Comparative Study of Biogas Production from Cocoa Pod, Maize Husk, Orange Peels, Pineapple Peels and Coconut Fiber Co-Digested With Yeast

M.A. Enaboifo, C.A. Adadu

ABSTRACT
Background: The demand and cost of domestic energy in Nigeria are on the increase, primarily due to the increasing human population and demand. This is compounded by desertification, increasing the cost of electricity, industrialization, lack of alternative such as solar, wind and nuclear energy. This study was conducted to compare the potential of biogas produced from anaerobic co-digestion of coconut fibre, cocoa pods, maize husk, orange peels, pineapple peels and yeast and to determine the effect of pH and retention time on biogas yield.

Methods: During the experiment, five batch reactors/digesters were used. The digesters were labeled A, B, C, D, E and each replicated three times. Digester A consist of 2g of yeast, 4g of coconut fibre, digester B consist of 2g of yeast, 4g of cocoa pods, digester C consist of 2g of yeast, 4g of maize husk, digester D consist of 2g of yeast, 4g of orange peels and digester E consist of 2g of yeast, 4g of pineapple peels. The pH was determined before corking the reactors.

Result: The results showed significant differences among the different substrate for biogas yield and methane component. Biodegradability of the different substrate, quality and retention time significantly affected the biogas yield in the five digesters. Digester loaded with maize husk produced significantly higher volume of biogas and methane component compared with other substrate. Increase in biogas yield for maize husk of 4g was 23.33ml with methane component of 61.78% for the 10 days hydraulic retention time. The retention time of 4, 5, 6 and 8 days significantly produced the highest volume of biogas in the other digesters. Based on the findings, maize husk and yeast blend could be a rich source of renewable energy option and would help arrest ecological disaster in addition to control of deforestation.

Key words: Biogas, Coconut fiber, Cocoa pod, Comparative study, Maize husk, Orange peels, Pineapple peels.
Collection of materials

Maize husk was collected from the University of Benin, Faculty of Agriculture research farm residue, pineapple peels, orange peels, cocoa pods and coconut fiber from Uselu market.

Pre-treatment operation

Pre-treatment operations involved weighing about 100g of the biomasses and allowing them to dry under direct sunlight for a period of 21 days to constant weight. The sun dried biomasses were then grounded to fine particles using mortar and pestle.

Experimental procedure

A set of five (5) batch reactors was used as digesters. Each digester contained fixed amount of yeast. The digesters were labeled A, B, C, D and E respectively. The dry weights of these biomasses were taken with a weighing balance which was then filled into the digesters.

Composition of the batch reactor digesters A to E are as follows: Digester A consist of 2g of yeast, 4g of coconut fibre, digester B consist of 2g of yeast, 4g of cocoa pods, digester C consist of 2g of yeast, 4g of maize husk, digester D consist of 2g of yeast, 4g of orange peels, digester E consist of 2g of yeast, 4g of pineapple peels. These substrates were then mixed with 100ml of distilled water and then corked to exclude air. The contents of the digesters were then allowed to ferment for a period of 12 days. The fermentation vessels were laid to stand upright supported with a retort stand in order to avoid disturbance of the sediments and the scum layer. Biogas measurement was then carried out using water displacement method (Momoh et al., 2008). The experiment was replicated three times. During the period of biogas production, daily reading of the amount of biogas produced and the pH before and after the experiment (Table 1) was determined using a pH meter. Data obtained from the volume of gas production for each of the systems was subjected to GenStat 12.1 for windows.

RESULTS AND DISCUSSION

The results of pH before and after the experiment are presented in Table 1. Significance difference was not observed in the pH in digester A and B but was observed in digester C, D and E before the experiment. Significance difference was observed in digester A, B, C, D and E after the experiment (Fig 1–6). The pH of digester C is 5.236 compare to 5.640, 5.453 and 4.820 for digester A,B,D and E. Day Two and three of the experiment shows that significant difference was not observed in digester B, C, D and E but was observed in digester A. In day four, five and six, significant difference was not observe in digester A,B,D and E but was observed in digester C. So also in day seven and nine where there was no significant different in digester A,B,C,D and E. In day eight, significant difference was not observed in digester A and B, D and E but was observed in digester B and C. Also in day ten where significant difference was not observed in digester BCD and Table 1: pH of the digesters.

| Digesters | pH before biogas production | pH after biogas production |
|-----------|-----------------------------|----------------------------|
| A         | 6.247<sup>a</sup>           | 5.640<sup>a</sup>           |
| B         | 6.333<sup>b</sup>           | 5.453<sup>a</sup>           |
| C         | 6.577<sup>c</sup>           | 5.263<sup>a</sup>           |
| D         | 5.830<sup>d</sup>           | 4.673<sup>a</sup>           |
| E         | 6.420<sup>e</sup>           | 4.820<sup>b</sup>           |
| Lsd       | (0.03452)                   | (0.06823)                   |

Fig 1: Graph of cumulative volume of biogas (ml).

Fig 2: Graph of cumulative volume of biogas (ml) against pH after biogas production.

Fig 3: Graph of daily volume of biogas (ml) for digester A against retention time.
E but was observed in digester A (Table 2). The biogas yield for digester C was 15.668, 9.666, 10.332 and 10.668ml higher than digester A, B, D and E.

The result showed that the pH before the experiment was within the optimum range for biogas production. The drop in pH to a more acidic level can be attributed to activities of aerobes and facultative aerobes which are essential to produce relevant acidic metabolites, which are acted on by methanogenic bacteria to produce methane which is in conjunction with the findings of (Farrel et al., 2008).

There was a slow commencement and gradual increase in biogas production with reference to retention time, until at its pick when it started decreasing. This can be attributed to microbial response to temperature requirement. This result agrees with the findings of Wei et al., (2011) who reported an increasing trend of biogas production from commencement and a drop after 30 days. Alkan-Ozkaynak and Karthikayan, (2011) also reported a high rate of biogas production from treated thin silage with a drop towards the end of the experiment.

The fast yield of biogas can be attributed to seeding of the digesters with yeast as an inoculums, pH and constituent of the substrates. This agrees with Abdurahman et al., (2013) who reported that during bio-methanation process, several factors including pH, mixing, operating temperature, nutrient availability and organic loading rates and microbial activity influence the overall methane yield. Irvan et al., (2012) also reported that in an anaerobic digestion, the microorganisms in anaerobic/anoxigenic conditions help in the stabilization of the organic matter by converting it into methane and other useful product. The biogas production variation can be attributed to the quality and quantity of agricultural materials, the nature, and composition of the digester feedstock. This agrees with Yerima and Richard (2012) who stated that different agricultural wastes gives different yield of methane mainly due to their degradability. Pavan et al., (2009) also reported that garden wastes are indeed known to yield much less biogas, relative to kitchen wastes, due to the higher proportion of poorly degradable lignocellulosic fibers. Reduction in biogas yield close to the end of experiment could be attributed to the utilization of the available nutrient in the digesters thereby reducing the organic reduction rate to produce methane. Khong et al., (2012) stated that...
acclimatization can be achieved by adding biomass to adjust the properties of the mixture in a certain proportion over a period of time. The authors stated that these could enhance the tolerance level, lag phase reduction before methane production and overall decrease in toxicity build up. The nutrients especially light ions can cause inhibition. Therefore, it should be noted that biogas yield could be affected by the nature, quality of the agricultural material, seeding of the inoculum, pH and hydraulic retention time.

CONCLUSION

Results obtained from this study have shown that biogas production from cocoa nut fiber, cocoa pod, maize husk, orange peel and pineapple peel could be highly enhanced by blending it with yeast as an inoculum. Blending maize husk and yeast produced the highest volume of biogas yield and methane component. This blend could be a rich source of renewable energy option and would help arrest ecological disaster in addition to control of deforestation.

REFERENCES

Abdullahi, I., Ismail, A., Musa, A.O. and Galadima, A. (2011). Effect of Kinetic Parameters on Biogas Production from Local Substrate using a Batch Feeding Digester. European Journal of Scientific Research. ISSN 1450 - 216x. 57(4): 626-634.

Abdurahman, N.H., Rosli, Y.M., Azhari, N.H., Tam, S.F. (2011). Biomethanation of Palm Oil Mill Effluent (POME) by Membrane Anaerobic System (MAS) using POME as a Substrate, World Academy of Sci., Eng. and Technol. 51: 419-424.

Adeleye, A., O. and Bamgbaye, O.M. (2012). Comparison of biogas productivity of cassava peels mixed with selected ratio with major livestock waste types. J. Agric. Research. 4(7): 571-577.

Adeyanju, A.A. (2008). Effect of Seedling of Wood Ash on Biogas Production Using Pig Waste and Cassava Peel. Journal of Engineering and Applied Sciences. 3: 245-245.

Adeyosoye, O.I., Adesokan, I.A. and Ekeocha, A.H. (2010). Estimation of Proximate Composition and Biogas Production from In vitro Gas Fermentation of Direct Potato (Ipomea batatas) and Wild Cocoyam (Colocasia esculenta) Peels. African Journal of Environmental Science and Technology. 4 (6): 388-391.

Alkan-Ozkaynak, A., Karmikayan, K.G. (2011). Anaerobic digestion of thin sillage for energy recovery and water reuse in corn-ethanol plants. Biore. Technol. 102(21): 9891-6.

Chotwattanasak, J., Puetpaiboon, U. (2011). Full Scale Anaerobic Digester for Treating Palm Oil Mill Wastewater. J. of Sustainable Energy and Environ. 2: 133-136.

Farrel, A.E., Plevin, R.J., Turner, B.T., Jones, A.D., O’Hare, M., Kammen, D.M. (2008) Ethanol can contribute to energy and environmental goals. Sci. 311: 506-508.

Ivan, T., Trisakti, B., Wongistanti, V., Tomiuchi, Y. (2012). Methane emission from digestion of palm oil mill effluent (POME) in a Thermophilic anaerobic reactor. Int. J. Sci. and Eng.3(1): 32-35.

Khong, F.C., Isa, M.H., Kuttly, S.R.M., Farhan, S.A. (2012). Anaerobic treatment of produce water. World Academy of Sci. and Technol. 62: 798-802.

Liu, D., Liu, D., Zeng, R.J., Angelidaki, I., (2006). Hydrogen and methane production from household solid waste in the two-stage fermentation process. Water Research. 40: 2230-2236.

Meena, K. and Vijay, V.K. (2010). Biogas for overcoming energy scarcity and climate change in India. Proceedings of the first international conference on ‘New Frontiers in Biofuels, DTU’ New Delhi.
Momoh, O.L. Yusuf; Nwaogazie, L.Ify (2008). Effect of waste paper on biogas production from co-digestion of cow dung and water hyacinth in Batch Reactors, J. Appl. Sc. Environ. Manage. 12(4): 95-98.

Nayono, S.E. (2010). Anaerobic digestion of organic wastes for energy. Scientific Publishing. ISBN 978-3-86644-464-5: 7-20.

Nipay, P.C. (2010). Influence of temperature on biogas production from *Pistia stratiotes*. Biological Wastes. 19: 267-274.

Nizami, A.S., Orozco, A., Groom, E., Dieterich, B., Murphy, J.D., (2012). How much gas can we get from grass? Applied Energy. 92: 783-790.

Patil, J.H., Molayan, L., Antony, R. and Hosur, M. (2011). Biomethanation of water hyacinth, poultry litter, cow manure and primary sludge: A comparative analysis. Research Journal of Chemical Sciences. 1(7): 22-26.

Pavan, P., Battistoni, P. and Mata-Alvarez, J. (2009). Performance of thermophilic semi-dry anaerobic digestion process changing the feed biodegradability. In II International Symposium Anaerobic Digestion of Solid Waste, [Mata-Alvarez, J., A. Tillehe and J. Cecchi, (eds.)], International Association of Water Quality, Barcelona, Spain. 57-64.

Rasheed, M.B. (2014). The effect of temperature on the biogas production from olive pomace. Zawia University Bulletin. 3(16): 1-14.

Tsunatu, D.Y., Azuaga, I.C. and Agabison, J., (2014). Evaluation of the effect of total solids concentration on biogas yields of agricultural wastes. International Research Journal of Environment Sciences. 3(2): 70-75.

Wei, Q., Chong, P., Wei, W., Zhong Zhi, Z. (2011). Biogas production from supernatant of hydrothermally treated municipal sludge by up flow anaerobic sludge blanket reactor. Biore. Technol. 102(21): 9904-9911.

Xuupeng, W. and Andrew, K., (2012). Predicting the total suspended solids in waste water: A Data Mining Approach. (Impact factor: 1:67), 001:10:1016/j.engappai: 2012.08.15.

Yejian, Z., Hairen, Y., Xiangyong, Z., Zhenjia, Z., Li, Y. (2011). High-rate mesophilic anaerobic digestion of palm oil mill effluent (POME) in expanded granular sludge bed (EGSB) reactor, International Conference on Agricultural and Natural Resources Engineering. Advances in Biomed. Eng. 3-5: 214-219.

Yerima, I. and Richard, T. Isa (2012). The energy potential of rice hull as biofuel for domestic use. Journal of Environmental Science and Resource Management. Cerresin Publications. 4: 84.