UTILIZATION OF OIL PALM FROND FOR ENZYME AND RENEWABLE FEEDSTOCK PRODUCTION USING SOLID STATE FERMENTATION

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UNIVERSITI TEKNOLOGI MALAYSIA

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DEDICATION

Specially dedicated to all my loved ones:
Atta, Ma, Shida, Rozi & the little one, Diana

~

True knowledge exist in knowing that you know nothing

Socrates

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They say life is all about the journey not the destination. This thesis is the accumulation of my four and half year's journey that involved long hours in the lab, countless mistakes and re-writes. But throughout this journey there are plenty of lessons learned; the good ones were good, but the bad ones were my greatest teacher. For that I must praise the lord, Allah SWT, for giving me the strength, persistence and most importantly patience. Looking back, my decision to do Phd was partly out of self-fulfilment and another because Dr. Adibah Yahya convinced me to do so. Knowing her closely for 8-years now, she is the best supervisor a student can ever wish; her humbleness, expertise, and devotion was truly inspiring. I can't remember a time leaving her office and not feeling motivated. Along the way, I had the chance to work with Dr. Musaalbakri Abdul Manan, who was briefly my co-supervisor. I am greatly indebted to his early comments of my proposal that altered the direction of this thesis. My appreciation also goes to the dynamic Professor Dr. Zainura Zainon and Dr. Che Hafizan, my LCA gurus, for without their assistance I would have been lost in uncharted waters. I would also like to thank Dr. Ang Siow Kuang, Dr. Noratiqah Kamsani and Dr. Huszalina Hussin for guiding me during the early stage of my study. My special mention goes to our beloved senior laboratory officer, Pn. Fatimah Harun, who would go the extra mile to help us with our laboratory needs. To my close buddies Dr. Shankar Ramanathan, Dr. Tengku Idzzan Nadzirah Tengku Idris, Ahmad Fawwaz Mohd Raji, Rohaya Mohd Noor, Zulkifli Nordin, Nur Syifaaiyah Abdul Aziz and Norulsazyani Mohd Safri, thank you for making this journey more colourful and bearable. And yes, how would I forget the caring Associate Professor Dr. Madihah Md Salleh and Professor Dr. Noor Aini Abdul Rashid, both who always *belanja makan* and never failed to ask, *"bila nak habis?"* In the end, I don't regret taking this journey, it was a meaningful one indeed. My heartiest thanks to all of you who have been part of it.

ABSTRACT

Oil palm frond (OPF) is the largest agro-residue and lignocellulose biomass in Malaysia amounting to 56 million tons every year. At present, it is mainly utilized as soil fertilizer and animal feed, whereas excess fronds are commonly burned to save up plantation space and to avoid contamination. Such practices undermine the economic value of OPF and contribute to environmental pollution. Tapping into its rich lignocellulose content, the study investigated bioconversion potential of frond petiole for lignocellulolytic enzyme production. Six locally isolated fungi *A. awamori* MMS4, *A. niger* EFB1, *A. fumigatus* SK1, *T. virens* UKM1, *T. viride* MM3, and *T. asperellum* MR1 were screened for their enzyme production capability under solid state fermentation. The fermentation was carried out in petri dish using OPF fibre (0.125 mm) at 60% moisture content and 35°C for 7 days. The fermentation produced enzyme mixture high in lignin peroxidase (20-222 Ug^{-1}), endoxylanase (6-109 Ug^{-1}) and endoglucanase (2-9 Ug^{-1}), alongside exolgucanase, β-glucosidase, manganese peroxidase and laccase. The multi-enzyme mixture was suitable for technical application and when tested for the enzymatic deinking of old newspaper achieved a pulp brightness of up to 51.5% and tensile strength of 34.0 Nm/g. To avoid generation of secondary waste, the remaining fermented OPF (post enzyme extraction) was re-fermented up to three cycles. This further increased enzyme production by 26-79% and fibre utilization by 14-26%. Such repeated fermentation also proved favourable in improving the sustainability and cost of enzyme production at each cycle. Fermented OPF that were no longer fermentable after three cycles was subjected to nutrient regeneration by enzymatic hydrolysis and autolysis. The process generated a nutrient rich hydrolysate containing carbon (1.79 gL^{-1}), nitrogen (0.11 gL^{-1}) and phosphorus (0.36 gL^{-1}) that were useable as growth medium and supported both bacterial and fungal growth. Overall, the study showed the potential bioconversion of OPF into valuable enzymes and the significance of re-fermentation and hydrolysis process to maximise usage of fermented waste as renewable feedstock.

ABSTRAK

Pelepah sawit (OPF) merupakan sisa agro dan biojisim lignoselulosa terbesar Malaysia dengan hasil buangan mencecah 56 juta tan setiap tahun. Pada masa ini, pelepah sawit digunakan sebagai baja tanah dan makanan haiwan, manakala lebihan pelepah dibakar bagi menjimatkan ruang ladang dan mengelakkan kontaminasi. Amalan sebegini merendahkan nilai ekonomi OPF dan menyumbang kepada pencemaran alam sekitar. Meraih kandungannya yang tinggi lignoselulosa, kajian ini menyiasat potensi bio-olahan pelepah sawit untuk penghasilan enzim lignoselulolitik. Enam kulat pencilan tempatan *A. awamori* MMS4, *A. niger* EFB1, *A. fumigatus* SK1, *T virens* UKM1, *T. viride* MM3, dan *T. asperellum* MR1 telah disaring keupayaan menghasilkan enzim melalui kaedah fermentasi pepejal. Fermentasi telah dilakukan di dalam piring petri menggunakan gentian OPF (0.125 mm) pada kandungan lembapan 60% dan suhu 35°C selama 7 hari. Proses fermentasi tersebut menghasilkan campuran enzim yang tinggi dengan lignin peroksidase (20-222 Ug^{-1}), endoksilanase (6-109 Ug^{-1}) dan endoglukanase (2-9 Ug^{-1}), serta eksoglukanase, β-glukosidase, mangan peroksidase dan lakkase. Campuran pelbagai enzim tersebut sesuai digunakan bagi aplikasi teknikal, dan apabila diuji dalam penyahdakwatan enzimatik surat khabar lama menghasilkan kecerahan pulpa sehingga 51.5% dan kekuatan tegangan 34.0 Nm/g. Bagi mengelakkan penjanaan sisa sekunder, baki OPF terfermentasi (pasca pengekstrakan enzim) telah difermentasikan semula sehingga tiga kitaran. Ia seterusnya meningkatkan pengeluaran enzim sebanyak 26-79% dan penggunaan serat sebanyak 14-26%. Fermentasi ulangan sebegini juga didapati bersesuaian untuk menambahbaik kemampanan serta kos penghasilan enzim pada setiap kitaran. OPF terpakai yang tidak lagi boleh difermentasi selepas tiga kitaran telah dikenakan penjanaan semula nutrisi melalui proses hidrolisis dan autolisis enzimatik. Proses tersebut menghasilkan hidrolisat bernutrisi tinggi yang mengandungi karbon (1.79 gL^{-1}), nitrogen (0.11 gL^{-1}) dan fosforus (0.36 gL^{-1}) yang boleh digunapakai sebagai medium pertumbuhan dan menyokong pertumbuhan kulat dan bakteria. Secara keseluruhan, kajian ini menunjukkan potensi bio-olahan OPF kepada enzim yang bernilai dan juga kepentingan proses fermentasi ulangan dan hidrolisis bagi memaksimumkan penggunaan bahan yang telah difermentasi sebagai bahan mentah yang boleh diperbaharui.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABTS	-	Azinobis ethyl benzothiazoline sulfonate
AC	-	Autoclaved pre-treatment
ACA	-	Alkaline and autoclaved pre-treatment
AL	-	Alkaline pre-treatment
BSA	-	Bovine serum albumin
BL	-	Boiling
CMC	-	Carboxymethyl cellulose
CMCase	-	Carboxymethyl cellulase
DNS	-	Dinitrosalicyclic acid
EFB	-	Empty fruit bunch
FAN	-	Free amino nitrogen
Fpase	-	Filter paperase
FTIR	-	Fourier-transform infrared spectroscopy
OPF	-	Oil palm frond
g	-	gram
HCL	-	Hydrochloric acid
HPLC	-	High performance liquid chromatography
ISO	-	International organization for standardization
L	-	Liter
LCA	-	Life cycle assessment
LiP	-	Lignin peroxidase
MF	-	Mesocarp fibre
Min	-	Minutes
Mg	-	Miligram
mL	-	Mililiter
MnP	-	Manganese peroxidase
MOW	-	Mixed office waste
MW	-	Molecular weight
NaOH	-	Sodium hydroxide
°C	-	Degree celsius

ONP	-	Oil news paper
OPT	-	Oil palm trunk
OPW	-	Old palm waste
PDA	-	Potato Dextrose Agar
PKF	-	Palm kernel shell
POME	-	Palm oil mill effluent
pNPG	-	p-nitrophenyl β-D-glucosidase
rpm	-	Rotation per minute
SEM	-	Scanning electron microscopy
SmF	-	Submerged fermentation
SSF	-	Solid state fermentation
TOC	-	Total organic carbon
TPC	-	Total phenolic concentration
TN	-	Total nitrogen
TP	-	Total phosphorus
U	-	Unit activity enzyme
UT	-	Untreated
v/v	-	Volume per volume
w/v	-	Weight per volume

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background information

About 56 million tonnes of oil palm frond (OPF) are generated every year and is possibly the largest agricultural waste in Malaysia (Abdullah *et al.*, 2016). However, the utilization of OPF and oil palm waste in general are quite limited. At present, OPF wastes are used for soil replenishment and as animal feed, while a larger portion are burned to save up plantation space and to avoid contamination (Ishida & Abu Hassan, 1997; Islam *et al.*, 2000; Lee *et al.*, 2016). Realising the potential of oil palm biomass, the Malaysian government initiated the *National Biomass Strategy 2020* to convert the largely underutilized biomass waste into value added bio-products such as enzymes, biofuel, bio-fertilizer, and bio-based chemicals (Malaysia, 2011).

Biomass waste with potentially high lignocellulose content such as OPF can be exploited for lignocellulolytic enzyme production (Saini *et al.*, 2015). A lignocellulolytic enzyme contain a mixture of cellulase, xylanase, and ligninolytic enzymes (Saini *et al.*, 2015). These enzymes are in demand today due to their widespread application in various industries (Anwar *et al.*, 2014). One such industry that can benefit from enzyme application is the pulp and paper industry. To date, they are one of the largest environmental polluters due to their over reliance on harmful high alkaline chemicals (Ashrafi *et al.*, 2015). Lignocellulolytic enzyme can be applied for wastepaper processing especially in the deinking and bleaching process (Davison & Finkelstein, 2012; Lee *et al.*, 2007). However, the biggest bottleneck for enzymatic application in industries is the high cost of enzyme production itself (Liu *et al.*, 2016).

Commercial enzymes are conventionally produced by submerged fermentation (SmF). Today, solid state fermentation (SSF) are gaining significant interest for enzyme production (Singhania *et al.*, 2010). The combination of SSF and filamentous fungi have yield promising results in the production of hydrolytic enzymes such as cellulase and xylanase. In addition, fungal fermentation under SSF is capable of producing higher volumetric extracellular enzymes than SmF (di Cologna *et al.*, 2017; Viniegra-González *et al.*, 2003). This is because filamentous fungi can thrive under low water environment and could consume nutrient directly by degrading the solid substrate (Manpreet *et al.*, 2005). Another advantage of SSF is that, it is simple and cheaper to operate. It uses low amount of water and the fermenter set-up does not require agitator and complex stirring mechanism (Pandey *et al.*, 2008).

Although lignocellulose biomass such as oil palm frond has great potential to be converted into value-added product such as lignocellulolytic enzyme, certain challenges related to its production such as cost and environmental impact has to be addressed. These crucial factors if left unchecked at lab-scale could become a hindrance in future up-scaling. For that reason, incorporating certain bio-refinery techniques such as re-fermentation and nutrient regeneration may be useful (Chang & Webb, 2017). Re-fermentation involves the re-use of fermented substrate for the production of same or other related product, while nutrient regeneration involves the retrieval of essential nutrient from fermented material (Koutinas *et al.*, 2005). Adopting such techniques in the production scheme could maximize substrate utilization, improve enzyme production and possibly generate other value added product along the way.

Finally, enzyme production has to be sustainable for it to be beneficial. Most claims on enzymes being a greener alternative to chemicals are not substantiated with quantitative findings (Jegannathan & Nielsen, 2013). Thus, environmental assessment of enzyme production is necessary for it to be truly sustainable. Today, life-cycle assessment (LCA) has become an indispensable tool to ascertain the sustainability of such process in a cheap and easy way.

1.2 Problem statements

In recent years, oil palm frond (OPF) has gained prominence due to its diverse usage potential. For example, OPF's leaflets and stems sections are rich in soil nutrient and can be utilized as natural soil fertilizers. However, other larger section of the frond such as the petiole are commonly burned, and this contributed to pollution and wastage of lignocellulose content. The study proposes to investigate the suitability and potential of OPF petiole as a substrate for solid state fermentation.

Fungal fermentation of heterogeneous lignocellulose substrate such as OPF are likely to produce a diverse enzyme mixture (Anwar *et al.*, 2014). At present, many SSF studies are mainly focused on hydrolytic enzymes such as cellulase and xylanase while disregarding enzymes such as lignin peroxidase, manganese peroxidase and laccase that might be presence in the mixture. Furthermore, these oxidative enzymes are often exclusively produced and researched using white-rot basidiomycetes fungi (e.g., *Phanerochaete* sp.)(Yoon *et al.*, 2014). This study intends to investigate all seven enzymes associated to the lignocellulolytic mixture using soft-rot ascomycetes fungi (e.g., *Aspergillus* and *Trichoderma* sp.) to better understand its enzymatic activity, composition and application potential.

Most fermentation studies today are too product oriented with little attention given to the fermented residue/substrate. At the end of fermentation or post-extraction process, fermented residue may still contain undigested fibre components, protein and microbial cells (Chang & Webb, 2017; Koutinas *et al.*, 2005). Discarding the solid residue would result in wastage of useful organic matter and contribute to the generation of secondary waste. Therefore, this study propose to re-ferment the fermented residue to increase its level of utilization and also to further hydrolyse it for the purpose of nutrient regeneration.

Lab-scale enzyme studies are often focused on process optimization and purification to increase enzymatic yield. Although this is important, other practical aspect such as cost, environmental impact and final applicability of the enzyme produced should also be given weight (da Gama Ferreira *et al.*, 2018; Olofsson *et al.*, 2017). Commercial enzymes are not only expensive to produce, its production process may not be as environmentally friendly as expected (Klein-Marcuschamer *et al.*, 2012). For that reason, the enzyme produced in this study are evaluated for its potential impact to environment and its enzymatic hydrolytic application on raw lignocellulose biomass and wastepaper while estimating the cost of enzyme produced at small scale.

1.3 Objectives

1. To analyse the physicochemical characteristic of oil palm frond petiole as lignocellulose substrate for solid state fermentation
2. To select the best lignocellulolytic enzyme producer among *Aspergillus* and *Trichoderma* species
3. To analyse the re-fermentation potential of fermented oil palm frond petiole and its effect on substrate utilization and lignocellulolytic enzyme production
4. To compare the enzymatic hydrolysis of fermented and non-fermented oil palm frond petiole for the production of nutrient rich medium
5. To evaluate the environmental impact and application potential of crude lignocellulolytic enzyme

1.4 Scope of study

The study only focuses on the petiole section of the oil palm frond and are subjected to physical modifications. The characterization of the frond petiole covered aspects of its chemical and elemental composition, size distribution, moisture content, surface area and porosity. Six filamentous fungi from *Aspergillus* and *Trichoderma* species were screened to determine the best lignocellulolytic enzyme producer and the selected strain were used throughout the study. Solid state fermentation was carried out using glass petri dish for the benefit of space and practicality. The re-fermentation of fermented frond petiole was studied in several cycles until the fermented substrate was no longer efficient in producing lignocellulolytic enzyme. The crude enzyme produced were applied for the bio-deinking of pre-treated old newspaper. The crude enzyme was also used for the enzymatic hydrolysis of non-fermented and fermented frond petiole for the production nutrient rich hydrolysate and autolysate. Both nutrient rich lysates were combined as autohydrolysate that would serve as a growth medium and tested on bacteria and fungi. The overall cost and environmental impact of crude lignocellulolytic enzyme production during initial fermentation and re-fermentation processes were assessed. Both assessments took into account the raw materials, chemicals and utilities used during the enzyme production process.

REFERENCES

Abalone, R., Cassinera, A., Gaston, A., & Lara, M. (2004) Some physical properties of amaranth seeds. *Biosystems Engineering,* 89(1), 109-117.

Abdel-Hamid, A. M., Solbiati, J. O., & Cann, I. K. (2013) Insights into lignin degradation and its potential industrial applications. *Advances in applied microbiology*. Academic Press, pp 1-28.

Abdul Khalil, H., Siti Alwani, M., Ridzuan, R., Kamarudin, H., & Khairul, A. (2008) Chemical composition, morphological characteristics, and cell wall structure of Malaysian oil palm fibers. *Polymer-Plastics Technology and Engineering,* 47(3), 273-280.

Abdul Manan, M., & Webb, C. (2018) Estimating fungal growth in submerged fermentation in the presence of solid particles based on colour development. *Biotechnology & Biotechnological Equipment,* 32(3), 618-627.

Abdullah, S. S. S., Shirai, Y., Ali, A. A. M., Mustapha, M., & Hassan, M. A. (2016) Case study: Preliminary assessment of integrated palm biomass biorefinery for bioethanol production utilizing non-food sugars from oil palm frond petiole. *Energy Conversion and Management,* 108, 233-242.

Abe, K., & Gomi, K. (2008) Food products fermented by Aspergillus oryzae. *The Aspergilli: Genomics, Medical Aspects, Biotechnology, and Research Methods.* CRC Press, pp 429-439.

Abu Yazid, N., Barrena, R., Komilis, D., & Sánchez, A. (2017) Solid-state fermentation as a novel paradigm for organic waste valorization: a review. *Sustainability,* 9(2), 224.

Ahlgren, S., Björklund, A., Ekman, A., Karlsson, H., Berlin, J., Börjesson, P., . . . Strid, I. (2015) Review of methodological choices in LCA of biorefinery systems-key issues and recommendations. *Biofuels, Bioproducts and Biorefining,* 9(5), 606-619.

Alam, M. Z., Muhammad, N., & Mahmat, M. E. (2005) Production of cellulase from oil palm biomass as substrate by solid state bioconversion. *American Journal of Applied Sciences,* 2(2), 569-572.

Aliyuc, A. S., Aziza, A. A., Yahya, A., & Lattiffa, Z. A. (2015) Potential of oil palm frond liquid extract and fiber as feedstock for bio-butanol production. *Jurnal Teknologi,* 40, 60.

Amani, P. (2012) *Regional environmental life cycle assessment for improving food chain sustainability*. Springer Gabler.

Amorim, G. M., Oliveira, A. C., Gutarra, M. L., Godoy, M. G., & Freire, D. M. (2017) Solid-state fermentation as a tool for methylxanthine reduction and simultaneous xylanase production in cocoa meal. *Biocatalysis and Agricultural Biotechnology,* 11, 34-41.

Ang, S. (2015) *Cellulase and xylanase production by Aspergillus fumigatus SK1 through solid state fermentation for ethanol production.* Ph.D. Thesis, Universiti Teknologi Malaysia, Skudai.

Ang, S., Shaza, E., Adibah, Y., Suraini, A., & 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., & 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., & 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., & 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.

Ashrafi, O., Yerushalmi, L., & Haghighat, F. (2015) Wastewater treatment in the pulp-and-paper industry: A review of treatment processes and the associated greenhouse gas emission. *Journal of environmental management,* 158, 146-157.

Baharuddin, A., Wakisaka, M., Shirai, Y., Abd-Aziz, S., Abdul Rahman, N., & Hassan, M. (2009) Co-composting of empty fruit bunches and partially treated palm oil mill effluents in pilot scale. *International Journal of Agricultural Research,* 4(2), 69-78.

Baharuddin, A. S., Razak, A., Asma, N., Rahman, A., Budiatman, S., Yoshihito, S., & Hassan, M. A. (2009) Biocoversion of oil palm empty fruit bunch by *Aspergillus niger* EB4 under solid-state fermentation. *Pertanika Journal of Tropical Agricultural Science,* 32(2), 143-151.

Bailey, M. J., Biely, P., & Poutanen, K. (1992) Interlaboratory testing of methods for assay of xylanase activity. *Journal of biotechnology,* 23(3), 257-270.

Bajpai, P., Anand, A., & Bajpai, P. K. (2006) Bleaching with lignin-oxidizing enzymes. *Biotechnology annual review,* 12, 349-378.

Bajpai, P., & Bajpai, P. K. (1998) Deinking with enzymes: a review. *Tappi journal,* 81(12), 111-117.

Bandikari, R., Poondla, V., & Obulam, V. S. R. (2014) Enhanced production of xylanase by solid state fermentation using *Trichoderma koeningi* isolate: effect of pretreated agro-residues. *3 Biotech,* 4(6), 655-664.

Berlin, A., Balakshin, M., Gilkes, N., Kadla, J., Maximenko, V., Kubo, S., & Saddler, J. (2006) Inhibition of cellulase, xylanase and β-glucosidase activities by softwood lignin preparations. *Journal of biotechnology,* 125(2), 198-209.

Bhargav, S., Panda, B. P., Ali, M., & Javed, S. (2008) Solid-state fermentation: an overview. *Chemical and Biochemical Engineering Quarterly,* 22(1), 49-70.

Bhat, M. (2000) Cellulases and related enzymes in biotechnology. *Biotechnology advances,* 18(5), 355-383.

Bicas, J. L., Maróstica, M. R., & Pastore, G. M. (2016) *Biotechnological Production of Natural Ingredients for Food Industry*: Bentham Science Publishers.

Binod, P., Janu, K., Sindhu, R., & Pandey, A. (2011) Hydrolysis of lignocellulosic biomass for bioethanol production. *Biofuels: alternative feedstocks and conversion processes*. Academic press. pp 229-250.

Bodirlau, R., & Teaca, C. (2009) Fourier transform infrared spectroscopy and thermal analysis of lignocellulose fillers treated with organic anhydrides. *Romanian Journal of Physics,* 54(1-2), 93-104.

Bommarius, A. S., Katona, A., Cheben, S. E., Patel, A. S., Ragauskas, A. J., Knudson, K., & Pu, Y. (2008) Cellulase kinetics as a function of cellulose pretreatment. *Metabolic engineering,* 10(6), 370-381.

Borin, G. P., Sanchez, C. C., de Souza, A. P., de Santana, E. S., de Souza, A. T., Leme, A. F. P., . . . de Castro Oliveira, J. V. (2015) Comparative secretome analysis of *Trichoderma reesei* and *Aspergillus niger* during growth on sugarcane biomass. *PloS one,* 10(6), e0129275.

Brodeur, G., Yau, E., Badal, K., Collier, J., Ramachandran, K., & Ramakrishnan, S. (2011) Chemical and physicochemical pretreatment of lignocellulosic biomass: a review. *Enzyme research,* 2011.

Buendía, M. R. P., Pardo-Giménez, A., & de Juan-Valero, J. A. (2016) Reuse of degraded *Pleurotus ostreatus* (Jacq.) P. Kumm. substrate by supplementation with wheat bran. Quantitative parameters. *Mycology,* 7(2), 53-63.

Burns, R. G., & Dick, R. P. (2002) *Enzymes in the Environment: Activity, Ecology, and Applications*. CRC Press.

Cademartori, P. H. G. d., Missio, A. L., Mattos, B. D., & Gatto, D. A. (2015) Effect of thermal treatments on technological properties of wood from two *Eucalyptus* species. *Anais da Academia Brasileira de Ciências,* 87(1), 471-481.

Cao, W., Sun, C., Liu, R., Yin, R., & Wu, X. (2012) Comparison of the effects of five pretreatment methods on enhancing the enzymatic digestibility and

ethanol production from sweet sorghum bagasse. *Bioresource technology,* 111, 215-221.

Cavalcante, R. S., Lima, H. L., Pinto, G. A., Gava, C. A., & Rodrigues, S. (2008) Effect of moisture on *Trichoderma conidia* production on corn and wheat bran by solid state fermentation. *Food and Bioprocess Technology,* 1(1), 100-104.

Cen, P., & Xia, L. (1999) Production of cellulase by solid-state fermentation. *Recent Progress in Bioconversion of Lignocellulosics*. Springer. pp 69-92.

Chancharoonpong, C., Hsieh, P.-C., & Sheu, S.-C. (2012) Enzyme production and growth of *Aspergillus oryzae* on soybean koji fermentation. *APCBEE Procedia,* 2, 57-61.

Chandra, R. P., Bura, R., Mabee, W., Berlin, d. A., Pan, X., & Saddler, J. (2007) Substrate pretreatment: the key to effective enzymatic hydrolysis of lignocellulosics? *Biofuels*. Springer. pp 67-93.

Chang, C.-W., & Webb, C. (2017) Production of a generic microbial feedstock for lignocellulose biorefineries through sequential bioprocessing. *Bioresource technology,* 227, 35-43.

Che Maail, C. M. H., Ariffin, H., Hassan, M. A., Shah, U. K. M., & Shirai, Y. (2014) Oil Palm Frond Juice as Future Fermentation Substrate: A Feasibility Study. *BioMed research international,* 2014.

Cheah, S.-C., Ooi, L. C., & Ong, A. S. (1989) Improvement in the protein content of palm kernel meal by solid state fermentation. *Proceedings of the World Congress on Vegetable Protein Utilization in Human Foods and Animal Feedstuffs*. The American Oil Chemists Society.

Cheirsilp, B., & Kitcha, S. (2015) Solid state fermentation by cellulolytic oleaginous fungi for direct conversion of lignocellulosic biomass into lipids: fed-batch and repeated-batch fermentations. *Industrial Crops and Products,* 66, 73-80.

Chen, H. (2013). *Modern Solid State Fermentation: Theory and Practice*. Netherlands: Springer.

Chen, J., & Zhu, Y. (2013) *Solid state fermentation for foods and beverages*: CRC Press.

Chen, X., Li, H., Sun, S., Cao, X., & Sun, R. (2016) Effect of hydrothermal pretreatment on the structural changes of alkaline ethanol lignin from wheat straw. *Scientific reports,* 6, 39354.

Chen, Y., Wan, J., Ma, Y., & Lv, H. (2010) Modification of properties of old newspaper pulp with biological method. *Bioresource technology,* 101(18), 7041-7045.

Chin, M. J., Poh, P. E., Tey, B. T., Chan, E. S., & Chin, K. L. (2013) Biogas from palm oil mill effluent (POME): Opportunities and challenges from Malaysia's perspective. *Renewable and Sustainable Energy Reviews,* 26, 717-726.

Chinedu, S. N., Nwinyi, O., Okafor, U. A., & Okochi, V. I. (2011) Kinetic Study and Characterization of 1, 4-β-Endoglucanase of *Aspergillus niger* ANL301. *Dynamic Biochemistry, Process Biotechnology and Molecular Biology,* 5(2), 41-46.

Christopher, L. (2013) Adding value prior to pulping: bioproducts from hemicellulose. *Global Perspectives on Sustainable Forest Management*, IntechOpen. pp 225.

Corredor, D., Salazar, J., Hohn, K., Bean, S., Bean, B., & Wang, D. (2009) Evaluation and characterization of forage sorghum as feedstock for fermentable sugar production. *Applied biochemistry and biotechnology,* 158(1), 164-179.

D'Agostini, É. C., Mantovani, T. R. D. A., Valle, J. S. d., Paccola-Meirelles, L. D., Colauto, N. B., & Linde, G. A. (2011) Low carbon/nitrogen ratio increases laccase production from basidiomycetes in solid substrate cultivation. *Scientia agricola,* 68(3), 295-300.

da Gama Ferreira, R., Azzoni, A. R., & Freitas, S. (2018) Techno-economic analysis of the industrial production of a low-cost enzyme using *E. coli*: the case of recombinant β-glucosidase. *Biotechnology for biofuels,* 11(1), 81.

da Silva Delabona, P., Cota, J., Hoffmam, Z. B., Paixão, D. A. A., Farinas, C. S., Cairo, J. P. L. F., . . . da Cruz Pradella, J. G. (2013) Understanding the cellulolytic system of *Trichoderma harzianum* P49P11 and enhancing saccharification of pretreated sugarcane bagasse by supplementation with pectinase and α-L-arabinofuranosidase. *Bioresource technology,* 131, 500-507.

Dahlan, I. (2000) Oil palm frond, a feed for herbivores. *Asian Australasian Journal of Animal Sciences,* 13, 300-303.

Dai, D., & Fan, M. (2014) Wood fibres as reinforcements in natural fibre composites: structure, properties, processing and applications. *Natural Fibre Composites: Materials, Processes and Properties*, 3-65.

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

Davison, B. H., & Finkelstein, M. (2012) *Biotechnology for Fuels and Chemicals: The Twenty-Fourth Symposium*: Springer Science & Business Media.

de Jong, W., & van Ommen, J. R. (2014) *Biomass as a Sustainable Energy Source for the Future: Fundamentals of Conversion Processes*: Wiley.

de Lourdes T. M. Polizeli, M., & Rai, M. (2016) *Fungal Enzymes*: CRC Press.

de Oliveira, S. L. R., Maciel, T. C., Sancho, S. O., & Rodrigues, S. (2016) Solid-state production of cellulase by *Melanoporia* sp. CCT 7736: a new strain isolated from coconut shell (*Cocos nucifera*). *Bioresources and Bioprocessing,* 3(1), 9.

Deacon, J. (2005) Fungal spores, spore dormancy, and spore dispersal. *Fungal Biology, 4th Edition*, 184-212.

Deacon, J. W. (2013) *Fungal Biology*. Wiley.

Delgado-Aguilar, M., González, I., Pèlach, M., De La Fuente, E., Negro, C., & Mutjé, P. (2015) Improvement of deinked old newspaper/old magazine pulp suspensions by means of nanofibrillated cellulose addition. *Cellulose,* 22(1), 789-802.

Desai, D. I., & Iyer, B. D. (2016) Biodeinking of old newspaper pulp using a cellulase-free xylanase preparation of *Aspergillus niger* DX-23. *Biocatalysis and Agricultural Biotechnology,* 5, 78-85.

Dhillon, G. S., & Kaur, S. (2016) *Agro-industrial wastes as feedstock for enzyme production: Apply and exploit the emerging and valuable use options of waste biomass*. Elsevier Science.

di Cologna, N. d. M., Gómez-Mendoza, D. P., Zanoelo, F. F., Giannesi, G. C., de Alencar Guimarães, N. C., de Souza Moreira, L. R., . . . Ricart, C. A. O. (2017) Exploring *Trichoderma* and *Aspergillus* secretomes: Proteomics approaches for the identification of enzymes of biotechnological interest. *Enzyme and microbial technology*, 109 (2018), 1-10.

Díaz, A. B., de Ory, I., Caro, I., & Blandino, A. (2012) Enhance hydrolytic enzymes production by *Aspergillus awamori* on supplemented grape pomace. *Food and bioproducts processing,* 90(1), 72-78.

dos Santos Aguilar, J. G., & Sato, H. H. (2017) Microbial proteases: production and application in obtaining protein hydrolysates. *Food research international.*

Druzhinina, I. S., Shelest, E., & Kubicek, C. P. (2012) Novel traits of *Trichoderma* predicted through the analysis of its secretome. *FEMS microbiology letters,* 337(1), 1-9.

Duda, M., & Shaw, J. S. (1997) Life cycle assessment. *Society,* 35(1), 38-43.

Dumitriu, S. (2004) *Polysaccharides: structural diversity and functional versatility*: CRC press.

El-Shishtawy, R. M., Mohamed, S. A., Asiri, A. M., Abu-bakr, M. G., Ibrahim, I. H., & Al-Talhi, H. A. (2014) Solid fermentation of wheat bran for hydrolytic enzymes production and saccharification content by a local isolate *Bacillus megatherium*. *BMC biotechnology,* 14(1), 1.

Ellilä, S., Fonseca, L., Uchima, C., Cota, J., Goldman, G. H., Saloheimo, M., . . . Siika-Aho, M. (2017) Development of a low-cost cellulase production process using *Trichoderma reesei* for Brazilian biorefineries. *Biotechnology for biofuels,* 10(1), 30.

Fadel, M. (2000) Production physiology of cellulases and ß-glucosidase enzymes of *Aspergillus niger* grown under solid state fermentation conditions. *OnLine Journal of Biological Sciences,* 1(5), 401-411.

Fang, Z., & Smith, R. L. (2016) *Production of Biofuels and Chemicals from Lignin*. Singapore: Springer.

Feijoo, S., González-García, S., Lema, J., & Moreira, M. (2017) Life cycle assessment of β-Galactosidase enzyme production. *Journal of Cleaner Production,* 165, 204-212.

FitzPatrick, M., Champagne, P., Cunningham, M. F., & Whitney, R. A. (2010) A biorefinery processing perspective: treatment of lignocellulosic materials for the production of value-added products. *Bioresource technology,* 101(23), 8915-8922.

Franden, M. A., Pilath, H. M., Mohagheghi, A., Pienkos, P. T., & Zhang, M. (2013) Inhibition of growth of *Zymomonas mobilis* by model compounds found in lignocellulosic hydrolysates. *Biotechnology for biofuels,* 6(1), 99.

Gabhane, J., William, S. P., Vaidya, A. N., Mahapatra, K., & Chakrabarti, T. (2011) Influence of heating source on the efficacy of lignocellulosic pretreatment–a cellulosic ethanol perspective. *Biomass and bioenergy,* 35(1), 96-102.

Gao, L., Sun, M. H., Liu, X. Z., & Che, Y. S. (2007) Effects of carbon concentration and carbon to nitrogen ratio on the growth and sporulation of several biocontrol fungi. *Mycological research,* 111(1), 87-92.

Gao, Y., Yu, H., Liu, P., Ma, C., Li, Q., & Jiang, W. (2018) Ending composting during the thermophilic phase improves cultivation substrate properties and increasing winter cucumber yield. *Waste management,* 79, 260-272.

Ghose, T. (1987) Measurement of cellulase activities. *Pure and applied Chemistry,* 59(2), 257-268.

Ghose, T., & Bisaria, V. S. (1987) Measurement of hemicellulase activities: part I xylanases. *Pure and applied Chemistry,* 59(12), 1739-1751.

Globe. (2005). Soil particle density protocol

Goedkoop, M., Heijungs, R., Huijbregts, M., De Schryver, A., Struijs, J., & Van Zelm, R. (2009) *ReCiPe 2008: A life cycle impact assessment method which*

comprises harmonised category indicators at the midpoint and the endpoint level, 1.

Goswami, D. Y., & Kreith, F. (2007) *Energy Conversion*. CRC Press.

Gottschalk, L. M. F., Paredes, R. D. S., Teixeira, R. S. S., Silva, A. S. A. D., & Bon, E. P. D. S. (2013) Efficient production of lignocellulolytic enzymes xylanase, β-xylosidase, ferulic acid esterase and β-glucosidase by the mutant strain *Aspergillus awamori* 2B. 361 U2/1. *Brazilian Journal of Microbiology,* 44(2), 569-576.

Griffin, D. H. (1996) *Fungal Physiology*: Wiley.

Grubert, E., & Kitasei, S. (2010) How energy choices affect fresh water supplies: a comparison of US coal and natural gas. *Worldwatch Institute*.

Guinée, J. B. (2006) *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards*. Netherlands: Springer.

Guldhe, A., Singh, B., Renuka, N., Singh, P., Misra, R., & Bux, F. (2017) Bioenergy: A Sustainable Approach for Cleaner Environment *Phytoremediation Potential of Bioenergy Plants*. Springer. pp 47-62.

Guo, H., Chang, Y., & Lee, D.-J. (2017) Enzymatic saccharification of lignocellulosic biorefinery: Research focuses. *Bioresource technology*. 252, 198-215.

Gupta, V. G., Schmoll, M., Herrera-Estrella, A., Upadhyay, R., Druzhinina, I., & Tuohy, M. (2014) *Biotechnology and biology of Trichoderma*. Newnes.

Hammel, K. (1997). Fungal degradation of lignin. *Driven by nature: plant litter quality and decomposition*, 33-45.

Hamzah, F., Idris, A., & 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.

Hansen, G. H., Lübeck, M., Frisvad, J. C., Lübeck, P. S., & Andersen, B. (2015) Production of cellulolytic enzymes from ascomycetes: comparison of solid state and submerged fermentation. *Process Biochemistry,* 50(9), 1327-1341.

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

Hashim, F., Yussof, H., Zahari, M., Rahman, R., & Illias, R. (2017) Enzymatic hydrolysis of pretreated fibre pressed oil palm frond by using sacchariseb C6. *IOP Conference Series: Materials Science and Engineering*.

Hashim, R., Nadhari, W. N. A. W., Sulaiman, O., Kawamura, F., Hiziroglu, S., Sato, M., . . . Tanaka, R. (2011) Characterization of raw materials and manufactured binderless particleboard from oil palm biomass. *Materials & Design,* 32(1), 246-254.

Hassan, A., Salema, A. A., Ani, F. N., & Bakar, A. A. (2010) A review on oil palm empty fruit bunch fiber-reinforced polymer composite materials. *Polymer Composites,* 31(12), 2079-2101.

Hatakka, A. (2005). Biodegradation of lignin. *Biopolymers Online*.

Héraux, F. M., Hallett, S. G., & Weller, S. C. (2005) Combining *Trichoderma virens*-inoculated compost and a rye cover crop for weed control in transplanted vegetables. *Biological Control,* 34(1), 21-26.

Hertwich, E. G., Mateles, S. F., Pease, W. S., & McKone, T. E. (2001) Human toxicity potentials for life-cycle assessment and toxics release inventory risk screening. *Environmental Toxicology and Chemistry,* 20(4), 928-939.

Hölker, U., Höfer, M., & Lenz, J. (2004) Biotechnological advantages of laboratory-scale solid-state fermentation with fungi. *Applied microbiology and biotechnology,* 64(2), 175-186.

Hong, L. S., Ibrahim, D., & Che Omar, I. (2010) Microscopic studies of oil palm frond during processing for saccharification. *The Internet Journal of Bioengineering,* 4(2), 1-13.

Hong, Y., Nizami, A. S., Pour Bafrani, M., Saville, B. A., & MacLean, H. L. (2013) Impact of cellulase production on environmental and financial metrics for lignocellulosic ethanol. *Biofuels, Bioproducts and Biorefining,* 7(3), 303-313.

Höök, M., & Tang, X. (2013) Depletion of fossil fuels and anthropogenic climate change—A review. *Energy Policy,* 52, 797-809.

Hou, C. T., & Shaw, J. F. (2008) *Biocatalysis and Bioenergy*. Wiley.

Hu, H., Van den Brink, J., Gruben, B., Wösten, H., Gu, J.-D., & De Vries, R. (2011) Improved enzyme production by co-cultivation of *Aspergillus niger* and *Aspergillus oryzae* and with other fungi. *International Biodeterioration & Biodegradation,* 65(1), 248-252.

Ibrahim, C. (2008) Development of applications of industrial enzymes from Malaysian indigenous microbial sources. *Bioresource technology,* 99(11), 4572-4582.

Irshad, M., Anwar, Z., & Kamboh, N. (2011) Production of xylanase by *Humicola lanuginosa* in solid state culture by screening lignocellulosic substrates. *Middle-East Journal of Scientific Research,* 8, 364-370.

Ishida, M., & Abu Hassan, O. (1997) Utilization of oil palm frond as cattle feed. *Japan Agricultural Research Quarterly,* 31(1), 41-47.

Islam, M., Dahlan, I., Rajion, M., & Jelan, Z. (2000) Productivity and nutritive values of different fractions of oil palm (*Elaeis guineensis*) frond. *Asian Australasian Journal of Animal Sciences,* 13(8), 1113-1120.

Itam, Z., Beddu, S., Kamal, N. L. M., Alam, M. A., & Ayash, U. I. (2016) The feasibility of palm kernel shell as a replacement for coarse aggregate in lightweight concrete. *IOP Conference Series: Earth and Environmental Science*.

Jahar, N. A., Pua, F.-l., Chyi, W. J., Mostapha, M., Zakaria, S., Chia, C. H., & Jaafar, S. N. S. (2017) Utilization of core oil palm trunk waste to methyl levulinate: physical and chemical characterizations. *Waste and Biomass Valorization*, 1-6.

Jahromi, M., Liang, J., Rosfarizan, M., Goh, Y. M., Shokryazdan, P., & Ho, Y. (2011) Efficiency of rice straw lignocelluloses degradability by *Aspergillus terreus* ATCC 74135 in solid state fermentation. *African Journal of Biotechnology,* 10(21), 4428-4435.

Jegannathan, K. R., & Nielsen, P. H. (2013) Environmental assessment of enzyme use in industrial production–a literature review. *Journal of Cleaner Production,* 42, 228-240.

Jönsson, L. J., Alriksson, B., & Nilvebrant, N.-O. (2013) Bioconversion of lignocellulose: inhibitors and detoxification. *Biotechnol Biofuels,* 6(1), 16.

Jönsson, L. J., & Martín, C. (2016) Pretreatment of lignocellulose: formation of inhibitory by-products and strategies for minimizing their effects. *Bioresource technology,* 199, 103-112.

Jørgensen, H., Kristensen, J. B., & Felby, C. (2007) Enzymatic conversion of lignocellulose into fermentable sugars: challenges and opportunities. *Biofuels, Bioproducts and Biorefining,* 1(2), 119-134.

Jørgensen, H., & Pinelo, M. (2016) Enzyme recycling in lignocellulosic biorefineries. *Biofuels, Bioproducts and Biorefining*, 11(1), 150-167.

Jung, Y. H., Kim, S., Yang, T. H., Lee, H. J., Seung, D., Park, Y.-C., . . . Kim, K. H. (2012) Aqueous ammonia pretreatment, saccharification, and fermentation evaluation of oil palm fronds for ethanol production. *Bioprocess and biosystems engineering,* 35(9), 1497-1503.

Kalaiarasi, K., & Parvatham, R. (2015) Optimization of process parameters for α-amylase production under solid-state fermentation by *Aspergillus awamori* MTCC 9997.

Kang, S., Park, Y., Lee, J., Hong, S., & Kim, S. W. (2004) Production of cellulases and hemicellulases by *Aspergillus niger* KK2 from lignocellulosic biomass. *Bioresource technology,* 91(2), 153-156.

Karimi, K., Shafiei, M., & Kumar, R. (2013) Progress in physical and chemical pretreatment of lignocellulosic biomass. *Biofuel technologies*. Springer. pp 53-96.

Karp, S. G., Faraco, V., Amore, A., Birolo, L., Giangrande, C., Soccol, V. T., . . . Soccol, C. R. (2012) Characterization of laccase isoforms produced by *Pleurotus ostreatus* in solid state fermentation of sugarcane bagasse. *Bioresource technology,* 114, 735-739.

Karpe, A. V., Harding, I. H., & Palombo, E. A. (2014) Comparative degradation of hydrothermal pretreated winery grape wastes by various fungi. *Industrial Crops and Products,* 59, 228-233.

Kavanagh, K. (2011) *Fungi: Biology and applications*. John Wiley & Sons.

Kaya, F., Heitmann, J. A., & Joyce, T. W. (2000) Influence of lignin and its degradation products on enzymatic hydrolysis of xylan. *Journal of biotechnology,* 80(3), 241-247.

Kheng, P. P., & Omar, I. C. (2005) Xylanase production by a local fungal isolate, *Aspergillus niger* USM AI 1 via solid state fermentation using palm kernel cake (PKC) as substrate. *Songklanakarin Journal of Science and Technology,* 27(2), 325-336.

Khosravihaftkhany, S., Morad, N., Teng, T. T., Abdullah, A. Z., & Norli, I. (2013) Biosorption of Pb (II) and Fe (III) from aqueous solutions using oil palm biomasses as adsorbents. *Water, Air, & Soil Pollution,* 224(3), 1-14.

Kiaei, M., Tajik, M., & Vaysi, R. (2014) Chemical and biometrical properties of plum wood and its application in pulp and paper production. *Maderas. Ciencia y tecnología,* 16(3), 313-322.

Kim, C. T. (2012) *Malaysian Water Sector Reform: Policy and Performance*: Wageningen Academic Publishers.

Kim, S. (2018) Enhancing bioethanol productivity using alkali-pretreated empty palm fruit bunch fiber hydrolysate. *BioMed research international.*

Kim, S., & Kim, C. H. (2013) Bioethanol production using the sequential acid/alkali-pretreated empty palm fruit bunch fiber. *Renewable Energy,* 54, 150-155.

Kinsella, S. (2012) Paperwork: comparing recycled to virgin paper. *The Environmental Paper Network, Asheville, North Carolina.*

Kitcha, S., & Cheirsilp, B. (2014) Bioconversion of lignocellulosic palm byproducts into enzymes and lipid by newly isolated oleaginous fungi. *Biochemical Engineering Journal,* 88, 95-100.

Klein-Marcuschamer, D., Oleskowicz-Popiel, P., Simmons, B. A., & Blanch, H. W. (2012) The challenge of enzyme cost in the production of lignocellulosic biofuels. *Biotechnology and bioengineering,* 109(4), 1083-1087.

Kline, L. M., Hayes, D. G., Womac, A. R., & Labbe, N. (2010) Simplified determination of lignin content in hard and soft woods via UV-spectrophotometric analysis of biomass dissolved in ionic liquids. *BioResources,* 5(3), 1366-1383.

Klöpffer, W. (1997) Life cycle assessment. *Environmental Science and Pollution Research,* 4(4), 223-228.

Kong, S., Loh, S., Bachmann, R. T., Choo, Y., Salimon, J., & Rahim, S. A. (2013) Production and physico-chemical characterization of biochar from palm kernel shell. *AIP Conference Proceedings.*

Koutinas, A., Arifeen, N., Wang, R., & Webb, C. (2007) Cereal-based biorefinery development: Integrated enzyme production for cereal flour hydrolysis. *Biotechnology and bioengineering,* 97(1), 61-72.

Koutinas, A., Wang, R.-H., & Webb, C. (2005) Development of a process for the production of nutrient supplements for fermentations based on fungal autolysis. *Enzyme and microbial technology,* 36(5), 629-638.

Kovárová-Kovar, K., & Egli, T. (1998) Growth kinetics of suspended microbial cells: from single-substrate-controlled growth to mixed-substrate kinetics. *Microbiology and molecular biology reviews,* 62(3), 646-666.

Kredics, L., Antal, Z., Manczinger, L., Szekeres, A., Kevei, F., & Nagy, E. (2003) Influence of environmental parameters on *Trichoderma* strains with biocontrol potential. *Food Technology and Biotechnology,* 41(1), 37-42.

Krijgsheld, P., Bleichrodt, R. v., Van Veluw, G., Wang, F., Müller, W., Dijksterhuis, J., & Wösten, H. (2013) Development in *Aspergillus*. *Studies in mycology,* 74, 1-29.

Kristiani, A., Abimanyu, H., Setiawan, A., & Aulia, F. (2013) Effect of pretreatment process by using diluted acid to characteristic of oil palm's frond. *Energy Procedia,* 32, 183-189.

Kumar, D., & Murthy, G. S. (2013) Stochastic molecular model of enzymatic hydrolysis of cellulose for ethanol production. *Biotechnology for biofuels,* 6(1), 1-20.

Kumar, M., Singhal, A., & Thakur, I. S. (2016) Comparison of submerged and solid state pretreatment of sugarcane bagasse by *Pandoraea* sp. ISTKB: enzymatic and structural analysis. *Bioresource technology,* 203, 18-25.

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

Kumar, R., Mago, G., Balan, V., & Wyman, C. E. (2009) Physical and chemical characterizations of corn stover and poplar solids resulting from leading pretreatment technologies. *Bioresource technology,* 100(17), 3948-3962.

Lai, L.-W., & Idris, A. (2013) Disruption of oil palm trunks and fronds by microwave-alkali pretreatment. *BioResources,* 8(2), 2792-2804.

Lai, L. W., Ibrahim, M., Rahim, N. M., Hashim, E. F., YA'COB, M. Z., Idris, A., & Akhtar, J. (2016) Study on composition, structural, and property changes of oil palm frond biomass under different pretreatments. *Cellulose chemistry and technology,* 50(9-10), 951-959.

Le, D. M., Sørensen, H. R., Knudsen, N. O., Schjoerring, J. K., & Meyer, A. S. (2014) Biorefining of wheat straw: accounting for the distribution of mineral elements in pretreated biomass by an extended pretreatment-severity equation. *Biotechnology for biofuels,* 7(1), 141.

Lee, C., Darah, I., & Ibrahim, C. (2007) Enzymatic deinking of laser printed office waste papers: Some governing parameters on deinking efficiency. *Bioresource technology,* 98(8), 1684-1689.

Lee, C., Ibrahim, D., Ibrahim, C. O., & Daud, W. R. W. (2011) Enzymatic and chemical deinking of mixed office wastepaper and old newspaper: paper quality and effluent characteristics. *BioResources,* 6(4), 3859-3875.

Lee, H., Hamid, S., & Zain, S. (2014) Conversion of Lignocellulosic Biomass to Nanocellulose: Structure and Chemical Process. *The Scientific World Journal,* 2014.

Lee, K. C., Arai, T., Ibrahim, D., Deng, L., Murata, Y., Mori, Y., & Kosugi, A. (2016) Characterization of oil-palm trunk residue degradation enzymes derived from the isolated fungus, *Penicillium rolfsii* c3-2 (1) IBRL. *Environmental Technology,* 37(12), 1550-1558.

Leu, S.-Y., & Zhu, J. (2013) Substrate-related factors affecting enzymatic saccharification of lignocelluloses: our recent understanding. *Bioenergy Research,* 6(2), 405-415.

Li, H., Kim, M.-J., & Kim, S.-J. (2009) Cost-cutting of nitrogen source for economical production of cellulolytic enzymes by *Trichoderma inhamatum* KSJ1. *Korean journal of chemical engineering,* 26(4), 1070-1074.

Lieberman, M., Marks, A. D., Smith, C. M., & Marks, D. B. (2007) *Marks' Essential Medical Biochemistry*. Lippincott Williams & Wilkins.

Lim, S.-H., & Ibrahim, D. (2013) Bioconversion of oil palm frond by *Aspergillus niger* to enhances it's fermentable sugar production. *Pakistan Journal ofBiological Sciences,* 16(18), 920-926.

Liu, G., Zhang, J., & Bao, J. (2016) Cost evaluation of cellulase enzyme for industrial-scale cellulosic ethanol production based on rigorous Aspen Plus modeling. *Bioprocess and biosystems engineering,* 39(1), 133-140.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951) Protein measurement with the Folin phenol reagent. *The Journal of Biological Chemistry,* 193(1), 265-275.

Lupoi, J. S., Singh, S., Parthasarathi, R., Simmons, B. A., & Henry, R. J. (2015) Recent innovations in analytical methods for the qualitative and quantitative assessment of lignin. *Renewable and Sustainable Energy Reviews,* 49, 871-906.

Madan, M., & Thind, K. S. (1998) *Physiology of Fungi*: APH Publishing Corporation.

Makawi, S., Taha, M. I., Zakaria, B. A., Siddig, B., Mahmod, H., Elhussein, A. R. M., & Kariem, E. (2009) Identification and quantification of 5-hydroxymethyl furfural HMF in some sugar-containing food products by HPLC. *Pakistan Journal of Nutrition,* 8(9), 1391-1396.

Malaysia, A. I. (2011) National Biomass Strategy 2020: New wealth creation for Malaysia's palm oil industry. *Agensi Inovasi Malaysia.* Kuala Lumpur.

Manan, M. A. (2014) *Design aspects of solid state fermentation.* Ph.D. Thesis. University of Manchester, United Kingdom.

Manan, M. A., & Webb, C. (2016) Extracted substrate colour as an indicator of fungal growth in solid state fermentation. *Malaysian Journal of Microbiology,* 12(6), 445-449.

Mandels, M., & Weber, J. (1969) The production of cellulases. *Advances in chemistry series,* 95, 391-414.

Manpreet, S., Sawraj, S., Sachin, D., Pankaj, S., & Banerjee, U. (2005) Influence of process parameters on the production of metabolites in solid-state fermentation. *Malaysian Journal of Microbiology,* 2(1), 1-9.

Marcelino, J. P., & Diaz, E. V. (2016) Frond pruning enhanced the growth and yield of eight-year-old oil palm (Jacq.) *Elaeis guineensis. Annals of Tropical Research,* 38(2), 96-105.

Marx, I. J., Van Wyk, N., Smit, S., Jacobson, D., Viljoen-Bloom, M., & Volschenk, H. (2013) Comparative secretome analysis of *Trichoderma asperellum* S4F8 and *Trichoderma reesei* Rut C30 during solid-state fermentation on sugarcane bagasse. *Biotechnol Biofuels,* 6(1), 172.

Mes-Hartree, M., Hogan, C., & Saddler, J. (1987) Recycle of enzymes and substrate following enzymatic hydrolysis of steam-pretreated aspenwood. *Biotechnology and bioengineering,* 30(4), 558-564.

Miller, G. L. (1959) Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical chemistry,* 31(3), 426-428.

Minor, J. L., Scott, C. T., & Atalla, R. H. (1993) Restoring bonding strength to recycled fibers. *Recycling Symposium*.

Mitchell, D. A., Berovič, M., & Krieger, N. (2006) *Solid-state fermentation bioreactor fundamentals: Introduction and overview*. Springer.

Mitchell, D. A., von Meien, O. F., Krieger, N., & Dalsenter, F. D. H. (2004) A review of recent developments in modeling of microbial growth kinetics

and intraparticle phenomena in solid-state fermentation. *Biochemical Engineering Journal,* 17(1), 15-26.

Mohamed Roslan, M. (2014) *Hydrolytic Catalysis of fungal cellulase and xylanase for deinking of old newspaper (ONP).* M. Sc. Thesis. Universiti Teknologi Malaysia, Skudai.

Montero, M. A., & Romeu, A. (1992) Kinetic study on the β-glucosidase-catalysed reaction of *Trichoderma viride* cellulase. *Applied microbiology and biotechnology,* 38(3), 350-353.

Montoya, S., Sánchez, O., & Levin, L. (2015) Production of lignocellulolytic enzymes from three white-rot fungi by solid-state fermentation and mathematical modeling. *African Journal of Biotechnology,* 14(15), 1304-1317.

MPOB. (2017) *Overview of the Malaysian oil palm industry 2017* Retrieved from Malaysia.

Musa, H., Han, P. C., Kasim, F. H., Gopinath, S. C., & Ahmad, M. A. (2017) Turning oil palm empty fruit bunch waste into substrate for optimal lipase secretion on solid state fermentation by *Trichoderma* strains. *Process Biochemistry,* 63, 35-41.

Nandakumar, M., Thakur, M., Raghavarao, K., & Ghildyal, N. (1994) Mechanism of solid particle degradation by *Aspergillus niger* in solid state fermentation. *Process Biochemistry,* 29(7), 545-551.

Naseeb, S., Sohail, M., Ahmad, A., & Khan, S. A. (2015) Production of xylanases and cellulases by *Aspergillus fumigatus* MS16 using crude lignocellulosic substrates. *Pakistan Journal of Botany,* 47, 779-784.

Negi, S., Gupta, S., & Banerjee, R. (2011) Extraction and purification of glucoamylase and protease produced by *Aspergillus awamori* in a single-stage fermentation. *Food Technology and Biotechnology,* 49(3), 310-315.

Nielsen, P. H., Oxenbøll, K. M., & Wenzel, H. (2007) Cradle-to-gate environmental assessment of enzyme products produced industrially in Denmark by Novozymes A/S. *The International Journal of Life Cycle Assessment,* 12(6), 432.

Nigam, P. S. N., & Pandey, A. (2009) *Biotechnology for agro-industrial residues utilisation: utilisation of agro-residues*. Netherlands: Springer.

Noratiqah, K. (2017) *Lignocellulolytic enzymes by Aspergillus sp. a1 and Bacillus sp. b1 isolated from gut of Bulbitermes sp. in solid state fermentation using sawdust as substrate*. Ph. D. Thesis. Universiti Teknologi Malaysia, Skudai.

Nordin, N. A., Sulaiman, O., Hashim, R., & Kassim, M. H. M. (2016) Characterization of different parts of oil palm fronds (*Elaeis guineensis*) and its properties. *International Journal on Advanced Science, Engineering and Information Technology,* 6(1), 74-76.

Norouzian, D., Akbarzadeh, A., Scharer, J. M., & Young, M. M. (2006) Fungal glucoamylases. *Biotechnology advances,* 24(1), 80-85.

Ofori-Boateng, C., & Lee, K. T. (2013) Sustainable utilization of oil palm wastes for bioactive phytochemicals for the benefit of the oil palm and nutraceutical industries. *Phytochemistry reviews,* 12(1), 173-190.

Öhgren, K., Bura, R., Saddler, J., & Zacchi, G. (2007) Effect of hemicellulose and lignin removal on enzymatic hydrolysis of steam pretreated corn stover. *Bioresource technology,* 98(13), 2503-2510.

Olofsson, J., Barta, Z., Börjesson, P., & Wallberg, O. (2017) Integrating enzyme fermentation in lignocellulosic ethanol production: Life-cycle assessment and techno-economic analysis. *Biotechnology for biofuels,* 10(1), 51.

Ortiz, G. E., Noseda, D. G., Ponce Mora, M. C., Recupero, M. N., Blasco, M., & Albertó, E. (2016) A comparative study of new *Aspergillus* strains for proteolytic enzymes production by solid state fermentation. *Enzyme research.*

Palonen, H. (2004) *Role of lignin in the enzymatic hydrolysis of lignocellulose*: VTT Technical Research Centre of Finland.

Panda, H. (2016) *Handbook on Coal, Lignin, Wood and Rosin Processing*. Niir Project Consultancy Services.

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

Pandey, A., Fernandes, M., & Larroche, C. (2008) *Current developments in solid-state fermentation*. Springer Science & Business Media.

Pandey, A., Negi, S., & Soccol, C. R. (2016) *Current developments in biotechnology and bioengineering: production, isolation and purification of industrial products*. Elsevier Science.

Pandey, A., Selvakumar, P., Soccol, C. R., & Nigam, P. (1999) Solid state fermentation for the production of industrial enzymes. *Current science,* 77(1), 149-162.

Pandey, K. (1999) A study of chemical structure of soft and hardwood and wood polymers by FTIR spectroscopy. *Journal of Applied Polymer Science,* 71(12), 1969-1975.

Pasqualotto, A. C. (2010) *Aspergillosis: from diagnosis to prevention*. Netherlands: Springer.

Pathak, P., Bhardwaj, N. K., & Singh, A. K. (2011) Optimization of chemical and enzymatic deinking of photocopier waste paper. *BioResources,* 6(1), 447-463.

Patil, M. B., & Dhake, A. B. (2014) Deinking of news paper pulp by β-glucosidase of *Penicillium purpurogenum*. *International Journal of Engineering Research and Science & Technology,* 3(2), 276-279.

Pérez, S., & Mazeau, K. (2004) Conformations, structures, and morphologies of celluloses. *Polysaccharides: Structural diversity and functional versatility.* New York. CRC Press.

Pergola, M., Persiani, A., Palese, A. M., Di Meo, V., Pastore, V., D'Adamo, C., & Celano, G. (2018) Composting: The way for a sustainable agriculture. *Applied Soil Ecology,* 123, 744-750.

Pfost, H., & Headley, V. (1976) Methods of determining and expressing particle size. *Feed Manufacturing Technology*, 512-520.

Pirota, R. D., Baleeiro, F. C., & Farinas, C. S. (2013) Saccharification of biomass using whole solid-state fermentation medium to avoid additional separation steps. *Biotechnology progress,* 29(6), 1430-1440.

Postgate, J. (1969) Chapter XVIII Viable counts and viability. *Methods in microbiology*. Elsevier. pp 611-628.

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

Puneet, P., Bhardwaj Nishi, K., & Singh Ajay, K. (2010) Enzymatic deinking of office waste paper: An overview. *IPPTA,* 22(2), 83-88.

Qi, B., Chen, X., Su, Y., & Wan, Y. (2011) Enzyme adsorption and recycling during hydrolysis of wheat straw lignocellulose. *Bioresource technology,* 102(3), 2881-2889.

Qu, Y., Luo, H., Li, H., & Xu, J. (2015) Comparison on structural modification of industrial lignin by wet ball milling and ionic liquid pretreatment. *Biotechnology Reports, 6*, 1-7.

Rahikainen, J. (2013) *Cellulase-lignin interactions in the enzymatic hydrolysis of lignocellulose*. Ph. D. Thesis. University of Helsinki, Finland.

Rahnama, N., Shah, M., Kalsom, U., Foo, H. L., Rahman, A., Aini, N., & Ariff, A. (2016) Production and characterisation of cellulase from solid state fermentation of rice straw by *Trichoderma harzianum* SNRS3. *Pertanika Journal of Tropical Agricultural Science,* 39(4), 507-531.

Raimbault, M. (1998) General and microbiological aspects of solid substrate fermentation. *Electronic Journal of Biotechnology,* 1(3), 26-27.

Ramanathan, S. (2018) *Production of biobutanol from pretreated lemon grass leaves using Clostridium beijerinckii SR1.* Ph. D. Thesis. Universiti Teknologi Malaysia, Skudai.

Ramos, L. P. (2003) The chemistry involved in the steam treatment of lignocellulosic materials. *Química Nova,* 26(6), 863-871.

Rao, D. G. (2010) *Introduction to biochemical engineering*: Tata McGraw-Hill Education.

Rawat, S., & Johri, B. N. (2013) Role of thermophilic microflora in composting *Thermophilic microbes in environmental and industrial biotechnology*. Springer; 137-169.

Richana, N., Winarti, C., Hidayat, T., & Prastowo, B. (2015) Hydrolysis of empty fruit bunches of palm oil (*Elaeis Guineensis Jacq.*) by chemical, physical, and enzymatic methods for bioethanol production. *International Journal of Chemical Engineering and Applications,* 6(6), 422.

Robson, G. (2006) Programmed cell death in the *Aspergilli* and other filamentous fungi. *Medical Mycology,* 44, S109-S114.

Roopesh, K., Ramachandran, S., Nampoothiri, K. M., Szakacs, G., & Pandey, A. (2006) Comparison of phytase production on wheat bran and oilcakes in solid-state fermentation by *Mucor racemosus*. *Bioresource technology,* 97(3), 506-511.

Rosales, E., Pazos, M., & Ángeles Sanromán, M. (2013) Feasibility of solid-state fermentation using spent fungi-substrate in the biodegradation of PAHs. *CLEAN–Soil, Air, Water,* 41(6), 610-615.

Roslan, A. M., Zahari, M. A. K. M., Hassan, M. A., & Shirai, Y. (2014) Investigation of oil palm frond properties for use as biomaterials and biofuels. *Tropical Agriculture and Development,* 58(1), 26-29.

Sabu, A., Pandey, A., Daud, M. J., & Szakacs, G. (2005) Tamarind seed powder and palm kernel cake: two novel agro residues for the production of tannase under solid state fermentation by *Aspergillus niger* ATCC 16620. *Bioresource technology,* 96(11), 1223-1228.

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

Saini, J. K., Saini, R., & Tewari, L. (2015) Lignocellulosic agriculture wastes as biomass feedstocks for second-generation bioethanol production: concepts and recent developments. *3 Biotech,* 5(4), 337-353.

Saithi, S., Borg, J., Nopharatana, M., & Tongta, A. (2016) Mathematical modeling of biomass and enzyme production kinetics by *Aspergillus niger* in solid-state fermentation at various temperatures and moisture contents. *Journal of Microbial and Biochemical Technology*, 8, 123-130.

Saka, S., Munusamy, M. V., Varman, M., Shibata, M., Tono, Y., & Miyafuji, H. (2008) Chemical constituents of the different anatomical parts of the oil

palm (*Elaeis guineensis*) for their sustainable utilization. *Natural Resources and Energy Environment.*

Sakurai, Y., Lee, T. H., & Shiota, H. (1977) On the convenient method for glucosamine estimation in koji. *Agricultural and Biological Chemistry,* 41(4), 619-624.

Salakkam, A. (2012) *Bioconversion of biodiesel by-products to value-added chemicals.* Ph.D Thesis. University of Manchester, United Kingdom.

Salathong, J. (2007) The sustainable use of oil palm biomass in Malaysia with Thailand's comparative perspective.

Sales, M. R., de Moura, R. B., da Silva, M. F., de Macedo, G. R., & Porto, A. L. F. (2011) Cellulase and xylanase production by *Aspergillus* species. *Annals of microbiology,* 61(4), 917-924.

Sambusiti, C., Ficara, E., Malpei, F., Steyer, J., & Carrère, H. (2012) Influence of alkaline pre-treatment conditions on structural features and methane production from ensiled sorghum forage. *Chemical engineering journal,* 211, 488-492.

Sangwan, P., Mor, V., Dhankhar, R., & Sukhani, S. (2015) Optimization of process parameters for cellulase and xylanase production using rice husk. *International Journal of pharma and bio sciences,* 6, 755-762.

Sanz, L., Montero, M., Redondo, J., Llobell, A., & Monte, E. (2005) Expression of an α-1, 3-glucanase during mycoparasitic interaction of *Trichoderma asperellum*. *FEBS journal,* 272(2), 493-499.

Satyanarayana, T., & Johri, B. N. (2005) *Microbial diversity: current perspectives and potential applications*. I.K. International.

Saud, H., Sariah, M., Ismail, M., Habib, S., & Kausar, H. (2013) Potential lignocellulolytic *Trichoderma* for bioconversion of oil palm empty fruit bunches. *Australian journal of crop science*. 7(3), 425.

Schmid, R. D., Hammelehle, R., & Schmidt-Dannert, C. (2016) *Biotechnology: An Illustrated Primer*. Wiley.

Shafawati, S. N., & Siddiquee, S. (2013) Composting of oil palm fibres and Trichoderma spp. as the biological control agent: A review. *International Biodeterioration & Biodegradation,* 85, 243-253.

Sharma, S., Sharma, V., & Kuila, A. (2016) Cellulase production using natural medium and its application on enzymatic hydrolysis of thermo chemically pretreated biomass. *3 Biotech,* 6(2), 1-11.

Shi, J., Sharma-Shivappa, R. R., & Chinn, M. S. (2012) Interactions between fungal growth, substrate utilization and enzyme production during shallow stationary cultivation of *Phanerochaete chrysosporium* on cotton stalks. *Enzyme and microbial technology,* 51(1), 1-8.

Shibata, M., Munusamy, M. V., Varman, M., Tono, Y., Miyafuji, H., & Saka, S. (2008) Characterization in chemical composition of the oil palm (Elaeis guineensis). *Journal of the Japan Institute of Energy,* 87, 383-388.

Shinoj, S., Visvanathan, R., Panigrahi, S., & Kochubabu, M. (2011) Oil palm fiber (OPF) and its composites: A review. *Industrial Crops and Products,* 33(1), 7-22.

Shioiri, T., Izawa, K., & Konoike, T. (2010) *Pharmaceutical Process Chemistry*. Wiley.

Shivanna, G. B., & Venkateswaran, G. (2014) Phytase production by *Aspergillus niger* CFR 335 and *Aspergillus ficuum* SGA 01 through submerged and solid-state fermentation. *The Scientific World Journal,* 2014.

Sidana, A., & Farooq, U. (2014) Sugarcane bagasse: a potential medium for fungal cultures. *Chinese Journal of Biology,* 2014.

Simarani, K., Hassan, M., Abd-Aziz, S., Wakisaka, M., & Shirai, Y. (2009) Effect of palm oil mill sterilization process on the physicochemical characteristics and enzymatic hydrolysis of empty fruit bunch. *Asian Journal of Biotechnology,* 1(2), 57-66.

Simmons, B. A., Schüth, F., & Peter, L. (2011) *Chemical and Biochemical Catalysis for Next Generation Biofuels*. Royal Society of Chemistry.

Singh, L. K., & Chaudhary, G. (2016) *Advances in Biofeedstocks and Biofuels, Volume One: Biofeedstocks and Their Processing*. John Wiley & Sons.

Singh, O., & Singh, R. (2006) Bioconversion of grape must into modulated gluconic acid production by *Aspergillus niger* ORS-4· 410. *Journal of applied microbiology,* 100(5), 1114-1122.

Singh, P., Sulaiman, O., Hashim, R., Peng, L. C., & Singh, R. P. (2013) Using biomass residues from oil palm industry as a raw material for pulp and paper industry: potential benefits and threat to the environment. *Environment, development and sustainability,* 15(2), 367-383.

Singh, R., Kumar, M., Mittal, A., & Mehta, P. K. (2016) Microbial enzymes: industrial progress in 21st century. *3 Biotech,* 6(2), 174.

Singhania, R. R., Sukumaran, R. K., Patel, A. K., Larroche, C., & 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.

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999) Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent *Methods in enzymology*. Elsevier. pp 152-178.

Siqueira, G., Arantes, V., Saddler, J. N., Ferraz, A., & Milagres, A. M. (2017) Limitation of cellulose accessibility and unproductive binding of cellulases by pretreated sugarcane bagasse lignin. *Biotechnology for biofuels,* 10(1), 176.

Skone, T. J. (2000) What is life cycle interpretation? *Environmental progress,* 19(2), 92-100.

Soetaert, W., & Vandamme, E. J. (2010) *Industrial Biotechnology: Sustainable Growth and Economic Success*. John Wiley & Sons.

Soleimaninanadegani, M. (2015) Evaluation of partial characterization of cellulase production by *Aspergillus fumigatus* SK1 under untreated oil palm empty fruit bunch (OPEFB) in solid state fermentation. *Bulletin of Environmental and Scientific Research,* 4(1-2), 15-20.

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

Sørensen, A., Lübeck, M., Lübeck, P. S., & Ahring, B. K. (2013) Fungal beta-glucosidases: a bottleneck in industrial use of lignocellulosic materials. *Biomolecules,* 3(3), 612-631.

Spiridon, I., & Anrade, A. (2005) Enzymatic deinking of old newspaper (ONP). *Progress in Paper Recycling,* 14(3), 14-18.

Su, X., Schmitz, G., Zhang, M., Mackie, R. I., & Cann, I. (2011) Heterologous gene expression in filamentous fungi. *Advances in applied microbiology,* 81, 1-61.

Sukumaran, R. K., Singhania, R. R., Mathew, G. M., & Pandey, A. (2009) Cellulase production using biomass feed stock and its application in lignocellulose saccharification for bio-ethanol production. *Renewable Energy,* 34(2), 421-424.

Sulaiman, O., Salim, N., Nordin, N. A., Hashim, R., Ibrahim, M., & Sato, M. (2012) The potential of oil palm trunk biomass as an alternative source for compressed wood. *BioResources,* 7(2), 2688-2706.

Sun, R.-C. (2009) Detoxification and separation of lignocellulosic biomass prior to fermentation for bioethanol production by removal of lignin and hemicelluloses. *BioResources,* 4(2), 452-455.

Sun, S., Sun, S., Cao, X., & Sun, R. (2016) The role of pretreatment in improving the enzymatic hydrolysis of lignocellulosic materials. *Bioresource technology,* 199, 49-58.

Sung, C. T. B. (2016) Availability, use, and removal of oil palm biomass in Indonesia. *Report for the International Council on Clean Transportation, University Putra, Malaysia.*

Suradi, S., Yunus, R., Beg, M., & Yusof, Z. (2009) Influence pre-treatment on the properties of lignocellulose based biocomposite. *National Conference on Postgraduate Research.* pp 67-78.

Swift, M. (1973) Estimation of mycelial growth during decomposition of plant litter. *Bulletins of the Ecological Research Committee*, 323-328.

Tan, J. P., Jahim, J. M., Harun, S., & Wu, T. Y. (2017) Overview of the potential of bio-succinic acid production from oil palm fronds. *Journal of Physical Science,* 28, 53.

Tanobe, V. O., Sydenstricker, T. H., Munaro, M., & Amico, S. C. (2005) A comprehensive characterization of chemically treated Brazilian sponge-gourds (*Luffa cylindrica*). *Polymer Testing,* 24(4), 474-482.

Teeri, T. T. (1997) Crystalline cellulose degradation: new insight into the function of cellobiohydrolases. *Trends in Biotechnology,* 15(5), 160-167.

Tengerdy, R. (1996) Cellulase production by solid substrate fermentation. *Journal of scientific & industrial research,* 55(5-6), 313-316.

Thakur, I. S. (2010) *Industrial Biotechnology: Problems and Remedies.* I.K. International Publishing House Pvt. Limited.

Thanapimmetha, A., Vuttibunchon, K., Titapiwatanakun, B., & Srinophakun, P. (2012) Optimization of solid state fermentation for reducing sugar production from agricultural residues of sweet sorghum by *Trichoderma harzianum*. *Chiang Mai Journal of Science,* 39(2), 270-280.

Thao, N. N., & Huong, N. H. (1992) Solid-state fermentation of Manioc to increase protein content. *Applications of Biotechnology totraditional fermented foods*, 100-104.

Then, Y. Y., Ibrahim, N. A., Zainuddin, N., Ariffin, H., & Wan Yunus, W. M. Z. (2013) Oil palm mesocarp fiber as new lignocellulosic material for fabrication of polymer/fiber biocomposites. *International Journal of Polymer Science,* 2013.

Tien, M. (1988) Lignin peroxidase of *Phanerochaete chrysosporium*. *Methods in enzymology,* 161, 238-299.

Toldra, F., & Kim, S. K. (2016) *Marine Enzymes Biotechnology: Production and Industrial Applications, Part II - Marine Organisms Producing Enzymes.* Elsevier Science.

Tortora, G. J., Funke, B. R., & Case, C. L. (2006) *Microbiology: An Introduction.* Benjamin Cummings.

Tu, M., Zhang, X., Paice, M., MacFarlane, P., & Saddler, J. N. (2009) The potential of enzyme recycling during the hydrolysis of a mixed softwood feedstock. *Bioresource technology,* 100(24), 6407-6415.

Tuomela, M., Vikman, M., Hatakka, A., & Itävaara, M. (2000) Biodegradation of lignin in a compost environment: a review. *Bioresource technology, 72*(2), 169-183.

Uzir, M., & Mat Don, M. (2007) Biochemical engineering-A concise introduction. *Universiti Sains Malaysia, Penang.*

Valmaseda, M., Almendros, G., & Martinez, A. (1991) Chemical transformation of wheat straw constituents after solid-state fermentation with selected lignocellulose-degrading fungi. *Biomass and bioenergy,* 1(5), 261-266.

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

Vimalashanmugam, K., & Viruthagiri, T. (2014) Optimization of operating parameters and kinetics of xylanase enzyme production under SSF by *Aspergillus niger* using response surface methodology. *Optimization,* 6(7), 3558-3572.

Viniegra-González, G., Favela-Torres, E., Aguilar, C. N., de Jesus Rómero-Gomez, S., Dıaz-Godınez, G., & Augur, C. (2003) Advantages of fungal enzyme production in solid state over liquid fermentation systems. *Biochemical Engineering Journal,* 13(2-3), 157-167.

Wang, R., Shaarani, S. M., Godoy, L. C., Melikoglu, M., Vergara, C. S., Koutinas, A., & Webb, C. (2010) Bioconversion of rapeseed meal for the production of a generic microbial feedstock. *Enzyme and microbial technology,* 47(3), 77-83.

Wells, D. E., Sibley, J. L., Gilliam, C. H., & Dozier Jr, W. A. (2012) Use of composted and fresh spent tea grinds as a potential greenhouse substrate component. *Compost Science & Utilization,* 20(3), 181-184.

Wertz, J. L., & Bédué, O. (2013) *Lignocellulosic Biorefineries*. EFPL Press.

Wittmann, C., Liao, J. C., Lee, S. Y., Nielsen, J., & Stephanopoulos, G. (2016) *Industrial Biotechnology: Products and Processes*. John Wiley & Sons.

Wood, T. M., & Bhat, K. M. (1988) Methods for measuring cellulase activities. *Methods in enzymology*. Academic Press. pp 87-112.

Wyman, C., & Yang, B. (2009) Cellulosic biomass could help meet California's transportation fuel needs. *California Agriculture,* 63(4), 185-190.

Wyman, C. E. (2013) *Aqueous pretreatment of plant biomass for biological and chemical conversion to fuels and chemicals*: John Wiley & Sons.

Wyman, C. E., Decker, S. R., Himmel, M. E., Brady, J. W., Skopec, C. E., & Viikari, L. (2005) Hydrolysis of cellulose and hemicellulose. *Polysaccharides: Structural diversity and functional versatility,* 1, 1023-1062.

Xia, L., & Cen, P. (1999) Cellulase production by solid state fermentation on lignocellulosic waste from the xylose industry. *Process Biochemistry,* 34(9), 909-912.

Xiao, C., & Anderson, C. T. (2013) Roles of pectin in biomass yield and processing for biofuels. *Frontiers in plant science,* 4, 67.

Xu, F., Yu, J., Tesso, T., Dowell, F., & Wang, D. (2013) Qualitative and quantitative analysis of lignocellulosic biomass using infrared techniques: a mini-review. *Applied energy,* 104, 801-809.

Xu, Q., Fu, Y., Gao, Y., & Qin, M. (2009) Performance and efficiency of old newspaper deinking by combining cellulase/hemicellulase with laccase-violuric acid system. *Waste management,* 29(5), 1486-1490.

Yang, B., Dai, Z., Ding, S.-Y., & Wyman, C. E. (2011) Enzymatic hydrolysis of cellulosic biomass. *Biofuels,* 2(4), 421-449.

Yang, X., Wang, J., Zhao, X., Wang, Q., & Xue, R. (2011) Increasing manganese peroxidase production and biodecolorization of triphenylmethane dyes by novel fungal consortium. *Bioresource technology,* 102(22), 10535-10541.

Yasin, N. H. M., Fukuzaki, M., Maeda, T., Miyazaki, T., Maail, C. M. H. C., Ariffin, H., & Wood, T. K. (2013) Biohydrogen production from oil palm

frond juice and sewage sludge by a metabolically engineered *Escherichia coli* strain. *International journal of hydrogen energy,* 38(25), 10277-10283.

Ying, T. Y., Teong, L. K., Abdullah, W. N. W., & Peng, L. C. (2014) The effect of various pretreatment methods on oil palm empty fruit bunch (EFB) and kenaf core fibers for sugar production. *Procedia Environmental Sciences,* 20, 328-335.

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

Yu, S., Trione, E., & Ching, T. (1984) Biochemical determination of the viability of fungal spores and hyphae. *Mycologia*, 608-613.

Yuliansyah, A. T., & Hirajima, T. (2012) Efficacy of hydrothermal treatment for production of solid fuel from oil palm wastes. *Resource management for sustainable agriculture.* IntechOpen.

Yunos, N. S. H. M., Baharuddin, A. S., Yunos, K. F. M., Naim, M. N., & Nishida, H. (2012) Physicochemical property changes of oil palm mesocarp fibers treated with high-pressure steam. *BioResources,* 7(4), 5983-5994.

Yunus, R., Salleh, S. F., Abdullah, N., & Biak, D. R. A. (2010) Effect of ultrasonic pre-treatment on low temperature acid hydrolysis of oil palm empty fruit bunch. *Bioresource technology,* 101(24), 9792-9796.

Zahari, M. A. K. M., Zakaria, M. R., Ariffin, H., Mokhtar, M. N., Salihon, J., Shirai, Y., & 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.

Zakaria, M. R., Fujimoto, S., Hirata, S., & Hassan, M. A. (2014) Ball milling pretreatment of oil palm biomass for enhancing enzymatic hydrolysis. *Applied biochemistry and biotechnology,* 173(7), 1778-1789.

Zambare, V. (2010) Solid state fermentation of *Aspergillus oryzae* for glucoamylase production on agro residues. *International Journal of Life Sciences,* 4, 16-25.

Zanirun, Z., Abd-Aziz, S., Ling, F., & Hassan, M. (2009) Optimisation of lignin peroxidase production using locally isolated *Pycnoporus* sp. Through factorial design. *Biotechnology (Faisalabad),* 8, 296-305.

Zanirun, Z., Bahrin, E. K., Lai-Yee, P., Hassan, M. A., & Abd-Aziz, S. (2014) Effect of physical and chemical properties of oil palm empty fruit bunch, decanter cake and sago pith residue on cellulases production by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2. *Applied biochemistry and biotechnology,* 172(1), 423-435.

Zha, Y., Muilwijk, B., Coulier, L., & Punt, P. J. (2012) Inhibitory compounds in lignocellulosic biomass hydrolysates during hydrolysate fermentation processes. *Journal of Bioprocessing and Biotechniques,* 2(1), 112-122.

Zhang, Y., Liu, Z., Hui, L., & Wang, H. (2018) Diols as solvent media for liquefaction of corn stalk at ambient pressure. *BioResources,* 13(3), 6818-6836.

Zhao, X., Zhang, L., & Liu, D. (2012) Biomass recalcitrance. Part I: the chemical compositions and physical structures affecting the enzymatic hydrolysis of lignocellulose. *Biofuels, Bioproducts and Biorefining,* 6(4), 465-482.

Zhou, S., Raouche, S., Grisel, S., Navarro, D., Sigoillot, J. C., & Herpoël-Gimbert, I. (2015) Solid-state fermentation in multi-well plates to assess pretreatment efficiency of rot fungi on lignocellulose biomass. *Microbial biotechnology,* 8(6), 940-949.

Zhu, Y., Xin, F., Zhao, Y., & Chang, Y. (2014) An integrative process of bioconversion of oil palm empty fruit bunch fiber to ethanol with on-site cellulase production. *Bioprocess and biosystems engineering,* 37(11), 2317-2324.