
Biogas Production and Characterization from Synergized Agricultural Wastes

By

Tambuwal, A. D. and Ogbiko, C*

Department of Pure and Applied Chemistry,
Faculty of Science,
Usmanu Danfodiyo University Sokoto, Nigeria
E-mail: cyrilgbiko@gmail.com

ABSTRACT

Anaerobic co-digestion strategies are needed to enhance biogas production from suitable substrate. Co-digestion of agricultural wastes with animal manure with low carbon content can improve process stability and methane production. In this study, anaerobic digestion of selected agricultural wastes and co-digestion using cow dung was conducted to determine the biogas potential. Co-digestion substantially increased the biogas yields by 44 to 47% over the control (fresh and dried synergized wastes). Methane was confirmed as the main constituent of the produced biogas

Keywords: Anaerobic, Agricultural Wastes, Biogas, Co-digestion, Methane

INTRODUCTION

Agricultural wastes have become an integral source of biogas production especially in areas where agriculture forms an important part of the economy. These wastes could pose danger to health of the populace especially if they litter the environment as they are known to be perfect habitat for pathogenic microorganism. They could cause soil loss and farmland damages if left unchecked. Garba *et al.*, 1996 have shown that these agricultural wastes like spent grains, straws among others can be converted to biogas.

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 composition of the biogas is dependent on the source of the substrate and handling of the digestion process (ECN, 2003). Anaerobic digestion (AD) is a technology widely used for treatment of organic waste for biogas production. Anaerobic digestion that utilizes manure for biogas production is one of the most promising uses of biomass wastes because it provides a source of energy while simultaneously resolving ecological and agrochemical issues. The anaerobic fermentation of manure for biogas production does not reduce its value as a fertilizer supplement, as available nitrogen and other substances remain in the treated sludge (Alvarez and Liden, 2007). Biogas technology is environmentally friendly and inexhaustible.

Nigeria has a large population of dairy beef hence generating large amounts of surplus manure that can be used in biogas plants to produce renewable energy. This organic waste if blended with suitable agricultural and industrial wastes increases biogas both qualitatively and quantitatively through synergistic effect (Ofoefule and Uzodima, 2006). Blending of suitable

agricultural wastes synergistically alone and with cow manure as an optimization approach has the potential of meeting both the rural and urban energy need of Nigeria. Studies demonstrated that using co-substrates in anaerobic digestion system improves the biogas yields due to the positive synergisms established in the digestion medium and the supply of missing nutrients by the co-substrates (Wei, 2000). Food waste is a desirable material to co-digest with dairy manure because of its high biodegradability (Zhang *et al.*, 2006, 2011; Li *et al.*, 2010; Wan *et al.*, 2011). This study was initiated to investigate the production of biogas production from different fruit and agricultural wastes blended with cow dung generated from Sokoto metropolis.

MATERIALS AND METHODS

Source of Samples

The materials used for this research work were vegetable and fruit wastes collected from various locations within Sokoto metropolis. While pumpkin, spinach stalk, banana and plantain peel were collected from Ramin Kura market, fresh watermelon residues were collected from Miyetti Allah area both in Sokoto metropolis.

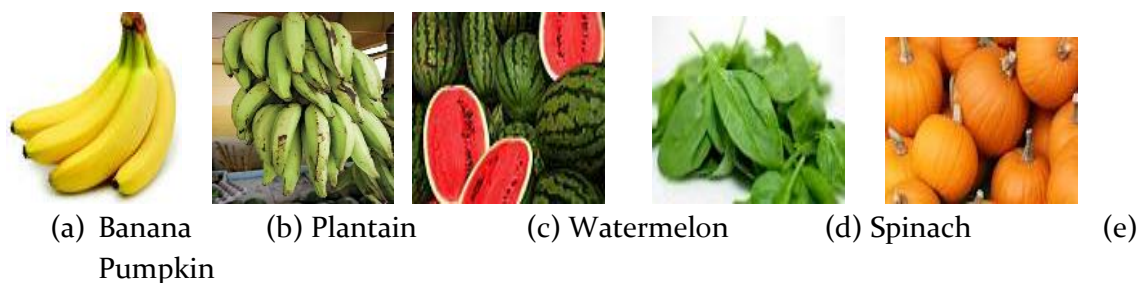


Figure 1: Views of the vegetable and fruits used as substrates for biogas production



Figure 2: View of the procured vegetable and fruit waste

Sampling and Sample Treatment

The fresh samples were chopped into smaller sizes to ease the digestion process. They were divided into three groups. The first group was sun dried for two week after which they were pulverized with the aid of mortar and piston to ensure homogeneity. This was coded the dried

synergized sample (DSS). The second were used fresh coded the fresh synergized sample (FSS) while the third group was the dried sample seeded with cow dung. This was coded the seeded dried sample (SDS). The samples were maintained under clean condition ready for experimentation.

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 A, B and C corresponding to DSS, FSS and SDS for the purpose of the study.

Preparation of Slurry

100 g of the DSS was fed into digester A and 400 cm³ of water was added hence making up a ratio of 1:4. 100 g of the FSS was fed into digester B and 400 cm³ of water was added hence making up a ratio of 1:4. 45 g of the SDS seeded with 5 g of cow dung were fed into digester C 300 cm³ of water was added hence making up a ratio of 1:6 (this was arrived at after preliminary research conducted on the best mixing ratio). Each was well stirred with the opening well sealed. The setup was monitored at least twice a day but the readings were taken every 24 hours at 12 noon every day for the 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.

RESULTS AND DISCUSSION

Figure 3 show the daily volume of biogas produced from the synergized substrates and Figure 4 shows the weekly biogas produced from the synergized substrates as well as that seeded with cow dung at 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.

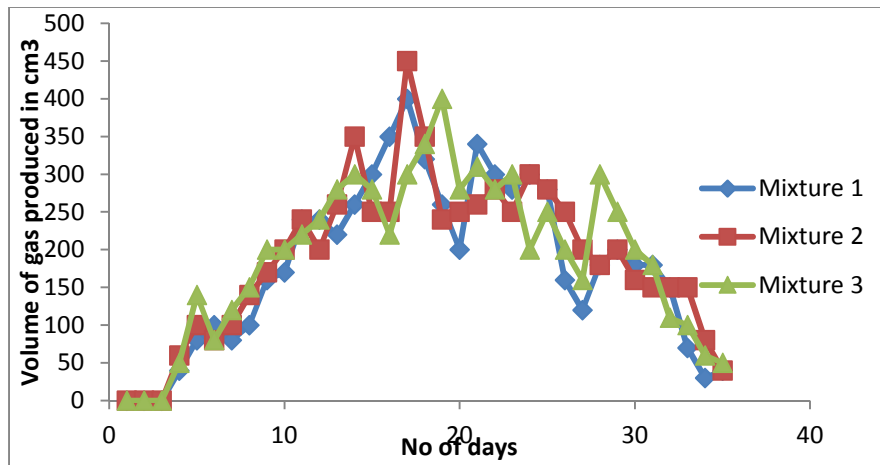


Figure 3: Daily biogas produced from synergized wastes throughout the retention Period.

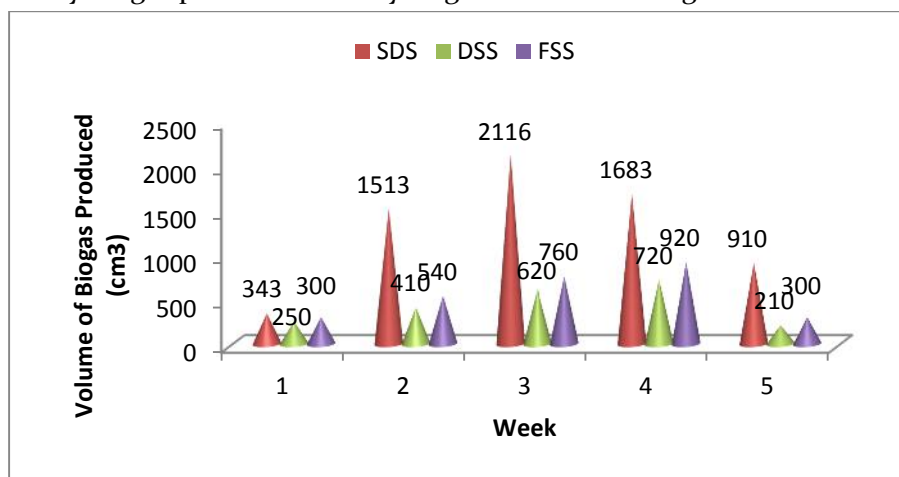


Figure 4: Weekly biogas produced from synergized and seeded wastes throughout the retention period.

Biogas production was used mainly as an indication of optimum production and the development of favorable conditions for microbial activity during the digestion process. On average, biogas productions started from all digesters on day 4 (Figure 5). The results showed that the co-digestion of samples with the seeded cow dung produced biogas earlier than the fresh and dried substrates (FSS and DSS) that were used as control groups throughout the 35 days retention periods (Figure 6). This might be due to the attribution of the positive synergetic effect of the co-digestion of the substrate and cow dung providing more balanced nutrients, increased buffering capacity, and decreased effect of toxic compounds (Mata-Alvarez *et al.*, 2000; Li *et al.*, 2009; Jianzheng *et al.*, 2011). The rapid initial biogas production in the SDS digester which peaks at week 3 unlike that of the FSS and DSS which peaks at week 4 might be due to shorter lag phase growth, the availability of readily biodegradable organic matter in the substrate, and the presence of high content of the methanogens. These results are in agreement to the findings of Budiyono *et al.* (2010) and Tamrat *et al.*, 2013 who also observed low level of biogas production due to the lag phase of microbial growth during these periods of the run.

The result of the GC-MS of the produced biogas and its confirmation are shown in Figures 5 and 6 respectively.

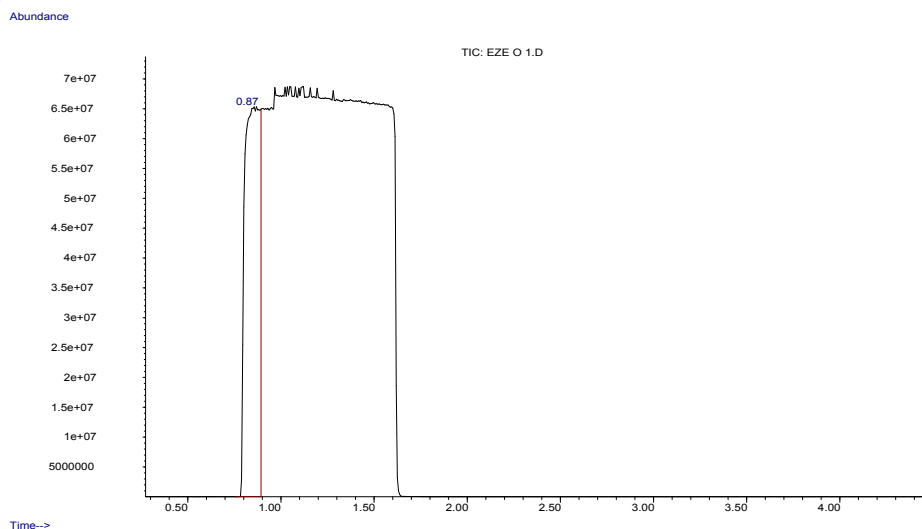


Figure 5: GC-MS of the synergized substrate

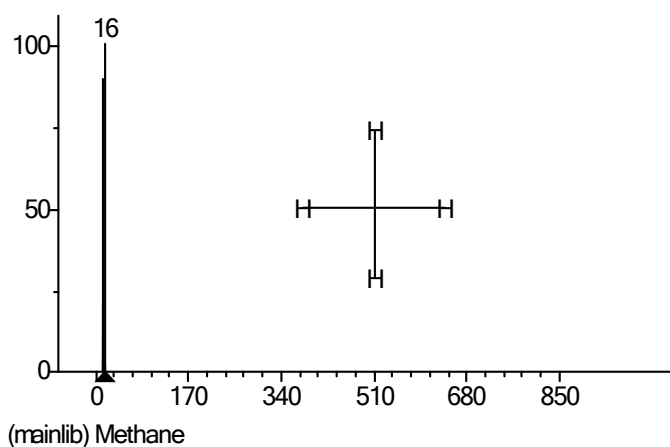


Figure 6: Confirmation of composition of biogas obtained for the synergized substrate

The results in Figures 7 and 8 clearly show methane as the main constituents of the gas and hence confirm the synergized samples as viable potential biogas materials

CONCLUSION

Organic synergized agricultural wastes co-digested with cow dung improved the biogas potential compared to the fresh and dried synergized substrate when used alone as seen in the highest average daily and cumulative biogas yield when used in 1:6 ratios. The entire results thus confirms that the blending of the synergized substrates with cow dung gave the best optimization in terms of the onset of biogas production and the cumulative yield of the produced biogas. This research thus provides a way for the utilization of this specific substrate for large scale biogas production. Further study could be carried to ascertain the optimum enhanced biogas yield.

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