penerapan Nilai Murni
Para pelajar akan di terangkan akan kepentingan bidang pertanian bagi keperluan kehidupan manusia. Pekerjaan pertanian merupakan bidang terbaik diceburi oleh manusia memandangkan ianya dilakukan dengan titik peluh sendiri dari ianya ditanami, dibajai sehinggalah diairi dan dimakan sendiri ataupun dijual bagi kegunaan manusia lain.

v) Bahan Yang Diperlukan
Al-Quran (berserta Waqaf & Ibtida) dan Kitab hadith pilihan (Muntakhab Hadith)

vi) Bilangan Pelajar
Lima orang dalam satu kumpulan

vii) Kaedah
Kumpulan para pelajar akan dibawa ke Masjid atau Surau di perkarangan sekolah/ universiti. Sepanjang perjalanan ke Masjid, para pelajar akan diminta untuk memerhati disekeliling tumbuhan dan alam sekitar disamping penerangan ada diberi tentang hubungan diantara manusia, air, baja, cahaya, rumpai, serangga, kotoran dan sambah serta sebagainya. Sementara itu para pelajar juga akan diterangkan serba sedikit adab-adab Sunnah ketika di masjid disamping Sunnah beristinjak dan berwudhuk. Sejurus di dalam masjid, para pelajar sekolah juga akan diperdengarkan Hadis akan kepentingan bercucuk tanam dan menyuburkan tanah disamping mengagungkan akan kebesaran Allah Subhanahuwataala terhadap ciptaannya berkaitan pertanian. Aplikasi digital Al-Quran dan Al-Hadith akan ditunjukajar.

viii) Penilaian
Para pelajar dinilai dalam cara mereka mengenalpasti kitaran bagi kehidupan serta hubungkait manusia dan tumbuhan.
Para pelajar akan diminta untuk bersama-sama membaca Al-Quran terutamanya untuk Surah Al-Fatihah.
Pembacaan Hadis berkenaan kelebihan bercucuk tanam juga akan dibaca oleh pelajar.
Kebolehan pelajar untuk membaca Al-Quran dan Hadis akan semoga dapat mendorong mereka menjadi pelajar yang cemerlang Duniawi dan Ukhrawi.

viv) Kos Terlibat
Tiada

2) Tajuk 2
Simulasi Traktor Enjin Pembakaran Dalaman dan Pengujian Tahap Kandungan Air

i) Penulis
Muhammad Hudzari Bin Haji Razali, Mohammad Mu’az Hashim, Zareen Binti Zulkifli, Samihah Binti Mustaffha dan Adzmi Yaacob

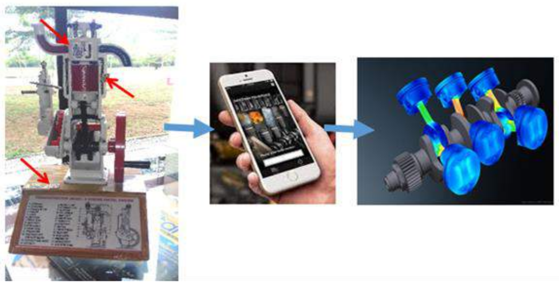
ii) Tujuan Pembelajaran
Para pelajar akan diterangkan akan kepentingan memahami pengoperasian enjin pembakaran dalaman bagi sesebuah traktor yang digunakan di perladangan beserta pengujian tahap kandungan air.

iii) ***Masa Diperlukan***
45 minit.

iv) Penerapan Nilai Murni
Para pelajar akan dapat memahami tentang operasi enjin pembakaran dalaman secara lengkap disamping kesedaran betapa kompleks nya pengoperasian bagi kegunaan dan keperluan manusia disamping perlu menjawap soalan-soalan yang akan diketengahkan sewaktu aktiviti. Begitu juga bagi pengujian tahap kandungan air.
v) Bahan Yang Diperlukan
Model enjin, Penderia Mudahalih Kandungan Air, Aplikasi pengimbas QR code, Smartphone, Akses Internet

vi) Bilangan Pelajar
Lima orang dalam satu kumpulan

vii) Kaedah
Model untuk simulasi enjin traktor akan dipertontonkan disamping penerangan terhadap pengoperasiannya. Simulasi visual juga akan dijalankan di handphone dengan mengakses melalui QR code. Gambar 1 dibawah menunjukkan aliran pembelajaran STEM untuk enjin traktor pembakaran dalaman.



Gambar 1: pembelajaran STEM untuk enjin traktor pembakaran dalaman.

Bagi pengujian air, para pelajar diminta untuk mendapatkan air di parit saliran terutamanya dipersekitaran tempat aktiviti dijalankan disamping penerangan diberikan terhadap keperluan air kepada tumbuhan. Penderia air mudahalih akan dijalankan bagi mendapatkan keputusan terhadap nilai ph, DO (Dissolved Oxigen), Turbidity dan sebagainya disamping kesannya terhadap hidupan persekitaran.

viii) Penilaian
Para pelajar akan diminta menjawab kuiz / soalan berkenaan kefahaman operasi enjin pembakaran dalam bagi sesebuah enjin traktor pertanian disampin kefahaman terhadap aturan serapan air oleh tumbuhan.
Para pelajar juga diminta mengenengahkan idea / pendapat melalui lakaran / tulisan berkenaan kaedah di masa hadapan bagi mendapatkan sumber tenaga melalui kelastarian pertanian seperti aplikasi sistem solar dan sebagainya.

iv) Kos Terlibat
Tiada

3) Tajuk 3
Keseimbangan nutrien untuk pertumbuhan tanaman

i) Penulis
Mohammad Mu'az Hashim, Muhammad Hudzari Bin Haji Razali, Zareen Binti Zulkifli, Samihah Binti Mustaffha dan Adzmi Yaacob

ii) Tujuan Pembelajaran
i. Para pelajar akan didedahkan mengenai kepentingan nutrien-nutrien tertentu dalam proses pertumbuhan tanaman. Setiap elemen seperti nitrogen (N), fosforus (P), kalium (K), dan mikronutrien mempunyai peranan masing-masing dalam pertumbuhan pokok.
ii. Menimbulkan sikap inkuiri dalam diri pelajar terhadap sesuatu yang diperhatikan; pokok yang kelihatan tidak normal pasti ada sesuatu penyebabnya.

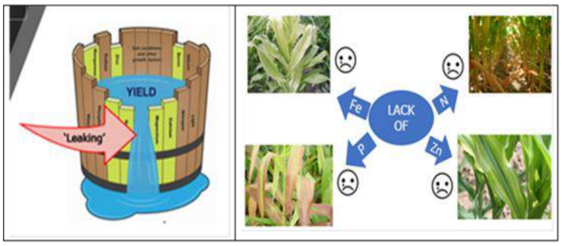
iii) *Masa Diperlukan*
45 minit

iv) Penerapan Nilai Murni
Kerjasama sebagai satu unit (nutrien-nutrien) dalam suatu system tumbuhan. Apabila berlaku kekurangan, walaupun satu sahaja nutrien, pertumbuhan pokok akan terjejas walaupun nutrien-nutrien lain dibekalkan secara mencukupi.

v) Bahan Yang Diperlukan
Benih pokok (jagung/sayuran), medium tanaman (peat moss/coconut fibre), baja tunggal sebagai sumber nutrien, Simulasi Law of Minimum (bekas/baldi rekaan khas), alatan visual untuk penerangan

vi) Bilangan Pelajar
Lima orang dalam satu kumpulan

vii) Kaedah
Pelajar akan diberikan beberapa simptom-simptom asas kekurangan nutrien dan dikehendaki untuk mengenalpasti nutrien yang tidak mencukupi dalam tumbuhan tersebut sebagaimana digambar 2 dibawah.



Gambar 2: Simulasi kekurangan zat dalam tumbesaran tumbuhan untuk aktiviti STEM.

viii) Penilaian
Sifat inkuiri yang timbul dalam diri pelajar akan membolehkan mereka lebih peka terhadap perkara di sekeliling mereka

viv) Kos Terlibat
RM50

Keputusan dan Perbincangan
Justeru, Karnival STEM@UiTM ini diadakan bagi mendokong matlamat agenda STEM Negara dalam melahirkan modal insan yang berkepakaran dalam bidang Sains dan Matematik melalui pelbagai aktiviti seperti pameran dan pertandingan. Karnival ini akan melibatkan hampir 2,000 orang pelajar sekolah menengah daripada 12buah sekolah yang diletakkan dibawah Program Mentor-Mentee STEM dan turut disertai oleh beberapa buah sekolah disekitar Selangor.

Kesimpulan
Melalui kaedah-kaedah yang diterapkan di dalam modul-modul STEM bagi berusaha membentuk golongan dibidang pertanian dimasa hadapan disamping membentuk dorongan keseniannya iaitu hubungan rapat manusia terhadap pertanian yang menjadi survival kehidupannya, pastinya InshaAllah dapat menarik minat serta menjelaskan kepada para pelajar akan kepentingan pendidikan dan pertanian untuk di ceburi yang ianya menjadi bahan asas untuk kehidupun disamping membentuk dorongan jiwa bagi memperoleh keredhaan Ilahi.

Penghargaan
Penulis mengucapkan ribuan terima kasih keatas pembiayaan logistik yang diberikan oleh pihak pengurusan Fakulti Perladangan dan Agroteknologi, UiTM disamping kerjasama oleh pihak STEM@UiTM, Timbalan Naib Canselor Penyelidikan dan jaringan Industri, Shah Alam , Selangor.

Rujukan
E. A. Z. Engku Alwi, N. Anas, W. R. Wan Taib, M. H. Razali, S. A. Saany and Z. Yaacob, (2017). Islamic Aqeedah Compliance Index: A Study of Malay Genome in Malaysia, International Journal of Academic Research in Business and Social Sciences, 2017, Vol. 7, No. 6

Karnival STEM@UiTM, 28 Ogos 2018, Menara Kejuruteraan, Tuanku Abdul Halim Muadzam Shah, UiTM, Shah Alam, Selangor, Malaysia

Mohd Hudzari Hj Razali (2012)." Computer Application In Agriculture Mechanization Education (Key Note Speaker)". International Conference on Human Computer Interaction & Learning Technologies (ICHCILT 2012) , 30-

31 March 2012, Abu Dhabi, United Arab Emirates

Mohd. Hudzari Haji Razali, Syed Hadzrullathfi Syed Omar And Mohd Shahril Othman, (2013). Qur'an And Science: Dakwah As Necessity for The Best Ummah, Lambert Academic Publishing, Saarbrucken, Germany, pp 68. ISBN 978-3-659, 38374-8

Muhammad Hudzari Haji Razali, Syazili Roslan, Muhammad Rahimi Osman, Muhammad Shahril Othman, Zulfakar Aspar and Engku Fadzli Hasan Syed Abdullah, (2017). Development of Intelligence Technique in Shariah Compliance Washing Machine via PLC. Journal of Artificial Intelligence, 10: 49-58

Norazmi Anas, Engku Ahmad Zaki Engku Alwi, Mohd Hudzari Razali & Nurul Hidayah Aziz. (2018). Integrai Kursus Pengajian Islam Dengan Bioteknologi di Universiti Awam (UA) Terpilih Di Malaysia. Idealogy, 3(1) : 68-79, 2018

R.M.Hudzari, R.Syazili, M.A.H.A Ssomad and B. Hayan (2016), Design and Development of Mechatronic Application in Agricultural Irrigation Device, Special Issues: Mechatronic System, World Journal of Engineering and Technology, Vol.04 No.03, ISSN:2331-4222

www.ipni.net/nutrifacts (dibuka pada 15 Oktober 2018)

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT06

Real-time Nutrient Film Technique Management and Monitoring System Using Internet of Thing

Mohd Ashraf Zainol Abidin*, Nur Nabilah Atiq Ramli, Iman Hazwam Abd Halim, and Mohamad Khairri Arshad
Universiti Teknologi MARA Perlis Branch, Arau Campus, 02600 Arau, Perlis, Malaysia.
*Corresponding author. Tel.: +604-988 2171, Email: ashrafzainol@perlis.uitm.edu.my

Abstract
Nutrient Film Technique (NFT) is a modern cultivation system that introduced under a hydroponic system that suitable to apply in a small or large unit area. However, conventional NFT system requires plenty of time and workforce to manage and monitor the fertilizer solution. Therefore, there is a need to improve the existing conventional NFT management and monitoring technique in order to save time and reduce workforce. Thus, we built the NFT management and monitoring system that can be monitored and get the real-time data of the several fertilizers' parameters based on the Internet of Thing (IoT) technology. The parameters such as electrical conductivity (EC), pH, temperature and water level were measured using sensors that connected to the Generic NanoFI microcontroller and Wi-Fi module ESP8266. Next, this system was calibrated to ensure the accuracy of data retrieved and sensitiveness of alarm systems. The result shows that this system was able to retrieve the real-time data of the fertilizer solution' parameters and sending the early alarm notification if any data is exceeded the range setting. Thus, based on the calibration results, it is a reliable system to manage and monitor the NFT fertilizer solution remotely.

Keywords: NFT management and monitoring system , Internet of Thing, microcontrollers, real-time data

Introduction

Nutrient Film Technique (NFT) is one type of closed hydroponic system that only producing crops by recirculating the nutrient solution which allows it to has high efficiency in utilizing water and nutrient usage (Burrage, 1993). In Malaysia, the NFT system has been giving good impacts on food security as well as high yield production. However, there are some problems arise from the system include the shortage of labor, difficulty in controlling the external factors of the natural environment and the lack of time for busy people to care the system (Changmai, Gertphol, & Chulak, 2018; Romadloni, 2015).

Although NFT only used a small area of land and growing plants in the absence of soil, it requires special care in terms of water temperature, water level, water acidity (pH) and the concentration of nutrient (EC/ppm) in water (Crisnapati, Wardana, Aryanto, & Hermawan, 2017). Due to the external factor of natural environment such as water temperature, the acidity of water, nutrient content in water can give big impacts on making sure the plant grows in very well condition and it is difficult to control all of them (Changmai et al., 2018).

Previous studies conducted by Changmai (2018), Romadloni (2015), and Ruenittinun (2017) show that introduction of the Internet of Things (IoT) technology in managing and monitoring agriculture make both processes become more easier and practical.

According to Anderson & Lee Rainie (2014), IoT can be defined as a global, invisible networked computing environment that built via the continued proliferation of smart sensors, cameras, software, databases and big data centers in a world-spanning information fabric. IoT is a network system that connected with small electronic devices equipped with sensors that functioning in detecting the operating environment of the system. There is a various IoT that functioning in detecting the operating environment of the system. One of them is the Plant Link system that made up from Link sensor and the base station. The base station responsible to handle all the analysis and connects to the router. The link informed the user the time for watering plants and can be programmed with sprinklers associated with specific plant types (Doknić, 2014).

Therefore, a new method is created and integrated with the conventional NFT system in order to allow farmers to manage and monitor the water temperature (℃), water level, the water acidity (pH) and the concentration of nutrient or electrical conductivity (EC). It involves the used of related sensors that can be connected to the microcontroller and displayed the appropriate data via the IoT. The system allow the user to obtain a real-time data and being notify if any data is exceeded the specific ranges remotely.

This paper focused on developing the real-time NFT management and monitoring system which involve the use of the IoT technology, and also calibration of the system to ensure the reliability and accuracy of the data retrieved and sensitiveness of alarm notification systems.

Materials and methods

Hardware and Software Development

Figure 1 illustrated the schematic diagram of the Internet of Things (IoT) system developed to manage and monitor the Nutrient Film Technique's (NFT) fertilizer solution. This system consists of power supply unit, microcontroller, sensors and actuators, and cloud storage. For the power supply unit, a single unit of 20,000 mAh power bank was found enough to operate this system for atleast one week before needs to be replaced with a power bank standby unit.

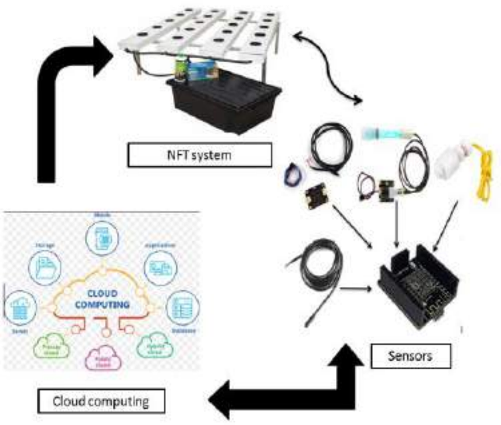


Figure 1: Schematic diagram of real-time NFT management and monitoring system

There are four different sensors installed in the system to monitor the level of water, acidity (pH), electrical conductivity (EC) and temperature. Each sensor has different specifications and level of accuracy depending on parameters that need to be measured.

For water level monitoring, a Horizontal Float Switch was used. This type of switch is widely used in in electronic, electrical, chemical, water treatment, drainage and other walks of life level control and alarm. It does not have a complex circuit, thus, can be easily installed in the fertilizer tank to monitor the level of water.

Analog pH sensor was installed in this system to measure the pH level in the water tank. This useful pH sensor kit comes with a pH probe that allows the user to dip it into the water tank and it also comes with a circuit board that can be connected directly to the microcontroller. It has the capability to measure the pH level from 0 to 14 with the accuracy of ±0.1pH at specific temperature of 25℃.

The level of EC was measured using SEN0244 Analog TDS (Total Dissolved Solids) sensor. The TDS measurement range is between 0 to 1,000 ppm with the accuracy of ±10% F.S (25℃). Both EC and TDS values can be used to measure the concentration of nutrient. However, the concentration of nutrient is commonly measure in EC unit (mS/cm). Thus, a specific mathematical equation was included in the programming code to convert the retrieve data from TDS units to EC units.

DS18B20 Digital Temperature sensor was used to measure the variation of temperature inside the water tank. This waterproof sensor is able to measure temperature variation between -55℃ to +125℃ ±0.5℃ accuracy from -10℃ to +85℃. It also can notify the user when the temperature is out of accepted range. The sensor is widely use in thermostatic controls, industrial systems, consumers products, thermometers, or any thermally sensitive system.

All four sensors were connected to the Generic NanoFi microcontroller that equipped with ESP8266 module as a communication medium through a wireless network to the internet. The use of wireless communication media provides the system with advantages that can be integrated with other tools and can be controlled via the Internet. In addition, the system connected to the network can be accessed using the browser based on the server address via the webpage. The next step is the authentication page where login is required before the main page can be accessed. Webserver can submit a request or receiving a response from the module objects. Requests sent will be processed in accordance with the specific function. Whenever there is a response, the server will received and stored the data in the cloud storage and then displayed it on a webpage.

For this real-time NFT management and monitoring system development, an open source software was used to write the arduino programming language. The programming language is very important to ensure the sensors and microcontroller are able to run the specific command properly. Entering an incorrect command will cause the system fail to run. Furthermore, if the system is running with incorrect command, it will collect the wrong data. To make worse, if the user did not realize that situation.

A webserver was used to collect, store and viewing the data online. This web tool is allowing the users to send data privately to the cloud, analyze and visualize the data, and trigger a reaction to the collected data.

Calibration of the System

The real-time NFT management and monitoring system was calibrated to identify the accuracy of the sensors and measure the sensitivity of alarm system developed.

The water level, acidity water (pH) value, electrical conductivity (EC) value and temperature value were taken three times using the real-time system. Next, those data were used to calculate the average data for each parameter. The accuracy of these sensors were calibrated by comparing those average data retreived from real-time system with the average data taken using existing measuring tools.

The water level sensor effectiveness was examined at different level of water available. For example, if the level of water is enough, the signal received should be ‘0’, however, when the water level is below the specific limit, the signal received should be ‘1’ and the Green LED at breadboard will be lighted up. Beside that, the alarm notification also will be send to the webpage.

For the acidity water (pH), the accuracy of the sensor was determined by comparing the average data taken using real-time system with recorded data from HI-98107 pHEP pH Tester. 0.0 to 14.0 pH is the range for this measuring equipment, while the accuray of it is around ±0.1 pH. The range for pH level was set up between 5.50 to 6.30 as stated in Table 1. If the pH level is out of range, the Yellow LED will be lighted up and the user will be noticed via online system.

Table 1: Specific range set up for each parameters

Parameters	Range Set up
pH	5.50 – 6.30
EC (mS/cm)	1.15 – 6.30
Temp (℃)	15.00 – 25.00

The electrical conductivity (EC) of fertilizer is measured using TDS sensor. This sensor was calibrated by comparing the average data obtained by real-time system with the average data recorded using HI-98331 Gro Line EC Tester. This measuring tool is able to record the conductivity values ranging from 0.00 to 4.00 mS/cm. Beside that, it also can be used to measure the temperature values between 0.0 to 50.0℃. The accuracy of this device is ±0.05 mS/cm and ±1℃ for EC and temperature values respectively. The alarm notification was set up to make sure that the range of EC values is between 1.15 and 6.30 mS/cm as mentioned in Table 1. The Blue LED will be lighted up and the notification will be sent out to the user spontaneously when the EC value is not in range.

Water temperature sensor was calibrated by comparing the average data retrieved using real-time system with the average data obtained from the measuring tool. The measuring tool use to measure the temperature value is the same tool used to measure EC level. The range set up for temperatures of the fertilizer is between 15.00 and 25.00 ℃. Like previous sensors, if the data obtained is out of range, the LED (Red) will be lighted up and the user will also get the notification via the internet.

Results and discussion

Data Acquasition

Table 2 shows the data acquisition of water level obtained during calibration process in the laboratory. As mentioned before in the calibration procedure, if the water level is below the specific limit, the signal received should be ‘1’. In contrast, when the water level above the specific limit, the signal received should be ‘0’. From three tests conducted for both conditions, the system was able to send a correct signal with zero percentage error.

Table 2: Data acquisition of water level

Below specific water level		
R1	R2	**R3**
1	1	1
Above specific water level		
R1	**R2**	**R3**
0	0	0

Mean values of pH, EC and temperature recorded using measuring tools and real-time system were shown in Table 3. From the result, it was found that there was no signifcant difference between methods use to measure all three parameters. Thus, it shows that the developed system is able to read data accurately.

Table 3: Data acquisition of pH, EC and temperature

Measuring tools			Real-time system		
pH	**EC**	**Temp**	**pH**	**EC**	**Temp**
5.5^{a}	0.21^{b}	27.0^{c}	5.4^{a}	0.21^{b}	27.0^{c}

*mean values with same superscript did not show any significant different ($p>0.05$)

Notification system

Table 4 shows the alarm notification reaction when the parameter levels are below, between and above the specific limit or ranges. The water level, pH, EC and temperature alarm notifications were represented by Green LED, Yellow LED, Blue LED and Red LED respectively. For the water level, we concern more on the lacking of water compare to excessive water level. Hence, the notification system was design only to turn ON the LED light when the water level is below the specific limit. While, for other parameters, they have their own range of level setting. The Yellow LED was light up when the pH levels are below or above the allowable range and turn OFF when the pH levels are within the acceptable range. Based on the calibration test conducted also, the alarm notification systems for EC and temperature also work accordingly. Besides notify the users through the LED light, this developed system was also sent the notification to the webserver, thus allow the users to monitor the condition of their fertilizer solution remotely.

Table 4: Notification system using different LED light colour

Parameters	LED	Specific limit / Range		
		Below	Between	Above
Water level	Green	[redacted]	OFF	
pH	Yellow	OFF	ON	
EC	Blue	OFF	ON	
Temp	Red	OFF	ON	

Conclusions

The real-time NFT management and monitoring system developed was calibrated. The result shows that the deloped system was able to retrieve the data such as level of water, pH, EC and temperature of the fertilizer solution accurately. Besides that, the system was also able to notify the users on any changes of those parameter level remotely.

References

Anderson, P. J., & Lee Rainie. (2014). Digital Life in 2025.

Burrage, S. (1993). Nutrient film technique in protected cultivation. Retrieved from http://www.actahort.org/books/323/323_1.htm

Changmai, T., Gertphol, S., & Chulak, P. (2018). Smart Hydroponic Lettuce Farm using Internet of Things. 2018 10th International Conference on Knowledge and Smart Technology (KST), 231–236. https://doi.org/10.1109/KST.2018.8426141

Crisnapati, P. N., Wardana, I. N. K., Aryanto, I. K. A. A., & Hermawan, A. (2017). Hommons: Hydroponic management and monitoring system for an IOT based NFT farm using web technology. 2017 5th International Conference on Cyber and IT Service Management, CITSM 2017. https://doi.org/10.1109/CITSM.2017.8089268

Doknić, V. (2014). Internet of Things Greenhouse Monitoring and Automation System. Monografia, (June), 22.

Romadloni, P. L. (2015). Rancang Bangun Sistem Otomasi Hidroponik NFT (Nutrient Film Technique) Ubiversitas Telkom. E-Proceeding of Applied Science, 1(1), 75–84. Retrieved from http://libraryeproceeding.telkomuniversity.ac.id/index.php/appliedscience/article/viewFile/70/72.

Ruengittinun, S., Phongsamsuan, S., & Sureeratanakorn, P. (2017). Applied internet of thing for smart hydroponic farming ecosystem (HFE). Ubi-Media 2017 - Proceedings of the 10th International Conference on Ubi-Media Computing and Workshops with the 4th International Workshop on Advanced E-Learning and the 1st International Workshop on Multimedia and IoT: Networks, Systems and Applications. https://doi.org/10.1109/UMEDIA.2017.8074148

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Merekabentuk Konseptual Laman Sesawang Berasaskan GIS bagi Kawalan Serangga Perosak dan Serangan Penyakit untuk Tanaman Padi.

Norasma, C. Y. N*., Faten, N. S. Z. A. and Rhushalshafira, R.
Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
**Corresponding Author, Tel: +603 89474892, E-mail: niknorasma@upm.edu.my*

Abstrak
Beras merupakan makanan ruji rakyat Malaysia dan tahap penghasilan kendiri (SSL) adalah sebanyak 71.5%. Kerajaan Malaysia telah menetapkan untuk menaikkan tahap SSL kepada 100% menjelang tahun 2020. Penghasilan beras dapat ditingkatkan melalui sistem pengurusan dan teknik penanaman yang baik. Oleh itu, maklumat mengenai serangan perosak dan gejala serangan penyakit amatlah penting kepada golongan petani bagi mengelak sebarang serangan sepanjang tempoh penanaman. Justeru, objektif kajian ini adalah untuk mencari dan mengkaji laman sesawang sedia ada yang menyediakan maklumat mengenai masalah ini dan merekabentuk konseptual laman sesawang berasaskan GIS bagi kawalan serangga perosak dan serangan penyakit untuk tanaman padi. Aplikasi ini akan membantu golongan petani untuk mencari solusi dan sekaligus membantu menguruskan penanaman padi dengan lebih baik. Aktiviti kajian ini dibahagikan kepada dua fasa. Fasa pertama melibatkan aktiviti mengkaji laman sesawang sedia ada dan fasa kedua adalah merekabentuk sistem maklumat yang mempunyai informasi mengenai serangga perosak dan jenis penyakit berdasarkan kepada kajian literatur. Dapatan daripada kajian ini adalah rekabentuk konseptual yang komprehensif bagi aplikasi atas talian dan boleh dijadikan garis panduan oleh pihak kerajaan pada masa akan datang. Kajian ini merupakan titik permulaan untuk melaksanakan Internet of Thing (IoT) dalam bidang pertanian. Sistem ini akan membantu golongan petani untuk mendapatkan maklumat mengenai cara mengawal serangga perosak dan serangan penyakit di sawah. Seterusnya produktiviti penghasilan beras dapat ditingkatkan dan konsep laman sesawang ini boleh digunakan untuk tanaman lain seperti kelapa sawit, getah, nenas dan jagung.

Keyword: Padi, Laman sesawang, sistem informasi, serangga perosak and penyakit

Pengenalan

Oryza sativa atau lebih dikenali sebagai padi adalah tanaman kedua terpenting di dunia. Dengan peningkatan populasi penduduk di Asia, dianggarkan 70% penghasilan beras diperlukan bagi menampung keperluan beras pada masa akan datang. Di Malaysia, purata keperluan seorang dewasa dalam masa sehari adalah dua pinggan setengah nasi (Rajamoorthy, Abdul Rahim, & Munusamy, 2015). Sehubungan itu, Menteri Pertanian Malaysia dan Industri Asas Tani telah memperkenalkan Dasar Agromakanan Negara (DAN) untuk memastikan bekalan makanan adalah mencukupi dan mengubah industri berdasarkan pertanian ke arah yang lebih kompetitif, mampan dan mampu meningkatkan pendapatan usahawan yang terlibat dalam industri ini. DAN 2011-2012 telah menekankan bahawa penghasilan beras tempatan harus ditingkatkan bagi memastikan 7% simpanan beras negara berjaya dijual ke negara luar. Bermula dari Rancangan Malaysia Ketiga (1976 – 1980), industri pertanian merupakan industri utama dalam polisi ekonomi kerajaan. Di bawah polisi ini, kerajaan membuka banyak tanah bagi tujuan penanaman padi dan menghasilkan peningkatan positif penghasilan beras di Malaysia sehingga ke hari ini.

Walau bagaimanapun, pengeluaran padi di Malaysia tidak mampu menangkis serangan penyakit dan serangga perosak (Kuok, 2015). Serangan ini boleh menyebabkan kerosakan yang serius dan menjejaskan kadar pengeluaran beras negara. Serangga perosak adalah organisma atau mikroba yang mempu mengurangkan hasil dan kualiti beras. Pengorek batang kuning, bena perang, bena belakang putih, kutu beruang dan ulat ratus adalah jenis-jenis serangga perosak yang sering dijumpai di kawasan sawah padi. Manakala hawar daun bakteria (BLB), reput batang, hawar seludang dan penyakit merah virus (tungro) merupakan serangan penyakit utama yang dihadapi oleh tanaman padi di Malaysia (Wee, 2011).

Oleh itu, bagi mengatasi masalah ini, mereka cipta laman sesawang menggunakan teknologi *Geographical Information System* (GIS) diperkenalkan. GIS merupakan teknologi pintar yang menggunakan perkakasan, perisian, data, kaedah dan tenaga kerja manusia untuk menguruskan dan memanipulasi data. Penggunaan GIS didalam bidang pertanian dapat memberi impak yang tinggi terutama melibatkan aktiviti pengurusan kualiti air, penentuan kesesuaian tanah mengikut aplikasi, pengurusan sumber semulajadi dan pengawalan serangan serangga perosak dan penyakit. Laman sesawang GIS merupakan teknologi yang memaparkan dan menganalisa data spatial di internet (ArcGIS, 2017). Justeru, mengintegrasikan teknologi ini ke dalam sektor pertanian mampu meningkatkan kualiti dan hasil sektor ini (Zhang et. Al., 2018). Ia menawarkan kaedah baharu kepada golongan petani untuk meningkatkan hasil tanaman tanpa perlu menggunakan perisian GIS atau lebih dikenali sebagai *Internet of Thing* (IoT).

Tujuan kajian ini dijalankan adalah untuk mengenal pasti laman sesawang berkonsepkan GIS sedia ada dengan mengkaji semula jurnal yang telah diterbitkan dan merekacipta rangka kerja berkonsepkan GIS yang mesra pengguna untuk kawalan serangga perosak dan penyakit padi. Garis panduan yang disediakan di dalam laman sesawang ini akan membantu golongan petani menguruskan dan memilih rawatan yang terbaik bagi meningkatkan hasil tanaman. Penggunaan laman sesawang berkonsepkan GIS untuk kawalan serangan serangga perosak dan penyakit merupakan inisiatif terbaik dalam usaha meningkatkan sistem pengurusan pertanian. Justeru itu, Jadual 1 di bawah menyenaraikan negara-negara yang telah menggunakan laman sesawang GIS termasuklah Malaysia.

Jadual 1: Aplikasi laman sesawang GIS di negara-negara luar termasuk Malaysia (Norasma, Faten & Rhushalshafira, 2018)

Negara	Komponen	Keterangan
Indonesia	Informasi pertanian, kalender penanaman dinamik, masa penanaman, jenis-jenis padi, penggunaan baja, penggunaan racun dan sistem pengairan.	Untuk menggantikan teknik penanaman tradisional kepada kaedah penanaman moden. Membantu para petani mendapatkan informasi mengenai teknik penanaman sekaligus meningkatkan kebolehan membuat keputusan (Suprato et al., 2016).
Filipina	Komponen pengurusan genealogi, sistem pengurusan data, GIS, aplikasi untuk mengekalkan, mengemaskini, dan membetulkan rekod genealogi, mengemaskini perubahan pertubuhan tanaman, aplikasi untuk menghasilkan buku lapangan dan menguruskan set bahan pembiakan, alat untuk menambah kaedah pembiakan baru, medan data baru, dan ciri-ciri baru; dan kaedah untuk penyerahan data.	Aplikasi ini ditubuhkan untuk memerangi masalah kemiskinan dan kebuluran di Filipina. Ia mengendalikan kepelbagaian data genom beras termasuklah data turutan, data genatik molekul dan sebagainya (McLaren et al., 2005).
Jepun	Maklumat tanah dan meteorologi dari eksperimen dikumpulkan melalui sistem pemantauan Teknologi Maklumat (IT) di lapangan. Mempunyai server web nod sensor pintar yang dilengkapi dengan rangkaian kamera dan sensor in-situ untuk pemantauan pertumbuhan agrometeorologi, tanah, dan tumbuhan	Parameter kelembapan dan maklumat agrometeorologi menggunakan sistem penderia jarak jauh. Dengan maklumat yang dikumpul, kekerapan pengairan boleh ditentukan dan dapat menjimatkan lebih banyak air untuk kegunaan selanjutnya. (Manzano Jr et al., 2011)
China	Peta serangan penyakit dan lokasi pemantauan serangga perosak. Peta sungai dan jalan raya. Dilengkapi peta daerah pentadbiran Chongqing. Peta status bencana (kuantiti penyakit tertinggi dalam ladang benih, kawasan bencana terkumpul, pentafsilan bencana).	Menganalisis perubahan spatial dan temporal serangan penyakit dan serangga perosak ke atas padi. Menyediakan maklumat berguna untuk amaran awal kepada pembuat keputusan untuk kawasan pengeluaran beras yang berisiko tinggi. (Wei Bao, Xuan Yu, & Wu, 2011)
India	Perkhidmatan peta, perkhidmatan data, metadata dan maklumat lain. Dibina dengan *Cascading Style Sheets* (CSS), halaman HTML, *Hypertext Preprocessor* (PHP), Halaman Pelayan Aktif (ASP).	Meningkatkan prestasi laman sesawang GIS dan memenuhi permintaan pelanggan dalam tempoh yang ditetapkan dengan cara yang bersesuaian. (Balamurugan, Kalaiarasi, & Arun Prasad, 2014)
Indonesia	Menggunakan perisian seperti ArcGIS, PHP, OpenLayers API, PostgreSQL + PostGIS (DBMS) Jquery, JavaScript, HTML, Macromedia Flash (8), Adobe Photoshop CS2, Suit Grafik Coreldraw (12), Adobe Dreamweaver CS3,	Membangunkan sistem sokongan pembuat keputusan berasaskan laman sesawang GIS untuk sistem pemantauan dalam pertanian. (Suresh Babu & Santosh Kumar, 2016)

	(Pelayaran laman sesawang Terbuka (*Open Source*)).	
Nigeria	Menggunkana perisian seperti Google Earth Pro, ArcGIS, bahasa pengaturcaraan Google Sketchup dan Ruby 2.0	Pembangunan laman sesawang ladang 3-Dimensi yang membolehkan petani memilih varieti tanaman yang lebih baik di kalangan tanaman utama yang ditanam di kawasan tersebut. (Obiyini & Ibrahim, 2015)
UPM, Malaysia	Menggunkana perisian seperti Open Source Server MapGuide, Extension Web MapGuide, PHP 5.2.1, Apache, MySQL dan Feature Data Object (FDO) untuk platform Windows. Manakala perisian Fedora Core telah digunakan dalam platform Linux. Perisian Mono diperlukan untuk memasang MapGuide Maestro bagi analisis spatial.	Sistem ini dibangunkan berasaskan prinsip (Pertanian Tepat) PF dan teknik pangkalan data yang sewajarnya digunakan agar pengguna mudah mengakses maklumat secara percuma dan mencari maklumat padi di kawasan mereka. (Norasma et al., 2013)

Metodologi

Untuk merancang sistem kawalan perosak dan penyakit, model *waterfall* telah dipilih. Model ini dibahagikan kepada lima fasa iaitu fasa pengumpulan dan analisis keperluan, fasa reka bentuk sistem, fasa pelaksanaan dan ujian penggunaan sistem dan fasa pemeliharaan (Baasil, 2012). Model ini dipilih kerana ia ringkas, mudah difahami dan dikemaskini (Kramer, 2018). Keputusan yang akan dicapai memenuhi keperluan pengguna dan dapat dilaksanakan dalam masa yang diperuntukkan.

Reka bentuk laman sesawang GIS

Sistem reka bentuk ialah model konseptual yang mentakrifkan struktur, tingkah laku dan sistem paparan yang menarik. Rajah 1 menunjukkan reka bentuk sistem di mana ia mempunyai 3 peringkat yang terdiri daripada penyimpanan data, server dan pelanggan. Peringkat pertama ialah antara muka pengguna yang diperuntukkan di bahagian pelanggan. Proses utama sistem adalah apabila pengguna memasukkan beberapa maklumat untuk disimpan dalam sistem, dan sistem akan menyimpan maklumat tersebut ke pangkalan data.

Rajah 1 Sistem rekabentuk (Norasma, Faten &

Rhushalshafira, 2018)

Pembangunan Sistem

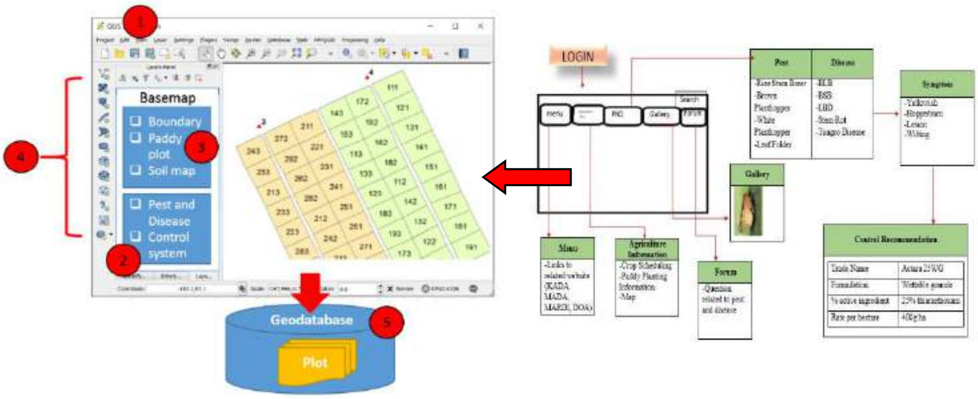
Fasa perancangan sistem adalah penting untuk memastikan pemaju mendapat gambaran awal mengenai sistem yang dicadangkan. Didalam proses membina laman sesawang yang cekap, adalah disyorkan untuk membangunkan sistem menggunakan perisian dari perisian sumber terbuka (Dodd, 2017). Perisian yang diperlukan untuk membangunkan sistem kawalan serangga perosak dan penyakit ialah Microsoft Words, Microsoft PowerPoint, Microsoft Project dan Apache Web Server. Manakala server yang diperlukan adalah Microsoft Windows Server 2012 atau CentOS Linux atau Ubuntu Server untuk bertindak sebagai sistem operasi tingkap, Apache, PHP dan MySQL. Keperluan perkakasan semasa pembangunan projek adalah Intel (R) CoreTM i5 CPU dengan seni bina Sistem Operasi 32-bit, RAM diperlukan adalah 16 GB dan penyimpanan yang diperlukan adalah 1TB.

Pengumpulan Data

Pengumpulan data dibahagikan kepada dua kategori; data spatial dan bukan spatial. Kedua-dua data itu diperolehi dari pelbagai agensi, khususnya Universiti Putra Malaysia (UPM), Jabatan Pertanian (DOA), Pihak Berkuasa Kemajuan Pertanian Kemubu (KADA), Institut Penyelidikan Beras Antarabangsa (IRRI) dan Jabatan Ukur dan Pemetaan Malaysia (JUPEM).

Hasil

Hasil akhir dari projek penyelidikan ini ialah satu rekabentuk konseptual laman sesawang berasaskan GIS untuk PND (perosak dan penyakit) berjaya dirangka. Ia disasarkan kepada petani dan semua fungsi dalam laman sesawang tersebut dapat membantu golongan petani memahami tanaman mereka. Laman sesawang ini terdiri daripada enam bahagian utama iaitu menu utama, maklumat pertanian, serangga perosak dan penyakit, galeri, forum dan kotak carian. Rajah 2 menunjukkan ilustrasi sistem kawalan PND.



Rajah 2: Rekabentuk konseptual sistem kawalan PND (Norasma, Faten & Rhushalshafira, 2018)

Laman sesawang berasaskan GIS untuk PND mempunyai maklumat mengenai serangga perosak dan serangan penyakit yang berlaku di Malaysia. Semua simptom kerosakan akibat serangan serangga perosak dan penyakit telah disenaraikan didalam laman ini. Ini membantu golongan petani membuat keputusan dan menyelesaikan masalah yang dihadapi dengan berkesan. Cadangan bagi mengatasi masalah ini diperolehi daripada KADA dan IADA Kerian. Petani perlu menekan butang PND, dan hasilnya akan menunjukkan cadangan bahan kimia untuk digunakan di lapangan. Oleh itu, petani boleh membuat keputusan berdasarkan cadangan dan boleh merancang untuk pengurusan yang lebih baik pada masa hadapan.

Jadual 2: Ringkasan rangka kerja laman sesawang berdasarkan GIS

Bil	Elemen	Keterangan
1	Aplikasi laman sesawang	Pelayaran: Chrome, Mozilla Firefox
2	Peta asas digital	Peta plot padi, siri tanah, peta jenis tanah
3	Lapisan operasi	Pertanyaan, tindihan, analisis spatial
4	Tugas dan alat di laman sesawang	Zum keluar, zum masuk, hasil analisis. penghasilan peta
5	Geodatabases	MySQL+ Server + PHP

Kesimpulan

Kajian ini berjaya membuat kajian literasi laman sesawang berdasarkan GIS sedia ada untuk PND di dalam dan luar negara. Sistem kawalan PND ini berpotensi untuk dilaksanakan berdasarkan rekabentuk konseptual yang telah dirangka. Sistem kawalannya berjaya direka untuk kegunaan golongan petani untuk mengekses maklumat mengenai tanah, hasil pengeluaran bagi setiap musim, maklumat mengenai PND serta bagaimana cara untuk mengawal PND. Penggunaan sumber terbuka dalam laman sesawang berasaskan GIS akan memberi manfaat kepada pengguna. Hal ini kerana tiada lagi laman sesawang berdasarkan GIS di Malaysia yang memfokuskan kepadan PND di sawah padi. Teknologi GIS dan aplikasi berasaskan laman sesawang masih diperingkat awal dan tidak digunakan sepenuhnya. Tidak seperti diperingkat antarabangsa, penggunaannya dalam bidang pertanian adalah meluas. Sistem ini juga bukan hanya tertumpu kepada pegawai pertanian sahaja, tetapi golongan pelajar juga boleh mengekses maklumat mengenai pengurusan PND di kawasan sawah padi di Malaysia. Walau bagaimanapun, rangka kerja ini hanya fokus kepada PND sahaja, oleh itu untuk kajian pada masa hadapan, aplikasi ini boleh diintegrasikan dengan sistem lain seperti sistem amaran awal, aplikasi ramalan hasil tanaman dan aplikasi sistem pengairan.

Penghargaan

Penulis mengucapkan ribuan terima kasih kapada Kementerian Pengajian Tinggi, Malaysia di bawah HICoE, Geran Penyelidikan Transnasional, Universiti Putra Malaysia (No Votes: 5526500) dan UPM GP-IPM (No Votes: 9611400) di atas sokongan kewangan yang diberikan.

Rujukan

ArcGIS Server. (2017). Design Concepts for Web GIS Applications. Retrieved November 8th, 2018 from https://enterprise.arcgis.com/en/server/latest/create-web-apps/windows/about-web-gis.htm

Balamurugan, M., Kalaiarasi, K., & Arun Prasad, S. (2014). Agriculture Land Information System Using Web GIS. International Journal of Innovative Research in Science, Engineering, and Technology, 13971-13976.

Bassil, Y. (2012). A Simulation Model for the Waterfall Software Development Life Cycle. International Journal of Engineering & Technology (iJET), Vol. 2 No. 5.

Dodd, R. (2017). Why More Companies are Adopting Open Source Technology. Retrieved November 12th, 2018 from https://about.gitlab.com/2017/03/03/why-choose-open-source/

Kramer, M. (2018). Best Practices in Systems Development Lifecycle: An Analyses Based on the Waterfall Model.

Kuok, T. (2015). Common Insect Pests of Rice and Their Natural Biological Control. UTAR Agriculture Science Journal, 49-59

Manzano Jr, V., Mizoguchi, M., Mitsuishi, S., & Ito, T. (2011). IT Field Monitoring in a Japanese System Rice of Intensification (J-SRI). Paddy Water Environ, 249-255.

McLaren, C., Bruskiewich, R., Portugal, A., & Cosico, A. (2005). The International Rice Information System. A Platform for Meta-Analysis of Rice Crop Data. International Rice Information System, 637-642.

MCMC. (2017). Internet Users Survey, Statistical Brief Number Twenty-One. Malaysia: Malaysian Communications and Multimedia Commission.

Norasma, C. Y. N., Faten, N. S. Z. A. and Rhushalshafira, R. (2018). Development of Conceptual Design for Web-Based GIS in Pest and Disease in Rice. International Conference on Kaizen in Management, Education, Social Science and Technology (ICMEST2018).

Norasma, C. Y. N., Shariff, A. R. M., Jahanshiri, E., Amin, M. S. M., Khairunniza-Bejo, S., & Mahmud, A. R. (2013). Web-based decision support system for paddy planting management. Pertanika Journal of Science and Technology. 21. 343-364.

Obiyini, A., & Ibrahim, A. (2015). A Web-Based Farm 3D Visualization Management System. Computer Science Systems Biology, 49-54.

Rajamoorthy, Y., Abdul Rahim, K., & Munusamy, S. (2015). Rice Industry in Malaysia: Challenges, Policies, and Implications. International Accounting and Business Conference 2015, 861-867.

Singh, A., Bansal, R., & Jha, N. (2015). Open Source Software vs Proprietary Software. International Journal of Computer Application, 26-31.

Suprato, Sari, A., Hendarto, J., Medi, & Herwanto, G. (2016). A Web-based System of Precision Farming Based Agricultural Information for Rice Farming Field Consultant in Blora Regency. International Journal of Electrical & Computer Sciences, 1-8.

Suresh Babu, D., & Santosh Kumar, K. (2016). A Web GIS BAsed Decision Support System for Agriculture Crop Monitoring System- A Case Study from Part of Medak District. Journal of Remote Sensing & GIS, 1-20.

Wee, T. (2011). Common Paddy Disease Identifier. 1-12.

Wei Bao, Y., Xuan Yu, M., & Wu, W. (2011). Design and Implementation of Database for a WebGIS-based RIce DIsease and Pest System. Procedia Environmental Sciences, 535-540.Wolfert.

Zhang, L., Dabipi, I. K., & Brown Jr, W. L. (2018). Internet of Things Applications for Agriculture. Internet of Things A to Z: Technologies and Applications, 507-528.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT08

PADI2U: Pembangunan Aplikasi Telefon Pintar untuk Pengurusan Padi di KADA Kelantan

R N Athirah [1], C Y N Norasma [1*], M R Ismail[2,3], F Azali[2] dan M H Omar[2]
[1]Jabatan Teknologi Pertanian, Fakulti Pertanian, Universiti Putra Malaysia, 43000 Serdang, Selangor
[2]Institut Pertanian Tropika dan Sekuriti Makanan (ITAFoS), Universiti Putra, Malaysia
[3]Jabatan Sains Tanaman, Fakulti Pertanian, Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia
*****Corresponding author Tel: +603-89474962 Email: niknorasma@upm.edu.my

Abstrak
Teknologi dalam pertanian telah menunjukkan potensi yang tinggi untuk menambahbaik dalam pengurusan pertanian. Hal ini selaras dengan tema revolusi industri 4.0 (I.R 4.0) yang sedang hangat dibentangkan di seluruh dunia, terutamanya negara kita, Malaysia. Kesedaran ini telah menarik perhatian para penyelidik untuk membangunkan teknologi kepada petani untuk memudahkan rutin harian mereka dan juga untuk mengurangkan kos pekerja dan meningkatkan pengeluaran hasil. Telefon pintar merupakan salah satu teknologi yang berguna dalam bidang pertanian kerana mudah untuk dibawa dan harganya juga berpatutan kepada pembeli. Telefon pintar membantu pengguna untuk mencari lokasi dan mengakses maklumat serta merakam gambar dan video. Justeru itu, kajian ini menyatukan kesemua fungsi ini untuk menghasilkan satu aplikasi telefon pintar yang bertujuan untuk menyalurkan maklumat tentang tanaman dan pengurusan ladang yang efektif kepada petani. Padi2U ialah aplikasi telefon mudah alih yang dibangunkan untuk membantu petani di KADA (Kelantan) bagi menguruskan sawah padi mereka. Aplikasi ini dibina menggunakan Master App Builder yang merupakan laman sesawang untuk menghasilkan aplikasi. Aplikasi ini mengandungi maklumat seperti variati PadiU Putra, maklumat lokasi kajian, rawatan yang digunakan di sawah padi, maklumat cuaca, pengurusan perosak dan penyakit, penggunaan baja dan imej multispektral dari awal penanaman sehingga penuaian hasil padi. Semua maklumat ini akan diterangkan dalam Bahasa Melayu yang mudah difahami oleh pengguna. Hasil akhir projek ini ialah pembangunan aplikasi telefon pintar yang berguna untuk pemantauan tanaman dan memperbaiki pengurusan yang sedia ada. Cara ini boleh diaplikasikan untuk tanaman yang lain juga seperti kelapa sawit dan getah. Aplikasi ini boleh dimuat turun melalui Google Playstore secara percuma pada masa hadapan.

Keyword: Teknologi pertanian, Aplikasi Telefon, Padi, Telefon Pintar

Pengenalan

Teknologi maklumat dan komunikasi telah menyediakan informasi tentang pelbagai bidang yang boleh diakses dan dimuat turun ke dalam alat telekomunikasi seperti komputer dan telefon mudah alih (Sibjan et al., 2014). Di dalam bidang pertanian, teknologi maklumat dan komunikasi merupakan bidang yang baru memfokuskan tentang pembangunan pertanian dan para petani boleh mengakses maklumat tersebut dengan mudah (Patel et al., 2016). Pada masa kini, aktiviti harian sangat bergantung kepada telefon mudah alih atau lebih dikenali sebagai telefon pintar berbanding tahun-tahun sebelum ini dimana telefon pintar belum dicipta. Telefon pintar kini boleh didapati di mana-mana kedai termasuklah di kawasan luar bandar (Patel et al., 2016). Telefon pintar merupakan teknologi terkini yang boleh digunakan oleh petani dan harganya juga berpatutan dan sekaligus membantu pengguna untuk mendapatkan maklumat secara maya (Patel et al, 2016). Telefon pintar yang boleh didapati dengan harga berpatutan serta lengkap dengan pelbagai sensor menjadikan ia satu peluang untuk para petani yang berada di luar bandar untuk mendapatkan maklumat terkini berkaitan pertanian (Pongnumkul et al., 2015). Manakala bagi petani berskala besar, mereka menggunakan teknologi ini untuk meningkatkan hasil pertanian mereka dan pengurusan tanaman yang lebih cekap dan efektif (Pongnumkul et al., 2015). Pada zaman sekarang, teknologi bergerak pantas sekali. Pemaju aplikasi telefon pintar perlu menghasilkan aplikasi yang seiring dengan kemajuan semasa untuk memenuhi permintaan pengguna dalam carian maklumat. Padi merupakan sumber utama negara tetapi mengalami masalah dari segi pengeluaran hasil berikutan beberapa faktor (Sasaki & Ashikari, 2018).Antaranya seperti kurangnya tahap pengurusan penyakit dan perosak padi, aktiviti kawalan penyakit dan perosak dilakukan lambat apabila padi sudah diserang penyakit dan perosak dan kurangnya tahap kecekapan dalam pengurusan tanaman padi (Sasaki & Ashikari, 2018). Selain itu, tiada sistem interaktif antara petani dan pegawai pertanian untuk mereka melaporkan sebarang masalah yang berlaku di sawah atau untuk mendapatkan sebarang maklumat berkaitan tanaman mereka. Jika tiada kawalan yang dijalankan, serangan penyakit dan perosak akan menjadi lebih teruk dan menjejaskan hasil tanaman. Jadi, teknologi aplikasi telefon pintar dihasilkan untuk mengurangkan masalah yang berlaku pada tanaman dan memudahkan para petani. Padi2U ialah aplikasi telefon pintar yang dicipta untuk petani dan pegawai pertanian untuk menyalurkan maklumat yang mudah untuk diperolehi melalui telefon pintar (Rajah 1). Aplikasi telefon pintar merupakan teknologi yang terbaik untuk meningkatkan hasil padi (Patel et al., 2016). Aplikasi ini mesra pengguna berbanding dengan laman sesawang yang dilayari melalui komputer atau di telefon pintar. Aplikasi telefon pintar menghasilkan tindakbalas segera dan cepat yang memberi kepuasan kepada para pengguna berbanding laman sesawang yang dilayari menerusi telefon kerana ia tidak akan memberikan tindakbalas segera malah ada sesetengah laman sesawang tidak serasi dengan telefon mudah alih. Objektif penyelidikan ini unuk menghasilkan aplikasi telefon pintar untuk pengguna mendapatkan maklumat yang cepat dan terkini secara efektif. Kandungan yang terdapat di dalam aplikasi ini seperti aktiviti penanaman padi, maklumat perosak dan penyakit dan imej multispektral yang merangkumi seluruh petak sawah dan maklumat kesihatan tanaman. Index tumbuhan digunakan untuk memantau tahap kesihatan tanaman. Pemerhatian telah bermula dari penanaman biji benih padi sehingga peringkat penuaian.

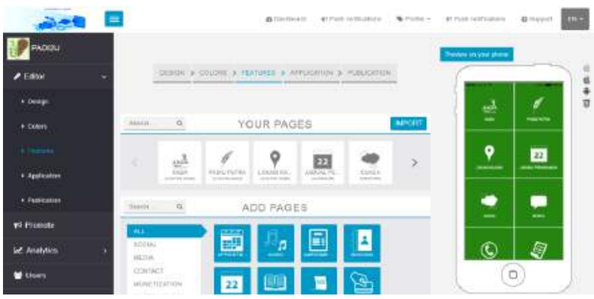
Rajah 1: Logo aplikasi Padi2U (Roslin et al, 2018)

Bahan dan Kaedah

Kaedah pembangunan aplikasi telefon pintar ini mengandungi empat peringkat (Jadual 1). Aplikasi telefon pintar ini dibina menggunakan perisian pembangunan aplikasi telefon yang dikenali sebagai *Master Apps Builder* (Rajah 2). *Graphical User Interface* (GUI) akan menunjukkan kandungan menu yang terdapat di dalam aplikasi telefon pintar ini. Antara kandungan yang terdapat dalam aplikasi ini ialah maklumat berkaitan Lembaga Kemajuan Pertanian Kemubu (KADA), maklumat PadiU Putra, maklumat lokasi sawah padi, cuaca, senarai penyakit dan perosak padi, kaedah kawalan, pembajaan, senarai pembekal alat-alat pertanian dan imej-imej multispektral (Rajah 3). Penyakit dan perosak padi yang disenaraikan adalah yang paling kerap ditemui di kawasan padi di Malaysia. Imej multispektral diambil menggunakan dron dan dianalisis menggunakan index tumbuhan untuk mengenalpasti kesihatan dan masalah di kawasan padi. Bahasa Melayu digunakan kerana mempertimbangkan majoriti latar belakang pengguna yang terdiri daripada petani yang menggunkan Bahasa Melayu sebagai bahasa untuk berkomunikasi. Selain itu, para petani boleh memuatnaik gambar atau aduan kepada pegawai pertanian mengenai masalah yang dihadapi di sawah melalui aplikasi ini.

Jadual 1: Peringkat pembangunan aplikasi telefon pintar (Padi2U).

Peringkat	Aktiviti
Peringkat Awal **Rekabentuk**	- Mengenalpasti masalah - Menentukan tujuan dan objektif kajian
Peringkat Rekabentu	- Membina seni bina sistem aplikasi telefon pintar
Peringkat Pembangunan	- Pengumpulan data - Proses pemasangan - Sistem konfigurasi
Peringkat Pelaksanaan	- Penerbitan aplikasi telefon pintar kepada umum.



Rajah 2: Perisian Master App Builder (Roslin et al, 2018)

Hasil Kajian dan Perbincangan

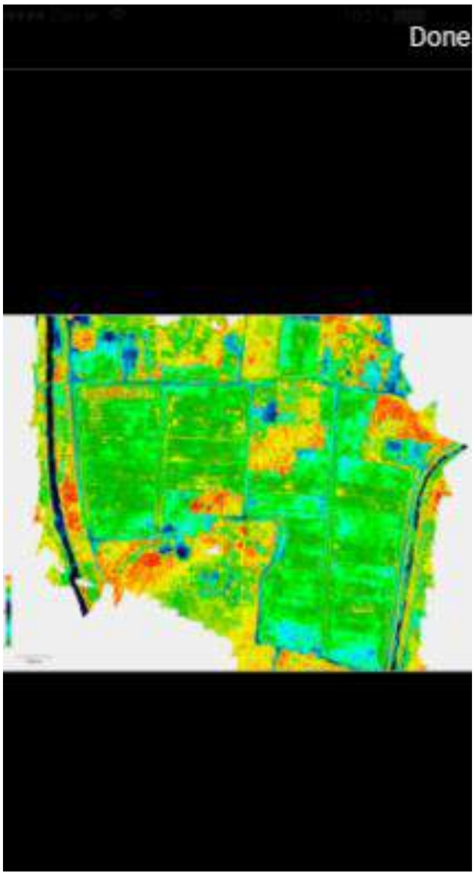
Melalui aplikasi ini, pengguna dapat memahami tentang pengurusan tanaman padi, selari dengan objektif pembangunan aplikasi telefon pintar iaitu untuk memberikan maklumat kepada pengguna khususnya para petani. Petani dapat mengenalpasti simptom-simptom penyakit pada padi sebelum serangan tersebut menjadi lebih parah (Rajah 4). Hasil daripada pemantauan tersebut, petani dapat menjalankan kawalan yang segera seperti yang diterangkan di dalam aplikasi tersebut dan menyelamatkan tanaman mereka daripada serangan penyakit dan perosak tanaman padi. Selain itu, maklumat yang diperolehi membolehkan mereka untuk memperbaiki amalan pertanian yang sering dilakukan kepada amalan yang lebih tepat dan efektif. Pengguna juga dapat membezakan variati PadiU Putra ini berbanding variati yang digunakan sekarang tentang kelebihan dan manfaat yang petani perolehi daripada teknologi variati baru yang dihasilkan ini. PadiU Putra merupakan variati yang tahan penyakit karah, banjir dan mendatangkan hasil yang banyak berbanding variati yang lain (Norasma et al, 2018). Berbanding aplikasi telefon pintar yang sedia ada sekarang, Padi2U mempunyai kelebihannya yang tersendiri, dimana imej multispektral turut terdapat di dalam aplikasi ini. Imej multispektral menunjukkan pertumbuhan tanaman untuk satu musim penanaman padi (Rajah 5). Melalui imej multispektral ini, segala masalah yang dihadapi di sawah dapat dikenalpasti dan penyelesaian masalah dapat dibuat dengan segera supaya masalah tanaman tidak belarutan. Imej yang dihasilkan dikumpul daripada awal penanaman padi sehingga padi dituai. Jadi, melalui imej-imej ini, perancangan awal dapat dibuat seperti perbandingan proses pertumbuhan padi pada awal penanaman sehingga dituai.

Rajah 3: GUI untuk aplikasi telefon pintar (Roslin et al, 2018).

Kesimpulan

Aplikasi telefon pintar ini adalah teknologi baru yang dapat membantu pengguna untuk mendapatkan maklumat dan menggunakan maklumat tersebut untuk memperbaiki pengurusan yang sedia ada pada masa hadapan dengan lebih baik dan efektif. Pada masa kini, hampir kesemua petani memiliki telefon pintar dan ia digunakan untuk pelbagai tujuan seperti untuk berkomunikasi, hiburan dan mencari maklumat. Teknologi aplikasi telefon pintar dalam bidang pertanian akan memberi harapan yang cerah untuk membantu para petani dan pegawai pengembangan pertanian untuk mempelajari mengenai tanaman mereka dari pelbagai aspek seperti mengenalpasti simptom-simptom penyakit dan serangan perosak, kawalan penyakit dan perosak, teknik kawalan, pembajaan dan kesihatan pokok di hujung jari. Imej multispektral yang dipaparkan melalui aplikasi telefon pintar ini memdedahkan kepada pengguna tentang imej udara yang membolehkan maklumat kesihatan pokok dan maklumat kawasan padi dikenalpasti. Jadi, aplikasi telefon pintar ini berguna untuk petani dan pegawai pertanian dalam memudahkan pengurusan tanaman. Pada masa akan datang, tidak mustahil jika teknologi dalam bidang pertanian akan menjadi lebih canggih berbanding masa kini dan tidak lagi memerlukan tenaga manusia untuk berkerja di ladang. Ia selaras dengan tema resolusi industri 4.0 (I.R 4.0) Malaysia yang kian diperkatakan pada masa ini. Di harap teknologi ini akan dapat membantu menaikan taraf negara kearah I.R 4.0.

Rajah 4: Senarai penyakit padi (Roslin et al, 2018).



Rajah 5. Imej multispektral dalam aplikasi Padi2U. (Roslin et al, 2018)

Rujukan

Norasma, C. Y. N., Sari, M. A., Fadzilah, M. A., Ismail, M. R., Omar, M. H., Zulkarami, B., ... & Tarmidi, Z. (2018, June). Rice crop monitoring using multirotor UAV and RGB digital camera at early stage of growth. In *IOP Conference Series: Earth and Environmental Science* (Vol. 169, No. 1, p. 012095). IOP Publishing.

Patel, H., & Patel, D. (2016). Survey of android apps for agriculture sector. charusat. net/NCSCA2016/NCSCA-2016_Conference-proceeding.

Pongnumkul, S., Chaovalit, P., & Surasvadi, N. (2015). Applications of smartphone-based sensors in agriculture: a systematic review of research. Journal of Sensors, 2015.

Roslin, A., Norasma, C. Y. N., Ismail, M. R., Azali, F. & Gani, S. S. A (2018). Padi2U: Mobile Application Development for Paddy Management in KADA Kelantan Joint Symposium Of The 8th International Agriculture Congress 2018 And 6 Th International Symposium For Food And Agriculture 2018 Conference Proceeding.

Sasaki, T., & Ashikari, M. (Eds.). (2018). Rice Genomics, Genetics and Breeding. Springer

Sibjan, C., Abinash, J., Sailendra, D., Ghimire, A. P., Joshi, D. R., & Abhishek, K. (2014). Information communication technology (ICT) for agriculture. In Food Science and Technology for Agro-entrepreneurship Development. 7th National Conference of Food Science & Technology (Food Conference-2014), 13-14 June 2014, Kathmandu, Nepal (pp. 86-90). Nepal Food Scientists and Technologists Association (NEFOSTA).

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-AIT09

Pengukuran Klorofil Daun Padi menggunakan indeks tumbuhan spektrum dari imej multispektral

Ang, Y.[1], Nik Norasma, C. Y.[2], Nor Athirah, R.[2], Mohd Razi, I.[3], Zulkarami, B.[3], Fadzilah, M. A.[3]

[1]*Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Selangor, Malaysia.*
[2]*Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Selangor, Malaysia*
[3]*Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, 43400 UPM Serdang*
Email: niknorasma@upm.edu.my; vincentangkhun@gmail.com

Abstrak

Pertanian persis (PA) adalah satu teknik penanaman untuk meningkatkan pengeluaran dan mengurangkan input bagi mengekalkan permintaan makanan di dunia. Kenderaan udara tanpa pemandu (UAV) atau lebih dikenali sebagai dron adalah salah satu alat yang digunakan dalam pemantauan tanaman untuk pertanian persis. Dron atau UAV adalah komponen penting dalam konsep PA untuk pengumpulan imej di lapangan. Kaedah tradisional, seperti penerokaan tanaman atau tinjauan lapangan, tidak berkesan dalam mengenal pasti status nutrien dan keadaan tanaman. Penggunaan teknologi seperti teknologi UAV dalam PA, akan membantu untuk membuat cerapan dan menilai tahap kesihatan tanaman secara cepat dan mudah. Objektif kajian ini adalah mengkaji nilai NDVI dan NDRE yang menggunakan aerial imej dan analisis imej objek (OBIA) serta mengesahkan indeks vegetatif (NDVI dan NDRE) dalam peta padi dengan menggunakan data klorofil dari SPAD meter.Keputusan menunjukkan NDVI ($R2 = 0.91$) dan NDRE ($R2 = 0.95$) yang menggunakan aerial imej dan analisis imej objek (OBIA) memberi korelasi linear positif dengan pembacaan SPAD. Hasil daripada projek ini, kami mendapati bahawa UAV berpotensi membantu pemantauan padi di lapangan.

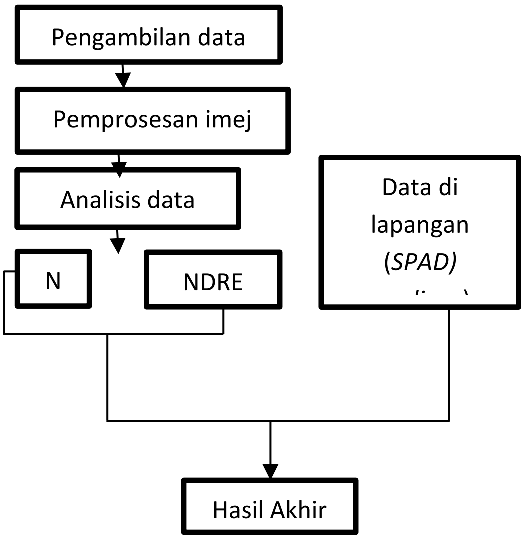
Kata kunci: Pertanian persis, Dron, Kenderaan Udara tanpa pemandu, tanaman padi, pernilaian tanaman.

Pengenalan

Pemantauan dan penilaian tanaman merupakan isu yang penting dalam tanaman pertanian. Pemantauan tanaman yang tepat boleh memberi rawatan awal kepada tanaman, akhirnya dapat mengekalkan jumlah pengeluaran hasil pertanian. Selain itu, pemantauan dan penilaian tanaman bergantung pada kaji selidik lapangan berasaskan sampel tanah yang mahal dan tidak cekap dalam pengawasan tanaman. Oleh itu, membangunkan kaedah pemantauan dan penilaian tanaman yang pesat, cekap dan tepat perlu di lakukan untuk mengatasi masalah ini. Teknologi penderiaan jauh (RS) adalah penyelesaian yang berkesan untuk mengkaji kuantiti biomas, indeks keluasan daun (LAI), dan kandungan klorofil (Fu et al., 2014). Dalam pertaniantepat, keadaan tanaman boleh dipantau berdasarkan parameter tanaman. Penderiaan jauh adalah salah satu teknologi yang bercirikan seni dan sains untuk mendapatkan dan menafsirkan maklumat tanpa sentuhan fizikal (Oza et al., 2008). Penderiaan jauh biasanya menggunakan penderia untuk mencapai pemerhatian udara, satelit dan kapal angkasa permukaan dan objek yang disasarkan. Umumnya, imej satelit telah digunakan sebagai sumber utama maklumat untuk menganalisis kesihatan tanaman dalam pertanian. Walau bagaimanapun, penderiaan jarak jauh dan satelit mempunyai kelemahan mereka sendiri. Berbanding dengan platform UAV, UAV boleh dikenalpasti sebagai penyelesaian baru untuk pengurusan dan pemantauan tanaman (Shamshiri et al., 2017). Salah satu cabaran menggunakan satelit adalah isu penutupan awan, yang akan menyebabkan resolusi imej yang tidak tepat (Valente et al., 2011). Tambahan pula, resolusi imej temporal adalah terbatas disebabkan harga yang mahal untuk memperolehi data tertentu. Kebelakangan ini, banyak indeks spektral telah digunakan untuk menganggarkan status kesihatan tanaman. Indeks yang paling popular ialah *normalized vegetative difference indeks* (NDVI). Imageri dari UAV boleh menggunakan penderia yang pelbagai seperti RGB, multispektral. Ia juga digunakan untuk mengukur kandungan klorofil dan indeks keluasan daun (LAI) (Verger et al., 2014). Sankaran et al. 2015 menggunakan penderia multispektral untuk menilai kadar kelangsungan hidup dan musim bunga gandum dengan menggunakan UAV dan indeks tumbuhan. Oleh itu, adalah penting untuk mengkaji kesihatan tanaman berdasarkan beberapa parameter seperti kandungan klorofil, nitrogen, LAI, biomas menggunakan pelbagai indeks tumbuhan. Dua jenis indeks tumbuhan seperti NDVI dan *Normalized Difference Red Edge* (NDRE) banyak digunakan dalam pemantauan tanaman menggunakan UAV. NDRE adalah indeks yang berasaskan *Red-Edge band* yang mampu menembusi lebih jauh ke kanopi dan daun tanaman daripada cahaya yang kelihatan (terutamanya radiasi biru dan merah) kerana klorofil yang lebih rendah penyerapan di rantau *Red-Edge* (Nguy-Robertson et al, 2012). Objektif kajian ini adalah mengkaji nilai NDVI dan NDRE yang menggunakan aerial imej dan analisis imej objek (OBIA) serta mengesahkan indeks vegetatif (NDVI / NDRE) dalam peta padi dengan menggunakan data klorofil dari SPAD meter.

Kaedah dan bahan

Kajian ini di jalankan di Ladang Merdeka, Ketereh, Kelantan yang terletak di pantai timur. Jumlah keluasan sawah adalah 20 ekar. Variati PadiU Putra dipilih untuk kajian ini. Ia merupakan variati padi yang di cipta oleh penyelidik UPM yang berfokuskan untuk menentang penyakit karah (S1) (UPM, 2016). PadiU Putra di tanam pada 30 Januari 2018.



Rajah 1: Metodologi yang digunakan dalam kajian ini.

Pengambilaan data

I. Pengumpulan sampel daun

Bacaan klorofil dari 5 sampel daun telah diambil dengan menggunakan alat SPAD untuk 8 point yang berbeza. 5 sampel tersebut merakam bacaan klorofil. Setiap sampel telah direkodkan dan dipurata untuk mendapatkan hasil yang terbaik.

II. Pemerolehan imej

Bagi pemerolehan imej, kamera RGB dan kamera multispektral (Parrot Sequoia) digunakan dalam penerbangan dron. Sebelum penerbangan, laluan penerbangan perlu di rangka dengan menggunakan perisian Mission Planner (http://ardupilot.org/planner/index.html). Parrot Sequoia mampu merakam 4 jenis *wavebands* yang merangkumi band hijau, band merah, band *Red-Edge*, dan *Near Infrared* (NIR). Pengumpulan data dilakukan pada waktu pagi di bawah awan yang jelas dan keadaan kelajuan angin rendah antara 08:30 pagi hingga 12:00 tengahari pada waktu tempatan pada 10 Februari 2018 pada Hari Ke-11 Selepas Penanaman (DAP). Untuk pemprosesan imej, perisian Agisoft Photoscan (http://www.agisoft.com/) digunakan. Ia menggunakan algoritma Struktur dari Motion (SfM) untuk membuat mosaik imej.

Jadual 1: Parameter asas untuk multispectral yang di gunakan pada UAV

Sensor	Spektrum bands (nm)	Resolusi (pixels)	Berat (g)
Parrot Sequoia	530, 640, 730, 770	1280× 960	107

Pemprosesan imej

Pra-pemprosesan imej mentah dimuat turun dari kad memori SD ke komputer dan ia diproses dengan lebih lanjut dalam perisian Agisoft Photoscan Professional. Imej mosaik akan dihasilkan melalui Agisoft photoscan Professional.

Analisis data

I. Perumusan indeks tumbuhan

Dua jenis indeks tumbuhan telah digunakan untuk memantau keadaan tanaman di sawah. Indeks NDVI dan NDRE dipilih untuk imej multispektral. Kemudian, nilai NDVI dan NDRE akan dianalisis dengan lebih lanjut menggunakan perisian eCognition.

Jadual 2: Indeks tumbuhan yang digunakan dalam kajian ini.

Indeks Tumbuhan	***Algorithm formula***
NDVI	(NIR-RED)/(NIR+RED)
NDRE	(NIR-RED EDGE)/(NIR+RED EDGE)

II. Analisis statistik antara indeks vegetatif (NDVI dan NDRE) dengan bacaan SPAD

Analisis statistik diantara NDVI dan nilai yang diperolehi daripada imej multispektral di analisis menggukana korelasi dengan sampel daun (nilai klorofil SPAD). Indeks vegetatif telah dikaji dengan regresi linear untuk membandingkan dua indeks vegetatif yang berbeza seperti NDVI dan NDRE dengan nilai klorofil dari alat SPAD. Analisis ini dijalankan dengan menggunkan perisian minitab 17 Perisian Statistik.

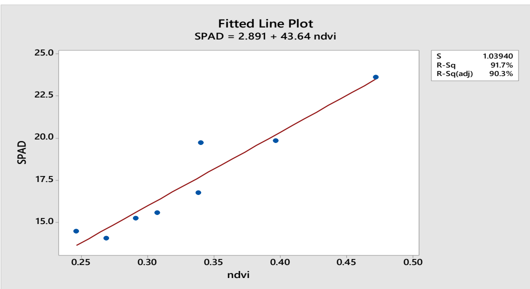
Keputusan dan perbincangan

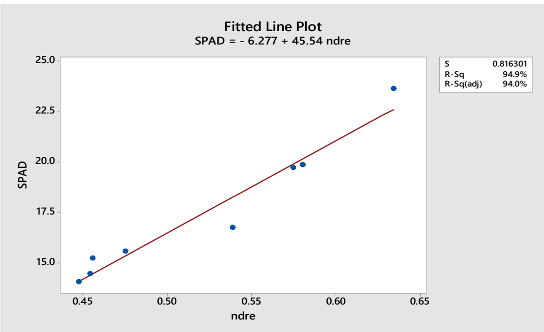
Hubungan Antara indeks tumbuhan (VI) dan bacaan klorofil SPAD

Terdapat korelasi linear positif antara pembacaan NDVI dan SPAD. NDVI menunjukkan korelasi tinggi dengan pembacaan SPAD (R^2 = 0.91). Pelbagai kajian telah dijalankan untuk menilai tanaman. Hasil daripadanya, menunjukkan terdapat hubungan linear antara indeks tumbuhan (NDVI) dengan hasil tanaman dan kandungan nutrien. Zhang et al. (2015) mencadangkan bahawa VI seperti NDVI boleh digunakan untuk mengenalpasti ciri-ciri tanaman padi. Terdapat juga korelasi linear positif antara bacaan NDRE dan SPAD. NDRE menunjukkan korelasi yang tinggi dengan pembacaan SPAD (R^2 = 0.95). Ini adalah kerana NDRE adalah indeks yang berasaskan *Red-Edge band* yang mampu menembusi lebih jauh ke kanopi dan daun tanaman daripada cahaya yang kelihatan (terutamanya radiasi biru dan merah) kerana klorofil yang lebih rendah penyerapan di rantau *Red-Edge*. Dalam erti kata lain, sensitiviti penyerapan yang berkaitan dengan kandungan klorofil tanaman jauh lebih tinggi di di kawasan *red-edge* (Nguy-Robertson et al, 2012). Kelebihan band *red-edge* adalah ciri pemantulan spektrum yang dicirikan oleh kegelapan di bahagian merah spektrum yang kelihatan, disebabkan oleh penyerapan oleh klorofil, berbeza dengan pemantulan yang tinggi dalam NIR, disebabkan cahaya yang berselerak dari pembiasan di sepanjang antara antara sel-sel daun dan ruang udara di dalam daun. Oleh itu, jalur *red-edge* boleh digunakan sebagai penanda aras untuk menentukan variasi antara ciri penyerapan dan pemantulan (Shafri et al., 2006).

Jadual 3: Korelasi antara NDVI dan NDRE dengan pembacaan klorofil

Ukuran	Indeks vegetatif	
Bacaan SPAD	NDVI	NDRE
	0.91	0.95





Rajah 2: Hubungan antara pembacaan klorofil SPAD, NDVI dan NDRE

Kesimpulan: NDRE dapat memberikan nilai indeks yang boleh menembusi kanopi dan ia lebih sesuai digunakan untuk pokok matang. Dengan kata lain ia sangat sensitif kepada klorofil dalam daun dan lebih baik jika dibandingkan dengan NDVI.

Penghargaan

Penulis mengucapkan ribuan terima kasih kapada Kementerian Pengajian Tinggi, Malaysia di bawah HICoE, Geran Penyelidikan Transnasional, Universiti Putra Malaysia (No Votes: 5526500) dan UPM GP-IPM (No Votes: 9611400) di atas sokongan kewangan yang diberikan.

Rujukan

Oza, S.R., S. Panigrahy and J.S. Parihar, 2008. Concurrent use of active and passive microwave remote sensing data for monitoring of rice crop. Int. J. Applied Earth Obst. Geoinform., 10: 296-304. DOI: 10.1016/j.jag.2007.12.002

Nguy-Robertson, A., Gitelson, A., Peng, Y., Vina, ˜ A., Arkebauer, T., Rundquist, D., 2012. Green leaf area index estimation in maize and soybean: combining vegetation indices to achieve maximal sensitivity. Agron. J. 104, 1336–1347.

Sankaran, S., Khot, L.R., Carter, A.H., Espinoza, C.Z., Jarolmasjed, S., Sathuvalli, V.R., Vandemark, G.J., Miklase, P.N., Carterf, A.H., Pumphrey, M.O., Knowles, N.R., et al., 2015. Lowaltitude, high resolution aerial imaging system for row and field crop phenotyping: a review. Eur.J.Agron. 70, 112-113

Shamshiri, R., Mahadi, M. R., Ahmad, D., Bejo, S. K., Aziz, A., Ishak, W.,Man, H. C. (2017). Controller Design for an Osprey Drone to Support Precision Agriculture Research in Oil Palm Plantations Written for presentation at the 2017 ASABE Annual International Meeting Sponsored by ASABE, (1700014), 2–13.

Shafri, H.Z.M., Salleh, M.A.M., & Ghiyamat, A., 2006. Hyperspectral remote sensing of vegetation using red edge position techniques. American Journal of Applied Science, 3(6), 1864-1871.

Valente João,sanz David, Barrientos Antonio, Cerro Jaime del, Ribeiro Ángela, Rossi Claudio,(2011). An Air-Ground Wireless sensor Network for Crop Monitoring, sensors 11, 6088-6108

Verger, A., N., Vigneau, Corentin Chéron, Jean-Marc Gilliot, Alexis Comar, Frédéric Baret, 2014 Green area index from an unmanned aerial system over wheat and rapeseed crops, In Remote Sensing of Environment, Volume 152,654-664

Zhang, G., Xiao, X., Dong, J., Kou, W., Jin, C., Qin, Y., Biradar, C. (2015). Mapping paddy rice planting areas through time series analysis of MODIS land surface temperature and vegetation index data. *ISPRS Journal of Photogrammetry and Remote Sensing*, *106*, 157–171. https://doi.org/10.1016/j.isprsjprs.2015.05.011

Inovasi Teknologi PadiUPutra. (2016). *Retrieved from* http://www.upm.edu.my/artikel/inovasi_teknologi_padiu_putra-33057?L=bm

Social Innovation for Community Building through Technology Simplification

Anas, M. M.*
Department of Biological and Agricultural Engineering
Faculty of Engineering, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia
**Corresponding Author, Tel: +03 89464442, E-mail: anas_mustafah@upm.edu.my*

Abstract

Social Innovation is a concept of promoting social development of a community through the introduction of innovation to promote the community to change for the better. The innovation here can be technological, economic, social or combinations of these that aims to improve the community standard of living. One way to start a social innovation is by understanding the problems of the community through experiential learning. A Social Innovation through Team Entrepreneurial Learning (SITEL) workshop was held in Kota Kinabalu, Sabah in June 2018 where one project focuses on stingless bee community in Kg. Mitabang, Kiulu. Through experiential learning of living, discussing and befriending the community, a project was born to help the community to improve their stingless bee honey production by the introduction of homemade stingless bee honey pump. The technology simplification uses items obtainable from local hardware store and aquarium shop to build the pump that could be self-made and self-maintained by the community through a training video. The feedback from the community was positive after the initial introduction of the pump where they are reporting honey production every two weeks compared to months prior to using the pumps.

Keywords: Social Innovation, Stingless Bee, Kelulut, Honey Pump, Rural Community

Introduction

Social Innovation is a concept of promoting social development of a community through the introduction of innovation to promote the community to change for the better. The innovation here can be technological, economic, social or combinations of these that aims to improve the community standard of living. One way to start a social innovation is by understanding the problems of the community through experiential learning. The White House, under Barack Obama administration had setup an Office of Social Innovation and Civic Participation to increase focus on social innovation in the United States (Christensen, Kirsch, & Syman, 2009).

In Europe, Social Innovation will gain more importance in the context of Europe2020 strategy as new innovation paradigm is established (Howaldt & Schwarz, 2010).

A Social Innovation through Team Entrepreneurial Learning (SITEL) workshop was held in Kota Kinabalu, Sabah in June 2018 where one project focuses on stingless bee community in Kg. Mitabang, Kiulu. Through experiential learning of living, discussing and befriending the community, a project was born to help the community to improve their stingless bee honey production by the introduction of homemade stingless bee honey pump.

In Malaysia, stingless bees (kelulut) farming are being developed locally for their commercial, environmental, educational and eco-tourism values. This make stingless bee farming as a new and potential booming agro-industry in Malaysia. Nowadays, many agrotourism has stingless beehive to attract tourist offering agro experience due to the harmless nature of the stingless bee. According to Malaysian Agricultural Research and Development Institute (MARDI), there was a huge export market for the honey and it has been labeled as a *superfood* (Abdul Rashid, 2016).

Jabatan Pertanian Sabah is actively promoting stingless to farmers in Sabah (Razan, 2017). During the Social Innovation through Entrepreneurial Learning (SITEL) workshop held in Kota Kinabalu in 2018, the author visited Kg Mitabang in Kiulu, Sabah. The farmers were mostly farming for self-sustenance with the major source of income coming from rubber. During the decline in rubber prices, life was not so good. However, they also had been introduced to the stingless bee farming which could help them to generate additional income.

However, their honey production was not much due to their harvesting method which still requires them to break apart the hive and pour the honey into a bucket. This is not the best practice for harvesting the honey since the practices retards the production and it delays the next harvesting to more than a month.

The current best practice is by using a honey pump. By using pumps, only a small cut is made to each honey pods to put in the suction pipe for harvesting the honey. Two sample pumps were provided to the community after the SITEL workshop. With the introduction of honey pump, the farmers could expect a harvesting cycle every 2 weeks. This had increased their productivity more than consumption and the stingless bee farming could be their new source of income.

The pumps that were provided to the farmers were homemade with materials obtainable from local hardware and aquarium shops. This technology simplification was done to allow these farmers to do the maintenance themselves in case of breakdown.

By using locally source materials self-maintenance is possible and hopefully it would also allow them to build their own pumps in the future to create a sustainable economic ecosystem in Sabah stingless bee farming.

Materials and methods

Pump design

The pump was designed following the basic concept of suction pumps similar to a milking machine. It is a straightforward operation pump and the parts to build the pump can be obtained from the local hardware store and aquarium shops.

The pump is mainly divided to two sections which is the power section and suction section. In the power section, a battery powers two pumps to generate suction. This creates a vacuum which allows the suction section to draw the honey from the honey pods.

The pump was designed to be kept in a waist pouch to allow a single hand operation for the pump. The pump box and the battery were placed inside the waist pouch. The container to collect the honey was set to hang on the waist pouch strap. With this arrangement, the user will only need to hold one suction nozzle to operate the pump. However, this proposed arrangement is a suggestion and is optional and may vary according to user preferences.

Parts

The pumps parts are listed as below:

1. 5V motor (2 units)
2. 4mm inner diameter silicone tube
3. 1L bottle (preferred size)
4. 4mm tee tube fitting
5. 4mm straight tube fitting (2 units)
6. Micro-USB charger cable
7. 3” switch box
8. 3” 1 gang 1 connector switch
9. 10000mAh powerbank

The pump was designed to run on powerbank supplying 5V to power the motors. The design choice here considers that other rechargeable battery types may require a specific charger cable which can be a challenge to find in case of fault. A powerbank utilizes a standard micro-usb cable that is used by an android phone. Hence, this makes it easier to obtain and may even be available in most household.

The two 5V motors used here had the outlet size of 4mm which leads to the choice of 4mm inner diameter tubing for the pump. Silicone or PVC tubing can be used for the pump. The pump had been built with both types of tubing and the difference is only on flexibility of the tubes. This choice will be left to user preference and ease of finding a suitable tube.

A 1-liter bottle was the preferred size based on feedback from user. A smaller bottle requires emptying more often and a bigger bottle is too heavy and is not recommended. The bottle must be hard walled and airtight to obtain the vacuum necessary for pump operations.

In the initial design phase, the pump casing was designed, and 3D printed. However, to suit the aim towards sustainability, a simpler casing was chosen. The 3” switch box and 3” switch was made to be the pump casing. They were sufficient in size to fit the two 5V pumps and the switch also act as the on/off button for the pump. They are easily obtainable, and the assembly is very simple.

Equipment and assembly

A list of major equipment required is as below:

1. Silicone glue
2. Soldering iron
3. Mini drill

The listed equipment above are essential but can be replaced with other suitable materials.

The silicone glue was used to seal the bottle-tube connection to have an airtight connection. The bottle-tube connection can be made by simply drilling a hole on the bottle and sticking the tube to the bottle using silicone glue. Another option is by using a straight connector which will allow tube change whenever necessary without compromising the vacuum of the bottle during operations. However, this is optional based on available materials that can be obtained by the local farmers. The completed pump is shown in Figure I.

Figure I. The completed homemade stingless bee pumps showing six pump boxes and three storage bottles.

Results and discussion

The Pump

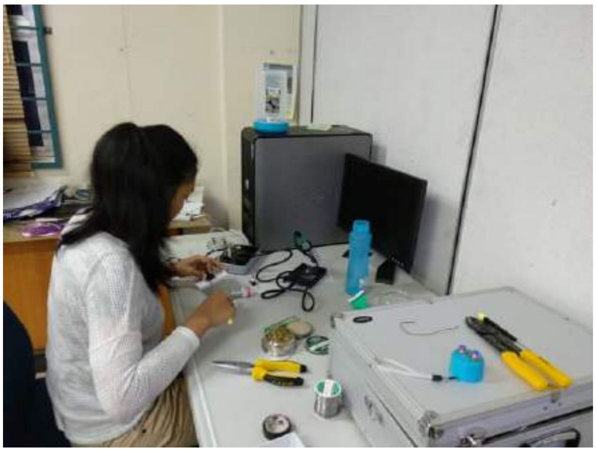
The pump was initially designed to be fitted into a waist pouch bag to allow single hand operations.

This arrangement had positive feedback from farmers in Kg Mitabang. However, a further test and feedback from a farmer in Lenggeng, Negeri Sembilan suggested that the pump be stored in a small bucket instead. The bucket is then to be hang near the stingless bee hive via a nail or screw. This will still allow single hand operations during harvesting but does not restrict movement due to waist pouch. This suggestion in changes in the final arrangements is welcome as it should be decided based on comfort and preference of the users themselves. Another suggested option was using backpack. With backpack, an additional modification to the pump to allow capacity monitoring is required as the storage bottles are situated at the back. A simple level tube installed at maximum capacity of the storage bottle is proposed. Two pumps had been mailed to the Kg Mitabang farmers for testing. The pumps had good feedback and more pumps are requested by the farmers from Kg Mitabang and the neighboring village. Figure II shows a farmer in Kg Mitabang harvesting the stingless bee honey by using the pump. Additional feedback from the farmer confirms the benefit of using pumps which increases his honey production. Currently the farmer can harvest every two weeks compared to more than a month between harvest previously.

Figure II. A farmer in Kg Mitabang using the homemade pump to harvest the stingless bee honey

The simplicity of building the pump was shown during an event, Global I-lead Stem Camp (GISC) and International STEM Olympiad (Istemo) 2018 held in December 2018. During the event, a 16 years old student took up the project of building additional pumps to be delivered to the Kg Mitabang community. During the event, she managed to complete six pumps within a day with additional day of setting up the storage bottles. Figure III shows the pump being built during GISC and Istemo 2018. This shows that the pump design was simple enough to be built by a student and could later be taught to the youth in the Kg Mitabang community moving forward in the project.

Figure III. A student building the pumps during GISC and Istemo 2018 event for Kg Mitabang community



Discussion

The main idea of the pump discussed here in this paper is its simplicity. This simplicity in the pump build is required to allow self-maintenance and is a step towards self-built pump for the rural farmers. In meeting this objective, the pump was built using materials sourced from local hardware and aquarium store. Thus, the basic building material as listed above is suggested based on available material locally in Serdang, Selangor. This will change based on location, but it is not expected to diverse too much.

A step-by-step video for building the pumps is also being planned to guide the farmers in the maintenance and building their own pump in the future. Currently video during the GISC and Istemo 2018 had been recorded. Another video is being planned with undergraduate student of the Department of Biological and Agricultural Engineering, UPM after which the final editing will be done. The video is planned to be provided after the farmers are familiar with the use of the pump in regular harvesting of the stingless bee honey. It is expected that the farmers will get to familiarize themselves with the pump and its parts during usage which will assist them to understand the guided video easier.

The use of the video will reduce the travelling cost compared to teaching the farmers face to face due to monetary limitation of the current project.

Around 20 more pumps will be provided to the Kg. Mitabang community as part of this project. It is hope that the Kg. Mitabang community will in the future be self-sufficient in maintenance and building their own pumps for stingless bee honey farming.

Furthermore, this technology simplification project is hopefully able to be extended to other communities and other crops to improve rural agricultural production. It is also hoped that this project will generate interest in the rural community youth in learning new technology and innovate and renew their interest to stay and contribute to their own community rather than migrate to the city.

Conclusions

A technological simplication for the design of stingless honey bee pump was done. The design had been tested for use by farmers in Kg. Mitabang with positive feedback both on suction capability and waist pouch design to allow single handed operation. Further work on the technological simplification project on the stingless bee honey pump is to provide sustainability by providing more pumps to the community as end user and development of training video for self-maintenance and towards self-building of the pump by the rural community.

References

Abdul Rashid, N. F. (2016). Madu kelulut superfood pertama di Malaysia. *Utusan Malaysia*.

Christensen, C., Kirsch, V., & Syman, K. (2009, January 8). The White House Office on Social Innovation: A New Paradigm for Solving Social Problems. *Huffington Post*. Retrieved from https://www.huffingtonpost.com/clayton-m-christensen/the-white-house-office-on_b_223759.html

Howaldt, J., & Schwarz, M. (2010). *Studies for Innovation in a Modern Working Environment-International Monitoring*. Retrieved from www.internationalmonitoring.com

Razan, M. (2017). Kementerian Pertanian ambil langkah promosi madu kelulut peringkat antarabangsa. *New Sabah Times*.

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Preliminary Evaluation of ORYZA (v3) Crop Growth Model for MR269 Rice Variety

Faiz, M.C.H. [1], Liyana, N.Y.[1], Nurulhuda, K.[1], Muharam, F.M.[2], Zulkafli, Z.[3], Zulkarami, B.[4], Razi Ismail, M.[4]
[1]*Department of Biological and Agricultural Engineering,*
Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[2]*Department of Agriculture Technology,*
Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[3]*Department of Civil Engineering,*
Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[4]*Institute of Tropical Agriculture And Food Security (ITAFoS),*
Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
**Corresponding Authors, Tel: +603 8946 6409, E-mails: 1) k_nurulhuda@upm.edu.my ; 2) muhamadfaiz.ch@gmail.com*

Abstract

Rice (Oryza sativa) is a staple food for more than half of the world's population, including about 30 million Malaysians. Rice self-sufficiency level (SSL) in Malaysia is currently at 70% and the level does not satisfy the local demand. Therefore, rice production needs to be increased to 80% by the year 2020 (MOA, 2015). The Malaysian Government aims to increase average rice grain production from 4.5 mt/ha to 6.0 mt/ha (Ismail, 2017). Among the ways to increase the production of rice is by improving crop management, such as finding best sowing dates, and best management practices such as optimum usage of fertilizer rates and rice varieties that suit weather conditions. Simulations of crop models are alternatives to costly trial experiments in exploring opportunities for increasing agricultural system productivity. Existing rice crop growth models have not been rigorously explored to assess productivity of Malaysian rice systems. Prior to scenario studies using a rice crop growth model, performance of the model must first be evaluated. Therefore, this paper reports preliminary evaluation on the performance of a rice crop growth model called ORYZA (v3). The model was evaluated against rice crop physiological properties collected at two farmers' plots at IADA KETARA, Terengganu. The preliminary evaluation indicates that ORYZA (v3) has a potential in simulating the physiological properties of MR269, but the model must be calibrated. Calibration of the model is currently on-going.

Keywords: Crop growth model, ORYZA (v3), nitrogen,MR269, rice

Introduction

Rice is a staple food for more than half of the world's population, including about 30 million Malaysians. In 2012, about 156 million ha of rice were harvested worldwide, and about 88% and 31% of this harvested area were in Asia and South East Asia, respectively (FAO, 2013). About 95% of global rice production occurs on soil that is flooded during at least part of the rice-cropping period (Buresh et al. 2008).

In South East Asia, the highest level of rice productivity are found in irrigated rice system with 95% of rice production compared to the other system like rainfed, upland, deep water and upland rice (Mutert & Fairhurst, 2015). Optimum productivity of rice crop can be achieved by determining the best sowing dates and best management practices (Kumar et al. 2010).

A comprehensive rice crop growth model can be used to understand complex and interactive processes in rice systems and to help farmers in making decision (Svensson, 2012). Simulations of crop growth models are alternatives to costly trial experiments in exploring opportunities for increasing agricultural system productivity, assessing effects of the agricultural systems on the environment, and forecasting the effects of climate change on the production (Gaydon et al., 2017; Kumar et al., 2010).

ORYZA (v3) was the latest result from continuous improvement of ORYZA2000 by the International Rice Research Institute (IRRI) in Los Banõs, Philippines (Li et al., 2017). ORYZA (v3) has not been evaluated for Malaysian rice varieties, site conditions and agronomic practices. Prior to simulation studies using a rice crop growth model, performance of the model must first be evaluated.

Therefore, the objective of this study is to perform preliminary evaluation on the performance of ORYZA (v3) in simulating rice physiological variables.

Materials and methods

Study site description

In this study, experiments were conducted at IADA KETARA, Besut, Terengganu, Malaysia. The IADA KETARA is one of the eight granary areas that was designated under the National Agricultural Policy for double cropping paddies through the introduction of high yield varieties and irrigation facilities. The overall size of the IADA KETARA rice granary is 12,000 ha (Yasar et al. 2015).

Two plots, each with an average size 1 hectare, were selected for this study. Experiments were conducted on Plot A and Plot B from 14 July to 30 November 2017 and from 19 July to 30 November 2017, respectively. Fertilizer was applied 3 times for each plot. For Plot A, fertilizer rates for first, second and third fertilizations were 34, 45 and 21 kg N ha^{-1} respectively. For Plot B the rates were 56, 76 and 35 kg N ha^{-1}. MR269 seeds were manually broadcast on both plots. MR269 is one of the most common local varieties. These two plots were managed by their owners. A weather station was also installed at the study area. Throughout the experiment, average sunshine hour was about 12 hours day^{-1}. The cumulative rainfall was about 2089 mm from July to the end of December 2017. The ambient temperature ranged from 23 to 35˚C. The average solar radiation was about 15296 watt m^{-2} day^{-1}, and average wind speed was about 0.3 m s^{-1}.

Field sampling
Agronomic samples were collected from Plot A and Plot B. Two quadrants with an area of 0.5 m X 0.5 m, were used for crop sampling in each experimental plot. Coordinates of sampling points were taken using Trimble Juno. The samples include number of plants, green leaf biomass, dead leaf biomass, stem biomass, storage organ biomass, and leaf area index. These samples were taken at three different growth stages, i.e., vegetative stage, reproductive stage and maturity stage. The fresh samples were carefully packed and transported to the laboratory at Universiti Putra Malaysia for separation of rice crop organs. The separated rice crop organs were dried and then weighted. The total area of the green leaves was measured using a bench top leaf area meter (Li-Cor 3100C, Li-cor Inc., Lincoln, NE, USA).

Selection of a crop growth model
ORYZA (v3) crop growth and development model is a process-based model that was developed to simulate the effects of nitrogen (N), water management and weather on rice crop physiological variables (i.e., leaf area index and biomass of crop organs including rice grain production), soil water content, and soil N dynamics (Li et al., 2017). Therefore, the model was selected in this study. ORYZA (v3) is the successor of ORYZA2000 and was recently modified to include the soil N dynamics and has only been evaluated for rice varieties and field practices in the Philippines (Bouman et al. 2001; Li et al. 2017).

Assumptions for preliminary assessment of the model
For simulation, ORYZA (v3) requires inputs of soil properties, crop properties and micrometeorological data. For preliminary evaluation, the soil chemical and some of the soil physical properties were adjusted to suit the actual conditions at the study area. The crop physiological properties were not calibrated for MR269. Instead, default values were used. Information of agronomic practices such as the rates of nitrogen fertilizers, dates of sowing and irrigation schedule were based on actual agronomic practices for both experimental plots. The weather input was prepared using the actual meteorological data collected by the weather station installed at study area.

Evaluation of model performance
Simulations by ORYZA (v3) were evaluated using the measured crop physiological data, namely the biomass of green leaf, dead leaf, stem, and storage organ/panicle, and leaf area index, collected from Plots A and B. Standard deviation of the observations (SD_{obs}, Eq.(1)), root mean square error ($RMSE$, Eq.(2)), correlation analysis (r^2, Eq.(3)) and modelling efficiency index (M_{eff}) were calculated and used to evaluate the performance of ORYZA (v3) (Li et al., 2017; Yuan, Peng, & Li, 2017). The observations are represented by X$_i$, while the simulations are represented by Y$_i$. $\bar{X}$ is mean of observations and n is number of data.

$$SD_{obs} = \sqrt{\frac{\sum_{i=1}^{n}(X_i-\bar{X})^2}{n-1}} \tag{1}$$

$$RMSE = \left(\sum_{i=1}^{n}\frac{(Y_i-X_i)^2}{n}\right)^{0.5} \tag{2}$$

$$r^2 = \frac{\left[\sum_{i=1}^{n}(X_iY_i)-\sum_{i=1}^{n}X_i\sum_{i=1}^{n}Y_i\right]^2}{\left[\sum_{i=1}^{n}(X_i)^2-\left(\sum_{i=1}^{n}X_i\right)^2\right]\left[\sum_{i=1}^{n}(Y_i)^2-\left(\sum_{i=1}^{n}Y_i\right)^2\right]} \tag{3}$$

$$M_{eff} = 1.0 - \frac{\sum_{i=1}^{n}(X_i-Y_i)^2}{\sum_{i=1}^{n}(X_i-\bar{X})^2} \tag{4}$$

Typically, model performance is considered good when M_{eff} and r^2 are closer to 1.0, while $RMSE$ must be compared to the SD_{obs} (Gaydon et al., 2017; Yuan et al., 2017).

Results and discussion
ORYZA (v3) performance
Fig. 1 shows comparison of simulated and measured variables over time for Plot A and Plot B. The simulated LAI was close to fit with the measured variables for both plots. However, for other rice physiological variables, the patterns show that the simulations often under-estimated the measurements. ORYZA (v3) shows good estimation of LAI where the M_{eff} is closer to 1 for both Plot A and Plot B.
However, ORYZA (v3) shows poor estimation for the other rice physiological variables based on the values of M_{eff}. The poor results are most likely because simulations were performed using default parameter values. Therefore, the next step is to calibrate the model for RM269 and actual soil conditions. In cases of small measurements, the analysis further demonstrates that the M_{eff} is a better indicator of a model performance compared to r^2. As an example, the total aboveground biomass (*WAGT*) for Plot A, the $r^2 = 1$, but the $M_{eff} = 0.4$. Further inspection of Fig. 1c showed that the model

poorly estimated the *WAGT*, which in agreement with the M_{eff}

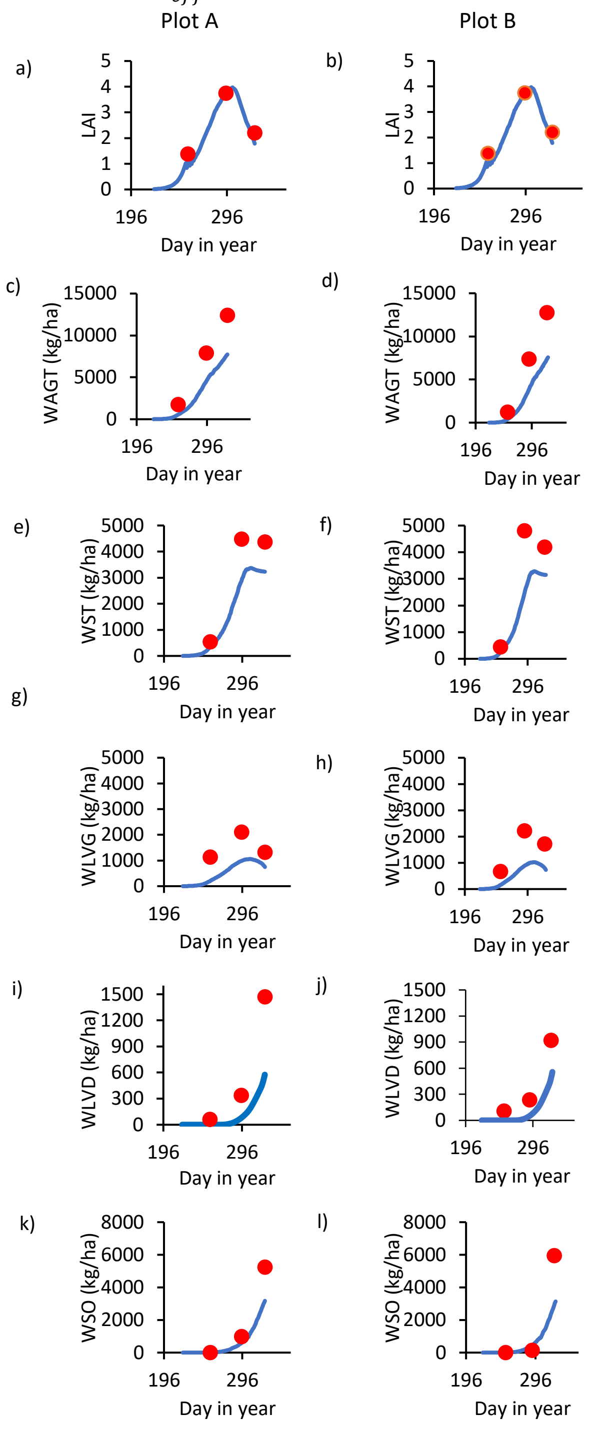


Fig. 1. Simulations (lines) and measurements (circles) of the leaf area index (LAI), total above ground biomass (WAGT), dry weight of stems (WST), dry weight of green leaves (WLVG), dry weight of dead leaves (WLVD) and dry weight of storage organs (WSO)

Table 1. Performance of ORYZA (v3) in simulating physiological variables over the entire growing season for variety MR269 for Plots A and B

Plot	Crop variables	SD_{obs}	$RMSE$	M_{eff}	r^2
A	LAI	1.2	0.3	0.9	1.0
	WAGT	5339.8*	3387.0*	0.4	1.0
	WST	2240.1*	1143.1*	0.7	1.0
	WLVG	514.1*	903.1*	-3.7	0.7
	WLVD	746.5*	537.5*	0.2	1.0
	WSO	2780.2*	1205.9*	0.7	1.0
B	LAI	1.4	0.2	1.0	1.0
	WAGT	5775.1*	3763.3*	0.4	1.0
	WST	2359.1*	1480.9*	0.4	0.9
	WLVG	788.9*	983.2*	-1.3	0.9
	WLVD	435.9*	278.3*	0.5	1.0
	WSO	3393.8*	1751.0*	0.6	1.0

* *Unit in kg ha^{-1}*

Conclusion

The preliminary evaluation suggests that ORYZA (v3) has a potential in simulating physiological variables of MR269, but the model must first be calibrated. Calibration of the model is currently on-going.

Acknowledgement

This study was funded by the Higher Institution Centre of Excellence (HICoE) Grant, Institute of Tropical Agricultural and Food Security and Geran Putra IPM (GP-IPM/2017/9583900). All authors would to thank Mr. Kas Wady Zakaria for assisting the sampling activities and the local farmers for their cooperation during experiments.

References

Bouman, B. A. ., Kropff, M. J., Tuong, T. P., M.C.S, W., & Laar, H. H. Van. (2001). *ORYZA 2000: modeling lowland rice*.

Buresh, R. J., Reddy, K. R., & Van Kessel, C. (2008). Nitrogen transformations in submerged soils. In J. S. Schepers & W. R. Raun (Eds.), *Nitrogen in Agricultural Systems* (pp. 401–436). Madison: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

FAO. (2013). Rice Market Monitor Vol. XVI.Gaydon, D. S., Balwinder-Singh, Wang, E., Poulton, P. L., Ahmad, B., Ahmed, F., … Roth, C. H. (2017). Evaluation of the APSIM model in cropping systems of Asia. *Field Crops Research*, *204*, 52–75. https://doi.org/10.1016/j.fcr.2016.12.015

Ismail, S. (2017). Industri Padi dan Beras, Memperkukuh Industri Padi dan Beras, (September).

Kumar, R. N., Sailaja, B., & Voleti, S. R. (2010). Crop Modelling with Special Reference to Rice Crop. *Agroforestry Systems*, *80*(3), 401–408. https://doi.org/10.1098/rsif.2009.0111

Li, T., Angeles, O., Marcaida, M., Manalo, E., Manalili, M. P., Radanielson, A., & Mohanty, S. (2017). From ORYZA2000 to ORYZA (v3): An improved simulation model for rice in drought and nitrogen-deficient environments. *Agricultural and Forest Meteorology*, *237–238*, 246–256. https://doi.org/10.1016/j.agrformet.2017.02.025

MOA. (2015). *Paddy Statistics of Malaysia 2014*. Retrieved from http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/perangkaan_padi_2014.pdf

Mutert, B. E., & Fairhurst, T. H. (2015). Developments in Rice Production in Southeast Asia, (April 2002).

Svensson, L. G. (2012). A Comprehensive Review of the CERES-Wheat, -Maize and -Rice Models Performance. *The Journal of Thoracic and Cardiovascular Surgery*, *136*, S11–S16. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.136.6095

Yasar, M., Siwar, C., & Firdaus, R. B. R. (2015). Assessing paddy farming sustainability in the Northern Terengganu Integrated Agricultural Development Area (IADA KETARA): A structural equation modelling approach. *Pacific Science Review B: Humanities and Social Sciences*, *1*(2), 71–75. https://doi.org/10.1016/j.psrb.2016.05.001

Yuan, S., Peng, S., & Li, T. (2017). Evaluation and application of the ORYZA rice model under different crop managements with high-yielding rice cultivars in central China. *Field Crops Research*, *212*(July), 115–125. https://doi.org/10.1016/j.fcr.2017.07.010

eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

Aktiviti Pemindahan Teknologi Melalui Testbed Teknologi MARDI

Badaruzzaman, M. N.
Pusat Penyelidikan Kejuruteraan IbuPejabat MARDI Serdang Selangor 1,
Corresponding author. Tel.: +603-89536515, Email:badar@mardi.gov.my

Abstrak
Kajian ini adalah mengenai aktiviti-aktiviti pemindahan teknologi MARDI di testbed teknologi MARDI bagi tahun 2017 dan 2018. Ia adalah sebahagian daripada aktiviti projek pembangunan RMKe 11, *pembangunan usahawan tekno moden yang kompetitif di pasaran domestik dan global* *di bawah sub projek B. Antara aktiviti pemindahan teknologi yang dikendalikan di testbed teknologi MARDI adalah latihan sangkut, perantis, demonstrasi/lawatan dan kursus. Pada tahun 2017, seramai 1352 peserta telah mendapat manafaat dari aktiviti pemindahan teknologi di testbed teknologi MARDI. Daripada jumlah ini, 575 peserta mengikuti latihan sangkut, 451 mengikuti demonstrasi/lawatan, 242 mengikuti kursus dan* dan *84 peserta mengikuti program perantis. Manakala pada tahun 2018 seramai 1,403 peserta mendapat latihan pemindahan teknologi di testbed teknologi MARDI di seluruh negara. Pada tahun 2018 seramai 478 peserta mengikuti latihan sangkut, 646 mengikuti demonstrasi/lawatan, 244 mengikuti kursus dan 35 peserta mengikuti program perantis.*

Kata penunjuk: testbed teknologi MARDI, pemindahan teknologi, latihan sangkut, perantis, kursus,demonstrasi

Pengenalan

Peranan Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI) didalam bidang penyelidikan dan seterusnya menghasilkan teknologi khususnya dalam bidang pemprosesan makanan adalah sangat penting bagi memajukan usahawan industri makanan negara kategori Industri Kecil dan Sderhana (IKS). Usahawan IKS menghadapi masalah kekurangan pengetahuan berkaitan teknologi pemprosesan makanan, penggunaan mesin, kawalan mutu produk, pembungkusan dan perlabelan yang tidak bermutu (Chua. et al. 2005).

MARDI telah membangunkan beberapa testbed di seluruh negara untuk membantu usahawan IKS mendapatkan khidmat bimbingan teknikal dan latihan *hands-on* bagi pengeluaran produk makanan menggunakan teknologi MARDI. Dengan itu usahawan IKS dapat mengeluarkan produk makanan yang berupaya untuk berkembang dan berdaya saing dipasaran dengan bantuan latihan teknologi di testbed teknologi MARDI.

Di testbed ini juga usahawan akan diberi peluang untuk mempelajari dan mencuba, serta meyakinkan diri sebelum membuat keputusan untuk melabor dalam perniagaan produk pemprosesan makanan kerana pelaburan terhadap penggunaan teknologi adalah tinggi. Usahawan dan bakal usahawan akan dapat meningkatkan pengetahuan dan kemahiran dalam menggunakan sistem dan teknologi untuk pengeluaran produk sedia ada dan produk baru untuk ujian pasaran

Sistem testbed teknologi MARDI juga menawarkan kemudahan pemprosesan dan khidmat kepakaran teknikal yang diperlukan untuk memulakan serta menguruskan proses inovasi teknologi dan perniagaan. Ini akan dapat merangsang proses inovasi teknologi di kalangan usahawan yang ingin berkembang dan berdaya saing di pasaran serta mengalakkan penglibatan usahawan dalam pengeluaran produk makanan terpilih bagi meningkatkan nilai tambahan hasil pertanian negara.

Testbed teknologi MARDI adalah makmal teknologi pemprosesan makanan yang dilengkapkan dengan mesin dan peralatan asas untuk pengeluaran berskala kecil bagi jenis produk makanan terpilih (Zainun et al. 2015). Terdapat 8 testbed teknologi MARDI yang terletak di stesen MARDI negeri yang menawarkan latihan teknikal dalam pelbagai kluster makanan. Jadual 1 ialah senarai testbed yang terdapat di MARDI.

Perkhidmatan yang ditawarkan berdasarkan kluster produk yang terdapat di setiap lokasi testbed. Pelanggan boleh memilih salah satu atau kombinasi atau keseluruhan perkhidmatan yang ditawarkan seperti Teknologi pengeluaran produk makanan terpilih, penggunaan sistem pengeluaran teknologi MARDI, pengendalian mesin dan peralatan, penggunaan bahan mentah sesuai dalam pembangunan formulasi, pembungkusan dan pelabelan, penentuan kualiti dan kawalan mutu, panduan mematuhi perundangan makanan, panduan persijilan termasuk Halal, MeSTI dan GMP, suntikan inovasi teknologi untuk pembangunan dan mempelbagaikan produk dan pengeluaran bagi tujuan ujian pasaran (Zainun.et al. 2015).

Testbed teknologi MARDI menyediakan kemudahan asas untuk menyokong program latihan MARDI dan untuk Pegawai Penyelidik MARDI menguji teknologi baharu yang dibangunkan untuk tujuan peningkatan skala, yang mana pada akhir teknologi akan digunakan oleh golongan ushawan dan golongan sasar. Selain ia digunakan sebagai *showcase* untuk mempromosikan sistem pengeluaran produk dan teknologi MARDI kepada pelawat ke testbed MARDI di seluruh negara.

Metodologi
Kaedah yang digunakan dalam memindahkan teknologi MARDI melalui testbed teknologi MARDI adalah melalui latihan yang diberikan adalah dalam bentuk *hands-on* berkaitan dengan pengeluaran produk di premis testbed berkenaan. Sistem testbed bukan hanya menawarkan latihan untuk pengeluaran produk makanan tetapi juga menawarkan khidmat kepakaran dan analisa kualiti yang diperlukan oleh usahawan untuk memulakan dan mengurus proses inovasi teknologi dan perniagaan mereka. Latihan yang terdapat di testbed ialah terdiri daripada latihan sangkut, latihan perantis, demonstrasi serta lawatan dan kursus.

Jadual 1 : Lokasi dan jenis pemprosesan di Testbed Teknologi MARDI

Lokasi	**Kumpulan produk**	**Jenis produk**
Stesen MARDI Bukit Raya, Kedah	Snek tradisional berasaskan beras	Karas,kuih ros, empeng dan rempeyek
Stesen MARDI Kuala Terengganu Terengganu	Hasilan ikan	Keropok kering, keropok lekor,sosej,sata moden,nugget dan kutlet
Stesen MARDI Pasir Puteh, Kelantan	Sos, minuman, jeruk, kuih tradisiona dan koji	Kuih baulu, akak, lemang, kuih cara, sos pencicah, sos rojak, sos tumis, jeruk buah-buahan serta sayuran, minuman dan serunding daging.
Stesen MARDI Kuching, Sarawak.	Minuman , makanan konvenien, hasilan bakeri dan hasilan ikan	Makanan dalam tin, minuman dalam tin, roti sandwic, roti ban, bebola ikan, kek ikan, jejari ikan dan keropok lekor
Stesen MARDI Kota Kinabalu, Sabah	Hasilan bakeri, hasilan ikan, minuman, snek buahan dan kuih tradisional	Roti sandwich, roti ban, pastry, bebola ikan, kek ikan , jejari ikan, keropok lekor, halwa buahan, buahan kering, kuih akak, kuih baulu dan pelbagai kuih bakar.
Stesen MARDI Cameron Highland, Pahang	Jem dan sapuan, sos dan minuman	Jem, topping, sos, minuman dan kordial strawberi
Stesen MARDI Seberang Perai, Pulau Pinang	Hasilan bakeri	Cokkies, roti ban, pastry,kek dan makanan tradisional berasaskan beras.

Latihan sangkut
Latihan sangkut adalah latihan *hands-on* pengeluaran produk tertentu di testbed teknologi MARDI. Tempoh penempatan peserta untuk mengikuti latihan ini di testbed MARDI adalah jangka pendek dan didalam bidang teknologi pemprosesan makanan daripada sumber seperti buah-buahan, sayur-sayuran, bijirin, kekacang, daging, ikan dan lain-lain. Usahawan perlu membuat permohonan rasmi kepada Pengarah, Pusat Promosi dan Pembangunan Usahawan MARDI, Serdang, Selangor untuk mengikuti latihan ini. Kadar bayaran yang dikenakan adalah mengikut jenis latihan yang akan menentukan penggunaan bahan mentah dan peralatan.
Kadar bayaran minimum RM100.00 dikenakan bagi setiap peserta latihan sangkut. Bahan mentah disediakan oleh peserta atau kos penyediaan bahan mentah ditanggung oleh peserta. Peserta yang berjaya akan ditempatkan di testbed MARDI seperti yang dinyatakan dalam Jadual 1 mengikut jenis kluster latihan yang dipohon. Pasukan petugas di testbed teknologi MARDI akan mendapatkan bahan mentah yang diperlukan untuk latihan dan mempastikan peralatan dan mesin yang digunakan dalam keadaan baik dan boleh digunakan. Latihan dijalankan mengikut teknologi MARDI. Semasa latihan peserta diberi pendedahan aspek teori dan latihan amali. Sijil penyertaan akan diberikan kepada peserta yang telah berjaya menyempurnakan latihan dengan jayanya.

Latihan Perantis
Latihan ini biasanya dilaksanakan kepada peserta yang telah mengikuti latihan sangkut, yang mana mereka mempunyai pengetahuan asas penggunaan peralatan mesin dan kaedah pemprosesan produk makanan. Peserta yang mempunyai hasrat untuk mengeluarkan produk makanan tertentu dan membuat ujian penerimaan pasaran untuk mengetahui samada produk makanan mempunyai pasaran yang baik dan akan mengambil masa kira-kira sebulan.
Peserta yang tidak mahu mengeluarkan modal untuk membeli peralatan untuk memproses produk sebelum mengetahui keboleh terimaan produk makanan di pasaran. Usahawan tersebut perlu

membuat permohonan secara rasmi kepada Pengarah, Pusat Promosi dan Pembangunan Usahawan MARDI, Serdang, Selangor untuk mengikuti latihan ini. Kadar bayaran yang dikenakan adalah mengikut jenis latihan yang akan menentukan penggunaan bahan mentah dan peralatan. Kadar bayaran minimum RM30.00 sehari dikenakan bagi setiap peserta latihan sangkut dan tempoh masa maksimum adalah 30 hari setahun.(Zainun.et al. 2015).

Lawatan/Demonstrasi

Program ini dilaksanakan di testbed untuk memberi penerangan secara lisan dan juga demonstrasi kepada pemprosesan produk makanan di testbed kepada tetamu yang melawat daripada agensi kerajaan dan swasta. Ia adalah maklumat teknikal yang awal mengenai teknologi yang ada di testbed yang diberikan kepada golongan benefisiari ini sebagai promosi untuk menyertai latihan seperti latihan sangkut dan perantis.

Kursus

Testbed juga digunakan sebagai premis untuk melaksanakan kursus oleh agensi dibawah kementerian dan pusat yang menguruskan program latihan di MARDI. Mereka yang melaksanakan program kursus pemprosesan makanan tidak mempunyai peralatan dan kepakaran untuk melaksanakannya. Teknologi pemprosesan makanan yang di testbed dapat dipindahkan kepada golongan sasar melaui kaedah ini

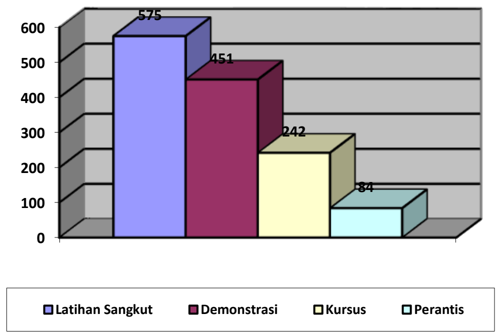
Data untuk penyertaan peserta bagi latihan sangkut, perantis, lawatan/demonstrasi dan kursus diambil daripada KPI projek pembangunan Rancangan Pembangunan RMKe-11 pembangunan usahawan tekno moden yang kompetitif di pasaran domestik dan global di bawah sub projek B untuk tahun 2017 dan 2018. Projek ini di ketuai oleh Dr Badaruzzaman bin Mohamad Noh .

Keputusan dan perbincangan

Pada 2017 jumlah bilangan peserta yang mendapat manafaat dari latihan pemindahan teknologi di testbed teknologi di seluruh Malaysia adalah seramai 1,352 orang seperti yang ditunjukkan dalam Rajah 1. Latihan sangkut merupakan aktiviti latihan yang paling kerap diadakan dan mendapat sambutan yang tinggi daripada peserta dengan penyertaan seramai 575 orang peserta pada tahun 2017. Ini di ikuti seramai 451 peserta mengikuti lawatan/demonstrasi, 242 orang peserta mengikuti kursus dan 84 orang peserta mengikuti program perantis.

Latihan sangkut mendapat sambutan yang tinggi daripada peserta kerana latihan ini bersifat *hand-on* serta tempoh latihan adalah pendek. Lawatan/demonstrasi serta kursus mendapat permintaan kedua dan ketiga tertinggi kerana program yang diaturkan ditestbed untuk memenuhi permintaan daripada badan kerajaan dan bukan kerajaan untuk kakitangan mereka dan kursus yang dikendalikan oleh mereka.

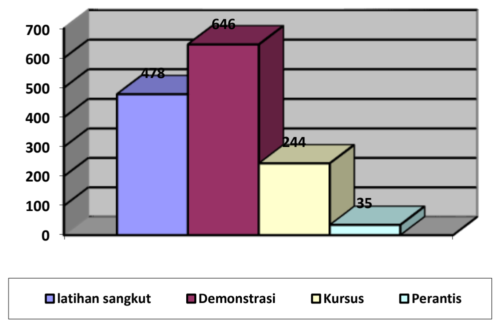
Perkhidmatan perantis mendapat permintaan yang rendah kerana program ini untuk usahawan membuat produk di testbed untuk tujuan ujian pasaran. Tidak ramai peserta yang mempunyai yang sudah bersedia dan mempunyai komitmen yang tinggi untuk meneruskan untuk pengeluaran produk berasaskan teknologi yang dipelajari.



Rajah 1 : Bilangan peserta mengikuti program testbed MARDI untuk tahun 2017

Pada 2018 jumlah bilangan peserta yang mendapat manafaat dari latihan pemindahan teknologi di testbed teknologi di seluruh Malaysia adalah 1403 orang seperti yang ditunjukkan dalam Rajah 2.

Bilangan peserta untuk mengikuti latihan sangkut adalah seramai 478 orang dan bilangannya menurun sedikit jika dibandingkan pada tahun 2017. Manakala pada 2018, demonstrasi/lawatan menunjukkan peningkatan bilangan peserta kepada 646 orang dan kursus mendapat sambutan yang sama jika di banding pada tahun 2017 iaitu seramai 242 orang. Bilangan peserta mengikuti program perantis di testbed MARDI pada 2018 mengalami penurunan kepada 35 orang peserta. Terdapat pelbagai faktor kepada penyertaan usahawan dan orang ramai kepada program latihan di testbed. Senarai faktor ikut kajian literiture



Rajah 2 : Bilangan peserta mengikuti program testbed MARDI untuk tahun 2018

Kesimpulan

Industri pemprosesan makanan IKS mempunyai masa depan yang cerah dan mempunyai peranan yang penting dalam sektor ekonomi negara. Produk makanan IKS akan dapat mecapai tahap mutu yang baik serta dapat dipasarkan jika mendapat bantuan teknologi MARDI. Testbed teknologi MARDI adalah merupakan medium pemindahan teknologi yang dapat menyampaikan teknologi MARDI kepada ushawan IKS dan golongan sasar melalui latihan sangkut, program perantis, lawatan/demonstrasi dan kursus. Secara tidak langsung Testbed teknologi MARDI telah berjaya membantu kejayaan usahawan melalui pemindahan teknologi MARDI dan lain-lain aktiviti-aktiviti.

Rujukan

Chua, H.P., Mahmus, A. and Sadi, S. (2015). Pencapaian 15 tahun latihan pemprosesan makanan Kuching-Ulasan.Berita Teknol. Makanan 1: 35-42

Zainun, C.A, Othman, M.T and Nursalwati, A. (2015). Manual prosedur operasi standard, prosedur umum perlaksanaan perkhidmatan sistem testbed teknologi MARDI 2: 1-20

Garis panduan perlaksanaan latihan sangkut teknologi MARDI (2014). Dokumen MS ISO 9001:2008 MARDI

Sariam, O. and Annuar, A.R. (2010). Effects of irrigation regime on irrigated rice. J. Trop. Agric. and Fd. Sc. 38(1): 1–