Increasing the biogas yield of a floating drum anaerobic digester using poultry droppings with banana (*Musa Paradisiacal*) peels

K A Adeniran¹, A O Adeniran¹, T J Sanusi¹ and D A Olasehinde²

¹Department of Agricultural and Biosystems Engineering, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria.  
²Department of Agricultural and Biosystems Engineering, Landmark University, Omu-Aran, Kwara State, Nigeria.

Corresponding E-mail: kadeniran_2003@yahoo.com

Abstract. An anaerobic digester was used to generate biogas using poultry droppings and banana (*Musa Paradisiacal*) peels. The digester was tested twice with a retention period of 35 days. The first test (control) was carried out with poultry droppings and water as the feedstock using a ratio of 1:2 kg. The second test was carried out using poultry droppings, water and banana (*Musa Paradisiacal*) peels as the feedstock using a ratio of 1:2:3 kg. The temperature of the slurry in the bio-digester was monitored and recorded three times daily. The ambient temperature measured during the first stage of the study was between 21–34°C while the slurry temperature was between 21 and 39.3°C. For the second stage of the study, the ambient temperature measured was between 21 and 32°C while the temperature of slurry measured was between 19.8 and 38°C. Higher ambient temperatures during the first test were responsible for the slurry temperature. The total volume of biogas produced during digestion for the first test was 83.38 litres while 121.3 litres was generated during the second test. The study shows that the biogas yield of the anaerobic digester was increased when poultry droppings were mixed with banana (*Musa Paradisiacal*) peels. Banana peels aided the digestion of poultry droppings in the digester.

1. Introduction

In most developing countries, wastes discharged from homes, industries and agricultural fields are indiscriminately disposed and sometimes released into natural water bodies. The discarded waste generate gases which if not effectively reutilized may lead to the pollution of the atmosphere, greenhouse effects and release of putrid smells. These wastes pose a threat to aquatic life and the health of human beings and animals. Proper reutilization of waste and the need to satisfy energy for domestic and industrial uses, and reduce appreciably the local pollution and greenhouse effects is the prospection and development of a new source of energy (biogas). The over reliance on fossil fuels as a primary energy source has had debilitating effects on the environment resulting in several phenomenon like the global climate change. Biogas digesters can be used for generation of combustible gas (methane) used for the generation of electricity and heating [1]. Floating-drum
digesters are recommended for biogas production because of their reliability and high performance [2]. Gas production from a given amount of feedstock depends on the type of feedstock used [3]. Nagamani [4] and Roos [5] reported that feedstocks that are commonly used in anaerobic digesters include livestock manures, waste feeds, food-processing wastes, slaughterhouse wastes, farm mortality, corn silage, ethanol stillage, glycerine as the product from biodiesel production, milk house wash water, fresh produce wastes, industrial wastes and sewage sludge. Adeniran [6] developed and tested batch and floating drum bio-digesters used for producing biogas from animal wastes. Sanathianathan [7] and Adeniran [8] reported the relative effectiveness of biogas production of different proportions of poultry wastes and cattle dung. The study shows that the largest volume of biogas production was obtained using a high concentration of poultry wastes to cow dung. Poultry wastes, therefore, are effective for the production of biogas than cow dung. Past studies showed that potato and orange peel improved biogas yield of anaerobic digesters [9,10]. The objective of this study was to test the effectiveness of using banana (*Musa paradisiaca*) peels as a catalyst for biogas production in a floating drum anaerobic digester using poultry droppings.

2. Materials and Method

2.1 Equipment and Experimental Work

A floating drum anaerobic digester (Fig. 1) with a capacity of 223.5 litres tank and a 191 litres gas tank was used in generating biogas using poultry droppings and banana (*Musa paradisiaca*) peels as feedstock. The first test (control) was carried out on the digester with a ratio of 1 kg of poultry droppings to 2 kg of water and the second test was carried out with a ratio of 1 kg of poultry droppings to 2 kg of water to 3 kg of banana (*Musa paradisiaca*) peels to improve the biogas yield. The major components of the anaerobic digester are slurry mixing tank, digester tank, gas holder tank, a scrubber tank, water displacement tank and a storage container. Other accessories include stirrer/mixer, hoses, valves, metallic inlet fittings, waste conduit and frame. A frame structure with mechanical grooves was constructed to a specific length above the tank to prevent the gas tank from tilting as well as also not to allow it fall off due to the pressure of the gas. The major tests carried during the study involved the purification of the methane gas produced [11]. Other gases such as water vapour, carbon dioxide (CO₂) and sulphur dioxide (SO₂) were removed from methane. Water vapour was removed by allowing the gas to pass through a water displacement tank placed at the exit of the digester. Methane was then released into the scrubber. The scrubber was used to absorb carbon dioxide (CO₂) and sulphur dioxide (SO₂) content of the gas and pass the gas to the storage container. Also the combustion test was carried out on gas produced to determine if it is inflammable or not.

Figure. 1. The floating drum anaerobic biogas digester

3. Results and Discussion

3.1 Temperature variations during the first test using poultry droppings with water

Table 1 show the temperatures in the morning temperature variations for both ambient and slurry conditions for a period of 30 days for the first test using poultry droppings mixed with water. The
temperature varied from 20 to 45°C (mesophilic range). Minimum and maximum ambient temperatures of 21 and 29°C respectively were obtained during the period of study, while for the slurry condition, minimum and maximum temperatures of 21 and 28.2°C respectively were obtained. The temperatures of the slurry obtained in the morning were lower than that of the ambient condition because of the ability walls of the digester to absorb more heat from the environment than it is able to emit heat. Table 1 also shows the minimum and maximum ambient temperatures of 28 and 34°C respectively were obtained for the afternoon variations, while for the slurry condition, the minimum and maximum temperatures obtained were 33.2 and 39.2°C respectively. At this time, the ambient temperature increased, resulting in a corresponding increase in the slurry temperature because the digester tank walls absorbed more heat from its surrounding. Table 1 show that the evening temperature variations, minimum and maximum ambient temperatures of 27 and 32°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 31 and 39°C respectively. The slurry temperatures were higher than the ambient temperatures because of the digester body coated black, which increases the amount of heat absorbed and thereby increasing the action of mesophilic bacteria [12].

Table 1: Temperature variation during the first test (Control)

| Day | Morning | Afternoon | Evening |
|-----|---------|-----------|---------|
|     | Ambient Temp. | Slurry Temp. | Ambient Temp. | Slurry Temp. | Ambient Temp. | Slurry Temp. |
| 6   | 25.0 °C | 23.8 °C | 34.0 °C | 39.2 °C | 32.0 °C | 39.2 °C |
| 7   | 25.0 °C | 23.8 °C | 34.0 °C | 39.0 °C | 32.0 °C | 39.0 °C |
| 8   | 28.0 °C | 27.5 °C | 28.0 °C | 33.5 °C | 27.0 °C | 33.5 °C |
| 9   | 27.0 °C | 26.3 °C | 33.0 °C | 38.4 °C | 31.0 °C | 38.4 °C |
| 10  | 25.0 °C | 23.8 °C | 33.0 °C | 38.7 °C | 31.0 °C | 38.7 °C |
| 11  | 25.0 °C | 24.5 °C | 33.0 °C | 38.4 °C | 31.0 °C | 38.4 °C |
| 12  | 29.0 °C | 28.2 °C | 33.0 °C | 38.3 °C | 32.0 °C | 38.3 °C |
| 13  | 26.0 °C | 24.5 °C | 28.0 °C | 33.2 °C | 27.0 °C | 33.2 °C |
| 14  | 27.0 °C | 26.3 °C | 30.0 °C | 35.7 °C | 27.0 °C | 35.7 °C |
| 15  | 25.0 °C | 23.8 °C | 32.0 °C | 36.8 °C | 30.0 °C | 36.8 °C |
| 16  | 27.0 °C | 26.4 °C | 32.0 °C | 36.6 °C | 31.0 °C | 36.6 °C |
| 17  | 27.0 °C | 26.4 °C | 33.0 °C | 37.9 °C | 31.0 °C | 37.9 °C |
| 18  | 26.0 °C | 25.6 °C | 34.0 °C | 39.0 °C | 32.0 °C | 39.0 °C |
| 19  | 26.0 °C | 24.5 °C | 31.0 °C | 34.4 °C | 29.0 °C | 34.4 °C |
| 20  | 26.0 °C | 24.5 °C | 32.0 °C | 36.7 °C | 31.0 °C | 36.7 °C |
| 21  | 26.0 °C | 24.8 °C | 34.0 °C | 39.2 °C | 32.0 °C | 37.2 °C |
| 22  | 26.0 °C | 24.8 °C | 33.0 °C | 37.8 °C | 30.0 °C | 35.7 °C |
| 23  | 25.0 °C | 25.0 °C | 33.0 °C | 37.6 °C | 30.0 °C | 35.3 °C |
| 24  | 27.0 °C | 25.6 °C | 34.0 °C | 39.0 °C | 31.0 °C | 36.7 °C |
| 25  | 28.0 °C | 27.2 °C | 33.0 °C | 37.7 °C | 29.0 °C | 35.6 °C |
| 26  | 24.0 °C | 23.8 °C | 34.0 °C | 39.1 °C | 32.0 °C | 38.0 °C |
| 27  | 22.0 °C | 22.0 °C | 33.0 °C | 37.6 °C | 31.0 °C | 35.3 °C |
| 28  | 22.0 °C | 21.7 °C | 34.0 °C | 39.0 °C | 32.0 °C | 36.7 °C |
| 29  | 21.0 °C | 21.0 °C | 33.0 °C | 38.0 °C | 31.0 °C | 35.8 °C |
| 30  | 26.0 °C | 25.3 °C | 31.0 °C | 34.6 °C | 28.0 °C | 31.0 °C |
| 31  | 24.0 °C | 23.2 °C | 32.0 °C | 37.0 °C | 30.0 °C | 34.1 °C |
| 32  | 24.0 °C | 24.0 °C | 34.0 °C | 38.8 °C | 32.0 °C | 34.9 °C |
| 33  | 22.0 °C | 21.0 °C | 33.0 °C | 38.2 °C | 31.0 °C | 35.0 °C |
| 34  | 26.0 °C | 25.3 °C | 33.0 °C | 38.0 °C | 31.0 °C | 35.0 °C |
Table 2 shows that the temperatures in the morning temperature variations for both ambient and slurry during the second phase of the experiment (using poultry droppings, water and banana (*Musa paradisiaca*) peels. The digester was able to keep the temperature within the mesophilic range (20 to 45°C). Minimum and maximum ambient temperatures of 21 and 26°C respectively were obtained, while for the slurry condition, minimum and maximum temperatures of were 19.8 and 24.8°C respectively. The afternoon temperature variations show that the minimum and maximum ambient temperatures of 26 and 37°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 31 and 39.3°C respectively. During this period, the ambient temperature increased, resulting in an increase in the slurry temperature because of the ability of the digester tank material and coating to absorb more heat from its surrounding. During the evening period, minimum and maximum ambient temperatures of 25 and 35°C respectively were obtained, while for the slurry condition, the minimum and maximum temperatures obtained were 27.5 and 39.3°C respectively. Comparing the temperatures recorded during the two tests, the slurry temperatures were higher during the second test than the first because the use of banana (*Musa paradisiaca*) peels as a catalyst increased the digestion rate resulting in an increase in the action of mesophilic bacteria. Also, the digester body coated black increased the amount of heat absorbed.

### 3.3 Volume of gas produced during the two tests

Fig. 2 shows the total volume of biogas obtained per day for each of the two tests conducted with digester. The digester was first tested with slurry made of poultry droppings and water mixed in a ratio of one 1 to 2kg. The hydraulic retention period was 35 days. After the 35th day, the total volume of gas produced in the bio-digester was 83.38 litres after which the gas was burnt off. With the valve opened halfway, the gas burned for about 40 minutes. The volume of slurry retained in the digester tank was about 37.4 litres which means about 22.6 litres of the slurry was converted to gas. Change in the colour of the slurry evacuated was noticed with none offensive odour.

The second test was carried out using poultry droppings, water and banana (*Musa paradisiaca*) peel at a mixing ratio of 1:2:3 for a retention period of 35 days. The hydraulic retention period was 35 days. On the fifth day after loading, the gas was again released into the atmosphere because it was none-combustible. No appreciable rise in the height of the gas tank was noted until the 14th day to about 7.6 cm after which combustibility test was carried out. The gas was combustible with a red-blue flame which indicated the presence of CH₄ gas. After the 35th day, the total volume of gas produced in the bio-digester
was 121.3 litres after which the gas was burnt off. With the valve opened halfway, the gas burned for about 55 minutes. The volume of slurry retained in the digester tank was about 24.7 litres which means about 35.3 litres of the slurry was converted to gas. Change in the colour of the slurry evacuated was noticed with a non-offensive odour. The total volume of biogas produced during the second test was 131.82 litres while that of the first test was 83.38 litres. Mixing banana (Musa paradisiaca) peels with poultry droppings, therefore, increased biogas generation by 50%. Ofoefule [13] obtained similar results, using cow dung blended with paper wastes increased cumulative biogas yield from 6.23±0.07 dm³/kg to 9.34±0.11 dm³/kg. Uzodinma [14] also observed that low flammable biogas from the maize bract waste can be enhanced significantly by blending with cow and swine dung. In this study, more digestion of the feedstock took place during the second test than the first because of the addition of banana peels. Ilori [15] and Aiwonegbe [16] reported similar results with plantain peels and leaves respectively.

4. Conclusion

The study shows that the biogas yield of poultry droppings can be increased by mixing it with banana (Musa paradisiaca) peels. The poultry droppings banana (Musa paradisiaca) peels blend gave the best results in terms of volume of biogas yield. Consequently, apart from chemical treatment, energy could also be tapped from banana (Musa paradisiaca) peels by blending it with the wastes from domestic animals that are readily available. The rate of biogas production was greatly affected by the temperature and the colour of the slurry. The study shows that banana (Musa paradisiaca) peels are a good catalyst for producing biogas (methane)

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