EFFECT OF PUMPKIN (*Telfairia occidentalis*) POD ON BIOGAS PRODUCTION FROM CO-DIGESTION OF YEAST *(Saccharomyces cerevsiae)* AND MAIZE COB IN BATCH REACTORS

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ABSTRACT
Anaerobic digestion (AD) is a technology widely used for treatment of organic waste for biogas production.This study was conducted in Faculty of Agriculture, University of Benin, Benin City to determine the biogas yield of blending pumpkin pod (0, 1, 2, 3 and 4g), yeast and maize cob (2g of yeast and 2g of maize cob) by means of batch experiment at mesophilic temperature, the effect of pumpkin pod composition in biogas yield and to analyse the composition effect on the biogas component.The experiment was arranged in a completely randomized design with three replicates using a set of five batch reactors. Each digester contained fixed amount of yeast and maize cob (2g of each), but an increasing amount of pumpkin pod (0 - 4g). The digesters were labeled A, B, C, D and E respectively. The % total solid composition was calculated and the pH determined before corking.The results showed significant differences among %composition of pumpkin pod for biogas yield and methane component. Yeast, % total solid composition and retention time significantly affected the biogas yield in the five-digesters. Digester loaded with 4g of pumpkin pod produced significantly higher volume of biogas and methane component compared with other loading rates. Increase in biogas yield for loading rate of 4g was 49.666ml for the 10 days hydraulic retention time. The retention time of 5, 6 and 7 days significantly produced the highest volume of biogas. The study showed that the blending of pumpkin pod, maize cob and yeast can be of rational inclusion in biogas production if properly harnessed.

KEYWORDS: Pumpkin pod, biogas, batch reactor, co-digestion, yeast, maize cob

1. INTRODUCTION
The production of biogas from renewable resources is becoming a prominent feature of most developed and developing countries of the world. Despite the variability of international opinion on this technology, it is agreed that it plays an important role in the domestic and agricultural life of the rural dwellers. It is used for cooking, crop drying and soil fertilizing (Meena and Vijay, 2010).

Co-digestion offers good opportunity to farmers to treat their own waste together with other organic substrates. As a result, farmers can treat their own residues properly and also generate additional revenues by treating and managing organic waste from other sources and by selling and/or using the products viz heat, electrical power and stabilized bio fertilizer (Adelekan and Bamgboye, 2012).Several work have been done on biogas generation from anaerobic digestion of agricultural and animal wastes (Xiupeng and Andrew, 2012; Momoh *et al.*, 2008; Uzodinma and Ofoefule 2009; Adelekan and Bamgboye, 2012;Adeyosoye *et al.*, 2010; Nizami *et al.*, 2012; Haberbauer and Kastner, 2010). The production of biogas from various biomasses has been used over time till date, as these biomasses are readily available, but not with the blending with yeast. Hence, the present study was carried out to determine the biogas yield of pumpkin pod, yeast and maize cob by means of batch experiment at mesophilic temperature.

2. MATERIALS AND METHODS

The experiment was carried out in the Crop Science Department's 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).

2.1 Preparation of Sample

The yeast and pumpkin pod were gotten from Uselu market, maize cob from the university research farm residue. Pretreatment operations involved weighing about 500g of pumpkin pod allowing it to dry for a period of 30 days, after which it was dried in an oven to constant weight. The oven dried pumpkin pod was further grounded to fine particles using a grinding mill. Similar operation was applied to the maize cob. The dry weights of these biomasses were then weighed with a weighing balance before introducing them into the digesters.

2.2 Experimental Procedure

A set of five batch reactors was used as digesters (Plate 1). Each digester (Plate 2) contained fixed amount of baker's yeast and maize cob, but an increasing amount of pumpkin pod. The digesters were labeled A, B, C, D and E respectively. The digester labeled A, had no pumpkin pod, 2g of yeast and 2g of maize cob. This digester acted as the control. Digester B consist of 1g of pumpkin pod, 2g of yeast and 2g of maize cob, digester C consist of 2g of pumpkin pod, 2g of yeast and 2g of maize cob, digester D consist of 3g of pumpkin pod, 2g of yeast and 2g of maize cob and digester E consist of 4g of pumpkin pod, 2g of yeast and 2g of maize cob. These biomasses was then mixed with 100ml of distilled water and then corked to exclude air under mesophilic temperature. The contents of the digesters were then allowed to ferment for a period of 12days. 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. Biomass 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 was determined using a pH meter. Data obtained from the volume of gas production for each of the systems was then subjected to GenStat 12.1 for windows.

Plate 1: An experimental set up

Plate 2: A unit experimental digester set up

3 RESULTS

The results of the total solid composition in each digester are presented in Table 1. The % total solid for digester E is 7.14, 16.67, 30, 50% higher than digester D, C, B and A. There was significance difference in the pH value of digester A, B, C and E but significant difference was not observed in the pH value of digester C and D (Table 2).The pH for digester E was 5.823 compare to 5.620, 5.610, 5.820 and 5.640 for digester D, C, B and A. Biogas production in day two in digester A, B and C show no significant difference and digester D and E also shows no significant difference. Day three digester A and B and C and D shows no significant difference but digester E was significantly different from digester A,B,C and D. Day four digester Band E and C and D was not significantly different but digester A was significantly different. Day five digester A,B and E was significantly different but digester Band C and C and D were not significantly different. Day six digester B and C were not significantly different but digester A, D and E were significantly different. Day seven digester A, B and C and D and E were not significantly different. Day eight significant difference was not observe in digester B,C, D and E but was observed in digester A. day nine and ten significant difference was not observed in digester A,B,C,D and E(Table 3). Biogas yield in digester E was 8.667, 18.666, 28.333 and 37 ml higher than digester D, C, B and A (Table 4). The result was also presented graphically: Figure 1 show the relationship between biogas produced (ml) and % total solid in 100ml of water against pumpkin pod. The relationship between the total volume of biogas yield, % total solid in 100ml of water and the amount of pumpkin pod (g) fed into the digesters is shown to have a trend effect that shows the dependence of biogas yield on the amount of pumpkin pod and the dependence of the % total composition of solid on the amount of pumpkin pod. In all cases, among different types of fitting lines to data points the best-fit curve was found out to be in the form of a polynomial relationship with $R^2 = 0.9896$ for cumulative biogas volume versus pumpkin pod and $R^2 = 0.9639$ for % total solids in 100ml of water versus pumpkin pod.

$$\boldsymbol{y = 3.4755e^{0.1723x}} \quad (3)$$
$$\boldsymbol{y = 9.3307e^{0.3509x}} \quad (4)$$

Where intercept is 3.4755 and 9.3307, slope is 0.1723 and 0.3509, $\boldsymbol{y}$ is the cumulative biogas yield (ml) in equation 1 and $\boldsymbol{y}$ is the% total solids in 100ml of water in equation 2, $\boldsymbol{x}$ is the pumpkin pod (g). Fig 2 shows the graph of cumulative volume of Biogas (ml) against pH after Biogas Production. The graph showed trend effect on the dependence of biogas yield on the pH of the digesters.

Table 1. Solid Composition

Digesters	Yeast(g)	Maize cob (g)	Pumpkin pod (g)	Total solids (g) in 100ml of water	% composition of solids in 100ml of water	Pumpkin pod composition (as % of total solids)
1	**2**	**3**	**4**	**5**	**6**	**7**
A	2	2	-	4	3.846	0
B	2	2	1	5	4.762	20.00
C	2	2	2	6	5.660	33.33
D	2	2	3	7	6.542	42.86
E	2	2	4	8	7.407	50.00

Column six and seven will be determined using equation. 1 (Momoh *et al.,* 2008).

$$Column\ 6 = \frac{\text{Column (5)}}{\text{Column (5)} + 100g\ of\ water} \times 100 \quad (1)$$

$$Column\ 7 = \frac{\text{Column (4)}}{\text{Column (5)}} \times 100 \quad (2)$$

Note: density of water is 1g/ml

Table 2. pH of the Digesters

Digesters	pH before Biogas Production	pH after Biogas Production
A	6.303^{d}	5.640^{b}
B	6.363^{c}	5.820^{a}
C	6.493^{b}	5.610^{c}
D	6.517^{b}	$5.620b^{c}$
E	6.570^{a}	5.823^{a}
Lsd	**(0.02349)**	**(0.02486)**

*Means with similar alphabets along the column are not significantly different at p<0.05

Table 3 Mean Daily Volume Biogas Produce

Treatments	Daily Volume of Biogas Produced (ml)									
	1	2	3	4	5	6	7	8	9	10
A	-	1.333^{b}	2.667^{cd}	0.667^{c}	1.333^{d}	1.333^{d}	1.333^{b}	1.333^{b}	1.667^{a}	0.667^{a}
B	-	2.000^{b}	2.000^{d}	5.000^{b}	3.667^{c}	2.333^{c}	1.667^{b}	2.667^{a}	1.333^{a}	1.333^{a}
C	-	2.333^{b}	4.667^{b}	7.000^{a}	5.000^{bc}	3.333^{c}	2.000^{b}	2.667^{a}	2.333^{a}	1.667^{a}
D	-	5.000^{a}	4.000^{bc}	8.000^{a}	6.000^{b}	5.333^{b}	7.000^{a}	3.000^{a}	1.333^{a}	1.333^{a}
E	-	5.000^{a}	7.000^{a}	5.333^{b}	10.000^{a}	8.000^{a}	8.000^{a}	3.333^{a}	2.000^{a}	1.000^{a}
Lsd	-	**(1.558)**	**(1.558)**	**(1.558)**	**(1.558)**	**(1.243)**	**(1.558)**	**(1.243)**	**(1.243)**	**(0.939)**

*Means with similar alphabets along the column are not significantly different at p<0.05

Table 4 Cumulative Volume of Biogas Produced

Treatments	Cumulative Volume of Biogas (ml)
A	12.666
B	21.666
C	31.000
D	40.999
E	49.666

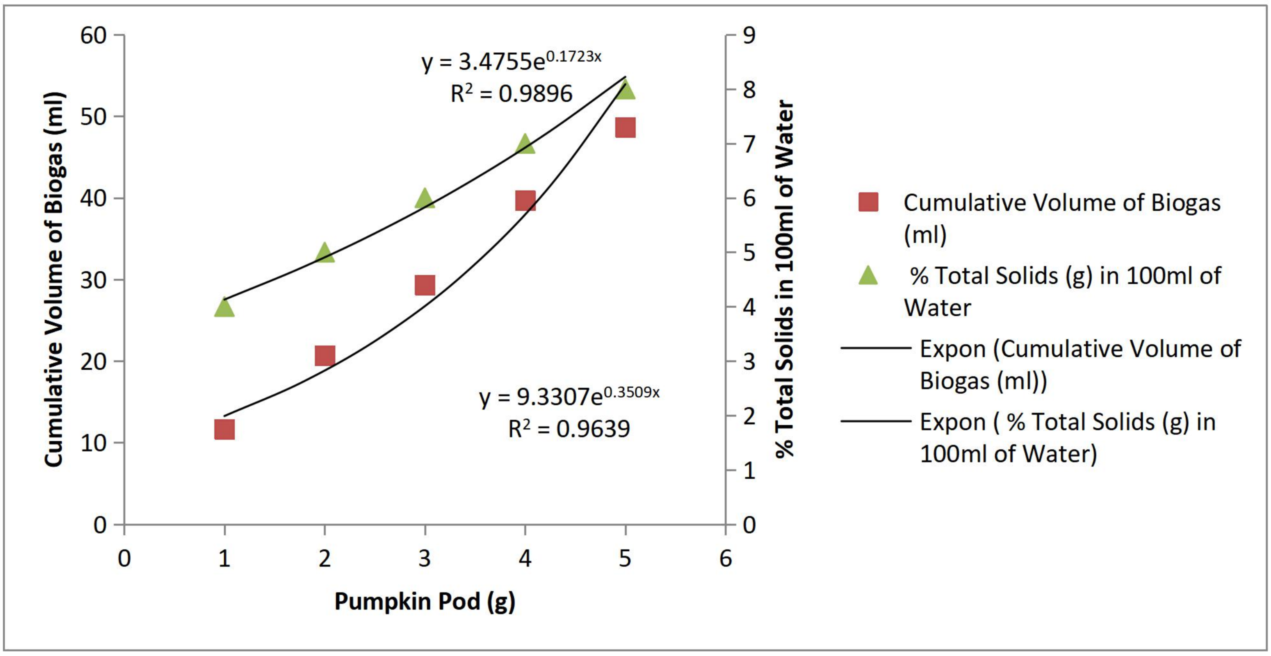

Figure 1: Relationship between Biogas Produced (ml) & % Total Solid in 100ml of Water against Pumpkin Pod

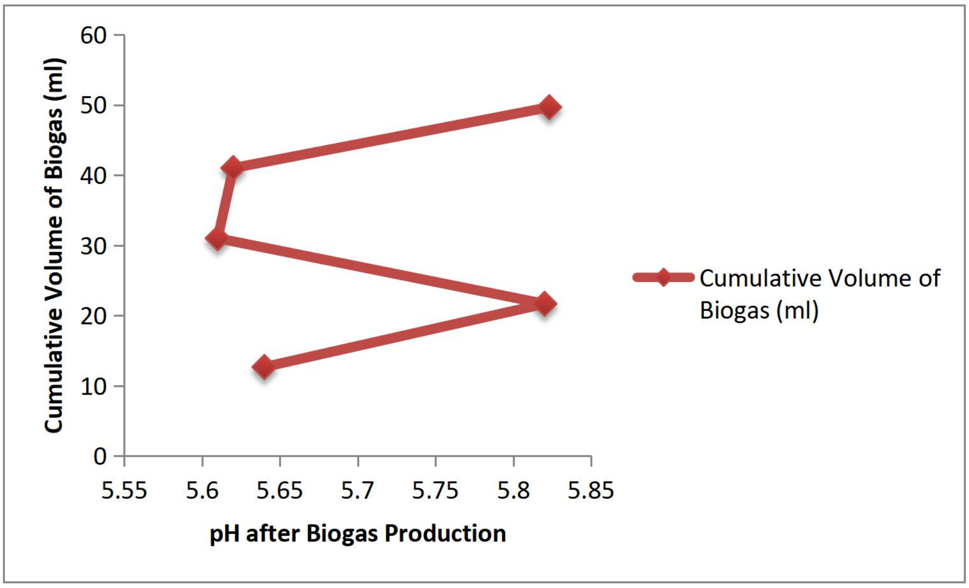

Figure 2: Cumulative Volume of Biogas (ml) against pH after Biogas Production

4. DISCUSSION

The findings revealed that the pH before the experiment was within the optimum range for biogas production. Determination for total solids of waste is an effective way of finding out the amount of nutrient that will be available for bacterial action during digestion. The percentage total solids result shows that it is within the range for biogas production when compared with (Ofoefule *et al.,* 2010).

The slight fluctuation in biogas yield at the beginning, middle and end period of the experiment might be attributed to the growth rate of bacterial, and the synergy existing among the composition. The yeast in the blend would have created a favorable environment that aided faster growth of the methanogens.

This agrees with Nordberg and Edstrom (2007) who predicted that biogas production rate in batch condition is directly proportional to specific growth rate of methanogenic bacteria in the bio digester.

The fast yield of biogas within a short waiting period (lag days) might be attributed to the blending of the substrate with yeast. Lawal *et al.* (2008) also observed rapid gas production when digester feed stocks were seeded with adequate bacterial isolates from previous digester. Ouedraogo (2009) report that, the use of microbial inoculum as cultures is a common practice during biogas production. The slight increase in biogas yield and methane component do to increase in pumpkin pod can be attributed to more appropriate C: N ratio and more balanced nutrients for the anaerobic microorganisms of biomethanation. Adeyosoye *et al.*, (2010) reported that recovery time for biogas production as well as the quality and quantity of biogas produced from agricultural, materials are a function of the nature, and composition of the digester feedstock.A too high C: N ratio means lack of nitrogen while too low value of C: N ratio leads to increase CH_4 production (Singh and Mandal, 2011).

The slight variation in the pH level might be attributed to the acidity balance, buffering do to addition of pumpkin pod and reduction in organic nitrogen to ammonium ion (NH4). Similar observation was reported by Satyanarayana *et al.* (2008). The equation $R^2 = 0.9896$ and $R^2 =$

0.9639 shows the coefficient of determination which explains proportion of cumulative biogas yield and pumpkin pod and % total solid and pumpkin pod. This means that the relationship between cumulative biogas yields, % total solid composition were 98.96% and 96.39.A maximum biogas production of 50 ml was observed at a pumpkin pod amount of 5g which lies somewhere between digester D and E. Above this value there was an observation of drop in biogas production. In essence increasing amount of pumpkin pod does not lead to spontaneous increase in biogas production. Many reasons have been proposed for this phenomenon like reduced mass transfer rate of substrates to bacteria or accumulation of inhibitory substances (Momoh *et al.,* 2008). This equation can be used as a regression model to deduce per cent (%) total solids concentration equivalent to producing maximum biogas volume. Therefore, it should be noted that biogas yield could be affected by the variation in pH, composition of total solid and nature of the materials.

5 CONCLUSION

From the result of this study, there is a high possibility of biogas generation in an anaerobic process by blending yeast as a catalyst with maize cob and pumpkin pod. Biogas yield in digester E was 8.667, 18.666, 28.333 and 37 ml higher than digester D, C, B and A. An increasing amount of pumpkin pod in the blending, result to an increasing amount of biogas. It was therefore concluded that the blending of pumpkin pod, maize cob and yeast can be of rational inclusion in biogas production if properly harnessed.

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