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Comparative Study of the Potential of Dog Waste for Biogas Production

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Abstract: The potential of dog waste to produce biogas and/or enhance the biogas productivity of some other animal and plant wastes was investigated. Two waste combinations of dog waste with field grass (DG), dog waste with cow dung (DC) and one single waste type of dog waste alone (D), were used in the investigations for comparing the potential of dog waste for biogas production. The results showed that D (7 kg), DG (10 kg), and DC (10 kg) were capable of producing a total of 178 L, 218 L and 296.7 L of biogas, respectively in a 50 L digester in 50 days. Hence, dog waste can be a source of biogas and a source of catalyst for prolonging the retention time of other waste samples such as field grass and cow dung. The result of the proximate and microbial analyses reveals that dog waste has high potential for biogas production that even though its quantity may be small, it is a good blend for other waste types such as field grass and cow dung.

Key words: Dog waste, biogas, cow dung, grass and bioenergy

INTRODUCTION

Biomass technology has found wide application in everyday life. It is widely used as source of biomass energy for cooking, heating and electricity generation for lighting and running of IC engines. The feedstock usually used is animal and plant wastes which are abundant in Nigeria and rest of the world. Most times, these wastes if not readily used constitute environmental and health hazard. The technology for biomass conversion for energy production is simple and easily adaptable. Most experts have succeeded in adapting this technology for biogas production for domestic cooking and heating water for cleaning.

Most advanced farms use this technology for generating gas utilized in IC engines that supply hot water in the farm and energy for other processing purposes. According to Gustav (2008), "On-farm anaerobic digestion has the potential to generate energy security for the host farm, diversify farm income and increase rural investment and employment opportunities". Advanced farm in developed countries utilize the waste from animal farms to generate electricity needed in the farms. For instance, in the last several years, a growing number of dairy farms in Wisconsin have installed GE Energy's Jenbacher biogas engines to generate needed renewable electricity for onsite power and the local grid (The Bioenergy Site Latest News, 2009), with the generator producing 633 kW at the Crave Brothers Farm, LLC in Waterloo, Wisconsin. The processes involved in the conversion of biomass into energy depend on the nature of the biomass materials. Hence, anaerobic digestion is involved in the conversion of easily degradable biomass.

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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 Wilkie (2000), anaerobic digestion has other benefits such as waste stabilization and liquefaction, and production of biogas, an alternative fuel for on-farm (or off-farm) use. The fertilizer value of the raw manure is conserved in the digested effluent (Field *et al.*, 1984; Dahlberg *et al.*, 1988) and there is also a considerable reduction in the number of pathogens (Demuynck *et al.*, 1985; Bendixen, 1994). In some investigations, it was found that the biofertilizer has better nutrient quality than the raw waste (Okoroigwe, 2007; Okoroigwe *et al.*, 2008).

There are difficulties faced by users of these wastes for energy production. Among the lot, include varying retention time, long time before flammability or large production of non-combustibles such as ammonia, carbon dioxide, hydrogen sulphide and various inhibitors. Research and development activities are going on in different parts of the world in search for solution to the aforementioned problems (Cristina *et al.*, 2009; Wang *et al.*, 2009). One of the ways of doing this is by blending wastes whose features are available. Feedstock rich in carbon are blended with some other ones with high nitrogen content to obtain proper C/N ratio that works well for optimum gas production.

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, dog waste ability to generate biogas is investigated. Even though dog waste is small it could be useful in enhancing the viability of other major wastes. This study aims at studying the viability of dog waste to produce combustible biogas when used as major feedstock or enhance the quality of others as a blend. The micro organism content of the waste is also studied and presented.

MATERIALS AND METHODS

The study took place at the National Centre for Energy Research and Development, (NCERD), University of Nigeria Nsukka. Nsukka is located at (6.9°N, 7.4°E) and 445m above sea level. The materials used during the experiment are classified into feedstock and equipment. The feedstock included cow dung, dog waste and field grass. They were collected from Nsukka abattoir, dog units at University of Nigeria Nsukka security post and Department of Veterinary medicine; and NCERD compound, respectively. The equipment used includes a Jenway 3510 pH meter (manufactured by Baloworld Scientific limited, Dunmow, Essex, EU); Three 50 L digesters, conical flasks, spatula, distilled water, Bunsen burner, calibrated 10 L plastic container, nutrient agar, Furnace, etc. Proximate analysis of the waste samples was carried out to determine the elementary composition of the wastes. pH was determined using the Jenway pH meter; temperature was determined using a thermocouple thermometer. The physicochemical properties of the wastes such as: ash, moisture and crude fibre content were determined according to the method outlined by Association of Analytical Chemists (AOAC, 1990), while fat content was obtained by Soxhlet extraction method (Pearson, 1976). Whereas Kjeldal method (Pearson, 1976) was applied in determining protein and nitrogen content of the waste samples, potassium was determined by flame photometry (Pearson, 1976) method. EDTA titrimetry (Vogel, 1962) described the method employed in determining the percentage calcium and magnesium content of a sample while Walky Black (1934) method was used in carbon content determination. Microbial analysis was determined using surface viable count method (Okore, 2004). The experiment was carried out during the dry season, from early December, 2008 to January 2009 at an average ambient temperature of 34°C. Three digesters A, B and C were charged. 5 kg of dog waste and 5 kg of field grass making 10 kg of waste and 30 kg of water, was charged into digester A. For digester B, 4 kg of dog waste and 6 kg of cow dung (10 kg of waste) with 30 kg of water was charged while 7 kg of dog waste alone and 21 kg of water was charged into digester C and each of them was thoroughly mixed. The varying quantities of the waste were because of limited supply of dog waste at the collection points. The charged digesters were monitored for a period of 50 days at the exhibition ground of NCERD under normal mesophilic temperature range of 38 to 46°C, to determine the effect of the dog waste on field grass and cow dung and vice versa.

RESULTS AND DISCUSSION

Figure 1 shows the pH variation in the digesters. One important factor that affects the gas production of methanogenic bacteria during anaerobic digestion is pH. The pH of digesting wastes maintained the normal reaction pH range of 6.6 to 7.8 after the 7th day. The result implies stabilization of anaerobes after the 7th day hence the result obtained were under normal biological reaction of the microorganisms.

The values of physicochemical properties such as TS, VS and C/N ratios in Table 1, show that these waste samples are good biogas production materials. For example, Shanmugam and Horan (2009) reported an optimum C/N ratio of 15.5-19 for maximum gas production in swine manure, though many scholars have reported different values. This could result from the type of feedstock used in the analysis. Similarly, differences are obvious since source of the anaerobic digestion feedstock come from animals fed with different ration at different places.

Although, the C/N ratio of DC is less than the reported optimum value, the gas production result (Fig. 2) shows that the values of C/N ratio of the samples in the Table 1 also reveal the suitability of the wastes for biogas production. The amount of total solids in Table 1 shows the amount of nutrient capable of sustaining the life of the microorganisms in the wastes. While volatile solids represent the percentage of the wastes convertible to gas. Both values show the viability of the wastes to produce gas.

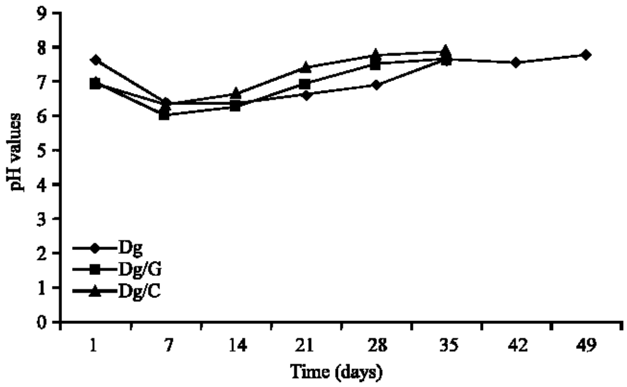

Fig. 1: pH variation of the wastes

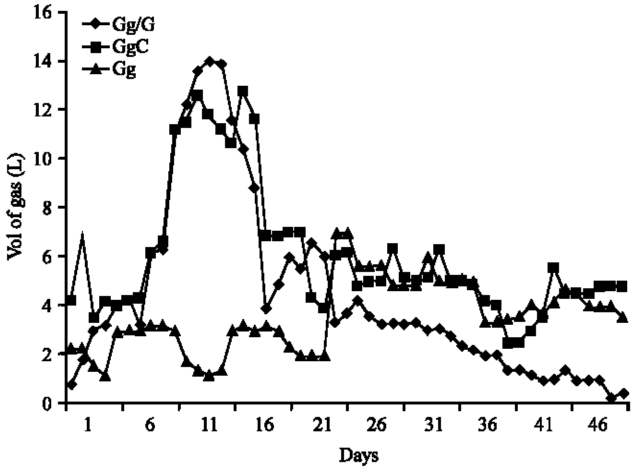

Fig. 2: Volume of gas produced by each waste per day

Table 1: Result of proximate analysis of the waste combinations

Parameters	Dog waste (D)	Dog waste and grass (DG)	Dog and cow wastes (DC)
Moisture (%)	98.5	92.75	99.5
Ash (%)	1.5	0.9	0.5
Protein (%)	2.19	1.09	1.31
Fat (%)	0.15	0.4	0.25
Fibre	0.55	1.4	0.95
Total solids (%)	96.00	94.75	92.85
Volatile solids (%)	5.0	4.8	10.3
Potassium (%)	1.5	1.1	3.0
Calcium (%)	0.06	0.06	0.06
Magnesium (%)	0.32	0.115	0.18
Phosphorus (mg/100 g)	0.48	0.59	0.48
Carbon (%)	2.98	1.64	6.38
Nitrogen (%)	0.175	0.21	0.35
Total solids	4.00	5.25	7.15
V solids	2.50	4.35	6.65
C:N ratio	17.0	7.8	18.2
Combustion time	20th day	6th day	5th day

For the 50-day testing of the wastes, a total of 178, 218 and 296.7 L of gas were recorded for Dog (D) only, Dog and Field grass (DG) and Dog and Cow (DC) wastes, respectively as shown in Fig. 2, even though the dog waste alone continued to produce gas for 59 days. This implies that the gas production rates (m^3/m^3/day) of the wastes, respectively are 0.0712, 0.0872 and 0.1187. In a similar work done by Uzodinma and Ofoefule (2009) a total of 0.0738 m^3 was collected using field grass only for 30 days giving a gas production rate of 0.0492 m^3/m^3/day. The combination of dog waste with field grass was an improvement over field grass only. By this, it is likely that the dog waste contains microbes that act on the molecular structure of grass materials to break it down for anaerobes to digest it. This could be investigated further to see whether dog waste can act as enzymes base for cellulosic digestion of grass. A gas production rate of 0.106 and 0.27 m^3/m^3/day had been reported by Okoroigwe (2005) and Maishanu and Maishanu (1998), respectively for cowdung digestion. The gas production rate obtained by blending cowdung with dog waste is an improvement over sole digestion of dog waste. It could be that the combination of the microbes present in both waste types such as the Bacteroides sp. (Table 3) is better for optimum gas production from dog. These organisms can be isolated in further work for biogas production. Another possible cause for difference in the values may be environmental. The weather and other climatic factors may play role in the performance of microbes during AD. Nevertheless, dog waste has a long retention time.

The Table 2 shows the result of the amount of microorganisms in the wastes at major times of the analysis. The Table shows that all the wastes had high microorganism content at the beginning which probably is as a result of combination of aerobic and anaerobic organisms. At flaming period the methanogenic organisms identified in Table 3 began to multiply and gradually died towards the end of gas production.

During the analysis, the methane production was monitored by testing the combustion of the gas produced. Whereas the rest of the waste sample combinations DC and DG produced combustible gas (methane) by the first 6 days, the dog waste alone (D) started burning by the 20th day. This could be attributed to its high ash and protein content (Table 1) compared to the rest of the test samples. The Table 3 shows the microbes present at different times of the digestion. A close examination of the microbial isolation Table 3 of all the samples, one could observe the presence of Butyrivibrio sp. This microorganism was present in the waste samples up to the combustion period. Could the presence of this organism inhibit or limit the quantity of methane produced in AD activities is another scientific investigation that needs to be verified. This then suggests reason why dog waste should not be digested without blending with either cow dung or field grass. The increase in the total viable count (Table 2) between the flaming period and at end of gas production of DC and DG may be caused by the presence of the microbes isolated in Table 3. The blending of dog waste with field grass improved the methane production of the later over the recorded time to combustion of 22 days reported by Uzodinma and Ofoefule (2009). This could be explained by the reasons given earlier such as the presence of methanogenic bacteria contributed by dog waste to enhance metabolic breakdown of plant cellulose in grass.

Table 2: Total viable count of the micro-organism in the waste types

	Charging period	Flaming period	End of gas production
Waste		(cfu mL^{-1})	
Dog waste	8.2×10^{14}	7.6×10^{11}	4.2×10^{8}
Dog waste and grass	7.2×10^{14}	6.2×10^{12}	3.8×10^{14}
Dog and cow wastes	4.6×10^{18}	5.7×10^{12}	7.2×10^{12}

Table 3: Types of micro-organism present in the wastes at different periods of digestion

Waste type	Charging period	Flaming period	End of gas production
Dog	*Butyrivibrio* sp. *Clostridium* sp. *Ruminococcus* sp. *Acetivibrio* sp. *Eubacterium-cellulosolvens.*	*Clostridium* sp. *Ruminococcus* sp. *Acetivibrio* sp. *Eubacterium-cellulosolvens.*	*Clostridium* sp.
Dog/cow	*Butyrivibrio* sp. *Clostridium-cellulolyticus,* *Clostridium-cellulosolvens,* *Bacteroides* sp. *Acetivibrio* sp.	*Acetivibrio-Cellulolyticus,* *Ruminococcus* sp. *Bacteroides* sp. *Eubacterium-cellulosolvens.*	*Acetivibrio-Cellulolyticus,* *Ruminococcus* sp. *Eubacterium* sp.
Dog/grass	*Acetivibrio-cellulolyticus,* *Clostridium-cellobioparum,* *Eubacterium-cellulosolvens,* *Butyrivibrio* sp.	*Acetivibrio-cellulolyticus,* *Ruminococcus* sp. *Clostridium-cellobioparum,* *Clostridium-thermocellum,* *Clostridium-cellulovorans.*	*Ruminococcus* sp. *Clostridium-thermocellum* *Clostridium-cellulovorans.*

CONCLUSION

Different biomass materials have different biogas generation potential. Whereas many have been tested to have high biogas viability, some need to be blended to improve their potential. Field grass for instance can be enhanced by blending with dog waste. Even though the later is limited in supply and production per animal (dog), it should not be neglected. Dog waste is not commonly used for biogas production for reasons that may hinge around its quantity and probably less gas production. But this research has shown that even though not usually largely produced, it can produce methane for cooking and can be combined with other plant and animal wastes to enhance its viability for biogas production. It is in no way an inhibitor. For the purposes of proper disposal of the waste it can be used for energy and biofertilizer production. From the forgoing experiment, it is not however advisable to depend on dog waste alone for biogas production, even though it has a long retention time, for the reasons presented in the results and discussion. It can also be inferred that dog waste is not dangerous to the other waste types used in the experiments. The authors however acknowledge some lapses, such as use of limited quantity of dog waste and uneven amount in all the samples, which may have affected the overall quantity of gas produced while proposing further work such as isolating some microbes from the medium.

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