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COMPARATIVE STUDY OF METHANE PRODUCTION FROM GROUNDNUT STRAW, BAMBARANUT STRAW AND MILKWEED PLANT

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ABSTRACT: A comparative analysis of methane yield from Bambaranut Straw, Groundnut Straw and milkweed Plant substrate was experimented using 30 litres batch digesters constructed from mechanical workshop, University of Agriculture Makurdi for the research work. Three replicates of 10kg, 8kg and 6kg for each substrate were digested for 30days of retention period. Water was heated at 25°C and added as a startup heat after loading. Temperature variation in the digester was measured using a thermometer and pH (ranged 5.0 – 7.0) was measured using the pH meter. Anaerobic digestion of the substrate of Bambaranut Straw yielded less compared to groundnut straw and milkweed plant yielded more. The bambaranut straw yielded less because of the much acidic level. Analysis of variance (ANOVA) revealed that there's no significant difference between the 10kg and 8kg while there is significant difference at 6kg for the substrates used.

Keywords: *Methane, Bambaranut, Groundnut, Milkweed Substrate, Water.*

I. INTRODUCTION

The big challenge of modern life as regard energy supply is the search for technology that will allow for more efficient and less cost effective way of producing energy, one technology that can successfully solve this world problem is anaerobic digestion (AD) (**1**). Agricultural waste have a large potential as an energy source, the increase in agricultural activities resulting to increased agricultural waste and the expansion of the renewable energy sector shows that agricultural wastes could play a vital role in the future of biofuels sources.

Renewable energy has remained one of the best alternative ways for sustainable energy development, especially for the rural and suburban areas. As fossils fuels become scarce and more expensive and carbon dioxide emission levels becomes of greater concern, the benefits and potential of biogas as a source of energy supply are being increasingly recognized (**2**). Biogas is methane rich gas produced from the anaerobic digestion of organic materials such as agricultural waste and biodegradable materials, biogas is produced when biomass is subjected to biological gasification (**3**). Methane is the major components of the biogas used in many homes for cooking and heating. It is odorless and colorless. Organic substances such as human, animal and agricultural waste can be digested under anaerobic to produce gas and sludgy used as fertilizer (**4**).

The production of methane is achieve effectively when factors such as pH value of the slurry in the digester is duely considered, the pH value of the slurry in the digester is an important indicator of methane organic performance. Gas is produced if the pH value of the substrate is between 6.6 and 7.6. Gas production is highest when the pH is between 7.0 and 7.2 (**5**). Beyond this pH limits, digestion can precede but with less efficiency as the loading rate of the substrate depending on the type of digester use affect the pH values which in turn result to rapid production of volatile acid with the resultant inhibition of the organic materials. It may also occur as a result of temporary presence of inhibitors and toxicants. Fluctuation in pH can be accommodated through proper control of temperature/loading rate and adequate mixing, however, effective and tight control of pH requires the availability of sufficient alkalinity to form buffer in the system.

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Due to the increasing rate of power failure in the country, both in houses, production factories which has resulted to low yield in economic standard as well as global warming of atmospheric condition which is caused as a result of excess carbon dioxide from fossil fuels therefore the need for renewable energy is called for in other to help in solving the current energy challenges in both urban and suburban environments by focusing on biomass production using by-products especially those from the agricultural sector (6). The purpose of this research work is to investigate Biomass yield (methane production) from Bambaranut straw, groundnut straw and milkweed.

II. MATERIALS AND METHODS

A. Description of the Digester

The digester component include the fermentation chamber (VF) the gas storage chamber (VGS) the gas collecting chamber (VC), the influent (VI) and the effluent chamber (VC) the components are shown diagrammatically in figure 1 below, the fermentation chamber is the chamber where the slurry charged in the digester is stored. The gas storage chamber is the upper frustum section of the digester; the gas collecting chamber is the chamber through which the stored gas exists from the digester to the gas collector through the loose or connecting pipes. The influent chamber channel through which the digester is charged while the digested slurry is discharged from the effluent chamber. The digesters are link to the condense water tanks which are linked to the gas collectors with the connecting pipes.

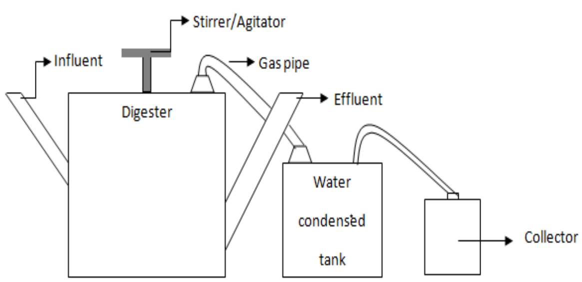

Fig 1: Digester

B. Biogas procedures process:

The subtract of ground nut straw, bambaranut straw as agriculture waste were obtained from Mbagbe Konshisha Local Government Area of Benue state while milk weed was gotten from North Bank Makurdi Local Government in Benue State. Nine (9) anaerobic size batch type digesters were constructed and used for this experiment. 30 liters volume digesters were used. Three replicates of 10%, 8% and 6% total solids (Ts) concentration each was digested for a retention time of 30 days. The gas yield (L/kgts) was measured from the 1st day to the 30th day of the digestion. The pH of the substrate was measured at an interval of 5days after loading. Temperature was measured using thermometer, the carbon /nitrogen ratio of the substrate was determined using proximate analysis before introducing it into the digesters.

C. Determination of composition of substrate (Bambaranut, groundnut straw and Milkweed) through proximate analysis

The moisture content was determined using the air-oven method, crude protein was determined using Kjeldahl method, crude fat determined using Soxhlet solvent extraction method all as described by **7** alongside crude fibre and ash content while Carbohydrate was determined by difference as reported by 8. Carbon content was determined using Walkely black method and the Nitrogen content was analyzed using regular macro-Kjekeldahl method

D. Determination of pH Measurements

pH measurement was carried out using a pH meter, the pH level of the substrate was measured before introducing it into the digester, and it was measured after 5 days interval during the retention time of 30 days.

E. Determination of Gas Measurement

The biogas produced from the digester in each case was collected in the gas collector and its volume determined using a graduated measuring cylinder.

F. Determination of Total solids (TS) concentration.

Total solid (TS) concentration was computed by weighing a stipulated gram of all the substrate after mixing from the digester. Each was kept in a peptic dish and weighed after which they were sun dried. Water content (W_C) of the substrate sample was computed from Equation 1 while the TS concentration was calculated from equation 2

$$W_C = \frac{Initial\ weight - weight}{Initial\ weight} \times 100\% \quad 1$$

$$TS\% = 100 - W_C\% \quad 2$$

G. Temperature Determination

A measured quantity of water was heated at a temperature of 25ºC and mixed with the 10kg substrate of each groundnut straw, bambaranut straw and milkweed, for the first replicates, the same heated quantity of water was mix with the 8kg substrate of each groundnut straw, bambaranut straw and milkweed and the same measured water was heated at the same 25˚C and mix with 6kg substrate of each groundnut straw, bambaranut straw and milkweed. The subsequent temperatures were measured by tipping the thermometer head in the effluent of the digesters for daily readings of the temperature.

III. RESULT AND DISCUSSION

A. Proximate Analysis of bambarnut straw, groundnut straw and milkweed

The proximate analysis of the substrate as shown on table 1, showed that bambaranut straw has the highest moisture content of 7.87%, which was followed by moisture content of groundnut straw with 6.88% and milkweed having the least moisture content of 6.57%. The ash content ranged from 3.76%-4.22% with milkweed having the highest value and bambaranut having the least value. Crude fibre ranged from 20.87%-24.89% with groundnut straw having the highest value and bambaranut having the least value. Fatty content ranged from 2.88%-5.98% with groundnut having the highest value and milkweed straw having the least value. The protein content ranged from 5.2%-6.2% with groundnut having the highest value and milkweed having the least value. The carbohydrates content ranged from 51.97%-59.02% with milkweed having the highest value and groundnut having the least value (see figure 2).

Table 1: Proximate Analysis of Bambarnut Straw, Groundnut Straw and Milkweed

Parameter	Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Milkweed	6.57	4.22	22.11	2.88	5.2	59.02
Groundnut Straw	6.88	4.08	24.89	5.98	6.2	51.97
Bambaranut Straw	7.87	3.76	20.87	5.30	6.0	56.20

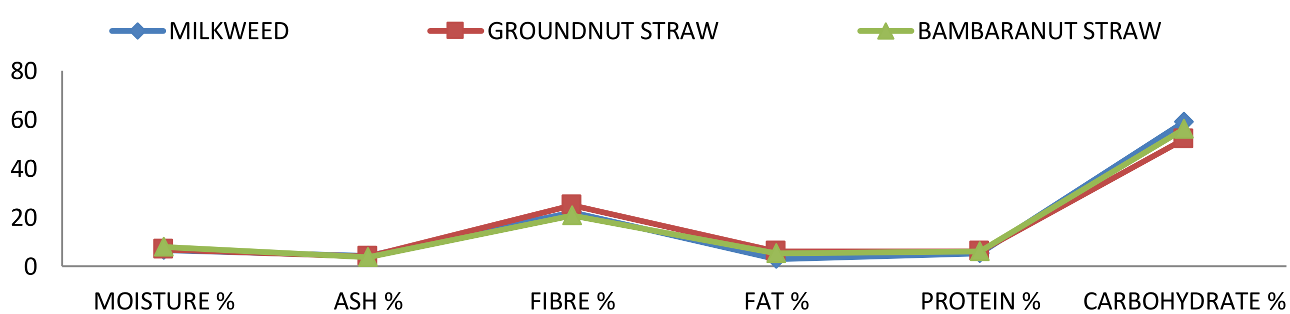

Fig 2: Composition trend of the different substrates

B. Discussion

Table 2 shows the biogas yield (L/kgTS) for the batch digestion of slurries of 10kg, 8kg and 6kg of total solid concentration from groundnut straw, bambaranut straw and milkweed substrates. The gas yield is of order 0.9480 (L/kgTS) > 0.6423(L/kgTS) > 0.4884(L/kgTS) quantity for groundnut straw, milkweed and bambaranut straw respectively.

ANOVA at $P < 0.05$ of the means of the gas produced for the different total solid showed that there was no significance difference in the gas yield of 10kg and 8kg slurries for the substrates but reveal a significance difference for the gas yield of 6kg slurries, total daily yield of the gas and pH across the substrates. The values for the slurries of 10kg, 8kg and 6kg total substrates for the period of gas yield are 6.6, 6.7 and 6.3 respectively. Implying that the slurries of higher total solid concentration has less acidic contents as compared to the lower total concentration of 6kg which in return indicates the presence of methanogenic that activate the gas production (**9**). In the absence of any other reagent, pH alone is an important factor in checking gas yield through an anaerobically batch digester system, gas production is highest when the pH is between 6.7 and 7.2 and beyond this, pH limit digestion can proceed but with less efficiency (**4**).

Further analysis using the Duncans New Multiple Range Test (at $P < 0.05$) of the means of the gas yield for the different total solid concentrations showed that there is no significant difference between slurries of 10kg and 8kg total solid concentration of the substrates while a significant difference was recorded in the 6kg total solid substrates and this could be a result of low acidic content in pH value that pave way for the micro bacteria to act on the slurries to aid gas product (**10**).

Table 2: Biogas yield from substrates

Substrate	Days of Detention	Temperature Range (°C)	Substrate Weight			Total Quantity Produced	pH Value
			10kg	8kg	6kg		
Milk weed	**26**	**23-38**	0.2961a	0.1865a	0.1596a	0.6423ab	6.6a
			(0.25)	(0.21)	(0.18)	(.56)	(.37)
Groundnut	**26**	**23-38**	0.2212a	0.2654a	0.4615a	0.9480a	6.7a
Straw			(0.25)	(0.21)	(0.67)	(.80)	(.55)
Banbaranut	**26**	**23-38**	0.2577a	0.1673a	0.0635a	0.4884b	6.3b
Straw			(0.23)	(0.17)	(0.12)	(.43)	(.74)

Different letters along columns indicate significant difference of means according to Duncan Multiple Range Test ($P \leq 0.05$)

Table 3: ANOVA

Source of Variation		Sum of Squares	df	Mean Square	F	Sig.
Biogas (10kg)	Substrate	0.073	2	0.037	0.619	0.541^{NS}
	Error	4.429	75	0.059		
	Total	4.502	77			
Biogas (8kg)	Substrate	0.140	2	0.070	1.857	0.163^{NS}
	Error	2.836	75	0.038		
	Total	2.977	77			
Biogas (6kg)	Substrate	2.116	2	1.058	6.430	0.003*

	Error	12.339	75	0.165		
	Total	14.454	77			
Daily Total	Substrate	2.846	2	1.423	3.724	0.029*
	Error	28.662	75	0.382		
	Total	31.509	77			
PH	Substrate	2.846	2	1.423	4.350	0.016*
	Error	24.538	75	0.327		
	Total	27.385	77			

Note: NS represent no significant difference while * represent significant difference @ P≤0.05

Milkweed at 26 detention days with temperature range of 23˚C -38˚C, revealed gas produced at 10kg was 0.2961 and last 6kg, gas yield was 0.1596 with standard deviation of 0.18. The total quantity of gas produced was 0.6423 at pH value of 6.6. Groundnut substrate at 26 detention days with temperature range of 23 - 38˚C was able to produce gas at 10kg 0.22129 standard deviation of 0.25, 8kg produced 0.2654 while 6kg produced gas of 0.4615 with 0.21 and 0.67 as standard deviation respectively with pH value of 6.7, the total quantity produced was 0.9480. Bambaranut substrate in 26 days detention period produced gas to 0.2577 at 10kg, 0.1673 at 8kg and 0.0635 with standard deviation of 0.23, 0.17 and 0.12 respectively; the total quantity produced was 0.4884 at pH value of 6.3.

Gas use for domestic purpose comprises of all living plant matter as well as organic wastes derived from human, animal and plants wastes, garbage. Sewage and trees are few examples of biomass. The result from the study revealed that, bambaranut straw, the highest gas yield was observed to be 0.3ml at a temperature range of 27˚C - 34˚C at a load rate of 10kg, this implies that the higher the load rate of bambaranut straw, the higher the gas production, this result agrees with the work of **11** who pointed out that, some substrates gas yield is dependent upon the loading rate of the substrate, and the least gas yield from bambaranut was 0.00ml which was observed on the 6kg of the substrate at temperature range of 28˚C -37˚C with a pH level of 6.0 thus implying that the pH level of the substrates affects its gas production as also stated by **9 and 12** who noted that the normal pH for a working biogas plant and for optimum production is between 6.7-7.0 hence the reason for poor gas production.

In terms of groundnut straw, the highest gas yield (0.5ml) was observed on the 10kg and 8kg load rate at a temperature range of 28 ˚C -37˚C and at same high temperature of 27 ˚C -36˚C and same load rate of 10kg and 8kg yielded the same 0.5ml thus implying that high load rate and high temperature promotes high gas yield in groundnut straw, as this is confirmed by the work of **4** who opined that the rate of methane production has been found to be sustainably higher at thermophilic temperature compared to standard mesophilic temperature and the lowest gas yield from groundnut straw was observed on 6kg load rate and at a temperature of 25˚C.

For milkweed, the highest gas yield of 1.2ml was observed on the 10kg load rate of the substrate at a temperature range of 29˚C -37˚C and the lowest gas yield of 0.1ml at a load rate of 6kg and at a temperature of 25˚C, this result also confirms the report of (**4**).

IV. CONCLUSION

It can be concluded from the results obtained that; Biogas (methane) yield increases with increase in number of detention period till final decomposition is reached, Biogas yield for the various agricultural waste types is in the order of bambaranut straw substrate > groundnut substrate > milkweed plant and Biogas yield increases with pH value of 6.7 – 7.0

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