# STUDIES ON THE POTENTIALS OF BIOGAS PRODUCTION USING KOLANUT HUSK SEEDED WITH POULTRY DROPPINGS AND RUMEN OF COW.

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**Abstract** – In Nigeria, biogas technology has remained at the level of institutional research work and preliminary schemes. Its progress being underdeveloped by unfamiliarity, researches at universities frequently considered as being too academic, lack of political will, and lack of an adequate coordinating framework. The main objective of this study is to highlight how agricultural wastes mostly generated in Nigeria could be used to generate high amount of biogas. This study evaluates biogas production from kolanut husk, poultry dropping and ruminant waste of cow using five (5) batch digesters of 2500g net weight capacity container operated at ambient temperature 27°C and 41°C for 154 days retention time and pH range of 7.13 -9.27 before and after the production. The digesters were charged with constant substrates and different water ratios due to the nature of substrates. Kolanut husk (KH); 500g/2500cm3 of water, poultry dropping (PD); 500g/1700cm3 of water and ruminant waste of cow (RC); 500g/1000cm3 of water for digesters A, B and C respectively while digesters D and E contained kolanut husk: poultry dropping (KH:PD); 500g at ratio 1:1/2500cm3 and kolanut husk: ruminant waste of cow (KH:RC); 500g at ratio 1:1/1600cm3 respectively. The Total volatile solid (TVS) of the substrates before 76.7%, 62.3%, 71.0% , 52.7% and 64.7% , after digestion and total biogas production were 3690, 84060, 33180, 62420 and 45220 (cm3). Daily biogas yield was measured by the downward water displacement method. In this research it was observed that Kolanut husk has poor biogas yield with less favourable physicochemical properties and acidic pH except when co-digested with suitable additives to create a positive mutual effect which increased the yield greatly.

**Keywords:** Agricultural waste, Biogas, Technology, Total volatile solid, Water displacement.

## INTRODUCTION

Agricultural wastes are residues gotten from the growing and processing of raw agricultural products. They are the non-product yields of production and processing of agricultural products that are likely to contain materials which are beneficial to man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world (Loehr, 2012). Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products and there is every possibility in the increase of agricultural wastes globally if developing countries continue to intensify farming systems (Overcash *et al.,* 1973) such as kolanut husk, poultry, dairy products, meat, fruits and rumen.

Kolanut is generally produced in Africa and it is cultivated to a large degree in Nigeria. Nigeria accounts for about 70% of the total world production of kola nuts (Oluokun and Oladokun, 1999). Kolanut is consumed on daily bases for its medicinal, stimulating and sustaining properties (Asogwa *et al.*, 2011). It also has industrial usage in pharmaceuticals, production of soft drinks, wines and in confectionaries (Dias, 2014). The kola nut husk is a by-product from the processed nut, is widely used for animal feeding because of its high nutritive quality. According to Babatunde and Hamzat (2005), broilers fed with kola nut husk meal diets had an exceptional growth performance. As a result of the reasonable quantity of farmer engaged in kola nut farming and large industrial demand, this pod has created waste disposal problems which has led to the use of kolanut husk for biogas production.

Biogas technology in times back has been viewed as a very good source of sustainable waste management and treatment. The need of an anaerobic digestion which mitigates a number of environmental problems is important.

 

Anaerobic digestion is a biochemical process which is used to degrade and stabilize complex organic matter by the actions of microorganism (Raposo *et al.,* 2011).

Thus, the main aim of this research is to investigate the potential of biogas in kolanut husk, ruminant waste of cow and poultry dropping as agricultural wastes by determining the physicochemical properties of the substrates before and after biogas production, evaluating the quantity of biogas production by the substrate and comparing the volume of biogas produced by the substrates has individual substrate and when blended.

## MATERIALS and METHOD

### Biogas Experimental Set-Up

The full setup of this study was the connection of an improvised 2.5l tin as digester, connected to 1000cm$^3$ measuring cylinder and immersed into a plastic bowl of water. This setup is known as the water displacement setup as shown in plate 1.

Plate 1 Pictorial Presentation of Experimental Setup

### Mixing Ratio of Digesters

The substrates were mixed with water according to the nature of the substrates and their ability to absorb water with 500g of each substrate to make perfect slurries. Digester A; 500g of the kola nut husk waste and 2500cm$^3$ of water to produce a kolanut husk slurry of ratio 1:5w/v, digester B; 500g of the poultry dropping waste and 1700cm$^3$ of water to produce a poultry dropping slurry of ratio 1:3.4w/v, digester C; 500g of Ruminant waste of cow and 1000cm$^3$ of water to produce a slurry of ratio 1:2w/v. the co-digesters were mixed Digester D; 250g of kolanut husk seeded with 250g of poultry dropping and 2500cm$^3$ of water to produce a kolanut husk/poultry dropping slurry of ratio 1:5w/v and lastly, Digester E; 250g of kolanut husk seeded with 250g of ruminant waste of cow and 1600cm$^3$ of water to produce a kolanut husk/ ruminant waste slurry of ratio 1:3.2w/v, having a total of five digesters and was allowed to stand as long as slurries stops biogas production. The pH of the slurries were determined using a metrohm pH meter before subjecting to anaerobic digestion and immediately it was confirmed that slurries has stopped gas production i.e. after close monitoring for a week. During the period of biogas production, room temperature and amount of biogas produced was measured and recorded at 3pm daily by using the water displacement method, in this method the volume of gas stored is equal to volume of water outlet (Havukainen, 2014) as shown in Plate 1.

**Physicochemical Properties Determination Before and After Production.**

Determination of physicochemical properties before and after biogas production, which includes: total solid, volatile solid, moisture content, ash content, pH, carbon content, nitrogen content, carbon-nitrogen content and temperature.

**Determination of Total solid concentration**

This was carried out by the method of (William, 2001) and was computed using the equation below

$$\%TS = \frac{(W_1 - W_2)}{(W_3 - W_2)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation(1)$$

**Determination of Volatile solid**

Volatile solid of the sample would be determined using Van Reeuwijk, (2002) procedure.

$$\%\ Volatile\ soild = \frac{(W_5 - W_6)}{(W_5 - W_4)} \times 100 - \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100 \ldots Equation(2)$$

**Determination of Moisture content**

This was carried out by the method of (William, 2001) and was computed using the equation below.

$$Moist\ (wt\%) = \frac{(A - B)}{(B - tare\ tin)} \times 100 \ldots\ldots\ldots\ldots Equation(3)$$

**Determination of Ash content**

The ash content would be determined using the method of

$$\%\ Ash = \frac{(W_9 - W_7)}{(W_8 - W_7)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots Equation(4)$$

**Determination of Carbon content**

The carbon was determined according to Bartlett *et al.,* (1994) equation:

$$Organic\ Carbon\ (\%) = \frac{0.003g \times N \times 10ml \times (1 - T/S)}{ODW} \times 100..Equation\ (5)$$

**Determination of Nitrogen content**

Nitrogen content of the sample was determined using William Telliard, (2001) procedure.

$$\%N = \frac{(a - b)}{s} \times M \times 1.4 \times mcf \ldots\ldots\ldots\ldots Equation(6)$$

**Determination of Carbon/Nitrogen Ratio**

These values allow us to use Bagudo *et al.*, (2008):

$$C/N = \frac{\%\ Organic\ carbon\ in\ the\ sample}{\%\ Nitrogen\ in\ the\ sample} \ldots\ldots\ldots\ldots Equation\ (7)$$

**RESULTS AND DISCUSSIONS**

**Results**

The results of determination of physicochemical properties before and after biogas production by the different substrates are presented in Tables 1 – 3.

**Table 1** Physicochemical analysis of substrates for digester A, B and C before and after anaerobic digestion of biogas

| Parameters | Digester A | | Digester B | | Digester C | |
|---|---|---|---|---|---|---|
| | Before digestion | After digestion | Before digestion | After digestion | Before digestion | After digestion |
| Total Solid (%) | 94.3 ± 0.29 | 85.3 ± 0.75 | 95.8 ± 0.44 | 84.3 ± 0.76 | 23.5 ± 0.87 | 76.7 ± 0.29 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Volatile Solid (%) | 76.7 ± 0.58 | 62.3 ± 0.67 | 62.3 ± 0.58 | 52.7 ± 0.58 | 71.0 ± 1.0 | 64.7 ± 0.58 |
| Carbon Content (%) | 14.0 ± 1.0 | 16.8 ± 0.29 | 36.7 ± 0.76 | 11.7 ± 1.26 | 12.0 ± 1.0 | 10.1 ± 0.29 |
| Nitrogen Content (%) | 0.65 ± 0.01 | 0.877 ± 0.02 | 1.28 ± 0.01 | 0.765 ± 0.02 | 0.54 ± 0.02 | 1.223 ± 0.02 |
| Carbon/Nitrogen Ratio (%) | 21.5 ± 1.6 | 19.2 ± 0.19 | 28.7 ± 0.59 | 15.2 ± 1.49 | 22.2 ± 1.82 | 8.26 ± 0.47 |
| Ash Content (%) | 12.2 ± 0.29 | 6.2 ± 0.58 | 28.3 ± 0.58 | 20.0 ± 0.29 | 2.8 ± 0.29 | 9.3 ± 0.58 |
| Moisture Content (%) | 5.2 ± 0.29 | 14.7 ± 0.75 | 3.5 ± 0.5 | 15.7 ± 0.76 | 21.3 ± 0.76 | 23.3 ± 0.29 |

Values are mean standard deviation of triplicate results.

Where:

Digester A = Powdery form of Kolanut Husks
Digester B = Powdery form of Poultry Droppings
Digester C = Rumen of cow

**Table 2** pH reading and Temperature reading before and after biogas production.

| **Digesters** | **Temperature °C** | | **pH Reading** | |
|---|---|---|---|---|
| | **Before digestion** | **After digestion** | **Before digestion** | **After digestion** |
| Digester A | 31.0 | 26.6 | 8.41 | 5.15 |
| Digester B | 30.4 | 27.4 | 7.30 | 7.90 |
| Digester C | 30.0 | 27.5 | 9.27 | 7.13 |
| Digester D | 29.9 | 27.5 | 7.58 | 7.59 |
| Digester E | 29.9 | 27.4 | 9.06 | 7.33 |

Key

| | |
|---|---|
| Digester A | Kolanut husks |
| Digester B | Poultry droppings |
| Digester C | Ruminant waste of cow |
| Digester D | Kolanut husk/Poultry droppings |
| Digester E | Kolanut husk/ Ruminant waste of cow |

**Table 3** Total cumulative of biogas production ($cm^3$) and individual retention time for digester A, B, C, D and E.

| **HT Weeks** | **Digester A ($cm^3$)** | **Digester B ($cm^3$)** | **Digester C ($cm^3$)** | **Digester E ($cm^3$)** | **Digester E ($cm^3$)** |
|---|---|---|---|---|---|
| **22** | **3690** | **73,230** | **32,500** | **53,230** | **42,310** |

**(154 days)**

**DISCUSSION**

**Biogas yield produced**

From Table 3 above, it was observed that poultry dropping has the higher production and kolanut husk has the lowest production, 100% kolanut husk started production at the 2nd day with the sum of 1170 $cm^3$ and gradually reduced in production till it stopped on the 89th day with zero production. The substrate produced total biogas of 3,690 $cm^3$ at 89 days retention time. It was observed that the biogas yield was very low and had pH reading of 5.15 which is acidic. The low production can be linked to the acidic pH because methanogens that produces biomethane are highly sensitive to pH (Garba and Atiku, 1992). Also, according to Ofoefule *et al.* (2010), adequate physicochemical properties like total solid, volatile solid, carbon content, nitrogen content, carbon:nitrogen ratio are known to affect biogas production. The low production of biogas could be due to the low percentage of TS used up in which the volatile solid is obtained, its low % carbon content and low C;:N ratio because optimum C:N ratio ranges between 20-30 because microbes responsible for biogas production takes up carbon 30 times faster that nitrogen (Uzodinma *et al.,* 2007). Igoni *et al.,* (2007) observed that gas production is increases with increase in %carbon and nitrogen concentration.

Poultry droppings started production on the 1st day with a production of 855 $cm^3$ at ambient temperature of 38°C. The production gradually increased on daily basis due to the activeness of methanogens present in the substrate. It had the best/optimum production on the 1st week with a production of 9,520 $cm^3$ of biogas and production of biogas stopped on the 154th day with zero production; it had a total production of 73,230 $cm^3$ at 154 day retention time. Thus, its high biogas production is also associated with the favourable physicochemical properties of the substrate i.e it high percentage of TS in which the volatile solid is obtained, its high % carbon content and C;N ratio, pH of 7.30 to 7.90 after production which is a very important factor for biogas production because bacteria responsible for biogas are required a neutral environment. This creates an enabling environment for the production of biogas because the microbes that convert waste to biogas are highly sensitive to pH (Manyi-Loh *et al.,* 2013).

Rumen of cow started production on the 1st day with 60 $cm^3$, the production gradually increased and later decreases with respect to temperature and the inactiveness of the methanogens. It has the best/optimum production on the 8th week with the sum of 4,670 $cm^3$ and stopped production on the 145th day with zero production. This substrate produced the total sum of 32,500 $cm^3$ at 145 days retention time; this is because waste coming from rumen of animal is known to contain the native microbial flora that aids in faster biogas production (Odeyemi, 1987; Ofoefule *et al.*, 2006).

Kolanut husk seeded with poultry dropping at ratio 1:1 started production on the 1st with sum of 670 $cm^3$ and had it best production on the 18th week with sum of 7420 $cm^3$. The digester stopped production on the 154th day with zero production and the total production of 53,230$cm^3$ at 154 days retention time and kolanut husk seeded with rumen of cow started production on the 2nd day with the sum of 510 $cm^3$ and production continues till it stopped production on the 153rd day with zero production. It had it best production on the 8th week with the sum of 7,540 $cm^3$and total production of the sum of 42,310 $cm^3$ at 153 days retention time. The statistical analysis revealed that there's significant differences when comparing the biogas yield of digesters A, B, C,D and E in this experiment with P values of 0.006, 0.000, 0.006, 0.006 and 0.000 respective where $P< 0.05$.

In this research it was observed that kolanut husks produces better with additive than when its used alone, this is because blending wastes can favourably enhance the physicochemical properties of the wastes as well as the microbial load of the blend especially at point of charging and peak of production (Ofoefule *et al.*, 2010). Thus, positive synergetic effect of the co-digestion of kolanut husk, ruminant waste of cow and poultry dropping provides more balanced nutrient, decreased the effect of toxic in it and also increased buffering capacity according to Aragaw and Gessesse, (2013).

**CONCLUSION**

The physicochemical properties of kolanut husk, poultry dropping and Rumen waste of cow was investigated. The result obtained for all these parameters shows that poultry droppings and Ruminant waste of cow are good substrates for biogas production. Poultry dropping which has the highest biogas yield has the most favourable physicochemical properties with highest % carbon content, nitrogen content, carbon:nitrogen ratio, total solid, the lowest moisture content and suitable pH. Kolanut husk has the lowest and poorest biogas yield with less favourable physicochemical properties and acidic pH which could be linked to it poor production except when co-digested with suitable additives i.e rumen of cow and poultry dropping to create a positive mutual effect to obtain a more balanced nutrient, decreased the effect of toxic in it and also increased buffering capacity increased the yield greatly.

## REFERENCES


1. Aragaw, T. and Gessesse, A. (2013). Co-digestion of Cattle Manure with Organic Kitchen Waste to Increase Biogas Production using Rumen Fluid as Inoculums, *International Journal of Physical Sciences*, ***8***(11), 443-450.
2. Asogwa, E.U., Otuonye, A.H., Mokwunye, F.C., Oluyole, K.A., Ndubuaku, T.C.N. and Uwagboe, E.O. (2011). Kolanut Production, Processing and Marketing in the South-Eastern States of Nigeria. A Review: Kola Programme Research, Cocoa Research Institute of Nigeria, Ibadan, Nigeria. *African Journal of Plant Science* ***5***(10), 547-551.
3. Babatunde, B.B. and Hamzat, R.A. (2005). Effects of Feeding Graded Levels of Kolanut Husk Meal on the Performance of Cockrels. *Nigeria Journal of Animal Production,* ***32***(1): 61-66.
4. Bagudo, B. U., Garba, B., Dangoggo, S.M. and Hassan, L.G., (2008). Comparative Study of Biogas Production from Locally Sourced Substrate Materials. *Nigerian Journal of Basic and Applied Sciences* ***2***(16): 269- 274
5. Bartlett, G.N., Craze, B., Stone, M.J. and Crouch, R. (1994). Guidelines for Analytical Laboratory Safety. Department of Conservation and Land Management, Sydney.
6. Dias, D. R. (2014). Agro Industrial Uses of Cocoa By-Products. *Cocoa and Coffee Fermentation. CRC Press, Boca Raton, FL.*
7. Garba, B. and Atiku, S.S. (1992). Effect of Operating Parameters on Biogas Production Rate. *Nigerian Journal of Renewable Energy.* **3**:36-44.
8. Havukainen, J., Uusitalo, V., Niskaen, A., Kapustina, V. and Horttanainen, M. (2014). Evaluation of Methods for Estimating Energy Performance of Biogas Production. *Renewable Energy,* ***66***: 232-240.
9. Holt J.G., Krieg N.R., Sneath P.H.A., Stanley J.T. and William S.T. (1994). Bergey's Manual of Determinative Bacteriology. Baltimore: Williams and Wilkins;
10. Igoni, A. H., Abowei, M. F. N., Ayotamuno, J. M. and Eze. C. L. (2007). Effect of Total Solids Concentration of Municipal Solid Waste in Anaerobic Batch Digestion on the Biogas Produced. *Journal of Food, Agriculture & Environment* ***5***(2): 333- 337.
11. Loehr, R. (2012). Agricultural Waste Management: Problems, Processes, and Approaches. *Elsevier.*
12. Manyi-Loh, C., Mampphweli, S., Meyer, E., Okoh, A., Makaka, G. and Simon, M. (2013). Microbial Anaerobic Digestion (bio-digesters) as an Approach to the Decontamination of Animal Wastes in Pollution Control and the Genration of Renewable Energy. *International Journal of Environmental Research and Public Health,* ***10***(9): 4390 – 4417.
13. Odeyemi, O. (1987). Research needs priorities and challenges in biogas production and technology in Nigeria. Paper delivered at the centre for genetic resources and biotechnology (NACGRAB) Seminar Ibadan Nigeria.
14. Ofoefule, A. U., Nwankwo, J. I. and Ibeto, C.N. (2010). Biogas Production from Paper Waste and its Blend with Cow Dung. *Advance in Applied Science Research* ***1***(2): 1-8. ISSN: 0976-8610.
15. Ofoefule, A.U. and Uzodinma, E.O.U. (2006). Optimization of the Qualitative and Quantitative Biogas Yield from Poultry Waste. *Proceedings of World Renewable Energy Congress IX*, August 19-25 2006, University of Florence, Italy, Elsevier UK.
16. Oluokun, J.A. and Oladokun, E.A. (1999). The Effects of Graded Levels of Brewers Spent Grains and Kolanut Pod Meal in the Performance, Characteristics and Carcass Quality of Rabbits. *Nigeria Journal of Animal Production,* ***26***: 71-77.
17. Overcash, M. R., Humenik, F.J., and Miner, J.R. (1973). Livestock Waste Management, eds. CRC Press, Boca Raton. 1973.

18. Raposo, F., De La Rubia, M.A., Fernandez-Cegri, V. and Borja, R. (2011). Anaerobic Digestion of Solid Organic Substrates in Batch Mode: An Overview Relating to Methane Yields and Experimental Procedures. *Renewable and Sustainable Energy Review,* ***16***, 861 – 877.
19. Uzodinma, E.O., Ofoefule, A.U., Eze, J.I. and Onwuka, N.D. (2007). Biogas Production from Blends of Agro-industrial Wastes. *Trends Appl. Sci. Res.* ***2***(6): 554-558.
20. Van Reeuwijk, L. P. (2002). *Procedures for Soil Analysis* (Technical paper 9, Sixth Edition). Netherlands: International Soil Reference and Information Centre. Retrieved from www.isric.org on 13th March, 2019.
21. William T. A. (2001). *Method 1684 Total, Fixed and Volatile Solids in Water, Solids, and Biosolids.* 1200 Pennsylvania Ave. NW Washington, DC 20460. https://doi.org/EPA-821-R-01-015 January