Preparation of Biomass Briquettes from Corncob and Uncarbonized Rice Residues

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Abstract- The selection of agro-waste briquettes for domestic and industrial cottage application depends on the fuel properties such as proximate and combustion characteristics. This work investigated the physiochemical properties of the briquettes produced from corncob and un-carbonized rice husk residues, with the aim to ascertain there rationality and fuel efficiency. A simple fabricated briquetting machine was used for densification. The results indicated that briquettes produced from these agro-wastes would make a good biomass fuel. However, results showed that corn cob briquettes has more positive attributes of biomass fuel compared to rice husk briquettes, this could be as the result of low moisture content of 2.0%, moderate ash content of 2.5%,high volatile matter of 12.0%, and high viability properties of the briquettes which helps in combustion, transportation and storage.

Indexed Terms- Rice husk, agricultural residue, biomass densification, Binder, Briquettes

I. INTRODUCTION

The danger behind global warming cannot be re-emphasized, as it become of international concern. Global warming and other air pollution have its basis from greenhouse gases which carbon dioxide is among the major contributors. Researchers have shown that, the level of CO_2 emission increased because the rate of the deforestation is very high compare to the afforestation effort in the country (Patomsok, 2008). The application of fuel wood for cooking has its own health hazards especially on women and children who are disproportionately exposed to the smoke apart from environmental effects (Patomsok, 2008). In rural houses, women and young children carried on the back or around them while cooking, spend hours every cooking with fuel wood. In some cases, the exposure is higher especially during raining season when cooking is done in an unaired kitchens and where fuel wood is used for heating of rooms to get it warmer. It was recorded that, indoor air pollution level from combustion of bio fuels in Africa are high and is above the standard set by United State Environmental Protection Agency (USEPA) for ambient level of these pollutants (Schrinding and Bruce, 2002). Exposure to biomass smoke enhances the risk of common diseases in human beings such as blindness and cataract. The smoke causes acute lower respiratory infection on children (ALRI). The most common one is pneumonia in children (Ezzati and Kammen, 2001). Finding alternative to hydrocarbon-based energy system has become a matter of economic and environmental importance. The ever-rising prices of kerosene and cooking gas coupled with the decreasing in the availability of fuel wood in Nigeria due to cutting down of trees (deforestation) is one of the problems that needs urgent attention. This draw the need to consider affordable sources of energy system for domestic and industrial uses in the country and energy sources should be renewable, eco-friendly as well as cheaper. The impact of agricultural waste on the environment depends not only on the amount generated but also the disposal methods used. Some methods pollute the environment. The potential threat posed by climate change, due to high emission level of greenhouses gases (CO_2) being the most important one has become a major stimulus for renewable energy source in general. The conversion of rice husk and other wastes materials is a clean environmental approach of transforming them into useful fuel briquettes to help reduce the over dependence of the households on charcoal for cooking and other industrial uses. It would also reduce the cutting down of trees which have an impact on the depletion of forest resources. The briquettes would serve as a substitute for fuel wood since it proves superior combustion characteristics over fuel wood and the material is readily available. The process is economical, low cost and affordable to the rural and low-income urban dwellers.

II. MATERIAL AND METHODS

This research work involved the collection of rice husk and corn cob and were crushed and grounded to fine powder using a grinding machine and sieved with a 2mm mesh. Cassava starch was purchased at Zuru New Market Kebbi State, Nigeria.

- BRIQUETTES FORMULATION: Briquettes were formulated using different percentages of corn cobs and rice husk. The ratios of rice husk and corn cobs were 100:0, 80:20, 70:30, 60:40 and 50:50 with the constant amount of starch 25g. Briquettes were produced using a fabricated briquetting machine and was sun-dried for three weeks **(**(Elinge *et al*, 2011).

- Moisture Content: Moisture content of the briquette samples was determined based on weight measurement before and after oven drying 2g of the sample was measured out (initial weight of the sample before drying) the sample and the crucible was placed in a drying oven set at 105°C for 24hrs. The crucible and its content were removed and placed in desiccators to cool at room temperature and re-weighed. The process was repeated until the weight after cooling is constant, and recorded as the final weight (final weight of the sample after oven drying) (Adekule *et al.,* 2015).

$$Moisture\ Content(\%) = \frac{Initial\ Weight\ of\ Sample - Final\ weight\ of Sample}{Initial\ Weight\ of\ Sample} \times 100$$

- Ash Content: Ash content of the sample briquettes was determined using a furnace residue from fixed carbon determination and was heated in a furnace ignited at 590^0C, for 2hrs and transfer into desiccators to cool down the material that was turn into white ash and weigh. Same process was repeated three time at 1hr interval until the weight is constant. The weight was recorded as the final weight of the ash (Adekunle *et al.,* 2015). The percentage ash content was calculated using equation below:

$$Ash\ Content(\%) = \frac{Weight\ of\ Ash}{Initial\ Weight\ of\ dry\ Sample} \times 100$$

- Fixed Carbon: The fixed carbon represents the amount of carbon that can be burnt by a primary current of air drawn through the hot bed of fuel (Moore and Johnson, 1999). The fixed carbon of the sample was determined using the following relation.

$$Fixed\ Carbon\ Content = 100 - [(MC\ \%) + (VM\ \%) + (AC\%)]$$

Where:
MC = Moisture Content
VM = Volatile Matte
AC = Ash Content

- Volatile Matter: The briquettes percentage volatile matter content was determined using Lenton furnace. The residue of the dry sample from moisture content determination was preheated at 300^0C for 2hrs to drive off the volatiles, the resulting sample was further heated at 470^0C 2hrs,to remove volatile matter, just the before materials was turn to ashes, and then cooled in desiccators (Adekunle *et al.,* 2015). The crucible with known weight and it content was weigh and as the percentage of weight loss, the percentage volatile matter was calculated using the equation below.

$$Volatile\ matter(\%) = \frac{Final\ Weight}{Original\ Weight} \times 100$$

- Ash Content: Ash content of the sample briquettes was determined using a furnace residue from fixed carbon determination and was heated in a furnace ignited at 590^0C, for 2hrs and transfer into desiccators to cool down the material that was turn into white ash and weigh. Same process was repeated three time at 1hr interval until the weight is constant. The weight was recorded as the final weight of the ash (Adekunle *et al.,* 2015). The percentage ash content was calculated using equation below.

$$Ash\ Content(\%) = \frac{Weight\ of\ Ash}{Initial\ Weight\ of\ dry\ Sample} \times 100$$

Where:

MC = Moisture Content

VM = Volatile Matte

AC = Ash Content

- Fibre Content: 2.0g of the sample into a cornical flask labelled Wo with 200ml of boiling 1.25% for 30 minutes then filtered and rinsed with hot distilled water 200ml of boiling 1.25% NaOH for 30 minutes filtered and washed, rinsed once with 10% HCl and twice with industrial methylated spirit, acetone or ethanol. Then finally rinsed with petroleum ether. Allowed to drain and the scrape the residue into a crucible, dried over night at 105^0C in the oven, cooled in a desiccator, weigh the sample and labelled W_1 was ashed at 550^0C for 90 minutes in a muffle furnace then cooled in a desiccator and weighed again as W_2 (Bakare,1985).

The % fibre content was calculated as: $\%\ fibre = \frac{W1-W2}{W0} \times 100$

- Nitrogen Content: This was determine based on the kjeldhal procedure and crude protein value was obtained by multiplying the nitrogen value by a factor of 6.5 while estimated of available carbohydrates was done by difference as: CHO=100-(%Ash+% CP+% CL +%Fibre.

Where: CHO, CP, and CL stands for Carbohydrate, Crude protein and Crude lipids

- Combustion Properties

- Calorific Value: The calorific or heating value is an important indicator of the quality of the pressed fuel briquettes. It measures the energy content of the briquettes. It is defined as the amount of heat evolved when a pressed fuel briquettes. The procedure of the ASTM standard D5373-02 (2003) was used to determine the calorific values of produce briquettes by using the equation.

$$Qv = \frac{C(Q1 - Q2)}{Wb}$$

Where:

Q_v = Heating/ Calorific value (kJ/kg),

C = Calibration of constant for biomass acid (0.6188),

Q_1 = Galvanometer deflection without sample,

Q_2= Galvanometer deflection due to test sample

W_b = Weight of sample.

- Ignition Time: Ignition time was determined as reported by (Oladeji, 2010). The samples was graduated in centimeters, ignited at the base and allowed to burn until it extinguished itself. The rate at which flame propagated was calculated by dividing the distance burnt by the time taken in seconds

$$\text{Ignition time} = \frac{distance\ burnt\ (mm)}{total\ tme\ taken\ (sec)}$$

- Burning Rate: Briquettes burning rate was determined by recording the briquettes weight before combustion and after the briquettes were completely burnt, the rate at which fire consume the briquette samples were calculated using equation (Onuegbu *et al.*, 2011).

$$Burning\ Rate = \frac{mass\ of\ total\ fuel\ comsume(g)}{total\ time\ taken(\text{min})}$$

Statistical Analysis: All data was reported as mean ± standard deviation. The values were analysed using statistical package for social sciences (SPSS) Windows Programme Version 20. Statistical significant differences between means were carried out using One-way analysis of variance (ANOVA)

Table: 1.Proximate Analysis of Briquettes

Sample ratios	Moisture Content%	Ash content%	Volatile Matter%	Nitrogen Content%	Fiber Content%	Fixed Carbon %

Rh 100:0	2.5±0.2	5.0±0.6	10.0±0.4	1.442±0.002	1.5±0.4	80.5±0.3
Cc 100:0	2.0±0.3	4.5±0.2	12.0±0.4	1.414±0.002	1.5±0.3	83.5±0.2
Rh/80:20	2.5±0.1	4.5±0.2	10.0±0.6	1.386±0.003	1.0±0.5	83.0±3.6
Rh/Cc70:30	3.0±0.1	4.0±0.1	9.0±0.5	1.834±0.002	1.5±0.4	84.0±2.6
Rh/Cc60:40	4.0±0.2	4.0±0.4	8.0±0.1	1.106±0.002	1.0±0.5	84.0±4.0
Rh/Cc50:50	5.0±0.5	4.5±0.3	10.0±0.4	1.218±0.002	1.5±0.8	80.5±0.3

Values Above Mean Value Of Standard Deviation of Triplicate Results

Key:
Rh - Rice Husk
Cc- Corncobs
Rh/Cc-Rice Husk and Corncobs (blend)

Table: 2. Physical Properties of Fuel Briquettes

Sample Ratio	Compressive Strength (N/mm^2)	Density (g/cm^3)	Afterglow Time (s)	Flame Propagation (Cm/s)
Rh 100:0	0.37	0.364	20	0.17
Cc 100:0	0.68	0.529	82	0.05
Rh/Cc 80:20	0.56	0.343	45	0.16
Rh/Cc 70:30	0.73	0.119	61	0.14
Rh/Cc 60:40	0.90	0.346	35	0.11
Rh/Cc 50:50	0.40	0.288	30	0.01

Values Above Mean Value Of Standard Deviation of Triplicate Results

Key:
Rh - Rice Husk
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Rh/Cc-Rice Husk and Corncobs (blend)

III. DISCUSSION

The proximate analysis results shows that the moisture content of corn cob is (2.0±0.3) and rice husk is (2.5±0.2), and ash content of corn cob is (4.5±0.2) and rice husk is (5.0±0.6), while the volatile matter of corncob content is (2.0±0.4) and rice husk is (10.0±0.4). This shows that briquettes produced from corncobs have better qualities of good fuel briquettes than rice husk briquettes because of the low contents of moisture, ash and high percentage of volatile matter. The non –blend corn cob with the value of 2.0±0.3 has less moisture content than blend briquettes with the following results: 2.5±0.1, 3.0±0.1, 4.0±0.2, and 5.0±0.5.This indicated that non blended corn cob produced good briquettes than blended briquettes. The same implied to rice husk briquettes, the value for non-blended rice husk is 2.5±0.2 which shows that it has less moisture content than the blended briquettes with these results 3.0±0.2, 4.0±0.2 and 5.0±0.5. It can be seen that moisture content falls within the limit of 10-15% as recommended by (Wilaipon, 2008), (Grover and Mishra, 1996), (Maciajewska, 2006) which helps in storage and combustibility. If the moisture content exceeded the range of 20% would result in the loss in energy during combustion (Idah and Mopah, 2013). Non-blended corn cob has the ash content of 4.4±0.2 which is higher compared to blended corn cob 4.0±0.1, 4.0±0.4. The non-blended rice husk has the ash content values of 4.5±0.2 and 4.5±0.3 which is higher compared to blended briquettes that has values of 4.5±0.2,4.0±0.4 and 4.5±0.3. High ash content usually leads to higher dust emission and affect combustion efficiency (Akowuah *et al.*, 2012). High ash content in briquettes may block air holes and eventually lowers the oxygen supply in the combustion chamber. The results agreed with the study of Demibas and Sahin 1998, who recommended that briquettes for domestic use should be easily ignitable, but high volatile and low ash content. The non-blended corn cob shows the highest value of volatile matter 0f 12±0.4 compared to the blended briquettes with the value of 10.0±0.6, 9.0±0.5, 8.0±0.1 and 10.0±0.4, non-blended rice husk briquettes has the volatile value of 10.0±0.4 which is similar to the blended briquettes with the value of 10.0±0.6 and 10±0.6 and has higher values compared to the two blended briquettes with the volatile value of 9.0±0.5 and 8.0±0.1. High volatile matter is an indication that briquettes will ignite easily and increase in flame length; it implies that during combustion process most of the fuel samples will volatile and burn as gas in the cook stove (Loo and Koppejan, 2004). The amount of volatile matter attributed to the high organic matter in the material as reported by (Olorunisola, 2007). After glow time of 20s and 82s were recorded for rice husk and corn cob briquettes, while the flame propagation rate of 0.5cm/s and 0.17cm/s were obtained for briquettes of rice husk and corn cob. The longer the afterglow time and slow in propagation rate for corn imply that, corncob briquettes would ignite easily but burn with high intensity for long period of time than the rice husk briquettes (Musa,2007).

Non-blended corn cob with value of 82 is higher than the blended ones with the values of 45sec, 61secs, 35sec and 30sec. this indicated that corn cob without blend can enhance the quality of the briquettes than the blended ones. The non –blended rice husk has the lowest values of the afterglow time than the blended ones, this shows that blended with these higher values of 45sec, 61sec, 35sec, and 30 sec will give a better briquettes than the non-blended rice husk. The non –blended corn cob with the lowest value of flame propagation of 0.05sec gives the bitter briquettes than the blended ones with the values of 0.16, 0.14, 0.11, 0.1 sec.

The non-blended rice husk has the higher value of flame propagation of 0.17sec than the blended ones, with the values of 0.16, 0.14, 0.11 and 0.1 sec which shows that blended ones gives a better briquettes fuel than the non-blended rice husk (Oladeji *et al*., 2009).The combustibility results shows that the briquettes with ratio of 80:20, 70:30, 60:40 boil two litres of water in 18minutes while the blended ration briquettes with 50:50 ratio boils in 22 minutes and non-blended corn cob took 20 minutes to boil the same quantity of water while non-blend rice husk took 22 minutes to the equal amount of water. Since the blended briquettes has the lowest moisture content and took less time to boil water than the non-blended corn cob and rice husk it is preferable to use the blended one.

The compressive strength of the corn cob and rice husk were found to be reasonable where corn cob has (0.68Nmm^2) and rice husk has the value of (0.37 Nmm^2) this show that briquettes produced from corn cob can be transported and store for a long period without breaking because of the high compressive strength it possess. The density of the corn cob briquettes was 0.529g/cm^3 and rice husk has 0.364g/cm^3. The two densities obtained compared favorably with the densities of notable biomass fuels such as coconut husk briquette banana peel, and groundnut briquettes.

CONCLUSION

In conclusion briquettes fuel produced from the two biomass would make a good biomass fuels. However, briquettes produced from corn cob shows more positive attributes of biomass fuel compared to rice husk briquettes, the good compressive strength and density of both the briquettes enable it not to crumble during transportation and storage.

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