
Comparative Study of the Biogas Potential of Pumpkin (*Telfairia occidentalis*) and Water Melon (*Citrullus lanatus*) Wastes Blended with Cow Dung

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ABSTRACT

Biogas production from watermelon and pumpkin wastes blended with cow dung was investigated. Three categories of digesters were charged. The first set was charged with fresh watermelon and pumpkin wastes (control), the second with dried watermelon and pumpkin wastes while the third with watermelon and pumpkin wastes seeded with cow dung. Anaerobic batch digestion took place for 35 days under ambient atmospheric conditions. Mean volume (cm³) of biogas yield from the fresh, dried and seeded wastes are 817.7 and 961, 442 and 278, 486 and 340 for watermelon and pumpkin respectively. The result revealed that the dried wastes blended with cow dung gave a higher biogas yield than the fresh wastes but was however lower than that of the fresh wastes. This is as a result of the hardening of the lignocellulosic materials brought about by drying as compared to when it was fresh and as such will take a longer time for methanogenic microorganisms to break it down. This explains why the highest biogas production was observed on the fourth week as against the third week for the fresh wastes. The results showed that the substrates are good materials for biogas production.

Key words: Biogas, Anaerobic digestion, Substrate, Cow dung

INTRODUCTION

Energy is an important factor to human existence. The inadequacy of energy supply is known to limit economic growth and adversely affect socio-economic activities as well as the quality of life. Furthermore, the increasing cost of fossil fuels, its epileptic supply to the end user and the prediction that current reserves may not last more than three decades has necessitated the need for alternative sources of energy in the developing countries (Bagudo *et al.*, 2008). Biogas is the gaseous product of the anaerobic digestion (decomposition without oxygen) of organic matter. It is typically made up of 50-80% methane, 20-40% carbon dioxide and traces of other gases like CO, H₂S, NH₃, O₂, H₂, N₂ and water vapour (Edelmann *et al.*, 1999). The production of biogas is one of the most nature's friendly and prospective alternative energy technologies, and development of this technology will continue hence researches aimed at the generation of biogas from naturally occurring sources will be viewed as a welcome development.

In Nigeria, solid waste disposal has become a serious problem in the metropolitan cities. These wastes are generated during food preparation and consumption as well as industrial,

farming and market operations (Filani and Abumere, 1982). Various treatments such as soaking in water, size reduction, and addition of organic solvents, alkali and acids, inorganic metals, among others have been added to organic wastes to upgrade their biogas yield (Chumet *et al.*, 1985; Perrone *et al.*, 2004; Chen *et al.*, 2007; Ofoefule *et al.*, 2009; Ofoefule *et al.*, 2011). Also, one known treatment method for improving the biogas production of various feed stocks is co-digesting them with animal and/or plant wastes (Mshandete *et al.*, 2004). Blending of animal and plant wastes bring about sustained onset of flammable gas production with higher cumulative biogas yield during the chosen retention period (Srinivasan *et al.*, 1997). This is because blending could enhance synergistic effect of the combined feed stocks.

Nigeria is one of the largest producers of *Citrullus lanatus* with over 347,000 tons in the year 2002 alone (Schippers, 2002). *Telfairia occidentalis* on the other hand is a tropical vine grown in West Africa as a leafy vegetable and for its edible seeds. The wastes have been used in composting and in recent times as animal feed. Hence, the present study was carried out to enhance pumpkin and watermelon wastes for renewable energy production by blending it with cow dung under anaerobic digestion. Positive results can give confidence to biogas plant owners on the feasibility of utilization of the mentioned biomass in biogas co-generation plants for electricity and heat production.

MATERIALS AND METHODS

Sources of Sample

Pumpkin (*Telfairia occidentalis*) and water melon (*Citrullus lanatus*) wastes were collected from Ramin Kura market while cow (*Bos primigenius*) dung was collected from Dundaye village both in Sokoto metropolis.

Sample Preparation

The fresh samples were chopped into smaller sizes to ease the digestion process. They were divided into two groups. One set was sun dried for one week after which they were pulverized with the aid of mortar and piston to ensure homogeneity. The second set was utilized fresh.

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 labeled P₁, P₂, P₃, W₁, W₂ and W₃ for the purpose of the study.



Figure 1: Cross section of the fabricated digesters

Preparation of Slurry and Loading of Digesters

100 g of fresh pumpkin and water melon wastes were fed into digesters P_1 and W_1 , respectively. 400 cm³ of water was added to each digester making a ratio of 1:4. 50 g of the dried samples were fed into digester P_2 and W_2 respectively. 300 cm³ of water was added to each digester making a ratio of 1:6. 50g comprising of 45 g of dried samples seeded with 5 g of cow dung were fed into digesters P_3 and W_3 respectively. 300 cm³ of water was added to each digester making a ratio of 1:6. All digesters were well stirred and the opening sealed. Readings corresponding to biogas production were taken every 24 hours at 12 noon each day for 35 days retention period. Each procedure was performed in triplicate.

Purification of the produced Biogas

The method of Bagudo *et al.*, (2008) with slight modification was used in the purification of the produced biogas. The digester was connected to a buckner filter flask containing silica gel to dry the biogas. The dried biogas was passed through another Buckner flask containing lead acetate solution in ethanoic acid. The lead acetate absorbed the H₂S gas from the biogas passing through it, forming black precipitates of lead sulphide. The resultant biogas was passed through another buckner flask containing NaOH solution to absorb carbon (IV) oxide. The resulting gas was collected using urine bag and stored for subsequent analysis.

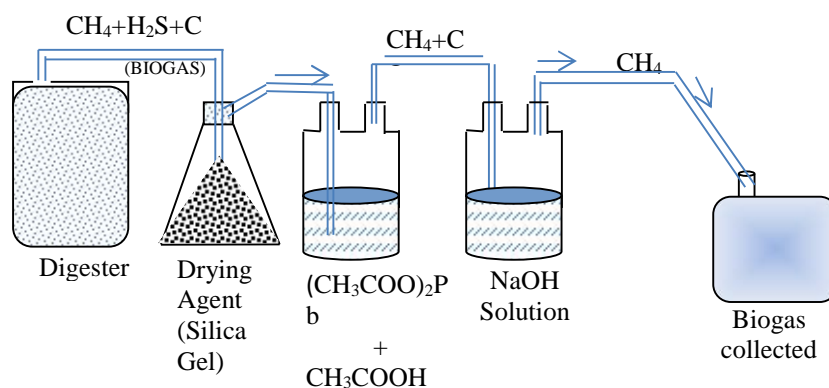


Figure 2: Biogas purification set up

RESULTS AND DISCUSSION

Figure 3 and 4 shows the daily volume of biogas produced from pumpkin and watermelon wastes. The volume of the gas produced was recorded together with ambient temperatures, slurry temperatures and pH. The ambient temperature, slurry temperature and pH ranges are 27°C-32°C, 32°C-43°C and 6.5 – 8.0 during the 35 day retention time period.

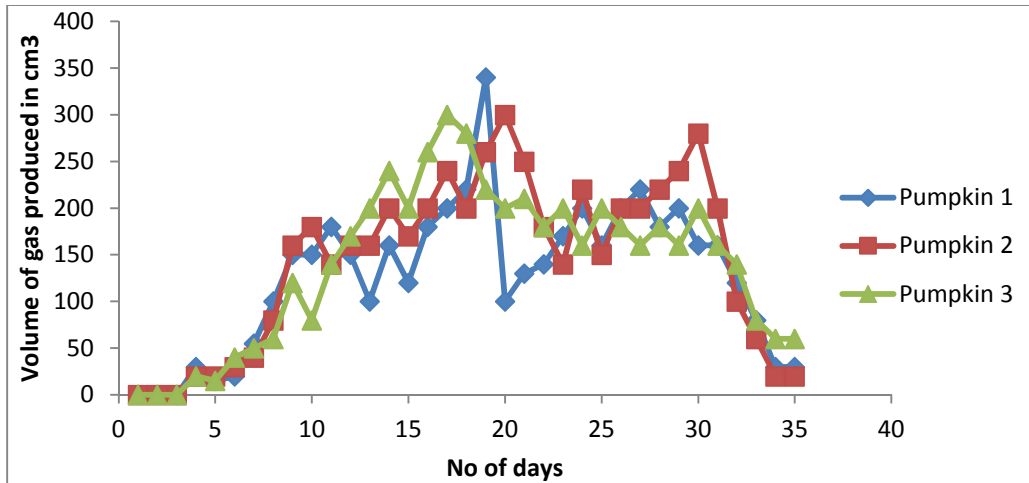


Figure 3: Daily biogas produced from pumpkin waste throughout the retention period

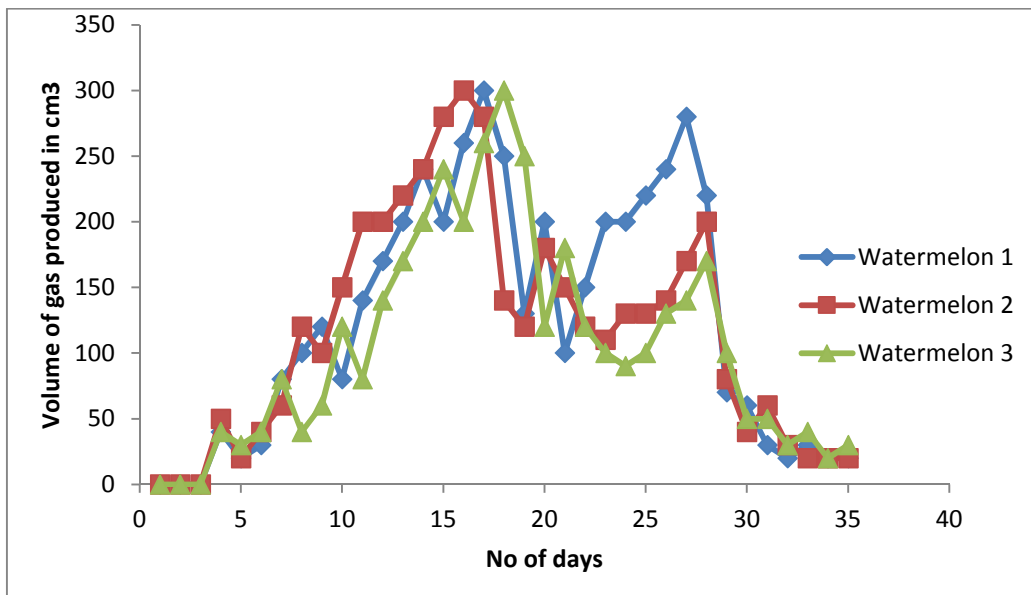


Figure 4: Daily biogas produced from watermelon waste throughout the retention period

Biogas production was noticed to start after 4 days. This is as a result of the presence of lignin, cellulose and hemicelluloses in the wastes which leads to an acidic condition which will make it difficult to biodegrade since it is known that the microbes degrading wastes are sensitive to pH and survive optimally at pH range of 6.5 – 8.0 (Mathew, 1982).

Figures 3 – 5 shows the mean weekly biogas production from the fresh pumpkin and watermelon wastes, dried pumpkin and watermelon wastes seeded with cow dung.

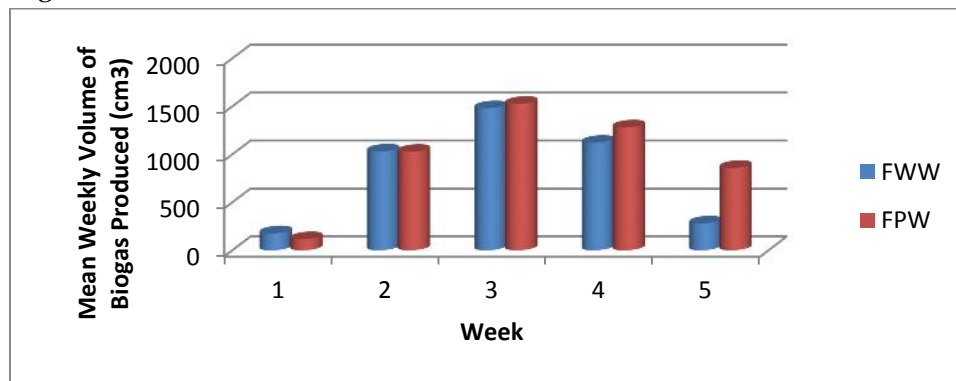


Figure 3: Weekly biogas produced from fresh watermelon and pumpkin wastes throughout the retention period. Key: FWW = Fresh watermelon waste, FPW = Fresh pumpkin waste

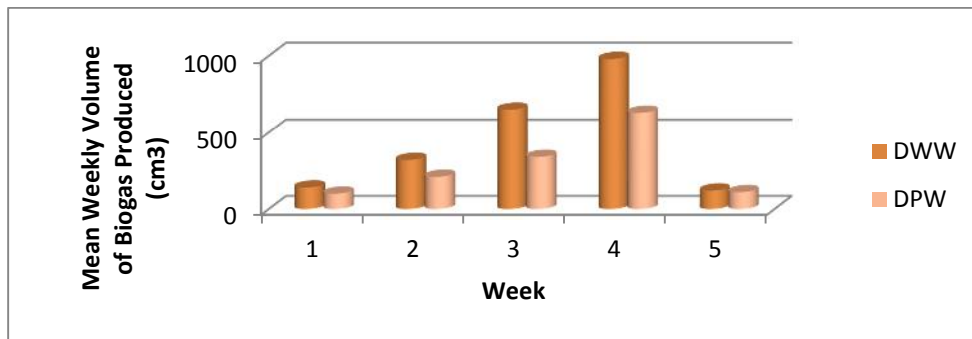


Figure 4: Weekly biogas produced from dried watermelon and pumpkin wastes throughout the retention period. Key: DWW = Dried watermelon waste, DPW = Dried pumpkin waste

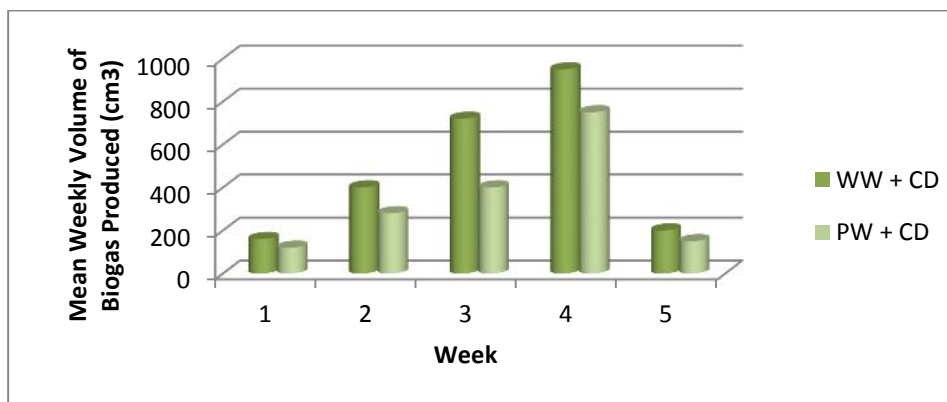


Figure 5: Weekly biogas produced from watermelon and pumpkin wastes seeded with cow dung throughout the retention period. Key: WW + CD = Watermelon waste + Cow dung, PW + CD = Pumpkin waste + Cow dung

The results show that the wastes seeded with cow dung produces a higher amount of biogas than the dried wastes but less than the fresh samples which serves as the control. This is in agreement from several researches which shows that wastes from ruminants such as cows were found to be very good inoculums for biogas production process because they already contain native microbial flora in their feces (Smith *et al.*, 1979; Abubakar, 1990; Arinze *et al.*, 2005). The gradual increase in the volume of biogas produced over the retention period could be due to a gradual degradation of the fiber and organic carbon contents of its undigested wastes and this accounts to why the volume of biogas produced peaks at week 3 for the fresh wastes as compared to week 4 for the dried wastes and that seeded with cow dung since these plant wastes have been reported to contain a higher carbon contents and under biogas technology they yield low gas due to presence of lignin in their structures (El-bassam, 1998, Kozo, 1996). The entire findings from this study is in agreement with the findings of Tambuwal (2005) and Odoh *et al.*, 2011.

CONCLUSION

This experimental study has shown that pumpkin and watermelon wastes are a potential organic waste for renewable energy production for developing countries such as Nigeria, where the vegetable and fruit are regularly consumed for their health benefits. The wastes hence should be properly harnessed by urban and rural dwellers for sustainable energy generation since the obtained results are indicating a high efficiency of anaerobic degradation. Such good biomass degradation by micro-organisms can be explained by the beneficial chemical composition of substrates for biogas production and by the buffering effect of the inocula during co-fermentation.

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