POTENTIAL OF MALAYSIAN SEAWEED EXTRACTS IN INHIBITING Ganoderma boninense AND IDENTIFICATION OF THEIR ANTIFUNGAL COMPOUNDS

SYAMIMI DIYANA BINTI ABDUL AZIZ

FBSB 2018 57

POTENTIAL OF MALAYSIAN SEAWEED EXTRACTS IN INHIBITING *Ganoderma boninense* AND IDENTIFICATION OF THEIR ANTIFUNGAL COMPOUNDS

By

SYAMIMI DIYANA BINTI ABDUL AZIZ

Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Master of Science

December 2018

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

POTENTIAL OF MALAYSIAN SEAWEED EXTRACTS IN INHIBITING *Ganoderma boninense* AND IDENTIFICATION OF THEIR ANTIFUNGAL COMPOUNDS

By

SYAMIMI DIYANA BINTI ABDUL AZIZ

December 2018

Chair : Zetty Norhana Balia Yusof, PhD
Faculty : Biotechnology and Biomolecular Sciences

Basal stem rot (BSR) disease is the most devastating disease in oil palm (*Elaies guineensis*) caused by a fungal pathogen, *Ganoderma boninense*. Various control measures have been tested but to date the utilization of seaweeds as a source of control agent has not been explored. This study investigated the antifungal potential of Malaysian seaweed extracts against *G. boninense* and identifying the potential antifungal compounds. Polar and non-polar compounds were extracted from $_{cf}$*Sargassum oligocystum*, *Caulerpa racemosa*, *Caulerpa racemosa* var. *lamourouxii* and $_{cf}$*Halimeda macrophysa* using water, methanol, chloroform, dichloromethane and hexane. Methanolic extracts from all species displayed the highest yield with an average of 15.25 % compared to dry weight. At 0.25 mg/mL, *C. racemosa* var. *lamourouxii* dichloromethane extract recorded the highest growth reduction against *G. boninense* with 46.82 % followed by *C. racemosa* var. *lamourouxii* hexane extract with 36.43 % and $_{cf}$*H. macrophysa* dichloromethane extract with 33.49 %. Statistical analysis from Kruskal-Wallis H test showed significant difference (H=77.23, *p*=.00) in growth reduction percentage between the different solvent. Dominant compounds detected via Gas Chromatography-Mass Spectrometry in extracts with antifungal potential were l-(+)-ascorbic acid 2,6-dihexadecanoate, phytol, tetradecanoic acid, isobutyl methylphosphonofluoridate and benzenamine,2-[2-(4-pyridinyl) ethyl]-. Further antifungal testing using standard phytol showed growth inhibition of *G. boninense* with 21 % inhibition and the amount of phytol in dichloromethane extracts were quantified via GC-MS. Dichloromethane extract of *C. racemosa* var. *lamourouxii*, $_{cf}$*H. macrophysa, C. racemosa and* $_{cf}$*S. oligocystum* contain 474, 117, 106 and 19 mg/L of phytol, respectively which were consistent with exhibited antifungal activities. These findings suggested that Malaysian seaweeds have potential as a source of natural and potent antifungal compounds for utilization in controlling the oil palm disease in Malaysia.

Abstrak tesis yang dikemukakan kepada Senat of Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

POTENSI EKSTRAK RUMPAI LAUT MALAYSIA DALAM PERENCATAN *Ganoderma boninense* DAN PENGENALPASTIAN SEBATIAN ANTIKULAT

Oleh

SYAMIMI DIYANA BINTI ABDUL AZIZ

Disember 2018

Pengerusi : Zetty Norhana Balia Yusof, PhD
Fakulti : Bioteknologi dan Sains Biomolekul

Penyakit reput pangkal batang ialah sejenis penyakit pokok kelapa sawit yang paling serius yang disebabkan oleh patogen kulat, *Ganoderma boninense*. Pelbagai kaedah pengurusan penyakit telah digunakan tetapi penggunaan rumpai laut sebagai sumber agen kawalan masih belum diterokai. Kajian ini menyiasat potensi antikulat oleh ekstrak rumpai laut Malaysia terhadap *G. boninense* dan pengenalpastian sebatian antikulat yang berpotensi. Sebatian berkutub dan tidak berkutub tersari daripada $_{cf}$*Sargassum oligocystum*, *Caulerpa racemosa*, *Caulerpa racemosa* var. *lamourouxii* dan $_{cf}$*Halimeda macrophysa* menggunakan akuas, metanol, kloroform, diklorometana dan heksana. Ekstrak metanol daripada semua spesis menunjukkan hasil tertinggi dengan purata sebanyak 15.25% berbanding berat kering. Pada kepekatan 0.25 mg/mL, ekstrak diklorometana *C. racemosa* var. *lamourouxii* merekodkan pengurangan pertumbuhan *G. boninense* yang tertinggi iaitu sebanyak 46.82 %, diikuti dengan ekstrak heksana *C. racemosa* dengan pengurangan pertumbuhan sebanyak 36.43 % dan ekstrak diklorometana $_{cf}$*H. macrophysa* dengan pengurangan pertumbuhan sebanyak 33.49 %. Analisis statistik daripada ujian Kruskal-wallis menunjukkan perbezaan bererti ($H=77.23$, $p=.00$) dalam peratusan pengurangan pertumbuhan dengan perbezaan pelarut. Antara sebatian dominan yang dikesan melalui GC-MS di dalam ekstrak yang mempunyai potensi antikulat ialah "l-(+)-ascorbic acid 2,6-dihexadecanoate", fitol, "tetradecanoic acid", "isobutyl methylphosphonofluoridate" dan "benzenamine,2-[2-(4-pyridinyl) ethyl]-". Cerakinan antikulat menggunakan fitol piawai menunjukkan perencatan pertumbuhan terhadap *G. boninense* sehingga 21 % dan kandungan phytol di dalam ekstrak diklorometana dikuantifikasi menggunakan GC-MS. Ekstrak diklorometana *C. racemosa* var. *lamourouxii*, $_{cf}$*H. macrophysa*, *C. racemosa* dan $_{cf}$*S. oligocystum,* masing-masing mengandungi fitol sebanyak 474, 117, 106 and 19 mg/L bertekalan dengan dapatan aktiviti antikulat yang ditonjolkan. Dapatan ini mencadangkan

bahawa rumpai laut Malaysia merupakan sumber sebatian antikulat yang mempunyai potensi yang tinggi sebagai sumber yang asli dan sebatian antikulat yang poten untuk digunakan dalam pengawalan penyakit kelapa sawit di Malaysia.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, all praises to Allah SWT for the strengths, the opportunity, the spirits and His blessings in accomplishing my master project and this thesis. In the first place, I would like to dedicate my appreciation to my supervisor, Dr. Zetty Norhana Balia Yusof for the knowledge that she passed to me, for her constructive feedback and constant support in my master project throughout these five semesters. I would like to thank my supervisory committee, Dr. Suriana Sabri from the Department of Microbiology, Faculty of Biotechnology and Biomolecular Sciences, UPM and Dr. Mohd. As'wad Abdul Wahab from the Department of Plant Pathology, Faculty of Agriculture, UPM for their continuous, helpful assistance and motivations in my experimental works.

This thesis would not have been possible without my parents blessing, Mr. Abdul Aziz Ahmad Ludin and Mrs. Fatimah Bebe Mohd Ali. I owe my deepest gratitude to my beloved parents for their endless prayers and supports in any way. Not to be forgotten, infinity thanks to my siblings, Muhd. Firzan, Anis Amira Aqila, Wildan and Abu Nu'man, my aunts, Aminah and Zulaiha and my big family that indirectly contributes to this success.

I am indebted to my laboratory mates and friends especially Atiqah, Kathrine Tan, Ayesha, Syazwan and Sharifah for all their encouragement and moral support end-to-end the project. Lastly, I offer my regards and blessings to UPM staffs and all of those who supported me in any respect during the completion of the project. I dedicate this thesis to my late grandmother, Mariam Bee whom I lost along my research journey.

Last but not least, I would like to express my extreme gratitude to Geran Putra IPS Universiti Putra Malaysia (Project No. 9511100) and MyBrain15 Ministry of Education for their funding and support to this research project.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Zetty Norhana Balia Yusof, PhD
Senior Lecturer
Fakulty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Chairperson)

Suriana Sabri, PhD
Senior Lecturer
Faculty of Biotechnology and Biomolecular Sciences,
Universiti Putra Malaysia
(Member)

Mohd. As'wad Abdul Wahab, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Syamimi Diyana Binti Abdul Aziz Gs45901

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Zetty Norhana Balia Yusof

Signature: _____
Name of Member of Supervisory Committee: Mohd Aswad Abdul Wahab

Signature: _____
Name of Member of Supervisory Committee: Suriana Sabri

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

et al.,	And friends
AA	l-(+)-Ascorbic acid 2,6-dihexadecanoate
BSR	Basal stem rot
Ca^{2+}	Calcium ion
cm	Centimetre
cf	Latin: confer (compare)
Cu^{2+}	Copper ion
◦C	Degree celcius
DMSO	Dimethyl-sulfoxide
EDTA	Ethylenediamine-tetraacetic acid
EA	Ethyl iso-allocholate
eV	Electron volt
GCMS	Gas chromatography mass spectrometry
g	Gram
g/mL	Gram per mililitre
µA	Microampere
µL	Microlitre
µg	Microgram
µm	Micrometre
mg/mL	Miligram per mililitre
mL	Mililitre
mm	Milimetre
MF	Molecular formula
MW	Molecular weight
NIST	National Institute of Standard and Technology
N	Nitrogen
PKC	Palm kernel cake
PPM	Parts per million
%	Percent
min^{-1}	Per minute
PDA	Potato dextrose agar

PRC	People's Republic of China
P	Phosphorus
P	Phytol
K	Potassium
R&D	Research and development
RT	Retention time
SA	Salicylic acid
sp.	Species (singular)
spp.	Species (plural)
SD	Standard deviation
SE	Standard error
TA	Tetradecanoic acid
USA	United states of America
USR	Upper stem rot

CHAPTER 1

INTRODUCTION

Malaysia is the world's major producer and exporter of palm oil after Indonesia by earnings of RM 64.58 billion (Din, 2017). As of 2017, Malaysia had 5.8 million hectares of total oil palm planted area (Malaysian Palm Oil Board, 2017). Oil palm is a major source of edible vegetable oil and biodiesel in Malaysia (Hushiarian *et al*., 2015). Apart from that, palm oil has been broadly used in many industries such as in the production of toiletries, cosmetics, candles, pharmaceutical products as well as animal feed manufacturing (Choo, 2013; Hushiarian *et al*., 2015; Zahazi & Alimon, 2004). While the biomass such as trunk and fronds were molded to be used in manufacturing of furniture, packaging, building and automobile industry (Basiron, 2015; Choo, 2013).

However, it is confronted with a devastating disease caused by a fungus, *Ganoderma boninense* that acts as the main factor of basal stem rot (BSR) disease (Hushiarian *et al*., 2015). It is a soil borne pathogen which is hard to control in a way that no effective method available that can completely handle the disease (Chong *et al*., 2017). Neglecting the disease will affect the yield of fresh fruit bunches which will trim down the production of crude palm oil. It was estimated that during 2020, 400 thousand hectares of oil palm plantations could be affected according to the annual growth rate of *G. boninense* (Roslan & Idris, 2012). Subsequently results in a huge loss in economy which was reported between RM225 million to RM1.5 billion per year (Arif *et al*., 2011; Ommelna *et al*., 2012). Many approaches to prevent this disease have been done such as sanitation but the most common method is by applying non-environmentally friendly fungicide which is also costly at the same time (Idris *et al*., 2002).

Therefore, a more environmentally friendly and sustainable remedy to this disease would be worth exploring. Natural products are non-toxic and secure to be used. Seaweeds or also known as macrolagae are marine plants known to be rich with active compounds with various biological activities (Choi et al., 2016; Fernando et al., 2017; Park et al., 2016; Sanjeewa et al., 2017). The potential for fungicidal activity had been discovered in certain seaweeds extracts. For example, aqueous, methanol, ethyl acetate, chloroform and ethanol fraction of red alga *Solieria robusta* demonstrated antifungal activity against five fruit spoiling fungi namely *Aspergillus flavus*, *A. niger*, *A. ochraceus*, *Penicillium funiculosum* and *Phytophthora infestans* (Khanzada *et al.,* 2007). In another study, five species of red alga *Laurencia* of various extracts were found to cause growth reduction of pathogenic fungi such as *Candida albicans*, *C. parapsilosis* and *Cryptococcus neoformans* (Stein *et al.,* 2011). More recent research by Rajasulochana and colleagues (2013) proposed the potential of *K. alvarezii* extracts in affecting the growth of fungal species. Result from this study reported that chloroform: methanol extract of *Kappaphycus alvarezii* actively against fungi *Aspergillus fumigates,*

Microsporum canis, Epidermophyton sp. and *C. albican* (Rajasulochana *et al*., 2013). Seaweeds are abundant in Malaysia and most of their potential and advantages are underexplored. If *G. boninense* infection in oil palm affects the production of oil palm's yield, it is hypothesized that the application of potential seaweed extracts on the infected palms might suppressed the fungal attack. This study aimed to discover the possession of antifungal characteristics and identification of the bioactive compounds in the abundantly available Malaysian seaweed extracts which could be the answer to the quest of an environmentally friendly approach to control the BSR disease in oil palm. Thus, this is the first study in Malaysia providing information on the antifungal property of Malaysian seaweed extracts against *G. boninense*.

1.1 Objectives

The main goals of this study is to investigate the antifungal potential of selected Malaysian seaweed extracts against *G. boninense* and the identification of the compounds responsible for the antifungal activity. The specific objectives of this research are:

1. To screen the antifungal activity of selected Malaysian seaweeds extracts against *G. boninense*.
2. To identify the potential bioactive compounds from seaweed extracts with inhibitory activity against *G. boninense.*
3. To quantify potential bioactive compounds content in seaweed extracts with antifungal property against *G. boninense.*

REFERENCES

Ab Kadir, M. I., Ahmad, M. R., Ismail, A., & Abdul Jabbar, H. (2016). Investigations on the cytotoxicity, neurotoxicity and dyeing performances of natural dye extracted from *Caulerpa lentillifera* and *Sargassum* sp. seaweeds. *Advances in Applied Sciences*, 1(3), 46–52.

Abbas, M., Saeed, F. & Suleria, H. A. R. (2018). Marine bioactive compounds: Innovative trends in food and medicine. *Plant-and Marine-Based Phytochemicals for Human Health: Attributes, Potential, and Use*, 61.

Abbruscato, P., Tosi, S., Crispino, L., Biazzi, E., Menin, B., Picco, A. M., & Tava, A. (2014). Triterpenoid glycosides from medicago sativa as antifungal agents against *pyricularia oryzae*. *Journal of Agricultural and Food Chemistry*, 62(46): 11030–11036.

Abdel-Aal, E. I., Haroon, A. M., & Mofeed, J. (2015). Successive solvent extraction and GC-MS analysis for the evaluation of the phytochemical constituents of the filamentous green alga *Spirogyra longata*. *Egyptian Journal of Aquatic Research*, 41(3): 233–246.

Abdul, H. P. S., Jawaid, M., Hassan, A., Paridah, M. T. & Zaido, A. (2012). Oil palm biomass fibres and recent advancement in oil palm biomass fibres based hybrid biocomposites. *Composites and Their Applications*.

Abdul Wahab, M. A., M, S., Paterson, R. R. M., Zainal Abidin, M. A., & Lima, N. (2011). Ergosterol analyses of oil palm seedlings and plants infected with *Ganoderma*. *Crop Protection*, 30(11): 1438–1442.

Abdullah, A., Adom, A., Shakaff, A., Ahmad, M., Zakaria, A., Saad, F., & Kamarudin, L. (2012). Hand-held electronic nose sensor selection system for basal stamp rot (BSR) disease detection. *Third International Conference on Intelligent Systems Modelling and Simulation*, 737–742.

Abirami, R. G. (2012). Anticancer activity of methanolic and aqueous extract of *Ulva Fasciata* in albino mice. *International Journal of Pharmacy and Pharmaceutical Sciences*, 4: 681-84.

Abiri, R., Shaharuddin, N. A., Maziah, M., Yusof, Z. N. B., Atabaki, N., Sahebi, M., & Hanafi, M. M. (2017). Role of ethylene and the APETALA 2/ethylene response factor superfamily in rice under various abiotic and biotic stress conditions. *Environmental and Experimental Botany*, 134: 33–44.

Acartürk, F., & Takka, S. (1999). Calcium alginate microparticles for oral administration: II: Effect of formulation factors on drug release and drug entrapment efficiency. *Journal of Microencapsulation*, 16(3): 275–301.

Adalbjörnsson, B. V., & Jónsdóttir, R. (2015). Enzyme-enhanced extraction of antioxidant ingredients from algae. *Methods in Molecular Biology*, 1308: 145–150.

Adey, W. H., & Loveland, K. (2007). Chapter 10 – Biomineralization and calcification: A key to biosphere and ecosystem function. *Dynamic Aquaria*, 141–154.

Agus, S., Hari, P., & Djafar. (2013). Early replanting program in *Ganoderma*-infected oil palm plantation. Proceedings of the 5th *MPOB-IOPRI International Seminar on Sustainable Management of Pests and Diseases in Oil Palm-the Way Forward*, November 22-23, 2013, Kuala Lumpur, Malaysia.

Ahmadi, P., Muharam, F. M., Ahmad, K., Mansor, S., & Abu Seman, I. (2017). Early detection of *Ganoderma* basal stem rot of oil palms using artificial neural network spectral analysis. *Plant Disease*, 101(6): 1009–1016.

Airanthi, M. K. W. A., Hosokawa, M., & Miyashita, K. (2011). Comparative antioxidant activity of edible Japanese brown seaweeds. *Journal of Food Science*, 76(1): C104–C111.

Al-Haj, N. A., Mashan, N. I., Mariana N. Shamsudin, H. M., & Charles S. Vairappan, Z. S. (2009). Antibacterial activity in marine algae *Eucheuma denticulatum* against *Staphylococcus aureus* and *Streptococcus pyogenes*. *Research Journal of Biological Sciences*, 4(4): 519–524.

Alengaram, U. J., Muhit, B. A. Al, & Jumaat, M. Z. Bin. (2013). Utilization of oil palm kernel shell as lightweight aggregate in concrete - A review. *Construction and Building Materials*, 38: 161–172.

Alexander, A., Sipaut, C. S., Chong, K. P., Lee, P. C., & Dayou, J. (2014). Sensitivity analysis of the detection of *Ganoderma boninense* infection in oil palm using FTIR. *Transactions on Science and Technology*, 1(1): 1–5.

Alexander, A., Sipaut, C. S., Dayou, J., & Chong, K. P. (2017). Oil palm roots colonisation by *Ganoderma boninense*: An insight study using scanning electron microscopy. *Journal of Oil Palm Research*, 29(2): 262–266.

Almaliky, B. S. A., Ahmad, Z. A. M., Kadir, J., & Yun, W. M. (2014). Pathogenicity of *Marasmiellus palmivorus* (Sharples) Desjardin comb. Prov. on Oil Palm *Elaeis guineensis*. *Wulfenia*, 19(8): 1–17.

Alqasoumi, S. I., Soliman, G. A., & Awaad, A. S. (2012). Anti-inflammatory activity, safety and protective effects of *Leptadenia pyrotechnica*, *Haloxylon salicornicum* and *Ochradenus baccatus* in ulcerative colitis. *Phytopharmacology*, 2(1): 58–71.

Altieri, C., Cardillo, D., Bevilacqua, A., & Sinigaglia, M. (2007). Inhibition of *Aspergillus spp*. and *Penicillium spp*. by fatty acids and their monoglycerides. *Journal of Food Protection*, 70(5): 1206–1212.

Ambika, S., & Sujatha, K. (2015). Antifungal activity of aqueous and ethanol extracts of seaweeds against sugarcane red rot pathogen (*Colletotrichum falcatum*). *Scientific Research and Essays*, 10(6): 232–235.

Andreea, C., Oana, A., & Beatrice, I. (2000). Antifungal activity of macroalgae extracts. *UASVM Bucharest*, Series A, LIII: 442–447.

Angel, L. P. L., Sundram, S., Ping, B. T. Y., Yusof, M. T., & Ismail, I. S. (2018). Profiling of antifungal activity of *Trichoderma virens* 159C involved in biocontrol assay of *Ganoderma boninense*. *Journal of Oil Palm Research*, 30(March): 83–93.

Araujo, G. S., Matos, L. J., Fernandes, J. O., Cartaxo, S. J., Gonçalves, L. R., Fernandes, F. A., & Farias, W. R. (2013). Extraction of lipids from microalgae by ultrasound application: prospection of the optimal extraction method. *Ultrasonics Sonochemistry*, 20(1): 95–98.

Aremu, A. O., Masondo, N. A., Rengasamy, K. R. R., Amoo, S. O., Gruz, J., Bíba, O., & Van Staden, J. (2015). Physiological role of phenolic biostimulants isolated from brown seaweed *Ecklonia maxima* on plant growth and development. *Planta*, 241(6): 1313–1324.

Arif, M., Roslan, A., Idris, A., & Ramle, M. (2011). Economics of oil palm pests and *Ganoderma* disease and yield losses. *Proceedings of the Third MPOB-IOPRI*.

Aruna, P., Mansuya, P., Sridhar, S., Kumar, J. S., & Babu, S. (2010). Pharmacognostical and antifungal activity of selected seaweeds from gulf of Mannar region. *Recent Research in Science and Technology*, 2(1): 115–119.

Asmida, I., Ahmad, I., Faezah, P., Norrizah, J. S., & Nornanysya, F. K. (2013). Seaweeds composition in littoral zone of Blue Lagoon, Port Dickson. BEIAC 2013 - 2013 IEEE *Business Engineering and Industrial Applications Colloquium*, 842–845.

Asmida, I., Noor Akmal, A. B., Ahmad, I., & Sarah Diyana, M. (2017). Biodiversity of macroalgae in blue lagoon, the straits of malacca, Malaysia and some aspects of changes in species composition. *Sains Malaysiana*, 46(1): 1–7.

Assis, K., Chong, K., Idris, A., & Ho, C. (2016). Economic loss due to *Ganoderma* disease in oil palm. World Academy of Science, Engineering and Technology, *International Journal of Social,*

Behavioral, Educational, Economic, Business and Industrial Engineering, 10(2): 631–635.

Azahar, T. M., Mustapha, J. C., Mazliham, S., & Boursier, P. (2011). Temporal analysis of basal stem rot disease in oil palm plantations: An analysis on peat soil. *International Journal of Engineering and Technology*, 11(3): 96–101.

Azman, M. D., Malek, R. A., Othman, N. Z., Peng, T., Idris, A., Then, C., & El Enshasy, H. A. (2012). Semi-industrial scale production of bio-control fungus: *Hendersonia* sp., a potential agent against *Ganoderma* oil palm disease. *AIChE Annual Meeting Conference Proceedings, Pittsburgh PA*.

Bakar, K., Mohamad, H., Latip, J., Tan, H. S., & Herng, G. M. (2017). Fatty acids compositions of *Sargassum granuliferum* and *Dictyota dichotoma* and their anti-fouling activities. *Journal of Sustainability Science and Management*, 12(2): 8–16.

Baleta, F. N., Laureta, L. V, Apines-Amar, M. J. S., Padilla, P. I. P., & Quinitio, G. F. (2011). Biological activity of extracts of *Sargassum oligocystum* (Magnaye) against aquaculture pathogenic bacteria. *Israeli Journal of Aquaculture-Bamidgeh*, 63.

Basiron, Y. (2015). Vision 2020–the palm oil phenomenon. *Growth*, 1962(2004).

Basiron, Yusof, & Weng, C. K. (2004). The Oil Palm and its Sustainability. *Journal of Oil Palm Research*, 16(1): 1–10.

Battacharyya, D., Babgohari, M. Z., Rathor, P., & Prithiviraj, B. (2015). Seaweed extracts as biostimulants in horticulture. *Scientia Horticulturae*, 196: 39–48.

Baweja, P., Kumar, S., Sahoo, D., & Levine, I. (2016). Seaweed in health and disease prevention, ed J Fleurence and I Levine: *Academic Press*.

Bayu, A., & Handayani, T. (2018). High-value chemicals from marine macroalgae: opportunities and challenges for marine-based bioenergy development. IOP Conference Series: *Earth and Environmental Science*, 209(1): 012046.

Benítez, T., Rincón, A. M., Limón, M. C., & Codon, A. C. (2004). Biocontrol mechanisms of *Trichoderma* strains. *International Microbiology*, 7(4): 249–260.

Bhadury, P., & Wright, P. C. (2004). Exploitation of marine algae: biogenic compounds for potential antifouling applications. *Planta*, 219(4): 561–78.

Bivi, M. R., Farhana, M. S. N., Khairulmazmi, A., & Idris, A. (2010). Control of *Ganoderma boninense*: A causal agent of basal stem rot disease in oil palm with endophyte bacteria in vitro. *International Journal of Agriculture and Biology*, *12*(6): 833-839.

Bivi, M. R., Farhana, M. S. N., Khairulmazmi, A., Idris, A., Ahmed, O. H., Zamri, R., & Sariah, M. (2012). *In vitro* effects of salicylic acid, calcium and copper ions on growth and sporulation of *Ganoderma boninense*. *African Journal of Biotechnology*, *11*(70): 13477-13489.

Bivi, M. S. H. R., Paiko, A. S., Khairulmazmi, A., Akhtar, M. S., Idris, A. S., Rahamah Bivi, M. S. H., & Idris, A. S. (2016). Control of basal stem rot disease in oil palm by supplementation of calcium, copper, and salicylic acid. *Plant Pathology Journal*, 32(5): 396–406.

Breton, F., Hasan, Y., Lubis, Z., & Franqueville, H. De. (2006). Characterization of parameters for the develpment of an early screening test for basal stem rot tolerance in oil palm progenies. *Journal of Oil Palm Research*, (Special Issue): 24–36.

Burkill, I. (1936). A dictionary of the economic products of the Malay peninsula. *Ministry of Agriculture and Cooperatives*, Kuala Lumpur, Malaysia.

Carballeira, N. M., O'Neill, R., & Parang, K. (2005). Racemic and optically active 2-methoxy-4-oxatetradecanoic acids: novel synthetic fatty acids with selective antifungal properties. *Chemistry and Physics of Lipids*, 136(1): 47–54.

Castillo, F., Hernández, D., Gallegos, G., Rodríguez, R., & Aguilar, C. N. (2012). Antifungal properties of bioactive compounds from plants. *Fungicides for Plant and Animal Diseases*, 81–106.

Cavas, L., & Yurdakoc, K. (2005). An investigation on the antioxidant status of the invasive alga *Caulerpa racemosa* var. *cylindracea* (*Sonder*) *Verlaque*, *Huisman, et Boudouresque* (*Caulerpales*, *Chlorophyta*). *Journal of Experimental Marine Biology and Ecology*, 325(2): 189–200.

Chabane, K., Bahbah, L., & Seridi, H. (2017). Marine seaweeds as biological indicators to assess metal pollution in a future natural marine reserve (Agueli Islet, Algeria). *Phycologia*, 56(4): 29.

Chaerle, L., Lenk, S., Hagenbeek, D., Buschmann, C., & Van Der Straeten, D. (2007). Multicolor fluorescence imaging for early detection of the hypersensitive reaction to tobacco mosaic virus. *Journal of Plant Physiology*, 164(3): 253–262.

Chanda, S., Dave, R., Kaneria, M., & Nagani, K. (2010). Seaweeds: A novel, untapped source of drugs from sea to combat Infectious diseases.

Current Research, Technology and Education Topics in Applied Microbiology and Microbial Technology, 473–480.

Chang, T. (2003). Effect of soil moisture content on the survival of *Ganoderma* species and other wood-inhabiting fungi. *Plant Disease*, 87(10): 1201–1204.

Chemat, F., Rombaut, N., Sicaire, A. G., Meullemiestre, A., Fabiano-Tixier, A. S., & Abert-Vian, M. (2017). Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications. A review. *Ultrasonics Sonochemistry*.

Choi, W. chul, Reid, S. N. S., Ryu, J. kwang, Kim, Y., Jo, Y. H., & Jeon, B. H. (2016). Effects of γ-aminobutyric acid-enriched fermented sea tangle (*Laminaria japonica*) on brain derived neurotrophic factor-related muscle growth and lipolysis in middle aged women. *Algae*, 31(2): 175–187.

Choi, Y. H. (2004). Metabolic discrimination of *Catharanthus roseus* leaves infected by phytoplasma using 1H-NMR spectroscopy and multivariate data analysis. *Plant Physiology*, 135(4): 2398–2410.

Chong, K. P. (2012). An evaluation of *Ganoderma* fungal colonization using ergosterol analysis and quantification. *The Planter*, 88: 311–319.

Chong, K. P., Dayou, J., & Alexander, A. (2017). Pathogenic nature of *Ganoderma boninense* and basal stem rot disease. *Detection and Control of Ganoderma boninense in Oil Palm Crop*. *Springer, Cham*, 5–12.

Chong, K. P., Rossall, S., & Atong, M. (2011). HPC fingerprints and *in vitro* antimicrobial activity of syringic acid, caffeic acid and 4-hydroxybenzoic acid against *Ganoderma boninense*. *Journal of Applied Sciences*, 11(13): 2284–2291.

Choo, Y. (2012). Dynamics of the Malaysian oil palm industry: Enhancing competitiveness. *Palm Oil Trade Fair and Seminar (POTS)*, Kuala Lumpur.

Choo, Y. M. (2013). PALM OIL: Processing, utilization and nutrition. *In Malaysia - Myanmar Palm Oil Trade Fair & Seminar* 2013 (POTS).

Chung, G. F. (2011). Management of *Ganoderma* diseases in oil palm plantations. *The Planter*, 87(39): 325–339.

Chung, W. C., Huang, J. W., & Huang, H. C. (2005). Formulation of a soil biofungicide for control of damping-off of Chinese cabbage (*Brassica chinensis*) caused by *Rhizoctonia solani*. *Biological Control*, 32(2): 287–294.

Clarke, D. D. (1972). The resistance of potato tissue to the hyphal growth of fungal pathogens. *Proceedings of the Royal Society B: Biological Sciences*, 181(1064): 303–317.

Collado-Vides, L., & Robledo, D. (1999). Morphology and photosynthesis of *Caulerpa* (*Chlorophyta*) in relation to growth form. *Journal of Phycology*, 35(2): 325–330.

Cooper, R. M., Flood, J., & Rees, R. W. (2011). *Ganoderma boninense* in oil palm plantations: current thinking on epidemiology, resistance and pathology. *The Planter*, 87(February): 515–526.

Corley, R. H. V., & Tinker, P. B. (2015). The Oil Palm. The Oil Palm. *Oxford, UK: Blackwell Science Ltd*.

Dagla, H. R., Paliwal, A., Rathore, M. S., & Shekhawat, N. S. (2012). Micropropagation of *Leptadenia pyrotechnica* (*forsk*.) decne: A multipurpose plant of an arid environment. *Journal of Sustainable Forestry*, 31(3): 283–293.

Dai, J., & Mumper, R. J. (2010). Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. *Molecules*, 15(10): 7313–7352.

Darmono, T. W. (2009). *Ganoderma* in oil palm in Indonesia: current status and prospective use of antibodies for the detection of infection. *Ganoderma diseases of perennial crops*, 249–266.

Darus, A., Seman, I., & Khairudin, H. (1993). Confirmation of *Ganoderma* infected palm by drilling technique. PORIM International Palm Oil Congress: Update and Vision (Agriculture). *PORIM, Malaysia*, 735–738.

Daud, N., Mohd Noor, N. H., Alimon, H., Abdul Rashid, N., & Baniyamin, N. E. (2015). Morphological studies of marine macroalgae at Sri Rusa Beach. *Journal of Science, Mathematics and Technology*, 2(1): 24–33.

Dawczynski, C., Schubert, R., & Jahreis, G. (2007). Amino acids, fatty acids, and dietary fibre in edible seaweed products. *Food Chemistry*, 103(3): 891–899.

de Borba, M. C., de Freitas, M. B., & Stadnik, M. J. (2018). *Ulvan* enhances seedling emergence and controls *Fusarium oxysporum* f. sp. phaseoli on common bean (*Phaseolus vulgaris* L.). *Crop Protection*.

de Felício, R., de Albuquerque, S., Young, M. C. M., Yokoya, N. S., & Debonsi, H. M. (2010). Trypanocidal, leishmanicidal and antifungal potential from marine red alga *Bostrychia tenella J. Agardh* (*Rhodomelaceae, Ceramiales*). *Journal of Pharmaceutical and Biomedical Analysis*, 52(5): 763–769.

de Gaillande, C., Payri, C., Remoissenet, G., & Zubia, M. (2017). *Caulerpa* consumption, nutritional value and farming in the Indo-Pacific region. *Journal of Applied Phycology*, 29: 2249–2266).

de La, A., Rosa, C., Calvache, G., Gómez, C., & Pedro, L. (2004). Stem and Root BorersTwo important pests of the oil palm crop in South America. In *International Conference on Pests and Diseases of Importance to the Oil Palm Industry. Fostering Global Cooperation in Instituting Quarantine ShieldMay 18-19, 2004 Kuala Lumpur, Malaysia* (No. L-0553). MPOB.

de Mesquita, M. M. F., Crapez, M. A. C., Teixeira, V. L. and, & Cavalcanti, D. N. (2018). Potential interactions bacteria-brown algae. *Journal of Applied Phycology*, 1–17.

Demir, N., Dural, B., & Yildirim, K. (2006). Effect of seaweed suspensions on seed germination of tomato, pepper and aubergine. *Journal of Biological Sciences*, 6(6): 1130–1133.

Demirel, Z., Yilmaz-koz, F.., Karabay-Yavasoglu, U. N., Ozdemir, G., & Sukatar, A. (2009). Antimicrobial and antioxidant activity of brown algae from the Aegean Sea*. Journal of the Serbian Chemical Society*, 74(6): 619–628.

Devi, O., Rao, K., Bidalia, A., Wangkheirakpam, R., & Singh, O. (2015). GC-MS analysis of phytocomponents and antifungal activities of *Zanthoxylum acanthopodium* DC. collected from Manipur, India. *European Journal of Medicinal Plants*, 10(1): 1–9.

Dheeb, B. I. (2015). Antifungal activity of alkaloids and phenols compounds extracted from black pepper *Piper nigrum* against some pathogenic fungi. *Journal of Biotechnology Research Center*, 9(2): 46–54.

Di Filippo-Herrera, D. A., Muñoz-Ochoa, M., Hernández-Herrera, R. M., & Hernández-Carmona, G. (2018). Biostimulant activity of individual and blended seaweed extracts on the germination and growth of the mung bean. *Journal of Applied Phycology*, 1–13.

Di Stasio, E., Van Oosten, M. J., Silletti, S., Raimondi, G., Dell'Aversana, E., Carillo, P., & Maggio, A. (2018). *Ascophyllum nodosum*-based algal extracts act as enhancers of growth, fruit quality, and adaptation to stress in salinized tomato plants. *Journal of Applied Phycology*, 30(4): 2675–2686.

Diabate, S., Franqueville, H. (De), Adon, B., Coulibaly, O. A., & Ake, S. (2009). The role of phenolic compounds in the determination of wilt disease tolerance of oil palm (*Elaeis guineensis JACQ*). *African Journal of Biotechnology*, 8(21): 5679–5690.

Din, A. K. (2017). Malaysian Oil Palm Industry Performance 2016 and Prospects for 2017. In *MPOB-Palm Oil Economic Review & Outlook Seminar*.

Doty, M. S., & Aguilar-Santos, G. (1966). Caulerpicin, a toxic constituent of Caulerpa. *Nature*, 211(5052):990.

Doty, M. S., & Aguilar-Santos, G. (1970). Transfer of toxic algal substances in marine food chains. *Pacific Science*, 24: 351–355.

Duniway, J. M. (2002). Status of chemical alternatives to methyl bromide for pre-plant fumigation of soil. *Phytopathology*, 92(12): 1337–1343.

El-Manawy, I., & Shafik, M. (2008). Morphological characterization of *Halimeda* (Lamouroux) from different biotopes on the red sea coral reefs of Egypt. *American-Eurasian Journal of Agricultural and Environmental Sciences*, 3(4): 532–538.

Elaine Lee, H. C., & Chong, K. P. (2015). Antimicrobial activity of *Elaeis guineensis* leaf extract against *Ganoderma boninense* of oil palm basal stem rot. *Pakistan Journal of Botany*, 47(4): 1593–1597.

Etcherla, M., & Narasimha Rao, G. M. (2014). In vitro study of antimicrobial activity in marine algae *Caulerpa taxifolia* and *Caulerpa racemosa* (*c. agardh*). *International Journal of Applied Biology and Pharmaceutical Technology*, 5(2): 57–62.

Falkowski, P. G., Barber, R. T., & Smetacek, V. (1998). Biogeochemical controls and feedbacks on ocean primary production. *Science*, 281(5374): 200–206.

Fao. (2016). State of world fisheries and aquaculture 2016 (spanish).

Farid, A. M., Azrul, W. A. W. M., Syazwan, S. A., Lee, S. Y., & Mohamed, R. (2018). First record of basal stem rot of foxtail palm *Wodyetia bifurcata* caused by *Ganoderma boninense* in Malaysia. *Plant Disease*, 102(7): 1461–1461.

Fayaz, M., Namitha, K. K. N., Murthy, K. N. C., Swamy, M. M., Sarada, R., Khanam, S., Ravishankar, G. A. (2005). Chemical composition, iron bioavailability, and antioxidant activity of *Kappaphycus alvarezzi* (*Doty*). *Journal of Agricultural and Food Chemistry,* 53(3): 792–7.

Ferdous Alam, A. S. A., Er, A. C., & Begum, H. (2015). Malaysian oil palm industry: Prospect and problem. *Journal of Food, Agriculture and Environment*, 13(2): 143–148.

Ferdouse, F., Løvstad Holdt, S., Smith, R., Murúa, P., & Yang, Z. (2018). The global status of seaweed production, trade and utilization. *FAO Globefish Research Programme*, Vol.124.

Fernando, I. P. S., Kim, H. S., Sanjeewa, K. K. A., Oh, J. Y., Jeon, Y. J., & Lee, W. W. (2017). Inhibition of inflammatory responses elicited by urban fine dust particles in keratinocytes and macrophages by diphlorethohydroxy-carmalol isolated from a brown alga *ishige okamurae*. *Algae*, 32(3): 261–273.

Ferreira, R. B., Monteiro, S. A. R. A., Freitas, R., Santos, C. N., Chen, Z., Batista, L. M., ... & Teixeira, A. R. (2007). The role of plant defence proteins in fungal pathogenesis. *Molecular Plant Pathology*, *8*(5): 677-700.

Flood, J., Bridge, P. D., & Holderness, M. (Eds.). (2000). *Ganoderma diseases of perennial crops*. CABI.

Flood, J., Husan, Y., Turner, P. D., & O'Grady, E. B. (2000). The spread of *Ganoderma* from infective sources in the field and its implications for management of the disease in oil palm. *Ganoderma Diseases of Perennial Crops*, 101–112.

Freile-Pelegrin, Y., & Morales, J. L. (2004). Antibacterial activity in marine algae from the coast of Yucatan, Mexico. *Botanica Marina*, *47*(2): 140-146.

Freires, I. de A., Murata, R. M., Furletti, V. F., Sartoratto, A., De Alencar, S. M., Figueira, G. M., & Rosalen, P. L. (2014). *Coriandrum sativum L*. (Coriander) essential oil: Antifungal activity and mode of action on *Candida* spp., and molecular targets affected in human whole-genome expression. *PLoS ONE*, 9(6): e99086.

Fu, C. W. F., Ho, C. W., Yong, W. T. L., Abas, F., & Tan, C. P. (2015). Effects of phenolic antioxidants extraction from four selected seaweeds obtained from Sabah. *PeerJ PrePrints*, *3*, e1249v1.

García-Seoane, R., Fernández, J. A., Villares, R., & Aboal, J. R. (2018). Use of macroalgae to biomonitor pollutants in coastal waters: Optimization of the methodology. *Ecological Indicators*, 84, 710–726.

Geissman, T. A. (1963). Flavonoid Compounds, Tannins, Lignins and, Related Compounds. *Comprehensive biochemistry Elsevier.* 9: 213-250.

Ghaneian, M. T., Ehrampoush, M. H., Jebali, A., Hekmatimoghaddam, S., & Mahmoudi, M. (2015). Antimicrobial activity, toxicity and stability of phytol as a novel surface disinfectant. *Environmental Health Engineering and Management Journal*, 2(1): 13–16.

Guiry, M. D. (2011). The Seaweed site. Retrieved from http://www.seaweed.ie/algae/seaweeds.php.

Gwinn, K. D. (2018). Bioactive natural products in plant disease control. *Studies in Natural Products Chemistry*, 56: 229–246.

Hahn, T., Lang, S., Ulber, R., & Muffler, K. (2012). Novel procedures for the extraction of fucoidan from brown algae. *Process Biochemistry*,47(12): 1691-1698.

Hamid, N., Ma, Q., Boulom, S., Liu, T., Zheng, Z., Balbas, J., & Robertson, J. (2015). Chapter 8 – Seaweed minor constituents. *Seaweed Sustainability*, 193–242.

Hasan, Y., & Turner, P. D. (1998). The comparative importance of different oil palm tissues as infection sources for basal stem rot in replantings. *Planter*, 74(864): 119–135.

Hayashi, L., Reis, R. P., dos Santos, A. A., Castelar, B., Robledo, D., de Vega, G. B., & Hurtado, A. Q. (2017). The cultivation of *Kappaphycus* and *Eucheuma* in tropical and sub-tropical waters. *Tropical Seaweed Farming Trends, Problems and Opportunities*, 55–90.

Hediat, M. Hs., & Najat, M. (2010). Antimicrobial activity and phytochemical analyses of *Polygonum aviculare L*. (*Polygonaceae*), naturally growing in Egypt. Saudi *Journal of Biological Sciences*, 17(1): 57–63.

Holdt, S. L., & Kraan, S. (2011). Bioactive compounds in seaweed: functional food applications and legislation. *Journal of Applied Phycology*, 23(3): 543–597.

Hushiarian, R., Yusof, N. A., & Dutse, S. W. (2015). Detection and control of *Ganoderma boninense*: strategies and perspectives. *SpringerPlus*, 2(1): 555.

Hwang, E. K., Park, C. S., & Baek, J. M. (2006). Artificial seed production and cultivation of the edible brown alga, *Sargassum fulvellum* (*Turner*) *C. Agardh*: Developing a new species for seaweed cultivation in Korea. *Journal of Applied Phycology*, 18(3–5): 251–257.

Ibañez, E., Herrero, M., Mendiola, J. A., & Castro-Puyana, M. (2012). Extraction and characterization of bioactive compounds with health benefits from marine resources: Macro and micro algae, cyanobacteria, and invertebrates. *Marine Bioactive Compounds*, 55–98.

Idris, A. (2013). The Official Portal of Malaysian Palm Oil Board. Retrieved November 8, 2015, from http://www.mpob.gov.my/

Idris, A., Ismail, S.., & Arifin, H. (2002). Control of *Ganoderma*-infected palm-development of pressure injection and field applications. *MPOB Information Series*.

Idris, A., & Maizatul, S. (2012a). Prolonging the productive life of *Ganoderma* infected oil palm with dazomet. *MPOB TT Information Series*, 108.

Idris, A., & Maizatul, S. (2012b). Stump treatment with Dazomet for controlling *Ganoderma* disease in oil palm. *MPOB TS Information*, 107.

Idris, A., Nurrashyeda, R., Maizatul, S., Madihah, A., Tarmizi, A., Kushairi, A., & Tony Peng, S. (2012). Biofertiliser *Hendersonia* GanoEF as biological control of *Ganoderma* in oil palm. *MPOB TT Information Series*, (508).

Idris, A. S. (1999). Basal stem rot (BSR) of oil palm (*Elaeis guineensis* Jacq.) in Malaysia: factors associated with variation in disease severity. *Wye College, Wye, UK*.

Idris, A. S., Ariffin, D., Swinburne, T. R., & T.A. Watt. (2000). The identity of *Ganoderma* species responsible for basal stem rot (BSR) disease of oil palm in Malaysia-pathogenicity test. *MPOB TT Information Series*, 103.

Idris, A. S., Hayakawa, S., & Basri, M W Noorhasimah, I and Ariffin, D. (2003). Pcr Technique for detection *Ganoderma*. *MPOB Information Series*, (June): 1–4.

Indira, K., Balakrishnan, S., Srinivasan, M., Bragadeeswaran, S., & Balasubramanian, T. (2013). Evaluation of in vitro antimicrobial property of seaweed (*Halimeda tuna*) from Tuticorin coast, Tamil Nadu, Southeast coast of India. *African Journal of Biotechnology*, 12(3): 284–289.

Inoue, Y., Hada, T., Shiraishi, A., Hirose, K., Hamashima, H., & Kobayashi, S. (2005). Biphasic effects of geranylgeraniol, teprenone, and phytol on the growth of *Staphylococcus aureus*. *Antimicrobial Agents and Chemotherapy*, 49(5): 1770–1774.

Iriti, M., & Faoro, F. (2009). Bioactivity of grape chemicals for human health. *Natural product communications* (Vol. 4).

Ismail, A. (1995). Rumpai laut Malaysia. *Dewan Bahasa dan Pustaka, Kementerian Pendidikan, Malaysia*.

Ismail, K., Abdullah, S., & Chong, K. (2014). Screening for potential antimicrobial compounds from *Ganoderma boninense*. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(SUPPL. 2): 6–9.

Jarecka, A., Saniewska, A., Bia, Z., & Jurzysta, M. (2008). The effect of *Medicago arabica*, *M. hybrida* and *M. sativa* saponins on the growth and development of *Fusarium oxysporum Schlecht* f. sp. tulipae apt. *Acta Agrobotanica*, 61(2): 147–155.

Jayaratne, R., Wettasinghe, P. C., Siriwardene, D., & Peiris, P. (2001). Systemic fungicides as a drench application to control white root

disease of rubber. *Journal of the Rubber Research Institute of Sri Lanka*, 84: 1–17.

Jebasingh, S. E. J., & Rosemary, S. (2011). Potential antibacterial activity of selected green and red seaweeds. *Journal of Pharmaceutical and Biomedical Sciences*, 05(05): 1–7.

Jha, B., Reddy, C., Thakur, M., & Rao, M. (2015). Seaweeds of India: The diversity and distribution of seaweed of Gujarat Coast. *Springer Science & Business Media*, Vol. 3.

Jiménez-Escrig, A., & Sánchez-Muñiz, F. J. (2000). Dietary fibre from edible seaweeds: Chemical structure, physicochemical properties and effects on cholesterol metabolism. *Nutrition Research*, 20(4): 585–598.

Jiménez, E., Dorta, F., Medina, C., Ramírez, A., Ramírez, I., & Peña-Cortés, H. (2011). Anti-phytopathogenic activities of macro-algae extracts. *Marine Drugs*, 9(5): 739–56.

Kabara, J. J., Swieczkowski, D. M., Conley, A. J., & Truant, J. P. (1972). Fatty acids and derivatives as antimicrobial agents. Antimicrobial Agents and Chemotherapy, 2(1): 23–28.

Kadam, S. U., Tiwari, B. K., & O'Donnell, C. P. (2013). Application of novel extraction technologies for bioactives from marine algae. *Journal of Agricultural and Food Chemistry*, 61(20): 4667-4675.

Kandale, A., Meena, A. K., Rao, M. M., Panda, P., Mangal, A. K., Reddy, G., & Babu, R. (2011) Marine Algae: An introduction, food value and medicinal uses. *Journal of Pharmacy Research*, 4(1): 219–221.

Kandan, A., Bhaskaran, R., & Samiyappan, R. (2010). *Ganoderma* – a basal stem rot disease of coconut palm in south Asia and Asia pacific regions. *Archives of Phytopathology and Plant Protection*, 43(15): 1445–1449.

Kandan, A., Radjacommare, R., Ramanathan, A., Raguchander, T., Balasubramanian, P., & Samiyappan, R. (2009). Molecular biology of *Ganoderma* pathogenicity and diagnosis in coconut seedlings. *Folia Microbiologica*, 54(2): 147–152.

Kandhasamy, M., & Arunachalam, K. (2008). Evaluation of in vitro antibacterial property of seaweeds of southeast coast of India. *African Journal of Biotechnology*, 7(12): 1958–1961.

Karthikaidevi, G., Manivannan, K., Thirumaran, G., Anantharaman, P., & Balasubaramanian, T. (2009). Antibacterial properties of selected green seaweeds from vedalai coastal waters; gulf of mannar marine biosphere reserve. *Global Journal of Pharmacology*, 3(2): 107–112.

Karthikeyan, S. C., Velmurugan, S., Donio, M. B. S., Michaelbabu, M., & Citarasu, T. (2014). Studies on the antimicrobial potential and structural characterization of fatty acids extracted from Sydney rock oyster *Saccostrea glomerata*. *Annals of Clinical Microbiology and Antimicrobials*, 13(1): 332.

Kaur, C. R., & Ang, M. (2009, October). Seaweed culture and utilization in Malaysia: Status, challenges and economic potential. In *Seminar on Developing the Seaweed Aquaculture Sector in Malaysia. MIMA Seminar Room*, 27.

Khairudin, H. (1990). Basal stem rot of oil palm: incidence, etiology and control. *Master of Agriculture Science thesis, Universiti Pertanian Malaysia, Selangor, Malaysia, Selangor, Malaysia*.

Khan, W., Rayirath, U. P., Subramanian, S., Jithesh, M. N., Rayorath, P., Hodges, D. M., & Prithiviraj, B. (2009). Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation*, 28(4): 386–399.

Khanzada, A. K., Shaikh, W., Kazi, T. G., Kabir, S., & Soofia, S. (2007). Antifungal activity, elemental analysis and determination of total protein of seaweed, *Solieria Robusta* (*Greville*) *Kylin* from the coast of Karachi. *Pakistan Journal of Botany*, 39(3): 931–937.

Khasawneh, M. A., Elwy, H. M., Hamza, A. A., Fawzi, N. M., & Hassan, A. H. (2011). Antioxidant, anti-lipoxygenase and cytotoxic activity of *Leptadenia pyrotechnica* (*Forssk.*) decne polyphenolic constituents. *Molecules*, 16(9): 7510–7521.

Kim, H. S., Sang, M. K., Jung, H. W., Jeun, Y. C., Myung, I. S., & Kim, K. D. (2012). Identification and characterization of *Chryseobacterium wanjuense* strain KJ9C8 as a biocontrol agent of *Phytophthora* blight of pepper. *Crop Protection*, 32: 129–137.

Knaff, D. B. (1991). Regulatory phosphorylation of chloroplast antenna proteins. *Trends in Biochemical Sciences*, 16: 82–83.

Kolanjinathan, K., & Saranraj, P. (2014). Pharmacological efficacy of marine seaweed *Gracilaria edulis* extracts against clinical pathogens. *Global Journal of Pharmacology*, 8(2): 268–274.

Kolsi, R. B. A., Frikha, D. O. N. Y. E. Z., Jribi, I. M. E. D., Hamza, A. S. M. A., Feki, L. O. T. F. I., & Belghith, K. A. R. I. M. A. (2015). Screening of antibacterial and antifongical activity in marine macroalgae and *Magnoliophytea* from the coast of Tunisia. *International Journal of Pharmacy and Pharmaceutical Sciences*, 7(3): 47–51.

Komatsu, T., Tatsukawa, K., Filippi, J., Sagawa, T., Matsunaga, D., Mikami, A., Aoki, M. (2007). Distribution of drifting seaweeds in eastern East China Sea. *Journal of Marine Systems*, 67(3–4): 245–252.

König, G. M., & Wright, A. D. (1997). *Laurencia rigida*: Chemical investigations of its antifouling dichloromethane extract. *Journal of Natural Products*, 60(10): 967–970.

Kua, Y., Gan, S., Ng, H., & Morris, A. (2014). The potential of ethyl lactate as a green solvent to extract carotenoids and vitamin E from crude palm oil. *International Symposium on Processing of Foods, Vegetables and Fruits*.

Kumar, S. R., Ramanathan, G., Subhakaran, M., & Inbaneson, S. J. (2009). Antimicrobial compounds from marine halophytes for silkworm disease treatment. *International Journal of Medicine and Medical Sciences*, 1(5): 184–191.

Kumari, S. S., Kumar, V. D., & Priyanka, B. (2017). Antifungal efficacy of seaweed extracts against fungal pathogen of silkworm, *Bombyx mori* L. *International Journal of Agricultural Research*, 12(3): 123–129.

Lacrosse, L., & Shakya, S. K. (2004, October). Clean and efficient biomass cogeneration technology in ASEAN. In *Power-Gen Asia conference and exhibition* :5-7.

Levine, I. (2016). Algae: A way of life and health. *Microalgae in health and disease prevention*. Academic Press :1-10.

Li, S., Zhang, H., Han, D., & Row, K. H. (2012). Optimization of enzymatic extraction of polysaccharides from some marine algae by response surface methodology. *Korean Journal of Chemical Engineering*, 29(5): 650–656.

Lim, S. J., Wan Aida, W. M., Maskat, M. Y., Latip, J., Badri, K. H., Hassan, O., & Yamin, B. M. (2016). Characterisation of fucoidan extracted from Malaysian *Sargassum binderi*. *Food Chemistry*, 209: 267–273.

Liu, A., Liu, D.-Q., Liang, T.-J., Yu, X., Feng, M.-T., Yao, L., Mao, S.-C. (2013). Caulerprenylols A and B, two rare antifungal prenylated para -xylenes from the green alga *Caulerpa racemosa*. *Bioorganic & Medicinal Chemistry Letters*, 23(9): 2491–2494.

Liu, S., Ruan, W., Li, J., Xu, H., Wang, J., Gao, Y., & Wang, J. (2008). Biological control of phytopathogenic fungi by fatty acids. *Mycopathologia*, 166(2): 93–102.

Liu, X., Ouyang, C., Wang, Q., Li, Y., Yan, D., Yang, D., & Guo, M. (2016). Effects of oil extracts of *Eupatorium adenophorum* on *Phytophthora*

capsici and other plant pathogenic fungi *in vitro*. *Pesticide Biochemistry and Physiology*, 140: 90-96.

Loh, S. K. (2017). The potential of the Malaysian oil palm biomass as a renewable energy source. *Energy Conversion and Management*, 141: 285–298.

Madihah, A. Z., Idris, A. S., & Rafidah, A. R. (2014). Polyclonal antibodies of *Ganoderma boninense* isolated from Malaysian oil palm for detection of basal stem rot disease. *African Journal of Biotechnology*, 13(34).

Maizatul, S., Idris, A., Madihah, A., Nasyaruddin, M., & Kushairi, A. (2012). *Burkholderia* GanoEB2 powder as biological control of *Ganoderma* in oil palm. *MPOB TT Information Series*, 507.

Malaysian Palm Oil Board. (2017). Malaysia Planted Area: Oil Palm. Retrieved January 6, 2019, from https://www.ceicdata.com/en/malaysia/planted-area-oil-palm

Manas, H. M., Deshmukhe, G., Venkateshwarlu, G., Chakraborty, S. K., Jaiswar, A. K., Mugaonkar, P. H., & Dar, S. A. (2015). Morphological comparison of different *Caulerpa* JV *Lamouroux* species along Maharashtra and Gujarat coast, India. *Indian Journal of Geo-Marine Sciences*, 44(5): 732–737.

Manivannan, K., Karthikai Devi, G., Anantharaman, P., & Balasubramanian, T. (2011). Antimicrobial potential of selected brown seaweeds from Vedalai coastal waters, Gulf of Mannar. *Asian Pacific Journal of Tropical Biomedicine*, 1(2): 114–20.

Maréchal, J. P., Culioli, G., Hellio, C., Thomas-Guyon, H., Callow, M. E., Clare, A. S., & Ortalo-Magné, A. (2004). Seasonal variation in antifouling activity of crude extracts of the brown alga *Bifurcaria bifurcata* (*Cystoseiraceae*) against cyprids of *Balanus amphitrite* and the marine bacteria *Cobetia marina* and *Pseudoalteromonas haloplanktis*. *Journal of Experimental Marine Biology and Ecology*, 313(1): 47–62.

Marinho-Soriano, E., Fonseca, P. C., Carneiro, M. A. A., & Moreira, W. S. C. (2006). Seasonal variation in the chemical composition of two tropical seaweeds. *Bioresource Technology*, 97(18): 2402–6.

Markom, M. A., Shakaff, A. Y. M., Adom, A. H., Ahmad, M. N., Hidayat, W., Abdullah, A. H., & Fikri, N. A. (2009). Intelligent electronic nose system for basal stem rot disease detection. *Computers and Electronics in Agriculture*, 66(2): 140–146.

Mason, T. L., & Bruce P., W. (1987). Inactivation of red beet β-glucan synthase by native and oxidized phenolic compounds. *Phytochemistry*, 26(8): 2197–2202.

Matanjun, P., Mohamed, S., Mustapha, N. M., & Muhammad, K. (2009). Nutrient content of tropical edible seaweeds, *Eucheuma cottonii*, *Caulerpa lentillifera* and *Sargassum polycystum*. *Journal of Applied Phycology*, 21(1): 75–80.

Matanjun, P., Mohamed, S., Mustapha, N. M., Muhammad, K., & Ming, C. H. (2008). Antioxidant activities and phenolics content of eight species of seaweeds from north Borneo. *Journal of Applied Phycology*, 20(4): 367–373.

Mayer, A. M. S., Rodríguez, A. D., Taglialatela-Scafati, O., & Fusetani, N. (2013). Marine pharmacology in 2009-2011: marine compounds with antibacterial, antidiabetic, antifungal, anti-inflammatory, antiprotozoal, antituberculosis, and antiviral activities; affecting the immune and nervous systems, and other miscellaneous mechanisms. *Marine Drugs*, 11(7): 2510–73.

McGaw, L. J., Jäger, A. K., & Van Staden, J. (2002). Isolation of antibacterial fatty acids from *Schotia brachypetala*. *Fitoterapia*, 73(5): 431–433.

McGinty, D., Letizia, C. S., & Api, A. M. (2010). Fragrance material review on phytol. *Food and Chemical Toxicology*, 48(SUPPL. 3): S59–S63.

Meher, L. C., Sagar, D. V., & Naik, S. N. (2006). Technical aspects of biodiesel production by transesterification—a review. *Renewable and sustainable energy reviews*, *10*(3): 248-268.

Michalak, I., & Chojnacka, K. (2014). Algal extracts: Technology and advances. *Engineering in Life Sciences*, 14(6): 581–591.

Mickymaray, S., & W Alturaiki. (2018). Antifungal efficacy of marine macroalgae against fungal isolates from bronchial asthmatic cases. *Molecules*, 23(11): 3032.

Ministry of Plantation Industries and Commodities Malaysia. (2006). The National Biofuel Policy. *MPOB, Malaysia*, (March), 1–13.

Misra, N. N., Rai, D. K., & Hossain, M., (2015). Chapter 10 – Analytical techniques for bioactives from seaweed. *Seaweed Sustainability*, 271–287.

Moncalvo, J. M. (2000). Systematics of *Ganoderma*. *Ganoderma diseases of perennial crops*, 23-45.

Moreira, A. C. P., Lima, E. D. O., Wanderley, P. A., Carmo, E. S., & de Souza, E. L. (2010). Chemical composition and antifungal activity of *Hyptis suaveolens* (*L*.) Poit leaves essential oil against *Aspergillus* species. *Brazilian Journal of Microbiology*, 41(1): 28–33.

Muniroh, M. S., Sariah, M., Zainal Abidin, M. A., Lima, N., & Paterson, R. R. M. (2014). Rapid detection of *Ganoderma*-infected oil palms by microwave ergosterol extraction with HPLC and TLC. *Journal of Microbiological Methods*, 100(1): 143–147.

Muta Harah, Z., Japar Sidik, B., Natrah, F., Emmclan, L., Wan Hazma, W., & Nordiah, B. (2014). Seaweed community of Merambong shoal, Sungai Pulai estuary, Johor. *Malayan Nature Journal*, 66(1): 117–131.

Muzaimah, S. A. S., Idris, A. S., Madihah, A. Z., & Kushairi, A. (2012). *Streptomyces* GanoSA1 powder as biological control of *Ganoderma* in oil palm. *MPOB TT Information Series*, 506.

Nagappan, H., Pee, P. P., Kee, S. H. Y., Ow, J. T., Yan, S. W., Chew, L. Y., & Kong, K. W. (2017). Malaysian brown seaweeds *Sargassum siliquosum* and *Sargassum polycystum*: Low density lipoprotein (LDL) oxidation, angiotensin converting enzyme (ACE), α-amylase, and α-glucosidase inhibition activities. *Food Research International*, 99: 950–958.

Nagaraj, S. R., & Osborne, J. W. (2014). Bioactive compounds from *Caulerpa racemosa* as a potent larvicidal and antibacterial agent. *Frontiers in Biology*, 9(4): 300–305.

Naher, L., Ho, C. L., Tan, S. G., Yusuf, U. K., & Abdullah, F. (2011). Cloning of transcripts encoding chitinases from *Elaeis guineensis Jacq*. and their expression profiles in response to fungal infections. *Physiological and molecular plant pathology*, *76*(2): 96-103.

Naher, L., Yusuf, U. K., Ismail, A., Tan, S. G., & Mondal, M. M. A. (2013). Review article ecological status of *Ganoderma* and basal stem rot disease of oil palms (*Elaeis guineensis Jacq*.). *Australian Journal of Crop Science*, 7(11): 1723–1727.

Najihah, N. I., Hanafi, M. M., Idris, A. S., & Hakim, M. A. (2015). Silicon treatment in oil palms confers resistance to basal stem rot disease caused by *Ganoderma boninense*. *Crop Protection*, 67: 151–159.

Narayani, C. G. S., Arulpriya, M., Ruban, P., Anantharaj, K., & Srinivasan, R. (2011). *In vitro* antimicrobial activities of seaweed extracts against human pathogens. *Journal of Pharmacy Research*, 44(7): 2076–2077.

Natarajan, S., Bhaskaran, R., & Shanmugan, N. (1986). Preliminary studies to develop techniques for early detection of Thanjavur wilt in coconut. *Indian Coconut Journal (India)*.

Nermal Kumar, J. I., Megha Barot, & Kumar, R. N. (2014). Phytochemical analysis and antifungal activity of selected seaweeds from Okha coast, Gujarat, India. *Journal of Coastal Life Medicine*, 3(7): 520–525.

Neustupa, J., & Nemcova, Y. (2018). Morphological allometry constrains symmetric shape variation, but not asymmetry, of *Halimeda tuna* (*Bryopsidales*, *Ulvophyceae*) segments. *PLoS ONE*, 13(10): e0206492.

Newman, D., Cragg, G., & Snader, K. (2003). Natural products as sources of new drugs over the period 1981-2002. *Journal of Natural Products*, 66: 1022–1037.

Nikan, M., Saeidnia, S., Manayi, A., & Saadatmand, S. (2017). Essential oils of four *Phlomis* species growing in Iran: Chemical composition, antimicrobial and antifungal activity. *Progress in Nutrition*, 19: 75–79.

Nurrashyeda, R., Idris, A., Maizatul, S., Madihah, A., & Kushairi, A. (2012a). *Amphinema* GanoEF2 powder as biological control of *Ganoderma* disease in oil palm. *MPOB TT Information Series*, 509.

Nurrashyeda, R., Idris, A., Maizatul, S., Madihah, A., & Kushairi, A. (2012b). *Phlebia* GanoEF3 powder as biological control of *Ganoderma* in oil palm. *MPOB TT Information Series*, 510.

Ohba, H. (1987). Culture studies on *Caulerpa* (*Caulerpales*, *Chlorophyceae*) II. Morphological variations of *C. racemosa* var. *laetevirens* under various culture conditions. *Japan Journal of Phycology*, 35: 178–188.

A. (2016). GC-MS analysis and antimicrobial properties of methanolic extracts of the marine algae *Skeletonema costatum* and *Chaetoceros spp*. *Biokemistri*, 28(1): 24–33.

Okwu, D. E., & Ighodaro, B. U. (2009). GC-MS evaluation of the bioactive compounds and antibacterial activity of the oil fraction from the stem barks of *Dacryodes edulis G. Don Lam. International Journal of Drug Development and Research*, *1*(1), 117-125.

Ommelna, B. G., Jennifer, A. N., & Chong, K. P. (2012). The potential of chitosan in suppressing *Ganoderma boninense* infection in oil palm seedlings. *Journal of Sustainability Science and Management*, 7(2): 186–192.

Omoruyi, B. E., Afolayan, A. J., & Bradley, G. (2014). Chemical composition profiling and antifungal activity of the essential oil and plant extracts of *Mesembryanthemum edule* (*L.*) *bolus* leaves. *African Journal of Traditional, Complementary, and Alternative Medicines: AJTCAM*, 11(4): 19–30.

Oranday, M. A., Verde, M. J., Martinez-Lozano, S. J., & Waksman, N. H. (2004). Active fractions from four species of marine algae. *Phyton (Buenos Aires)*, 73, 165-170.

Osbourn, A. (1996). Saponins and plant defence — a soap story. *Trends in Plant Science*, 1(1): 4–9.

Pandian, P., Selvamuthukumar, S., & Manavalan, R. (2011). Screening of antibacterial and antifungal activities of red marine algae *Acanthaphora spicifera* (*Rhodophyceae*). *Journal of Biomedical Science and Research*, 3(3): 444–448.

Pangestuti, R., & Kim, S. K. (2011). Biological activities and health benefit effects of natural pigments derived from marine algae. *Journal of Functional Foods*, 3(4): 255–266.

Park, H. J., Lee, M. S., Shim, H. S., Lee, G. R., Chung, S. Y., Kang, Y. M., & Shim, I. (2016). Fermented *Saccharina japonica* (*Phaeophyta*) improves neuritogenic activity and TMT-induced cognitive deficits in rats. *Algae*, 31(1): 73–84.

Parveen, Z., Mazhar, S., Siddique, S., Manzoor, A., & Ali, Z. (2017). Chemical composition and antifungal activity of essential oil from *Xanthium strumarium L*. leaves. *Indian Journal of Pharmaceutical Sciences*, 79(2): 316–321.

Paterson, R. R. M. (2007). *Ganoderma* disease of oil palm-A white rot perspective necessary for integrated control. *Crop Protection*, 26(9): 1369–1376.

Paterson, R. R. M., Sariah, M., & Lima, N. (2013). How will climate change affect oil palm fungal diseases? *Crop protection*, 46: 113-120.

Paul, V. J., & Puglisi, M. P. (2004). Chemical mediation of interactions among marine organisms. *Natural Product Reports*, 21(1): 189–209.

Pavlić, B., Bera, O., Teslić, N., Vidović, S., Parpinello, G., & Zeković, Z. (2018). Chemical profile and antioxidant activity of sage herbal dust extracts obtained by supercritical fluid extraction. *Industrial Crops and Products*, 120: 305–312.

Pawar, D. S., & Nasreen, S. (2016). Phytochemical screening and antifungal activity of *Bauhinia racemosa* and *Dolichandrone falcata*. *International Journal of Applied Research*, 2(8): 243–245.

Pepeljnjak, S., Jugoslavica, I. J., & Maysinger, D. (1981). Influence of microencapsulated propolis extract on *Bacillus-subtilis* strain ip-5832. *Acta Pharmaceutica Jugoslavica*, 31(1): 27–32.

Peres, J. C. F., Carvalho, L. R. De, Gonçalez, E., Berian, L. O. S., & Felicio, J. D. (2012). Evaluation of antifungal activity of seaweed extracts. *Ciência e Agrotecnologia*, 36: 294–299.

Phang, S. M., Sim, M. C., Yow, Y. Y., Yeong, H. Y., & Lim, P. E. (2013). *Halimeda* (*Bryopsidales, Chlorophyta*) from the Sulu-Sulawesi region and Layang-Layang Island of Malaysia. *Taxonomy of Southeast Asian*

Seaweeds II. Institute of Ocean and Earth Sciences, University of Malaya Monograph Series, *15*, 1-38.

Phang, S.-M., Shaharuddin, S., Noraishah, H., & Sasekumar, A. (1996). Studies on *Gracilaria changii* (*Gracilariales, Rhodophyta*) from Malaysian mangroves. *Hydrobiologia*, 326–327(1): 347–352.

Phang, S. (1984). Seaweed resources of Malaysia. *Wallaceana* (Malaysia).

Phang, S. M. (2006). Seaweed resources in Malaysia: Current status and future prospects. *Aquatic Ecosystem Health & Management*, 9(2): 185–202.

Phang, S. M., Lewmanomont, K. & Lim, P. E. (2008). Taxonomy of Southeast Asian Seaweeds (2nd ed.). Institute of Ocean and Earth Science (IOES), University of Malaya.

Phosri, C., Rodriguez, A., Sanders, I. R., & Jeffries, P. (2010). The role of mycorrhizas in more sustainable oil palm cultivation. *Agriculture, Ecosystems and Environment*, 135(3): 187–193.

Picman, A. K., Schneider, E. F., & Picman, J. (1995). Effect of flavonoids on mycelial growth of Verticillium albo-atrum. *Biochemical Systematics and Ecology*, 23(7–8): 683–693.

Plaza, M., Santoyo, S., Jaime, L., & Reina, G. G. (2010). Screening for bioactive compounds from algae. *Journal of Pharmaceutical and Biomedical Analysis*, 51(2): 450–455.

Pohl, C. H., Kock, J. L. F., & Thibane, V. S. (2011). Antifungal free fatty acids: a review. *Science against Microbial Pathogens: Current Research and Technological Advances*, 1(February): 61–71.

Prabha, V., Prakash, D. J., & Sudha, P. N. (2013). Analysis of bioactive compounds an antimicrobial activity of marine algae *Kappaphycus alvarezii*. *International Journal of Pharmaceutical Sciences and Research*, 4(1): 306–310.

Pramanick, P., Zaman, S., & Mitra, A. (2014). An International peer review e-3 journal of sciences section D: Environmental Sciences A review on tropical seaweed diversity. *Journal of Chemical, Biological and Physical Sciences*, 4(January 2016): 3909–3920.

Rajasulochana, P., Krishnamoorthy, P., & Dhamotharan, R. (2013). An investigation on the antioxidants, antifungal and antibacterial of the *Kappaphycus alvarezii*. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 4(1): 586–594.

Ranganayaki, P., Susmitha, S., & Vijayaraghavan, R. (2014). Study on metabolic compounds of *Kappaphycus alvarezii* and its *in-vitro* analysis of anti-inflammatory activity. *International Journal of Current Research and Academic Review*, 2(10): 157–166.

Rao, A. K. (1991). Basal stem rot 'Ganoderma' problem in oil palm smallholdings-the West Johor experience. In *Proceedings of Ganoderma workshop, Bangi, Selangor, Malaysia, 11 September 1990.* (pp. 36-48). Palm Oil Research Institute of Malaysia.

Rees, R. W., Flood, J., Hasan, Y., Potter, U., & Cooper, R. M. (2009). Basal stem rot of oil palm (*Elaeis guineensis*); Mode of root infection and lower stem invasion by *Ganoderma boninense*. *Plant Pathology*, 58(5): 982–989.

Rees, R. W., Flood, J., Hasan, Y., Wills, M. A., & Cooper, R. M. (2012). *Ganoderma boninense* basidiospores in oil palm plantations: Evaluation of their possible role in stem rots of *Elaeis guineensis*. *Plant Pathology*, 61(3): 567–578.

Renault, S., De Lucca, A. J., Boue, S., Bland, J. M., Vigo, C. B., & Selitrennikoff, C. P. (2003). CAY-I, a novel antifungal compound from cayenne pepper. *Medical mycology*, *41*(1): 75-82.

Richter, D. L., & Glaeser, J. A. (2015). Wood decay by Chlorociboria aeruginascens (Nyl.) Kanouse (*Helotiales, Leotiaceae*) and associated basidiomycete fungi. *International Biodeterioration and Biodegradation*, 105: 239–244.

Roslan, A., & Idris, A. S. (2012). Economic impact of *Ganoderma* incidence on Malaysian oil palm plantation – A Case Study in Johor. *Oil Palm Industry Economic Journal*, 12(1): 24–30.

Rostagno, M. A., & Prado, J. M. (2013). Natural product extraction: principles and applications. *Royal Society of Chemistry*, 351–372.

Rouphael, Y., De Micco, V., Arena, C., Raimondi, G., Colla, G., & De Pascale, S. (2017). Effect of *Ecklonia maxima* seaweed extract on yield, mineral composition, gas exchange, and leaf anatomy of zucchini squash grown under saline conditions. *Journal of Applied Phycology*, 29(1): 459–470.

Rozlianah, F. S., Jualang, A. G., & Chong, K. P. (2015). Fatty acids and Phenols Involved in Resistance of oil palm to *Ganoderma boninense*. *Advances in Environmental Biology*, 9(7): 11–16.

Ruibal, C., Platas, G., & Bills, G. F. (2005). Isolation and characterization of melanized fungi from limestone formations in Mallorca. *Mycological Progress*, *4*(1): 23-38.

Sahebi, M., Hanafi, M. M., van Wijnen, A. J., Akmar, A. S. N., Azizi, P., Idris, A. S., Foroughi, M. (2017). Profiling secondary metabolites of plant defence mechanisms and oil palm in response to *Ganoderma boninense* attack. *International Biodeterioration and Biodegradation*, 122: 151–164.

Sahebi, M., Hanafi, M. M., Wong, M. Y., Idris, A. S., Azizi, P., Jahromi, M. F., ... & Mohidin, H. (2015). Towards immunity of oil palm against Ganoderma fungus infection. *Acta physiologiae plantarum*, *37*(10): 195.

Sahri, M. M., & Dian, N. L. H. M. (2011). Formulation of trans-free and low saturated margarine. *Journal of Oil Palm Research*, 23(April); 958–967.

Saidani, K., Bedjou, F., Benabdesselam, F., & Touati, N. (2012). Antifungal activity of methanolic extracts of four Algerian marine algae species. *African Journal of Biotechnology*, 11(39): 9496–9500.

Sanderson, F., & Pilotti, C. (1997). Ganoderma basal stem rot: an enigma, or just time to rethink and old problem? *Planter*, 73(858): 489–493.

Sang, M. K., Kim, J. Do, Kim, B. S., & Kim, K. D. (2011). Root treatment with rhizobacteria antagonistic to *Phytophthora Blight* affects anthracnose occurrence, ripening, and yield of pepper fruit in the plastic house and field. *Phytopathology*, 101(6): 666–678.

Sang, M. K., Kim, J.-G., & Kim, K. D. (2010). Biocontrol activity and induction of systemic resistance in pepper by compost water extracts against *Phytophthora capsici*. *Phytopathology*, 100(8): 774–783.

Sanjeewa, K. K. A., Fernando, I. P. S., Kim, E. A., Ahn, G., Jee, Y., & Jeon, Y. J. (2017). Anti-inflammatory activity of a sulfated polysaccharide isolated from an enzymatic digest of brown seaweed *Sargassum horneri* in RAW 264.7 cells. *Nutrition Research and Practice*, 11(1): 3–10.

Sanjeewa, K. K. A., Fernando, I. P. S., Kim, S. Y., Kim, H. S., Ahn, G., Jee, Y., & Jeon, Y. J. (2018). *In vitro* and *in vivo* anti-inflammatory activities of high molecular weight sulfated polysaccharide; containing fucose separated from *Sargassum horneri*: Short communication. *International Journal of Biological Macromolecules*, 107(PartA): 803–807.

Santoso, H., Gunawan, T., Jatmiko, R. H., Darmosarkoro, W., & Minasny, B. (2011). Mapping and identifying basal stem rot disease in oil palms in North Sumatra with QuickBird imagery. *Precision Agriculture*, 12(2): 233–248.

Sardari, S., Csizmadia, F., Wiebe, L. I., Knaus, E. E., Parang, K., & Daneshtalab, M. (2006). Synthesis and antifungal activities of myristic acid analogs. *Archiv Der Pharmazie*, 329(11): 475–482.

Sasidharan, S., Chen, Y., Saravanan, D., Sundram, K. M., & Yoga Latha, L. (2011). Extraction, isolation and characterization of bioactive compounds from plants' extracts. *African Journal of Traditional, Complementary and Alternative Medicines*, 8(1): 1–10.

Saviranta, N. M. M., Julkunen-Tiitto, R., Oksanen, E., & Karjalainen, R. O. (2010). Leaf phenolic compounds in red clover (*Trifolium pratense L*.) induced by exposure to moderately elevated ozone. *Environmental Pollution*, 158(2): 440–446.

Schmitz, H. (1930). Poisoned food technique. *Industrial and Engineering Chemistry-Analytical Edition*, 2(4): 361–363.

Schwarze, F. W. M. R., Jauss, F., Spencer, C., Hallam, C., & Schubert, M. (2012). Evaluation of an antagonistic *Trichoderma* strain for reducing the rate of wood decomposition by the white rot fungus *Phellinus noxius*. *Biological Control*, 61(2): 160–168.

Seidel, V., & Taylor, P. W. (2004). In vitro activity of extracts and constituents of Pelagonium against rapidly growing mycobacteria. *International journal of antimicrobial agents*, *23*(6): 613-619.

Sharma, N., & Tripathi, A. (2008). Effects of *Citrus sinensis*(*L*.) *Osbeck* epicarp essential oil on growth and morphogenesis of *Aspergillus niger*(*L*.) *Van Tieghem*. *Microbiological Research*, 168: 337–344.

Shimabukuro, H., Miyamoto, N., & Hamaguchi, M. (2013). Morphology and distribution of *Sargassum oligocystum* (*Fucale, Phaeophyceae*) in the Ryukyu Islands, Japan. *Journal of Japanese Botany*, 88(2): 94–102.

Shobier, A. H., Abdel Ghani, S. A., & Barakat, K. M. (2016). GC/MS spectroscopic approach and antifungal potential of bioactive extracts produced by marine macroalgae. *Egyptian Journal of Aquatic Research*, 42(3): 289–299.

Silva, F., Ferreira, S., Duarte, A., Mendona, D. I., & Domingues, F. C. (2011). Antifungal activity of *Coriandrum sativum* essential oil, its mode of action against *Candida* species and potential synergism with amphotericin B. *Phytomedicine*, 19(1), 42–47.

Situmorang, E. C., Prameswara, A., Sinthya, H. C., Mathius, N. T., & Liwang, T. (2013). Morphology and histology identification of fungal endophytes from oil palm roots in *Ganoderma boninense* endemic area. *Microbiology Indonesia*, 7(4): 198–204.

Soares, F., Fernandes, C., Silva, P., Pereira, L., & Goncalves, T. (2016). Antifungal activity of carrageenan extracts from the red alga *Chondracanthus teedei* var. *lusitanicus*. *Journal of Applied Phycology*, 28(5): 2991–2998.

Soković, M. (2001). *Antifungal activities of essential oils of selected aromatic and medicinal plants in vitro and in vivo* (Doctoral dissertation, Ph. D. Thesis, Faculty of Biology, University of Belgrade: Belgrade: Yugoslavia).

Spinelli, F., Noferini, M., & Costa, G. (2006). Near infrared spectroscopy (NIRs): Perspective of fire blight detection in asymptomatic plant material. *Acta Horticulturae*, 704(704): 87–90.

Stein, E. M., Colepicolo, P., Afonso, F. A. K., & Fujii, M. T. (2011). Screening for antifungal activities of extracts of the Brazilian seaweed genus *Laurencia* (*Ceramiales, Rhodophyta*). *Brazilian Journal of Pharmacognosy*, 21(2), 290–295.

Stengel, D. B., & Connan, S. (2015). Natural products from marine algae. *Springer*.

Sundram, S., Meon, S., Seman, I. A., & Othman, R. (2015). Application of arbuscular mycorrhizal fungi with *Pseudomonas aeruginosa* UPMP3 reduces the development of *Ganoderma* basal stem rot disease in oil palm seedlings. *Mycorrhiza*, 25(5): 387–397.

Supramaniam, C. V. (2016, July 23). Molecular interaction between *Ganoderma boninense* and young oil palm. *School of Biosciences*.

Suryanto, D., Wibowo, R. H., Siregar, E. B. M., & Munir, E. (2012). A possibility of chitinolytic bacteria utilization to control basal stems disease caused by Ganoderma boninense in oil palm seedling. *African Journal of Microbiology Research*, *6*(9): 2053-2059.

Susanto, A. (2009). Basal stem rot in Indonesia. Biology, economic importance, epidemiology, detection and control. In Proceedings of International Workshop on Awareness, Detection and Control of Oil Palm Devastating Diseases. Kuala Lumpur Convention Centre. Universiti Putra Malaysia Press, Malaysia. 2009.

Susanto, A., Sudharto, P. S., & Purba, R. Y. (2005). Enhancing biological control of basal stem rot disease (*Ganoderma boninense*) in oil palm plantations. *Mycopathologia* 159: 153–157.

Švecová, E., Colla, G., & Crinò, P. (2016). Antifungal activity of *Boerhavia diffusa L.* extract against *Phytophthora spp*. in tomato and pepper. *European Journal of Plant Pathology*, 1–8.

Svetaz, L., Tapia, A., López, S. N., Furlán, R. L. E., Petenatti, E., Pioli, R., & Zacchino, S. A. (2004). Antifungal chalcones and new caffeic acids esters from *Zuccagnia punctata* acting against soybean infecting fungi. *Journal of Agricultural and Food Chemistry*, 52(11): 3297–3300.

Talley, L. D., Pickard, G. L., Emery, W. J., & Swift., J. H. (2011). Ocean dimensions, shapes, and bottom materials. *Descriptive Physical Oceanography*, 7–27.

Talreja, S. (2018). Evaluation of methanolic extract of seaweed *Ulva lactuca* against resistant pathogenic fungal and microbial strains. *Papirex Indian Journal of Research*, 6(2).

Tanduyan, S., Gonzaga, R., & Bensig, V. (2013). Off bottom culture of *Caulerpa lentillifera* in three different water levels in the marine waters of San Francisco, Cebu, Philippines. *Journal of Coral Reef Studies*, 15(Supplement): 123–132.

Tay, Z. H., & Chong, K. P. (2016). The potential of papaya leaf extract in controlling *Ganoderma boninense*. *IOP Conference Series: Earth and Environmental Science*, 36, 1–7.

Thenu, T. (1997). A taxonomic study of seaweeds of North Sulawesi, Indonesia. Universitas Pattimura, Ambon, Indonesia.

Thompson, A. (1931). Stem-rot of the oil palm in Malaya. Bull. *Department Agric., Straits Settlements and FMS. Sci.* Series 6.

Torres, G. A., Sarria, G. A., Martinez, G., Varon, F., Drenth, A., & Guest, D. I. (2016). Bud rot caused by *Phytophthora palmivora*: A destructive emerging disease of oil palm. *Phytopathology*, 106(4): 320–329.

Upgade, A., & Bhaskar, A. (2013). Characterization and medicinal importance of phytoconstituents of *Carica papaya* from down south Indian region using gas chromatography and mass spectroscopy. *Asian Journal of Pharmaceutical and Clinical Research*, 6(SUPPL.4): 101–106.

Utomo, C., & Niepold, F. (2000). The development of diagnostic tools for *Ganoderma* in oil palm. *Ganoderma diseases of perennial crops. Wallingford*: CABI, 12: 235-247.

Van Bruggen, A., Gamliel, A., & Finckh, M. (2016, January 1). Plant disease management in organic farming systems. Pest Management Science. *John Wiley & Sons, Ltd*.

Verlaque, M., Boudouresque, C. F., Meinesz, A., & Gravez, V. (2000). The *Caulerpa racemosa* complex (*Caulerpales, Ulvophyceae*) in the Mediterranean Sea. *Botanica Marina*, 43(1): 49–68.

Vinodkumar, S., Indumathi, T., & Nakkeeran, S. (2017). *Trichoderma asperellum* (NVTA2) as a potential antagonist for the management of stem rot in carnation under protected cultivation. *Biological Control*, 113: 58–64.

Vinoth, S., Gurusaravanan, P., Sivakumar, S., & Jayabalan, N. (2019). Influence of seaweed extracts and plant growth regulators on in vitro regeneration of *Lycopersicon esculentum* from leaf explant. *Journal of Applied Phycology*, 1–14.

Virdiana, I., Hasan, Y., Aditya, R., & Flood, J. (2010). Testing the effects of oil palm replanting practices (windrowing, fallowing and poisoning) on incidence of *Ganoderma*. *Proceeding of The International Oil Pollution Compensation*, (2): 7.

Wang, G., Sun, J., Liu, G., Wang, L., Yu, J., Liu, T., & Wu, S. (2014). Comparative analysis on transcriptome sequencings of six Sargassum species in China. *Acta Oceanologica Sinica*, 33(2): 37–44.

Wei, Q. S., Aizat, M. F., Diyanti, A., Ishak, W. M. F., Salleh, H., Wong, K. N. S. W. S., & Adli, H. K. (2019). *Kappaphycus alvarezii* sp., *Sargassum polycystum* sp. and *Manihot esculenta* sp. as photo-sensitizers in dye-sensitized solar cells. *AIP Conference Proceedings*, (p. 020028).

Wijesinghe, W. A. J. P., & Jeon, Y. J. (2012). Enzyme-assistant extraction (EAE) of bioactive components: A useful approach for recovery of industrially important metabolites from seaweeds: A review. *Fitoterapia* 83(1), 6-12.

Wong, C. L., & Phang, S. M. (2004). Biomass production of two *Sargassum* species at Cape Rachado, Malaysia. Asian Pacific Phycology in the 21st Century: Prospects and Challenges Dordrecht: *Springer Netherlands*, 79-88.

Wong, L. C., Bong, C. F. J., & Idris, A. S. (2012). *Ganoderma* species associated with basal stem rot disease of oil palm. *American Journal of Applied Sciences*, 9(6): 879–885.

Wuyts, N., De Waele, D., & Swennen, R. (2006). Extraction and partial characterization of polyphenol oxidase from banana (*Musa acuminata Grande naine*) roots. *Plant Physiology and Biochemistry*, 44(5–6): 308–314.

Yip, W. H., Joe, L. S., Mustapha, W. A. W., Maskat, M. Y., & Said, M. (2014). Characterisation and stability of pigments extracted from *Sargassum binderi* obtained from Semporna, Sabah. *Sains Malaysiana*, 43(9): 1345–1354.

Yoshie, Y., Wang, W., Hsieh, Y., & Suzuki, T. (2002). Compositional difference of phenolic compounds between two seaweeds, *Halimeda spp. Tokyo University of Fisheries*, 88: 21–24.

Yu, G., & Chong, K. (2018). Selected biomarkers from oil palm-*Ganoderma* infected tissues for detection of basal stem rot disease. *WMSU Reseacrh Journal*, (37): 1–13.

Zahazi M, W., & Alimon, A. R. (2004). Use of palm kernel cake and oil palm bay products in compound feed. *Palm Oil Developments*, 40(March 2015): 5–9.

Zain, N., Seman, I. A. B. U., Kushairi, A., & Ramli, U. M. I. S. (2013). Metabolite profiling of oil palm towards understanding basal stem rot (BSR) disease. *J. Oil Palm Res*, *25*(1): 58-71.

Zakaria, N. A., Ibrahim, D., Shaida, S. F. & Supardy, N. A. (2011). Phytochemical composition and antibacterial potential of hexane extract from malaysian red algae, *Acanthophora spicifera* (*Vahl*) *Borgesen*. *World Applied Science Journal*, 4(14): 496–501.

Zaneveld, J. S. (1959). The utilization of marine algae in tropical South and East Asia. *Economic Botany*, 13(2): 89–131.

Zare-Shehneh, M., Askarfarashah, M., Biosci, L. E.-I. J., & 2014, U. (2014). Biological activities of a new antimicrobial peptide from *Coriandrum sativum*. *International Journal of Biosciences (IJB)*, 4(6): 89–99.

Zawawi, M. H., Idris, M. H., Kamal, A. H. M., & King, W. S. (2015). Taxonomic assessment of seaweed community from the coastal areas of Bintulu, Sarawak, Malaysia. *Songklanakarin Journal of Science and Technology*, 37(2): 147–153.

Zubia, M., Payri, C., & Deslandes, E. (2008). Alginate, mannitol, phenolic compounds and biological activities of two range-extending brown algae, *Sargassum mangarevense* and *Turbinaria ornata* (*Phaeophyta: Fucales*), from Tahiti (French Polynesia). *Journal of Applied Phycology*, 20(6): 1033–1043.

Zuldin, W., Shaleh, S., & Shapawi, R. (2019). Growth, biomass yield, and proximate composition of sea vegetable, *Caulerpa macrodisca* (*Bryopsidales, Chlorophyta*) cultured in tank. *Philippine Journal of Science*, 148(1): 1–6.