UNIVERSITI PUTRA MALAYSIA

PRODUCTION OF LIPASE AND RECOVERY OF BY-PRODUCTS IN SOLID STATE FERMENTATION BY Aspergillus niger DSMZ 2466 USING PALM KERNEL CAKE AS SUBSTRATE

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By

ANUSHA NAIR

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

July 2014

DEDICATION

…. Many things in life will catch your eye…..

…. but few will catch your heart...

I dedicate this thesis

To my wonderful and ever-loving parents, sister and in-laws who has always been my shoulder of happiness

To my husband, Sugumar Munisamy and children, Yeshvint and Danshikaa who has always been the pillar of my success

To my supervisor, Prof Dr. Arbakariya B. Ariff for his kind patience and the constant generosity in providing knowledge

To my advisor and immediate manager, Dr Hirzun Mohd. Yusof for endless support and motivations

And to my beloved friends; Dr. Lim Chin Ming, Ho Li Sim, Jaime Low Yoke Sum and Kua Shwu Fun for their constant support and encouragement.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

PRODUCTION OF LIPASE AND RECOVERY OF BY-PRODUCTS IN SOLID STATE FERMENTATION BY *Aspergillus niger* DSMZ 2466 USING PALM KERNEL CAKE AS SUBSTRATE

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July 2014

Chairman: **Professor Arbakariya B. Ariff, PhD**

Faculty: **Biotechnology and Biomolecular Sciences**

Bacteria, yeast, and fungi are known potential producers of extracellular lipases. Fungal species are preferably cultivated in solid-state fermentation (SSF), while bacteria and yeast are usually cultivated in submerged fermentation (SLF). Lipase production in SLF systems has been well established. The use of SSF as a robust platform for upstream and downstream processing has yet to be reported. Thus, this research study focuses on the fungal growth morphology, fermentation and downstream processing of lipase as well as the analysis of other valuable products from the SSF system using palm kernel cake (PKC) as substrate.

Lipase production by several fungal strains (*Trichoderma viride* SDTC EDF 002, *Aspergillus niger* SDTC SRW-4, A*spergillus terreus* DSMZ 5770 and *Aspergillus niger* DSMZ 2466) using SSF and SLF systems in 500 mL flask were investigated. Lipase production in SSF was substantially higher compared to SLF except for *Trichoderma viride* SDTC EDF 002. The highest lipase activities and total protein content were obtained in SSF with *A. niger* SDTC SRW-4 (44.43 U g^{-1}; 176.36 mg g-^{1}) and *A. niger* DSMZ 2466 (42.05 U g^{-1}; 176.28 mg g^{-1}). The highest lipase activity (15.34 U mL^{-1}) in SLF was also obtained with *A. niger* DSMZ 2466. Relationship studies showed positive correlation between spore diameter (quadratic, R^2; 0.999) and branch diameter (linear, R^2; 0.971) with lipase activity for both of these *A. niger* strains.

Further enhancement of lipase production (305.09 U g^{-1}; 7.3-fold) in SSF from one the best performing fungal strain, *A. niger* DSMZ 2466 was achieved by supplementing PKC with glucose (0.1%, w/w), NH_4NO_3 (0.05%, w/w) and palm oil (2%, v/w). Improvisation on extraction method showed that cellulase treatment and grinding of the solid fermented material as additional steps was able to increase enzyme recovery by 193% and 185%, respectively. The crude extracellular lipases extracted from SSF was purified using 10 kDa MWCO PLC membrane, QFF anion exchanger and gel filtration (Sephacryl S-200 HR) with a yield of 22% and purification fold of 44. Lipase from *A. niger* DSMZ 2466 has a molecular weight of 45.4 kDa, highly active and stable under moderate alkaline conditions (pH 6.0 to 8.0) and at moderate temperatures (35°C to 45°C). Citric acid (5.020 g kg^{-1}), malic acid (2.370 g kg^{-1}) and oxalic acid (1.435 g kg^{-1}) were present in the buffer extract of the fermented substrate. The total amino acid and reducing sugars in the solid fermented material after lipase extraction process showed increment of 2-fold and 3-fold, respectively. The substantial increment in all essential amino acids (EAAs) content in the fermented SSF substrate suggests its suitability to be used as animal feed ingredient.

The proposed SSF platform for lipase production in this study; in which low-cost agricultural by-product is used as substrate with the ability to utilize the solid fermented substrate as animal feed ingredient, has potential for industrial application. This platform is able to reduce the lipase production cost and also eliminate environmental problems related to solid agriculture wastes disposal. The potential added value of the fermented substrate for application as animal feed is another advantage of the SSF system for enzyme production as compared to SLF.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PENGHASILAN LIPASE DAN PEMULIHAN PRODUK SAMPINGAN DALAM FERMENTASI FASA PEPEJAL OLEH *Aspergillus niger* DSMZ 2466 MENGGUNAKAN HAMPAS ISIRONG KELAPA SAWIT SEBAGAI SUBSTRAT

Oleh

ANUSHA NAIR

Julai 2014

Pengerusi: **Professor Arbakariya Ariff, PhD**

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Bakteria, yis dan kulat dikenali sebagai pengeluar berpotensi lipases ekstraselular. Spesies kulat biasanya dikultur dalam fermentasi substrat pepejal (FSP), manakala bakteria dan yis biasanya dikultur dalam keadah fermentasi substrat cecair (FSC). Pengeluaran enzim lipase dalam sistem FSC telah mantap. Penggunaan FSP sebagai platform yang mantap untuk proses huluan dan hiliran masih belum dilaporkan. Oleh itu, kajian penyelidikan ini memberi tumpuan kepada morfologi pertumbuhan kulat, fermentasi dan pemprosesan hiliran lipase serta analisis produk berharga daripada sistem FSP dengan menggunakan hampas isirong kelapa sawit sebagai substrat.

Pengeluaran lipase oleh beberapa jenis kulat (*Trichoderma viride* SDTC EDF 002, *Aspergillus niger* SDTC SRW-4, *Aspergillus terreus* DSMZ 5770 dan *Aspergillus niger* DSMZ 2466) menggunakan FSP dan FSC dalam kelalang 500 mL telah dikaji. Daripada semua jenis kulat yang telah diuji, pengeluaran lipase dalam FSP adalah jauh lebih tinggi berbanding dengan FSC kecuali *Trichoderma viride* SDTC EDF 002. Aktiviti lipase tertinggi dan kandungan protein jumlah diperolehi dalam FSP adalah strain *A. niger* SDTC SRW-4 (44.43 g U^{-1}; 176.36 mg g^{-1}) dan *A. niger* DSMZ 2466 (42.05 U g^{-1}; 176.28 mg g^{-1}). Aktiviti lipase (15.34 U mL^{-1}) yang tertinggi dalam FSC juga diperoleh dengan *A. niger* DSMZ 2466. Kajian menunjukkan hubungan korelasi positif antara diameter spora (kuadratik, R^2,0.999) dan diameter cabangan (linear, R^2;0.971) dengan aktiviti lipase bagi kedua-dua jenis *A. niger*.

Pengeluaran lipase (305.09 U g^{-1}; 7.3 kali ganda) oleh kulat paling berprestasi tinggi, *A. niger* DSMZ 2466 telah ditingkatkan dengan menambah PKC dengan glukosa (0.1 % w/w), NH_4NO_3 (0.05 % w/w) dan minyak sawit (2%, v/w). Pengubahsuaian ke atas kaedah pengekstrakan menunjukkan bahawa rawatan selulase dan pengisaran bahan pepejal selepas fermentasi sebagai langkah proses penambahan dapat meningkatkan pemulihan enzim masing-masing sebanyak 193% dan 185%. Kaedah pengekstrakan lipase yang diekstrak daripada FSP telah ditulenkan menggunakan membran 10 kDa PLC, kolum penukar anion dan penapisan gel (Sephacryl S-200 HR) menghasilkan 22% enzim dengan penulenan 44 kali ganda. Enzim lipase dari *A. niger* DSMZ 2466 mempunyai berat molekul sebanyak 45.4 kDa, sangat aktif dan stabil di bawah keadaan alkali yang sederhana (pH 6.0 hingga 8.0) dan pada suhu yang sederhana (35°C hingga 45°C). Penimbal substrat fermentasi juga dikesan mengandungi asid sitrik (5.020 g kg^{-1}), asid malik (2.370 g kg^{-1}) dan asid oksalik (1.435 g kg^{-1}). Jumlah asid amino dan gula terturun dalam bahan pepejal terfermentasi selepas proses pengekstrakan menunjukkan peningkatan masing-masing sebanyak 2 dan 3 kali ganda. Peningkatan yang besar dalam kandungan asid amino perlu dalam substrat FSP selepas fermentasi menunjukkan kesesuaiannya sebagai ramuan makanan haiwan.

Platform FSP yang dicadangkan dalam kajian ini bagi pengeluaran lipase, di mana bahan kos rendah digunakan sebagai substrat dan penghasilan substrat fermentasi pepejal sebagai ramuan makanan haiwan mempunyai potensi dalam bidang perindustrian. Platform ini juga mampu mengurangkan kos pengeluaran lipase dan juga memberi penyelesaian kepada masalah alam sekitar yang berkaitan dengan pelupusan sisa pertanian. Nilai potensi tambahan sistem FSP untuk pengeluaran enzim berbanding FSC adalah penggunaan substrat selepas fermentasi sebagai makanan haiwan.

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I certify that a Thesis Examination Committee has met on 9 July 2014 to conduct the final examination of Anusha Nair a/p Chandran on her thesis entitled "Production of Lipase and Recovery of By-products in Solid State Fermentation by *Aspergillus Niger* DSMZ 2466 using Palm Kernel Cake as Substrate" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

ATPS:	Aqueous Two-Phase System
AKTA:	High Performance Purification System
CE:	Capillary Electrophoresis
EAA:	Essential Amino Acid
EFB:	Empty Fruit Bunch
ELSD:	Evaporative Light Scattering Detector
GC:	Gas Chromatography
HMM:	Hidden Markov Model
HPLC:	High Performance Liquid Chromatography
IC:	Ionic Chromatography
NEAA:	Non-essential Amino Acid
RQ:	Research Question
SLF:	Submerged Liquid Fermentation
SSF:	Solid State Fermentation
PDA:	Potato Dextrose Agar
PKC:	Palm Kernel Cake
PKM:	Palm Kernel Meal
POME:	Palm Oil Mill Effluent
PPF:	Palm Press Fibre
SEM:	Scanning Electron Microscope
TCA:	Tricarboxylic acid
UV:	Ultraviolet

CHAPTER 1

INTRODUCTION

Enzymes have emerged as one of the most important product from biotechnology industry leading the current demand of green and sustainable technology. 75% of the industrial enzyme market are occupied by hydrolytic enzymes such as proteases, lipases and amylases (Sharma *et al*., 2001; Li and Zong, 2010). Lipases have numerous industrial applications from food technology to detergent and bioremediation which has urged researchers for the discovery of new processes in producing this enzyme at low cost.

Lipases are found in many species of animals, plants, and microorganisms. Lipases (triacylglycerol acylhydrolase, E.C. 3.1.1.3) are able to catalyze reaction on primary hydroxyl groups of triglyceride to release fatty acids from positions 1 and 3 to give free fatty acid and di- and, or monoglycerides. The benefits of lipases are high substrate specificity under mild conditions and in organic solvents. (Sharma *et al.*, 2001; Kempka *et al*., 2008).

Microbial lipases can be produced using submerged liquid fermentation (SLF) or solid state fermentation (SSF). Most enzymes or approximately 90% of all industrial biocatalysts produced currently are using SLF system with genetically modified microorganisms (Contesini *et al*., 2010) to obtain higher productivity which is of higher production cost. On the other hand with SSF system, agro-industrial residues were used as fermentation substrate due to their low cost, easy accessibility and high nutrient compositions (Mateos Diaz *et al.*, 2006; Azeredo *et al.*, 2007). However, SSF has some limitations in selection of microbes that are able to grow in low moisture conditions, and problems in controlling temperature, pH, humidity and air flow in the solid matrix (Contestini *et al*., 2010). These parameters has to be optimized to obtain an effective and efficient process.

Carbon and nitrogen sources in the growth medium are among important factors to increase lipase production besides cultivation conditions of pH and temperature (Cihangir and Sarikaya, 2004). Carbon source is able to increase growth rate at early phases. Product formation that are growth-associated or partially growth-associated processes will benefit from these supplements because the production of primary metabolites are associated with good microbial growth (Pau and Omar, 2004). Therefore, the medium formulation that is required for optimal microbial growth for specific strains and the products will have to be determined.

The importance of good microbial growth leads to early fungal spore germination and the cell extension to a form hyphae which colonizes the substrate material. This growing hyphae tips able to secrete various enzymes (Wösten *et al*., 1991) which then degrades large molecules in the substrate into smaller forms to be taken up by the fungi as nutrients. These fungal characteristics such as spore development, hyphae and branching patterns are able to be investigated and may influence product yield (Wösten *et al*., 1991; Moukha *et al*., 1993). However, accurate quantification of these complex morphologies is still a challenge in elucidating morphology and product formation relationship in SSF.

Several agricultural wastes that was experimented in SSF for lipase production includes rice bran (Venkata Rao *et al*., 1993), olive cake and sugar cane bagasse (Cordova *et al*., 1998), gingelly oil cake (Kamini *et al*., 1998), babassu oil cake (Gombert *et al*., 1999), wheat bran (Mahadik *et al*., 2002), and Jatropha curcas seed cake (Mahanta *et al*., 2008). In our study, the use of agricultural residue as fermentation substrate for SSF was focused on using palm kernel cake (PKC) which is a by-product from the extraction of palm kernels and produced in abundance. In accordance to Malaysian Palm Oil Board report, production of PKC in Malaysia was 2.2 million tons in 2007 and estimated to be 5 million tons worldwide. PKC contains 50% carbohydrate and 15-20% protein (Knudsen, 1997), and categorized as a medium quality animal feed due to the low nutrition content (O'Mara *et al.*, 1999; Ramachandran *et al.*, 2007).

Several reports has been published utilizing PKC as the SSF fermentation substrate such as for production of alpha-amylase (Ramachandran *et al*., 2004), xylanase (Kheng and Omar, 2005) , phytase (Roopesh *et al.*, 2006) and beta-mannanase (Abdeshahian *et al*., 2010; Ab *et al*., 2011). No studies has been conducted for production of lipases utilizing PKC in SSF system. Most of the reports focused on investigating the ability of the specific fungus to grow on PKC and optimizing the production of enzymes by nutrient supplementations.

SSF was also successful in the production of other secondary products such as organic acids, pesticides, and aromatic compounds (Virupakshi *et al*., 2005; Botella *et al*., 2007; Li *et al*., 2011). The main reason that the microbial fermentation process is able to produce high yields of organic acids is due to the synthesis of tricarboxylic acid (TCA) pathway (Kapritchkoff *et al.*, 2006). Apart from the microorganism used, formations of these products were enhanced by the usage of agro-industrial residues (Koutinas *et al*., 2007) that are rich in the nutrient composition and suitable to be used as fermentation substrate. More recently, due to the high abundance of this substrate, significant attention has been drawn to increase the nutritional value of PKC as animal feed using fermentation processes or supplementation of enzymes. This technique is employed to increase the amino acid composition in the solid media (Iluyemi *et al*., 2006) and digestibility of the solid material.

The high suitability of PKC to be used as fermentation substrate in SSF and lower capital investment in SSF processes compared to SLF (Castilho *et al*., 2000) suggest the need to investigate and develop an efficient SSF system for lipase production using PKC as the fermentation substrate. The use of a competitive platform such as SSF that uses low cost material as the main fermentation substrate may able to bring higher returns in enzymes production.

The specific objectives of this study were:

i. To compare the ability of various fungal strains (*A. niger* DSMZ 2466, *A. niger* SRW-4, *T. viride* EDF 002 and *A. terreus* DSMZ 5770) in producing lipase using SLF and SSF process utilizing palm kernel cake (PKC) as fermentation substrate
ii. To analyze the relationship between morphological characteristics of the fungi and their ability in producing lipase in SSF
iii. To formulate media based on palm kernel cake (PKC) as substrate with the supplements of nutrients for improvement of lipase production in SSF by the selected fungal producing strain, *A. niger* DSMZ 2466
iv. To propose efficient lipase extraction methods from solid fermented material of SSF
v. To analyze organic acids from liquid extracted from SSF grown with *A. niger* DSMZ 2466 using PKC as substrate
vi. To identify the suitability of using the solid fermented material of PKC as animal feed by profiling the sugars and amino acids content

REFERENCES

Ab, S., Darah, I., & Omar, I. (2011). Utilization of palm kernel cake for the production of mannanase by an indigenous filamentous fungus, *Aspergillus niger* USM F4 under solid substrate fermentation. *The Internet Journal of Microbiology, 9*(1), 1-19.

Abdeshahian, P., Samat, N., Hamid, A. A., & Yusoff, W. M. W. (2010). Utilization of palm kernel cake for production of β-mannanase by *Aspergillus niger* FTCC 5003 in solid substrate fermentation using an aerated column bioreactor. *Journal of Industrial Microbiology and Biotechnology, 37*(1), 103-109.

Abdul Khalil, H. P. S., Firdaus, M. Y. N., Jawaid, M., Anis, M., Ridzuan, R., & Mohamed, A. R. (2010). Development and material properties of new hybrid medium density fibreboard from empty fruit bunch and rubberwood. *Materials & Design, 31*(9), 4229-4236.

Ahmadi, A. R., Ghoorchian, H., Hajihosaini R., & Khanifar, J. (2010). Determination of the amount of protein and amino acids extracted from the microbial protein (SCP) of lignocellulosic wastes. *Pakistan Journal of Biological Sciences*, *13*(8), 355-361.

Akbar, E., Yaakob, Z., Kamarudin, S. K., Ismail, M., & Salimon, J. (2009). Characteristic and composition of *Jatropha curcas* oil seed from Malaysia and its potential as biodiesel feedstock feedstock. *European Journal of Scientific Research, 29*(3), 396-403.

Alimon, A. (2004). The nutritive value of palm kernel cake for animal feed. *Palm Oil Developments, 40*(1), 12-14.

Alkan, H., Baysal, Z., Uyar, F., & Dogru, M. (2007). Production of lipase by a newly isolated *Bacillus coagulans* under solid-state fermentation using melon wastes. *Applied Biochemistry and Biotechnology, 136*(2), 183-192.

Aminuddin, H., Khan, A. M., Abidin, H., Madzlan, K. & Suri, R. (2007). Effect of different rates of agitation on mycelium growth and amino acid composition of *Lentinula edodes* in submerged cultures. *Journal of Tropical Agriculture and Food Science, 35*(1), 139–146.

Anthony, T., Chandra Raj, K., Rajendran, A., & Gunasekaran, P. (2003). High molecular weight cellulase-free xylanase from alkali-tolerant *Aspergillus fumigatus* AR1. *Enzyme and Microbial Technology, 32*(6), 647-654.

AOAC Official Method 973.18. Fiber (acid detergent) and lignin in animal feed. Official Methods of Analysis of AOAC International. 16th edition. AOAC International, USA; 1995 (pp. 28–29).

Aravindan, R., Anbumathi, P., & Viruthagiri, T. (2007). Lipase applications in food industry. *Indian Journal of Biotechnology, 6*(2), 141.

Archana, A., & Satyanarayana, T. (1997). Xylanase production by thermophilic *Bacillus licheniformis* A99 in solid-state fermentation. *Enzyme and Microbial Technology, 21*(1), 12-17.

Azeredo, L. I., Gomes, P., Sant'Anna, G., Jr., Castilho, L., & Freire, D. G. (2007). Production and regulation of lipase activity from *Penicillium restrictum* in submerged and solid-state fermentations. *Current Microbiology, 54*(5), 361-365.

Babu, K., & Satyanarayana, T. (1995). α-Amylase production by thermophilic *Bacillus coagulans* in solid state fermentation. *Process Biochemistry, 30*(4), 305-309.

Balan, V., Rogers, C. A., Chundawat, S. P. S., Sousa, L. C. & Slininger, P. J. (2009). Conversion of extracted oil cake fibers into bioethanol including DDGS, canola, sunflower, sesame, soy, and peanut for integrated biodiesel processing. *Journal of the American Oil Chemist' Society*, *86*, 157–165.

Barry, D., Chan, C., & Williams, G. (2009). Morphological quantification of filamentous fungal development using membrane immobilization and automatic image analysis. *Journal of Industrial Microbiology & Biotechnology, 36*(6), 787-800.

Basheer, S. M., Chellappan, S., Beena, P., Sukumaran, R. K., Elyas, K., & Chandrasekaran, M. (2011). Lipase from marine *Aspergillus awamori* BTMFW032: Production, partial purification and application in oil effluent treatment. *New biotechnology, 28*(6), 627-638.

Beare-Rogers, J., Dieffenbacher, A., & Holm, J. (2001). Lexicon of lipid nutrition (IUPAC Technical Report). *Pure and Applied Chemistry, 73*(4), 685-744.

Benjamin, S., & Pandey, A. (2001). Isolation and characterization of three distinct forms of lipases from *Candida rugosa* produced in solid state fermentation. *Brazilian Archives of Biology and Technology, 44*(2), 213-221.

Bhavsar, K., Ravi Kumar, V., & Khire, J. (2012). Downstream processing of extracellular phytase from *Aspergillus niger*: Chromatography process vs. aqueous two phase extraction for its simultaneous partitioning and purification. *Process Biochemistry, 47*(7), 1066-1072.

Boonmee, A. (2012). Hydrolysis of various Thai agricultural biomasses using the crude enzyme from *Aspergillus aculeatus* Iizuka FR60 isolated from soil. *Brazilian Journal of Microbiology, 43(2),* 456-466.

Bornscheuer, U. T., Bessler, C., Srinivas, R., & Hari Krishna, S. (2002). Optimizing lipases and related enzymes for efficient application. *Trends in Biotechnology, 20*(10), 433-437.

Bose, A., & Keharia, H. (2013). Production, characterization and applications of organic solvent tolerant lipase by *Pseudomonas aeruginosa* AAU2. *Biocatalysis and Agricultural Biotechnology, 2*(3), 255-266.

Boswell, G. P. (2008). Modelling mycelial networks in structured environments. *Mycological Research, 112*(9), 1015-1025.

Botella, C., Diaz, A., De Ory, I., Webb, C., & Blandino, A. (2007). Xylanase and pectinase production by *Aspergillus awamori* on grape pomace in solid state fermentation. *Process Biochemistry, 42*(1), 98-101.

Brumlik, M. J., & Buckley, J. T. (1996). Identification of the catalytic triad of the lipase/acyltransferase from *Aeromonas hydrophila*. *Journal of Bacteriology, 178*(7), 2060-2064.

Brzozowski, A., Derewenda, U., Derewenda, Z., Dodson, G., Lawson, D., Turkenburg, J., & Thim, L. (1991). A model for interfacial activation in lipases from the structure of a fungal lipase-inhibitor complex. *Nature, 351*(6326), 491-494.

Burkert, J., Maugeri, F., & Rodrigues, M. (2004). Optimization of extracellular lipase production by *Geotrichum* sp. using factorial design. *Bioresource Technology, 91*(1), 77-84.

Cao, Y., & Tan, H. (2002). Effects of cellulase on the modification of cellulose. *Carbohydrate Research, 337*(14), 1291-1296.

Carlsen, M., Spohr, A. B., Nielsen, J., & Villadsen, J. (1996). Morphology and physiology of an α-amylase producing strain of *Aspergillus oryzae* during batch cultivations. *Biotechnology and Bioengineering, 49*(3), 266-276.

Carvalho, P. D. O., Contesini, F. J., Bizaco, R., Calafatti, S. A., & Macedo, G. A. (2006). Optimization of enantioselective resolution of racemic ibuprofen by native lipase from *Aspergillus niger*. *Journal of Industrial Microbiology & Biotechnology, 33*(8), 713-718.

Castilho, L. R., Alves, T. L., & Medronho, R. A. (1999). Recovery of pectolytic enzymes produced by solid state culture of *Aspergillus niger*. *Process Biochemistry, 34*(2), 181-186.

Castilho, L. R., Polato, C. M. S., Baruque, E. A., Sant'Anna Jr, G. L., & Freire, D. M. G. (2000). Economic analysis of lipase production by *Penicillium* *restrictum* in solid-state and submerged fermentations. *Biochemical Engineering Journal, 4*(3), 239-247.

Chen, C. P., Kernytsky, A. & Rost, B. (2002). Transmembrane helix predictions revisited. *Protein Science, 11*, 2774–2791.

Chimata, M. K., Sasidhar, P., & Challa, S. (2010). Production of extracellular amylase from agricultural residues by a newly isolated *Aspergillus* species in solid state fermentation. *African Journal of Biotechnology, 9*(32), 5162-5169.

Chin, F. (2001). Palm kernel cake (PKC) as a supplement for fattening and dairy cattle in Malaysia. *7th Meet. of FAO Regional Working Group on Grazing and Feed Resources for SE Asia, Manado, Indonesia*.

Choct, M. (2006). Enzymes for the feed industry: past, present and future. *World's Poultry Science Journal, 62*(1), 5-16.

Chong, C., Zulkifli, I., & Blair, R. (2008). Effects of dietary inclusion of palm kernel cake and palm oil, and enzyme supplementation on performance of laying hens. *Asian-australas. Journal of Animal Sciences, 21*(7), 1053-1058.

Cihangir, N., & Sarikaya, E. (2004). Investigation of lipase production by a new isolate of *Aspergillus* sp. *World Journal of Microbiology and Biotechnology, 20*(2), 193-197.

Cohen, J. (1988). Statistical power analysis for the behavioral sciencies. New Jersey: Lawrence Erlbaum Associates Publishers.

Cohen, S. A., & De Antonis, K. M. (1994). Applications of amino acid derivatization with 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate. Analysis of feed grains, intravenous solutions and glycoproteins. *Journal of Chromatography A, 661*(1-2), 25–34.

Cold Spring Harbor Laboratory. (2013, July 24). Full genome map of oil palm indicates way to raise yields and protect rainforest: Single gene identified whose regulation controls oil palm yield. *ScienceDaily*. Retrieved February 10, 2015 from www.sciencedaily.com/releases/2013/07/130724134258.htm

Contesini, F. J., Lopes, D. B., Macedo, G. A., Nascimento, M. d. G., & Carvalho, P. d. O. (2010). *Aspergillus* sp. lipase: Potential biocatalyst for industrial use. *Journal of Molecular Catalysis B: Enzymatic, 67*(3), 163-171.

Coradin, J. H., Braun, A., Viccini, G., Krieger, N., & Mitchell, D. A. (2011). A three-dimensional discrete lattice-based system for modeling the growth of aerial hyphae of filamentous fungi on solid surfaces: A tool for investigating micro-scale phenomena in solid-state fermentation. *Biochemical Engineering Journal, 54*(3), 164-171.

Cordova, J., Nemmaoui, M., Ismaıli-Alaoui, M., Morin, A., Roussos, S., Raimbault, M., & Benjilali, B. (1998). Lipase production by solid state fermentation of olive cake and sugar cane bagasse. *Journal of Molecular Catalysis B: Enzymatic, 5*(1), 75-78.

Cotter, D. A., Miura-Santo, L. Y., & Hohl H. R. (1969). Ultrastructural changes during germination of *Dictyostelium discoideum* spores. *Journal of Bacteriology, 100*, 1020-1026.

Cox, P., & Thomas, C. (2004). Classification and measurement of fungal pellets by automated image analysis. *Biotechnology and Bioengineering, 39*(9), 945-952.

Cui, Y., Van der Lans, R., & Luyben, K. (1997). Effect of agitation intensities on fungal morphology of submerged fermentation. *Biotechnology and Bioengineering, 55*(5), 715-726.

Cygler, M., Schrag, J. D., & Ergan, F. (1992). Advances in structural understanding of lipases. *Biotechnology Genetics Engineering Review, 10*, 143-184.

Dairo, F., & Fasuyi, A. (2008). Evaluation of fermented palm kernel meal and fermented copra meal proteins as substitute for soybean meal protein in laying hens diets. *Journal of Central European Agriculture, 9*(1), 35-44.

De Almeida Siqueira, E., Mizuta, K., & Giglio, J. (1997). *Pycnoporus sanguineus*: a novel source of α-amylase. *Mycological Research, 101*(2), 188-190.

De Nicolás-Santiago, S., Regalado-González, C., García-Almendárez, B., Fernández, F. J., Téllez-Jurado, A., & Huerta-Ochoa, S. (2006). Physiological, morphological, and mannanase production studies on *Aspergillus niger* uam-gs1 mutants. *Electronic Journal of Biotechnology, 9*(1), 50-60.

De Souza, D. F., & Peralta, P. (2001). Production of amylase by *Aspergillus tamari* in solid state fermentation at high initial glucose concentrations. *Acta Scientiarum, 23*(2), 599-602.

Dhillon, G. S., Oberoi, H. S., Kaur, S., Bansal, S., & 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.

Di Luccio, M., Capra, F., Ribeiro, N. P., Vargas, G. D., Freire, D. M., & de Oliveira, D. (2004). *Effect of temperature, moisture, and carbon supplementation on lipase production by solid-state fermentation of soy cake by Penicillium simplicissimum.* Paper presented at the Proceedings of the Twenty-Fifth Symposium on Biotechnology for Fuels and Chemicals, Breckenridge, CO.

Díaz-Malváez, F., García-Almendárez, B., Hernández-Arana, A., Amaro-Reyes, A., & Regalado-González, C. (2013). Isolation and properties of β-xylosidase from *Aspergillus niger* GS1 using corn pericarp upon solid state fermentation. *Process Biochemistry, 48*(7), 1018-1024.

Durand, A. (2003). Bioreactor designs for solid state fermentation. *Biochemical Engineering Journal, 13*(2), 113-125.

Durand, A., Renaud, R., Almanza, S., Maratray, J., Diez, M., & Desgranges, C. (1993). Solid state fermentation reactors: from lab scale to pilot plant. *Biotechnology Advances, 11*(3), 591-597.

Dutra, J. V., C. Terzi, S., Bevilaqua, J., Damaso, M. T., Couri, S., Langone, M. P., & Senna, L. (2008). Lipase production in solid-state fermentation monitoring biomass growth of *Aspergillus niger* using digital image processing. *Applied Biochemistry and Biotechnology, 147*(1-3), 63-75.

Edem, D. (2002). Palm oil: Biochemical, physiological, nutritional, hematological and toxicological aspects: A review. *Plant Foods for Human Nutrition (Formerly Qualitas Plantarum), 57*(3), 319-341.

El-Sabbagh, N., McNeil, B., & Harvey, L. M. (2006). Dissolved carbon dioxide effects on growth, nutrient consumption, penicillin synthesis and morphology in batch cultures of *Penicillium chrysogenum*. *Enzyme and Microbial Technology, 39*(2), 185-190.

Ertuğrul, S., Dönmez, G., & Takaç, S. (2007). Isolation of lipase producing *Bacillus* sp. from olive mill wastewater and improving its enzyme activity. *Journal of Hazardous Materials, 149*(3), 720-724.

Fang, T. J., Liao, B.C., & Lee, S.C. (2010). Enhanced production of xylanase by *Aspergillus carneus* M34 in solid-state fermentation with agricultural waste using statistical approach. *New biotechnology, 27*(1), 25-32.

FAO. (2012). Food and Agriculture Organization of the United Nations. http://faostat.fao.org/default.aspx.

Farinas, C. S., Vitcosque, G. L., Fonseca, R. F., Neto, V. B., & Couri, S. (2011). Modeling the effects of solid state fermentation operating conditions on endoglucanase production using an instrumented bioreactor. *Industrial Crops and Products, 34*(1), 1186-1192.

Ferrato, F., Carriere, F., Sarda, L., & Verger, R. (1997). A critical reevaluation of the phenomenon of interfacial activation. *Methods in Enzymology, 286*, 327-347.

Fiechter, G., Sivec, G. & Mayer, H.K. (2013). Application of UHPLC for simultaneous analysis of free amino acids and biogenic amines in ripened acid-curd cheeses. *Journal of Chromatography B*, *927*, 191-200.

Fodor, K., Harmat, V., Neutze, R., Szilágyi, L., Gráf, L., & Katona, G. (2006). Enzyme: substrate hydrogen bond shortening during the acylation phase of serine protease catalysis. *Biochemistry, 45*(7), 2114-2121.

Fojan, P., Jonson, P. H., Petersen, M. T., & Petersen, S. B. (2000). What distinguishes an esterase from a lipase: a novel structural approach. *Biochimie, 82*(11), 1033-1041.

Fujii, R., Utsunomiya, Y., Hiratake, J., Sogabe, A., & Sakata, K. (2003). Highly sensitive active-site titration of lipase in microscale culture media using fluorescent organophosphorus ester. *Biochimica et Biophysica Acta (BBA)-Molecular and Cell Biology of Lipids, 1631*(2), 197-205.

Gallant, S. R., Vunnum, S., & Cramer, S. M. (1996). Optimization of preparative ion-exchange chromatography of proteins: linear gradient separations. *Journal of Chromatography A, 725*(2), 295-314.

Gawande, P. V. & Kamat, M. Y. (1999). Production of *Aspergillus* xylanase by lignocellulosic waste fermentation and its application. *Journal of Applied Microbiology*, *87*, 511–519.

Gessesse, A., & Mamo, G. (1999). High-level xylanase production by an alkaliphilic *Bacillus* sp. by using solid-state fermentation. *Enzyme and Microbial Technology, 25*(1), 68-72.

Gibbs, P., Seviour, R., & Schmid, F. (2000). Growth of filamentous fungi in submerged culture: problems and possible solutions. *Critical Reviews in Biotechnology, 20*(1), 17-48.

Glogauer, A., Martini, V. P., Faoro, H., Couto, G. H., Müller-Santos, M., Monteiro, R., & Krieger, N. (2011). Identification and characterization of a new true lipase isolated through metagenomic approach. *Microbial Cell Factories, 10*(1), 1-15.

Goldberg, I., Rokem, J. S., & Pines, O. (2006). Organic acids: old metabolites, new themes. *Journal of Chemical Technology and Biotechnology, 81*(10), 1601-1611.

Gombert, A. K., Pinto, A. L., Castilho, L. R., & Freire, D. M. G. (1999). Lipase production by *Penicillium restrictum* in solid-state fermentation using babassu oil cake as substrate. *Process Biochemistry, 35*(1), 85-90.

Grimm, L., Kelly, S., Krull, R., & Hempel, D. (2005). Morphology and productivity of filamentous fungi. *Applied Microbiology and Biotechnology, 69*(4), 375-384.

Gupta, R., Gupta, N., & Rathi, P. (2004). Bacterial lipases: an overview of production, purification and biochemical properties. *Applied Microbiology and Biotechnology, 64*(6), 763-781.

Gupta, S., Kapoor, M., Sharma, K. K., Nair, L. M., & Kuhad, R. C. (2008). Production and recovery of an alkaline exo-polygalacturonase from *Bacillus subtilis* RCK under solid-state fermentation using statistical approach. *Bioresource Technology, 99*(5), 937-945.

Gutarra, M. E., Cavalcanti, E. C., Castilho, L., Freire, D. G., & Sant'Anna, G., Jr. (2005). Lipase Production by Solid-State Fermentation. In B. Davison, B. Evans, M. Finkelstein & J. McMillan (Eds.), *Twenty-Sixth Symposium on Biotechnology for Fuels and Chemicals* (pp. 105-116): Humana Press.

Haack, M. B., Olsson, L., Hansen, K., & Eliasson Lantz, A. (2006). Change in hyphal morphology of *Aspergillus oryzae* during fed-batch cultivation. *Applied Microbiology and Biotechnology, 70*(4), 482-487.

Hasan, F., Shah, A. A., & Hameed, A. (2009). Methods for detection and characterization of lipases: A comprehensive review. *Biotechnology Advances, 27*(6), 782-798.

Hashim, A. (2012). Determination of optimal conditions for laccase production by *Pleurotus ostreatus* using sawdust as solid medium and its use in phenol degradation. *Journal of Baghdad for Science, 9*(3), 491-499.

Hendrickson, H. S. (1994). Fluorescence-based assays of lipases, phospholipases, and other lipolytic enzymes. *Analytical Biochemistry, 219*(1), 1-8.

Heng, G., & Shiyi, L. (1996). The kinetics of lysine batch fermentation. *Chinese Journal of Biotechnology, 12*, 219-225.

Himmel, M. E., Ruth, M. F., & Wyman, C. E. (1999). Cellulase for commodity products from cellulosic biomass. *Current Opinion in Biotechnology, 10*(4), 358-364.

Hiol, A., Jonzo, M. D., Druet, D., & Comeau, L. (1999). Production, purification and characterization of an extracellular lipase from *Mucor hiemalis f. hiemalis*. *Enzyme and Microbial Technology, 25*(1), 80-87.

Houde, A., Kademi, A., & Leblanc, D. (2004). Lipases and their industrial applications: an overview. *Applied Biochemistry and Biotechnology, 118*(1-3), 155 -170.

Hwang, H., Kim, S., Xu, C., Choi, J., & Yun, J. (2004). Morphological and rheological properties of the three different species of basidiomycetes *Phellinus* in submerged cultures. *Journal of Applied Microbiology, 96*(6), 1296-1305.

Ibrahim-Granet, O., & Bertrand, O. (1996). Separation of proteases: old and new approaches. *Journal of Chromatography B: Biomedical Sciences and Applications, 684*(1), 239-263.

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

Iluyemi, F., Hanafi, M., Radziah, O., & Kamarudin, M. (2006). Fungal solid state culture of palm kernel cake. *Bioresource Technology, 97*(3), 477-482.

Imandi, S. B., Karanam, S. K., & Garapati, H. R. (2010). Optimization of process parameters for the production of lipase in solid state fermentation by *Yarrowia lipolytica* from Niger seed oil cake (Guizotia Abyssinica). *Journal of Microbial and Biochemical Technology, 2*, 28-33.

Iyayi, E. A., & Davies, B. I. (2005). Effect of enzyme supplementation of palm kernel meal and brewer's dried grain on the performance of broilers. *International Journal of Poultry Science, 4*(2), 76-80.

Jaeger, K., Dijkstra, B., & Reetz, M. (1999). Bacterial biocatalysts: molecular biology, three-dimensional structures, and biotechnological applications of lipases. *Annual Reviews in Microbiology, 53*(1), 315-351.

Jette, J.-F., & Ziomek, E. (1994). Determination of lipase activity by a rhodamine-triglyceride-agarose assay. *Analytical Biochemistry, 219*(2), 256-260.

John, R. P., Nampoothiri, K. M., & Pandey, A. (2006). Solid-state fermentation for l-lactic acid production from agro wastes using *Lactobacillus delbrueckii*. *Process Biochemistry, 41*(4), 759-763.

Jones, C. L., & Lonergan, G. T. (1997). Prediction of phenol-oxidase expression in a fungus using the fractal dimension. *Biotechnology Letters, 19*(1), 65-69.

Joshi, C., & Khare, S. (2012). Purification and characterization of *Pseudomonas aeruginosa* lipase produced by SSF of deoiled Jatropha seed cake. *Biocatalysis and Agricultural Biotechnology, 2*(1), 32-37.

Kamini, N. R., Mala, J. G. S., & Puvanakrishnan, R. (1998). Lipase production from *Aspergillus niger* by solid-state fermentation using gingelly oil cake. *Process Biochemistry, 33*(5), 505-511.

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

Kapritchkoff, F. M., Viotti, A. P., Alli, R. C., Zuccolo, M., Pradella, J. G., Maiorano, A. E., & Bonomi, A. (2006). Enzymatic recovery and purification of polyhydroxybutyrate produced by *Ralstonia eutropha*. *Journal of Biotechnology, 122*(4), 453-462.

Karaffa, L., & Kubicek, C. P. (2003). *Aspergillus niger* citric acid accumulation: do we understand this well working black box? *Applied Microbiology and Biotechnology, 61*(3), 189-196.

Kashmiri, M. A., Adnan, A., & Butt, B. W. (2006). Production, purification and partial characterization of lipase from *Trichoderma viride*. *African Journal of Biotechnology, 5*(10), 878-882.

Kelly, S. T., & Zydney, A. L. (2000). Protein fouling during microfiltration: comparative behavior of different model proteins. *Biotechnology and Bioengineering, 55*(1), 91-100.

Kempka, A. P., Lipke, N. L., da Luz Fontoura Pinheiro, T., Menoncin, S., Treichel, H., Freire, D. M. G., & de Oliveira, D. (2008). Response surface method to optimize the production and characterization of lipase from *Penicillium verrucosum* in solid-state fermentation. *Bioprocess and Biosystems Engineering, 31*(2), 119-125.

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.

Kim, E. K., Jang, W. H., Ko, J. H., Kang, J. S., Noh, M. J., & Yoo, O. J. (2001). Lipase and its modulator from *Pseudomonas* sp. strain KFCC 10818: Proline-to-glutamine substitution at position 112 induces formation of enzymatically active lipase in the absence of the modulator. *Journal of Bacteriology, 183*(20), 5937-5941.

Knudsen, K. E. B. (1997). Carbohydrate and lignin contents of plant materials used in animal feeding. *Animal Feed Science and Technology, 67*(4), 319-338.

Kober, L., Zehe, C., & Bode, J. (2013). Optimized signal peptides for the development of high expressing CHO cell lines. *Biotechnology and Bioengineering, 110*(4), 1164-1173.

Koutinas, A. A., Malbranque, F., Wang, R., Campbell, G. M., & Webb, C. (2007). Development of an oat-based biorefinery for the production of L (+)-lactic acid by *Rhizopus oryzae* and various value-added coproducts. *Journal of Agricultural and Food Chemistry, 55*(5), 1755-1761.

Krizsan, S. J., & Huhtanen, P. (2013). Effect of diet composition and incubation time on feed indigestible neutral detergent fiber concentration in dairy cows. *Journal of Dairy Science, 96*(3), 1715-1726.

Kumar, A., & 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.

Lawal, T., Iyayi, E., Adeniyi, B., & Adaramoye, O. (2010). Biodegradation of palm kernel cake with multienzyme complexes from fungi and its feeding value for broilers. *International Journal of Poultry Science, 9*(7), 695-701.

Lee, K. T., & Ofori-Boateng, C. (2013). Production of palm biofuels toward sustainable development. *Sustainability of Biofuel Production from Oil Palm Biomass* (pp. 107-146): Springer.

Leštan, M., Pečavar, A., Leštan, D., & Perdih, A. (1993). Amino acids in chitin — glucan complex of *Aspergillus niger*. *Amino Acids, 4*(1-2), 169-176.

Lopez, J. A., Lazaro, C.C., Castilho, L. R., Freire, D. M. G. & Castro, A. M. (2013). Characterization of multienzyme solutions produced by solid-state fermentation of babassu cake, for use in cold hydrolysis of raw biomass. *Biochemical Engineering Journal, 77*, 231– 239.

Li, N., & Zong, M.-H. (2010). Lipases from the genus *Penicillium*: Production, purification, characterization and applications. *Journal of Molecular Catalysis B: Enzymatic, 66*(1–2), 43-54.

Li, X., Rezaei, R., Li, P., & Wu, G. (2011). Composition of amino acids in feed ingredients for animal diets. *Amino Acids, 40*(4), 1159-1168.

Li, Z. J., Shukla, V., Fordyce, A. P., Pedersen A. G., & Wenger, K. S. (2000). Fungal morphology and fragmentation behaviour in a fed-batch *Aspergillus oryzae* fermentation at the production scale. *Biotechnology and Bioengineering*, *70*, 300–312.

Lim, J. S., Lee, J. H., Kim, J. M., Park, S. W., & Kim, S. W. (2006). Effects of morphology and rheology on neofructosyltransferase production by *Penicillium citrinum*. *Biotechnology and Bioprocess Engineering, 11*(2), 100-104.

Macedo, G., Park, Y., & Pastore, G. (1997). Partial purification and characterization of an extracellular lipase from a newly isolated strain of *Geotrichum* sp. *Revista de Microbiologia, 28*(2), 90-95.

Madhusudhan, M., & Raghavarao, K. (2012). Aqueous Two-Phase Extraction for the Recovery of Beet Pigments and Enzymes. *Red Beet Biotechnology* (pp. 393-408): Springer.

Mahadik, N. D., Puntambekar, U. S., Bastawde, K. B., Khire, J. M., & Gokhale, D. V. (2002). Production of acidic lipase by *Aspergillus niger* in solid state fermentation. *Process Biochemistry, 38*(5), 715-721.

Mahanta, N., Gupta, A., & Khare, S. K. (2008). Production of protease and lipase by solvent tolerant *Pseudomonas aeruginosa* PseA in solid-state fermentation using Jatropha curcas seed cake as substrate. *Bioresource Technology, 99*(6), 1729-1735.

Maia, M., Heasley, A., Camargo de Morais, M., Melo, E., Morais Jr, M., Ledingham, W., & Lima Filho, J. (2001). Effect of culture conditions on lipase production by *Fusarium solani* in batch fermentation. *Bioresource Technology, 76*(1), 23-27.

Mala, J. G., Edwinoliver, N. G., Kamini, N. R., & Puvanakrishnan, R. (2007). Mixed substrate solid state fermentation for production and extraction of lipase from *Aspergillus niger* MTCC 2594. *Journal of General Applied Microbiology, 53*(4), 247-253.

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, 1*(2), 1-9.

Mateos Diaz, J. C., Rodríguez, J. A., Roussos, S., Cordova, J., Abousalham, A., Carriere, F., & Baratti, J. (2006). Lipase from the thermotolerant fungus *Rhizopus homothallicus* is more thermostable when produced using solid state fermentation than liquid fermentation procedures. *Enzyme and Microbial Technology, 39*(5), 1042-1050.

Mazaheri, D., & Shojaosadati, S. A. (2013). Mathematical models for microbial kinetics in solid state fermentation: A review. *Iranian Journal of Biotechnology, 11*(3), 156-167.

Menoncin, S., Domingues, N. M., Freire, D. M. G., Toniazzo, G., Cansian, R. L., Oliveira, J. V., & Treichel, H. (2010). Study of the extraction, concentration, and partial characterization of lipases obtained from *Penicillium verrucosum* using solid-state fermentation of soybean bran. *Food and Bioprocess Technology, 3*(4), 537-544.

Mhetras, N., Bastawde, K., & Gokhale, D. (2009). Purification and characterization of acidic lipase from *Aspergillus niger* NCIM 1207. *Bioresource Technology, 100*(3), 1486-1490.

Mienda, B. S., Idi, A., & Umar, A. (2011). Microbiological features of solid state fermentation and its applications - An overview. *Research in Biotechnology, 2*(6), 21-26.

Mirnawati, Y. R., Marlida, Y., & Kompiang, I. P. (2011). Evaluation of palm kernel cake fermented by *Aspergillus niger* as substitute for soybean meal protein in the diet of broiler. *International Journal of Poultry Science, 10*(7), 537-541.

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.

Moeller, L., Strehlitz, B., Aurich, A., Zehnsdorf, A., & Bley, T. (2007). Optimization of citric acid production from glucose by *Yarrowia lipolytica*. *Engineering in Life Sciences, 7*(5), 504-511.

Moukha, S. M., Wösten, H. A., Asther, M., & Wessels, J. G. (1993). In situ localization of the secretion of lignin peroxidases in colonies of *Phanerochaete chrysosporium* using a sandwiched mode of culture. *Journal of General Microbiology, 139*(5), 969-978.

MSMD Resources. (2012). Palm kernel meal. Retrieved February 10, 2015 from www.msmd.com.my/palm-kernel-meal.

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

Mukherjee, A. K., Adhikari, H., & Rai, S. K. (2008). Production of alkaline protease by a thermophilic *Bacillus subtilis* under solid-state fermentation (SSF) condition using *Imperata cylindrica* grass and potato peel as low-cost medium: Characterization and application of enzyme in detergent formulation. *Biochemical Engineering Journal, 39*(2), 353-361.

Müller, C., McIntyre, M., Hansen, K., & Nielsen, J. (2002). Metabolic engineering of the morphology of *Aspergillus oryzae* by altering chitin synthesis. *Applied and Environmental Microbiology, 68*(4), 1827-1836.

Müller, C., Spohr, A. B., & Nielsen, J. (2000). Role of substrate concentration in mitosis and hyphal extension of *Aspergillus*. *Biotechnology and Bioengineering, 67*(4), 390-397.

Mussatto, S. I., Ballesteros, L. F., Martins, S., & Teixeira, J. A. (2012). Use of Agro-Industrial Wastes in Solid-State Fermentation Processes. In K.Y. Show and X. Guo. *Industrial Waste* (pp.122-141). Portugal: InTech.

Mustaffa, A. (1987). Palm kernel cake as a new feed for cattle. *Asian Livestock, 11*(5), 49-50.

Mustranta, A., Forssell, P., & Poutanen, K. (1993). Applications of immobilized lipases to transesterification and esterification reactions in nonaqueous systems. *Enzyme and Microbial Technology, 15*(2), 133-139.

Namboodiri, V. M. H., & Chattopadhyaya, R. (2000). Purification and biochemical characterization of a novel thermostable lipase from *Aspergillus niger*. *Lipids, 35*(5), 495-502.

Nampoothiri, K. M., Baiju, T., Sandhya, C., Sabu, A., Szakacs, G., & Pandey, A. (2004). Process optimization for antifungal chitinase production by *Trichoderma harzianum*. *Process Biochemistry, 39*(11), 1583-1590.

Nandakumar, M., Thakur, M., Raghavarao, K., & Ghildyal, N. (1999). Studies on catabolite repression in solid state fermentation for biosynthesis of fungal amylases. *Letters in Applied Microbiology, 29*(6), 380-384.

Nath, M. & Hindumathy, C. K. (2012). Isolation, optimization and purification of lipase from *Myroides Odoratimimus*. *International Journal of Latest Research in Science and Technology, 1*(3), 239-246.

Nawani, N., Singh, R., & Kaur, J. (2006). Immobilization and stability studies of a lipase from thermophilic *Bacillus* sp: The effect of process parameters on immobilization of enzyme. *Electronic Journal of Biotechnology, 9*(5).

nee'Nigam, P. S. (2009). Production of organic acids from agro-industrial residues *Biotechnology for Agro-Industrial Residues Utilisation* (pp. 37-60): Springer.

Ng, F. Y., Yew, F. K., Basiron, Y., & Sundram, K. (2011). A renewable future driven with Malaysian palm oil-based green technology. *Journal of Oil Palm & the Environment (JOPE), 2*, 1-7.

Ng, W.-K., Lim, H.-A., Lim, S.-L., & Ibrahim, C.-O. (2002). Nutritive value of palm kernel meal pretreated with enzyme or fermented with *Trichoderma koningii* (Oudemans) as a dietary ingredient for red hybrid tilapia (*Oreochromis* sp.). *Aquaculture Research, 33*(15), 1199-1207.

Nogueiro Estevinho, B., Ferraz, A., Rocha, F., Santos, L., & Alves, A. (2009). Uncertainty in the determination of glucose in aqueous solutions by high-performance liquid chromatography with evaporative light scattering detection. *Journal of Separation Science, 32*(18), 3116-3125.

Ollis, D. L., Cheah, E., Cygler, M., Dijkstra, B. & Frolow, F. (1992). The alpha/beta hydrolase fold. *Protein Engineering, 5*(3), 197-211.

O'Mara, F., Mulligan, F., Cronin, E., Rath, M., & Caffrey, P. (1999). The nutritive value of palm kernel meal measured in vivo and using rumen fluid and enzymatic techniques. *Livestock Production Science, 60*(2), 305-316.

Ooi, C. W., Tey, B. T., Hii, S. L., Kamal, S. M. M., Lan, J. C. W., Ariff, A., & Ling, T. C. (2009). Purification of lipase derived from *Burkholderia* *pseudomallei* with alcohol/salt-based aqueous two-phase systems. *Process Biochemistry, 44*(10), 1083-1087.

Padmapriya, B., Rajeswari, T., Noushida, E., Sethupalan, D. G., & Venil, C. K. (2011). Production of lipase enzyme from *Lactobacillus* spp. and its application in the degradation of meat. *World Applied Sciences Journal, 12*(10), 1798-1802.

Pallares, J., Rodriguez, S., & Sanroman, A. (1996). Citric acid production in submerged and solid state culture of *Aspergillus niger*. *Bioprocess Engineering, 15*(1), 31-33.

Pandey, A. (1992). Recent process developments in solid-state fermentation. *Process Biochemistry, 27*(2), 109-117.

Pandey, A., Benjamin, S., Soccol, C. R., Nigam, P., Krieger, N., & Soccol, V. T. (1999). The realm of microbial lipases in biotechnology. *Biotechnology and Applied Biochemistry, 29*(2), 119-131.

Pang, P. K., Lee, C. K., Ibrahim, D., & Che Omar, I. (2006). *Production Of Cellulase And Xylanase Via Solid State Fermentation And Its Application In The Enzymatic Deinking Of Laser Printed Waste Papers*. Paper presented at the Asean Biochemistry Seminar, Surabaya, Indonesia.

Pansuriya, R. C., & Singhal, R. S. (2010). Response surface methodology for optimization of production of lovastatin by solid state fermentation. *Brazilian Journal of Microbiology, 41*(1), 164-172.

Papagianni, M. (2004). Fungal morphology and metabolite production in submerged mycelial processes. *Biotechnology Advances, 22*(3), 189-259.

Papagianni, M., Mattey, M., & Kristiansen, B. (1999). Hyphal vacuolation and fragmentation in batch and fed-batch culture of *Aspergillus niger* and its relation to citric acid production. *Process Biochemistry, 35*(3), 359-366.

Parton, R., Fischer, S., Malhó, R., Papasouliotis, O., Jelitto, T., Leonard, T., & Read, N. (1997). Pronounced cytoplasmic pH gradients are not required for tip growth in plant and fungal cells. *Journal of Cell Science, 110*(10), 1187-1198.

Patil, S. R., & Dayanand, A. (2006). Production of pectinase from deseeded sunflower head by *Aspergillus niger* in submerged and solid-state conditions. *Bioresource Technology, 97*(16), 2054-2058.

Pau, H. S., & Omar, I. C. (2004). Selection and optimization of lipase production from *Aspergillus flavus* USM A10 via solid state fermentation (SSF) on rice husks and wood dusts as substrates. *Pakistan Journal of Biological Sciences, 7*, 1249-1256.

Paul, G., Kent, C., & Thomas, C. (1994). Image analysis for characterizing differentiation of *Penicillium chrysogenum*. *Food and Bioproducts Processing, 72*(2), 95-105.

Pazouki, M., Najafpour, G., & Hosseini, M., R. (2008). Kinetic models of cell growth, substrate utilization and bio-decolorization of distillery wastewater by *Aspergillus fumigatus* UB260. *African Journal of Biotechonology, 7*(9), 1369-1376.

Peach, M., Marsh, N. & Macphee, D. J. (2012). Protein solubilization: attend to the choice of lysis buffer. *Methods in Molecular Biology,* 869, 37-47.

Peksel, A., Torres, N., Liu, J., Juneau, G., & Kubicek, C. P. (2002). 13C-NMR analysis of glucose metabolism during citric acid production by *Aspergillus niger*. *Applied Microbiology and Biotechnology, 58*(2), 157-163.

Pignède, G., Wang, H., Fudalej, F., Gaillardin, C., Seman, M., & Nicaud, J.-M. (2000). Characterization of an extracellular lipase encoded by LIP2 in *Yarrowia lipolytica*. *Journal of Bacteriology, 182*(10), 2802-2810.

Plassard, C., & Fransson, P. (2009). Regulation of low-molecular weight organic acid production in fungi. *Fungal Biology Reviews, 23*(1–2), 30-39.

Polgar, L. (2005). The catalytic triad of serine peptidases. *Cellular and Molecular Life Sciences CMLS, 62*(19-20), 2161-2172.

Pons, M., Drouin, J., Louvel, L., Vanhoutte, B., Vivier, H., & Germain, P. (1998). Physiological investigations by image analysis. *Journal of Biotechnology, 65*(1), 3-14.

Ramachandran, S., Patel, A. K., Nampoothiri, K. M., Chandran, S., Szakacs, G., Soccol, C. R., & Pandey, A. (2004). Alpha amylase from a fungal culture grown on oil cakes and its properties. *Brazilian Archives of Biology and Technology, 47*(2), 309-317.

Ramachandran, S., Singh, S. K., Larroche, C., Soccol, C. R., & Pandey, A. (2007). Oil cakes and their biotechnological applications–A review. *Bioresource Technology, 98*(10), 2000-2009.

Ramesh, M., & Lonsane, B. (1991). Ability of a solid state fermentation technique to significantly minimize catabolic repression of α-amylase production by *Bacillus licheniformis* M27. *Applied Microbiology and Biotechnology, 35*(5), 591-593.

Rezende, M. I., Barbosa, A. d. M., Vasconcelos, A. F. D., & Endo, A. S. (2002). Xylanase production by *Trichoderma harzianum rifai* by solid state fermentation on sugarcane bagasse. *Brazilian Journal of Microbiology, 33*(1), 67-72.

Ribeiro, B. D., Castro, A. M. d., Coelho, M. A. Z., & Freire, D. M. G. (2011). Production and use of lipases in bioenergy: a review from the feedstocks to biodiesel production. *Enzyme Research 2011, 2011*, 1-16.

Robinson, T., McMullan, G., Marchant, R., & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. *Bioresource Technology, 77*(3), 247-255.

Robson, G. D., Wiebe, M. G., & Trinci, A. P. (1991). Exogenous cAMP and cGMP modulate branching in *Fusarium graminearum*. *Journal of General Microbiology, 137*(4), 963-969.

Rodriguez-Fernandez, D. E., Parada, J. L., Medeiros, A. B., de Carvalho, J. C., Lacerda, L. G., Rodriguez-Leon, J. A., & Soccol, C. R. (2013). Concentration by ultrafiltration and stabilization of phytase produced by solid-state fermentation. *Process Biochemistry, 48*(2), 374-379.

Rodriguez Couto, S., & Sanromán, M. A. (2005). Application of solid-state fermentation to ligninolytic enzyme production. *Biochemical Engineering Journal, 22*(3), 211-219.

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.

Ruiz, H. A., Rodríguez-Jasso, R. M., Rodríguez, R., Contreras-Esquivel, J. C., & Aguilar, C. N. (2012). Pectinase production from lemon peel pomace as support and carbon source in solid-state fermentation column-tray bioreactor. *Biochemical Engineering Journal, 65*, 90-95.

Sabu, A., Augur, C., Swati, C., & Pandey, A. (2006). Tannase production by *Lactobacillus* sp. ASR-S1 under solid-state fermentation. *Process Biochemistry, 41*(3), 575-580.

Sadhukhan, R., Roy, S., Raha, S., Manna, S., & Chakrabarty, S. (1992). Induction and regulation of alpha-amylase synthesis in a cellulolytic thermophilic fungus *Myceliophthora thermophila* D14 (ATCC 48104). *Indian Journal of Experimental Biology, 30*(6), 482-486.

Saenphoom, P., Liang, J., Ho, Y., Loh, T., & Rosfarizan, M. (2011). Effect of enzyme treatment on chemical composition and production of reducing sugars in palm *(Elaeis guineenis)* kernel expeller. *African Journal of Biotechnology, 10*(68), 15372-15377.

Salihu, A., Alam, M. Z., AbdulKarim, M. I., & Salleh, H. M. (2012). Lipase production: An insight in the utilization of renewable agricultural residues. *Resources, Conservation and Recycling, 58*(0), 36-44.

Sandhya, C., Sumantha, A., Szakacs, G., & Pandey, A. (2005). Comparative evaluation of neutral protease production by *Aspergillus oryzae* in submerged and solid-state fermentation. *Process Biochemistry, 40*(8), 2689-2694.

Sarkar, N. & Aikat, K. (2012). Cellulase and xylanase production from rice straw by a locally isolated fungus *Aspergillus fumigatus* NITDGPKA3 under solid state fermentation – statistical optimization by response surface methodology. *Journal of Technology Innovations in Renewable Energy, 1,* 54-62.

Saxena, A., Tripathi, B. P., Kumar, M., & Shahi, V. K. (2009). Membrane-based techniques for the separation and purification of proteins: An overview. *Advances in Colloid and Interface Science, 145*(1), 1-22.

Saxena, R., Sheoran, A., Giri, B., & Davidson, W. (2003). Purification strategies for microbial lipases. *Journal of Microbiological Methods, 52*(1), 1-18.

Schmid, R. D., & Verger, R. (1998). Lipases: interfacial enzymes with attractive applications. *Angewandte Chemie International Edition, 37*(12), 1608-1633.

Schmidt, C. G., & Furlong, E. B. (2012). Effect of particle size and ammonium sulfate concentration on rice bran fermentation with the fungus *Rhizopus oryzae*. *Bioresource Technology, 123*, 36-41.

Schrag, J. D., & Cygler, M. (1997). Lipases and αβ hydrolase fold. *Methods in Enzymology, 284*, 85-107.

Schrag, J. D., Li, Y., Wu, S., & Cygler, M. (1991). Ser-His-Glu triad forms the catalytic site of the lipase from *Geotrichum candidum*. *Nature, 351*, 761-764.

Sharma, P. K., Singh, K., Singh, R., Capalash, N., Ali, A., Mohammad, O., & Kaur, J. (2012). Characterization of a thermostable lipase showing loss of secondary structure at ambient temperature. *Molecular Biology Reports, 39*(3), 2795-2804.

Sharma, R., Chisti, Y., & Banerjee, U. C. (2001). Production, purification, characterization, and applications of lipases. *Biotechnology Advances, 19*(8), 627-662.

Shata, H., & Farid, M. A. F. (2012). Optimization of extraction parameters for keratinase recovery from fermented feather under solid state fermentation by *Streptomyces* sp. NRC 13S. *Journal of Applied Biology and Chemistry, 55*(3), 149-156.

Sindhu, R., Suprabha, G. N. & Shashidhar S. (2009). Optimization of process parameters for the production of a- amylase from *Penicillium* *janthinellum* (NCIM 4960) under solid state fermentation. *African Journal of Microbiology Research*, *3*(9), 498-503.

Singh, S. & Banerjee, U. C. (2007). Purification and characterization of *trans*-3-(4-ethoxyphenyl) glycidic acid methyl ester hydrolyzing lipase from *Pseudomonas aeruginosa*. *Process Biochemistry, 42,* 1063–1068.

Singh, A. K., & Mukhopadhyay, M. (2012). Overview of fungal lipase: A review. *Applied Biochemistry and Biotechnology*, *166*(2), 486-520.

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

Singhania, R. R., Soccol, C. R., & Pandey, A. (2008). Application of tropical agro-industrial residues as substrate for solid-state fermentation processes. In A. Pandey, C. R. Soccol & C. Larroche. *Current Developments in Solid-state Fermentation* (pp. 412-442).New Delhi: AsiaTech Publishers.

Smeltzer, M. S., Hart, M. E., & Iandolo, J. J. (1992). Quantitative spectrophotometric assay for staphylococcal lipase. *Applied and Environmental Microbiology, 58*(9), 2815-2819.

Snellman, E. A., & Colwell, R. R. (2008). Transesterification activity of a novel lipase from *Acinetobacter venetianus* RAG-1. *Antonie van Leeuwenhoek, 94*(4), 621-625.

Soliman, N. A., Knoll, M., Abdel-Fattah, Y. R., Schmid, R. D., & Lange, S. (2007). Molecular cloning and characterization of thermostable esterase and lipase from *Geobacillus thermoleovorans* YN isolated from desert soil in Egypt. *Process Biochemistry, 42*(7), 1090-1100.

Solis-Pereyra, S., Favela-Torres, E., Gutiérrez-Rojas, M., Roussos, S., Saucedo-Castañeda, G., Gunasekaran, P., & Viniegra-Gonzalez, G. (1996). Production of pectinases by *Aspergillus niger* in solid state fermentation at high initial glucose concentrations. *World Journal of Microbiology and Biotechnology, 12*(3), 257-260.

Sonnhammer, E., Von Heijne, G., & Krogh, A. (1998). *A hidden Markov model for predicting transmembrane helices in protein sequences.* Paper presented at the Proceedings of the International Conference on Intelligent Systems for Molecular Biology.

Sosa, D., Boucourt, R. & Dustet, J. C. (2012). Use of mathematical modeling on the solid-state fermentation processes of fibrous substrates for animal feeding. *Cuban Journal of Agricultural Science, 46*(2), 119-126.

Spohr, A., Dam Mikkelsen, C., Carlsen, M., Nielsen, J., & Villadsen, J. (1998). Online study of fungal morphology during submerged growth in a small flow through cell. *Biotechnology and Bioengineering, 58*(5), 541-553.

Sugihara, A., Shimada, Y., Nakamura, M., Nagao, T., & Tominaga, Y. (1994). Positional and fatty acid specificities of *Geotrichum candidum* Lipases. *Protein Engineering, 7*(4), 585-588.

Sulaiman, F., Abdullah, N., Gerhauser, H., & Shariff, A. (2011). An outlook of Malaysian energy, oil palm industry and its utilization of wastes as useful resources. *Biomass and Bioenergy, 35*(9), 3775-3786.

Svendsen, A. (2000). Lipase protein engineering. *Biochimica et Biophysica Acta (BBA) - Protein Structure and Molecular Enzymology, 1543*(2), 223-238.

Swift, M. J. (1973). The estimation of mycelial biomass by determination of the hexosamine content of wood tissue decayed by fungi. *Soil Biology and Biochemistry, 5*(3), 321-332.

Taing, O., & Taing, K. (2007). Production of malic and succinic acids by sugar-tolerant yeast *Zygosaccharomyces rouxii*. *European Food Research and Technology, 224*(3), 343-347.

Teng, Y., Xu, Y., & Wang, D. (2009). Changes in morphology of *Rhizopus chinensis* in submerged fermentation and their effect on production of mycelium-bound lipase. *Bioprocess and Biosystems Engineering, 32*(3), 397-405.

Tengerdy, R.P. & Szakacs, G. (2003). Bioconversion of lignocellulose in solid substrate fermentation. *Biochemical Engineering Journal, 13*, 169–179.

Thomas, C. R. (1992). Image analysis: putting filamentous microorganisms in the picture. *Trends in Biotechnology, 10*, 343-348.

Thomsen, M. (2005). Complex media from processing of agricultural crops for microbial fermentation. *Applied Microbiology and Biotechnology*, *68*(5), 598–606.

Tran, C., Sly, L., & Mitchell, D. (1998). Selection of a strain of *Aspergillus* for the production of citric acid from pineapple waste in solid-state fermentation. *World Journal of Microbiology and Biotechnology, 14*(3), 399-404.

Treichel, H., de Oliveira, D., Mazutti, M. A., Di Luccio, M., & Oliveira, J. V. (2010). A review on microbial lipases production. *Food and Bioprocess Technology, 3*(2), 182-196.

Tsai, S.-P., Datta, R., Basu, R., & Yoon, S.-H. (2011). Syngas conversion method using asmmetric membrane and anaerobic microorganism: Google Patents.

Ugwuanyi, J. O., McNeil, B., & Harvey, L. M. (2009). Production of protein-enriched feed using agro-industrial residues as substrates. In nee' Nigam and Pandey. *Biotechnology for Agro-Industrial Residues Utilisation* (pp. 77-103).UK, India: Springer.

Vakhlu, K. & Kour, A. (2006). Yeast lipases: enzyme purification, biochemical properties and gene cloning. *Electronic Journal of Biotechnology, 9*(1), 68-85.

Vandenberghe, L. P. S., Soccol, C. R., Pandey, A., & Lebeault, J. M. (2000). Solid-state fermentation for the synthesis of citric acid by *Aspergillus niger*. *Bioresource Technology, 74*(2), 175-178.

Vardanega, R., Remonatto, D., Arbter, F., Polloni, A., Rigo, E., Ninow, J. L., & Di Luccio, M. (2008). A systematic study on extraction of lipase obtained by solid state fermentation of soybean meal by a newly isolated strain of *Penicillium* sp. *World Journal of Chemistry, 3*(2), 55-60.

Venkata Rao, P., Jayaraman, K., & Lakshmanan, C. M. (1993). Production of lipase by *Candida rugosa* in solid state fermentation. 1: determination of significant process variables. *Process Biochemistry, 28*(6), 385-389.

Venus, J., & Richter, K. (2006). Production of lactic acid from barley: Strain selection, phenotypic and medium optimization. *Engineering in Life Sciences, 6*(5), 492-500.

Vernet, T., Ziomek, E., Recktenwald, A., Schrag, J. D., de Montigny, C., Tessier, D., & Cygler, M. (1993). Cloning and expression of *Geotrichum candidum* lipase II gene in yeast. Probing of the enzyme active site by site-directed mutagenesis. *Journal of Biological Chemistry, 268*(35), 26212-26219.

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.

Virupakshi, S., Babu, K. G., Gaikwad, S. R., & Naik, G. R. (2005). Production of a xylanolytic enzyme by a thermoalkaliphilic *Bacillus* sp. JB-99 in solid state fermentation. *Process Biochemistry, 40*(1), 431-435.

Wang, L., Ridgway, D., Gu, T., & Moo-Young, M. (2005). Bioprocessing strategies to improve heterologous protein production in filamentous fungal fermentations. *Biotechnology advances, 23*(2), 115-129.

Wang, P., & Zhou, R. (2006). Determination of organic acids exuded from plant roots by high performance liquid chromatography. *Chinese Journal of Chromatography, 24*(3), 239-243.

Ward, P. L., Wohlt, J. E., Zajac, P. K. & Cooper, K. R. (2000). Chemical and physical properties of processed newspaper compared to wheat straw and wood shavings as animal bedding. *Journal of Dairy Sci*ence, *83*, 359-367.

Wardman, R. C. (1995). *Determination and removal of gluconic acid in reduced alcohol wine and high acid grape juice.* Lincoln University.

Wenzig, E., Lingg, S., Kerzel, P., Zeh, G., & Mersmann, A. (1993). Comparison of selected methods for downstream processing in the production of bacterial lipase. *Chemical Engineering and Technology, 16*(6), 405-412.

Wijewickrama, G. T., Albanese, A., Kim, Y. J., Oh, Y. S., & Murray, P. S. (2006). Unique membrane interaction mode of group IIF phospholipase A2. *Journal of Biological Chemistry, 281*(43), 32741-32754.

Williams, P. (1995). Digestible amino acids for non-ruminant animals: theory and recent challenges. *Animal Feed Science and Technology, 53*(2), 173-187.

Wolski, E., Menusi, E., Remonatto, D., Vardanega, R., & Arbter, F. (2009). Partial characterization of lipases produced by a newly isolated *Penicillium* sp. in solid state and submerged fermentation: A comparative study. *LWT - Food Science and Technology, 42*(9), 1557-1560.

Wösten, H. A., Moukha, S. M., Sietsma, J. H., & Wessels, J. G. (1991). Localization of growth and secretion of proteins in *Aspergillus niger*. *Journal of General Microbiology, 137*(8), 2017-2023.

Xiang, X., & Morris, N. R. (1999). Hyphal tip growth and nuclear migration. *Current Opinion in Microbiology, 2*(6), 636-640.

Xie, G., & West, T. (2006). Citric acid production by *Aspergillus niger* on wet corn distillers grains. *Letters in Applied Microbiology, 43*(3), 269-273.

Younesi, H., Najafpour, G., & Mohamed, A. R. (2005). Ethanol and acetate production from synthesis gas via fermentation processes using anaerobic bacterium, *Clostridium ljungdahlii*. *Biochemical Engineering Journal, 27*(2), 110-119.

Yuhazri, M., Sihombing, H., Umar, N., Saijod, L., & Phongsakorn, P. (2012). Solid fuel from empty fruit bunch fiber and waste papers Part 1: Heat Released from Combustion Test. *Global Engineers and Technologists Review, 2*(1), 7-13.

Zahari, M. W., & Alimon, A. (2004). Use of palm kernel cake and oil palm by-products in compound feed. *Palm Oil Developments, 40*, 5-8.

Zhou, Y.-J., Hu, C.-L., Wang, N., Zhang, W.-W., & Yu, X.-Q. (2013). Purification of porcine pancreatic lipase by aqueous two-phase systems of polyethylene glycol and potassium phosphate. *Journal of Chromatography B, 926*, 77-82.

Znidarsic, P., & Pavko, A. (2001). The Morphology of Filamentous Fungi in Submerged Cultivations as a Bioprocess Parameter. *Food Technology and Biotechnology, 39*, 237-252