International Journal of AGRICULTURE AND BIOSCIENCES

www.ijagbio.com P-ISSN: 2305-6622 E-ISSN: 2306-3599 editor@ijagbio.com

RESEARCH ARTICLE

Performance Evaluation of Biogas Yield from Jackfruit Waste Co-Digestion with Cow Paunch and Poultry Droppings in Batch Mode

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ARTICLE INFO

Received: December 10, 2014
Revised: January 13, 2015
Accepted: February 02, 2015

Key words:
Anaerobic digestion
Biogas
Co-digestion
Cow paunch
Jackfruit
Poultry droppings

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ABSTRACT

Four one-liter plastic bottles were used as anaerobic micro-digesters in a study to compare biogas production from mixtures of jackfruit waste co-digested with cow paunch and poultry droppings. It was found out that the mixture slurry of jackfruit waste and cow paunch (JW-CP) had the highest cumulative biogas yield of 610.20 ml/TMS than the mixture of jackfruit waste and poultry droppings (JW-PD) with the cumulative biogas yield of 550.66 ml/TMS within the 30 days hydraulic retention time (HRT). It was also observed that JW-CP produced less cumulative biogas of 298.28 ml/TMS within the first 10 days of observation compared with JW-PD with 380.80 ml/TMS within the same period. This is predicated with the fact that poultry droppings degrade faster than cow paunch. It was also observed that gas production reduced seriously in mono-digested substrate jackfruit waste alone (JW-A); cow paunch alone (CP-A); and poultry droppings alone (PD-A)) because of lack of synergistic nutrients with biogas yield of 343.56m/TMS, 265.65ml/TMS and 314.60ml/ TMS respectively. Result also show that JW-A had increase in gas yield from 343.56ml/TMS to 610.20ml/TMS within 30 days observation when co-digested with cow paunch an increase of about 77.56%; also, increased cumulative biogas yield from 314.60ml/TMS to 550.66ml/TMS when co-digested with poultry droppings within the same 30 days observation period. The trend of cumulative biogas yield at the end of the 30 days HRT was JW-CP > JW-PD >JW-A > PD-A > CP-A. The aim of this study is to evaluate the performance of biogas production from jackfruit waste co-digested with cow paunch and poultry dropping in batch mode.

Cite This Article as: Umeghalu ICE, IF Okonkwo, JO Ngini and CC Okoye, 2015. Performance evaluation of biogas yield from jackfruit waste co-digestion with cow paunch and poultry droppings in batch mode. Inter J Agri Biosci, 4(1): 35-37. www.ijagbio.com

INTRODUCTION

Nigeria is faced with energy crisis despite her richness in energy resources. This has resulted in the urban poor and rural dwellers to depend on biomass for their energy needs. Being an agrarian country in which agriculture plays an important role in her economic life, large quantities of biomass residues are generated from agricultural activities especially in the rural areas where farming is practiced. Umeghalu *et al.* (2012) reported that huge quantity of animal manure suitable for biogas production are generated from animals annually in Nigeria of which only small proportion of them are used by farmers as fertilizer or for feeding fishes. The rest of the animal manures are mis-managed resulting in large scale contamination of land, water and air. Unmanaged organic waste not only represent a threat to environmental quality, but also posses a potential energy value that is not currently being utilized despite the abundance of the solid wastes (Mshandete *et al.,* 2006). Mattocks (1980) reported that these biomass residues are potential feedstocks for biogas production.

Biogas, a gas produced through anaerobic digestion process is composed of approximately 50-60% methane, 40-50% carbon dioxide, water vapour, nitrogen, sulfur, and other trace compounds, is a cheap alternative energy (Angeldaki *et al*., 1993). It is produced from renewable sources and it plays important role in the domestic and agricultural life of many countries of the world especially in Asia, America, and Europe where it is used for cooking, heating, transportation, and as soil fertilizer

(Ofoefule *et al.*, 2010; Umeghalu *et al*., 2012; Chukwuma *et al*., 2012). Biogas generation takes place in an oxygen-free environment. It uses anaerobic bacteria that live only in the absence of oxygen to break down complex organic compounds in fairly well defined stages in a process known as anaerobic digestion (AD). The effluent at the end of digestion can be used for growing crop as fertilizer (Campos *et al*., 1999).

Anaerobic digestion process occur in three stages; in the first stage (hydrolysis process), the bacteria break down the biodegradables (fats, carbohydrates, and proteins) to soluble compounds; in the second stage of the process, the acetogens convert the soluble compounds to organic acids while in the third stage, the methanogens convert the organic acids to methane and carbon dioxide and the other products of the process (Goswani *et al.*, 2011; Budiyono et al., 2010; Ntengwe *et al*., 2010; Nwabanne *et al*., 2012). Methane yield is enhanced through co-digestion technology because of positive synergisms established in the digestion medium and supply of missing nutrients by the co-substrates (Anette and Angelidaki, 2009; Casey, 2010; Stalin and Prabhu, 2007). Co-digestion is the simultaneous digestion of a homogeneous mixture of two or more substrates (Mata-Alvarez *et al.*, 2000).

Jackfruit (*Artocarpus heterophyllu lam*) is a large fruit of a milky-juice tree, of *Moraceae* family. The edible, pulpy part represents the parianth. Jackfruit is the largest edible fruit in the world and was believed to have originated in the forests of the Western Ghats (India), where it still grows in the wild, as well as in the evergreen forests of Assam and Myanmar (Bobbio *et al.*, 1977). It is cultivated throughout Bangladesh, Burma, India, Indonesia, Malaysia.

Jackfruit has been reported to contain high levels of protein, starch, calcium, and thiamine (Bhatia *et al*., 1955). The juicy pulp of the ripe fruit is eaten fresh as a dessert. The bulbs (excluding the seeds) are rich in sugar, fairly well in carotene and also contain vitamin C (Bobbio *et al.*, 1977). Jackfruit is also rich in nutrients such as sodium, potassium, iron, vitamin B6, calcium, zinc, and many other nutrients. Jackfruit can lower blood pressure, cure fever and diarrhea.

Much attention has not been given to the crop by researchers leading to underdevelopment of the crop as a potential feedstock for biofuel production. At present jackfruit is mainly grown for its ornamental values in Nigeria. Biogas production from jackfruit may increase due to the vast area of land and abundant labour available for growing the crop in the country. The consumption of its seeds is still not popular as it is regarded as waste or feed for domestic animals and as such would not compete largely with human or animal food. Jackfruit as feedstock will be relatively less expensive for biogas production and would not compete with human and animal consumption.

The aim of this study is to compare the biogas production potentials of jackfruit waste co-digested with cow paunch and poultry droppings in batch mode under suboptimum conditions in line with ongoing global research efforts at discovering more energy crops and developing other sources of renewable energy.

MATERIALS AND METHODS

Material for the study

Ripe jackfruits were purchased from Eke Ojoto Market in Idemili South Local Government Area of Anambra State of Nigeria. Fresh cow paunch (CP) was obtained from Umeba Slaughter House at Umuoji, while poultry droppings were collected fresh from F.C. Muonwem Poultry Farm Limited, Uke in Idemili North Local Government Area of Anambra State, Nigeria. Four plastic bottles of 1liter volume were used as micro-digesters for the study. Also 2 plastic containers of 20 liter volume each were used for partial decomposition of the substrates.

Preparation of the substrates

The jackfruits were sliced and the seeds extracted. Thereafter, both the fruits' consolidated and abortive perigones were sliced to sizes of about 2 to 3 cm and soaked in the 20 liter plastic container for a period of 20 days while the cow paunch was soaked for 15 days for partial decomposition. Pre-treatment of substrates before anaerobic decomposition process breaks down cellulose or lignin materials physically, chemically and biologically thereby aiding the microbes for faster digestion of organic materials (Katima, 2001; Ofuefule *et al*., 2012).

Charging of digesters

The micro-digesters were charged in the following order as shown bellow at the end of the partial decomposition:

Digester 1 (D1): 300gm of jackfruit waste alone (JW-A) + 600gm of water.

Digester 2 (D2): 150gm of jackfruit waste (JW) + 150 gm of cow paunch (CP) + 600 of water **or** (JW-CP).

Digester 3 (D3): 150gm of jackfruit waste (JW) + 150 gm of poultry droppings (PD) + 600 of water **or** (JW-PD).

Digester 4 (D4): 300gm of cow paunch alone (CP-A) + 600gm of water.

Digester 5 (D5): 300gm of poultry droppings alone (PD-A) + 600gm of water.

The micro-digesters were stirred thoroughly on daily basis to ensure intimate contact of the waste with micro-organisms responsible for converting the wastes to biogas. Daily biogas production was measured by downward displacement of the water in the trough by the gas produced and recorded as the difference between the initial reading at the beginning of each day and the final reading at the end of the same day (Pound *et al*., 1981). pH of the waste slurries were monitored daily for a period of 5 days to ensure stability of the slurries. Ambient and slurry temperatures were monitored daily all through the retention period.

RESULTS AND DISCUSSION

The comparative evaluation of cumulative biogas yield (CBY) of all the various mixtures of jackfruit waste co-digested with cow paunch and poultry droppings is represented in Figure 1. Results show that JW+PD had the highest biogas yield of 380.80ml/TMS within the first 5 to 10days of observation than JW+CP while JW-CP had 298.25ml/TMS, while poultry droppings alone (PD-A) had 110.28 ml/TMS cow paunch alone (CP-A) gave 99.76

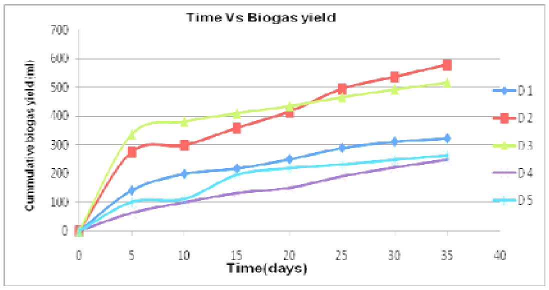

Fig. 1: Plot of cumulative biogas yield of various mixtures of jackfruit co-digested with animal manures.

ml/TMS within the period under consideration. The trend of cumulative biogas yield from the substrates is in the order of D3 >D2 >D1>D5 >D4.

However, result shows that at the end of the 30 days hydraulic retention time (HRT) D2 (JW-CP) was noted to have surpassed D3 (JW+PD) in cumulative biogas yield with yields of 610.20ml/TMS and 550.66ml/TMS respectively. This could be explained by the fact that poultry droppings degrade faster than the cow paunch (Ezeoha and Idike, 2012). Jackfruit waste alone (JW-A), poultry droppings alone (PD-A) and cow paunch alone (CP-A) were single substrate digestions used as data baseline (Buendia *et al*., 2009). The order of their cumulative biogas yield was D1> D5 >D4. From the studies, it was also observed that jackfruit waste alone (JW-A) had a cumulative biogas yield as a single substrate digestion of 343.56 ml/TMS and increased in cumulative biogas yield of 610.20ml/TMS and 550.66ml/TMS (about 77.56% and 60.27%) when co-digested with cow paunch and poultry droppings respectively. This increase in cumulative biogas yield is predicated to positive synergisms established by the substrates in the digestion medium by the substrates by supplying each other with the missing nutrients resulting to the increased cumulative biogas yield (Pound et al., 1981; Ofoefule *et al.*, 2010; Chukwuma *et al*., 2012).

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