UNIVERSITI PUTRA MALAYSIA

ASSESSMENT ON DIVERSITY AND BIOACTIVE COMPOUNDS PRESENT IN ENDOPHYTIC FUNGI ISOLATED FROM Rhizophora mucronata IN MATANG MANGROVE FOREST RESERVE, PERAK, MALAYSIA

TUAN NORAIDA TUAN HAMZAH

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By

TUAN NORAIDA TUAN HAMZAH

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

April 2018

DEDICATION

In the name of Allah S.W.T., the most Benevolent and ever Merciful
All praise be to Allah S.W.T.

Specially dedicated to:

My Parents

TUAN HAMZAH SAYED MOHD & TENGKU SUPIAH TENGKU BUANG

My Siblings

TUAN SARIF TUAN HAMZAH
TUAN SHARIFATUL MUZLIM TUAN HAMZAH
TUAN SHARIHAZIL TUAN HAMZAH
TUAN SHAHRIHAIRUL AMI TUAN HAMZAH
TUAN SHARIFAH NURHAFISAH TUAN HAMZAH
TUAN SARIFAH SAHARIAH TUAN HAMZAH
SAYED HASSAN BASRI TUAN HAMZAH
SAYED KHALIL KHUSAIRI TUAN HAMZAH

My Fiancée

MUHAMMAD AMIRUL SHAFIQ ZAINAL SHAH

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

ASSESSMENT ON DIVERSITY AND BIOACTIVE COMPOUNDS PRESENT IN ENDOPHYTIC FUNGI ISOLATED FROM *Rhizophora mucronata* IN MATANG MANGROVE FOREST RESERVE, PERAK, MALAYSIA

By

TUAN NORAIDA BINTI TUAN HAMZAH

April 2018

Chairman : Prof. Rozi Mohamed, PhD
Faculty : Forestry

Rhizophora mucronata is an important ecosystem entity of the Malaysian mangrove forest. Because the tree grows in an extreme environment, any organism that is isolated from this tree is of huge interest due to its potential in having novel bioactive compounds. This study aimed to assess endophytic fungal diversity isolated from mangrove plant, *R*. *mucronata*, to evaluate the bioactivities exhibited by selected fungal endophytes, and to isolate and identify compounds associated with the selected endophytic fungi extracts. In the present work, a total of 78 fungal isolates were isolated, identified and characterized from the leaf tissues of *R. mucronata*. All strains were identified using primer internal transcribed spacer 1 (ITS1) and internal transcribed spacer 4 (ITS4). The DNA sequences of the strains recorded high similarities to their respective species in the GenBank. Phylogenetic trees were constructed and analyzed using Maximum Likelihood (ML) criteria together with 78 mangrove endophytic fungal sequences and 117 additional sequences of fungal species incorporated from the GenBank. Most of the dominating fungal endophytes were from the genus *Pestalotiopsis*, followed by *Alternaria* and *Cladosporium*. Six isolates representing the genera *Alternaria*, *Fusarium*, *Nigrospora*, *Pestalotiopsis*, *Phoma*, and *Xylaria*, were screened for their antagonism activities. The antagonism tests were evaluated through dual culture and non-volatile compound assay. Dual culture test assay revealed their inhibition percentages against the phytopathogenic fungus *Fusarium solani* between 49-69%, and 1-25% when using non-volatile test assay. The fungal isolates were further screened for their antibacterial activities against four pathogenic bacteria, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. Of the six isolates, only *Fusarium lateritium* and *Xylaria* sp. showed antibacterial activities against tested bacteria, with the Minimum Inhibitory Concentration

(MIC) and Minimum Bactericidal Concentration (MBC) ranging from 0.5 to 2 mg/mL. The 1,1-diphenyl-2-picrylhydrazyl(DPPH) radical scavenging assay recorded antioxidant activity in *Xylaria* sp. with 3-fold higher when compared to *F. lateritium*.

The chemical constituents of *F. lateritium* and *Xylaria* sp. were determined via Gas Chromatography (GC) with Mass Spectrometry (MS) and Flame Ionization Detector (FID). These two fungal species were chosen based on their positive activities in several assays conducted in the previous section before, including, antagonism, antibacterial and antioxidant assay. Overall, 69 compounds were identified from ethyl acetate and hexane extracts of *F. lateritium* and *Xylaria* sp..Compounds such as phenylethyl alcohol, phenylacetic acid, cetene, and 2,4-Ditert-butylphenol, were commonly found in all the extracts of both fungal species. Variations of constituents were found in all extracts for both fungal isolates. Hexane extracts of *F. lateritium* and *Xylaria* sp. both recorded a greater variation in chemicals identified. While there were almost similar compounds identified from ethyl acetate extracts of both fungal isolate. Evaluation on the biological activities exhibited by *F. lateritium* and *Xylaria* sp. before, with the presence of these compounds, proved that these two fungal isolates have great potential as antimicrobial agents. Screening the endophytic fungal community associated with *Rhizophora mucronata*, and bioactivities exhibited by the selected isolates has proved that mangroves endophytic fungi could be a potential source in finding the bio-control agent and another important source for vital bioactive compounds.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGUKURAN DALAM KEPELBAGAIAN KULAT ENDOFITIK DAN BIOAKTIF KOMPAUN YANG BERSEKUTU DENGAN *Rhizophora mucronata* DI HUTAN SIMPAN PAYA BAKAU MATANG, PERAK, MALAYSIA

Oleh

TUAN NORAIDA BINTI TUAN HAMZAH

April 2018

Pengerusi : Prof. Rozi Mohamed, PhD
Fakulti : Perhutanan

Rhizophora mucronata adalah entiti ekosistem penting di hutan bakau Malaysia. Oleh kerana pokok bakau ini tumbuh dalam persekitaran yang melampau, mana-mana organisma yang dipencilkan daripada pokok ini mempunyai kepentingan yang besar kerana ia berpotensi dalam menghasilkan kompaun bioaktif yang baru. Kajian ini bertujuan untuk mengakses diversiti kulat endofitik yang di pencilkan dari pokok bakau, *R. mucronata*, untuk mengenal pasti aktiviti biologi yang dihasilkan oleh kulat endofitik yang terpilih, dan juga untuk mengenalpasti kompaun kimia yang terdapat di dalam ekstrak kulat endofitik tersebut. Dalam kajian ini, sejumlah 78 kulat telah dipencilkan daripada tisu daun *R. mucronata* dan diidentifikasi. Semua pencilan telah dikenal pasti dengan menggunakan pencetus penjarak jujukan dalam 1 (ITS1) dan penjarak jujukan dalam 4 (ITS4). Jujukan DNA daripada pencilan yang direkodkan mempunyai persamaan tinggi dengan spesies masing-masing dalam pangkalan data GenBank. Pokok filogenetik telah dibina dan dianalisis menggunakan kriteria *Maximum Likelihood* (ML) bersama-sama dengan 78 jujukan kulat endofitik paya bakau dan 117 jujukan jujukan kulat tambahan dari GenBank. Sebahagian besar kulat endofitik didominasi oleh genus *Pestalotiopsis*, diikuti oleh *Alternaria* dan *Cladosporium*. Enam pencilan mewakili genus *Alternaria*, *Fusarium*, *Nigrospora*, *Pestalotiopsis*, *Phoma* dan *Xylaria*, selanjutnya disaring untuk aktiviti antagonis. Aktiviti antagonis setiap kulat di akses melalui ujian dwikultur dan juga ujian tidak meruap. Ujian dwikultur telah mempamerkan peratusan perencatan terhadap kulat patogenik *Fusarium solani* di antara 49-69%, dan 1-25% apabila menggunakan ujian tidak meruap. Daripada enam pencilan, hanya *Fusarium lateritium* dan *Xylaria* sp. menunjukkan aktiviti antibakteria terhadap bakteria patogenik, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa* dan *Staphylococcus aureus*, dengan

Kepekatan Minimum Perencatan (MIC) dan Kepekatan Minimim Bakteria (MBC) yang terdiri daripada 0.5-2 mg/mL. Ujian (*1,1-diphenyl-2-picrylhydrazyl*) DPPH radikal memerangkap mencatatkan aktiviti antioksidan dalam *Xylaria* sp. sebagai 3 kali ganda lebih tinggi berbanding *F*. *lateritium*. Dua kulat endofitik, *F*. *lateritium* dan *Xylaria* sp. telah menunjukkan aktiviti dalam pelbagai ujian yang dijalankan dengan pelbagai reaksi.

Konstituen kimia dua spesies kulat endofitik telah ditentukan melalui Gas Chromatography (GC) dengan Mass Spektrometri (MS) dan Flame Pengionan Detector (FID). Kedua-dua spesies kulat ini dipilih kerana aktiviti positif mereka dalam beberapa ujian yang telah dijalankan sebelum ini, termasuk ujian antagonis, antibakteria dan antioksidan. Secara keseluruhan, 69 kompaun telah dikenal pasti daripada ekstrak etil asetat dan heksana *F*. *lateritium* dan *Xylaria* sp.. Kompaun seperti *phenylethyl alcohol*, *phenylacetic acid*, *cystiene*, *cetene* and *2,4-Ditert-butylphenol*, telah ditemui dalam ekstrak kedua-dua spesies kulat. Kedua-dua ekstrak heksana *F. lateritium* dan *Xylaria* sp., telah merekodkan lebih banyak kepelbagaian dalam kompaun kimia yang dikenal pasti. Walaubagaimanapun, untuk ekstrak etil asetat, sebatian yang telah dikenal pasti daripada kedua-dua isolat kulat adalah hampir sama. Penilaian mengenai aktiviti biologi yang dipamerkan oleh *F. lateritium* dan *Xylaria* sp. dalam seksyen sebelum ini, dan juga dengan pengenalpastian kompaun-kompaun penting seperti ini, membuktikan bahawa dua ekstrak kulat tersebut mempunyai potensi yang besar sebagai antimikrob. Saringan komuniti endofitik kulat yang terdapat di dalam tisu daun *R*. *mucronata* dan bioaktiviti yang dipamerkan oleh pencilan yang dipilih membuktikan bahawa kulat endofitik yang dipencilkan dari pokok bakau boleh menjadi satu sumber dalam pencarian agen kawalan biologi. Selain itu, ia juga penting bagi tujuan pengekstrakan kompaun-kompaun yang mempunyai aktiviti anti-mikrobial.

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I certify that a Thesis Examination Committee has met on 6 April 2018 to conduct the final examination of Tuan Noraida Tuan Hamzah on her thesis entitled "Assessment on Diversity and Bioactive Compounds Present in Endophytic Fungi Isolated from *Rhizophora mucronata* in Matang Mangrove Forest Reserve, Perak, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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

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- the research conducted and the writing of this thesis was under our supervision;
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Signature: _____
Name of Chairman of Supervisory Committee: Prof. Dr. Rozi Mohamed

Signature: _____
Name of Member of Supervisory Committee: Dr. Razak Terhem

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A	Alpha
B	Beta
ha	Hectare
km	Kilometer
^{O}C	Degree Celcius
µg	Microgram
µL	Microliter
µM	Micromolar
mM	Millimolar
ng	Nanogram
PCR	Polymerase Chain Reaction
µm	Micrometre
MMFR	Matang Mangrove Forest Reserve
CCD	Charged Couple Device
dbh	Diameter at breast height
DNA	Deoxyribonucleic acid
RNA	Ribonucleic acid
E	East
EV	Electric vehicle
FID	Flame ionization detector
G	Gram
GC	Gas Chromatography
H	Hour
ITS	Internal Transcribed Spacer

M	Metre
Mg	Milgram
Min	Minute
ML	Maximum likelihood
GTR	General time reversible
G+I	Gamma distributed with invariant sites
mL	Millilitre
MS	Mass spectrometry
NCBI	NationalCentre for Biotechnology Information
MIC	Minimum Inhibitory Concentration
MBC	Minimum Bactericidal Concentration
DPPH	1,1-diphenyl-2-picrylhydrazyl
NaOCl	Sodium hypochlorite
BSV	Bootstrap value
PEA	Phenylethyl alcohol
DTBP	2,4-Ditert-butylphenol
FORDIA	Forest Research, Development and Innovation Agency
Rpm	Revolutions per minute
RI	Retention index
UPM	Universiti Putra Malaysia
IBS	Institute of Bioscience

CHAPTER 1

INTRODUCTION

1.1 General

Fungal species identification is estimated to have reached up to 1.5 million fungal species (Hawksworth, 2004), and of these, only 7% were being identified (Schmit and Muller, 2007). Of these values, marine fungal species constituted roughly about 1,500, since it was last recorded by Hyde et al. (1998) which excluded lichens and also many more fungi that are not yet fully described (Thatoi *et al*., 2013). These values, however, are increasing annually, since most researchers are starting to realize how vital it is to discover the undiscovered. Different areas, or regions might provide the researchers with varies fungal distribution. This is due to fungal behaviors which sometimes can be selective towards specific niches and ecosystem. Despite the limited information available on these fungal species, hints that captured by most researchers are, it is vital for them to investigate more on the fungal diversity, hoping to discover novel fungal species from the various niche (de Souza Sebastianes *et al*., 2013). The variety of fungal species might render different benefits. Thus, this makes it an important task for the researchers in investigating the fungal diversity and abundance, but also the bioactive compounds they potentially produced. Previously, high numbers of described metabolites have been linked to the investigation of the terrestrial sources of where the fungi have been isolated (Bugni and Ireland, 2004). Therefore, natural products chemists and pharmacologists have diverted their attention from studying typical areas to areas that were less investigated. Examples of such scarcely explored niches that might offer a significant amount of unprecedented bioactive compounds are ecological areas such as oceans and rainforest such as mangroves. Mangroves are unique intertidal forest wetlands formed at the interface between land and sea which typically occurred in tropical and sub-tropical latitudes with diverse organisms. The global extent of mangroves are 152, 360 km2, with 51,050 km2 of them are from Southeast Asia (Spalding, 2010). In Southeast Asia, Indonesia harbored the most mangroves with 31,890 km2 coverage. While Malaysia ranked second with 580,000 ha of mangroves (34,000 ha are in Sabah, 140,000 ha in Sarawak, and 100,000 ha in Peninsular Malaysia). Mangrove forests protect coastlines from wave action and prevent coastal erosion, besides reducing damages inland caused by storms. They are well adapted to their extreme environmental conditions of high salinity, fluctuations in sea level, high temperatures and anaerobic soils, through pneumatophores roots, salt excreting leaves and viviparous water dispersed propagules. Not only mangrove plants but organisms including fungi, inhabiting the environment will also have to adapt in their own ways to survive the harsh conditions of the mangroves. Out of a large number of

estimated fungal species, Hyde listed 120 fungal species, originated from 29 mangroves around the globe (Hyde, 1990). These included 87 Ascomycetes, 31 Deuteromycetes, and 2 Basidiomycetes. Up to the year 1995, 169 species of fungi have been described to be isolated from Malaysian mangroves (Alias *et al*., 1995). Fungi adapted themselves with the environment by altering their metabolic pathways and producing unique secondary metabolites that may help them to survive the conditions (Ronsberg *et al*. 2013). These facts make endophytic fungus isolated from such environment as a promising target in the search for novel secondary metabolites (Debbab *et al*. 2012).

Secondary metabolites are produced resulting from the modification and combinations of reactions from primary metabolic pathways (Roopa *et al*., 2015). These bioactive compounds commonly found in various plant species despite different genera or family, and various metabolites can be expressed from a single species under different environmental conditions (Shukla *et al*., 2014). The commonly distributed metabolite groups are alkaloids, polyketides, terpenes, and steroids (Roopa *et al*., 2015). There were a tremendous number of significant bioactive compounds that have been extracted from the plants, for example, taxol or paclitaxel which was extracted from *Taxus brevifolia* (Zhao *et al*., 2010). Taxol is a chemical substance that has been widely used as anticancer drugs and also effective against non-cancerous conditions like the polycystic kidney disease (Zhou *et al*., 2010; Malik *et al*., 2011). Taxol extraction from the tree of *T*. *brevifolia* has been limited due to several factors such as the slow-growing of Taxus tree, low yield of taxol production from Taxus tree, besides may cause death to the tree, due to the removal of the Taxus barks (Rooppa *et al*., 2015). This limitation has caused researchers to find the alternative method for isolating compounds like taxol and other bioactive compounds (Roopa *et al*., 2015) from organisms such as bacteria and fungi.

Endophytic fungi isolated from mangroves have illustrated its ability in producing tremendous novel bioactive compounds (Elavarasi *et al*., 2012). They were proved to be a potential reservoir of natural compounds with a vital pharmacological activity that could be an advantage in the development of novel medicinal agents (Zhang *et al*., 2006). There are more than 200 endophytic fungal species that have been successfully isolated and identified from mangrove plants and have been demonstrated to be a well-established source for structurally diverse and biologically active secondary metabolites (Pang and Mitchell, 2005; Li *et al*., 2009). These endophytic fungi carry a vital role as potential biological control agents, sources of novel compounds for disease treatment and crop protection. Many have reported that novel secondary metabolites that were extracted from mangrove fungi are widely used in the pharmaceutical industry as primary compounds for several drugs includes antiviral, anticancer, antibiotic and immunosuppressive drugs (Blunt *et al*., 2013). Generally, the production of secondary metabolites that are potentially useful for pharmaceutical and agricultural applications is wide-ranging among mangroves endophytic fungi (Maria *et al*., 2005). There were

a variety of chemical entities with unique structures and potent bioactivities have been isolated from mangrove endophytic fungi and suggested to have a high potential to be exploited in various fields such as agriculture, medicine and industrial field (Nithya and Muthumary, 2011). One interesting example is a compound that was extracted from unknown endophytic fungi, isolated from mangrove plant, *Kandelia candel* and was characterized as cyclic depsipeptide 1962A. The compound exhibited significant cytotoxic activities when tested against human breast cancer during MTT assay (Huang *et al*., 2007). While, in an investigative study performed by Lin et al. (2008), two polyketides that were extracted from endophytic fungi, *Penicillium* sp., which was previously isolated from a mangrove plant, *Aegiceras corniculatum*, also exhibited strong cytotoxic activity.

1.2 Problem Statement

In Matang Mangrove Forest Reserve (MMFR) Perak, in the year 2000-2009 working plan, the research needs including, evaluating the economic viability of using stumps for charcoal purposes, the impact of agricultural bunds on mangrove vegetation, and floristic diversity and conservation. While in the present working plan of 2010-2019, the management has recommended several new and additional research needs that shall be conducted in MMFR, including screening for pharmacological activities of mangrove plant species. Despite the million benefits own by the mangrove endophytic fungi, no studies on microorganisms particularly fungi associated with mangrove plant have been performed in MMFR. Matang Mangrove Forest Reserve is known as the best-managed mangrove forest. However, the organisms present in the environment is not well studied. Previous studies (de Souza Sebastianes *et al*., 2013; Li *et al*., 2016), have described that there was a variety of fungal diversity isolated from several mangrove species involving regions such as Brazil and China. While in Malaysia, there were only several studies investigating the organisms associated with mangrove species and its benefits. More research is needed in order to discover the potential of these mangrove endophytic fungi. Not only the genetic diversity of the isolated mangrove endophytic fungi but also the potential bioactivities that could be exhibited by the fungi. To date, only several studies on the mangrove endophytic fungi have been conducted in Malaysia particularly on the diversity and the production of bioactive compounds.

1.3 Justification

Matang Mangrove Forest Reserve is globally known as the best-managed mangrove forest. However, the organism documentation since the previous plan included only macro-organisms such as vegetations, faunas such as crabs and birds. While an ecosystem is made up of not only macro-organisms but microorganisms such as bacteria and fungi. Therefore, assessing the genetic diversity of mangroves endophytic fungi associated

with the mangrove plants could be used in establishing the diversity of organisms in MMFR. Along with the state forestry management work plan, to screen the pharmacological properties of the mangrove plant, this study will provide in-depth investigation focusing not only the mangrove plant but also organisms associated with the mangrove plant. Evaluating the biological activities potentially exhibited by the fungal endophytes could be a preliminary step in investigating the potential benefits owned by the mangroves endophytic fungi. Identification of chemical constituents of these mangrove endophytic fungi may prove that mangroves harbor not only variety of fungal species, but also fungal with diverse bioactive compounds.

1.4 Objectives

The general objective of this study was to assess the genetic diversity of mangrove endophytic fungi and its potential bioactivities isolated from mangrove plant, *Rhizophora mucronata*, from Matang Mangrove Forest Reserve (MMFR), Perak.

The specific objectives of this study include:

1. To assess the genetic diversity of mangrove's endophytic fungi isolated from the mangrove plant, *Rhizophora mucronata* by DNA sequencing of the ITS1 and ITS4 regions.
2. To evaluate potential bioactivities exhibited by selected endophytic fungal species via *in vitro* studies.
3. To determine the chemical constituents of the selected endophytic fungal species via GC-MS and GC-FID.

REFERENCES

Abbasi, A. M., Khan, M. A., Ahmad, M., Zafar, M., Khan, H., Muhammad, N., & Sultana, S. (2009). Medicinal plants used for the treatment of jaundice and hepatitis based on socio-economic documentation. *African Journal of Biotechnology*, 8(8).

Abdool-Gaffar, M. S., Ambaram, A., Ainslie, G. M., Bolliger, C. T., Feldman, C., Geffen, L., Nyamande, K. (2011). Guideline for the management of chronic obstructive pulmonary disease: 2011 update. *SAMJ: South African Medical Journal*, 101(1): 63-73.

Abraham, S., Basukriadi, A., Pawiroharsono, S., & Sjamsuridzal, W. (2015). Insecticidal activity of ethyl acetate extracts from culture filtrates of mangrove fungal endophytes. *Mycobiology*, 43(2): 137-149.

Ai, W., Wei, X., Lin, X., Sheng, L., Wang, Z., Tu, Z., & Liu, Y. (2014). Guignardins A–F, spirodioxynaphthalenes from the endophytic fungus *Guignardia* sp. KcF8 as a new class of PTP1B and SIRT1 inhibitors. *Tetrahedron*, 70(35): 5806-5814.

Aldeco-Pérez, E., Rudler, H., Parlier, A., Alvarez, C., Apan, M. T., Herson, P., & Toscano, A. (2006). A simple synthesis of cytotoxic endoperoxide lactones. *Tetrahedron letters*, 47(51): 9053-9056.

Aleksovski, S., Sovova, H., Ќurapova, B., & Poposka, F. (1998). *Supercritical CO2 extraction and Soxhlet extraction of grape seeds oil*.

Alias, S. A., Kuthubutheen, A. J., & Jones, E. B. G. (1995). Frequency of occurrence of fungi on wood in Malaysian mangroves. In *Asia-Pacific Symposium on Mangrove Ecosystems* (pp. 97-106). Springer Netherlands.

Al-Olayan, E. M., El-Khadragy, M. F., Aref, A. M., Othman, M. S., Kassab, R. B., & Abdel Moneim, A. E. (2014). The potential protective effect of *Physalis peruviana* L. against carbon tetrachloride-induced hepatotoxicity in rats is mediated by suppression of oxidative stress and downregulation of MMP-9 expression. *Oxidative medicine and cellular longevity*, *2014*.

Al-Reza, S. M., Rahman, A., & Kang, S. C. (2009). Chemical composition and inhibitory effect of essential oil and organic extracts of *Cestrum nocturnum* L. on food-borne pathogens. *International journal of food science & technology*, 44(6): 1176-1182.

Alwathnani, H. A., & Perveen, K. (2012). Biological control of *Fusarium* wilt of tomato by antagonist fungi and cyanobacteria. *African Journal of Biotechnology*, 11(5): 11001105.

Aly, A. H., Debbab, A., Kjer, J., & Proksch, P. (2010). Fungal endophytes from higher plants: a prolific source of phytochemicals and other bioactive natural products. *Fungal diversity*, 41(1): 1-16.

Aly, A. H., Debbab, A., & Proksch, P. (2011). Fungal endophytes: unique plant inhabitants with great promises. *Applied microbiology and biotechnology*, 90(6): 1829-1845.

Amann, R. I., Ludwig, W., & Schleifer, K. H. (1995). Phylogenetic identification and in situ detection of individual microbial cells without cultivation. *Microbiological reviews*, 59(1): 143-169.

An, C. Y., Li, X. M., Luo, H., Li, C. S., Wang, M. H., Xu, G. M., & Wang, B. G. (2013). 4-Phenyl-3, 4-dihydroquinolone derivatives from *Aspergillus nidulans* MA-143, an endophytic fungus isolated from the mangrove plant *Rhizophora stylosa*. *Journal of natural products*, 76(10): 1896-1901.

Ananda, K., & Sridhar, K. R. (2002). Diversity of endophytic fungi in the roots of mangrove species on the west coast of India. *Canadian Journal of Microbiology*, 48(10): 871 878.

Ananda, K., & Sridhar, K. R. (2004). Diversity of filamentous fungi on decomposing leaf and woody litter of mangrove forests in the southwest coast of India. *Current science,* 1431-1437.

Andreote, F. D., Jiménez, D. J., Chaves, D., Dias, A. C. F., Luvizotto, D. M., Dini-Andreote, F., & de Melo, I. S. (2012). The microbiome of Brazilian mangrove sediments as revealed by metagenomics. *PloS one*, 7(6): e38600.

Angel, L. P. L., Yusof, M. T., Ismail, I. S., Ping, B. T. Y., Azni, I. N. A. M., Kamarudin, N. H., & Sundram, S. (2016). An *in vitro* study of the antifungal activity of *Trichoderma virens* 7b and a profile of its non-polar antifungal components released against *Ganoderma boninense*. *Journal of Microbiology*, 54(11): 732-744.

Anitha, A., & Rabeeth, M. (2010). Degradation of fungal cell walls of phytopathogenic fungi by lytic enzyme of *Streptomyces griseus*. *African Journal of Plant Science*, 4(3): 061-066.

Arnold, A. E., Maynard, Z., & Gilbert, G. S. (2001). Fungal endophytes in dicotyledonous neotropical trees: patterns of abundance and diversity. *Mycol*. *Res*. 105(12): 1502 150

Arnold, A. E., &Herre, E. A. (2003). Canopy cover and leaf age affect colonization by tropical fungal endophytes: ecological patterns and process in *Theobroma cacao* (Malvaceae). *Mycologia,* 95:388–398.

Arunkumar, S., & Muthuselvam, M. (2009). Analysis of phytochemical constituents and antimicrobial activities of *Aloe vera* L. against clinical pathogens. *World Journal of Agricultural Sciences*, 5(5): 572-576.

Azahar, M., & Shah, N. N. M. (2003). A working plan for the Matang Mangrove Forest Reserve, Perak: the third 10-year period (2000–2009) of the second rotation. *State Forestry Department of Perak, Ipoh*.

Azevedo, J. L., Maccheroni, J. W., Pereira, J. O., &Araújo, W. L. (2000). Endophytic microrganisms: a review on insect control and recent advances on tropical plants. *Electron J Biotechnol*. 3:40-65.

Bae, H., Sicher, R. C., Kim, M. S., Kim, S. H., Strem, M. D., Melnick, R. L., & Bailey, B. A. (2009). The beneficial endophyte *Trichoderma hamatum* isolate DIS 219b promotes growth and delays the onset of the drought response in *Theobroma cacao*. *Journal of Experimental Botany*, 60(11): 3279-3295.

Bai, Z. Q., Lin, X., Wang, J., Zhou, X., Liu, J., Yang, B., & Liu, Y. (2015). New meroterpenoids from the endophytic fungus *Aspergillus flavipes* AIL8 derived from the mangrove plant *Acanthus ilicifolius*. *Marine drugs*, 13(1): 237-248.

Bandaranayake, W. M. (2002). Bioactivities, bioactive compounds and chemical constituents of mangrove plants. *Wetlands ecology and management*, 10(6): 421-452.

Baraban, E. G., Morin, J. B., Phillips, G. M., Phillips, A. J., Strobel, S. A., & Handelsman, J. (2013). Xyolide, a bioactive nonenolide from an Amazonian endophytic fungus, *Xylaria feejeensis*. *Tetrahedron letters*, 54(31): 4058-4060.

Banerjee, D. (2011). Endophytic fungal diversity in tropical and subtropical plants. Res. J. Microbiol. 6: 54-62

Bernardi-Wenzel, J. (2008). Bioprospecting and cytological and molecular characterization of endophytic fungi isolated from Luehea divaricata (Martius et Zuccarini): Study of host endophyte-plant interaction. *Maringá: UEM* .

Bharathidasan, R., & Panneerselvam, A. (2012). Antioxidant activity of the endophytic fungi isolated from mangrove environment of karankadu, Ramanathapuram district. *International Journal of Pharmaceutical Sciences and Research*, 3(8): 2866.

Bin, G., Yanping, C., Hong, Z., Zheng, X., Yanqiu, Z., Huaiyi, F., & Chenxiao, Z. (2014). Isolation, characterization and anti-multiple drug resistant (MDR) bacterial activity of endophytic fungi isolated from the

mangrove plant, *Aegiceras corniculatum*. *Tropical Journal of Pharmaceutical Research*, *13*(4): 593-599.

Blunt, J. W., Copp, B. R., Keyzers, R. A., Munro, M. H., & Prinsep, M. R. (2013). Marine natural products. *Nat. Prod. Rep*, 30(2): 237-323.

Boonphong, S., Kittakoop, P., Isaka, M., Pittayakhajonwut, D., Tanticharoen, M., & Thebtaranonth, Y. (2001). Multiplolides A and B, New Antifungal 10-Membered Lactones from *Xylaria* multiplex. *Journal of natural products*, 64(7): 965-967.

Botella, L. &Diez, J. J. (2011). Phylogenic diversity of fungal endophytes in Spanish stands of *Pinus halepensis*. *Fungal Diversity*, 47:9–18

Bowles, B. L. & Miller, A. J. (1993). Antibotulinal properties of selected aromatic and aliphatic aldehydes. *Journal of Food Protection*, 56(9): 788-794.

Bowles, B. L., Sackitey, S. K., & Williams, A. C. (1995). Inhibitory effects of flavor compounds on *Staphylococcus aureus* WRRC B124. *Journal of Food Safety*, 15(4): 337-347.

Brady, S. F., & Clardy, J. (2000). CR377, a new pentaketide antifungal agent isolated from an endophytic fungus. *Journal of natural products*, 63(10): 1447-1448.

Bugni, T. S., & Ireland, C. M. (2004). Marine-derived fungi: a chemically and biologically diverse group of microorganisms. *Natural Product Reports*, 21(1): 143-163.

Busi, S., Peddikotla, P., Upadyayula, S. M., & Yenamandra, V. (2009). Isolation and biological evaluation of two bioactive metabolites from *Aspergillus gorakhpurensis*. *Records of Natural Products*, 3(3): 161.

Busi, S., Rajkumari, J., & Hnamte, S. (2014). Feeding deterrence, acute toxicity and sublethal growth effects of kojic acid isolated from *Aspergillus funiculosus*. *The Natural Products Journal*, 4(1): 18-22.

Calvo, A. M., Wilson, R. A., Bok, J. W., & Keller, N. P. (2002). Relationship between secondary metabolism and fungal development. *Microbiology and molecular biology reviews*, 66(3): 447-459.

Cannon, P. F., & Simmons, C. M. (2002). Diversity and host preference of leaf endophytic fungi in the Iwokrama Forest Reserve, Guyana. *Mycologia*, 94(2): 210-220.

Castro, H., Romao, S., Gadelha, F. R., & Tomás, A. M. (2008). *Leishmania infantum*: provision of reducing equivalents to the mitochondrial

tryparedoxin/tryparedoxin peroxidase system. *Experimental parasitology*, 120(4): 421-423.

Casella, T. M., Eparvier, V., Mandavid, H., Bendelac, A., Odonne, G., Dayan, L., & Stien, D. (2013). Antimicrobial and cytotoxic secondary metabolites from tropical leaf endophytes: isolation of antibacterial agent pyrrocidine C from *Lewia infectoria* SNB GTC2402. *Phytochemistry*, 96: 370-377.

Cazar, M. E., Schmeda-Hirschmann, G., & Astudillo, L. (2005). Antimicrobial butyrolactone derivatives from the Ecuadorian soil fungus *Aspergillus terreus* Thorn.var terreus. *World Journal of Microbiology and Biotechnology*, 21(6-7): 1067-1075.

Chaturvedi, D., Goswami, A., Saikia, P. P., Barua, N. C., & Rao, P. G. (2010). Artemisinin and its derivatives: a novel class of anti-malarial and anti-cancer agents. *Chemical Society Reviews*, 39(2): 435-454.

Chen, G., Lin, Y., Vrijmoed, L. L. P., & Fong, W. F. (2006). A new isochroman from the marine endophytic fungus 1893. *Chemistry of natural compounds*, 42(2): 138-141.

Chen, Y. H., Lu, M. C., Chang, Y. C., Hwang, T. L., Wang, W. H., Weng, C. F., & Sung, P. J. (2012). Pseudoalteromone A: a novel bioactive ubiquinone from a marine bacterium Pseudoalteromonas sp. CGH2XX (Pseudoalteromonadaceae). *Tetrahedron Letters*, 53(13): 1675-1677.

Chen, L., Zhang, Q. Y., Jia, M., Ming, Q. L., Yue, W., Rahman, K., & Han, T. (2016). Endophytic fungi with antitumor activities: Their occurrence and anticancer compounds. *Critical reviews in microbiology*, 42(3): 454-473.

Cheng, Y., Schneider, B., Riese, U., Schubert, B., Li, Z., & Hamburger, M. (2004). FarinosonesA− C, Neurotrophic Alkaloidal Metabolites from the Entomogenous Deuteromycete *Paecilomyces farinosus*. *Journal of natural products*, 67(11): 1854-1858.

Cheng, S. S., Liu, J. Y., Hsui, Y. R., & Chang, S. T. (2006). Chemical polymorphism and antifungal activity of essential oils from leaves of different provenances of indigenous cinnamon (*Cinnamomum osmophloeum*). *Bioresource technology*, 97(2): 306-312.

Cheng, S. S., Liu, J. Y., Chang, E. H., & Chang, S. T. (2008). Antifungal activity of cinnamaldehyde and eugenol congeners against wood-rot fungi. *Bioresource technology*, 99(11): 5145-5149.

Cheng, Z. S., Pan, J. H., Tang, W. C., Chen, Q. J., & Lin, Y. C. (2009). Biodiversity and biotechnological potential of mangrove-associated fungi. *Journal of Forestry Research*,20(1):63-72.

Choi, J., Kang, H. J., Kim, S. Z., Kwon, T. O., Jeong, S. I., & Jang, S. I. (2013). Antioxidant effect of astragalin isolated from the leaves of *Morus alba* L. against free radical-induced oxidative hemolysis of human red blood cells. *Archives of pharmacal research*, 36(7): 912-917.

Chokpaiboon, S. (2015). Anticancer and antiangiogenic agents from endophytic fungi isolated from Thai mangrove plants (Doctoral dissertation, Chulalongkorn University).

Choo, J., Sabri, N. B. M., Tan, D., Mujahid, A., & Müller, M. (2015). Heavy metal resistant endophytic fungi isolated from *Nypa fruticans* in Kuching Wetland National Park. *Ocean Science Journal*, 50(2): 445-453.

Clardy, J., & Walsh, C. (2004). Lessons from natural molecules. *Nature*, 432(7019): 829.

Clay, K., & Schardl, C. (2002). Evolutionary origins and ecological consequences of endophyte symbiosis with grasses. *The American Naturalist*, 160(S4): S99-S127.

Coley, P. D., & Barone, J. A. (1996). Herbivory and plant defenses in tropical forests. *Annual review of ecology and systematics*, 27(1): 305-335.

Congeevaram, S., Dhanarani, S., Park, J., Dexilin, M., & Thamaraiselvi, K. (2007). Biosorption of chromium and nickel by heavy metal resistant fungal and bacterial isolates. *Journal of hazardous materials*, 146(1-2): 270-277.

Cook, M. B., Chow, W. H., & Devesa, S. S. (2009). Oesophageal cancer incidence in the United States by race, sex, and histologic type, 1977–2005. *British journal of cancer*, 101(5): 855.

Cornelissen, T. G., & Fernandes, G. W. (2001). Induced defences in the neotropical tree *Bauhinia brevipes* (Vog.) to herbivory: effects of damage-induced changes on leaf quality and insect attack. *Trees*, 15(4): 236-241.

Corre, J., Lucchini, J. J., Mercier, G. M., & Cremieux, A. (1990). Antibacterial activity of phenethyl alcohol and resulting membrane alterations. *Research in Microbiology*, 141(4): 483-497.

Coşkuntuna, A., & Özer, N. (2008). Biological control of onion basal rot disease using *Trichoderma harzianum* and induction of antifungal compounds in onion set following seed treatment. *Crop Protection*, 27(3): 330-336.

Costa, I. P., Maia, L. C., & Cavalcanti, M. A. (2012). Diversity of leaf endophytic fungi in mangrove plants of northeast Brazil. *Brazilian Journal of Microbiology*, 43(3): 1165 1173.

Crozier, J., Thomas, S. E., Aime, M. C., Evans, H. C., &Holmes, K. A. (2006). Molecular characterization of fungal endophytic morpho species isolated from stems and pods of *Theobroma cacao*. *Plant Pathology*, 55(6): 783-791.

Cui, J. L., Guo, T. T., Ren, Z. X., Zhang, N. S., & Wang, M. L. (2015). Diversity and antioxidant activity of culturable endophytic fungi from alpine plants of *Rhodiola crenulata*, *R*. *angusta*, and *R*. sachalinensis. *Plos one*, 10(3): e0118204.

Dahdouh-Guebas, F., & Jayatissa, L. P. (2009). A bibliometrical review on pre-and post tsunami assumptions and facts about mangroves and other coastal vegetation asprotective buffers. *Ruhuna Journal of Science*.

Daouk, R. K., Dagher, S. M., & Sattout, E. J. (1995). Antifungal activity of the essential oil of *Origanum syriacum* L. *Journal of Food Protection*, 58(10): 1147-1149.

Das, S., Lyla, P. S., & Khan, S. A. (2006). Marine microbial diversity and ecology: importanceand future perspectives. *Current Science*, 1325-1335.

Davey, M. L., Heegaard, E., Halvorsen, R., Kauserud, H., & Ohlson, M. (2013). Amplicon-pyrosequencing-based detection of compositional shifts in bryophyte-associated fungal communities along an elevation gradient. *Molecular Ecology*, 22(2): 368-383.

de Souza Sebastianes, F. L., Romao-Dumaresq, A. S., Lacava, P. T., Harakava, R., Azevedo, J. L., de Melo, I. S., & Pizzirani-Kleiner, A. A. (2013). Species diversity of culturable endophytic fungi from Brazilian mangrove forests. *Current genetics*, 59(3): 153-166.

dos Reis Celestino, J., de Carvalho, L. E., da Paz Lima, M., Lima, A. M., Ogusku, M. M., & de Souza, J. V. B. (2014). Bioprospecting of Amazon soil fungi with the potential for pigment production. *Process Biochemistry*, 49(4): 569-575.

Debbab, A., Aly, A. H., & Proksch, P. (2011). Bioactive secondary metabolites from endophytes and associated marine derived fungi. *Fungal Diversity*, 49(1): 1.

Debbab, A., Aly, A. H., & Proksch, P. (2012). Endophytes and associated marine derived fungi ecological and chemical perspectives. *Fungal Diversity*, 57(1): 45-83.

Dehpour, A. A., Yousefian, M., Kelarijani, S. J., Koshmoo, M., Mirzanegad, S., Mahdavi, V., & Bayani, M. J. (2012). Antibacterial activity and composition of essential oils of flower *Allium rotundum*. *Adv Environ Biol*, 6: 1020-5.

Deng, Z., Zhang, R., Shi, Y., Tan, H., & Cao, L. (2014). Characterization of Cd-, Pb-, Zn resistant endophytic *Lasiodiplodia* sp. MXSF31 from metal accumulating *Portulaca oleracea* and its potential in promoting the growth of rape in metal-contaminated soils. *Environmental Science and Pollution Research*, 21(3): 2346-2357.

Devine, D. A., & Hancock, R. E. (2002). Cationic peptides: distribution and mechanisms of resistance. *Current pharmaceutical design*, 8(9): 703-714.

Dharmaputra, O. S. (2003). Control of Aflatoxigenic *Aspergillus flavus* in Peanuts Using Nonaflatoxigenic *A*. *flavus*, *A*. *niger* and *Trichoderma harzianum*. *BIOTROPIA-The Southeast Asian Journal of Tropical Biology*, 21.

dos Reis Almeida, F. B., Cerqueira, F. M., do Nascimento Silva, R., Ulhoa, C. J., & Lima, A. L. (2007). Mycoparasitism studies of *Trichoderma harzianum* strains against *Rhizoctonia solani*: evaluation of coiling and hydrolytic enzyme production. *Biotechnology letters*, 29(8): 1189-1193.

Dong, T. G., Ho, B. T., Yoder-Himes, D. R., & Mekalanos, J. J. (2013). Identification of T6SS dependent effector and immunity proteins by Tn-seq in Vibrio cholerae. *Proceedings of the National Academy of Sciences*, 110(7): 2623-2628.

Douanla-Meli, C., Langer, E., & Mouafo, F. T. (2013). Fungal endophyte diversity and community patterns in healthy and yellowing leaves of *Citrus limon*. *Fungal Ecology*, 6(3): 212-222.

Dubey, S. C., & Suresh, M. (2006). Randomly amplified polymorphic DNA markers for *Trichoderma* species and antagonism against *Fusarium oxysporum* f. sp. ciceris causing chickpea wilt. *Journal of phytopathology*, 154(11-12): 663-669.

Dufosse, L., Fouillaud, M., Caro, Y., Mapari, S. A., & Sutthiwong, N. (2014). Filamentous fungi are large-scale producers of pigments and colorants for the food industry.*Current opinion in biotechnology*, 26: 56-61.

Duke, N. C. (2006). *Australia's mangroves: the authoritative guide to Australia's mangrove plants*. MER.

Duke, N. C., Meynecke, J. O., Dittmann, S., Ellison, A. M., Anger, K., Berger, U., & Koedam, N. (2007). A world without mangroves?. *Science*, 317(5834): 41-42.

Ebrahim, W., Kjer, J., El Amrani, M., Wray, V., Lin, W., Ebel, R., & Proksch, P. (2012). Pullularins E and F, two new peptides from the endophytic fungus Bionectria ochroleuca isolated from the mangrove plant Sonneratia caseolaris. *Marine drugs*, 10(5): 1081-1091.

Elavarasi, A., Rathna, G. S., & Kalaiselvam, M. (2012). Taxol producing mangrove endophytic fungi *Fusarium oxysporum* from *Rhizophora annamalayana*. *Asian Pacific Journal of Tropical Biomedicine*, 2(2): S1081-S1085.

Elavarasi, A., Peninal, S., Rathna, G. S., & Kalaiselvam, M. (2014). Studies on antimicrobial compounds isolated from mangrove endophytic fungi. *World J. Pharma. Pharm.q Sci*, 3: 734-744.

Elkhayat, E. S., & Goda, A. M. (2017). Antifungal and cytotoxic constituents from the endophytic fungus Penicillium sp. *Bulletin of Faculty of Pharmacy, Cairo University*, 55(1): 85-89.

FAO, U. (2007). The world's mangroves 1980-2005. *FAO Rome, Italy*.

Faryal, R., Yusuf, M., Munir, M., Tahir, F., & Hameed, A. (2007). Enhancement of Cr 6+ removal by *Aspergillus niger* RH 19 using a biofermenter. *Pak J. Bot*, 39: 1873-1881.

Felício, R. D., Pavão, G. B., Oliveira, A. L. L. D., Erbert, C., Conti, R., Pupo, M. T., & Yokoya, N. S. (2015). Antibacterial, antifungal and cytotoxic activities exhibited by endophytic fungi from the Brazilian marine red alga *Bostrychia tenella* (Ceramiales). *Revista Brasileira de Farmacognosia*, 25(6): 641-650.

Finkel, T., & Holbrook, N. J. (2000). Oxidants, oxidative stress and the biology of ageing. *Nature*, 408(6809): 239.

Firakova, S., Proksa, B., & Šturdíková, M. (2007).Biosynthesis and biological activity of enniatins. *Die Pharmazie-An International Journal of Pharmaceutical Sciences*, 62(8): 563-568.

Fisher, P. J., Petrini, O., Petrini, L. E., & Sutton, B. C. (1994).Fungal endophytes from the leaves and twigs of Quercus ilex L. from England, Majorca and Switzerland. *New phytologist*, 127(1): 133-137.

Fisher, K., & Phillips, C. A. (2006). The effect of lemon, orange and bergamot essential oils and their components on the survival of *Campylobacter jejuni*, *Escherichia coli* O157, *Listeria monocytogenes*, *Bacillus cereus* and *Staphylococcus aureus* in vitro and in food systems. *Journal of Applied Microbiology*, 101(6): 1232-1240.

Flores, A. C., Pamphile, J. A., Sarragiotto, M. H., & Clemente, E. (2013). Production of 3 nitropropionic acid by endophytic fungus *Phomopsis longicolla* isolated from *Trichilia elegans* A. JUSS ssp. elegans and evaluation of biological activity. *World Journal of Microbiology and Biotechnology*, 29(5): 923-932.

Fox, E. M., & Howlett, B. J. (2008). Biosynthetic gene clusters for epipolythiodioxopiperazines in filamentous fungi. *Mycological research*, 112(2): 162-169.

Froehlich, J., & Petrini, O. (2000). Endophytic fungi associated with palms. *Mycological Research*, 104(10), 1202-1212.

Gaiero, J. R., McCall, C. A., Thompson, K. A., Day, N. J., Best, A. S., & Dunfield, K. E. (2013). Inside the root microbiome: bacterial root endophytes and plant growth promotion. *American journal of botany*, 100(9):, 1738-1750.

Gangadevi, V., & Muthumary, J. (2007). Preliminary studies on cytotoxic effect of fungal taxol on cancer cell lines. *African Journal of Biotechnology*, 6(12).

Gazis, R., & Chaverri, P. (2010). Diversity of fungal endophytes in leaves and stems of wild rubber trees (*Hevea brasiliensis*) in Peru. *Fungal ecology*, 3(3): 240-254.

George, T. K., Asok, A. K., Shabanamol, S., Rebello, S., Fathima, P. A. & Jisha, M. S. (2015). Diversity of *Bruguiera cylindrica* and *Rhizophora candelaria* from Ayiramthengu mangrove ecosystem, Kerala. *Annals of Biological Research*, 6(9):55-63.

Geweely, N. S. (2011). Investigation of the optimum condition and antimicrobial activities of pigments from four potent pigment-producing fungal species. *Journal of Life Sciences*,5(9): 201.

Ghizelini, A. M., Mendonça-Hagler, L. C. S., & Macrae, A. (2012). Microbial diversity in Brazilian mangrove sediments: a mini review. *Brazilian Journal of Microbiology*, 43(4): 1242-1254.

Giesen, W., Wulffraat, S., Zieren, M., & Scholten, L. (2007). Mangrove guidebook for Southeast Asia. *Mangrove guidebook for Southeast Asia.*

González, V., & Tello, M. L. (2011). The endophytic mycota associated with Vitis vinifera in central Spain. *Fungal Diversity*, 47(1): 29-42.

Graikou, K., Kapeta, S., Aligiannis, N., Sotiroudis, G., Chondrogianni, N., Gonos, E., & Chinou, I. (2011). Chemical analysis of Greek pollen-Antioxidant, antimicrobial and proteasome activation properties. *Chemistry Central Journal*, 5(1): 33.

Gurnani, N., Gupta, M., Mehta, D., & Mehta, B. K. (2016). Chemical composition, total phenolic and flavonoid contents, and in vitro antimicrobial and antioxidant activities of crude extracts from red chilli seeds (*Capsicum frutescens* L.). *Journal of Taibah University for Science*, 10(4): 462-470.

Gunatilaka, A. L. (2006). Natural products from plant-associated microorganisms: distribution, structural diversity, bioactivity, and implications of their occurrence. *Journal of Natural Products*, 69(3): 509-526.

Guthrie, J. L., & Castle, A. J. (2006). Chitinase production during interaction of *Trichoderma aggressivum* and *Agaricus bisporus*. *Canadian journal of microbiology*, 52(10): 961 967.

Hajieghrari, B., Torabi-Giglou, M., Mohammadi, M. R., & Davari, M. (2008). Biological potantial of some Iranian Trichoderma isolates in the control of soil borne plant pathogenic fungi. *African Journal of Biotechnology*, 7(8).

Hameed, A., Khoshkbarforoushha, A., Ranjan, R., Jayaraman, P. P., Kolodziej, J., Balaji, P., & Khan, S. U. (2016). A survey and taxonomy on energy efficient resource allocation techniques for cloud computing systems. *Computing*, 98(7): 751-774.

Hammerschmidt, L., Debbab, A., Ngoc, T. D., Wray, V., Hemphil, C. P., Lin, W., & Aly, A. H. (2014). Polyketides from the mangrove-derived endophytic fungus *Acremonium strictum*. *Tetrahedron Letters*, 55(24): 3463-3468

Hamzah, T.N.T., Hakeem, K., Waseem, M.A., & Munir, O. Insights of Endophytic Fungi in Mangroves, Unpublished.

Han, K., Friesz, T. L., & Yao, T. (2013). A partial differential equation formulation of Vickrey's bottleneck model, part II: Numerical analysis and computation. *Transportation Research Part B: Methodological*, 49: 75-93.

Harada, H., Yamashita, U., Kurihara, H., Fukushi, E., Kawabata, J., & Kamei, Y. (2002). Antitumor activity of palmitic acid found as a selective cytotoxic substance in a marine red alga. *Anticancer research*, 22(5): 2587-2590.

Harwig, J., & Scott, P. M. (1971).Brine shrimp (Artemia salina L.) larvae as a screening system for fungal toxins. *Applied microbiology*, 21(6): 1011-1016.

Hawksworth, D. L. (2004). (183-187) Limitation of Dual Nomenclature for Pleomorphic Fungi. *Taxon*, 53(2): 596-598.

He, X., Han, G., Lin, Y., Tian, X., Xiang, C., Tian, Q., & He, Z. (2012). Diversity and decomposition potential of endophytes in leaves of a *Cinnamomum camphora* plantation in China. *Ecological research*, 27(2): 273-284.

Helander, I. M., Alakomi, H. L., Latva-Kala, K., Mattila-Sandholm, T., Pol, I., Smid, E. J., & von Wright, A. (1998). Characterization of the action of selected essential oil components on Gram-negative bacteria. *Journal of agricultural and food chemistry*, 46(9): 3590-3595.

Higgins, K. L., Arnold, A. E., Miadlikowska, J., Sarvate, S. D., & Lutzoni, F. (2007). Phylogenetic relationships, host affinity, and geographic structure of boreal and arctic endophytes from three major plant lineages. *Molecular phylogenetics and evolution*, 42(2): 543 555.

Howell, C. R. (2003). Mechanisms employed by *Trichoderma* species in the biological control of plant diseases: the history and evolution of current concepts. *Plant disease*, 87(1): 4-10.

Hsouna, A. B., Trigui, M., Mansour, R. B., Jarraya, R. M., Damak, M., & Jaoua, S. (2011). Chemical composition, cytotoxicity effect and antimicrobial activity of *Ceratonia siliqua* essential oil with preservative effects against *Listeria* inoculated in minced beef meat. *International journal of food microbiology*, 148(1): 66-72.

Huang, W. Y., Cai, Y. Z., Xing, J., Corke, H., & Sun, M. (2007). A potential antioxidant resource: endophytic fungi from medicinal plants. *Economic Botany*, 61(1): 14-30.

Hugenholtz, P., & Pace, N. R. (1996). Identifying microbial diversity in the natural environment: a molecular phylogenetic approach. *Trends in biotechnology*, 14(6): 190-197.

Hwang, B. K., Lim, S. W., Kim, B. S., Lee, J. Y., & Moon, S. S. (2001). Isolation and *in vivo* and *in vitro* antifungal activity of phenylacetic acid and sodium phenylacetate from S*treptomyces humidus*. *Applied and Environmental Microbiology*, 67(8): 3739-3745

Hyde, K. D. (1990). Intertidal fungi from warm temperate mangroves of Australia, including *Tunicatispors australiensis*, gen. et. sp. Nov. *Australian Systematic Botany*, 3(4): 711 718.

Hyde, K. D., Jones, E. G., Leaño, E., Pointing, S. B., Poonyth, A. D., & Vrijmoed, L. L. (1998). Role of fungi in marine ecosystems. *Biodiversity and Conservation*, 7(9): 1147-1161.

Hyde, K. D., & Soytong, K. (2008).The fungal endophyte dilemma. *Fungal Divers*, 33(163): e73. Del

Iram, S., Zaman, A., Iqbal, Z., & Shabbir, R. (2013). Heavy Metal Tolerance of Fungus Isolated from Soil Contaminated with Sewage and Industrial Wastewater. *Polish Journal of Environmental Studies*, 22(3)

Isaac, S. (1994). Mycology Answers: Many fungi are brightly coloured; does pigmentation provide any advantage to those species?. *Mycologist*, 8(4): 178-179.

Jalgaonwala, R. E., & Mahajan, R. T. (2011).Evaluation of hydrolytic enzyme activities of endophytes from some indigenous medicinal plants. *Journal of Agricultural Technology*, 7(6): 1733-1741.

Jones, S., Zhang, X., Parsons, D. W., Lin, J. C. H., Leary, R. J., Angenendt, P., & Hong, S. M. (2008). Core signaling pathways in human pancreatic cancers revealed by global genomic analyses. *science*, 321(5897): 1801-1806

Joseph, B., & Priya, R. M. (2011). Bioactive Compounds from Endophytes and their Potential in. *American Journal of biochemistry and Molecular biology*, 1: 291-309.

Ju, Z. R., Qin, X., Lin, X. P., Wang, J. F., Kaliyaperumal, K., Tian, Y. Q., & Liu, Y. (2016). New phenyl derivatives from endophytic fungus *Botryosphaeria* sp. SCSIO KcF6 derived of mangrove plant *Kandelia candel*. *Natural product research*, 30(2): 192-198.

Kai, M., Effmert, U., Berg, G., & Piechulla, B. (2007). Volatiles of bacterial antagonists inhibit mycelial growth of the plant pathogen *Rhizoctonia solani*. *Archives of microbiology*,187(5): 351-360.

Kamala, T., & Indira, S. (2011). Evaluation of indigenous *Trichoderma* isolates from Manipur as biocontrol agent against *Pythium aphanidermatum* on common beans. *3 Biotech*, 1(4): 217-225.

Kasote, D. M. (2013).Flaxseed phenolics as natural antioxidants. *International Food Research Journal*, 20(1).

Katoch, M., Singh, A., Singh, G., Wazir, P., & Kumar, R. (2017). Phylogeny, antimicrobial, antioxidant and enzyme-producing potential of fungal endophytes found in *Viola odorata*. *Annals of Microbiology*, 67(8): 529-540.

Kathiresan, K. (2003). How do mangrove forests induce sedimentation?. *Revista de biologia tropical*, 51(2): 355-360.

Kathiresan, K. (2010). Importance of mangrove forests of India. *Journal of coastal environment*, 1(1): 11-26.

Katz, D. H., Marcelletti, J. F., Khalil, M. H., Pope, L. E., & Katz, L. R. (1991). Antiviral activity of 1-docosanol, an inhibitor of lipid-enveloped viruses

including herpes simplex. *Proceedings of the National Academy of Sciences*, 88(23): 10825-10829.

Khara, H. S., & Hadwan, H. A. (1990). In vitro studies on antagonism of *Trichoderma* spp. against *Rhizoctonia solani* the causal agent of damping off of tomato. *Plant Disease Research*, 5(2): 144-147.

Kharwar, R. N., Mishra, A., Gond, S. K., Stierle, A., & Stierle, D. (2011). Anticancer compounds derived from fungal endophytes: their importance and future challenges. *Natural product reports*, 28(7): 1208-1228.

Kawazu, K., Zhang, H., Yamashita, H., & Kanzaki, H. (1996). Relationship between the pathogenicity of the pine wood nematode, Bursaphelenchus xylophilus, and phenylacetic acid production. *Bioscience, biotechnology, and biochemistry*, 60(9): 1413-1415.

Khalili, E., Sadravi, M., Naeimi, S., & Khosravi, V. (2012).Biological control of rice brown spot with native isolates of three *Trichoderma* species. *Brazilian Journal of Microbiology*, 43(1): 297-305.

Khosla, S., Atkinson, E. J., Melton III, L. J., & Riggs, B. L. (1997). Effects of age and estrogen status on serum parathyroid hormone levels and biochemical markers of bone turnover in women: a population-based study. *The Journal of Clinical Endocrinology & Metabolism*, 82(5): 1522-1527.

Kjer, J., Debbab, A., Aly, A. H., & Proksch, P. (2010).Methods for isolation of marine-derived endophytic fungi and their bioactive secondary products. *Nature protocols*, 5(3): 479-490.

Kogel, K. H., Franken, P., & Hückelhoven, R. (2006). Endophyte or parasite–what decides?. *Current opinion in plant biology*, 9(4): 358-363.

Klaiklay, S., Rukachaisirikul, V., Phongpaichit, S., Pakawatchai, C., Saithong, S., Buatong, J., & Sakayaroj, J. (2012). Anthraquinone derivatives from the mangrove-derived fungus *Phomopsis* sp. PSU-MA214. *Phytochemistry Letters*, 5(4): 738-742.

Kokpol, U., Thebpatiphat, S., Boonyaratavej, S., Chedchuskulcai, V., Ni, C. Z., Clardy, J., & Miles, D. H. (1990). Structure of trigonostemone, a new phenanthrenone from the Thai plant *Trigonostemon reidioides*. *Journal of natural products*, 53(5): 1148-1151.

Koukol, O., Kolařík, M., Kolářová, Z., & Baldrian, P. (2012).Diversity of foliar endophytes in wind-fallen *Picea abies* trees. *Fungal Diversity*, 54(1): 69-77.

Kristensen, E., Bouillon, S., Dittmar, T., & Marchand, C. (2008). Organic carbon dynamics in mangrove ecosystems: a review. *Aquatic Botany*, 89(2): 201-219.

Kumar, S., Stecher, G., & Tamura, K. (2016). MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molecular biology and evolution*, 33(7): 1870-1874.

Kumar, P. P., Kumaravel, S., & Lalitha, C. (2010). Screening of antioxidant activity, total phenolics and GC-MS study of *Vitex negundo*. *African Journal of Biochemistry Research*, 4(7): 191-195.

Kumar, N. S., Nazeer, R. A., & Jaiganesh, R. (2012). Purification and identification of antioxidant peptides from the skin protein hydrolysate of two marine fishes, horsemackerel (*Magalaspis cordyla*) and croaker *(Otolithes ruber*). *Amino Acids*, 42(5): 1641-1649.

Kusari, S., Pandey, S. P., & Spiteller, M. (2013). Untapped mutualistic paradigms linking host plant and endophytic fungal production of similar bioactive secondary metabolites.*Phytochemistry*, 91: 81-87.

Lachance, P. A., Nakat, Z., & Jeong, W. S. (2001). Antioxidants: an integrative approach. *Nutrition*, 17(10): 835-838.

Lai, L. S., Chou, S. T., & Chao, W. W. (2001). Studies on the antioxidative activities of Hsian tsao (*Mesona procumbens* Hemsl) leaf gum. *Journal of Agricultural and Food Chemistry*, 49(2): 963-968.

Landum, M. C., do Rosário Félix, M., Alho, J., Garcia, R., Cabrita, M. J., Rei, F., & Varanda, C. M. (2016). Antagonistic activity of fungi of *Olea europaea* L. *against Colletotrichum acutatum*. *Microbiological research*, 183: 100-108.

Latiff, A., & Faridah-Hanum, I. (2014). Mangrove Ecosystem of Malaysia: Status, Challenges and Management Strategies. In *Mangrove Ecosystems of Asia* (pp. 1-22). Springer,New York, NY.

Lattanzio, V., Lattanzio, V. M., & Cardinali, A. (2006).Role of phenolics in the resistance mechanisms of plants against fungal pathogens and insects. *Phytochemistry: Advances in research*, 661: 23-67.

Lau, M. K., Arnold, A. E., & Johnson, N. C. (2013).Factors influencing communities of foliar fungal endophytes in riparian woody plants. *Fungal Ecology*, 6(5): 365-378.

Lee, J. C., Lobkovsky, E., Pliam, N. B., Strobel, G., & Clardy, J. (1995). Subglutinols A and B: immunosuppressive compounds from the endophytic fungus *Fusarium subglutinans*. The Journal of Organic Chemistry, 60(22): 7076-7077.

Lee, S., Crous, P. W., & Wingfield, M. J. (2006). Pestalotioid fungi from Restionaceae in the Cape floral kingdom. *Studies in Mycology*, 55: 175-187.

Lee, J. W., Fang, X., Gupta, N., Serikov, V., & Matthay, M. A. (2009). Allogeneic human mesenchymal stem cells for treatment of *E. coli* endotoxin-induced acute lung injury in the ex vivo perfused human lung. *Proceedings of the National Academy of Sciences*, 106(38): 16357-16362.

Li, J. Y., Strobel, G., Harper, J., Lobkovsky, E., & Clardy, J. (2000). Cryptocin, a potent tetramic acid antimycotic from the endophytic fungus *Cryptosporiopsis* cf. q uercina. *Organic Letters*, 2(6): 767-770.

Li, M. Y., Xiao, Q., Pan, J. Y., & Wu, J. (2009). Natural products from semi-mangrove flora: source, chemistry and bioactivities. *Natural product reports*, 26(2): 281-298.

Li, X. J., Zhang, Q., Zhang, A. L., &Gao, J. M. (2012). Metabolites from *Aspergillus fumigatus*, an endophytic fungus associated with *Melia azedarach*, and their antifungal, antifeedant, and toxic activities. *J. Agric. Food Chem*, 60(13): 3424-3431.

Li, Jing, Yanyu Xue, Jie Yuan, Yongjun Lu, Xun Zhu, Yongcheng Lin, and Lan Liu. "Lasiodiplodins from mangrove endophytic fungus *Lasiodiplodia* sp. 318#." *Natural product research* 30, no. 7 (2016): 755-760.

Liang, H., Xing, Y., Chen, J., Zhang, D., Guo, S., & Wang, C. (2012). Antimicrobial activities of endophytic fungi isolated from *Ophiopogon japonicus* (Liliaceae). *BMC complementary and alternative medicine*, 12(1): 238.

Liebezeit, G., & Rau, M. T. (2006). New Guinean mangroves—Traditional usage and chemistry of natural products. *Senckenbergiana maritima*, 36(1): 1-10.

Lin, Z., Zhu, T., Fang, Y., Gu, Q., & Zhu, W. (2008). Polyketides from *Penicillium* sp. JP-1, an endophytic fungus associated with the mangrove plant *Aegiceras corniculatum*. *Phytochemistry*, 69(5): 1273-1278.

Liu, F., & Ng, T. B. (2000). Antioxidative and free radical scavenging activities of selectedmedicinal herbs. *Life sciences*, 66(8): 725-735.

Liu, Y., Zhu, Y. G., Chen, B. D., Christie, P., & Li, X. L. (2005). Influence of the arbuscular mycorrhizal fungus *Glomus mosseae*on uptake of arsenate by the As hyperaccumulator fern *Pteris vittata* L. *Mycorrhiza*, 15(3): 187-192.

Liu, X., Dong, M., Chen, X., Jiang, M., Lv, X., & Yan, G. (2007).Antioxidant activity and phenolics of an endophytic *Xylaria* sp.from Ginkgo biloba. *Food chemistry*, 105(2): 548-554.

Liu, X., Dong, M., Chen, X., Jiang, M., Lv, X., & Zhou, J. (2008).Antimicrobial activity of an endophytic *Xylaria* sp. YX-28 and identification of its antimicrobial compound 7 amino 4-methylcoumarin. *Applied Microbiology and Biotechnology*,78(2): 241-247.

Liu, Q., Parsons, A. J., Xue, H., Fraser, K., Ryan, G. D., Newman, J. A., & Rasmussen, S. (2011). Competition between foliar *Neotyphodium lolii* endophytes and mycorrhizal *Glomus* spp. fungi in *Lolium perenne* depends on resource supply and host carbohydrate content. *Functional Ecology*, 25(4): 910-920.

Liu, Y., Chen, S., Liu, Z., Lu, Y., Xia, G., Liu, H., & She, Z. (2015). Bioactive metabolites from mangrove endophytic fungus *Aspergillus* sp. 16-5B. *Marine drugs*, 13(5): 3091-3102.

Lombardo, M., Sonawane, D. P., Quintavalla, A., Trombini, C., Dhavale, D. D., Taramelli, D., & Taglialatela-Scafati, O. (2014). Optimized Synthesis and Antimalarial Activity of 1, 2-Dioxane-4-carboxamides. *European journal of organic chemistry*, 2014(8): 1607-1614.

Lucchini, J. J., Corre, J., & Cremieux, A. (1990).Antibacterial activity of phenolic compounds and aromatic alcohols. *Research in Microbiology*, 141(4): 499-510.

Ma, L. Y., Liu, D. S., Li, D. G., Huang, Y. L., Kang, H. H., Wang, C. H., & Liu, W. Z. (2016). Pyran Rings Containing Polyketides from Penicillium raistrickii. *Marine drugs*, 15(1): 2.

Maharachchikumbura, S. S., Guo, L. D., Cai, L., Chukeatirote, E., Wu, W. P., Sun, X., & Hyde, K. D. (2012). A multi-locus backbone tree for *Pestalotiopsis*, with a polyphasic characterization of 14 new species. *Fungal Diversity*, 56(1): 95-129.

Malik, S., Cusidó, R. M., Mirjalili, M. H., Moyano, E., Palazón, J., & Bonfill, M. (2011). Production of the anticancer drug taxol in *Taxus baccata* suspension cultures: a review. *Process Biochemistry*, 46(1): 23-34.

Mancini, M., Pagano, G., Cappellini, G., Livi, L., Rider, M., Catani, J., & Fallani, L. (2015). Observation of chiral edge states with neutral fermions in synthetic Hall ribbons. *Science*, 349(6255), 1510-1513.

Mapari, S. A., Meyer, A. S., & Thrane, U. (2006).Colorimetric characterization for comparative analysis of fungal pigments and natural food colorants. *Journal of agricultural and food chemistry*, 54(19): 7027-7035.

Mapari, S. A., Thrane, U., & Meyer, A. S. (2010). Fungal polyketide azaphilone pigments as future natural food colorants?. *Trends in biotechnology*, 28(6): 300-307.

Maria, G. L., & Sridhar, K. R. (2003). Diversity of filamentous fungi on woody litter of five mangrove plant species from the southwest coast of India. *Fungal Diversity*, 14(14): 109-126.

Maria, G. L., Sridhar, K. R., & Raviraja, N. S. (2005). Antimicrobial and enzyme activity of mangrove endophytic fungi of southwest coast of India. *Journal of Agricultural technology*, 1: 67-80.

McAlpine, J. B., Bachmann, B. O., Piraee, M., Tremblay, S., Alarco, A. M., Zazopoulos, E., & Farnet, C. M. (2005). Microbial genomics as a guide to drug discovery and structural elucidation: ECO-02301, a novel antifungal agent, as an example. *Journal of natural products*, 68(4): 493-496.

Mei, W. L., Zheng, B., Zhao, Y. X., Zhong, H. M., Chen, X. L. W., Zeng, Y. B., & Dai, H. F. (2012). Meroterpenes from endophytic fungus A1 of mangrove plant Scyphiphora hydrophyllacea. *Marine drugs*, 10(9): 1993-2001.

Mendes, R., Pizzirani-Kleiner, A. A., Araujo, W. L., & Raaijmakers, J. M. (2007). Diversity of cultivated endophytic bacteria from sugarcane: genetic and biochemical characterization of *Burkholderia cepacia* complex isolates. *Applied and environmental microbiology*, 73(22): 7259-7267.

Meng, L. H., Zhang, P., Li, X. M., & Wang, B. G. (2015). Penicibrocazines A–E, five new sulfide diketopiperazines from the marine-derived endophytic fungus *Penicillium brocae*. *Marine drugs*, 13(1): 276-287.

Mo, E. K., & Sung, C. K. (2007). Phenylethyl alcohol (PEA) application slows fungal growth and maintains aroma in strawberry. *Postharvest biology and technology*, 45(2): 234 239.

Monks, T. J., & Jones, D. C. (2002).The metabolism and toxicity of quinones, quinonimines, quinone methides, and quinone-thioethers. *Current drug metabolism*, 3(4): 425-438.

Mou, H., Iamazaki, E., Zhan, H., Orblin, E., & Fardim, P. (2013).Advanced studies on the topochemistry of softwood fibres in low-consistency refining as analyzed by FE-SEM, XPS, and ToF-SIMS. *BioResources*, 8(2): 2325-2336

Mouad, B., & Mostefa, B. (2015). Climatic variations and phenology of pools in the region of constantine (algeria). *European Scientific Journal, ESJ*, 11: (33).

Murthy, N. K., Pushpalatha, K. C., & Joshi, C. G. (2011). Antioxidant activity and phytochemical analysis of endophytic fungi isolated from *Lobelia nicotianifolia*. *J Chem Pharm Res*, 3(5): 218-225.

Najafi, M. F., Deobagkar, D., & Deobagkar, D. (2005). Potential application of protease isolated from *Pseudomonas aeruginosa* PD100. *Electronic Journal of Biotechnology*, 8(2): 79 85.

Naik, M., Meher, L. C., Naik, S. N., & Das, L. M. (2008).Production of biodiesel from high free fatty acid Karanja (*Pongamia pinnata*) oil. *Biomass and bioenergy*, 32(4): 354-357.

Nakano, M. M., & Zuber, P. (1998). Anaerobic growth of a "strict aerobe"(*Bacillus subtilis*). *Annual Reviews in Microbiology*, 52(1): 165-190.

Nisa, H., Kamili, A. N., Nawchoo, I. A., Shafi, S., Shameem, N., & Bandh, S. A. (2015). Fungal endophytes as prolific source of phytochemicals and other bioactive natural products: a review. *Microbial pathogenesis*, 82: 50-59.

Nithya, K., & Muthumary, J. (2011). Bioactive metabolite produced by *Phomopsis* sp., an endophytic fungus in Allamanda cathartica Linn. *Recent Research in Science and Technology*, 3(3).

Novas, M. V., Iannone, L. J., Godeas, A. M., & Cabral, D. (2009).Positive association between mycorrhiza and foliar endophytes in *Poa bonariensis*, a native grass. *Mycological progress*, 8(1): 75.

Olmo-Ruiz, M., & Arnold, A. E. (2014). Interannual variation and host affiliations of endophytic fungi associated with ferns at La Selva, Costa Rica. *Mycologia*, 106(1): 8 21.

Oliveira, A. L. L. D., Felício, R. D., & Debonsi, H. M. (2012). Marine natural products: chemical and biological potential of seaweeds and their endophytic fungi. *Revista Brasileira de Farmacognosia*, *22*(4): 906-920.

Onn, M. L., Lim, P. T., Mujahid, A., Proksch, P., & Müller, M. (2016).Initial screening of mangrove endophytic fungi for antimicrobial compounds and heavy metal biosorption potential. *Sains Malaysiana*, 45(7): 1063-1071.

Orlandelli, R. C., Almeida, T. T. D., Alberto, R. N., Polonio, J. C., Azevedo, J. L., & Pamphile, J. A. (2015). Antifungal and proteolytic activities of endophytic fungi isolated from *Piper hispidum* Sw. *Brazilian Journal of Microbiology*, 46(2): 359-366.

Osorio-Guillén, J., Lany, S., Barabash, S. V., & Zunger, A. (2006). Magnetism without magnetic ions: percolation, exchange, and

formation energies of magnetism promoting intrinsic defects in CaO. *Physical review letters*, 96(10): 107203.

Owen, N. L., & Hundley, N. (2004).Endophytes–the chemical synthesizers inside plants. *Science progress*, 87(2): 79-99.

Padmavathi, A. R., Abinaya, B., & Pandian, S. K. (2014). Phenol, 2, 4-bis (1, 1-dimethylethyl) of marine bacterial origin inhibits quorum sensing mediated biofilm formation in the uropathogen *Serratia marcescens*. *Biofouling*, 30(9): 1111-1122.

Paiva, S. R. D., Lima, L. A., Figueiredo, M. R., & Kaplan, M. A. C. (2004). Plumbagin quantification in roots of Plumbago scandens L. obtained by different extraction techniques. *Anais da Academia Brasileira de Ciências*, 76(3): 499-504.

Paliany, A. S., Sivasothy, Y., Awang, K., Rizman-Idid, M., & Alias, S. A. (2014). Marine derived fungi of Peninsular Malaysia–a biochemical perspective. *Chiang Mai J. Sci*, 41: 894-909.

Pang, K. L., & Mitchell, J. I. (2005). Molecular approaches for assessing fungal diversity in marine substrata. *Botanica Marina*, 48(5-6): 332-347.

Park, J. H., Choi, G. J., Lee, H. B., Kim, K. M., Jung, H. S., Lee, S. W., & Kim, J. C. (2005). Griseofulvin from *Xylaria* sp. strain F0010, an endophytic fungus of *Abies holophylla* and its antifungal activity against plant pathogenic fungi. *J Microbiol Biotechnol*, 15(1): 112-117.

Parker, S. R., Cutler, H. G., Jacyno, J. M., & Hill, R. A. (1997).Biological activity of 6-pentyl-2 H-pyran-2-one and its analogs.Journal of agricultural and food chemistry, 45(7): 2774-2776.

Parthasarathi, S., Sathya, S., Bupesh, G., Samy, R. D., Mohan, M. R., Kumar, G. S., & Balakrishnan, K. (2012). Isolation and characterization of antimicrobial compound from marine *Streptomyces hygroscopicus* BDUS 49. *World J Fish Mar Sci*, 4(3): 268-277.

Perl, T., Jünger, M., Vautz, W., Nolte, J., Kuhns, M., Borg-von Zepelin, M., & Quintel, M. (2011).Detection of characteristic metabolites of *Aspergillus fumigatus* and *Candida* species using ion mobility spectrometry–metabolic profiling by volatile organic compounds. *Mycoses*, 54(6).

Petrini, O., Stone, J., & Carroll, F. E. (1982). Endophytic fungi in evergreen shrubs in western Oregon: a preliminary study. *Canadian Journal of Botany*, *60(*6): 789-796.

Phongpaichit, S., Rungjindamai, N., Rukachaisirikul, V., & Sakayaroj, J. (2006). Antimicrobial activity in cultures of endophytic fungi isolated

from *Garcinia* species. *FEMS Immunology & Medical Microbiology*, 48(3): 367-372.

Pittayakhajonwut, P., Suvannakad, R., Thienhirun, S., Prabpai, S., Kongsaeree, P., & Tanticharoen, M. (2005).An anti-herpes simplex virus-type 1 agent from *Xylaria mellisii* (BCC 1005). *Tetrahedron Letters*, 46(8): 1341-1344.

Pongcharoen, P., Promtet, W., Yenradee, P., & Hicks, C. (2008). Stochastic optimisation timetabling tool for university course scheduling. *International Journal of Production Economics*, 112(2): 903-918.

Pootong, A., Norrapong, B., & Cowawintaweewat, S. (2017). Antifungal activity of cinnamaldehyde against *Candida albicans*. *Southeast Asian Journal of Tropical Medicine and Public Health*, 48(1): 150-158.

Porras-Alfaro, A., & Bayman, P. (2011). Hidden fungi, emergent properties: endophytes and microbiomes. *Annual review of phytopathology*, 49.

Potshangbam, M., Devi, S. I., Sahoo, D., & Strobel, G. A. (2017). Functional Characterization of Endophytic Fungal Community Associated with *Oryza sativa* L. and *Zea mays* L. *Frontiers in Microbiology*, 8.

Prihanto, A. A., Firdaus, M., & Nurdiani, R. (2012). Anti-methicillin resistant *Staphylococcus aureus* (MRSA) of methanol extract of mangrove plants leaf: preliminary report. *Drug Invent Today*, 4: 439-40.

Pudhom, K., & Teerawatananond, T. (2014). Rhytidenones A–F, spirobisnaphthalenes from *Rhytidhysteron* sp. AS21B, an endophytic fungus. *Journal of natural products*, 77(8): 1962-1966.

Puri, S. C., Verma, V., Amna, T., Qazi, G. N., & Spiteller, M. (2005).An Endophytic Fungus from *Nothapodytes foetida* that Produces Camptothecin. *Journal of natural products*, 68(12): 1717-1719.

Qin, H. N., & Boufford, D. E. (2007).Rhizophoraceae. *Flora of China*, 13: 295-299.

Rahman, A., & Kang, S. C. (2009).Inhibition of foodborne pathogens and spoiling bacteria by essential oil and extracts of Erigeron ramosus (Walt.)BSP. *Journal of food safety*, 29(2): 176-189.

Ramasamy, K., Lim, S. M., Bakar, H. A., Ismail, N., Ismail, M. S., Ali, M. F., & Cole, A. L. (2010). Antimicrobial and cytotoxic activities of Malaysian endophytes. *Phytotherap research*, 24(5): 640-643.

Ranković, B. R., Kosanić, M. M., & Stanojković, T. P. (2011). Antioxidant, antimicrobial and anticancer activity of the lichens *Cladonia furcata*,

Lecanora atra and *Lecanora muralis*. *BMC complementary and alternative medicine*, 11(1): 97.

Ratnaweera, P. B., de Silva, E. D., Williams, D. E., & Andersen, R. J. (2015). Antimicrobial activities of endophytic fungi obtained from the arid zone invasive plant *Opuntia dillenii* and the isolation of equisetin, from endophytic *Fusarium sp*. *BMC complementary and alternative medicine*,15(1): 220.

Rateb, M. E., & Ebel, R. (2011).Secondary metabolites of fungi from marine habitats. *Natural product reports*, 28(2): 290-344.

Redman, R. S., Kim, Y. O., Woodward, C. J., Greer, C., Espino, L., Doty, S. L., & Rodriguez, R. J. (2011). Increased fitness of rice plants to abiotic stress via habitat adapted symbiosis: a strategy for mitigating impacts of climate change. *PLOS one*, 6(7): e14823.

Reino, J. L., Guerrero, R. F., Hernández-Galán, R., &Collado, I. G. (2008).Secondary metabolites from species of the biocontrol agent *Trichoderma*. *Phytochemistry Reviews*, 7(1): 89-123.

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and social psychology bulletin*, 26(4): 419-435

Ren, C. G., & Dai, C. C. (2012). Jasmonic acid is involved in the signaling pathway for fungal endophyte-induced volatile oil accumulation of *Atractylodes lancea* plantlets. *BMC plant biology*, 12(1): 128.

Rhoden, S. A., Garcia, A., Bongiorno, V. A., Azevedo, J. L., & Pamphile, J. A. (2012). Antimicrobial Activity of Crude Extracts of Endophytic Fungi Isolated from Medicinal Plant *Trichilia elegans* A. Juss. *Journal of Applied Pharmaceutical Science*, 2(8): 57.

Rivera-Orduña, F. N., Suarez-Sanchez, R. A., Flores-Bustamante, Z. R., Gracida-Rodriguez, J. N., & Flores-Cotera, L. B. (2011). Diversity of endophytic fungi of *Taxus globosa* (Mexican yew). *Fungal Diversity*, 47(1): 65-74.

Rönsberg, D., Debbab, A., Mándi, A., Vasylyeva, V., Böhler, P., Stork, B., & Wray, V. (2013). Pro-apoptotic and immunostimulatory tetrahydroxanthone dimers from the endophytic fungus *Phomopsis longicolla*. *The Journal of organic chemistry*, 78(24): 12409-12425.

Roopa, G., Madhusudhan, M. C., Sunil, K. C. R., Lisa, N., Calvin, R., Poornima, R., & Geetha, N. (2015). Identification of Taxol-producing endophytic fungi isolated from *Salacia oblonga* through genomic mining approach. *Journal of Genetic Engineering and Biotechnology*, 13(2): 119-127.

Rouissi, W., Ugolini, L., Martini, C., Lazzeri, L., & Mari, M. (2013).Control of postharvest fungal pathogens by antifungal compounds from *Penicillium expansum*. *Journal of food protection*, 76(11): 1879-1886.

Roslan Ariffin & Nik Mohd Shah, N.M., 2013. A Working Plan for the Matang Mangrove Forest Reserve, Perak: Sixth Revision of the first 10-year Period (2010–2019) of the Third Rotation. State Forestry Department of Perak, Malaysia, 229 pp.

Roslani, M. A., Mustapha, M. A., Lihan, T., & Juliana, W. W. (2013, November).Classification of mangroves vegetation species using texture analysis on Rapideye satellite imagery.In *AIP Conference Proceedings* (Vol. 1571, No. 1, pp. 480-486).AIP.

Rukachaisirikul, V., Rodglin, A., Sukpondma, Y., Phongpaichit, S., Buatong, J., & Sakayaroj, J. (2012). Phthalide and isocoumarin derivatives produced by an *Acremonium* sp. isolated from a mangrove *Rhizophora apiculata*. *Journal of natural products*, 75(5): 853-858.

SAID, S., & PIETRO, R. (2002). Enzymes of industrial and biotechnological interest. *Editora Eventos e Livraria, 121p* .

Saikkonen, K., Gundel, P. E., & Helander, M. (2013). Chemical ecology mediated by fungal endophytes in grasses. *Journal of chemical ecology*, 39(7): 962-968.

Salvadori, M. R., Lepre, L. F., Ando, R. A., do Nascimento, C. A. O., & Correˆa, B. (2013). Biosynthesis and uptake of copper nanoparticles by dead biomass of *Hypocrea lixii* isolated from the metal mine in the Brazilian Amazon region. *PloS one*, 8(11): e80519.

Sánchez-Herrera, L. M., Ramos-Valdivia, A. C., De La Torre, M., Salgado, L. M., & Ponce Noyola, T. (2007).Differential expression of cellulases and xylanases by *Cellulomonas flavigena* grown on different carbon sources. *Applied microbiology and biotechnology*, 77(3): 589-595.

Sangmanee, P., & Hongpattarakere, T. (2014). Inhibitory of multiple antifungal components produced by Lactobacillus plantarum K35 on growth, aflatoxin production and ultrastructure alterations of Aspergillus flavus and Aspergillus parasiticus. *Food Control*, 40: 224-233.

Saravanakumar, K., & Kathiresan, K. (2014).Bioremoval of the synthetic dye malachite green by marine Trichoderma sp. *SpringerPlus*, 3(1): 631.

Sarma, V. V., Hyde, K. D., & Vittal, B. P. R. (2001). Frequency of occurrence of mangrove fungi from the east coast of India. *Hydrobiologia*, 455(1-3): 41-53.

Sarwar, M., & Frankenberger, W. (1995).Fate of L-phenylalanine in soil and its effect on plant growth. *Soil Science Society of America Journal*, 59(6): 1625-1630.

Schock-Kusch, D., Xie, Q., Shulhevich, Y., Hesser, J., Stsepankou, D., Sadick, M., & Gretz, N. (2011). Transcutaneous assessment of renal function in conscious rats with a device for measuring FITC-sinistrin disappearance curves. *Kidney international*, 79(11): 1254 1258.

Schulz, B., Boyle, C., Draeger, S., Römmert, A. K., & Krohn, K. (2002). Endophytic fungi: a source of novel biologically active secondary metabolites. *Mycological Research*, 106(9): 996-1004.

Schulz, B., & Boyle, C. (2005).The endophytic continuum. *Mycological research*, 109(6): 661 686.

Schmit, J. P., & Mueller, G. M. (2007).An estimate of the lower limit of global fungal diversity. *Biodiversity and conservation*, 16(1): 99-111.

Score, A. J., Palfreyman, J. W., & White, N. A. (1997).Extracellular phenoloxidase and peroxidase enzyme production during interspecific fungal interactions. *International Biodeterioration & Biodegradation*, 39(2-3): 225-233.

Setyawan, A. D., & Ulumuddin, Y. I. (2012).Species diversity and distribution of *Bruguiera* in Tambelan Islands, Natuna Sea, Indonesia. In *Proc Soc Indon Biodiv Intl Conf* (Vol. 1, pp. 82-90).

Setyawan, A. D., Ulumuddin, Y. I., & Ragavan, P. (2014). Mangrove hybrid of *Rhizophora* and its parental species in Indo-Malayan region. *Nusantara Bioscience*, 6: 67-79.

Seyhan, A. T., Tanoğlu, M., & Schulte, K. (2009). Tensile mechanical behavior and fracture toughness of MWCNT and DWCNT modified vinyl-ester/polyester hybrid nanocomposites produced by 3-roll milling. *Materials Science and Engineering: A*, 523(1-2): 85-92.

Shang, Z., Li, X. M., Li, C. S., & Wang, B. G. (2012). Diverse Secondary Metabolites Produced by Marine-Derived Fungus Nigrospora sp. MA75 on Various Culture Media. *Chemistry & biodiversity*, 9(7): 1338-1348.

Sharma, U., Katoch, D., Sood, S., Kumar, N., Singh, B., Thakur, A., & Gulati, A. (2013). Synthesis, antibacterial and antifungal activity of 2-amino-1, 4-naphthoquinones using silica-supported perchloric acid (HClO 4-SiO 2) as a mild, recyclable and highly efficient heterogeneous catalyst.

Shon, M. Y., Kim, T. H., & Sung, N. J. (2003). Antioxidants and free radical scavenging activity of *Phellinus baumii* (*Phellinus* of Hymenochaetaceae) extracts. *Food chemistry*, 82(4): 593-597.

Shorr, A. F. (2009). Review of studies of the impact on Gram-negative bacterial resistance on outcomes in the intensive care unit. *Critical care medicine*, 37(4): 1463-1469.

Shreaz, S., Bhatia, R., Khan, N., Maurya, I. K., Ahmad, S. I., Muralidhar, S., & Khan, L. A. (2012). Cinnamic aldehydes affect hydrolytic enzyme secretion and morphogenesis in oral *Candida* isolates. *Microbial pathogenesis*, 52(5): 251-258.

Shukla, S. T., Habbu, P. V., Kulkarni, V. H., Jagadish, K. S., Pandey, A. R., & Sutariya, V. N. (2014). Endophytic microbes: a novel source for biologically/pharmacologically active secondary metabolites. *Asian J Pharmacol Toxicol*, 2(3): 1-6.

Siameto, E. N., Okoth, S., Amugune, N. O., & Chege, N. C. (2010). Antagonism of *Trichoderma farzianum* isolates on soil borne plant pathogenic fungi from Embu District, Kenya. *Journal of Yeast and Fungal Research*, 1(3): 47-54.

Sieber, S. A., & Marahiel, M. A. (2005). Molecular mechanisms underlying nonribosomal peptide synthesis: approaches to new antibiotics. *Chemical reviews*, 105(2): 715-738.

Siddiquee, S., Cheong, B. E., Taslima, K., Kausar, H., & Hasan, M. M. (2012).Separation and identification of volatile compounds from liquid cultures of *Trichoderma harzianum* by GC-MS using three different capillary columns. *Journal of chromatographic science*, 50(4): 358-367.

Singh, L. P., Gill, S. S., & Tuteja, N. (2011).Unraveling the role of fungal symbionts in plant abiotic stress tolerance. *Plant signaling & behavior*, 6(2): 175-191.

Smith, A. R. B., Hosker, G. L., & Warrell, D. W. (1989). The role of pudendal nerve damage in the aetiology of genuine stress incontinence in women. *BJOG: An International Journal of Obstetrics & Gynaecology*, 96(1): 29-32.

Song, Y. R., Choi, M. S., Choi, G. W., Park, I. K., & Oh, C. S. (2016). Antibacterial activity of cinnamaldehyde and estragole extracted from plant essential oils against *Pseudomonas syringae*pv. actinidiae causing bacterial canker disease in kiwifruit. *The plant pathology journal*, 32(4): 363.

Spalding, M. (2010). *World atlas of mangroves*. Routledge.

Spalding, M., Kainuma, M., & Collins, L. (2010). World atlas of mangroves. A collaborative project of ITTO, ISME, FAO, UNEP-WCMC. *London, UK: Earthscan*.

Spalding, M., McIvor, A., Tonneijck, F., Tol, S., & Eijk, P. V. (2014). Mangroves for coastal defence.

Staniek, A., Woerdenbag, H. J., & Kayser, O. (2009). Taxomyces andreanae: a presumed paclitaxel producer demystified?. *Planta medica*, 75(15): 1561-1566.

Stierle, A., Strobel, G., & Stierle, D. (1993).Taxol and taxane production by Taxomyces andreanae, an endophytic fungus of Pacific yew. *Science*, 260(5105): 214-216.

Strobel, G., Yang, X., Sears, J., Kramer, R., Sidhu, R. S., & Hess, W. M. (1996).Taxol from *Pestalotiopsis microspora*, an endophytic fungus of *Taxus wallachiana*. *Microbiology*, 142(2): 435-440.

Strobel, G. A. (2003). Endophytes as sources of bioactive products. *Microbes and infection*, 5(6): 535-544.

Strobel, G., & Daisy, B. (2003).Bioprospecting for microbial endophytes and their natural products. *Microbiology and molecular biology reviews*, 67(4): 491-502.

Strobel, G. (2006). Harnessing endophytes for industrial microbiology. *Current opinion in microbiology*, 9(3): 240-244.

Strobel, G., Daisy, B., Castillo, U., & Harper, J. (2004). Natural products from endophytic microorganisms. *Journal of Natural products*, 67(2): 257-268.

Strobel, G. A., Knighton, B., Kluck, K., Ren, Y., Livinghouse, T., Griffin, M., & Sears, J. (2008). The production of myco-diesel hydrocarbons and their derivatives by the endophytic fungus *Gliocladium roseum* (NRRL 50072). *Microbiology*, 154(11): 3319-3328.

Stuart, R. M., Romão, A. S., Pizzirani-Kleiner, A. A., Azevedo, J. L., & Araújo, W. L. (2010). Culturable endophytic filamentous fungi from leaves of transgenic imidazolinone tolerant sugarcane and its non-transgenic isolines. *Archives of microbiology*, 192(4): 307-313.

Sturz, A. V., & Christie, B. R. (1996).Endophytic bacteria of red clover as agents of allelopathic clover-maize syndromes. *Soil Biology and Biochemistry*, 28(4-5): 583 588.

Sturz, A. V., Christie, B. R., & Matheson, B. G. (1998). Associations of bacterial endophyte populations from red clover and potato crops with potential for beneficial allelopathy. *Canadian Journal of Microbiology*, 44(2): 162-167.

Suciatmih, & Maman, R. (2013). Endophytic fungi isolated from mangrove plant and have antagonism role against *Fusarium* wilt. *ARPN J Agril Biol Sci*, 8(3): 253-257.

Suganthy, N., & Pandima Devi, K. (2016).In vitro antioxidant and anti-cholinesterase activities of *Rhizophora mucronata*. *Pharmaceutical biology*, 54(1): 118-129.

Sultan, S., Shah, S.A.A., Sun, L., Ramasami, K., Cole, A., Blunt, J., H.G M.M., Weber J.F.F. (2011). Bioactive fungal metabolites of 9PR2 isolated from roots of *Callophyllum ferrugineum. International Journal of Pharmacy and Pharmaceutical Science*, 3:7 9

Sun, X., Guo, L. D., & Hyde, K. D. (2011).Community composition of endophytic fungi in Acer truncatum and their role in decomposition. *Fungal Diversity*, 47(1): 85-95.

Suryanarayanan, T. S., Kumaresan, V., & Johnson, J. A. (1998).Foliar fungal endophytes from two species of the mangrove Rhizophora. *Canadian Journal of microbiology*, 44(10): 1003-1006.

Suryanarayanan, T. S., & Kumaresan, V. (2000).Endophytic fungi of some halophytes from an estuarine mangrove forest. *Mycological Research*, 104(12): 1465-1467.

Suryanarayanan, T. S., Murali, T. S., & Venkatesan, G. (2002). Occurrence and distribution of fungal endophytes in tropical forests across a rainfall gradient. *Canadian Journal of Botany*, 80(8): 818-826.

Sutherland, I. E., Sproull, R. F., & Harris, D. F. (1999). *Logical effort: designing fast CMOS circuits*. Morgan Kaufmann.

Sziderics, A. H., Rasche, F., Trognitz, F., Sessitsch, A., & Wilhelm, E. (2007). Bacterial endophytes contribute to abiotic stress adaptation in pepper plants (*Capsicum annuum* L.). *Canadian journal of microbiology*, 53(11): 1195-1202

Tam, N. F., & Wong, Y. S. (1995). Mangrove soils as sinks for wastewater-borne pollutants. *Hydrobiologia*, 295(1-3): 231-241.

Tan, R. X., & Zou, W. X. (2001). Endophytes: a rich source of functional metabolites. *Natural product reports*, 18(4): 448-459.

Tao, G., Liu, Z. Y., Hyde, K. D., Lui, X. Z., & Yu, Z. N. (2008). Whole rDNA analysis reveals novel and endophytic fungi in *Bletilla ochracea* (Orchidaceae). *Fungal Divers*, 33: 101-122.

Teixeira, M. F., Martins, M. S., Da Silva, J. C., Kirsch, L. S., Fernandes, O. C., Carneiro, A. L., & Durán, N. (2012). Amazonian Biodiversity: Pigments from *Aspergillus* and *Penicillium*-Characterizations,

Antibacterial Activities and their Toxicities. *Current Trends in Biotechnology & Pharmacy*, 6(3).

Tejesvi, M. V., Kini, K. R., Prakash, H. S., Subbiah, V., & Shetty, H. S. (2007). Genetic diversity and antifungal activity of species of *Pestalotiopsis* isolated as endophytes from medicinal plants. *Fungal Divers*, 24: 37-54.

Thatoi, H., Behera, B. C., Mishra, R. R., & Dutta, S. K. (2013). Biodiversity and biotechnological potential of microorganisms from mangrove ecosystems: a review. *Annals of microbiology*, 63(1): 1-19.

Ting, A. S. Y., Hoon, T. S., Kay, W. M., & Ern, C. L. (2010).Characterization of Actinobacteria with Antifungal Potential against *Fusarium* Crown-rot Pathogen. *Pest Technology*, 4(1): 65-69.

Todar, K. (2004). *Pseudomonas* and related bacteria.Todar's online text book of bacteriology.

Tong, W.Y., Darah, I., Latiffah, Z. (2011). Antimicrobial activities of endophytic fungal isolated from medicinal herb *Orthosiphon stamineus* Benth. Journal of Medicinal Plants Research, 5(5): 831-836.

Tudor, D., Robinson, S. C., & Cooper, P. A. (2013).The influence of pH on pigment formation by lignicolous fungi.*International Biodeterioration & Biodegradation*, 80: 22-28.

Turco, R. F., Kennedy, A. C., & Jawson, M. (1992). *Microbial indicators of soil quality* (No.PB 93-156198/XAB). Purdue Univ., Lafayette, IN (United States).

Udayanga, D., Liu, X., McKenzie, E. H., Chukeatirote, E., Bahkali, A. H., & Hyde, K. D. (2011). The genus *Phomopsis*: biology, applications, species concepts and names of common phytopathogens. *Fungal Diversity*, 50(1): 189.

Ul-Hassan, S. R., Strobel, G. A., Booth, E., Knighton, B., Floerchinger, C., & Sears, J. (2012). Modulation of volatile organic compound formation in the Mycodiesel-producing endophyte Hypoxylon sp. CI-4. *Microbiology*, 158(2): 465-473.

U'Ren, J. M., Lutzoni, F., Miadlikowska, J., & Arnold, A. E. (2010). Community analysis reveals close affinities between endophytic and endolichenic fungi in mosses and lichens. *Microbial ecology*, 60(2): 340-353.

Vaish, D. K., & Sinha, A. P. (2006). Evaluation of fungal antagonists against *Rhizoctonia solani* causing sheath blight of rice. *Indian Journal of Agricultural Research*, 40(2): 79-85.

Vasundhara, M., Baranwal, M., & Kumar, A. (2016).*Fusarium tricinctum*, an endophytic fungus exhibits cell growth inhibition and antioxidant activity. *Indian journal of microbiology*, 56(4): 433-438.

Varsha, K. K., Devendra, L., Shilpa, G., Priya, S., Pandey, A., & Nampoothiri, K. M. (2015). 2, 4-Di-tert-butyl phenol as the antifungal, antioxidant bioactive purified from a newly isolated *Lactococcus* sp. *International journal of food microbiology*, 211: 44-50.

Venkatachalam, R., Subban, K., & Paul, M. J. (2008). Taxol from Botryodiplodia theobromae (BT 115)-An endophytic fungus of *Taxus baccata*. *Journal of Biotechnology*, 136: S189-S190.

Venkatachalam, M. A., Weinberg, J. M., Kriz, W., & Bidani, A. K. (2015).Failed tubule recovery, AKI-CKD transition, and kidney disease progression. *Journal of the American Society of Nephrology*, 26(8): 1765-1776.

Viszwapriya, D., Subramenium, G. A., Prithika, U., Balamurugan, K., & Pandian, S. K. (2016). Betulin inhibits virulence and biofilm of *Streptococcus pyogenes* by suppressing ropB core regulon, sagA and dltA. *Pathogens and disease*, 74(7).

Waller, F., Achatz, B., Baltruschat, H., Fodor, J., Becker, K., Fischer, M., & Franken, P. (2005). The endophytic fungus *Piriformospora indica* reprograms barley to salt-stress tolerance, disease resistance, and higher yield. *Proceedings of the National Academy of Sciences of the United States of America*, 102(38): 13386-13391.

Wang, Q. X., Li, S. F., Zhao, F., Dai, H. Q., Bao, L., Ding, R., & Liu, H. W. (2011). Chemical constituents from endophytic fungus *Fusarium oxysporum*. *Fitoterapia*, 82(5): 777 781.

Wang, L. W., Xu, B. G., Wang, J. Y., Su, Z. Z., Lin, F. C., Zhang, C. L., & Kubicek, C. P. (2012). Bioactive metabolites from *Phoma* species, an endophytic fungus from the Chinese medicinal plant *Arisaema erubescens*. *Applied microbiology and biotechnology*, 93(3): 1231-1239.

Wang, H., DelVescovo, D., Yao, M., & Reitz, R. D. (2015). Numerical study of RCCI and HCCI combustion processes using gasoline, diesel, iso-butanol and DTBP cetane improver. *SAE International Journal of Engines*, 8(2015-01-0850): 831-845.

Weber, D., Sterner, O., Anke, T., Gorzalczancy, S., Martino, V., & Acevedo, C. (2004).Phomol, a new antiinflammatory metabolite from an endophyte of the medicinal plant *Erythrina crista-galli*. *The Journal of Antibiotics*, 57(9): 559-563.

Wheeler, K. A., & Hocking, A. D. (1993). Interactions among xerophilic fungi associated with dried salted fish. *Journal of Applied Bacteriology*, 74(2): 164-169.

White, M. B., Carvalho, M., Derse, D., O'Brien, S. J., & Dean, M. (1992).Detecting single base substitutions as heteroduplex polymorphisms. *Genomics*, 12(2): 301-306.

Wibowo, M., Prachyawarakorn, V., Aree, T., Mahidol, C., Ruchirawat, S., & Kittakoop, P. (2016).Cytotoxic sesquiterpenes from the endophytic fungus *Pseudolagarobasidium acaciicola*. *Phytochemistry*, 122: 126-138.

Wightman, F., & Lighty, D. L. (1982).Identification of phenylacetic acid as a natural auxin in the shoots of higher plants. *Physiologia Plantarum*, 55(1): 17-24.

Wojcechowskyj, J. A., & Doms, R. W. (2010).A potent, broad-spectrum antiviral agent that targets viral membranes. *Viruses*, 2(5): 1106-1109.

Wu, C. L., Chien, S. C., Wang, S. Y., Kuo, Y. H., & Chang, S. T. (2005). Structure-activity relationships of cadinane-type sesquiterpene derivatives against wood-decay fungi. *Holzforschung*, 59(6): 620-627.

Wu, Y., Chung, A., Tam, N. F. Y., Pi, N., & Wong, M. H. (2008).Constructed mangrove wetland as secondary treatment system for municipal wastewater. *Ecological Engineering*, 34(2:: 137-146.

Wu, H., Zhang, F., Williamson, N., Jian, J., Zhang, L., Liang, Z., & Zheng, Y. (2014). Effects of Secondary Metabolite Extract from *Phomopsis occulta* on β-Amyloid Aggregation. *PloS one*, 9(10): e109438.

Xu, J. (2015). Bioactive natural products derived from mangrove-associated microbes. *RSC Advances*, 5(2): 841-892.

Yadav, A., Kon, K., Kratosova, G., Duran, N., Ingle, A. P., & Rai, M. (2015). Fungi as an efficient mycosystem for the synthesis of metal nanoparticles: progress and key aspects of research. *Biotechnology letters*, 37(11): 2099-2120.

Yan, H. J., Li, X. M., Li, C. S., & Wang, B. G. (2012). Alkaloid and anthraquinone derivatives produced by the marine-derived endophytic fungus Eurotium rubrum. *Helvetica Chimica Acta*, 95(1): 163-168.

Yeh, H. F., Luo, C. Y., Lin, C. Y., Cheng, S. S., Hsu, Y. R., & Chang, S. T. (2013). Methods for thermal stability enhancement of leaf essential oils and their main constituents from indigenous cinnamon (Cinnamomum osmophloeum). *Journal of agricultural and food chemistry*, 61(26): 6293-6298.

Yogeswari, S., Ramalakshmi, S., Neelavathy, R., & Muthumary, J. (2012).Identification and comparative studies of different volatile fractions from *Monochaetia kansensis* by GCMS. *Global Journal of Pharmacology*, 6(2): 65-71.

Yoon, M. A., Jeong, T. S., Park, D. S., Xu, M. Z., Oh, H. W., Song, K. B., & Park, H. Y. (2006). Antioxidant effects of quinoline alkaloids and 2, 4-di-tert-butylphenol isolated from *Scolopendra subspinipes*. *Biological and Pharmaceutical Bulletin*, 29(4): 735-739.

Yossa, N., Patel, J., Macarisin, D., Millner, P., Murphy, C., Bauchan, G., & Lo, Y. M. (2014). Antibacterial activity of cinnamaldehyde and sporan against *Escherichia coli* O157: H7 and *Salmonella*. *Journal of food processing and preservation*, 38(3): 749-757.

Zafra-Rojas, Q. Y., Cruz-Cansino, N., Ramírez-Moreno, E., Delgado-Olivares, L., Villanueva Sánchez, J., & Alanís-García, E. (2013). Effects of ultrasound treatment in purple cactus pear (*Opuntia ficus-indica*) juice. *Ultrasonics sonochemistry*, 20(5): 1283-1288.

Zainuddin, N., Alias, S.A., Lee, C.W., Ebel, R., Othman, N.A., Mukhtar, M.R., Awang, K. 2010. Antimicrobial activities of marine fungi from Malaysia.*Botanica Marina*, 53: pp 507-513.

Zang, L. Y., Wei, W., Guo, Y., Wang, T., Jiao, R. H., Ng, S. W., & Ge, H. M. (2012). Sesquiterpenoids from the mangrove-derived endophytic fungus *Diaporthe* sp. *Journal of natural products*, 75(10): 1744-1749.

Zanwar, A. A., Hegde, M. V., & Bodhankar, S. L. (2010). In vitro antioxidant activity of ethanolic extract of *Linum usitatissimum*. *Pharmacologyonline*, 1: 683-696.

Zeng, Y. B., Gu, H. G., Zuo, W. J., Zhang, L. L., Bai, H. J., Guo, Z. K., & Dai, H. F. (2015). Two new sesquiterpenoids from endophytic fungus J3 isolated from mangrove plant *Ceriops tagal*. *Archives of pharmacal research*, 38(5): 673-676.

Zhang, H. W., Song, Y. C., & Tan, R. X. (2006). Biology and chemistry of endophytes. *Natural product reports*, 23(5): 753-771.

Zhang, M., Li, N., Chen, R., Zou, J., Wang, C., & Dai, J. (2014). Two terpenoids and a polyketide from the endophytic fungus Trichoderma sp. Xy24 isolated from mangrove plant *Xylocarpus granatum*. *J Chin Pharm Sci*, 23(6): 424-424.

Zhang, P., Li, X. M., Liu, H., Li, X., & Wang, B. G. (2015). Two new alkaloids from *Penicillium oxalicum* EN-201, an endophytic fungus derived from the marine mangrove plant *Rhizophora stylosa*. *Phytochemistry Letters*, 13: 160-164.

Zhao, J., Zhou, L., Wang, J., Shan, T., Zhong, L., Liu, X., &Gao, X. (2010). Endophytic fungi for producing bioactive compounds originally from their host plants. *Curr Res, Technol Educ Trop Appl Microbiol Microbial Biotechnol*, 1: 567-576.

Zhao, Q., Xie, B., Yan, J., Zhao, F., Xiao, J., Yao, L., & Huang, Y. (2012). In vitro antioxidant andantitumor activities of polysaccharides extracted from *Asparagus officinalis*.*Carbohydrate Polymers*, 87(1): 392-396.

Zhou, R., Zeng, K., Wu, W., Chen, X., Yang, Z., Shi, S., & Wu, C. I. (2007). Population genetics of speciation in nonmodel organisms: I. Ancestral polymorphism in mangroves. *Molecular Biology and Evolution*, 24(12): 2746-2754.

Zhou, X., Zhu, H., Liu, L., Lin, J., & Tang, K. (2010). A review: recent advances and future prospects of taxol-producing endophytic fungi. *Applied microbiology and biotechnology*, 86(6): 1707-1717.

Zhou, X. M., Zheng, C. J., Song, X. P., Han, C. R., Chen, W. H., & Chen, G. Y. (2014). Antibacterial α-pyrone derivatives from a mangrove-derived fungus Stemphylium sp. 33231 from the South China Sea. *The Journal of antibiotics*, 67(5): 401.

Zhu, J. X., Li, Y. C., & Meng, L. (2008). Comparative study on different parts of taxol producing endophytic fungi from *T. chinesis* in Taihang Mountain. *Biotechnol Bull*, 4: 191-194.

Zimmerman, N. B., & Vitousek, P. M. (2012). Fungal endophyte communities reflect environmental structuring across a Hawaiian landscape. *Proceedings of the National Academy of Sciences*, 109(32): 13022-13027.

Zou, Y., Tong, L. P. S. G., & Steven, G. P. (2000).Vibration-based model-dependent damage (delamination) identification and health monitoring for composite structures—a review. *Journal of Sound and vibration*, 230(2): 357-378.

Zughaier, S. M., Ryley, H. C., & Jackson, S. K. (1999). A melanin pigment purified from an epidemic strain of *Burkholderia cepacia* attenuates monocyte respiratory burst activity by scavenging superoxide anion. *Infection and immunity*, 67(2): 908-913.