

Title: Generation and Analysis of CO₂ and CH₄ Content of Biogas Generated from Pig Manure, Fruit and Vegetable Wastes

Abstract

Biogas is a combustible mixture of gases consisting mainly of methane (CH₄) and carbon dioxide (CO₂.) The gases formed are the waste products of the respiration of the decomposer microorganisms, the composition of the gases depends on the substance that is being decomposed. If the material consists of mainly carbohydrates, such as glucose and other simple sugars and high-molecular compounds (polymers) such as cellulose and hemicellulose, the methane production is low. However, if the fat content is high, the methane production is likewise going to be high (Jørgensen, 2009).

This work explores the production of biogas using fruit and vegetable wastes mixed with pig manure in an anaerobic digester. Phytochemical screening, proximate analysis of the fruit waste, vegetable waste and the pig waste were carried out. The composition of CO₂ and CH₄ content in biogas generated were CO₂ 28.1% and CH₄ 68.9%. The substrates used for this research were peels and seeds of orange, tomato, cucumber, efo shoko (leafy vegetable) and pig manure. The combustibility of biogas was tested and the anaerobic digestion was allowed for 22days. Co-digestion between fruit and vegetable wastes and pig manure produces biogas without chemical addition to the system. The biogas yield of a given biomass is not a fixed value, but depends on factors such as temperature and retention time in the reactor and a number of micro- and macronutrients also present in the right amounts. It is thus not possible to digest, for example, fats or sugars on their own. There may also be some synergetic effects when different biomasses are mixed – that is, the production achieved is larger than the sum of the individual potentials. The opposite can also be true. The phytochemical studies were carried out according to the protocols of Evans (Murali *et al.*,2013). The proximate analyses was carried out for carbohydrates using Anthrone method, Total Lipids Using Bligh & Dyer Method; Crude Fibre, moisture content, total ash, and crude protein method as described by AOAC (1995); The moisture content of the pig manure ranged from 61% to 87.35% and had the highest moisture content which indicates that relatively helped to increase methanogenic activity and the rate of methane production will function with optimum pH 6.41. High moisture content provides greater activity of water which predicts growth of microorganisms. (Iheanacho and Udebuani, 2009). With the high content of the methane obtained is a high indication that the

waste materials used are a good source of biogas and can be used to provide a cleaner environment.

Introduction

Biogas is a combustible mixture of gases consisting mainly of methane (CH_4) and carbon dioxide (CO_2 .) The gases formed are the waste products of the respiration of the decomposer microorganisms and the composition of the gases depends on the substance that is being decomposed. If the material consists of mainly carbohydrates, such as glucose and other simple sugars and high-molecular compounds (polymers) such as cellulose and hemicellulose, the methane production is low. However, if the fat content is high, the methane production is likewise going to be high [1].

Biogas-generating technology is a favorable dual-purpose technology at present: the biogas generated can be used to meet energy requirements while the organic residue is a useful fertilizer [2]. This in turn will give a cleaner environment. The production of methane during the anaerobic digestion of biologically degradable organic matter depends on the amount and kind of the material added to the system. In India and China alone, there are more than one million small, simple plants, each treating waste (sewage, animal manure, crop residues, etc.) from a single household. The biogas is used in the housekeeping for cooking and the digested biomass used as a fertilizer.

This study aims at the production of biogas from biologically degradable wastes by co-digestion system and analyzing the percentage composition of CH_4 and CO_2 in biogas produced.

MATERIALS AND METHODS

Substrate collection

Fruit and vegetable wastes were collected from an Ikorodu market and mixed with pig manure collected from a pig farm in Ogun state is used as substrates for biogas production.

Fabrication of Anaerobic Digester

The anaerobic biogas generation digester of fruit and vegetable wastes mixed with pig manure was fabricated using two (20L) plastic container, two $\frac{1}{2}$ inch plastic valve, glue, bicycle tube and gas hose $\frac{1}{2}$ inch diameter $\times$ 40cm length. An opening was made on the cover of the two plastic containers just about the size of the plastic valve, the valves were inserted into opening made on the cover while glue and clay was added around the sides of the valve to make it air tight and firm. Then, gas hose $\frac{1}{2}$ inch diameter $\times$ 40cm were firmly inserted into the valves and channeled into a bicycle tube which will serve as storage for the gas generated.

Sample Preparation.

The mixture of biodegradable waste - peels and seeds of orange, tomato, cucumber, efo shokor (leafy vegetable) were chopped into smaller size, slurry obtained by mixing fresh pig manure and tap water.

5kg of the substrate was fed into the first digester while 17kg of substrate was fed to the second digester before the mouth was properly sealed. The two digesters were fed once and placed in an open space.



Figure 1: The fabricated digester

Data Collection and Analysis

Proximate analysis (carbohydrates, crude fibre, moisture content, crude ash, protein and crude fat) was carried out on wastes used.

The CO_2 and CH_4 composition of biogas was also determined using absorption method

Ca(OH)₂ is prepared to absorb CO₂ from biogas (purifying the gas) while the percentage of CO₂ absorbed is calculated using

$$\% \text{ of CO}_2 = \frac{M_1 - M_2}{M_1} \times 100\%$$

Where M₁ = mass of biogas before removal of CO₂

M₂ = mass of methane and other gases after removal of CO₂

% of CH₄ = 100% - (CO₂ + 3% (H₂S and other gases))

The 3% average is given to (H₂S and other gases) because they range between 1-5% in biogas composition.

To validate, the amount of CO₂ in CaCO₃ formed is determined by Standardization of EDTA with CaCO₃

Reagents used and Preparation

i. EDTA

ii. ZnSO₄ to standardize EDTA

iii. Ammonia buffer solution

iv. Eriochrome black T indicator.

v. Ca(OH)₂

PROXIMATE ANALYSIS OF THE VEGETABLES AND FRUITS

PARAMETERS	CHO %	PROTEIN %	CRUDE FAT %	MOISTURE %	ASH %	CRUDE FIBRE %
Leafy Vegetable	8.89	1.20	0.195	65.5	4.5	3.62

CUCUMBER	4.77	2.02	0.08	72.28	3.32	0.54
Orange	7.45	1.11	0.16	80.7	1.08	1.90
Tomato	15.17	7.00	6.17	61.0	2.30	8.91

RESULTS AND DISCUSSIONS

Effect of moisture:

The moisture content ranged from 61% to 87.35% pig manure had the highest moisture content which indicates that relative methanogenic activity will increase and the rate of methane production will function with optimum pH 6.41. High moisture content provides greater activity of water which predicts growth of microorganisms. (Iheanacho and Udebuani, 2009).

Effect of minerals:

The ash content from 1.08% to 4.5% confirms presence of essential minerals like calcium, sodium, potassium but when in high quantity could be used to retard growth of certain microorganisms due to presence of toxic elements.

Effect of crude fiber:

The crude fiber ranged from 0.04% - 8.91% is fairly low (Lee *et al.*, 2003) stated that crude fiber is an important component of methane production and that methane production decreases as the content of crude fiber increases confirming substrate with the lowest crude fiber have the highest methane production.

Effect of crude fat:

The crude fat ranged from 0.08% to 6.17% the proportion of carbohydrate, protein, and lipid in a feedstock will influence biogas yield and composition with lipid yielding higher volumes of biogas per gram of feed material than both carbohydrate and protein (Weiland 2010, Heaven *et al.*, 2011, Zamalloa *et al.*, 2011).

117 **Effect of Carbohydrate:**

118 The carbohydrate content ranged from 4.77% - 15.17% which is fairly low. However, if material
119 that is been decomposed consists mainly of carbohydrate methane production will be low due to
120 the fact that microbes involved in digesting carbohydrate rich diet are different, they would
121 produce propionate which will remove hydrogen from methane production.

122 **Effect of Crude protein:**

123 The crude protein ranged from 1.11% to 7.00% is fairly low. Crude protein measures all sources
124 of nitrogen in feedstock, high protein feedstock could modulate bacteria fermentation in the
125 digester.

126 The presence of these and in the various compositions is able to help in the methane yield.

127 **Biogas Production**

128 Biogas generation in one of the digesters constructed was evident pressure build-up was noted
129 after 14 days of startup while biogas generation in the second digester stopped due to
130 introduction of oxygen to the system as the digester cover was force off as a result of improper
131 sealing of the mouth of the digester.

132

133

134

135 Shown in **Fig 2** below



Biogas Composition:

Percentage of methane and carbon dioxide in biogas varies with the maturities of feed stock, temperature, water content, loading rate of raw material and bacterial actions.

Biogas Composition	CH ₄	CO ₂
	68.9	28.1

CONCLUSION

This investigation shows that biogas can be successfully produced from co-digestion of manure with fruitS and vegetable wastes without any chemical addition to the system. The quality of methane composition in biogas and quantity of biogas produced depends on the composition of materials fed to the digester, fat and moisture content is important in methane yield. Through anaerobic digestion of fruit and vegetable wastes we can avoid the emission of harmful greenhouse gases and make a positive contribution to a cleaner environment. Production of biogas from fruit and vegetable waste is a major step toward harnessing the least utilized renewable energy resource.

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