DEVELOPMENT OF *Mycorrhizae* LIKE spp. AND *Trichoderma* spp. COCKTAIL FOR DEGRADATION OF OIL PALM EMPTY FRUIT BUNCH

ZAHARADDEEN UMAR

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DEDICATION

This thesis is dedicated to my parents, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my family, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

The accumulation of Oil Palm Empty Fruit Bunch (OPEFB) in large quantity contributes to environmental pollution. The usual means of disposing this waste such as burning in incinerators leads to secondary pollution. The present study aims to find an efficient and practical approach to revalorize OPEFB as renewable and cost effective substrate for production of lignocellulolytic enzymes. A total of nine *Mycorrhizae* like fungi and six *Trichoderma* isolates stock were collected from Biorefinery Technology Research Laboratory. The isolates were studied for biocompatibility on Potato Dextrose Agar (PDA) and Mandel medium. The solid state fermentation was conducted using mono and mixed-culture of *Mycorrhizae* CS2 like fungi and *Trichoderma* A4 sp. and untreated OPEFB along with four different media. The activity of enzymes and reducing sugar during fermentation process was analyzed. The biocompatibility test showed that *Mycorrhizae* spp. and *Trichoderma* spp. could grow together on both PDA and Mendel medium. The highest enzymes activities were produced at 76% final moisture content, 500µm substrate, initial pH 7.0, inoculum size 1×10^7, incubation at 30℃ and consortium growth on OPEFB supplemented with Mandel medium. The highest CMCase and xylanase activities of mixed culture was 38.67 U/g and 111.88 U/g and single culture was CS2 37.66 U/g and 100.59 U/g both in Mandel medium. Interestingly, highest lignin peroxidase activity (0.000323 U/g and 0.000215U/g) were recorded from mono cultures of CS2 on medium B and C respectively. The highest reducing sugar production of 0.0383 U/g and 0.0785 U/g were recorded from single CS2 and mixed cultures both from mandel medium. The finding of the study suggest that OPEFB is a cheap renewable substrate that can be used for lignocellulolytic enzyme production and also indicates that *Mycorhizae* and *Trichoderma* consortium could be a good alternative for enzymes production.

ABSTRAK

Pengumpulan sisa tandan buah kelapa sawit (OPEFB) yang banyak telah menyumbang kepada pencemaran alam sekitar. Kaedah yang biasa digunakan adalah dengan pembakaran dalam incinerator yang boleh menyumbang kepada pencemaran sekunder. Kajian ini bertujuan mencari pendekatan yang effective dan praktikal untuk mengguna semula tandan buah kelapa sawit sebagai substrat yang diperbaharui dan kos efektif untuk pengeluaran enzim lignoselulolitik. Sebanyak sembilan *Mycorrhizae* spp. dan enam isolat *Trichoderma* dikumpulkan dari Makmal Penyelidikan Teknologi Biorefineri. Kajian biokopatibility telah dijalan dengan menggunakan 4 Mikorizae dan 4 *Trichorderma* di atas media PDA dan Mandel. Penapaian dalam keadaan pepejal dilakukan dengan menggunakan kultur tunggal dan kultur campuran campuran fungi seperti *Mycorrhizae* CS2 dan *Trichoderma* sp. A4 serta OPEFB yang tidak dirawat bersama dengan empat media yang berbeza. Ujian biokompatibiliti menunjukkan bahawa *Mycorrhizae* spp. dan *Trichoderma* spp. boleh tumbuh bersama di atas PDA dan media Mandel. Aktiviti enzim lignocsellulolytic tertinggi dihasilkan pada 76% lembapan, saiz substrat 500 µm, pH awal 7.0, saiz inokulum 1×10^7 spore /ml serta inkubasi pada 30°C. Pertumbuhan konsortium *Mycorrhizae* spp. dan *Trichoderma* spp. pada OPEFB dalam medium Mandel. Aktiviti CMCase dan xylanase adalah tertinggi dalam kultur campuran iaitu 38.67 U/g dan 111.88 U/g. Kultur tunggal Mikorizae CS2 menghasilkan cellulose and xylanase sebanyak 37.66 U/g dan 100.59 U/g dalam medium Mandel. Walaubagaimanapun altiviti lignin peroksidase adalah sangat rendah (0.000323 U/g dan 0.000215 U/g) samada pada kultur tunggal atau campuran pada medium B dan C. Aktiviti gula peruduksi tertinggi 0.0383 U/g dan 0.0785 U/g dicatatkan dari Mikorhizae CS2 tunggal dan kultur campuran dari medium Mandel. Hasil kajian menunjukkan bahawa tandan buah kelapa sawit dan konsortium *Mycorhizae* dan *Trichoderma* berupaya untuk menghasilkan enzim lignocellulosik dengan menggunakan kaedah SSF.

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LIST OF ABBREVIATIONS

°C	-	Degree Celsius
AMF	-	*Arbuscular Mycorrhizae* Fungi
CMCase	-	Carboxymethyl-cellulase
DNS	-	Dinitrosalicyclic acid
g	-	Gram
h	-	hour
H_2SO_4	-	Sulphuric acid
HCl	-	Hydrochloric acid
H_2O_2	-	Hydrogen Peroxide
L	-	Liter
LiP	-	Lignin peroxidase
min	-	Minute
mL	-	Milliliter
MnP	-	Manganese peroxide
NA	-	Not available
NaOH	-	Sodium hydroxide
nm	-	Nanometer
PDA	-	Potato Dextrose Agar
rpm	-	Rotation per minute
SSF	-	Solid-State Fermentation
U/g	-	Unit of enzyme per gram
UTM	-	Universiti Teknologi Malaysia
v/v	-	Volume per volume
w/v	-	Weight per volume
µL	-	Micro liter
µm	-	Micro meter

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Interaction between *Mycorrhizae* and *Trichoderma* is environmentally friendly to reduce agrochemical damage of the product and has synergistic effect of plant disease as biological control (Martínez-Medina *et al.*, 2009). Microbial inoculants interaction of *Mycorrhizae* spp. and *Trichoderma* spp. has the capability to promote growth of plan height, shoot, root, phosphorous uptake for numerous biochemical, physiological function and resistance of plant pathogen (Tchameni *et al.*, 2011). Microorganism play vital role as intermediate for recycling of lignocellulosic materials, degradation, also use as means of waste management toward environmental pollution. The development of microbial advancement and technology has many role toward the efficiency and utilization of renewable materials and use with considerable success in many area such as biocontrol agent industrial fermentation, plant growth hormones, antibiotic production and others (Kaur *et al.*, 2013).

Mycorrhizal fungi could promote and sustain the oil palm growth either by its present in soil naturally or through pre-plantation management of *Mycorrhizal.* This technique will ensure the establishment of new crops and do not exhaust soil nutrients rapidly (Kaur et al., 2014). The use of biocontrol agents such as *Trichoderma* spp. requires particular attention because of the possibility that these antagonists fungi interact not only with plant pathogens fungal but also with *Mycorrhizal* fungi such as AMF (Sharma *et al.*, 2016; Vosátka and Gryndler, 1999). The free-living microbial inoculants such as *Trichorderma* spp. could also stimulate the *Mycorrhizal* spp. colonization.

1.2 Objectives of the Study

The objectives of this study are:

a. To perform the biocompatibility test of *Mycorrhizae* like spp. and *Trichorderma* spp. in solid Mandel medium and Potato Dextrose Agar (PDA).
b. To identify the consortium growth of *Mycorrhizae* like spp. and *Trichorderma* spp. based on lignocellulolytic enzyme production performance in different medium using Oil Palm Empty Fruit Bunch (OPEFB) as a carbon source.
c. To analyse the lignocellulolytic enzymes and reducing sugar production by consortium growth of *Mycoryzae* like spp. and *Trichorderma* spp. in different medium using Oil Palm Empty Fruit Bunch (OPEFB) as a substrate.

1.3 Problem Statement

As the lignocellulose biomass contain polysaccharide which hydrolyzed by enzymatic or acidic processes. Acidic hydrolysis has disadvantages toward the generation of hazardous acidic waste and it is difficult to recover fermentable sugar. Enzymatic hydrolysis is more efficient and preferred, the process is under rapid development and has high capability of improvement in cost and efficiency for utilization of biomass. Usually, the enzymes production is very expensive, as a result of 40-60% production cost is raw materials. The enzymes cost economics can be brought down by some strategies such as use of cheaper and abundant lignocellulose biomass, solid state fermentation is cost effective, and use of microbial for higher enzymes production (Dhillon *et al.*, 2012). Lignocellulosic biomass uses in biorefinery as raw materials for production of enzymes, chemicals, and bioenergy. Difference sources would generate lignocellulosic feedstock which include empty palm oil fruit bunch, sugarcane bagasse, wheat brand straw, corn straw, wood, corn cobs and even newspaper, waste paper from office. The significance of biorefinery is bioconversion of lignocellulosic biomass to chemicals and bioenergy (Liguori and Faraco, 2016; Sperandio and Ferreira Filho, 2019). Cheap sources of renewable biomass into medium for the production of lignocellulose enzymes could help to decrease the production costs of enzymatic complexes that can hydrolyse lignocellulose residues for the formation of fermented syrups, thus contributing to the economic production of bioethanol (Camassola and Dillon, 2007).

1.4 Significance of the Study

Recent studies reveal that formulation of microbial bioinoculants for bio fertilizer and bio pesticides as a substitute agrochemicals in developing countries are at early stage of investigation (Mishra and Arora, 2016). Currently there is challenges of many features of co-culture need to understand and address the co-culture toward commercial enzymes production (Sperandio and Ferreira Filho, 2019). Development of lignocellulosic materials conversion to polymers and fine chemicals is another big challenges (Isikgor and Becer, 2015).

REFERENCES

Abo-Elyousr, K. A., Abdel-Hafez, S. I. and Abdel-Rahim, I. R. (2014). Isolation of *Trichoderma* and evaluation of their antagonistic potential against *Alternaria porri*. *Journal of Phytopathology*. 162(9), 567-574.

Ahn, Y., Lee, S. H., Kim, H. J., Yang, Y.-H., Hong, J. H., Kim, Y.-H. and Kim, H. (2012). Electrospinning of lignocellulosic biomass using ionic liquid. *Carbohydrate Polymers*. 88(1), 395-398.

Allen, S.-A. A., REE, A. G., Ayodeji, S.-A. M. and Deborah, S.-A. E. (2016). Lignocelluloses: An Economical and Ecological Resource for Bio-Ethanol Production–A Review. *Management*. 1(3), 128-144.

Almeida, J. B., de Mancilha, I. M., Vannetti, M. C. D. and Teixeira, M. A. (1995). Microbial protein production by *Paecilomyces variotii* cultivated in eucalyptus hemicellulosic hydrolyzate. *Bioresource Technology*. 52(2), 197-200.

Amer, M. and Abou-El-Seoud, I. (2008). *Mycorrhizal* Fungi and *Trichoderma harzianum* as Biocontrol Agents for Suppression of *Rhizoctonia solani* Damping off Disease of Tomato. *Communications in Agricultural and. Applied. Biological Science*. 73(2), 217-232.

Ang, S., Shaza, E., Adibah, Y., Suraini, A. and Madihah, M. (2013). Production of cellulases and xylanase by *Aspergillus fumigatus* SK1 using untreated oil palm trunk through solid state fermentation. *Process Biochemistry*. 48(9), 1293-1302.

Ang, S., Yahya, A., Abd Aziz, S. and Md Salleh, M. (2015). Isolation, screening, and identification of potential cellulolytic and xylanolytic producers for biodegradation of untreated oil palm trunk and its application in saccharification of lemongrass leaves. *Preparative Biochemistry and Biotechnology*. 45(3), 279-305.

Ang, S. K. and Abd-Aziz, S. (2015). Potential uses of xylanase-rich lignocellulolytic enzymes cocktail for oil palm trunk (OPT) degradation and lignocellulosic ethanol production. *Energy & Fuels*. 29(8), 5103-5116.

Anwar, Z., Gulfraz, M. and Irshad, M. (2014). Agro-industrial lignocellulosic biomass a key to unlock the future bio-energy: a brief review. *Journal of Radiation Research and Applied Sciences*. 7(2), 163-173.

Aro, N., Pakula, T. and Penttilä, M. (2005). Transcriptional regulation of plant cell wall degradation by filamentous fungi. *FEMS Microbiology Reviews*. 29(4), 719-739.

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

Babu, I. and Rao, G. (2007). Lipase production by *Yarrowia lipofyäca* NCIM 3589 in solid state fermentation using mixed substrate. *Research Journal of Microbiology*. 2, 469-474.

Bahrin, E., Ibrahim, M., Abd Razak, M., Abd-Aziz, S., Shah, U. M., Alitheen, N. and Salleh, M. M. (2012). Improved cellulase production by *Botryosphaeria rhodina* from OPEFB at low level moisture condition through statistical optimization. *Preparative Biochemistry and Biotechnology*. 42(2), 155-170.

Bahrin, E. K., Seng, P. Y. and Abd-Aziz, S. (2011). Effect of oil palm empty fruit bunch particle size on cellulase production by *Botryosphaeria* sp. under solid state fermentation. *Australian Journal of Basic and Applied Sciences*. 5(3), 276-280.

Bansal, N., Tewari, R., Soni, R. and Soni, S. K. (2012). Production of cellulases from *Aspergillus niger* NS-2 in solid state fermentation on agricultural and kitchen waste residues. *Waste Management*. 32(7), 1341-1346.

Bhat, M. and Bhat, S. (1997). Cellulose degrading enzymes and their potential industrial applications. *Biotechnology Advances*. 15(3-4), 583-620.

Board, Malaysia. Palm. Oil. (2009). Retrieved 7" January 2010 from http://econ. mpob. gov. my/economy. *EID_web. htm* (2009).

Boroujeni, M. E., Das, A., Prashanthi, K., Suryan, S. and Bhattacharya, S. (2012). Enzymatic screening and random amplified polymorphic DNA fingerprinting of soil streptomycetes isolated from Wayanad District in Kerala, India. *Journal of Biological Sciences*. 12(1), 43-50.

Brijwani, K., Oberoi, H. S. and Vadlani, P. V. (2010). Production of a cellulolytic enzyme system in mixed-culture solid-state fermentation of soybean hulls supplemented with wheat bran. *Process Biochemistry*. 45(1), 120-128.

Camassola, M. and Dillon, A. (2007). Production of cellulases and hemicellulases by *Penicillium echinulatum* grown on pretreated sugar cane bagasse and wheat bran in solid-state fermentation. *Journal of Applied Microbiology*. 103(6), 2196-2204.

Carere, C. R., Sparling, R., Cicek, N. and Levin, D. B. (2008). Third generation biofuels via direct cellulose fermentation. *International Journal of Molecular Sciences*. 9(7), 1342-1360.

Chaudhary, H. S., Soni, B., Shrivastava, A. R. and Shrivastava, S. (2013). Diversity and versatility of actinomycetes and its role in antibiotic production. *Journal of Applied Pharmaceutical Science*. 3(8), S83-S94.

Chen, H. (2013). Modern solid state fermentation. *Netherlands: Springer*.

Christopherson, M. R., Suen, G., Bramhacharya, S., Jewell, K. A., Aylward, F. O., Mead, D. and Brumm, P. J. (2013). The genome sequences of *Cellulomonas fimi* and "*Cellvibrio gilvus*" reveal the cellulolytic strategies of two facultative anaerobes, transfer of "*Cellvibrio gilvus*" to the genus *Cellulomonas*, and proposal of *Cellulomonas gilvus* sp. nov. *PloS one*. 8(1), e53954.

Colla, G., Nardi, S., Cardarelli, M., Ertani, A., Lucini, L., Canaguier, R. and Rouphael, Y. (2015a). Protein hydrolysates as biostimulants in horticulture. *Scientia Horticulturae*. 196, 28-38.

Colla, G., Rouphael, Y., Bonini, P. and Cardarelli, M. (2015b). Coating seeds with endophytic fungi enhances growth, nutrient uptake, yield and grain quality of winter wheat. *International Journal of Plant Production*. 9(2), 171-190.

Colla, G., Rouphael, Y., Di Mattia, E., El-Nakhel, C. and Cardarelli, M. (2015c). Co-inoculation of *Glomus intraradices* and *Trichoderma atroviride* acts as a biostimulant to promote growth, yield and nutrient uptake of vegetable crops. *Journal of the Science of Food and Agriculture*. 95(8), 1706-1715.

Couto, S. R. and Herrera, J. L. T. (2006). Industrial and biotechnological applications of laccases: a review. *Biotechnology Advances*. 24(5), 500-513.

da Silva Delabona, P., Pirota, R. D. P. B., Codima, C. A., Tremacoldi, C. R., Rodrigues, A. and Farinas, C. S. (2013). Effect of initial moisture content on two Amazon rainforest *Aspergillus* strains cultivated on agro-industrial residues: Biomass-degrading enzymes production and characterization. *Industrial Crops and Products*. 42, 236-242.

Das, P., Solanki, R. and Khanna, M. (2014). Isolation and screening of cellulolytic actinomycetes from diverse habitats. *International Journal of Advanced Biotechnology and Research*. 5(3), 438-451.

Dashtban, M., Schraft, H. and Qin, W. (2009). Fungal bioconversion of lignocellulosic residues; opportunities & perspectives. *International Journal of Biological Sciences*. 5(6), 578.

de Vries, R. P. and Visser, J. (2001). *Aspergillus* enzymes involved in degradation of plant cell wall polysaccharides. *Microbiology and Molecular Bioliology. Reviews.* 65(4), 497-522.

Dhillon, G. S., Brar, S. K., Kaur, S., Metahni, S. and M'hamdi, N. (2012). Lactoserum as a moistening medium and crude inducer for fungal cellulase and hemicellulase induction through solid-state fermentation of apple pomace. *Biomass and Bioenergy*. 41, 165-174.

Dhillon, G. S., Oberoi, H. S., Kaur, S., Bansal, S. and Brar, S. K. (2011). Value-addition of agricultural wastes for augmented cellulase and xylanase production through solid-state tray fermentation employing mixed-culture of fungi. *Industrial Crops and Products*. 34(1), 1160-1167.

Doni, F., Isahak, A., Zain, C. R. C. M., Ariffin, S. M., Mohamad, W. N. a. W. and Yusoff, W. M. W. (2014). Formulation of *Trichoderma* sp. SL2 inoculants using different carriers for soil treatment in rice seedling growth. *SpringerPlus*. 3(1), 532.

dos Santos, F. A., Iulianelli, G. C. and Tavares, M. I. B. (2016). The use of cellulose nanofillers in obtaining polymer nanocomposites: properties, processing, and applications. *Materials Sciences and Applications*. 7(05), 257.

Dwivedi, P., Vivekanand, V., Pareek, N., Sharma, A. and Singh, R. P. (2011). Co-cultivation of mutant *Penicillium oxalicum* SAUE-3.510 and *Pleurotus ostreatus* for simultaneous biosynthesis of xylanase and laccase under solid-state fermentation. *New Biotechnology*. 28(6), 616-626.

Farinas, C. S. (2015). Developments in solid-state fermentation for the production of biomass-degrading enzymes for the bioenergy sector. *Renewable and Sustainable Energy Reviews*. 52, 179-188.

Fernandes, A. N., Thomas, L. H., Altaner, C. M., Callow, P., Forsyth, V. T., Apperley, D. C., Kennedy, C. J. and Jarvis, M. C. (2011). Nanostructure of cellulose microfibrils in spruce wood. *Proceedings of the National Academy of Sciences*. 108(47), E1195-E1203.

Fujii, K., Uemura, M., Hayakawa, C., Funakawa, S. and Kosaki, T. (2013). Environmental control of lignin peroxidase, manganese peroxidase, and laccase activities in forest floor layers in humid Asia. *Soil Biology and Biochemistry*. 57, 109-115.

Gardner, K. and Blackwell, J. (1974). The structure of native cellulose. *Biopolymers: Original Research on Biomolecules*. 13(10), 1975-2001.

Gervais, P. and Molin, P. (2003). The role of water in solid-state fermentation. *Biochemical Engineering Journal*. 13(2-3), 85-101.

Gilbert, H. J. and Hazlewood, G. P. (1993). Bacterial cellulases and xylanases. *Microbiology*. 139(2), 187-194.

Giovannetti, M., Fortuna, P., Citernesi, A. S., Morini, S. and Nuti, M. P. (2001). The occurrence of anastomosis formation and nuclear exchange in intact *Arbuscular Mycorrhizal* networks. *New Phytologist*. 151(3), 717-724.

Glazer, A. N. and Nikaido, H. (2007). *Microbial Biotechnology: Fundamentals of Applied Microbiology*. Cambridge University Press.

Godden, B., Ball, A. S., Helvenstein, P., Mccarthy, A. J. and Penninckx, M. J. (1992). Towards elucidation of the lignin degradation pathway in actinomycetes. *Microbiology*. 138(11), 2441-2448.

Goh, C. S., Tan, K. T., Lee, K. T. and Bhatia, S. (2010). Bio-ethanol from lignocellulose: status, perspectives and challenges in Malaysia. *Bioresource Technology*. 101(13), 4834-4841.

Gomez del Pulgar, E. M. and Saadeddin, A. (2014). The cellulolytic system of *Thermobifida fusca*. *Critical Reviews in Microbiology*. 40(3), 236-247.

Govindarajulu, M., Pfeffer, P. E., Jin, H., Abubaker, J., Douds, D. D., Allen, J. W., Bücking, H., Lammers, P. J. and Shachar-Hill, Y. (2005). Nitrogen transfer in the *Arbuscular Mycorrhizal* symbiosis. *Nature*. 435(7043), 819.

Guerriero, G., Fugelstad, J. and Bulone, V. (2010). What do we really know about cellulose biosynthesis in higher plants? *Journal of Integrative Plant Biology*. 52(2), 161-175.

Hamedani, K., Soudbakhsh, M., Das, A., Prashanthi, K., Bhattacharya, S. and Suryan, S. (2012). Enzymatic screening, antibacterial potential and molecular characterization of streptomycetes isolated from Wayanad district in Kerala, India. *International Journal of Pharma and Bio Sciences*. 2(1), 201-210.

Hamzah, F., Idris, A. and Shuan, T. K. (2011). Preliminary study on enzymatic hydrolysis of treated oil palm (Elaeis) empty fruit bunches fibre (EFB) by using combination of cellulase and β 1-4 glucosidase. *Biomass and Bioenergy*. 35(3), 1055-1059.

Han, M., Kim, Y., Kim, S. W. and Choi, G. W. (2011). High efficiency bioethanol production from OPEFB using pilot pretreatment reactor. *Journal of Chemical Technology & Biotechnology*. 86(12), 1527-1534.

Harman, G. E. (2011). Multifunctional fungal plant symbionts: new tools to enhance plant growth and productivity. *New Phytologist*. 189(3), 647-649.

Harmsen, P., Huijgen, W., Bermudez, L. and Bakker, R. (2010). Literature review of physical and chemical pretreatment processes for lignocellulosic biomass. Wageningen UR-Food & Biobased Research.

Ibrahim, M., Razak, M., Phang, L., Hassan, M. and Abd-Aziz, S. (2013). Crude cellulase from oil palm empty fruit bunch by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2 for fermentable sugars production. *Applied Biochemistry and Biotechnology*. 170(6), 1320-1335.

Ikubar, M. R. M., Manan, M. A., Salleh, M. M. and Yahya, A. (2018). Solid-state fermentation of oil palm frond petiole for lignin peroxidase and xylanase-rich cocktail production. *3 Biotech*. 8(5), 259.

Irfan, M., Nadeem, M. and Syed, Q. (2014). One-factor-at-a-time (OFAT) optimization of xylanase production from *Trichoderma viride*-IR05 in solid-state fermentation. *Journal of Radiation Research and Applied Sciences*. 7(3), 317-326.

Ishola, M., Millati, R., Syamsiah, S., Cahyanto, M., Niklasson, C. and Taherzadeh, M. (2012). Structural changes of oil palm empty fruit bunch (OPEFB) after fungal and phosphoric acid pretreatment. *Molecules*. 17(12), 14995-15012.

Isikgor, F. H. and Becer, C. R. (2015). Lignocellulosic biomass: a sustainable platform for the production of bio-based chemicals and polymers. *Polymer Chemistry*. 6(25), 4497-4559.

Jamiołkowska, A., Księżniak, A., Hetman, B., Kopacki, M., Skwaryło-Bednarz, B., Gałązka, A. and Thanoon, A. H. (2017). Interactions of *Arbuscular Mycorrhizal* fungi with plants and soil microflora. *Acta Scientiarum. Polonorum . Hortorum Cultus*. 16(5), 89-95.

Jeffrey, L. (2008). Isolation, characterization and identification of actinomycetes from agriculture soils at Semongok, Sarawak. *African Journal of Biotechnology*. 7(20).

Jung, Y. H., Kim, I. J., Han, J.-I., Choi, I.-G. and Kim, K. H. (2011). Aqueous ammonia pretreatment of oil palm empty fruit bunches for ethanol production. *Bioresource Technology*. 102(20), 9806-9809.

Juturu, V. and Wu, J. C. (2012). Microbial xylanases: engineering, production and industrial applications. *Biotechnology Advances*. 30(6), 1219-1227.

Kamsani, N., Salleh, M. M., Yahya, A. and Chong, C. S. (2016). Production of lignocellulolytic enzymes by microorganisms isolated from *Bulbitermes* sp. termite gut in solid-state fermentation. *Waste and Biomass Valorization*. 7(2), 357-371.

Kaur, S., Dhillon, G. S., Brar, S. K., Chauhan, V. B., Chand, R. and Verma, M. (2013). Potential Eco-friendly Soil Microorganisms: Road Towards Green and Sustainable Agriculture *Management of Microbial Resources in the Environment* (pp. 249-287) Springer.

Kaushik, P., Mishra, A. and Malik, A. (2014). Dual application of agricultural residues for xylanase production and dye removal through solid state fermentation. *International Biodeterioration & Biodegradation*. 96, 1-8.

Kelly-Yong, T. L., Lee, K. T., Mohamed, A. R. and Bhatia, S. (2007). Potential of hydrogen from oil palm biomass as a source of renewable energy worldwide. *Energy Policy*. 35(11), 5692-5701.

Klemm, D., Heublein, B., Fink, H. P. and Bohn, A. (2005). Cellulose: fascinating biopolymer and sustainable raw material. *Angewandte Chemie International Edition*. 44(22), 3358-3393.

Kohler, J., Caravaca, F., del Mar Alguacil, M. and Roldán, A. (2009). Elevated CO2 increases the effect of an *Arbuscular Mycorrhizal* fungus and a plant-growth-promoting rhizobacterium on structural stability of a semiarid agricultural soil under drought conditions. *Soil Biology and Biochemistry*. 41(8), 1710-1716.

Kolakovic, Ruzica. Nanofibrillar cellulose in drug delivery. Master,s Thesis. University of Helsiki Finland; 2013.

Krishna, C. (2005). Solid-state fermentation systems—an overview. *Critical Reviews in Biotechnology*. 25(1-2), 1-30.

Kuhad, R. C., Gupta, R. and Singh, A. (2011). Microbial cellulases and their industrial applications. *Enzyme Research*. 2011.

Kuhad, R. C. and Singh, A. (1993). Lignocellulose biotechnology: current and future prospects. *Critical Reviews in Biotechnology*. 13(2), 151-172.

Kuhad, R. C., Singh, A. and Eriksson, K.-E. L. (1997). Microorganisms and enzymes involved in the degradation of plant fiber cell walls *Biotechnology in the Pulp and Paper Industry* (pp. 45-125)Springer.

Kumar, A. and Kanwar, S. S. (2012). Lipase production in solid-state fermentation (SSF): recent developments and biotechnological applications. *Dynamic Biochemistry, Process Biotechnology and Molecular Biology*. 6(1), 13-27.

Kumar, A. K. and Sharma, S. (2017). Recent updates on different methods of pretreatment of lignocellulosic feedstocks: a review. *Bioresources and Bioprocessing*. 4(1), 7.

Kumar, P., Barrett, D. M., Delwiche, M. J. and Stroeve, P. (2009). Methods for pretreatment of lignocellulosic biomass for efficient hydrolysis and biofuel production. *Industrial & Engineering Chemistry Research*. 48(8), 3713-3729.

Kumar, V., Verma, D., Archana, A. and Satyanarayana, T. (2013). Thermostable bacterial xylanases *Thermophilic Microbes in Environmental and Industrial Biotechnology* (pp. 813-857) Springer.

Li, X.-h., Yang, H.-j., Roy, B., Wang, D., Yue, W.-f., Jiang, L.-j., Park, E. Y. and Miao, Y.-g. (2009). The most stirring technology in future: Cellulase enzyme and biomass utilization. *African Journal of Biotechnology*. 8(11).

Liguori, R. and Faraco, V. (2016). Biological processes for advancing lignocellulosic waste biorefinery by advocating circular economy. *Bioresource Technology*. 215, 13-20.

Lim, S.-H. and Ibrahim, D. (2013). Bioconversion of Oil Palm Frond by *Aspergillus niger* to Enhances It's Fermentable Sugar Production. *Pakistan Journal of Biological Sciences*. 16(18), 920.

Lin, H., Wang, B., Zhuang, R., Zhou, Q. and Zhao, Y. (2011). Artificial construction and characterization of a fungal consortium that produces cellulolytic enzyme system with strong wheat straw saccharification. *Bioresource Technology*. 102(22), 10569-10576.

Lo, Y.-C., Lu, W.-C., Chen, C.-Y., Chen, W.-M. and Chang, J.-S. (2010). Characterization and high-level production of xylanase from an indigenous cellulolytic bacterium Acinetobacter junii F6-02 from southern Taiwan soil. *Biochemical Engineering Journal*. 53(1), 77-84.

Lochner, A., Giannone, R. J., Rodriguez, M., Shah, M. B., Mielenz, J. R., Keller, M., Antranikian, G., Graham, D. E. and Hettich, R. L. (2011). Use of label-free quantitative proteomics to distinguish the secreted cellulolytic systems of *Caldicellulosiruptor bescii* and *Caldicellulosiruptor obsidiansis*. *Applied and. Environmental. Microbiology*. 77(12), 4042-4054.

López-Bucio, J., Pelagio-Flores, R. and Herrera-Estrella, A. (2015). *Trichoderma* as biostimulant: exploiting the multilevel properties of a plant beneficial fungus. *Scientia Horticulturae*. 196, 109-123.

Louhasakul, Y., Cheirsilp, B. and Prasertsan, P. (2016). Valorization of palm oil mill effluent into lipid and cell-bound lipase by marine yeast *Yarrowia lipolytica* and their application in biodiesel production. *Waste and Biomass Valorization*. 7(3), 417-426.

Ludwig-Müller, J. and Güther, M. (2007). Auxins as signals in *Arbuscular Mycorrhiza* formation. *Plant Signaling & Behavior*. 2(3), 194-196.

Lykidis, A., Mavromatis, K., Ivanova, N., Anderson, I., Land, M., DiBartolo, G., Martinez, M., Lapidus, A., Lucas, S. and Copeland, A. (2007). Genome sequence and analysis of the soil cellulolytic actinomycete *Thermobifida fusca* YX. *Journal of Bacteriology*. 189(6), 2477-2486.

Lynd, L. R., Weimer, P. J., Van Zyl, W. H. and Pretorius, I. S. (2002). Microbial cellulose utilization: fundamentals and biotechnology. *Microbiology and Molecular Biology Reviews.* 66(3), 506-577.

Ma, F., Wang, J., Zeng, Y., Yu, H., Yang, Y. and Zhang, X. (2011). Influence of the co-fungal treatment with two white rot fungi on the lignocellulosic degradation and thermogravimetry of corn stover. *Process Biochemistry*. 46(9), 1767-1773.

Ma, K. and Ruan, Z. (2015). Production of a lignocellulolytic enzyme system for simultaneous bio-delignification and saccharification of corn stover employing co-culture of fungi. *Bioresource Technology*. 175, 586-593.

Malherbe, S. and Cloete, T. E. (2002). Lignocellulose biodegradation: fundamentals and applications. *Reviews in Environmental Science and Biotechnology*. 1(2), 105-114.

Mandels, M. and Weber, J. (1969). Cellulases and their applications. *Advances in Chemistry Series*. 95, 391.

Martínez-Medina, A., Roldán, A. and Pascual, J. A. (2011). Interaction between *Arbuscular Mycorrhizal* fungi and *Trichoderma harzianum* under conventional and low input fertilization field condition in melon crops: growth response and *Fusarium wilt* biocontrol. *Applied Soil Ecology*. 47(2), 98-105.

Martínez-Medina, A., Pascual, J. A., Lloret, E. and Roldán, A. (2009). Interactions between *Arbuscular Mycorrhizal* fungi and *Trichoderma harzianum* and their effects on *Fusarium wilt* in melon plants grown in seedling nurseries. *Journal of the Science of Food and Agriculture*. 89(11), 1843-1850.

Martins, D. A. B., do Prado, H. F. A., Leite, R. S. R., Ferreira, H., de Souza Moretti, M. r. M., da Silva, R. and Gomes, E. (2011a). Agroindustrial wastes as substrates for microbial enzymes production and source of sugar for bioethanol production *Integrated Waste Management-Volume II* IntechOpen.

Martins, S., Mussatto, S. I., Martínez-Avila, G., Montañez-Saenz, J., Aguilar, C. N. and Teixeira, J. A. (2011b). Bioactive phenolic compounds: production and extraction by solid-state fermentation. A review. *Biotechnology Advances*. 29(3), 365-373.

Mastouri, F., Björkman, T. and Harman, G. E. (2010). Seed treatment with *Trichoderma harzianum* alleviates biotic, abiotic, and physiological stresses in germinating seeds and seedlings. *Phytopathology*. 100(11), 1213-1221.

Mathew, G. M., Sukumaran, R. K., Singhania, R. R. and Pandey, A. (2008). Progress in research on fungal cellulases for lignocellulose degradation.

Mishra, J. and Arora, N. K. (2016). Bioformulations for plant growth promotion and combating phytopathogens: A sustainable approach *Bioformulations: for Sustainable Agriculture* (pp. 3-33) Springer.

Mitchell, D. A., Krieger, N. and Beroviˇc, M. (2006). Solid-state fermentation bioreactor foundamental introduction and overview. In Solid-State Fermentation Bioreactors (pp. 1-12). Springer, Heidelberg.

Mittal, V., Singh, O., Nayyar, H., Kaur, J. and Tewari, R. (2008). Stimulatory effect of phosphate-solubilizing fungal strains (*Aspergillus awamori* and *Penicillium* *citrinum*) on the yield of chickpea (*Cicer arietinum* L. cv. GPF2). *Soil Biology and Biochemistry*. 40(3), 718-727.

Miyasaka, S. C. and Habte, M. (2001). Plant mechanisms and *Mycorrhizal* symbioses to increase phosphorus uptake efficiency. *Communications in Soil Science and Plant Analysis*. 32(7-8), 1101-1147.

Mohammed, M., Salmiaton, A., Azlina, W. W., Amran, M. M., Fakhru'l-Razi, A. and Taufiq-Yap, Y. (2011). Hydrogen rich gas from oil palm biomass as a potential source of renewable energy in Malaysia. *Renewable and Sustainable Energy Reviews*. 15(2), 1258-1270.

Morales, L. O., Iakovlev, M., Martin-Sampedro, R., Rahikainen, J. L., Laine, J., van Heiningen, A. and Rojas, O. J. (2014). Effects of residual lignin and heteropolysaccharides on the bioconversion of softwood lignocellulose nanofibrils obtained by SO2–ethanol–water fractionation. *Bioresource Technology*. 161, 55-62.

Moreira, L. (2008). An overview of mannan structure and mannan-degrading enzyme systems. *Applied Microbiology and Biotechnology*. 79(2), 165.

Mtui, G. Y. (2012). Lignocellulolytic enzymes from tropical fungi: Types, substrates and applications. *Scientific Research and Essays*. 7(15), 1544-1555.

Mushtaq, F., Abdullah, T. A. T., Mat, R. and Ani, F. N. (2015). Optimization and characterization of bio-oil produced by microwave assisted pyrolysis of oil palm shell waste biomass with microwave absorber. *Bioresource Technology*. 190, 442-450.

Nelson, D. L., Lehninger, A. L. and Cox, M. M. (2008). *Lehninger Principles of Biochemistry*. Macmillan.

Noratiqah, K., Madihah, M., Aisyah, B. S., Eva, M. S., Suraini, A. and Kamarulzaman, K. (2013). Statistical optimization of enzymatic degradation process for oil palm empty fruit bunch (OPEFB) in rotary drum bioreactor using crude cellulase produced from *Aspergillus niger* EFB1. *Biochemical Engineering Journal*. 75, 8-20.

Öhgren, K., Bengtsson, O., Gorwa-Grauslund, M. F., Galbe, M., Hahn-Hägerdal, B. and Zacchi, G. (2006). Simultaneous saccharification and co-fermentation of glucose and xylose in steam-pretreated corn stover at high fiber content with *Saccharomyces cerevisiae* TMB3400. *Journal of Biotechnology*. 126(4), 488-498.

Ooijkaas, L. P., Weber, F. J., Buitelaar, R. M., Tramper, J. and Rinzema, A. (2000). Defined media and inert supports: their potential as solid-state fermentation production systems. *Trends in Biotechnology*. 18(8), 356-360.

Orzua, M. C., Mussatto, S. I., Contreras-Esquivel, J. C., Rodriguez, R., de la Garza, H., Teixeira, J. A. and Aguilar, C. N. (2009). Exploitation of agro industrial wastes as immobilization carrier for solid-state fermentation. *Industrial Crops and Products*. 30(1), 24-27.

Pandey, A. (2003). Solid-state fermentation. *Biochemical Engineering Journal*. 13(2-3), 81-84.

Pandey, A., Soccol, C. R. and Mitchell, D. (2000). New developments in solid state fermentation: I-bioprocesses and products. *Process Biochemistry*. 35(10), 1153-1169.

Pandey, A. K., Edgard, G. and Negi, S. (2016). Optimization of concomitant production of cellulase and xylanase from *Rhizopus oryzae* SN5 through EVOP-factorial design technique and application in Sorghum Stover based bioethanol production. *Renewable Energy*. 98, 51-56.

Pérez, J., Munoz-Dorado, J., De la Rubia, T. and Martinez, J. (2002). Biodegradation and biological treatments of cellulose, hemicellulose and lignin: an overview. *International Microbiology*. 5(2), 53-63.

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

Piarpuzan, D., Quintero, J. A. and Cardona, C. A. (2011). Empty fruit bunches from oil palm as a potential raw material for fuel ethanol production. *Biomass and Bioenergy*. 35(3), 1130-1137.

Pleanjai, S., Gheewala, S. H. and Garivait, S. (2007). Environmental evaluation of biodiesel production from palm oil in a life cycle perspective. *Asian Journal on Energy and Environ*. 8(1), 15-32.

Potumarthi, R., Baadhe, R. R. and Bhattacharya, S. (2013). Fermentable sugars from lignocellulosic biomass: technical challenges *Biofuel Technologies* (pp. 3-27)Springer.

Prasad, S., Singh, A. and Joshi, H. (2007). Ethanol as an alternative fuel from agricultural, industrial and urban residues. *Resources, Conservation and Recycling*. 50(1), 1-39.

Qureshi, S. S., Nizamuddin, S., Baloch, H. A., Siddiqui, M., Mubarak, N. and Griffin, G. (2019). An overview of OPS from oil palm industry as feedstock for bio-oil production. *Biomass Conversion and Biorefinery*. 1-15.

Rabello, G. C., Pirota, R. D. P. B., Barros, G. O. F. and Farinas, C. S. (2014). Addendum to Issue 1-ENZITEC 2012Simultaneous biosynthesis of biomass-degrading enzymes using co-cultivation of *Aspergillus niger* and *Trichoderma reesei*. *Biocatalysis* and *Biotransformation*. 32(4), 236-243.

Raghavarao, K., Ranganathan, T. and Karanth, N. (2003). Some engineering aspects of solid-state fermentation. *Biochemical Engineering Journal*. 13(2-3), 127-135.

Rahman, S., Choudhury, J. and Ahmad, A. (2006). Production of xylose from oil palm empty fruit bunch fiber using sulfuric acid. *Biochemical Engineering Journal*. 30(1), 97-103.

Rahman, S., Choudhury, J., Ahmad, A. and Kamaruddin, A. (2007). Optimization studies on acid hydrolysis of oil palm empty fruit bunch fiber for production of xylose. *Bioresource Technology*. 98(3), 554-559.

Ramos-Sánchez, L. B., Cujilema-Quitio, M. C., Julian-Ricardo, M. C., Cordova, J. and Fickers, P. (2015). Fungal lipase production by solid-state fermentation. *Journal of Bioprocessing & Biotechniques*. 5(2), 1.

Rashid, S. S., Alam, M. Z., Karim, M. I. A. and Salleh, M. H. (2009). Management of palm oil mill effluent through production of cellulases by filamentous fungi. *World Journal of Microbiology and Biotechnology*. 25(12), 2219-2226.

Razak, M. N. A., Ibrahim, M. F., Yee, P. L., Hassan, M. A. and Abd-Aziz, S. (2012). Utilization of oil palm decanter cake for cellulase and polyoses production. *Biotechnology and Bioprocess Engineering*. 17(3), 547-555.

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

Rojas-Rejón, O. A., Poggi-Varaldo, H. M., Ramos-Valdivia, A. C., Martínez-Jiménez, A., Cristiani-Urbina, E., De La Torre Martínez, M. and Ponce-Noyola, T. (2011). Production of cellulases and xylanases under catabolic repression conditions from mutant PR-22 of *Cellulomonas flavigena*. *Journal of Industrial Microbiology & Biotechnology*. 38(1), 257-264.

Rouphael, Y., Cardarelli, M., Bonini, P. and Colla, G. (2017). Synergistic action of a microbial-based biostimulant and a plant derived-protein hydrolysate enhances lettuce tolerance to alkalinity and salinity. *Frontiers in Plant Science*. 8, 131.

Rouphael, Y., Cardarelli, M., Rea, E. and Colla, G. (2012). Improving melon and cucumber photosynthetic activity, mineral composition, and growth performance under salinity stress by grafting onto Cucurbita hybrid rootstocks. *Photosynthetica*. 50(2), 180-188.

Rouphael, Y., Franken, P., Schneider, C., Schwarz, D., Giovannetti, M., Agnolucci, M., De Pascale, S., Bonini, P. and Colla, G. (2015). *Arbuscular Mycorrhizal* fungi act as biostimulants in horticultural crops. *Scientia Horticulturae*. 196, 91-108.

Ruqayyah, T. I., Jamal, P., Alam, M. Z. and Mirghani, M. E. S. (2013). Biodegradation potential and ligninolytic enzyme activity of two locally isolated *Panus tigrinus* strains on selected agro-industrial wastes. *Journal of Environmental Management*. 118, 115-121.

Saha, B. C. (2003). Hemicellulose bioconversion. *Journal of Industrial Microbiology and Biotechnology*. 30(5), 279-291.

Saini, A., Aggarwal, N. K., Sharma, A. and Yadav, A. (2015). Actinomycetes: a source of lignocellulolytic enzymes. *Enzyme Research*. 2015.

Sajith, S., Priji, P., Sreedevi, S. and Benjamin, S. (2016). An overview on fungal cellulases with an industrial perspective. *Journal of Nutrition and Food Sciences*. 6(1), 461.

Saldajeno, M., Chandanie, W., Kubota, M. and Hyakumachi, M. (2008). Effects of interactions of *Arbuscular Mycorrhizal* fungi and beneficial saprophytic mycoflora on plant growth and disease protection *Mycorrhizae: Sustainable Agriculture and Forestry* (pp. 211-226)Springer.

Sánchez, C. (2009). Lignocellulosic residues: biodegradation and bioconversion by fungi. *Biotechnology Advances*. 27(2), 185-194.

Scheller, H. V. and Ulvskov, P. (2010). Hemicelluloses. *Annual Review of Plant Biology*. 61.

Schreiner, R. P. and Bethlenfalvay, G. J. (1995). *Mycorrhizal* interactions in sustainable agriculture. *Critical Reviews in Biotechnology*. 15(3-4), 271-285.

Schuster, A. and Schmoll, M. (2010). Biology and biotechnology of *Trichoderma. Applied Microbiology and Biotechnology*. 87(3), 787-799.

Sharma, P., Kumawat, K. and Kaur, S. (2016). Plant Growth Promoting Rhizobacteria in Nutrient Enrichment: Current Perspectives *Biofortification of Food Crops* (pp. 263-289)Springer.

Singh, R., Kumar, M., Mittal, A. and Mehta, P. (2016a). Lignocellulolytic enzymes: Biomass to biofuel. *International Journal of Advanced Research*. 4(10), 2175-2182.

Singh, R., Kumar, M., Mittal, A. and Mehta, P. (2016b). Lignocellulolytic Enzymes: Biomass to Biofuel. *International Journal of Advanced Research*, 4(10). pp.2175-2182

Singh, S., Madlala, A. M. and Prior, B. A. (2003). *Thermomyces lanuginosus*: properties of strains and their hemicellulases. *FEMS Microbiology Reviews*. 27(1), 3-16.

Singhania, R. R., Patel, A. K., Soccol, C. R. and Pandey, A. (2009). Recent advances in solid-state fermentation. *Biochemical Engineering Journal*. 44(1), 13-18.

Singhania, R. R., Sukumaran, R. K., Patel, A. K., Larroche, C. and Pandey, A. (2010). Advancement and comparative profiles in the production technologies using solid-state and submerged fermentation for microbial cellulases. *Enzyme and Microbial Technology*. 46(7), 541-549.

Singhania, R. R., Sukumaran, R. K., Rajasree, K. P., Mathew, A., Gottumukkala, L. and Pandey, A. (2011). Properties of a major β-glucosidase-BGL1 from *Aspergillus niger* NII-08121 expressed differentially in response to carbon sources. *Process Biochemistry*. 46(7), 1521-1524.

Soccol, C. R., da Costa, E. S. F., Letti, L. A. J., Karp, S. G., Woiciechowski, A. L. and de Souza Vandenberghe, L. P. (2017). Recent developments and innovations in solid state fermentation. *Biotechnology Research and Innovation*. 1(1), 52-71.

Somerville, C. (2006). Cellulose synthesis in higher plants. *Annual Review of Cell Developmental Biology* 22, 53-78.

Sorek, N., Yeats, T. H., Szemenyei, H., Youngs, H. and Somerville, C. R. (2014). The implications of lignocellulosic biomass chemical composition for the production of advanced biofuels. *BioScience*. 64(3), 192-201.

Sorieul, M., Dickson, A., Hill, S. and Pearson, H. (2016). Plant fibre: molecular structure and biomechanical properties, of a complex living material, influencing its deconstruction towards a biobased composite. *Materials*. 9(8), 618.

Sperandio, G. B. and Ferreira Filho, E. X. (2019). Fungal co-cultures in the lignocellulosic biorefinery context: A review. *International Biodeterioration & Biodegradation*. 142, 109-123.

Srivastava, R., Khalid, A., Singh, U. and Sharma, A. (2010). Evaluation of *Arbuscular Mycorrhizal* fungus, fluorescent *Pseudomonas* and *Trichoderma harzianum* formulation against *Fusarium oxysporum* f. sp. *lycopersici* for the management of tomato wilt. *Biological Control*. 53(1), 24-31.

Sukumaran, R. K., Singhania, R. R. and Pandey, A. (2005). Microbial cellulases-production, applications and challenges. *Journal of Scientific and Industrial Research* Vol 64 (pp, 832-844.

Sundram, S. (2013). The effects of *Trichoderma* in surface mulches supplemented with conidial drenches in the disease development of *Ganoderma* basal stem rot in oil palm. *Journal of Oil Palm Research*. 25(3), 314-325.

Tan, L., Yu, Y., Li, X., Zhao, J., Qu, Y., Choo, Y. M. and Loh, S. K. (2013). Pretreatment of empty fruit bunch from oil palm for fuel ethanol production and proposed biorefinery process. *Bioresource Technology*. 135, 275-282.

Tari, C., Genckal, H. and Tokatlı, F. (2006). Optimization of a growth medium using a statistical approach for the production of an alkaline protease from a newly isolated *Bacillus* sp. L21. *Process Biochemistry*. 41(3), 659-665.

Tchameni, S. N., Ngonkeu, M., Begoude, B., Nana, L. W., Fokom, R., Owona, A., Mbarga, J., Tchana, T., Tondje, P. and Etoa, F. (2011). Effect of *Trichoderma asperellum* and *Arbuscular Mycorrhizal* fungi on cacao growth and resistance against black pod disease. *Crop Protection*. 30(10), 1321-1327.

Tester, R. F. and Al-Ghazzewi, F. H. (2013). Mannans and health, with a special focus on glucomannans. *Food Research International*. 50(1), 384-391.

Turner, P. and Gillbanks, R. (2003). Oil Palm Management and Cultivation. *The Incorporated Society of Planters*.

Várnai, A., Siika-aho, M. and Viikari, L. (2010). Restriction of the enzymatic hydrolysis of steam-pretreated spruce by lignin and hemicellulose. *Enzyme and Microbial Technology*. 46(3-4), 185-193.

Vijayaraghavan, P., Vincent, S. P. and Dhillon, G. (2016). Solid-substrate bioprocessing of cow dung for the production of carboxymethyl cellulase by *Bacillus halodurans* IND18. *Waste Management*. 48, 513-520.

Vikineswary, S., Abdullah, N., Renuvathani, M., Sekaran, M., Pandey, A. and Jones, E. (2006). Productivity of laccase in solid substrate fermentation of selected agro-residues by *Pycnoporus sanguineus. Bioresource Technology*. 97(1), 171-177.

Vosátka, M. and Gryndler, M. (1999). Treatment with culture fractions from *Pseudomonas putida* modifies the development of *Glomus fistulosum Mycorrhiza* and the response of potato and maize plants to inoculation. *Applied Soil Ecology*. 11(2-3), 245-251.

Wahid, M. B., Weng, C. K. and Masri, R. (2007). Palm oil: nature's gift to Malaysia and Malaysia's gift to the world. *Proceedings of the 2007 2007 Conference on Plantation Commodities,, Putra World Trade Centre, Kuala Lumpur (Malaysia), 3-4 Jul 2007*: Malaysian Cocoa Board,

Wan, C. and Li, Y. (2012). Fungal pretreatment of lignocellulosic biomass. *Biotechnology Advances*. 30(6), 1447-1457.

Wang, M.-L., Choong, Y.-M., Su, N.-W. and Lee, M.-H. (2003). A rapid method for determination of ethanol in alcoholic beverages using capillary gas chromatography. *Journal of Food and Drug Analysis*. 11(2).

Wang, Z., Zhu, J., Zalesny Jr, R. S. and Chen, K. (2012). Ethanol production from poplar wood through enzymatic saccharification and fermentation by dilute acid and SPORL pretreatments. *Fuel*. 95, 606-614.

Wilson, D. B. (1992). Biochemistry and genetics of actinomycete cellulases. *Critical Reviews in Biotechnology*. 12(1-2), 45-63.

Woo, H. L., Hazen, T. C., Simmons, B. A. and DeAngelis, K. M. (2014). Enzyme activities of aerobic lignocellulolytic bacteria isolated from wet tropical forest soils. *Systematic and Applied Microbiology*. 37(1), 60-67.

Wu, Q.-S., Srivastava, A. K. and Zou, Y.-N. (2013). AMF-induced tolerance to drought stress in citrus: a review. *Scientia Horticulturae*. 164, 77-87.

Wyman, C. E. (1994). Ethanol from lignocellulosic biomass: technology, economics, and opportunities. *Bioresource Technology*. 50(1), 3-15.

Yasmeen, Q., Asgher, M., Sheikh, M. A. and Nawaz, H. (2013). Optimization of ligninolytic enzymes production through response surface methodology. *Bioresources*. 8(1), 944-968.

Yildiz, S. Y. and Oner, E. T. (2014). Mannan as a promising bioactive material for drug nanocarrier systems *Application of Nanotechnology in Drug Delivery* IntechOpen.

Yoon, L. W., Ang, T. N., Ngoh, G. C. and Chua, A. S. M. (2014). Fungal solid-state fermentation and various methods of enhancement in cellulase production. *Biomass and Bioenergy*. 67, 319-338.

Yusof N. Z, Gani S.S.A, Siddiqui Y, Fadzillah, N , Mokhtar M, and Hasan Z.A.A. (2016). Potential uses of oil palm (*Elaeis guineensis*) leaf extract in topical application. *Journal of Oil Palm Research*. 28(4), 520-530.

Zahari, M. A. K. M., Abdullah, S. S. S., Roslan, A. M., Ariffin, H., Shirai, Y. and Hassan, M. A. (2014). Efficient utilization of oil palm frond for bio-based products and biorefinery. *Journal of Cleaner Production*. 65, 252-260.

Zahari, M. A. K. M., Zakaria, M. R., Ariffin, H., Mokhtar, M. N., Salihon, J., Shirai, Y. and Hassan, M. A. (2012). Renewable sugars from oil palm frond juice as an alternative novel fermentation feedstock for value-added products. *Bioresource Technology*. 110, 566-571.

Zhu, J., Pan, X., Wang, G. and Gleisner, R. (2009). Sulfite pretreatment (SPORL) for robust enzymatic saccharification of spruce and red pine. *Bioresource Technology*. 100(8), 2411-2418.