



## Biogas Production From Banana and Plantain Peels Blended With Cow Dung in An *In vitro* Biodigester System

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### ABSTRACT

The rising cost of fossil oil as source of energy as a result of its diminishing supplies coupled with attendant pollution problems associated with petroleum and allied products calls for the search for alternative energy source. The research aim to produce biogas from fresh, dried and cow dung seeded banana and plantain peels. The experiment was carried out using an improvised laboratory anaerobic digester for a period of 35 days. The volume of gas generated during the retention period were in the order seeded sample > fresh sample > dried sample. The banana peels was seen to be a better biogas producer when compared to plantain peels with the biogas produced showing a calorific value 6684 kcal/kg as compared to 6535 kcal/kg for plantain peels. The physico-chemistry of fresh samples and spent slurries in the biodigesters revealed a slight drop in pH from 7.2 to 5.68 and 7.4 to 6.1 for the plantain and banana peels respectively. This study holds promise in developing countries and notably in rural areas where electricity and are scarce and biological waste are in abundance.

**Keywords:** Banana peels, Biodigester; Biogas; Plantain peels

### INTRODUCTION

Renewable energy is a major area for research and development especially from biological waste streams (Deublein and Steinhauser, 2010). Approximately 1.3 billion tonnes of food waste are unused each year; this reduces the food for human consumption and a large amount of them ends up in "land-fills" with the production of methane gas (FAO 2011). Anaerobic digestion in a biodigester is a way to utilize organic waste efficiently, producing not only a combustible gas (methane) but also functioning as a waste disposal system. This increases the availability of gas for cooking as well as reducing the amount of waste that has to be transported to land-fills or to centralize processing facilities (Croxatto Vega *et al.*, 2014). Vaid *et al* 2013 reported that food waste not only makes anaerobic digestion desirable but makes it cost efficient, reduces greenhouse gas emissions at landfills, utilizes existing infrastructure for food waste diversion and meets local and state waste diversion goals. The pollution which results from temporary storage of the food waste at household level is also avoided by such a strategy.

Energy problem generally is caused as a result of the dependency on fossil fuel energy

sources which are not only limited but unsustainable in the near future. Switching to rely on renewable energy sources will definitely ameliorate or solve this energy problem in a sustainable way. In most African countries, fire wood is commonly used as a source of fuel whereas huge wastes in the form of crop wastes, human and animal wastes are either burnt or left to rot in the farms and factory dumps (Dioha *et al.*, 2003; Ezeonou, 2002; FAO, 2000). In Nigeria, solid waste disposal arising from food preparation and consumption as well as industrial, farming and market operations has become a serious problem in the metropolitan cities (Filani and Abumere, 1982).

Banana a tropical fruit cultivated in over 130 countries worldwide is the second largest cultivated crop compared with other fruits (Mohapatra *et al.*, 2010). Banana can be consumed in the fresh form and 80% of ripe banana is processed as ingredient in many types of food such as baby food, banana streamed pastry, deep fried banana, sun-dried banana, sweet banana crisp, and banana stirs. In general banana peel is abandoned as a solid

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waste which decomposes to produce noxious gases such as hydrogen sulphide and ammonia. Plantain on the other hand, is commonly consumed as a major food staple in Nigeria. It can be boiled, fried, roasted and even used to produce “Agadagidi” an alcoholic beverage. Aside its individual family consumers, the peels abound as wastes and their disposal also poses a challenge to the consumers with the poor waste management system available especially in developing countries. These were the reasons behind the choice of these wastes. This paper reports on the comparative studies of the biogas potential of plantain peels, banana peels and cow dung when used to enhance the quality of others as a blend.

## METHODOLOGY

### Location and Duration

The experiment was conducted at the Sokoto Energy Research Centre (SERC) central laboratory, Usmanu Danfodiyo University (13.1246° N, 5.1994° E) Sokoto, Sokoto State Nigeria during the dry season from February to March 2016.

### Sources of Sample

Plantain (*Musa parasidiaca*) peels and banana (*Musa accuminata*) peels were collected from Ramin Kura market while cow (*Bos primigenius*) dung was collected from Dundaye village both in Sokoto metropolis.

### Sample and Slurry Preparation

Both wastes were collected fresh, chopped by hand into small pieces (2-3 mm length) and sorted into three portions. The fresh portion was dried from two week before being reduced to fine powder with the aid of mortar and pestle. Its slurry was prepared by macerating the dried substrate with distilled water in the ratio of 1:4. While, the second portion was finely grounded with water in an electric milling machine in the ratio 1:4, the third portion was seeded with cow dung in the ratio 1:6 water to waste (ratio arrived at after preliminary trial). The slurries were quickly loaded into their respective biodigesters.

### Fabrication of Digesters

Cylindrical cans were used as the digesters and plastic basins were used as water trough. To each can, a hole was bored on the lid of the can and a polyvinyl chloride tube was inserted into the hole and fixed with araldite adhesive to ensure that the digester was airtight. This

served as the outlet for the generated biogas. The free end of the rubber tube was then inserted, through water contained in a partly filled water trough into an inverted measuring cylinder that has also been filled with water, to serve as the biogas collection system. The biogas was collected by downward displacement of water. The tins were properly labeled for the purpose of the study.

### Loading of Digesters

All digesters were cleaned up and well drained. Equal concentrations of the slurry were poured into their respective digester. The digesters were made air-tight by lubricating the open end with grease and operated with a rubber stopper (cork). A delivery tube was connected to the digesters which convey the gas to another 1000 ml conical flask containing a brine solution and another delivery tube connected from the conical flask containing a brine solution into an outlet. The digesters were set up and allowed to undergo anaerobic digestion for a retention period of 35 days. The amount of gas produced on weekly basis was measured using water displacement method adapted from Bolarinwa and Ugoji, 2010. Readings corresponding to biogas production were taken every 24 hours at 12 noon each day for the retention period. The pH of the substrate prior to loading the digester and its spent slurry was determined. Each procedure was performed in triplicate.

## RESULTS AND DISCUSSION

The pH of the fresh and spent slurry is shown in figure 1. The pH in the biodigesters was observed to decrease over the first 14 days after which the values stabilized. The pH of samples is one of basic parameters that affect biogas production and is used to rationalize the biogas production potential. The pH of the spent slurry decreases because as digestion commences there is bound to be the formation of sulphide in the slurries due to the breakdown of biodegradable sulphur containing organic and inorganic compounds likewise the formation of fatty acids by acetogenic methanogens during the process of digestion (Bagudo, 2007). It was also noticed that the Ph recorded for the banana peel substrate is not the ideal pH of 6 – 7 since Bacteria responsible for biogas requires a neutral environment since the microbes that

convert waste to biogas are highly pH sensitive (Garba and Sambo, 1992).

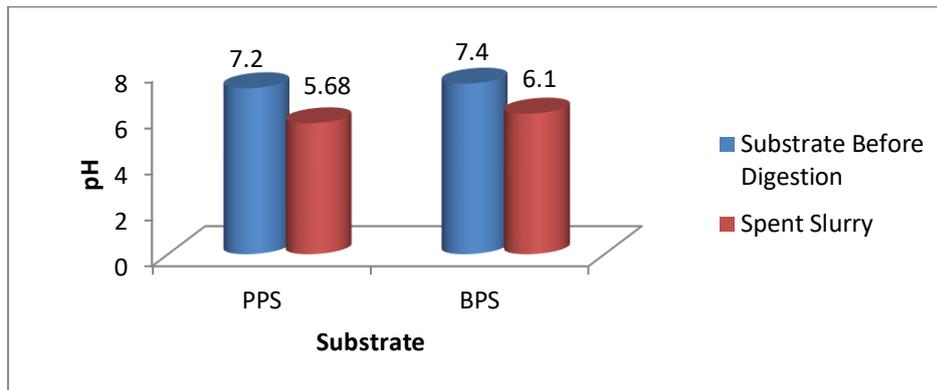


Figure 1: pH of the fresh and spent slurry

Key: BPS = Banana peel substrate, PPS = Plantain peel substrate.

### Daily Biogas Production

This research work was done during the dry season with a temperature range of 30 – 34°C and during the 35 day retention time. Figures 1 and 2 show the daily and weekly volume of biogas produced while figure 3 shows the calorific value of the produced biogas from the banana and plantain peels substrates.

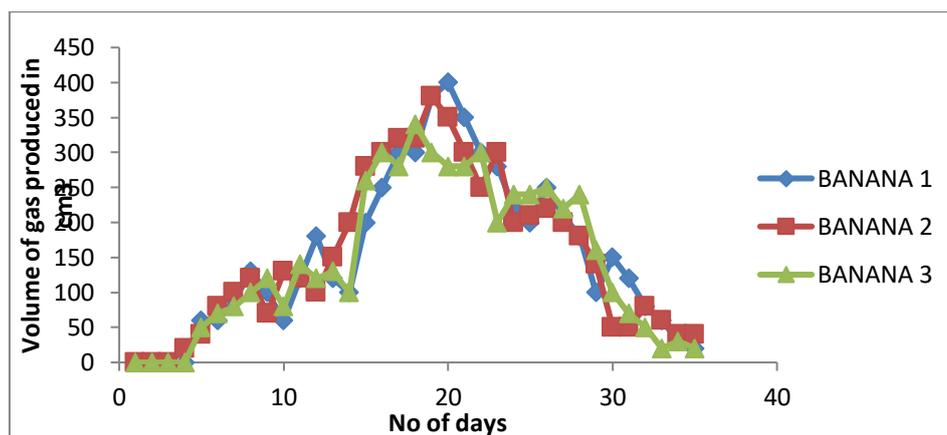


Figure 1(a): Daily biogas produced from banana peel substrate throughout the retention period.

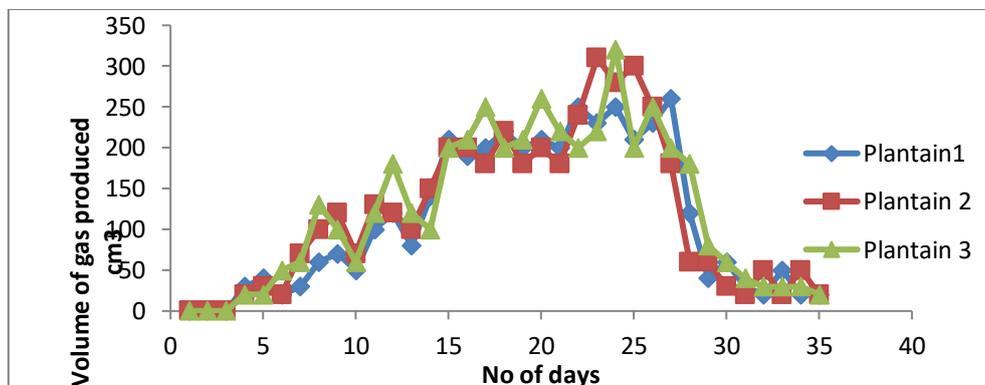


Figure 1(b): Daily biogas produced from plantain peel substrate throughout the retention period.

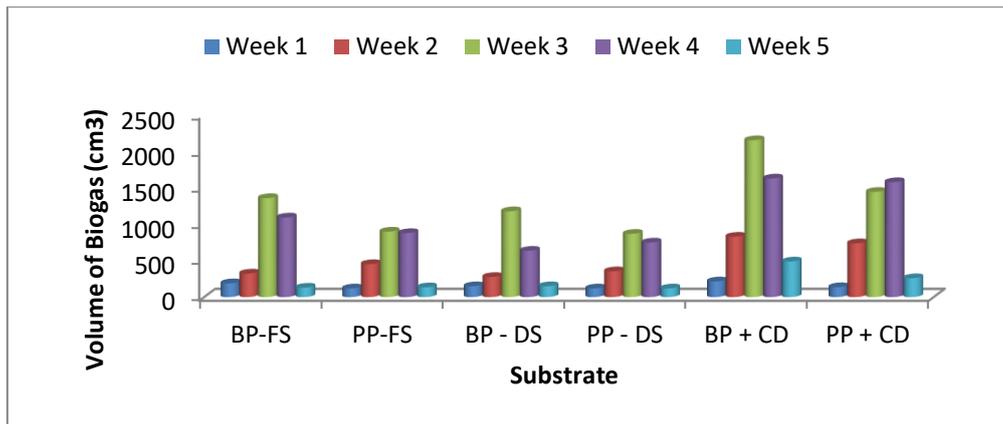


Figure 2: Weekly Biogas Production

Key: BP - FS = Banana peel fresh substrate, PP - FS = Plantain peel fresh substrate, BP - DS = Banana peel dried substrate, PP - DS = Plantain peel dried substrate, BP + CD = Banana peel seeded with cow dung, PP + CD = Plantain peel seeded with cow dung

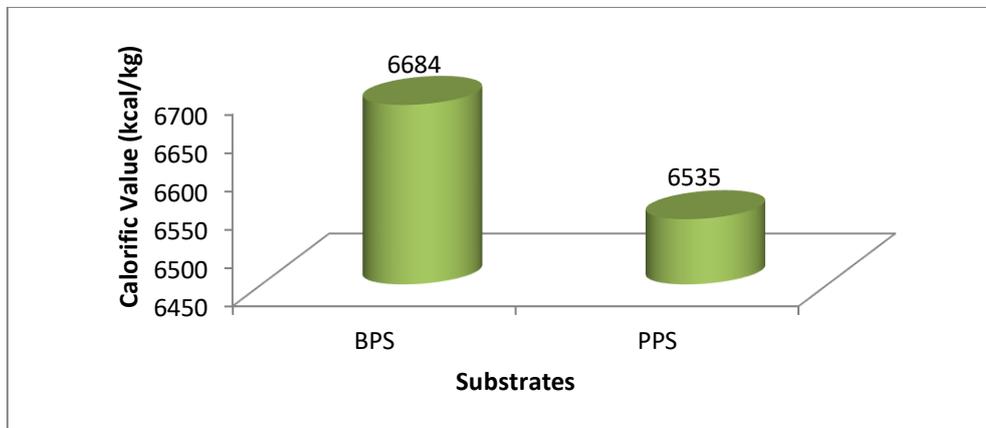


Figure 3: Calorific value of the produced biogas

Key: BP = Banana peel substrate, PPS = Plantain peel substrate

The results presented in figures 1 and 2 showed that the substrate seeded with cow dung which has been acknowledged as the best biogas producer amongst animal wastes when blended with suitable substrates. It produces the highest volume of biogas throughout the retention period when compared to both banana and plantain substrates used. This may be due to the rich flora of microorganism supplied by the animal waste which is capable of hydrolyzing a large amount of polysaccharide, which includes starch and biodegradable organic matter compared to the fresh and dried substrates when used independently (Odeyemi, 2004). The digester containing the fresh substrates of both plantain and banana substrates produces more than their dried counterpart and that of the fresh banana substrate produces more cumulative biogas than its fresh plantain substrate counterpart. This may be because of a tougher

lignin, cellulose and hemicelluloses in the waste of plantain peel (figure 2). Lignin suppresses biodegradation and the higher the lignin content, the lower the biogas yield (Adelekan and Bamgboye, 2009). This may have contributed to the poor performance of the waste.

**Conclusion**

In this study, the banana and plantain peels seeded with cow dung yielded more biogas than when used independently. The results of this research also shows that both fresh and dry plantain peels produces lesser amount of biogas compared to that of banana peels hence will require pre-treatment to enhance its biogas yield. This technology will help curtail the overdependence on oil which at today usage rate will dry up in future. This will help create different ways whereby power or energy can be generated as well eliminate the name tag

associated with the substrates as being nuisance causing environmental pollution. Aside cow dung other animal wastes can be utilized to optimize the biogas production from both banana and plantain peels.

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