ANAEROBIC DIGESTION OF PINEAPPLE WASTE USING A MICROBIAL CONSORTIUM

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ABSTRACT

Anaerobic digestion of the agro-industrial pineapple waste has great potential to generate biogas, an alternative energy resource to compensate the deprivation of global fossil fuel over the years. The objectives of this study were to identify and characterize a microbial consortium (MC) from Palm Mill Oil Effluent (POME) as well as preliminarily evaluate its potential as a biogas producer through pineapple waste anaerobic digestion. The MC was subjected to gram and methylene blue staining techniques, Dinitrosalicylic Acid (DNS) method, 16S rRNA and Internal Transcribed Spacer (ITS) sequencing, and phylogenetic tree analysis. Next, gas production from the anaerobic digestion was analyzed by water displacement and Residual Gas Analyzer (RGA). Based on the phenotypic and genotypic identification, the MC was comprised of four bacteria, including *Bacillus cereus*, *Acinetobacter radioresistens, Klebsiella* sp., and *Stenotrophomonas maltophilia,* as well as a fungus *Aspergillus fumigatus*. The *A.radioresistens* strain in this study was found to be a novel facultative anaerobe strain with the potential of producing biogas. Higher overall cellulase activity of the MC was found in contrast to the amylase activity during the pineapple waste digestion process. The water displacement method showed potential gas production of 287±135 cm^3, comprising of 80.15% nitrogen, 16.94% oxygen, 2.63% water vapours, 0.19% carbon dioxide, 0.08% hydrogen sulphide and 0.01% hydrogen. In conclusion, this study had successfully identified and characterized the MC as well as determined its potential in biogas production, although the gas analysis showed an absence of the desired biogas, methane which could be acquired through further optimization of the biodigestion process.

ABSTRAK

Pencernaan anaerobik sisa nanas yang diperoleh dari industri pertanian dipercayai berpotensi menghasilkan biogas, satu sumber tenaga alternatif bagi mengimbangi kemerosotan bahan api fosil global sepanjang tahun. Objektif-objektif kajian ini adalah bagi mengenalpasti dan mencirikan konsortium mikrob (MC) dari efluen minyak kilang kelapa sawit (POME) serta membuat penilaian awal tentang potensinya sebagai penghasil biogas dari pencernaan anaerobik sisa nanas. MC tersebut disubjekkan kepada teknik-teknik pewarnaan gram dan methylene biru, metod Asid Dinitrosalisilik (DNS), penjujukan 16s rRNA dan *Internal Transcribed Spacer* (ITS) serta analisis pohon filogenetik. Kemudian, produksi gas dari pencernaan anaerobik itu dianalisis oleh metod sesaran air dan penganalisa sisa gas (RGA). Berdasarkan pengenalan fenotip dan genotip, MC itu terdiri daripada empat bakteria, termasuk *Bacillus cereus, Acinetobacter radioresistens, Klebsiella* sp., dan *Stenotrophomonas maltophilia*, serta *Aspergillus fumigatus* fungus. Strain *A.radioresistens* di dalam kajian ini ditemui sebagai strain anaerob fakultatif novel yang berpotensi menghasilkan biogas. Aktiviti selulase bagi MC secara keseluruhan adalah lebih tinggi berbanding aktiviti amilase semasa proses pencernaan sisa nanas. Metod sesaran air menunjukkan potensi penghasilan gas sebanyak 287±135 cm^3 yang terdiri daripada 80.15% nitrogen, 16.94% oksigen, 2.63% wap air, 0.19% karbon dioksida, 0.08% hidrogen sulfida dan 0.01% hidrogen. Kesimpulannya, kajian ini telah berjaya mengenalpasti dan mencirikan MC tersebut serta menentukan potensinya dalam menghasilkan biogas, walaupun analisis gas menunjukkan ketiadaan biogas yang dikehendaki, metana yang mungkin mampu diperoleh melalui pengoptimuman proses pencernaan tersebut yang lebih lanjut.

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LIST OF ABBREVIATIONS

MC	-	Microbial Consortium
POME	-	Palm Oil Mill Effluent
DNS	-	Dinitrosalicylic Acid
PCR	-	Polymerase Chain Reaction
NJ	-	Neighbour Joining
RGA	-	Residual Gas Analyzer
ITS	-	Internal Transcribed Spacer
CO_2	-	Carbon Dioxide
GC	-	Gas Chromatography
ETP	-	Economic Transformation Program
COD	-	Chemical Oxygen Demand
C/N	-	Carbon/Nitrogen
BOD	-	Biological Oxygen Demand
CH_4	-	Methane
H_2	-	Hydrogen
C/N	-	Carbon/Nitrogen
MJ	-	Mega Joules
GWh	-	Gigawatt Hours

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Anaerobic digestion is a biochemical process which drives the degradation of a wide variety of biomass through the microbial action (Adekunle & Okolie, 2015; Divya, Gopinath, & Christy, 2015). Four biochemical reaction stages are involved in the anaerobic digestion process, including hydrolysis, acidogenesis, acetogenesis and methanogenesis process (Divya *et al*., 2015; Wang, 2014). Not only known to be a critical degrading component in solid waste and waste water treatment, the anaerobic digestion system is currently played a crucial role in generating an environmental-friendly renewable energy resource, biogas, an alternative to the finite fossil fuel (Divya *et al.*, 2015). Biogas is defined as gas produced as a result from organic matters degradation due to microorganisms' actions in which it includes methane, hydrogen, nitrogen, hydrogen sulphide and carbon dioxide (Minde, Magdum, & Kalyanraman, 2013; Divya *et al.*, 2015). Apart from the benefit of less greenhouse gaseous emission, the production of biogas can also lead to a decrease in energy production cost as this alternative energy resource can be harvested from biomass or industrial and agricultural wastes (Divya *et al.*, 2015)..

In general, the microbial communities which participate in the anaerobic digestion process to produce biogas are derived from animal manure such as cow dung and poultry manure (Eze & Agbo, 2010; Ukpabi *et al*., 2017). Recent study has found in which the utilization of specific known novel microbial consortium is more effective to generate biogas in contrast to the unidentified microbial consortium from animal manure (Kumar *et al.,* 2014; Mirdamadian *et al.,* 2011). As the identity of each species in the microbial community is known, this made easier for the anaerobic digestions' regulation within an anaerobic digester as specific microbes can be dedicated to specific phase of anaerobic digestion process. Thus, the identification and creation of a novel anaerobic microbial consortium is essential to obtain satisfactory biogas production.

Other than animal manure, Palm Oil Mill Effluent (POME), a byproduct from the oil palm industry, has also been known to be a host of various anaerobic microbes which participate in the biogas generation via anaerobic digestion process (Meesap *et al.*, 2012; Neoh *et al.*, 2013; Wakil, Adelabu, & Fasiku, 2013; Wong, Teng, & Ong, 2014). A potential effective anaerobic microbial consortium (MC) can be developed from the POME-derived microbial inoculum in order to gain better quality and quantity of biogas production (Wakil, Adelabu, & Fasiku, 2013; Wong, Teng, & Ong, 2014). Therefore, the isolation of microbial colonies from POME is seen as a great platform to discover new MC which can be integrated into the anaerobic digestion process to effectively produce biogas.

Besides microbial consortium introduction, the utilization of biomass as feedstock in the anaerobic system is also a driving factor for biogas production (Divya *et al.,* 2015). Biomass can be comprised of organic materials such as animal manure, municipal solid waste and agro-industrial waste (Divya *et al.,* 215). As the Malaysias' pineapple plantation intensifies in parallel with the 11th Malaysia Plan, it is forecasted that there will be an increase in pineapple waste generation (Ruekeith, 2015). Pineapple waste can be comprised of leaves, stalks, and crown which are discarded during the canned fruit making process and it accounts about 40% to 80% of the pineapple (Mohd Zain *et al.*, 2012). Therefore, the resulted increasing amount

of accumulated pineapple waste is seen as a potential feedstock for anaerobic digestion system to generate biogas. In addition to renewable energy generation, the anaerobic digestion on pineapple wastes also helps in mitigating the negative environmental repercussion of the particular agricultural wastes' inefficient management.

Multiple scientific studies have shown evidence of the pineapple wastes' capacity in serving as feedstock in biogas production (Chulalaksananukul, Sinbuathong, & Chulalaksananukul, 2012; Ugwoke & Ekpe, 2011). In this present study, four anaerobic bacteria and a fungus isolated from POME were determined in terms of their phenotype and genotype criteria. The microbes were then mixed together in order to create an effective MC for biogas generation. Next, the efficiency and capacity of this microbial inoculum to produce biogas using pineapple waste was examined and the gas released from the particular anaerobic digestion process was analyzed.

1.2 Problem Statement

In the execution of anaerobic digestion, anaerobic microbes are known to own the potential to facilitate the process via utilization of biomass or agricultural waste (Wang, 2014). Although a number of scientific studies centralized in the anaerobic degradation for biogas production have been performed over the years, the search for efficient anaerobic microbes must continue due to the huge diversity of the microbial world. The microbial identification study and databases help to widen the knowledge spectrum regarding the potential biogas producer-anaerobic microbes.

Besides the use of an efficient MC, the carbon sources or organic materials are the key factors affecting the anaerobic digestion process (Divya *et al.*, 2015). Pineapple waste has a high potential to serve as a substrate for anaerobic digestion to generate biogas (Reungsang & Sreela-or, 2013). As the production and plantation of pineapple is predicted to increase in parallel with the 11th Malaysia Plan, the need to find a measure to address the issue of increasing pineapple waste generation is extremely crucial (Lun, Wai, & Ling, 2014; Ruekeith, 2015). This is because the increasing accumulation of pineapple fruit wastes will potentially cause unfavorable environmental liabilities. Hence, the utilization of pineapple waste as an optional feedstock in anaerobic digestion for biogas production is seen as an excellent measure to mitigate the environmental concern, along with creating a new clean renewable energy resource (Chulalaksananukul *et al.*, 2012).

Next, the generation of biogas from anaerobic digestion system is an advantage to the world population due to its capacity to mitigate global high rate of fossil fuel consumption to support increasing demand and population (Divya *et al.*, 2015). Besides that, the increment of greenhouse gas emission to the atmosphere, particularly in Malaysia, can also be addressed by the production of biogas which is environmentally friendly (Abdeshahian *et al.*, 2016). Thus, through the use of biogas, despite fossil fuel such as crude oil and coal, a clean energy can be used to generate electricity and heat to the global population (He, 2010; Onojo *et al*., 2013).

1.3 Objectives

The objectives of this study were:

1. To identify the microbial consortium used for anaerobic digestion of pineapple waste.

2. To evaluate the performance of biogas production by microbial consortium.

1.4 Scope of Study

The following scopes are performed to acquire the objectives:

1. Isolation of POME-derived microbial species.

2. Phenotype profiling of microbial consortium: Identification and characterization of microbes according to gram staining, methylene blue staining as well as Dinitrosalicyclic Acid (DNS) assays for cellulase and amylase activities.

3. Genotype profiling of microbial consortium: Identification of the microbial consortium through 16s rRNA and Internal Transcribed Spacer (ITS) sequencing techniques prior to phylogenetic analysis using the Neighbour-Joining (NJ) method.

4. Investigation of the microbial consortium's capacity to generate biogas through pineapple waste anaerobic digestion process using water displacement method within 4 days of retention time.

5. Identification and analysis of gas composition using Residual Gas Analyzer (RGA).

1.5 Significance of Study

The current established database on anaerobic microbes which are involved in biogas production needs to be updated regularly. Hence, more research studies on new potential microbial inoculum should be performed. Next, POME has also been seen as an alternative source, other than animal manures to acquire efficient microbial consortium to be integrated into the anaerobic digestion process for biogas production. Furthermore, both the evolutionary study of anaerobic microbial consortium and its hydrolytic enzymes activity can help to gain in depth understanding of specific function of each microbial species in the consortium. As the pineapple cultivation for exportation expands annually, this would definitely result in massive amount of waste generation which can lead to a serious environmental problem. Therefore, in this study, the utilization of pineapple waste as a substrate in anaerobic digestion to potentially generate the desired biogas could account for economic and environmental benefits to global population.

REFERENCES

Abdeshahian, P., Shiun, J., Shin, W.,& Hashim, H. (2016). Potential of Biogas Production from Farm Animal Waste in Malaysia. *Renewable and Sustainable Energy Reviews*, *60*, 714–723.

Abimbola, O., & Olumide, O. (2014). Evaluation of Biogas Production from Food Waste. *The International Journal of Engineering and Science*, *3*(1), 1–7.

Acharya, T. (2015). Gram Staining: Principle, Procedure and Results. Retrieved October 20, 2017, from http://microbeonline.com/gram-staining-principle-procedure-results/

Adekunle, K. F., & Okolie, J. A. (2015). A Review of Biochemical Process of Anaerobic Digestion. *Advances in Bioscience and Biotechnology*, *6*, 205–212.

Ahamd, S., & Tahar, R. (2014). Selection of Renewable Energy Sources for Sustainable Development of Electricity Generation System Using Analytical Hierachy Process; A Case of Malaysia. *Renewable Energy*, *63*, 458–66.

Ahamed, J., Raiyan, M., Hossain, M. D., Rahman, M.,& Salam, B. (2016). Production of Biogas from Anaerobic Digestion of Poultry Droppings and Domestic Waste Using Catalytic Effect of Silica Gel. *International Journal of Automotive and Mechanical Engineering.*, *13*(2), 3503–3517.

Ahmad, A., Ismail, S., & Bhatia, S. (2003). Water Recycling From Palm Oil Mill Effluent (POME) Using Membrane Technology. *Desalination*, *157*(1–3), 87–95.

Ahmad, S., Tahar, R., Muhammad-Sukki, F., Munir, A., & Rahim, R. (2015). Role of Feed-In Tariff Policy In Promoting Solar Photovoltaic Investments in Malaysia; A System Dynamics Approach. *Energy*, *84*, 808–15.

Akhwanzada, S., & Tahar, R. (2012). Strategic Forecasting of Electricity Demand Using System Dynamics Approach. *International Journal of Environment Science and Development*, *3*, 328–33.

Alrumman, S., Mostafa, Y., Eifan, S., Alamri, S., & Hesham, A. (2014). Isolation of Thermoalkalophilic-a-Amylase Producing Bacteria and Optimization of Potato Waste Water Medium for Enhancement of a-Amylase Production. *Advances in Life Science and Technology*, *20*, 41–51.

American Biogas Council. (2016). About Biogas: Frequent Questions. Retrieved December 1, 2017, from https://www.americanbiogascouncil.org/biogas_questions.asp

Anderson, R. (1979). *Biological Path to Self Reliance*. New York: Van No Strand Reinhold Company.

Appels, L., Baeyens, J., Degreve, J., & Dewil, R. (2008). Principles and Potential of The Anaerobic Digestion of Waste-Activated Sludge. *Progress in Energy and Combustion Science*, *34*, 755–781.

Ash, C., Farrow, J. A., Dorsch, M., Stackenbrandt, E., & Collins, M. D. (1991). Comparative Analysis of Bacillus anthracis, Bacillus cereus, and Related Species on The Basis of Reverse Transcriptase of 16s rRNA. *International Journal of Systematic Bacteriology*, *41*, 343–346.

Asikong, B. E., Idire, S. O., & Tiku, D. R. (2016). Microorganisms Associated with Biogas Production Using Vegetable (Telfairia occidentalis) Wastes , Banana Peel and Pig Dung as Substrates. *British Microbiology Research Journal*, *16*(3), 1–12.

Babaee, A., & Shayegan, J. (2011). 'Effect of Organic Loading Rates (OLR) on Production of Methane from Anaerobic Digestion of Vegetables Waste' in *World Renewable Energy Congress 2011-Sweden*, 411–417. Linkoping, Sweden.

Baharuddin, A. S., Nafis, M., Razak, A., Hock, L. S., & Ahmad, M. N. (2010). Isolation and Characterization of Thermophilic Cellulase-Producing Bacteria from Empty Fruit Bunches-Palm Oil Mill Effluent Compost. *American Journal of Applied Sciences*, *7*(1), 56–62.

Bardiya, N., & Khanna, S. (1996). Biomethanation of Banana Peel and Pineapple Wastes . Biores Technol. *Bioresource Technology*, *58*, 73–76.

Bayard, R., Le Hyaric, R., Chardin, C., Benbelkacem, H., Bollon, J., Escudie, R., & Buffiere, P. (2012). Influence of Moisture Content on the Specific Methanogenic Activity of Dry Mesophilic Municipal Solid Waste Digestate. *Journal of Chemical Technology and Biotechnology*, *102*, 822–827.

Beevi, B., Jose, P. P., & Madhu, G. (2013). Effect of Total Solid Concentration on Anaerobic Digestion of The Organic Fraction of Municipal Solid Waste. *International Journal of Scientific and Research Publications*, *3*(8), 1–5.

Berger, S. (2017). *GIDEON Guide to Medically Important Bacteria: 2017 Edition* (2017th ed.). California: GIDEON Informatics, Inc. Retrieved from https://books.google.com.my/books?id=xdQVDgAAQBAJ

Bond, T., & Templeton, M. R. (2011). Energy for Sustainable Development History and Future of Domestic Biogas Plants in The Developing World. *Energy for Sustainable Development*, *15*(4), 347–354.

Botheju, D., Lie, B., & Bakke, R. (2010). Oxygen Effects in Anaerobic Digestion. *Modelling Identification and Control*, *30*(4), 191–201.

Bottone, E. J. (2010). Bacillus Cereus , A Volatile Human Pathogen, *23*(2), 382–398.

Brack, P., Dann, S., Wijayantha, K. G. U., Adcock, P., & Foster, S. (2016). A Simple , Low-cost , and Robust System to Measure the Volume of Hydrogen Evolved by Chemical Reactions with Aqueous Solutions. *Journal of Visualized Experiments*, (114), 1–7.

Braga, R. M., Queiroga, T. S., Calixto, G. Q., Almeida, H. N., & Melo, D. M. A. (2015). The Energetic Characterization of Pineapple Crown Leaves. *Environmental Science and Pollution Research*, *22*, 18987–18993.

Braunstein, H., & Tomasulo, M. (1976). Indole-Positive Strains of Klebsiella pneumoniae Producing Hydrogen Sulfide in iron-Agar Slants. *American Journal of Clinical Pathology*, *65*(5), 702–7025.

Brinkman, F. S. L., & Leipe, D. (2001). 'Phylogenetic analysis' in A. Baxevanis & B. F. Ouellette (Eds.), *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* (2nd ed.) *2*, 323–358. Canada: John Wiley & Sons Inc.

Brooke, J. S. (2012). Stenotrophomonas maltophilia : an Emerging Global Opportunistic Pathogen, *25*, 2–41.

Bruckner, M. (2016). Gram Staining. Retrieved October 20, 2017, from https://serc.carleton.edu/microbelife/research_methods/microscopy/gramstain.html.

Bukhari, N., Ngatiman, M., Loh, S., & Choo, Y. (2013). Characteristics of Palm Oil Mill Effluent (POME) in An Anaerobic Biogas Digester. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*, *16*(1), 225–231.

Buleon, A., Colonna, P., Planchot, V., & Ball, S. (1998). Starch Granules: Structure and Biosynthesis. *International Journal of Biological Macromoles*, *23*(2), 85–112.

Cai, W., Li, J., & Zhang, Z. (2007). The Characteristics and Mechanisms of Phenol Biodegradation by Fusarium sp. *Journal of Hazardous Materials*, *148*(1–2), 38–42.

Chae, K. J., Jang, A., Yim, S., & Kim, I. (2008). The Effects of Digestion Temperature and Temperature Shock on The Biogas Yields from The Mesophilic Anaerobic Digestion of Swine Manure. *Bioresource Technology*, *99*(1), 1–6.

Chaiprasert, P., Hudayah, N., & Auphimai, C. (2017). Efficacies of Various Anaerobic Starter Seeds for Biogas Production from Different Types of Wastewater. *Biomedical Research International*, *2017*, 1–13.

Cheba, B. A., & Zaghloul, T. (2008). Isolation and Identification of Marine Bacterium and Optimization of Its Amylase Production. *Journal of Applied Biology & Biotechnology*, *1*(1), 29–33.

Chen, W. M., Chang, J. S., Chiu, C. H., Chang, S. C., Chen, W. C., & Jiang, C. M. (2005). Caldimonas Taiwanensis sp. nov., A Amylase Producing Bacterium Isolated from A Hot Spring. *Systemic and Applied Microbiology*, *28*(5), 415–420.

Chong, M., Abdul, R., Shirai, Y., & Ali, M. (2009). Biohydrogen Production by Clostridium butyricum EB6 from Palm Oil Mill Effluent. *International Journal of Hydrogen Energy*, *34*(2), 764–771.

Choonut, A., Saejong, M., & Sangkharak, K. (2014). The Production of Ethanol and Hydrogen from Pineapple Peel by Saccharomyces cerevisiae and Enterobacter aerogenes. *Energy Procedia*, *52*, 242–249.

Choubane, S., Khelil, O., & Cheba, B. (2015). Bacillus sp. R2 a-Amylase Production Optimization: Pasta Cooking Water as Medium of Amylase Production. *African Journal of Biotechnology*, *14*(47), 3184–3189.

Chulalaksananukul, S., Sinbuathong, N., & Chulalaksananukul, W. (2012). Bioconversion of Pineapple Solid Waste under Anaerobic Condition through Biogas Production, *17*(5), 734–742.

Clarridge III, J. (2004). Impact of 16S rRNA Gene Sequence Analysis for Identification of Bacteria on Clinical Microbiology and Infectious Diseases. *Clinical Microbiology Reviews*, *17*(4), 840–862.

Coulibaly, L., Gourene, G., & Agathos, N. (2004). Utilization of Fungi for Biotreatment of Raw Wastewaters. *African Journal of Biotechnology*, *2*(12), 620–630.

Crawford, R. L. (1981). *Lignin Biodegradation and Transformation The Biochemistry of the Nucleic Acids (9th ed.)*. New York: John Wiley and Sons.

Das, S., Singh, S., Sharma, V., & Soni, M. (2011). Biotechnological of Industrially Important Amylase Enzyme. *International Journal of Pharmancy and*

Pharmaceutical Sciences., *2*(1), 486–496.

Dashtban, M., Maki, M., Leung, K. T., Mao, C., & Qin, W. (2010). Cellulase Activities in Biomass Conversion : Measurement Methods and Comparison, (May), 1–8.

Divya, D., Gopinath, L. R., & Christy, P. M. (2015). A Review on Current Aspects and Diverse Prospects for Enhancing Biogas Production in Sustainable Means. *Renewable and Sustainable Energy Reviews*, *42*, 690–699.

Economic Transformation Programme. (2013). EPP 5: Developing Biogas Facilities at Palm Oil Mills. Retrieved April 10, 2016, from http://etp.pemandu.gov.my

Erdogan-Yildirim, Z., Burian, A., Manafi, M., & Zeitlinger, M. (2011). Impact of pH on Bacterial Growth and Activity of Recent Fluoroquinolones in Pooled Urine. *Research in Microbiology*, *162*(3), 249–252.

Eze, J., & Agbo, K. (2010). Studies on The Microbial Spectrum in Anaerobic Biomethannization of Cow Dung in 10 m3 Fixed Dome Biogas Digester. *International Journal of Physical Sciences*, *5*(9), 1331–1337.

Ezeji, T., & Bahl, H. (2006). Purification, Characterization and Synergistic Action of Phytate Resistant Alpha Amylase and Alpha Glucosidase from Geobacillus thermodenitrificans HRO10. *Journal of Biotechnology*, *125*(1), 27–38.

Figueira, E. L. Z., & Hirooka, E. Y. (2000). Culture Medium for Amylase Production by Toxigenic Fungi. *Brazilian Archives Biology and Technology*, *43*, 461–467.

Folakemi, O., Omowumi, P., & Ibiyemi, S. (2008). Cellulase Production by some Fungi Cultured on Pineapple Waste. *Nature and Science*, *6*(2), 64–79.

GForce Green Energy Sdn. Bhd. (2015). POME. Retrieved April 17, 2016, from http://gfg-energy.com/pome/rebiogas_plant.html

Gopinath, L. R., Christy, P. M., Mahesh, K., & Divya, R. B. D. (2014). Identification and Evaluation of Effective Bacterial Consortia for Efficient Biogas Production, *8*(3), 80–86.

Goswami, R., Chattopadhyay, P., Shome, A., Banerjee, S., Chakraborty, A., Mathew, A., & Chaudhury, S. (2015). An Overview of Physico-Chemical Mechanisms of Biogas Production by Microbial Communities: A Step Towards Sustainable Waste Management. *3 Biotech*, *6*(72), 12.

Grim, J., & Johansson, M. (2012). *Evaluation of A Biogas Plant in Adeiso , Ghana*. Master Thesis, Swedish University of Agricultural Sciences, Sweden.

Gusakov, A., Kondratyeva, E., & Sinitsyn, A. (2011). Comparison of Two Methods for Assaying Reducing Sugars in the Determination of Carbohydrase Activities. *Internation Journal of Analytical Chemistry*, *2011*, 1–4.

Hafez, H., Nakhla, G., El, M. H., & Elbeshbishy, E. (2010). Effect of Organic Loading on A Novel Hydrogen Bioreactor. *International Journal of Hydrogen Energy*, *35*(1), 81–92.

He, P. (2010). Anaerobic Digestion: An Intriguing Long History in China. *Waste Management*, *30*(4), 549–50.

Houbron, E., Torrijos, M., & Capdeville, B. (1999). An Alternative Use of Biogas Applied at The Water Denitrification. *Water Science and Technology*, *40*(8), 112–5.

Igwe, J. (2014). Production of Biogas from Paper Waste Blended With Cow Dung. *Journal of Environmental Science, Toxicology and Food Technology*, *8*(10), 58–68.

Irfan, M., Safdar, A., Syed, Q., & Nadeem, M. (2012). Isolation and Screening of Cellulolytic Bacteria from Soil and Optimization of Cellulase Production and Activity. *Turkish Journal of Biohemistry*, *37*(July), 287–293.

Islam, M. A., Ethiraj, B., Cheng, C., Yousuff, A., & Khan, M. M. (2017). Electrogenic and Antimethanogenic Properties of Bacillus cereus for Enhanced Power Generation in Anaerobic Sludge-Driven Microbial Fuel Cell. *Energy & Fuels*, *31*(6), 6132–6139.

Ivanov, V. (2015). *Environmental Microbiology for Engineers* (2nd ed.). Florida: CRC Press. Retrieved from https://books.google.com.my/books?id=1731CwAAQBAJ&pg

Izumi, K., Okishio, Y., Nagao, N., Niwa, C., Yamamoto, S., & Toda, T. (2010). Effects of Particle Size on Anaerobic Digestion of Food Waste. *International Biodeterioration & Biodegradation*, *64*(7), 601–608.

Jahangeer, S., Khan, N., Jahangeer, S., Sohail, M., Shahzad, S., Ahmad, A., & Khan, S. A. (2005). Screening and Characterization of Fungal Cellulases Isolated from The Native Environmental Source. *Pakistan Journal of Botany*, *37*(3), 739–748.

Janda, J., & Abbott, S. (2007). 16S rRNA Gene Sequencing for Bacterial Identification in the Diagnostic Laboratory : Pluses , Perils , and Pitfalls. *Journal of Clinical Microbiology*, *45*(9), 2761–2764.

Jorgensen, P. J. (2009). *Biogas-Green Energy*. (A. B. Nielsen & F. Bendixen, Eds.) (2nd ed.). Tjele, Denmark: Aarhus University.

Jurick, W. M., Vico, I., Whitaker, B. ., Gaskins, V. L., & Janisiewicz, W. J. (2012). Application of the 2-Cyanoacetamide Method for Spectrophotometric Assay of Cellulase Enzyme Activity. *Plant Pathology Journal*, *11*(1), 38–41.

Kardooni, R., Yusoff, S., & Karl, F. (2016). Renewable Energy Technology Acceptance in Peninsular Malaysia. *Energy Policy*, *88*, 1–10.

Karmakar, M., & Ray, R. (2011). Current Trends in Research and Application of Microbial Cellulase. *Research Journal of Microbiology*, *6*(1), 41–53.

Ketnawa, S., Chaiwut, P., & Rawdkuen, S. (2012). Food and Bioproducts Processing Pineapple Wastes : A Potential Source for Bromelain Extraction. *Food and Bioproducts Processing*, *90*(3), 385–391.

Kim, H., Yonn, B., Choung, D., Oh, H., Katsuragi, T., & Tani, Y. (1999). Characterization of a Biosurfactant, Mannosylerythritol Lipid Produced from Candida sp. SY16. *Applied Microbiology and Biotechnology*, *52*(5), 713–721.

Kiran, E. U., Trzcinski, A. P., Ng, W. J., & Liu, Y. (2014). Bioconversion of Food Waste to Energy : A Review, *134*, 389–399.

Kumar, M., Samuel, J., Lakshmishri, U., & Banerjee, R. (2014). Biomethanation of Pineapple Wastes Using Potent Anaerobic Consortia Substituting Cow Manure. *Environmental Engineering and Management Journal*.

Kumar, R., Singh, S., & Singh, O. V. (2008). Biochemical of Lignocellulosic Biomass: Biochemical and Molecular Perspectives. *Journal of Industrial Microbiology and Biotechnology*, *35*(5), 377–391.

Kwietniewska, E., & Tys, J. (2014). Process Characteristics, Inhibition Factors and Methane Yields of Anaerobic Digestion Process, with Particular Focus on Microalgal Biomass Fermentation. *Renewable and Sustainable Energy Reviews*, *34*, 491–500.

Kwon, K. S., Kang, H. G., & Hah, Y. C. (1992). Purification and Characterization of Two Extracellular Beta-Glucosidase from Aspergillus nidulans. *FEMS Microbiology Letters*, *76*(1–2), 149–153.

Latge, J. (1999). Aspergillus fumigatus and Aspergillosis. *Clinical Microbiology Reviews*, *12*(2), 310–350.

Li, Z., Yao, G., Wu, R., Gao, L., Kan, Q., & Liu, M. (2015). Synergistic and Dose-Controlled Regulation of Cellulase Gene Expression in Penicillium oxalicum.

PLOS Genetic, *11*(9), 1–45.

Liu, D., Zhang, R., Yang, X., Wu, H., Xu, D., Tang, Z., & Shen, Q. (2011). Thermostable Cellulase Production of Aspergillus fumigatus Z5 under Solid-State Fermentation and Its Application in Degradation of Agricultural Wastes. *International Biodeterioration & Biodegradation*, *65*(5), 717–725.

Lun, O. K., Wai, T. B., & Ling, L. S. (2014). Pineapple Cannery Waste as A Potential Substrate for Microbial Biotransformation to Produce Vanillic Acid and Vanillin, *21*(3), 953–958.

Maile, I. I., & Muzenda, E. (2014). 'Production of Biogas from Various Substrates under Anaerobic Conditions' in *International Conference on Innovative Engineering Technologies*, 78–80.

Maki, M., Leung, K. T., & Qin, W. (2009). The Prospects of Cellulase-Producing Bacteria for The Bioconversion of Lignocellulosic Biomass. *International Journal of Biological Sciences*, *5*(5), 500–516.

Malaysia Energy Information Hub. (2015). Summary-Final Energy Demand. Retrieved April 10, 2016, from http://meih.st.gov.my/statistics

Malaysian Pineapple Industry Board. (2016). Pineapple Info: Marketing. Retrieved April 15, 2016, from http://mpib.gov.my/en/pasaran

Mamun, M. R. A., & Torii, S. (2017). Enhancement of Methane Concentration by Removing Contaminants from Biogas Mixtures Using Combined Method of Absorption and Adsorption. *International Journal of Chemical Engineering*, *2017*, 1–9.

Martin, K. J., & Rygiewicz, P. T. (2005). Fungal-Specific PCR Primers Developed for Analysis of The ITS Region of Environmental DNA Extracts. *BMC Microbiology*, *11*, 1–11.

May, G., & Spanos, C. (2006). *Fundamentals of Semiconductor Manufacturing and Process Control*. Hoboken, New Jersey: John Wiley & Sons, Inc.

Mazzucotelli, C. A., Ponce, A. G., Kotlar, C. E., & Moreira, R. (2013). Isolation and Characterization of Bacterial Strains with A Hydrolytic Profile with Potential Use in Bioconversion of Agroindustial By-Products and Waste. *Food Science and Technology*, *33*, 295–303.

Meesap, K., Boonapatcharoen, N., Techkarnjanaruk, S., & Chaiprasert, P. (2012). Microbial Communities and Their Performances in Anaerobic Hybrid Sludge Bed-Fixed Film Reactor for Treatment of Palm Oil Mill Effluent under Various Organic Pollutant Concentrations. *Journal of Biomedicine and Biotechnology*, *2012*, 1-11.

Melloul, E., Luggi, S., Anais, L., Arne, P., Costa, J., Fihman, V., Briard, B., Dannaoui, E., Guillot, J., Decousser, J-W., Beauvais, A., & Botterel, F. (2016). Characteristics of Aspergillus fumigatus in Association with Stenotrophomonas maltophilia in An In Vitro Model of Mixed Biofilm. *PLoS ONE*, *11*(11), 1–18.

Minde, G. P., Magdum, S. S., & Kalyanraman, V. (2013). Biogas as A Sustainable Alternative for Current Energy Need of India, *4*, 121–132.

Mirdamadian, S., Khayam-Nekoui, S., & Ghavanti, H. (2011). Reduce of Fermentation Time in Composting Process by Using A Special Microbial Consortium. *World Academy of Science , Engineering and Technology*, *76*, 533–537.

Moemen, D., Bedir, T., Awad, E., & Ellayeh, A. (2015). Fungal Keratitis: Rapid Diagnosis Using Methylene Blue Stain. *Egyptian Journal of Basic and Applied Science*, *2*, 289–294.

Mohd Zain, N. A., Shen, N. S., Suhaimi, M. S., Hasan, N. B., & Aziman, S. N.

(2012). Jurnal Teknologi Full paper Potential Use of Liquid Pinapple Waste for Bioethanol Production by Immobilized Bakers ' Yeast, *59*, 43–47.

Monnet, F. (2003). *An Introduction to Anaerobic Digestion of Organic Wastes.* Scotland.

Moyes, R., Reynolds, J., & Breakwell, D. (2009). Differential Staining of Bacteria: Gram Stain. *Current Protocol in Microbiology*.

Muller, J., & Polak, A. (2003). *Antifungal Agents Advances and Problems*. (E. Jucker, Ed.). Ettingen, Switzerland: Springer Basel AG.

Musa, Z. (2014, March). Demand for Pineapples. *The Star Online*. Johor Bahru. Retrieved from http://www.thestar.com.my/news/community/2014/03/31/demand-for-pineapples-three-new-markets-show-interest-in-the-fresh-fruit/

Mutschlechner, M., & Wagner, A. O. (2015). Biological Pre-treatment: Enhancing Biogas Production Using The Highly Cellulolytic Fungus Trichoderma Viride. *Waste Management*, *43*, 98–107.

Nagao, N. (2012). Maximum Organic Loading Rate for The Single-Stage Wet Anaerobic Digestion of Food Waste. *Bioresource Technology*, *118*, 210–218.

Naik, L., Gebreegziabher, Z., Tumwesige, V., Babulo, B., Mwirigi, J., & Austin, G. (2014). Factors Determining the Stability and Productivity of Small Scale Anaerobic Digesters. *Biomass and Bioenergy*, *70*, 51–57.

Nakthong, N., Wongsagonsup, R., & Amornsakchai, T. (2017). Characteristics and Potential Utilization of Starch from Pineapple Stem Waste. *Industrial Crops and Products*, *105*, 74-82.

Naskeo Environnement. (2009). The Biogas. Retrieved December 1, 2017, from http://www.biogas-renewable-energy.info/biogas_composition.html

Nasr, N., Elbeshbishy, E., Hafez, H., & Naggar, M. H. (2012). Comparative Assessment of Single-Stage and Two-Stage Anaerobic Digestion for The Treatment of Thin Stillage. *Bioresource Technology*, *111*, 122–126.

Nasr, N., Elbeshbishy, E., Hafez, H., Nakhla, G., & El, M. H. (2012). Bioresource Technology Comparative Assessment of Single-Stage and Two-Stage Anaerobic Digestion for The Treatment of Thin Stillage. *Bioresource Technology*, *111*, 122–126.

Neethu, K., Rubeena, M., Sajith, S., Sreedevi, S., Priji, P., Unni, K. N., Josh, M. K. S., Jisha, V. N., Pradeep, S. & Benjamin, S. (2012). A Novel Strain of Trichoderma Viride Shows Complete Lignocellulolytic Activities, *2012*(3), 1160–1166.

Neoh, C., Yahya, A., Adnan, R., Majid, Z., & Ibrahim, Z. (2013). Optimization of Decolorization of Palm Oil Effluent (POME) by Growing Cultures of Aspergillus Fumigatus using Response Surface Methodology. *Environemntal Science and Pollution Research*, *20*(5), 2912–2923.

Nochur, S. V., Roberts, M., & Demain, A. L. (1993). True Cellulase Production by Clostridium thermocellum Grown on Different Carbon Sources. *Biotechnology Letters*, *15*(6), 641–646.

Nwuche, C., Aoyagi, H., & Ogbonna, J. (2014). Treatment of Palm Oil Effluent by A Microbial Consortium Developed from Compost Soils. *International Scholarly Research Notices*, *2014*, 1–8.

O-Thong, S., Boe, K., & Angelidaki, I. (2012). Thermophilic Anaerobic Co-digestion of Oil Palm Empty Fruit Bunches with Palm Oil Mill Effluent for Efficient Biogas Production. *Journal Applied Energy*, *93*, 648–654.

Okudoh, V., Trois, C., Workneh, T., & Schmidt, S. (2014). The Potential of Casaava

Biomass and Applicable Technologies for Sustainable Biogas Production in South Africa: A Review. *Renewable and Sustainable Energy Reviews*, *39*, 1035–1052.

Onojo, O., Chukwudebe, G., Okafor, E., Ononiwu, G., Chukwuchekwa, N., Opara, R., & Dike, D. (2013). Estimation Of The Electric Power Potential Of Human Waste Using Students Hostel Soak-Away Pits . *American Journal of Engineering Research (AJER)*, *2*(9), 198–203.

Parajuli, P. (2011). *Biogas Measurement Techniques and The Associated Errors.* University of Jyvaskyla.

Park, S., Cho, M., Lim, J. K., Kim, J., Hwan, J., Kwon, D. Y., & Park, C. (2007). A New Colorimetric Method for Determining the Isomerization Activity of Sucrose Isomerase. *Bioscience, Biotechnology and Biochemistry*, *71*(2), 583–586.

Pathan, F. S., Khan, Z., Semwal, P., George, S., & Dilip, C. (2012). Study of Residual Gas Analyser (RGA) Response towards Known Leaks Study of Residual Gas Analyser (RGA) Response towards Known Leaks. *Journal of Physics: Conference Series*, *390*, 1–6.

Paul, D. (2016). Microorganisms and α -Amylase: A Concise Reveiw. *Innovare Journal of Sciences*, *4*(4), 1–5.

Pavia, D., Lampman, G., Kritz, G., & Engel, R. (2006). *Introduction to Organic Laboratory Techniques: A Microscale Approach* (4th ed.). St. Paul, MN: Cengage Learning, Brooks/Cole Publishing Co.

Pechsuth, M., Prasertsan, P., & Ukita, M. (2001). High-Rate Anaerobic Treatment of Palm Oil Mill Effluent. *Songklanakarin Journal Science of Technology*, *23*, 779–787.

Perez, J., Munos-Dorado, J., de la Rubia, T., & Martinez, J. (2002). Biodegradation and Biological Treatments of Cellulose, Hemicellulose and Lignin: An Overview. *International Microbiology*, *5*(2), 53–63.

Pike Research. (2012). *Renewable Biogas Methane Recovery and Utilization in Landfills and Anaerobic Digesters: Municipal Solid Waste, Agricultural, Industrial, and Wastewater Market Report and Analysis and Forecasts.* Boulder.

Polvinen, K., Lethonen, P., Leisola, M., & Visuri, K. (1991). 'Pilot-Scale production and Properties of Lignin Peroxidases' in G. Leatham & M. Himmel (Eds.), *Enzymes in Biomass Conversion* , 225–235. American Chemical Society.

Poszytek, K., Ciezkowska, M., & Sklodowska, A. (2016). Microbial Consortium with High Cellulolytic Activity (MCHCA) for Enhanced Biogas Production, *7*(March), 1–11.

Pryce, T. M., Palladino, S., Kay, I. D., & Coombs, G. W. (2003). Rapid Identification of Fungi by Sequencing The ITS1 and ITS2 Regions Using an Automated Capillary Electrophoresis System. *Medical Mycology*, *41*, 369–381.

Qu, X., He, P., Shao, L., & Bouchez, T. (2009). Effect of Moisture Content on Anaerobic Methanization of Municipal Solid Waste. *Huan Jing Ke Xue*, *30*(3), 918–923.

Raboni, M., & Urbini, G. (2014). Production and Use of Biogas in Europe : A Survey of Current Status and Perspectives. *Ambiente & Agua, 9*,1-12.

Rahayu, A., Karsiwulan, D., Yuwono, H., Trisnawati, I., Mulyasari, S., Rahardjo, S., Hokermin, S. & Paramita, V. (2015). *POME-to-Biogas*. (B. Castermans, H. Yuwono, R. Hardison, & V. Paramita, Eds.) (2nd ed.). Jakarta Selatan: Winrock International.

Rani, D., & Nand, K. (2003). Ensilage of Pineapple Processing Waste For Methane Generation. *Waste Management*, *24*(5), 523–28.

Reungsang, A., & Sreela-or, C. (2013). Bio-Hydrogen Production from Pineapple Waste Extract by Anaerobic Mixed Cultures. *Energies*, *6*, 2175–2190.

Roha, S. (2013). Determination of Sugar Content in Pineapple Waste Variety N36. *International Food Research Journal*, *20*(4), 1941–1943.

Ruekeith, G. O. (2015, November). Malaysia Pineapple Industry Board Looks to Control Five Per Cent of The Global Market. *Borneo Post Online*. Kuching. Retrieved from http://www.theborneopost.com/2015/11/30/malaysia-pineapple-industry-board-looks-to-control-five-per-cent-of-the-global-market/

Ryan, M., Fitzgerald, G. F., Sinderen, D. V., (2006). Screening for and Identification of Starch- , Amylopectin- , and Pullulan-Degrading Activities in Bifidobacterial Strains, *72*(8), 5289–5296.

Sacchi, C. T., Whitney, A. M., Mayer, L. W., Morey, R., Steigerwalt, A., Boras, A., Weyant, R. S., & Popovic, T. (2002). Sequencing of 16S rRNA Gene : A Rapid Tool for Identification of Bacillus anthracis. *Emerging Infectious Diseases*, *8*(10), 1117–1123.

Sagagi, B., Garba, B., & Usman, N. (2009). Studies on Biogas Production From Fruits and Vegetable Waste. *Bayero Journal of Pure Applied Science*, *2*(1), 115–8.

Sagar, K., Bashir, Y., Phukan, M. M., & Konwar, B. K. (2013). Isolation Of Lipolytic Bacteria From Waste Contaminated Soil : A Study With Regard To Process Optimization For Lipase. *International Journal of Scientific & Technology Research*, *2*(10), 214–218.

Saha, B. C. (2003). Hemicellulose Bioconversion. *Journal of Industrial Microbiology and Biotechnology*, *30*, 279–291.

Saheed, O. K., Jamal, P., Karim, M. I. A., Alam, Z., & Muyibi, S., A. (2013). Cellulolytic Fruit Wastes: A Potential Suppport for Enzyme Assisted Protein Production. *Journal of Biological Sciences, 13*(5), 379-385.

Sankari, D., & Divagar, M. (2015). Comparative Analysis of Amylase Production by Proteus from Different Soil Habitat. *International Journal of Pharmacy and Pharmaceutical Sciences*, *7*(1), 1–4.

Santosh, Y., Sree, K., Kohli, S., & Rana, V. (2004). Enhancement of Biogas Production From Solid Substrates Using Different Techniques-A Review. *Bioresource Technology*, *95*, 1–10.

Satyanaraya, T., Noorwez, S. ., Kumar, S., Rao, J., Ezhilvannan, M., & Kaur, P. (2004). Development of An Ideal Starch Saccharification Process Using Amylolytic Enzymes from Thermophiles. *Biochemical Society Transactions*, *32*(Pt 2), 276–8.

Schoch, C. L., Seifert, K. A., Huhndorf, S., Robert, V., Spouge, J. L., & Levesque, C. A. (2012). Nuclear Ribosomal Internal Transcribed Spacer (ITS) Region as A Universal DNA Barcode Marker for Fungi. *Proceedings of the National Academy of Sciences*, *109*(16), 6241–6246.

Sebola, M., Tesfagiorgis, H., & Muzenda, E. (2015). Effect of Particle Size on Anaerobic Digestion of Different Feedstocks. *South African Journal of Chemical Engineering*, *20*(3), 11–26.

Shah, F. A., Mahmood, Q., Shah, M. M., Pervez, A., & Asad, S. A. (2014). Microbial Ecology of Anaerobic Digesters : The Key Players of Anaerobiosis. *The Scientific World Journal*, *2014*, 1–21.

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., Singh, S., Bali, V., Sharma, L., & Mangla, J. (2014). Production of Fungal Amylases Using Cheap, Readily Available Agriresidues, for Potential Application in Textile Industry. *Biomedical Research International*, *2014*, 1–9.

Singh, S., Singh, S., Bali, V., Sharma, L., & Mangla, J. (2014). Production of Fungal Amylases Using Cheap , Readily Available Agriresidues , for Potential Application in Textile Industry. *Biomedical Research International*, *2014*, 1–9.

Smitha, R. (2010). *Dual Production of Endotoxin and Amylase from Bacillus Thuringiensis subsp. Kurstaki by Fermentation and Eficacy Studies of Endotoxin Against Eriophyid Mite*. Ph.D Thesis, University of Calicut, India.

Sommer, S., Moller, H., & Peterson, S. (2002). *Reduction in Methane and Nitrous Oxide Emission from Animal Slurry Through Anaerobic Digestion. Proceedings of the Third International Symposium*. Netherlands: Millpress Science Publisher.

Srinivasan, R., Karaoz, U., Volegova, M., Mackichan, J., & Kato-, M. (2015). Use of 16S rRNA Gene for Identification of a Broad Range of Clinically Relevant Bacterial Pathogens. *PLOS ONE*, 10(2), 1–22.

Stetzenbach, L. D., & Yates, M. V. (2003). *The Dictionary of Environmental Microbiology*. California: Elsevier Science.

Tangphatsornruang, S., Naconsie, M., Thammarongtham, C., & Narangajavana, J. (2005). Isolation and Characterization of An Alpha-Amylase Gene in Cassava (Manihot Esculenta). *Plant Physiology and Biochemistry*, *43*(9), 821–827.

The Star. (2012a, October 21). United Plantations Plans More Biogas Plants. *Sustainable Energy Development Authority Malaysia.* Kuala Lumpur. Retreived from http://seda.gov.my/

The Star. (2012b, December 11). Advocating Green Practices. *Sustainable Energy Development Authority Malaysia.* Kuala Lumpur. Retreived from http://seda.gov.my/

Tille, P. (2013). *Bailey & Scott's Diagnostic Microbiology* (13th ed.). Missouri: Elsevier MOSBY. Retrieved from https://books.google.com.my/books?id=DVhPAQAAQBAJ

Tumuluru, J. S., Sokhansanj, S., Wright, C. T., & Kremer, T. (2012). 'GC Analysis of Volatiles and Other Products from Biomass Torrefaction Process' in M. Mohd (Ed.), *Advanced Gas Chromatography-Progress in Agricultural, Biomedical and Industrial Applications*, 211–230. Croatia: InTech.

Turner, P., Taylor, S., Clarke, E., Harwood, C., Cooke, K., & Frampton, H. (2004). Calibration Effects During Natural Gas Analysis Using A Quadrupole Mass Spectrometer. *Trends in Analytical Chemistry*, *23*(4), 281–287.

Ugwoke, D., & Ekpe, E. (2011). Comparative Study of Biogas Generations from Pineaple Peels and Spent Maize Grains Wastes and Their Ph - Parametric Correlations Using A Galvanized Iron Fixed-Dome Biodigester. *Global Journal of Science Frontier Research*, *11*(9), 12–20.

Ukpabi, C., Nitwunka, O., Emole, E., Ndulaka, J., Nwachukwu, I., & Esenamunjor, C. (2017). Biogas Production from Blends of Cow and Fowl Dung Using Locally Made Anaerobic Digester. *Energy and Power*, *7*(2), 37–40.

Vardhini, R. D. S., Naik, B. R., Neelima, M., & Ramesh, A. B. (2013). Screeining and Production of a-Amylase from Aspergillus Niger Using Zero Value Material for Solid State Fermentation. *International Journal of Pharmacy and*

Pharmaceutical Sciences, *5*(1), 55–60.

Vercoe, P., Makkar, H. P., & Schlink, A. (Eds.). (2010). *In Vitro Screening of Plant Sources for Extra-Nutritional Attributes in Ruminants: Nuclear and related Methodologies*. New York: Springer. Retrieved from https://books.google.com.my/books?id=F58Hj-o8qpgC

Voća, N., Krička, T., Ćosić, T., Rupić, V., Jukić, Ž., & Kalambura, S. (2005). Digested Residue as A Fertilizer After The Mesophilic Process of Anaerobic Digestion. *Plant Soil Environment*, *2005*(6), 262–266.

Wakil, S., Adelabu, B., & Fasiku, S. A. (2013). Production of Bioethanol from Spontaneous Fermentation of Palm Oil Mill Effluent (POME). *Researcher*, *5*(2), 28–35.

Wang, J. (2014). Decentralized Biogas Technology of Anaerobic Digestion and Farm Ecosystem : Opportunities and Challenges, *2*(March), 1–12.

Wang, W., Song, Y., Wang, Y., Gao, Y., Jing, R., & Cui, Z. (2011). Biodiversity of Mesophilic Microbial Community BYND-8 Capability of Lignocellulose Degradation and Its Effect on Biogas Production, *31*(1), 253–258.

Webster, J., & Weber, R. W. S. (2007). *Introduction to Fungi* (3rd ed.). New York: Cambridge University Press. Retrieved from http://www.dbbe.fcen.uba.ar/contenido/objetos/WEBSTER30521807395_1400021643840195.pdf

Wei, C., Sieng, L., Hussaini, A., Zulkarnian, A., Apun, K., Bilung, L., & Vincent, M. (2015). Molecular Technique Identification of The Microbial Population in Palm Oil Mill Effluent (POME). *Journal of Oil Palm Research*, *27*(3), 293–298.

Wirth, R., Kovács, E., Maróti, G., Bagi, Z., Rákhely, G., & Kovács, K. L. (2012). Characterization of A Biogas-Producing Microbial Community by Short-Read Next Generation DNA Sequencing. *Biotechnology for Biofuels*, *5*(41), 1–16.

Wong, Y., Teng, T., & Ong, S. (2014). RSC Advances Suspended Growth Kinetic Analysis on Biogas Generation from Newly Isolated Anaerobic Bacterial Communities for Palm Oil Mill Effluent at Mesophilic. *Royal Society of Chemistry Advances*, *4*, 64659–64667.

Xu, G. (1997). History of The Gram Stain and How It Works. Retrieved October 20, 2017, from http://www.uphs.upenn.edu/bugdrug/antibiotic_manual/gram1.htm

Yamane, K., Suzuki, H., & Nisizawa, K. (2008). Purification and Properties of Extracellular and Cell-bound Cellulase Components of Pseudomonas Fluorescens var. cellulosa. *The Journal of Biochemistry*, *67*(1970), 19–35.

Zeikus, J. (2012). The Biology of Methanogenic Bacteria. *Bacteriological Reviews*, *105*, 169–173.

Zeshan Karthikeyan, O., & Visvanathan, C. (2012). Effect of C/N ratio and Ammonia-N Accumuluation in A Pilot-Scale Thermophilic Dry Anaerobic Digester. *Bioresource*, *113*, 294–302.

Zhang, H. (2010). *Enzymatic Hydrolysis ,Bbioethanol and Biogas PotentialT Tests on Cellulosic Materials*. Swedish University.

Zhang, J., Sun, K., Wu, M., & Zhang, L. (2006). Influence of Temperature on Performance of Anaerobic Digestion of Municipal Solid Waste. *Journal of Environmental Sciences*, *18*(4), 810–815.

Zhao, Y., Niu, W., Sun, Y., Hao, H., Yu, D., Xu, G., Shang, X., Tang, X., Lu, S., Yue, J., and Li, Y. (2015). Identification and Characterization of a Serious Multidrug Resistant Stenotrophomonas maltophilia Strain in China. *Biomedical Research International*, *2015*, 1–10.

Zverlove, V., Heigl, W., Kock, D. E., Kellermann, J., Kollmeier, T., & Schwarz, W.

(2010). Hydrolytic Bacteria in Mesophilic and Thermophilic Degradation of Plant Biomass. *Engineering in Life Science*, *10*(6), 528–536.