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PRODUCTION OF BIOGAS USING DIFFERENT RATIOS OF GOAT AND DOG DUNG MIXED WTH CORN COB AND RICE CHAFF

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Investigations were conducted to evaluate the viability of corncob and rice chaff co-digested with goat and dog dungs in the production of biogas. The study was carried out at mesophillic condition in six mini laboratory digester fabricated using guage 16 metal sheets with 80L capacity for five weeks retention time. Five different ratios of goat and dog dungs were blended with the feedstock. The ratio of the blends is as follows; sample A: Corn cob, Rice chaff, Goat dungs (25%), Dog dung (25%), sample B: Corn cob, Rice chaff, Goat dungs (50%), Dog dung (50%),sample C: Corn cob, Rice chaff, Goat dungs (75%), Dog dung (75%), sample D: Corn cob, Rice chaff, Goat dungs (25%), Dog dung (75%), sample E: Corn cob, Rice chaff, Goat dungs (75%), Dog dung (25%), sample F: (negative control) Corn cob, Rice chaff only. The gas yield was analysed using the chromatography system which is composed of the gas chromatography equipment and a recorder for plotting chromatographs. The equipment model is Hp6890 with HP ChemStation and Rev. A09.01 (1206) software. The result showed thatsampleE is the richest of all the samples in terms of the proximate and physiochemical compositions. The biogas constituents obtained showed that sample A produced 56 % CH_4, 0.11 % NH_3, 0.16 % CO, 0.17 % H_2S, 42.64 % CO_2, Sample B produced 60.80 % CH_4, 0.86 % NH_3, 0.71 % CO, 0.55 % H_2S and 0.52 % CO_2, Sample C produced 61.35 % CH_4, 0.41 % NH_3, 0.41 % CO, 0.68 % H_2S, 37.12 % CO_2, Sample D contains 50.70 % CH_4, 0.24 % NH_3, 0.79 % CO, 1.05 % H_2S, and 47.13 % CO_2. Sample E contains 63.54 % CH_4, 0.93 % NH_3, 0.84 % CO, 0.54 % H_2S, 34.12 % CO_2. The control sample collected from a domestic cooking gas cylinder contained 56.12 % CH_2, 0.14 % NH_3, 0.22 % CO, 0.23 % H_2S and 43.20 % CO_2. Over the 5 weeks period of digestion; the yield for the samples were 40L, 47L, 42L, 38L and 65L respectively for samples A,B, C, D and E respectively while sample F produced no gas throughout the digestion period. The value recorded for sample E represented the highest value obtained among the samples. Thesubstrates by these results were considered a suitable substitute for biogas production.

INTRODUCTION

Biogas is a gaseous mixture generated during anearobic digestion processes using waste water, solid waste (e.g. at landfills), organic waste, e.g. animal manure, and other sources of biomass. Anaerobic digestion is the biological degradation of biomass in oxygen-free conditions. In the absence of oxygen, anaerobic bacteria will ferment biodegradable matter into methane (40-70%), carbon dioxide (30-60%), hydrogen (0-1%) and hydrogen sulfide (0-3%), a mixture called biogas.

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Biogas is formed solely through the activity of bacteria. Although the process itself generates heat, additional heat is required to maintain the ideal process temperature of at least 35°C. (Welink *et al*., 2007). Biogas can be produced on a very small scale for household use, mainly for cooking and water heating or on larger industrial scale, where it can either be burnt in power generation devices for on-site (co)generation, or upgraded to natural gas standards for injection into the natural gas network as biomethane or for use directly as gaseous biofuel in gas engine-based captive fleets such as buses. The feedstock, e.g. animal dung or sewage, is converted to a slurry with up to 95% water, and – for small-scale applications – fed into a purpose-built digester. Digesters come in many forms and sizes, which may range from 1 m^3 for a small household unit to some 10 m^3 for a typical farm plant and more than 1,000 m^3 for a large installation. Biogas production in such cases can be both continuous and in batches with digestion taking place for a period from ten days to a few weeks (Gupta, 2011).

Anaerobic digestion is the decomposition, in the absence of air, of plant and animal remains that can be easily acted upon by micro-organisms especially bacteria. The major product of this bacterial activity is the release of biogas (a mixture of combustible methane, trace carbon dioxide, water and hydrogen sulphide) in a specially designed device known as biodigester. Anaerobic digestion of animal wastes has been found to have a long time benefit. According to In some investigations, it was found that the biofertilizer has better nutrient quality than the raw waste (Okoroigwe, 2007 and Okoroigwe*et al*., 2008). In view of search for the solutions of anaerobic digestion of animal and plant wastes as well as exploring the potentials of all decomposable wastes, the ability to generate biogas with the blend of goat, dog and plant waste (i.e. corn cob) is investigated. Though the waste from goat and dogmay be small as compared to cow and other livestock, they could be useful in enhancing the viability of other major wastes (particularly the plant waste – corn cob). This study aims at investigating the viability of the blend of goat,dog dung and corn cob as waste to produce combustible biogas when used as major feedstock or enhance the quality of others as a blend.

MATERIALS AND METHODS

The study was conducted using 80**L** metallic digester of height 60cm**.** The digester was designed and constructed with guage 16 metal sheets in the metal workshop of the Yaba College of Technology, Yaba, Lagos,Nigeria.Corn cob was procured from local roasted corn sellers in Lagos and the rice chaff was from a local rice milling industry in Ekiti State. The Corn cobs used for this study were milled using the dry attrition mill. This was to reduce their sizes and increase the surface area of the wastes for faster degradation. The rice chaff was boiled to reduce the lignin content which tends to prevent enzymatic breakdown of the chaff.

Goat dung was collected freshly (i.e. in the morning as first waste at dawn) from a local abattoir (Odo Eran) inCele area of Lagos state while the dog dung was collected at a veterinary outlet in Surulere also inLagosstate, Nigeria.The dog dung was collected at a veterinary outlet in Surulere, Lagos. The goat and dog dung were added at the following ratio; Corn cob, Rice chaff, Goat dungs (25%), Dog dung (25%), Corn cob, Rice chaff, Goat dungs (50%), Dog dung (50%), Corn cob, Rice chaff, Goat dungs (75%), Dog dung (75%), Corn cob, Rice chaff, Goat dungs (25%), Dog dung (75%), Corn cob, Rice chaff, Goat dungs (75%), Dog dung (25%). The moisture, crude protein, ash, fat, crude fiber and carbohydrate contents of the corncob, rice chaff, goat and dog dung were determined as described by AOAC (2005), The gas yield was analyzed using the chromatography system which is composed of the gas chromatography equipment and a recorder for plotting chromatographs. The equipment model is Hp6890 with HP ChemStation and Rev. A09.01 (1206) software.

RESULTS AND DISCUSSION

Table 1 shows the result of the moisture content obtained when corncob and rice chaff were co-digested with goat and dung at different ratios. Sample A (1:1) Sample B (50:50), Sample C (75:75), Sample D (25:75), Sample E (75:25). While Sample F represent the control sample without the addition of animal dung. The weekly assessment over 5 weeks period as reported in Table 9: The moisture contents varies significantly ($P \leq 0.5$) across the week, for sample A with the exception of the values obtained for the 1st weeks (99.175 %) which does not differ significantly ($P \leq 0.05$) from the value obtained in the 4th week (99.265%). The highest moisture content value was recorded on the 4th week (99.265 %) while the lowest moisture content value was recorded on the 5th week (98.125%) for sample A. The moisture content results across the sample shows a significant difference ($P \leq 0.5$) with Sample B (50:50) having the highest moisture content of 99.32 % and sample C (99.005%) showing the least moisture content value in the 1st week of digestion. Sample C (75:75) recorded the highest content moisture value (99.26%) for week 2 while sample A(25:25) recorded the lowest moisture content value for week 2.For the 3rd week of digestion, Sample C (75:75) recorded the highest moisture content value (99.23 %) while sample D (25:75) recorded the lowest moisture content value sample B (50:50) with moisture content value (99.355%) and sample B (50:50) with moisture content value of (98.645%) represented the highest values for week 4 and week 5 while the lowest values were represented by sample E (75:25) with moisture content value (99.10%) and sample A (25:25) with moisture content value (98.125%) respectively.

The control sample F recorded the highest value (99.29%) and lowest moisture content value of (98.925 %). The moisture content for the samples varied significantly ($P \leq 0.05$) across the weeks. Table 2 shows the result of the ash content obtained from the bioreactor samples. The ash content across the samples shows a significant difference ($P \leq 0.5$) with Sample C (75:75) having the highest value of (0.315 %) and sample B (50:50) showing the least value of 0.160 % in the 1st week of digestion. Sample A(25:25) recorded the highest value of 0.320 % for week 2 while sample E (75:25) recorded the lowest value of 0.205 % for week 2.For the 3rd week of digestion, Sample A (25:25) recorded the highest ash content of 0.315 % while sample B (50:50) recorded the lowest value of 0.180 %. Sample A (25:25) with ash content of 0.245% and sample D (25:75) with ash content of 0.125 % represented the lowest values for week 4 while week 5 the highest ash content value of 0.405 % was in sample A (25:25) while its lowest ash content value of 0.002 % was found in sample C (75:75). The control sample had the highest ash content value of 0.260 % on the 1st and 2ndweek while the lowest ash content value of 0.180 % was recorded on the 3rdweek.

Table 3 shows the result of the protein content obtained from the bioreactor samples. The protein content results across the sample shows a significant difference ($P \leq 0.5$) with Sample D (25:75) showing the highest ash content value (0.430 %) and sample A (25:25) showing the least value of 0.320 % in the 1st week of digestion. Sample D (25:75) recorded the highest protein content value (0.440 %) for week 2 while sample C (75:75) recorded the lowest ash content value of 0.250 % for week 2.For the 3rd week of digestion, Sample D (25:75) recorded the highest protein content value (0.600 %) while sample A(25:25) recorded the lowest protein content value of 0.340. Sample A (25:25) with protein content value (0.450 %) and sample D (25:75) with protein content value of (0.330 %) represented the lowest values for week 4 while week 5 recorded the highest protein content value of 0.520 % in sample B (50:50) while its lowest protein content value of 0.560 % was recorded by sample C (75:75). The control sample recorded its highest protein content value of 0.520 on the 5th week while the lowest protein content value of 0.270 % was recorded on the 4th week. Table 4 shows the result of the fat content obtained from the bioreactor samples.

(0.020 %) and sample E (75:25) with fat content value of (0.010 %) represented the highest and lowest values for week 4 while week 5 recorded the highest fat content value of 0.020 % in sample B (50:50) while its lowest fat content value of 0.010 % was recorded by sample A(25:25). The control sample recorded its highest fat content value of 0.020 % on the 2nd and 3rd week while the lowest fat content value of 0.010 % was recorded on the 4th week. Table 5 shows the result of the carbohydrate(CHO) content obtained from the bioreactor samples. The CHO content results across the sample shows a significant difference (P ≤0.5) with Sample C (75:75) showing the highest CHO content value (0.285 %) and sample D (25:75) showing the least value of 0.110 % in the 1st week of digestion.

Table 1.Weekly moisture content (%) of the samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	99.175^{b}±0.025	99.11^{a}±0.005	99.215^{c}±0.005	99.265^{b}±0.015	98.125^{a}±0.015
B	99.32^{d}±0.01	99.15^{bc}±0.02	99.14^{b}±0.02	99.355^{c}±0.025	98.765^{d}±0.005
C	99.005^{a}±0.005	99.26^{d}±0.02	99.23^{c}±0.03	99.235^{b}±0.015	98.645^{c}±0.045
D	99.175^{b}±0.005	99.18^{c}±0.00	99.01^{a}±0.00	99.21^{b}±0.03	98.385^{b}±0.025
E	99.200^{bc}0.000	99.245^{d}±0.005	99.11^{b}±0.01	99.10^{a}±0.01	98.745^{cd}±0.045
F	99.23^{c}±0.020	99.135^{ab}±0.005	99.26^{c}±0.01	99.29^{bc}±0.03	98.925^{e}±0.015

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 2.Weekly total ash content (%) of the samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	0.230^{b}±0.010	0.320^{d}±0.01	0.315^{d}±0.005	0.245^{c}±0.015	0.405^{c}±0.005
B	0.160^{a}±0.000	0.300^{c}±0.000	0.180^{a}±0.000	0.140^{a}±0.000	0.190^{a}±0.00
C	0.315^{e}±0.005	0.270^{c}±0.010	0.275^{c}±0.005	0.190^{b}±0.010	0.002^{a}±0.000
D	0.275^{d}±0.005	0.220^{ab}±0.02	0.240^{b}±0.010	0.125^{a}±0.015	0.220^{a}±0.020
E	0.245^{bc}±0.015	0.205^{a}±0.015	0.225^{b}±0.005	0.130^{a}±0.00	0.325^{b}±0.015
F	0.260^{cd}±0.000	0.260bc±0.010	0.180^{b}±0.010	0.240^{c}±0.020	0.220^{b}±0.000

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 3.Weekly crude protein content (%) of the samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	0.320^{a}±0.00	0.420^{b}±0.00	0.340^{a}±0.00	0.450^{b}±0.000	0.770^{c}±0.000
B	0.390^{b}±0.000	0.400^{b}±0.040	0.440^{ab}±0.040	0.390^{ab}±0.004	0.560^{ab}±0.040
C	0.400^{b}±0.000	0.250^{a}±0.040	0.520^{bc}±0.040	0.360^{ab}±0.040	0.570^{ab}±0.040
D	0.430^{b}±0.000	0.440^{b}±0.000	0.600^{c}±0.000	0.330^{a}±0.040	0.660^{bc}±0.040
5B	0.275^{a}±0.045	0.400^{b}±0.040	0.540^{bc}±0.040	0.270^{a}±0.000	0.640^{b}±0.040
E	0.300^{a}±0.000	0.370^{b}±0.000	0.480^{b}±0.040	0.270^{a}±0.040	0.520^{a}±0.000

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 4.Weekly fat content (%) of the samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	0.015^{a}±0.005	0.010^{a}±0.000	0.020^{b}±0.000	0.010^{a}±0.000	0.010^{a}±0.000
B	0.010^{a}±0.000	0.015^{a}±0.005	0.010^{a}±0.000	0.020^{b}±0.000	0.020^{b}±0.000
C	0.010^{a}±0.000	0.010^{a}±0.000	0.015^{ab}±0.005	0.010^{a}±0.000	0.010^{a}±0.000
D	0.01^{a}±0.000	0.015^{a}±0.005	0.010^{a}±0.000	0.020^{b}±0.000	0.020^{b}±0.000
E	0.01^{a}0.000	0.010^{a}±0.000	0.010^{a}±0.000	0.010^{a}±0.000	0.015^{ab}±0.005
F	0.01^{a}±0.000	0.020^{a}±0.000	0.020^{b}±0.000	0.015^{ab}±0.005	0.010^{a}±0.000

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

The fat content results across the sample shows a significant difference (P ≤0.5) with Sample A (25:25) having the highest fat content of0.015% and sample E (75:25) having the least value of 0.010 % in the 1st week of digestion. Sample D (25:75) recorded the highest ash content value (0.015 %) for week 2 while sample C (75:75) recorded the lowest fat content value of 0.250 % for week 2.For the 3rd week of digestion, Sample A (25:25) recorded the highest fat content value (0.020 %) while samples B,D and E recorded the lowest fat content value of 0.010 %. Sample B (50:50) with fat content value

Sample C (75:75) recorded the highest CHO content value (0.210 %) for week 2 while sample B (50:50) recorded the lowest CHOcarbohydrate content value of 0.135 % for week 2.For the 3rd week of digestion, Sample B (50:50) recorded the highest CHO carbohydrate content value (0.280 %) while samples A(25:25) recorded the lowest CHO content value of 0.110 %. Sample E (75:25) with fat content value (0.490 %) and sample A (25:25) with CHO content value of (0.030 %) represented the highest and lowest values for week 4 while week 5 recorded the highest CHO content value of 0.715 % in sample D (25:75) while its lowest CHO carbohydratecontent value of 0.275 % was recorded by sample E (75:25). The control sample recorded its highest CHOcarbohydratecontent value of 0.325 % on the 5th week while the lowest CHO carbohydratecontent value of 0.055 % was recorded on the 3rd week. Table 6 shows the results of the pH content of all the samples for the 5 weeks assessment. The pH varies significantly (P ≤0.5) across the weeks, for the samples. Sample E had the highest value of 7.11 and 5.99 within the 1stand 2ndweeks of digestion, while sample C had the lowest value of 5.69 within the 1st week and sample B had the lowest value of 5.12 during the 2nd week of digestion.

the highest pH content value of (7.11) sample C (5.69) showing the least value in the 1st week of digestion. Sample E (75:25) recorded the highest pH value (5.99) for week 2 while sample B (50:50) recorded the lowest pH value of 5.12 for week 2.For the 3rdand 4thweeks of digestion, Sample C and B recorded the highest and lowest pH values of 8.30 and 6.42 respectively while for 5th week, Sample E had the highest value of 8.24 while Sample F had the lowest value of 7.15 recorded the highest pH value (8.30) while sample B (50:50) recorded the lowest pH value. Sample C (75:75) with pH value (8.30) and sample B (50:50) with pH value of (6.40) represented the highest values for week 4 and week 5 respectively while the lowest values were represented by sample B (50:50) with pH value (6.42) and sample B (50:50)

Table 5.Weekly carbohydrate content (%)of the samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	0.260^{b}±0.020	0.145^{a}±0.005	0.110^{ab}±0.000	0.030^{a}±0.000	0.690^{a}±0.020
B	0.120^{a}±0.010	0.135^{a}±0.015	0.280^{c}±0.01	0.095^{ab}±0.015	0.495^{b}±0.015
C	0.285^{b}±0.015	0.210^{a}±0.070	0.130^{b}±0.020	0.205^{bc}±0.035	0.675^{c}±0.015
D	0.110^{a}±0.000	0.140^{a}±0.010	0.135^{b}±0.015	0.315^{c}±0.085	0.715^{c}±0.005
E	0.265^{b}±0.055	0.190^{a}±0.010	0.115^{b}±0.025	0.490^{d}±0.010	0.275^{a}±0.015
F	0.200^{ab}±0.020	0.215^{a}±0.005	0.055^{a}±0.015	0.185a^{bc}±0.055	0.325^{a}±0.015

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 6. Weekly pH values of samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	7.025^{d}±0.005	5.18b0.000	7.485^{b}±0.005	7.485^{b}±0.005	7.675^{d}±0.015
B	6.77^{b}±0.01	5.125^{a}0.005	6.420^{a}±0.00	6.420^{a}±0.000	7.285^{b}±0.005
C	5.695^{a}±0.025	5.195^{c}0.005	8.305^{f}±0.005	8.305^{f}±0.005	7.33^{c}±0.000
D	6.885^{c}±0.015	5.21^{d}±0.00	7.885^{e}±0.005	7.885^{e}±0.005	7.690^{d}±0.000
E	7.115^{e}±0.005	5.99^{f}±0.00	7.840^{d}±0.00	7.840^{d}±0.00	8.245^{e}±0.005
F	7.12^{e}±0.000	5.33^{e}±0.00	7.620^{c}±0.00	7.620^{c}±0.00	7.155^{a}±0.005

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 7.Weekly temperature values of samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	28.50±0.00	28.1±0.0	28.4±0.0	28.2±0.0	27.30±0.00
B	28.60±0.00	27.9±0.0	28.4±0.0	28.2±0.0	27.30±0.00
C	28.3±0.0	28.1±0.0	27.8±0.0	28.0±0.0	26.80±0.00
D	28.3±0.0	28.1±0.0	29.1±0.0	28.1±0.0	27.40±0.00
E	28.1±0.0	28.2±0.0	29.7±0.0	28.3±0.0	27.20±0.00
F	28.1±0.0	28.2±0.0	28.2±0.0	28.1±0.0	27.00±0.00

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 8.Weekly total solid values (%) of samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	8.225^{c}±0.225	8.945^{d}±0.055	7.845^{b}±0.045	7.265^{b}±0.065	10.865^{e}±0.025
B	6.780^{a}±0.110	8.475^{c}±0.175	8.580^{c}±0.180	6.415^{a}±0.255	10.635^{d}±0.005
C	9.925^{d}±0.065	7.385^{b}±0.185	7.475^{a}±0.075	7.665^{b}±0.155	7.050^{a}±0.050
D	8.250^{c}±0.050	6.200^{a}±0.000	9.990^{d}±0.000	7.875^{b}±0.315	10.615^{d}±0.025
E	8.000^{bc}±0.00	7.55^{b}±0.050	8.880^{c}±0.120	9.000^{c}±0.110	10.255^{c}±0.045
F	7.700^{b}±0.200	8.640^{cd}±0.040	7.395^{a}±0.065	7.100^{ab}±0.300	10.075^{b}±0.015

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Furthermore, other results were obtained when corncob and rice chaff were co-digested with goat and dung at different ratios. Sample A (25:25) Sample B (50:50), Sample C (75:75), Sample D (25:75), Sample E (75:25). While Sample F represent the control sample without the addition of animal dung. The weekly assessment over 5 weeks period as reported in Table 6: The pH varies significantly (P ≤0.5) across the week, for the samples. The pH results across the sample shows a significant difference (P ≤0.5) with Sample E (75:25) having

The control sample recorded its highest pH values of 7.62 on the 3rd and 4th week while the lowest pH value was recorded on the 1st week. Table 7 shows the result of the temperature (Temp) obtained from the bioreactor samples. The temperature results across the sample shows a significant difference (P ≤0.5) with Sample B and E having the highest and lowest values of 28.60^{0}C and 28.10^{0}C within the first week of digestion. Sample E had the highest values of temperature for the 2nd, 3rdand4th weeks with values of 28.2^{0}C, 29.7^{0}C and

28.3^{0}Crespectively while Samples B, C and D had the lowest values of 27.9 ^{0}C, 27.8 ^{0}C and 28.1 ^{0}C respectively. For 5th week, Sample D had the highest temperature of 27.4 ^{0}C while E had the lowest temperature of 27.0 ^{0}C respectively. Showing the highest temperature value (28.60^{0}C) and sample E having the lowest temperature of 28.60^{0}C in the 1st week of digestion (50:50) showing the highest Temp value (28.60^{0}C) and sample E (28.10^{0}C) showing the least value in the 1st week of digestion. Sample E , had the highest temperature values offor week 2 and 3 while sample B (50:50) recorded the lowest Temp value of 27.9 ^{0}C for week 2.For the 3rd week of digestion, Sample E (75:25) recorded the highest Temp value (29.70^{0}C) while sample C (75:75) recorded the lowest Temp value of 27.80^{0}C.

value of (6.42) represented the highest and lowest values for week 4.Week 5 recorded the highest TS value of 10.87 in sample A (25:25) while its lowest TS value of 7.05 was recorded by sample C (75:75). The control sample recorded its highest TS value of 10.25 on the 5thweek while the lowest TS of 7.55 was recorded on the 2nd week. Table 9 shows the result of the volatile solid (VS) content obtained from the bioreactor samples. The VS results across the sample shows a significant difference (P ≤0.5) with Sample B (50:50) showing the highest VS value (998.40) and sample C (75:75) showing the least value of 996.85 in the 1st week of digestion. Sample E (75:25) recorded the highest VS value (997.95) for week 2 while sample A (25:25) recorded the lowest VS value of 996.80 for week 2.

Table 9.Weekly volatile solid values (mg/l) of samples from the digesting materials

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	997.70^d±0.10	996.80^a±0.10	996.85^a±0.05	997.55^a±0.15	995.80^a±0.20
B	998.40^e±0.00	997.00^a±0.00	998.25^d±0.05	998.60^c±0.00	999.81^d±0.00
C	996.85^a±0.05	997.30^b±0.10	997.40^b±0.10	998.10^b±0.10	999.80^d±0.00
D	997.25^b±0.05	997.60^b±0.00	997.55^{bc}±0.15	998.75^c±0.15	999.70^d±0.10
E	997.55^{cd}±0.15	997.95^c±0.15	997.75^c±0.05	998.70^c±0.00	996.75^b±0.15
F	997.40^{bc}±0.00	997.40^b±0.00	998.20^d±0.10	997.60^a±0.20	997.80^b±0.00

Data were presented as mean±SE. Values with different alphabet letters along the same column (lower case) were significantly different (P≤0.05).

Table 10. Shows the weekly biogas yield for all sample ratios for 5 weeks from the various bioreactors

Treatments /Bioreactors	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
A	-	-	25	32	40
B	-	20	35	40	47
C	-	18	30	35	42
D	-	15	22	30	38
E	10	35	42	55	65
F	-	-	-	-	-

Table 11. Result of the biogas constituents from the gas chromatographic analyses

Gas samples from different treatments	CH_4	NH_3	CO	H_2S	CO_2
A	56	0.11	0.16	0.17	42.64
B	60.80	0.86	0.71	0.55	0.52
C	61.35	0.41	0.41	0.68	37.12
D	50.78	0.24	0.79	1.05	47.13
E	63.54	0.93	0.84	0.54	34.13
-ve CONTROL	56.12	0.14	0.22	0.23	43.20

Sample E (75:25) with Temp value (28.30^{0}C) and sample C (75:75) with temp value of (28.0^{0}C) represented the highest and lowest values for week 4.Week 5 recorded the highest temp value of 27.4^{0}C in sample D (25:75) while its lowest temp value of 26.8^{0}C was recorded by sample C (75:75). The control sample recorded its highest temperature values of 28.0 ^{0}C on the 2nd and 3rd weeks while the lowest temperature value of 27.0 ^{0}C was recorded on the 5th week. Table 8 shows the result of the total solid (TS) content obtained from the bioreactor samples. The TS results across the sample shows a significant difference (P ≤0.5) with Sample C (75:75) showing the highest TS value (9.92) and sample B (50:50) showing the least value of 6.78 in the 1st week of digestion.

Sample A (25:25) recorded the highest TS value (8.22) for week 2 while sample B (50:50) recorded the lowest TS value of 6.78 for week 2.For the 3rd week of digestion, Sample D (25:75) recorded the highest TS value (9.99) while sample C (75:75) recorded the lowest TS value of 7.47. Sample E (75:25) with TS value (9.00) and sample B (50:50) with TS

For the 3rd week of digestion, Sample B (25:25) recorded the highest VS value (998.25) while sample A (25:25) recorded the lowest VS value of 996.85. Sample D (25:75) with VS value (998.75) and sample A (25:25) with VS value of (997.55) represented the highest and lowest values for week 4 and week 5 respectively. The highest VS value of 999.81 was recorded in sample B (50:50) while its lowest VS value of 995.80 was recorded by sample A (25:25). The control sample recorded its highest VS value of 998.20 on the 3rd week while the lowest VS value of 995.80 was recorded on the 1st and 2nd week.

DISCUSSION

Table 1, shows the result of the moisture content of the samples over five weeks of anaerobic digestion. The values obtained for the samples varies significantly with no consistent reduction or increase in value noticed i.e. the value obtained were fluctuating rather than increasing or decreasing in a particular order. Moisture content of the digestate is very important in the activities of the bio digestion, the wetter the material, the more suitable it will be to handled with standard pumps and bio reactor stirrers instead of energy intensive concrete pumps and physical nears of movement (Doelle, 2001). Also the lesserthe material the more volume and area it takes up relative to the level of gas produced. The high moisture content obtained in this experiment is suitable for optimum bio gas yield. The values obtained in this work are higher than those obtained by Ofoefule *et al*. (2010), who worked on the effect of anaerobic digestion or the micro flora of animal wastes, digesting and modeling of process parameters, but similar to the result obtained by Okoroigwe*et al.*(2010) who worked on the comparative study of the potential of Dog waste for biogas production.

According to Okoroigwe *et al*. (2010) high yield of biogas obtained by the combination of cow dung and dog dung is attributed to the high nutrient value of the dung contributed by the high protein and fat content. The high protein and fat content makes high nutrient available for the micro-organism thereby making the digestion rate faster and enhancing the production of gas. This was supported by Ezekoye (2013) in the comparative study of biogas production using plantain almond leaves and pig dung. He stated that the growth and catabolism of microbes need various kinds of nutrients especially element of carbon, nitrogen and phosphorus, for high quality of methane carbon is required for building of the cell structure of the methanogenicbacteria. The nutrient content of the dung is a reflection of the quality of feed available to them. Damisa *et al*. (2008) comparing the proximate composition of collusion residues of corn straw and corncob as biomass material observed a high crude protein content in the corncob compared to the straw. The high protein content served as nitrogen source required for growth and efficient enzyme expression by the organism. The nutrient values in this work increases with increase in the mixing ratio of the dumgs indicating the efficiency of the blends as opposed to using a singular substrate for the process. The ash and carbohydrate content obtained in this work compares favorably with the result obtained by Okoroigwe *et al*. (2010), and the yield of biogas was attributed to the carbohydrate content. The bacteria in the digest must have a suitable food in order to grow and develop and this was supplied adequately by the dung's co-digested with the feed-stock. It was reported that animal manure actually provides a relatively small amount of biogas when compared to other feedstock, however combining animal waste with other feeds stock would greatly increase biogas production. The rich nutritional contents and high energy potential of the control samples makes it a good material for generating biogas, however this cannot be possible without combining it with appropriate manure supplied by the animal dung with high methane bacteria producing potential.

For optimum functioning, the anaerobic micro-organism requires a neutral environment. The pH and temperature values recorded in this work are similar to those obtained by Ofiefile *et al*. (2010). Both acid and methane forming bacteria could not survive pH values of 4 and 10 hence the values recorded in this work are suitable for the growth of methanogenic bacteria. It was reported that methane production increases with increase in temperature and most anaerobic temperature performed well at pH range between 6.8-7.2.Therefore fluctuation in the temperature and pH obtained in this work could result into fluctuation in the yield of gas produced by the bioreactor. The temperature and pH of the system can be kept at optimum level by proper monitoring throughout the digestion period. Increased temperature is also reported to facilitate faster gas yield. This operation at higher temperature facilitates greater sterilization of the end digestate. The pH of manures slurries is largely determined by the strength and equilibrium of carbonic acid-bicarbonate buffers, violate faulty acids and ammonia in the deep storage tanks for slurries. pH would also be a function of depth because of an increasing solubility of carbon dioxide under increasing hydrostatic pressure (Meena and Vijay, 2010). Decreasing violate fatty acid concentration would tend to increase pH. Methanogenic bacteria are inhibited seriously at pH below 6.5.

The result obtained for the total solid and violated solids are similar to those obtained by Abubakar *et al*. (2012) who reported that total solids and volatile solids is a vital aspect in evaluating anaerobic digestion performance. Fluctuation in volatile solids was reported to be due to probable sampling difficulties. Although there is still tendency for further TS and VS reduction with low or non biogas production, it is pressurable because of the inherent biodegrable constituent, consequently higher ammonia concentration could contribute to process inhibition. According to Nielsen and Angelidakl, {2008} animal manure such as cattle manure contains lignocelluloses rich material hence makes anaerobic digestion quile un-optimum. The total solid content recorded in this work falls between low solid (<10%) and medium solid (15-20%) standard for anaerobic digestion system (Vandevivere, 1999). Volatile solids in organic wastes are measured as total solids minus the ash contents, as obtained by complete combustion of the feed wastes. Waste characterized by high volatile solids and low non-biodegradable matter is best suited for anaerobic digestion. The composition of waste affects the yield and biogas quality as well as the compost quality. The volume of gas generated weekly for each sample ratio is shown above. There was no gas yield for all sample ratios in the first week of digestion except for sample E. The non activities in the samples with no yield could be due to slow fermentation rate. The amount of gas produced was monitored by measuring its volume and the average temperature / pH. The same activity was observed by Ilaboya *et al*., (2010) who worked on biogas generation from agricultural wastes and analysis of the effect of alkaline on gas generation. They reported that the yield within the early week of digestion changes repeatedly. They attributed this to the fact that micro-organism responsible for biogas production has consumed a large number of substrate and hence subsequent drop in activity.

The study conducted by Eze and Ojike (2012) using maize waste for biogas generation experienced no gas yield within the first 9 days of digestion, the gas only became flammable on the 10^{th} day. Vivekanadan and Kamaraj (2011) also carried out a study using cow dung as co- substrate with rice chaff at different substrate ratio and the first yield was noticed on the 3^{rd} day of digestion which agreed with result observed, for sample E in this current work that produces a cumulative yield of 10L on the first week of digestion. The production day as recorded in this work may be due to slow rate of the breakdown of organic matter which may be as a result of the temperature and pH adjustments. However maintaining optimum temperature and pH make the yield faster (Berson *et al.*, 2007). The slow yield may also be due to the time it takes for the micro- organism to adjust to the bio- reactor environment. As reported earlier sample E was the first to produce gas and the cumulative yield for the first week was 10L.It also recorded the highest yield of 65L over the 5 weeks digestion period, this was followed by sample B which was not flammable until the 2nd week of digestion where a total of 20L was observed, and the cumulative over the 5 weeks period was 40L, the lowest yield over the 5 weeks digestion period was observed in sample D with a cumulative total of 38L and there was no gas produced in the period of digestion. There was fluctuation in the yield for each sample on a daily basis before the final commutation was recorded at the end of the week for each of the samples. The flammability of the gas in each of the sample is attributed to the better anaerobic environmental condition provided by the biogas with the temperature and pH optimum for the activities of the micro-organism in the digester. The yield could also be attributed to the high protein content in the feed stock which was degraded to cellulotic materials during fermentation to yield biogas by microorganisms secreting some extra cellular enzymes (Oseni and Elperigin, 2007).The rapid increase after series of little or no activities could be due to the catabolic activities of the organisms resulting inthe breakdown of the organic matter in the digester to produce gas. Feed stocks like rice lust, corn cob, and rice chaff in this work also contributed to the yield by acting as good inoculums because they increase the number of microbes in the digestion process. Vivekanadan and Kamaraj (2011) used rice chaff and cow dung as co-substrate at 2 different ratios and the report showed that the digester case with the highest dung ratio produces the highest yield.This justifies the result obtained in this report that recorded the highest gas yield in sample E which has the highest dung ratio, particularly the ratio of the goat dung being higher than that of the dog dung. Uzodinma and Ofoefile (2009) observed that the combination of dog and cow dung generated methane after 6 days of digestion whereas dog dung alone generated methane after 20 days. They attributed this to the high ash and yield produced from the dog dung, same was also recorded in this work and the yield produced for sample with high dog dung ratio was low compared to those produced by dung's with high goat dung. This suggested that dog dung should not be used without blending with cow dungs or goat dung as used in this work. Okoroigwe (2005) reported that the gas production obtained by blending cow dung with dog dung waste is an improvement over the sole digestion of dog wastes. Vive-Kanadan and Kaman, (2011) recorded no significant yield of gas when rice chaff alone is used as a feed stock for biogas production, this support the result obtained for the control sample (F)in this work which involves the digestion of corn cob and rice chaff as feed stock without the addition of animal dung.

High yield could also be attributed to pre – treatment given to the feed stock before use, hydrothermal pre – treatment offered an accelerated pre – hydrolysis of the cellulosic and hemicelluloses part of volatile matter of the cellulosic and hemicelluloses part of volatile matter during the treatment process, this makes available a higher amount of easily degradable volatile matter to the methanogenic bacteria for its conversion. The biogas obtained from the samples comprises of methane (CH_4), Ammonia gas (NH_3), hydrogen sulphide gas (H_2S), carbon dioxide (CO_2), and carbon II oxide. The percentage of methane obtained for all samples tested are higher than the other gas produced. These results are similar to those obtained by Adegun and Yarru (2013) who worked on cattle dung biogas as a renewable energy for rural laboratories and Swanand *et al.* (2012) who worked on low pressure separation techniques of biogas into methane and carbon dioxide employing PDMS membrane. The quantity of methane produced shows how effective the bioreactor was. Also the highest methane content was recorded by sample E containing the highest goat to dog dung ratio which corresponds to the high volume produced by the sample. The value is also higher than that produced by the control sample which suggests that at the right bioreactor condition, the biogas yield can be high enough to be compressed and used for domestic cooking. The result obtained also sees samples B and C producing higher methane content than that obtained in the control sample.

The raw gas contains several impurities, like water, dust, H_2S, CO_2, siloxanes, hydrocarbons, NH_3, oxygen and several other elements, that must be removed in order to reach certain standards of quality. Adegun and Yarris(2013) reportedly removed this impurities from the biogas by first passing it through a solution of sodium hydroxide for the absorption of carbon dioxide and hydrogen sulphide components of the biogas and through a filter dryer to (dehydrate) absorb the moisture that may have accompanied it before passing to the spooter and then compressing it into the gas cylinder. Hydrogen sulfide is the chemical compound with the formula H_2S. It is a colorless, very poisonous, flammable gas with the characteristic foul odor of rotten eggs. It results mostly from the bacterial breakdown of organic matter in the absence of oxygen, such as in swamps and sewers; this process is commonly known as anaerobic digestion and is the main process in biogas formation. Due to its corrosive nature, H_2S have to be removed in an early state of the biogas upgrading process. Hydrogensulphide can also be removed by Absorption of H_2S in liquids. This can be either physical or chemical. Physical absorption involves dissolving the trace component in the solvent, whereas chemical absorption involves dissolving the component followed by a chemical reaction of the trace component and the solvent. Ammonia (NH_3) is often removed from gas by a washing process with diluted nitric or sulfuric acid especially in industrial large scale cleaning processes. The use of these acids demands installations made of stainless steel that can be expensive for small scale applications like biogas cleaning. Ammonia (NH_3) can also be removed with units filled with activated carbon and is also eliminated in some of the CO_2-removing units, like adsorption processes and absorption processes with water (Hagen *et al.*, 2001).

Physical and chemical CO_2 absorption is based on the principle of separation of CO_2 and CH_4 by using an absorbent as solvent. The mostly used method is the use of water as physical absorbent typically at a pressure of 1000-2000 kPa (Tynell, 2005). Water solvent is also effective on H_2S absorption (Persson, 2003; Schomaker *et al.*, 2000; Wellinger and Lindberg, 2005; Krich *et al*., 2005; Tynell, 2005). After scrubbing, the water can be regenerated by using a stripping low pressure column, where it is brought into contact with air or steam and inert gas in case of high concentration of H_2S. This induces the CO_2 to move into the gas phase according to the chemical equilibrium (Krich *et al*., 2005). The separation efficiency of this technique is 95% (Schomaker *et al*., 2000). This technology is simple and relatively inexpensive; moreover the loss of CH_4 is relatively small (less than 2%) because of the large difference in solubility of CO_2 and CH_4 (Kriche*t al*., 2005). The pH and temperature of the digester could also contribute to the yield; the pH recorded in this work was fluctuating between 5.69 and 8.30 while the temperature was in the range between 26.80 ^{0}C- 28. 50^{0}C. It was reported that methane production increases with an increase in temperature and most anaerobic organisms performed well at pH range of 6.8 – 7.2.Therefore, the fluctuation in the yield could also be due to the fluctuation in the pH and temperature of the biogas environment. However, the temperature and pH of the digester was kept within, the optimum level by proper monitoring throughout the digestion period. There was no biogas yield in the control sample throughout the digestion period. This is due to the fact that the control sample contains a blend of the feed stock only without the addition of animal dungs that was meant to supply the methanogenic bacteria and other microorganism that will decompose the feedstock in the anaerobic bioreactor system to produce biogas. This is in agreement with the anatomy of biogas generation described by Ilaboya *et al.* (2010).

Conclusion

Different biomass materials have different biomass generation potential, this study investigated the biogas generation potential of corncob and rice chaff and co-digested with goat and dog dung in portable air tight bioreactor designed for anaerobic digestion of the substrate mix. The yield (biogas) produced shows that the feed stock used in the work has high biogas generating potential which shows that anaerobic digestion technique is a variable option for generating energy at low cost while also combating environmental and health hazards that could result from indiscriminate disposal of the waste which serves as the material for the generation of utilizable energy.

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