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Evaluation on Biogas Production using *Jatrophacurcas* (Physic Nut) Pressed Cake Slurry

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Abstract
Evaluation of biogas production using (Physic Nut) Jatrophacurcas cake slurry was carried out in Keffi. Micheal Madson Experimental setup was employed and 2.5l capacity of Experimental Biogas plant constructed in Plant Science and Biotechnology Laboratory, Department of Biological Sciences, Nasarawa State University, Keffi was used to investigate the anaerobic digestion in generating biogas from Jatrophacurcas pressed seed cake. The digester was charge with Jatrophacurcas pressed cake slurry in a ratio of 2:1:2 to water. The mesophilic temperatures range attained within the testing period were 21-40°C. While pH levels were 6.0-8.0 pH level, respectively. The result obtained from the production showed that JatrophaCurcas pressed cake slurry produced 9433mL within the 30 days retention period. During the digestion, the volume of biogas production and change in pH indicate that at neutral pH and moderately high temperature (40°C), the highest peak of gas production was attained and at alkaline pH range and low level temperature, there was very poor gas production. In terms of environmental factors in relations to biogas production, it is noted that temperature at 36-40°C was favored producing the mean production gas of 545mL. The least volume obtained at 21-25°C with 71.33mL of gas production. So also in pH, slightly acidic/alkaline and neutral pH were found to produce the highest yield volume of gas having mean production of 384.7mL and 220ml at pH of 6.6 – 7.0 while the lowest yield production obtained was 220mL at pH of 6.0-6.5 level. These results showed that Jatrophacurcas pressed seed cake could be a source of renewable gas if managed properly. Both pH and temperature have significant role in anaerobic digestion.

Keyword: *Jatrophacurcas*, cake slurry, pH, temperature

INTRODUCTION
Energy is one of the most important factors to global prosperity. The dependence on fossil fuels as primary energy source has led to global climate change, environmental degradation, and human health problems. By the year 2040, it is predicted that the world will have a population of 9 to 10 billion people that must be provided with energy and materials (Okkerse *et al*., 1999). Moreover, the recent rise in oil and natural gas prices may drive the current economy towards alternative energy source such as biogas. Various forms of biomass such as vegetation, animal dung and plant products are providing safe and convenient sources of energy as in the form of biogas and liquid fuel. Biomass such as cattle dung, agro-residues, plant residues, organic wastes from industrial processing in spite of

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being biodegradable, create much nuisance in the environment. These easily available alternative resources can be harnessed by anaerobic fermentation of this waste matter producing biogas that are efficient. Although there are technological hurdles in this area of research yet they have proved to be much more efficient and environment benign than non-conventional sources of energy. During past 20 years, several modifications in biogas plants have been done to overcome the technological and operational hurdles like modifications are done in Deenbandhu and KVIC biogas plants to run them on high solid concentration of cattle dung for attaining higher biogas production (Maheshwari *et al*., 2006).Several biological process to convert biomass to energy, and thus provide a source of fuel, have been studied in recent decades (Raynal *et al*.,1988). One of the most important process for this purpose is the anaerobic digestion of organic matter to obtain biogas (consisting mainly of CH_4CO_2 as a product of the metabolic action of methanogenic microbial consortia. Another benefit of utilizing biomass is that the solid residual product from anaerobic degradation can be used as organic fertilizer (Ahring, 2003).Researchers have generally focused on the production of biodiesel from *Jatrophacurcas*, while few studies have investigated biogas production from *Jatrophacurcas* seed cake (Singh *et al*.,2008) studied biogas production from *Jatrophacurcas* seed cake enriched with cattle dung and operated by semi-continuous single operation. Based on these findings it was concluded that *Jatrophacurcas* seed cake is a good source, due to high conversion rates and efficiencies obtained. The press cake is rich in organic matter (Abreu, 2007). This research is aimed at evaluating the Potential of Biogas Production Using *Jatrophacurcas* Pressed cake slurry in Keffi, Nasarawa State.

MATERIALS AND METHOD

Preparation of Seed: Indigenous *JatrophaCurcas* seeds were collected(plate 1) and the damaged seeds were discarded, the seeds in good condition were cleaned, hulled and dried.The whitish seeds were ground prior to oil extraction using soxhlet apparatus and n-hexane used as solvent(Henning, 2003). A 2.5 lt of amber bottle served as digester which constituted the prepared slurry and the bottle was inserted into the water bath that controls the temperature fluctuation to be maintained at mesophilic range. The amber bottle was then tightly closed with a stopper and channel to the first conical flask mounted on the retort stand. Rubber tube was used to channel the glass rod inserted in the flask while tightly covered with stopper. This flask served as carbon dioxide scrubber and contained 1mole of sodium hydroxide plus small quantity of phenolphthalein, which is a pH indicator that turns pink/violet in dilute solutions having pH above 8.2 and later colorless when it is below 8.2. The carbon dioxide scrubber usually fades when saturated with carbon dioxide. The second conical flask which is held by the retort stand was linked with the carbon dioxide scrubber flask, while containing ordinary water plus methyl orange. This serves as displacement bottle supporting Mariotte Principle of Quantifying Methane, and the added drops of methyl orange only simplified the volumetric reading of the gas produced in the graduated cylinder that was channeled to the last conical flask (Ukpai *et al*., 2012).

Preparation of Organic Waste Slurry

500g of *Jatrophacurcas* press cake was mixed with 1000ml of water in ratio 2:1:2 inside a big rubber bowl; the collected ruminant waste in the gut was filtered using fine sieve until 100ml of liquid innocula was obtained, then added to the mixture and stirred properly. The slurry pH was determined using a digital pH meter which was about 7.22pH value. Due to some factors which affect the microbial constituent (innocula) responsible for the anaerobic

degradation that resulted to their death, 100ml of the innoculawere introduced again to revive the biogas production on the 12th day of retention period (Ukpai *et al*., 2012).

Experimental Procedure

The prepared organic waste was charged into the digester and gets connected to the experimental setup. Temperature, pH level and volume of gas produced readings were taken in every 24 hours. The digester was also shaken twice daily, while the displacement bottle which is the second conical flask containing water plus methyl orange was topped once the water goes down (Ukpai *et al*., 2012).

RESULTS AND DISCUSSION

Full data of biogas daily production in relation to temperature and pH in the digester were obtains (Table 1). The production started with a poor performance of about 200ml, which gradually increased to 350ml at day 5, before it dropped to 180ml. At day 12, production increased to an impressive volume of 712ml which continued to appreciate gradually until it reached its optimum production on the 19th day, producing 840ml of biogas before gradually decreasing to zero (0) in producing biogas which was on the 30thday (last day of its retention time). The higher the temperature rises the more production increases; looking at the production in days 12 to 23. While when it drops production decreases as seen in days 7,8, 29 and 30 respectively. Values of pH variations per daily production of biogas are shown and best yield obtained was pH on the 19th day (Table 1).

Table 1: `Effects of temperature and pH level on the daily gas production

Day	Quantity of Gas production (ml)	Temperature (^oC)	pH level
1	200.00	21	8.00
2	635.60	30	7.90
3	336.00	31	7.60
4	386.00	30	7.40
5	373.00	28	7.80
6	350.00	29	6.50
7	180	25	7.20
8	98	22	6.90
9	0	28	6.00
10	0	21	7.20
11	0	21	6.90
12	712	38	7.30
13	423	33	7.00
14	410	36	6.40
15	380	29	7.10
16	300	27	7.50
17	620	39	7.20
18	730	39	6.80
19	840	40	6.60
20	530	37	6.90
21	523	40	7.00
22	300	33	6.80

23	310	38	6.30
24	230	36	7.20
25	210	28	6.80
26	193	26	7.00
27	93	23	7.50
28	41	21	7.10
29	30	21	6.00
30	0	21	7.90

Explain Table 2, 3 before Table 4. The Tables should come in between

Biogas Production in Relation to Different Levels of Temperatures

The biogas production based on the groups that were obtained and temperature at 21-25^{o}C produced a total of 642ml in 9 days, having the average value of 71.33 ml per day recording the lowest yield of biogas production (Table 4). Followed by 26-30^{o}C producing 2827.60 ml with an average value of 314.18ml in 9 days of daily gas productions, then 31-35^{o}C with an average value of 353ml as recorded in table 4.

The best result was obtained at 36-40^{o}C temperature level, producing 4905ml in 9 days having an average point of 545ml of biogas production as shown in (Table 4).

ANOVA was carried out and the result, showed significance difference at 5% level degree e of freedom having p-value of 1.21E-05 **(**Table 5**)**.

Comparison between the groups proved the, least significance differences that exist with one another in terms of biogas yield. The results showed significance in all the comparisons (Table 6).

Table 2: The effect of temperatures on production of biogas

Temperature	Days	Sum	Average	Variance
Temp 21-25 (^{o}C)	**9**	642	71.33	5929.75
Temp 26-30 (^{o}C)	**9**	2827.6	314.18	30249.03
Temp 31-35 (^{o}C)	**3**	1059	353	3999
Temp 36-40 (^{o}C)	**9**	4905	545	41018.50

Table 3: Analysis of Variance (ANOVA) for temperature

Source of Variance	SS	Df	MS	F	P-Value	F crit
Between Group	1014790	3	338263.40	14.06	1.21E-05	2.98
Within Groups	625576.3	26	24060.63			
Total	1640366	29				

P>0.05 Significance at 0.00000121 (0.121-E) to 0.05

Table 4: The least significance Difference (LSD) between the temperatures.

Source of LSD i.e Temp. (°C)	LSD Calc. LSD=t0.5/2DFW √MSW	2 Average of the Source	(ya-yb)	LSD
A & B	142.589	71.333 & 314.178	242.845	242.845 ≥ 142.589 **
A & C	201.651	71.333 & 353	281.667	281.667 ≥ 201.651 **
A & D	142.589	71.333 & 545	473.667	473.667 ≥ 142.589 **
B & C	201.651	314.178 & 353	38.822	38.822 ≥ 201.651 ##
B & D	142.589	314.178 & 545	230.822	230.822 ≥ 142.589 **
C & D	201.651	353 & 545	192	192 ≥ 201.651 ##

P > 0.05

Key A - Temp. 21 – 25 (°C) B - Temp. 26 – 30 (°C) C - Temp. 31 – 35 (°C)

D - Temp. 36 – 40 (°C) ## - Significance ** - No Significant

Biogas Production in Relation to pH Level

The average of the grouped were analyzed per daily production, showing the best yield at 6.6 – 7.0 having an average of 384.7ml (Table 7)followed by 7.6 -8.0 with an average production of 308.92ml (Table 7),294.2ml was produced at 7.1 - 7.5 which slightly increased at 7.6 – 8.0 with an average value of 308.92ml (Table 7).The lowest volume of gas was obtained at 6.0 -6.5 recording an average volume of 220mL of biogas production (Table 7).

The ANOVA showed significant at 5% level degree of freedom comparing with p-value of 0.651395 obtained (Table 8).

Least Significant Difference was analyzed, showing no significance between 6.0 – 6.5 and 6.6 – 7.0, 6.0 -6.5 and 7.1 - 7.5, 6.0 -6.5 and 7.6 – 8.0, 6.6 -7.0 and 7.1 – 7.5, 6.6 – 7.0 and 7.6 – 8.0, 7.1 -7.5 and 7.6 -8.0 pH value respectively (Table 8).

Table 7: The Effect of pH on Production of Biogas

Group	Days	Sum	Average	Variance
6.0-6.5 pH level	5	1100	220	36400
6.6-7.0 pH level	10	3847	384.7	74763.34
7.1-7.5 pH level	10	2942	294.2	56092.62
7.6-8.0 pH level	5	1544.60	308.92	54713.63

Table 8: The least significance Difference (LSD) between the pH levels

Source of LSD i.e pH level	LSD Calc. LSD=t0.5/2DFW √MSW	2 Average of the Source	(ya-yb)	LSD
A & B	274.193	220 & 384.7	164.7	164.7 ≥ 274.194 ##
A & C	274.193	220 & 294.2	74.2	74.2 ≥ 274.193 ##
A & D	316.611	220 & 308.92	88.92	88.92 ≥ 316.611 ##
B & C	223.877	384.7 & 294.2	90.5	90.5 ≥ 223.877 ##
B & D	274.193	384.7 & 308.92	75.78	75.78 ≥ 274.193 ##
C & D	274.193	294.2 & 308.92	14.72	14.72 ≥ 274.193 ##

P>0.05
Key A - 6.0 – 6.5 pH level B - 6.6 – 7.0 pH level C - 7.1 – 7.5 pH level
D - 7.6 - 8.0 pH level ** - Significance ##- No Significance

The best yield (635.6ml) of biogas obtained within the range of pH 6.6-7.0 at 40^{o}C and the lowest yield (30ml) at pH 6.0-6.5 and 21^{0}C might be due to temperature fluctuations because numerous or prolonged temperature drops can results in unbalanced population of methanogens and lead to pH problems (Marchaim, 1992).

In trying to analyze the effect of temperature, different level of temperatures were grouped per daily production in (Table 4).From the result temperature between 36-40^{o}C records the best yield of biogas and 21-25^{o}C were lowest as recorded (Table 4).One way ANOVA showed significance difference that exist in the four groups of the temperature and obtained the p-value of 1.21E-05 at 0.05 degree of freedom, which is highly significant. The LSD shows that there is significant difference between B&C, and C&D (Table 6). From this result, it is clear that the more temperature raises the more the activities in the digester increases which resulted to high yield of biogas volume (Table 6). The result also agrees with the report of Oyewole (2010), where he observed more gas production with increase in temperature and with the statement of Lawal*et al.* (2001) that the biogas production is favored with an increased temperature and drops as temperature decreases, so the rate of biogas production declines.

The summary of levels in pH growth recorded during the daily biogas productions showed 6.6-7.0 pH valued produced the mean volume gas of 384.7mL while 6.0-6.5 pH value produced 220mL of biogas mean (Table 7). This is highly Not significant as proved by analysis of variance (ANOVA) as shown in (Table 8) with p-value of 0.651395 at 5% level degree of freedom.

The LSD table showed no significant difference in production between 6.0-6.5, 6.6-7.0, 7.1-7.5 and 7.6-8.0.This result agreed with the findings of Ukpai*et al.* (2012) that a neutral pH was found to be most favorable at the mesophilic temperature. The result is always in line with

the work of Marchaim, (1992) who state that most microbes (anaerobic continuum) grew best under neutral pH condition, since equilibrium of enzymatic reaction or destroying the enzymes. In the case of production it is in line with (Garba, 1995) where he obtained best yield by adjusting pH to slightly alkaline. Also the entire result in relation to pH variations disagree with the statement of Ciolkasz*et al.,* (2012) where he mentioned that 8.5 pH value gives best yield at mesophilic.

CONCLUSION

After evaluating the *Jatrophacurcas* slurry in an anaerobic digestion, the result showed that *jJatrophacurcas* pressed cake could be a source of renewable gas if managed properly. Both pH and temperature have significant roles in anaerobic digestion. I therefore recommend that more researches should be done on the production of biogas from *Jatrophacurcas* slurry.

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