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Comparative study of biogas production from cocoa pod, maize husk, orange peels, pineapple peels, and coconut fiber co-digested with yeast

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Abstract
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 in crop science laboratory Faculty of Agriculture, University of Benin, Benin City 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. The experiment was arranged in a completely randomized design with three replicates using a set of five batch reactors. The digesters were labeled A, B, C, D and E respectively. 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. 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. Based on these findings, for obtaining optimum biogas yield, 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.

Keywords: *Comparative study, biogas, cocoa pod, maize husk, orange peels, pineapple peels, coconut fiber*

Introduction
Anaerobic digestion (AD) is a multi-biological process which is eco-friendly in which microorganisms act in synergy to convert organic waste into biogas and a stable product (Soil conditioner) for agricultural practices without any noxious effect on the environment in the absence of oxygen and the presence of anaerobic microorganisms (Adeyosoye *et al.*, 2010). This process of anaerobic digestion involves hydrolysis, acidogenesis, acetogenesis and methanogenesis reactions (Rasheed, 2014). Anaerobic digestion and biogas technology provide a suitable approach for proper management of organic wastes and at the same time, an alternative to generating renewable energy, alleviating environmental challenges and enhancing agricultural production through the generation of soil conditioner (Tsunatu *et al.*, 2014). Numerous studies have been done on biogas generation from anaerobic digestion of organic waste (Xiupeng and Andrew, 2012; Momoh *et al.*, 2008; Adelekan and Bamgboye, 2012; Nizami *et al.*, 2012; Adeyanju, 2008; Chotwattanasak and Puetpaiboon, 2011;

Abdurahman et al., 2013; Abdurahman *et al.*, 2011; Patil *et al.*, 2011; Liu *et al.*, 2006; Nayono, 2010; Irvan *et al.*, 2012; Abdullahi *et al.*, 2011;Yejian *et al.*, 2011). The production of biogas from various biomasses has been used over time till date, as these biomasses are readily available. The present study therefore, was carried out 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 determine the effect of pH and retention time on biogas yield.

Materials and Methods

Experimental Location: The experiment was carried out in the Crop Science Laboratory, Faculty of Agriculture, University of Benin, Benin city (longitude 05^0 O4" and 06^0 43"E and Latitude 5^0 44"N and 07^0 34"N).

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.

Table1 . pH of the Digesters

Digesters	pH before Biogas Production	pH after Biogas Production
A	6.247^b	5.640^e
B	6.333^{bc}	5.453^d
C	6.577^d	5.263^c
D	5.830^a	4.673^a
E	6.420^c	4.820^b
Lsd	**(0.03452)**	**(0.06823)**

Result

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, 5.5453, 4.673 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 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.

Table 3 Cumulative Volume of Biogas Produced

Treatments	Cumulative Volume of Biogas (ml)
A	7.665
B	13.667
C	23.333
D	13.001
E	12.665

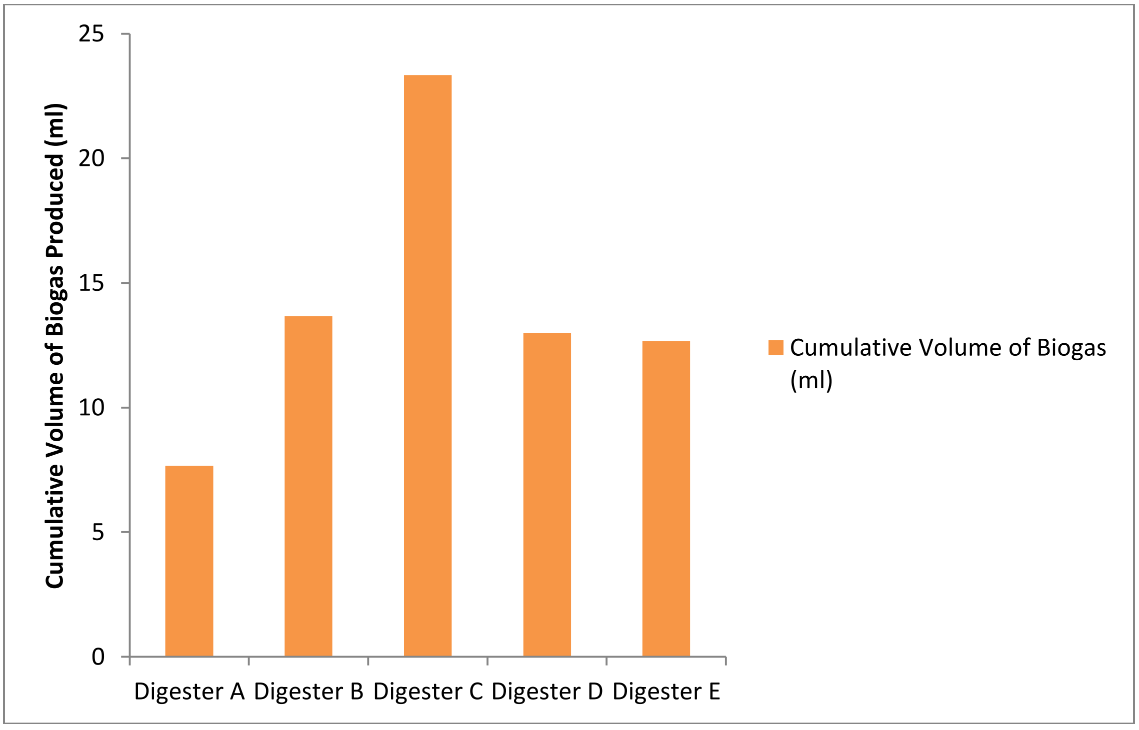

Fig 1: Graph of Cumulative Volume of Biogas Produced(ml)

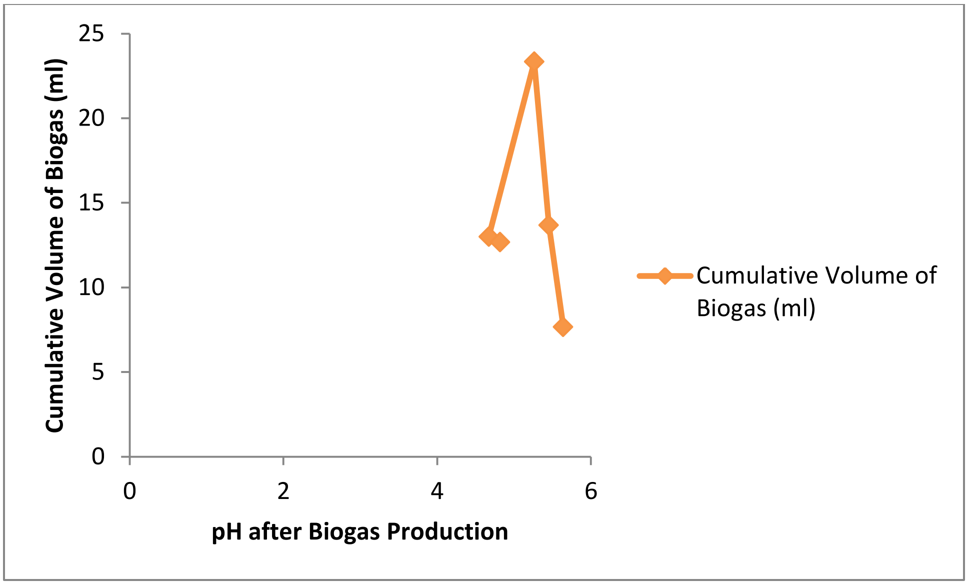

Fig 2: Graph of Cumulative Volume of Biogas (ml) against pH after Biogas Production

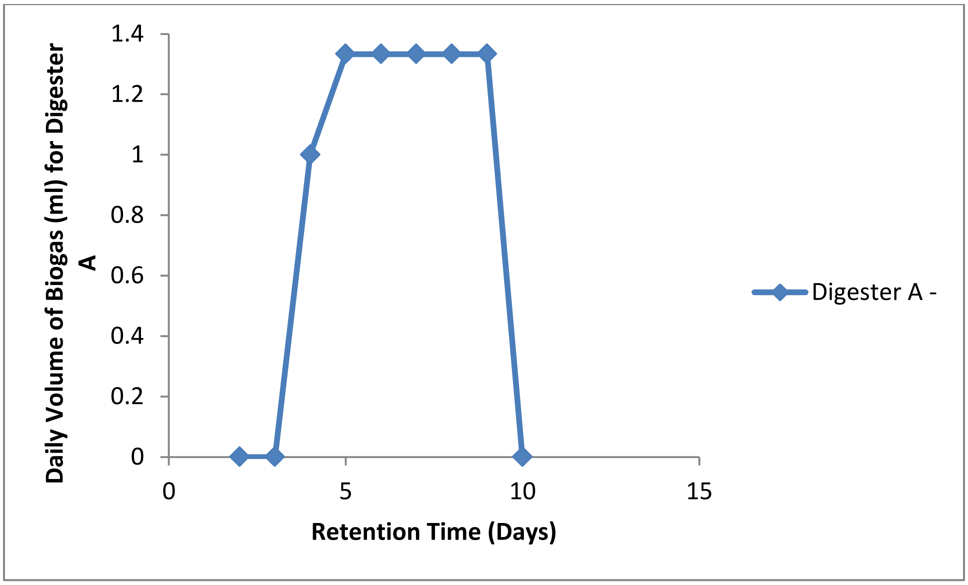

Fig 3: Graph of Daily Volume of Biogas (ml) for Digester A against Retention Time.

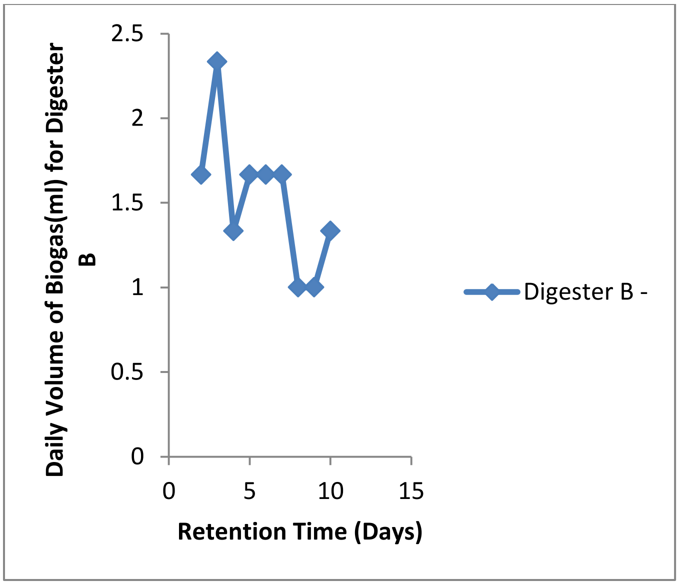

Fig 4: Graph of Daily Volume of Biogas (ml) for Digester B against Retention Time.

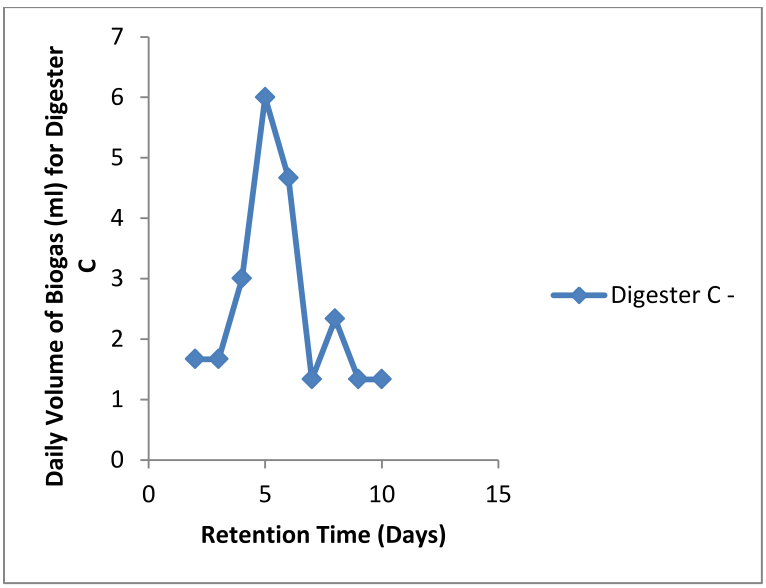

Fig 5: Graph of Daily Volume of Biogas (ml) for Digester C against Retention Time.

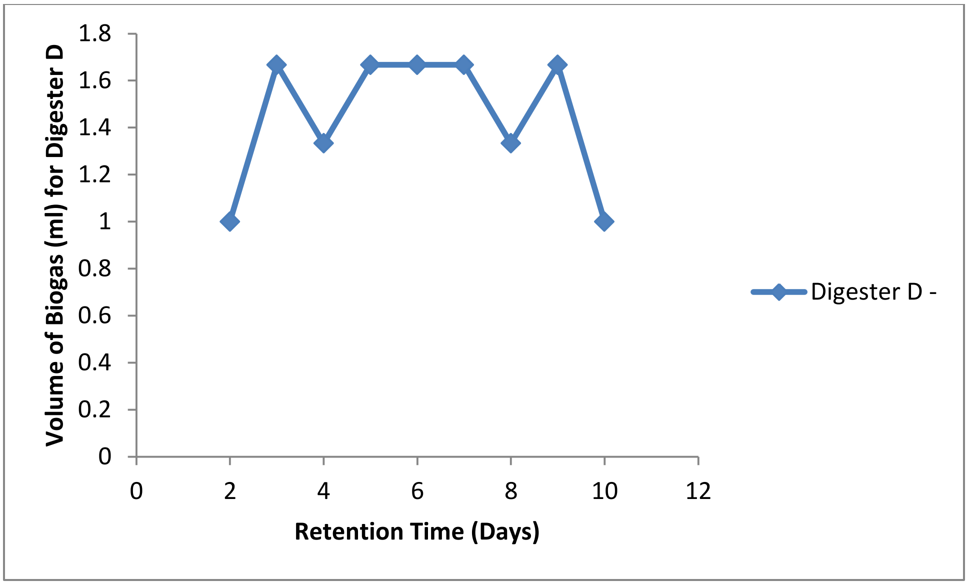

Fig 5: Graph of Daily Volume of Biogas (ml) for Digester D against Retention Time.

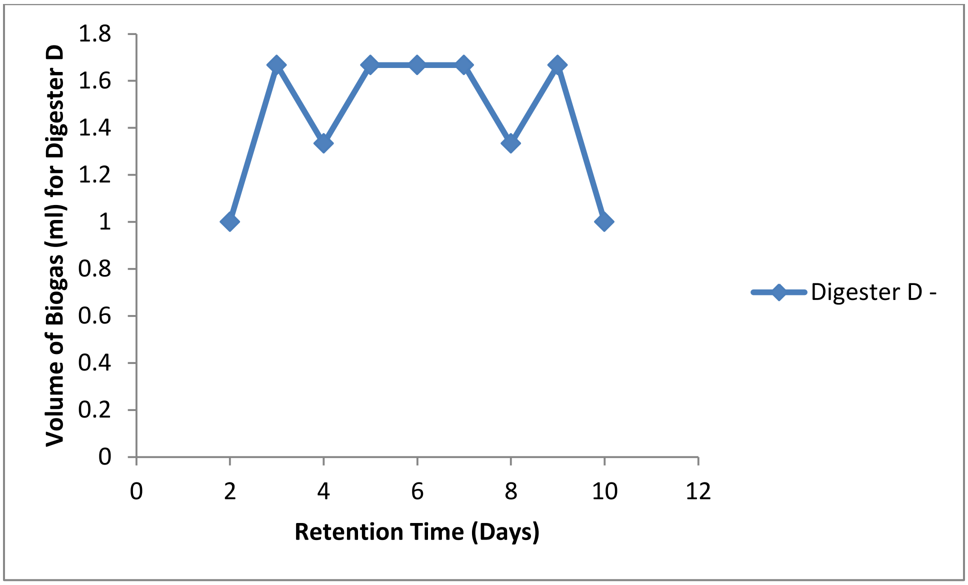

Fig 6: Graph of Daily Volume of Biogas (ml) for Digester E against Retention Time.

Discussion

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 agree 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 and Recommendation

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.

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