BIOMASS POWER CRITICAL TOOL IN FIGHTING CLIMATE CHANGE

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ABSTRACT

This work carried out the comparative analysis of briquettes produced from commonly found agricultural wastes product (Maize husk and millet husk) in order to have the maximum utility of the materials. The briquettes are produced based on ratio of 80:20, 70:30, 60:40 and 50:50. While 100:0 (unblended) was used as control for each biomass. 25 % starch paste was used as binder to have a homogenous solution. The briquettes were produced using a simple extruder briquetting machine. The proximate analysis of the raw samples shows that the moisture content of the respective biomass has increased by two fold of the briquettes sample produced and the ash content is less while the briquettes have very high volatile matter which enhance combustion and give briquettes more quality as fuel. Higher ratios of blended briquettes of maize husk have a good flame propagation, high density, ignite faster and produced small amount of ash content after combustion. Hardness, compressive strength and combustibility test of the briquettes produced ascertained all these properties. In conclusion, maize husk briquettes give a better briquettes quality compared to millet husk briquettes.

Keywords: Density, Briquetting, Binder, Combustion, Biomass

Introduction

The increase in the energy demand and its use in Nigeria is due to the rapid growth in population and industries has raised concern about the economic and environmental impacts of the power generation based on national energy sources. Kerosene and gas are the major cooking fuels and they are all finite. 30% per cent of people in Nigeria rely on the above for cooking while only few uses electric cooker even in urban areas (Adegbulgbe, 1994). In the rural areas and majority households in the urban centers since electric power is grossly erratic and inadequate. The cost of purchase and maintenance of both petrol and diesel powered generators has increased the use of kerosene in lamps and lanterns. Past experiences have shown that scarcity and ever increasing prices of kerosene have forced the rural dwellers and urban poor to abandon the use of kerosene stove in favor of the comparatively cheaper fuel wood and charcoal which is the substitute source of energy. Hence, small scale agro industries such as bakeries use fuel wood as source of energy, but using biomass (briquettes) as an alternative for energy source is more preferable because of its suitability, low emission of smoke thereby saving the environment (Adegbulgbe, 1994).

Briquetting of the abundant biomass in Nigeria represents one of the possible solutions to the energy challenge in the country; it can also act as a preventive measure to many ecological problems, such as deforestation and global warming at large. Biomass materials are usually very bulky and have very low density which makes it very difficult to transport. Densification of this biomass is one of the solutions to the aforementioned problem (Akinbani, 2001). Briquetting quality is evaluated mainly by the density. If produced at low cost and made conveniently accessible to consumers, briquettes could serve as complement to fire wood, charcoal and kerosene for domestic use and agro-industry operations, thereby reducing their high demand. Briquettes also have other advantages over fuel wood in terms of greater heat intensity, cleanness, convenience to use and relatively require small space for storage (Akinbani, 2001).

MATERIALS AND METHODS

Sample Collection: Samples of millet stalk and maize husk were collected from Aliero, while cassava starch was purchased at the Sokoto central Market, Sokoto State.

Preparation of the Sample: The collected samples were crushed to fine powder using grinding machine. The powder samples were sun-dried for three days and then pulverized and sieved with 80 mm mesh sieve to obtain a fine particle size. The samples were kept in a polythene bag until required for preparation of briquettes.

Preparation of Briquettes: A cylindrical mould of 16cm in length and 2.5 cm internal diameter was constructed. A metal bar of 2.5 cm diameter was used in pushing the formed briquettes out of the moulding cylinder. 25g of starch and 100:0, 80:20, 70:20, 60:40 and 50:50 of maize husk and millet husk were weighed out using a triple beam balance into a 100ml plastic basin, they were thoroughly mixed with the slurry of the starch (the binder), the blend was then loaded into the cylinder mould and compressed with a screw presser and kept for 15 minutes. The densified briquette was pushed out of the mould with the aid of a metal bar. The same procedure was

repeated for the other ratio. The produced briquettes were air dried for three weeks (Elinge *et al.*, 2018).

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 samples before drying) the sample and the crucible was put in a drying oven set at 105°C for 24hrs. The crucible and its content was removed and put in desiccators to cool at room temperature and re-weighed. The process was repeated until the weight after cooling is constant, and was recorded as the final weight (final weight of the sample after oven drying) (Adekunle *et al.*, 2015).

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

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°C for 2hrs to drive off the volatiles, the resulting sample was further heated at 470°C 2hrs, to remove volatile matter, just before the materials were turned to ashes, and then cooled in desiccators (Adekunle *et al.*, 2015). The crucible with known weight and its content were weighed and as the percentage of weight loss, the percentage volatile matter was calculated using the equation below.

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

Ash Content: The ash contents of the briquettes were determined. A portion of 2g were placed in a pre-weighed porcelain crucible and transferred into a preheated muffle furnace set at a temperature of 600°C for 1 hour after which the crucible and its contents were allowed to cool. The crucible and its content were weighed and the new weight noted. 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.

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

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 equation.

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

Where: **MC** = Moisture Content, **VM** = Volatile Matter, **AC** = Ash Content

Fibre Content: 2.0g of the sample was weighed and put into a conical flask labelled W₀ with 200ml of boiled 1.25% for 30minutes it was then filtered and rinsed with 200ml of hot distilled

water. 1.25% NaOH was boiled for 30 minutes and was filtered and rinsed with 10% of HCl and was washed with industrial methylated spirit, acetone or ethanol and then finally rinsed with petroleum ether. It was allowed to drain dry and the residue was scraped into a clean crucible to dry over night at the 105⁰C, cooled in a desiccator. The sample was weighed and labelled W₁ and ash at 550⁰C for 90 minutes in a muffle furnace then cooled in a desiccator and weighed again as W₂ (Bakare, 1985)

The % fibre content was calculated as:

$$\% \text{ fibre} = \frac{W_1 - W_2}{W_0} \times 100$$

Lipid content: 2g of the sample was weighed into a labelled porous thimble and covered with clean white cotton wool, 200ml of petroleum ether into the dry 250ml dried extraction flask, the covered porous thimble was placed into the condenser and assemble the apparatus and extracted for 6 hours, the sample was then removed from water bath after it was petroleum ether free, the extraction flask containing the lipid at 105⁰C- 110⁰C for 1 hour, then cooled in a desiccator and the weight after cooling was noted (Bakare *et al.*, 1985).

$$\% \text{ of lipid} = \frac{W_3 - W_2}{W_1} \times 100$$

Key: W₀ – weight of the porous thimble, W₁- weight of thimble + sample, W₁-W₀ – weight of sample, W₂- weight of empty extraction flask, W₃- weight of extraction flask+ ether

Compressive Strength: The compressive strength of the briquette was determined using a compressive testing machine. The length and the width of the briquettes were measured and recorded. The machine was on and allowed to warm up for 4 minutes. The sample was placed on the movable bed, and the control lever was applied upward to bring contact between the upper fixed bed and the movable lower bed on which the samples were sit. The reading was taken the moment the crack is noticed in the briquette samples showing that the sample is compressed. The value of the reading was recorded.

$$\text{Compressivestrength} = \frac{\text{compressive force (Ft)}}{\text{cross sectional area of the sample (Ac)}}$$

Where: cross sectional area = Length × Width

Density: The density of the briquettes was determined using a weighing balance by taking the weight of all the briquettes samples and dimension measurement using a vernier caliper. The volume was calculated using $\pi r^2 h$.

$$Density = \frac{Mass(g)}{Volume(cm^3)}$$

Where: π = Pie, r = radius, h = height

Calorific Value: The calorific value measures the energy content of the briquettes. The procedure of the ASTM standard D5373-02 (2003) was used to determine the calorific values of produce briquettes by using the equation.

$$Q_v = \frac{C(Q_1 - Q_2)}{W_b}$$

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 were 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.

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

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

$$BurningRate = \frac{mass\ of\ total\ fuel\ consume\ (g)}{total\ time\ taken(min)}$$

Combustibility Test: Water Boiling Test was conducted by combusting 100g of briquettes of different percentage of binders (gum arabic and starch) samples respectively using charcoal stove to compare the fuel combustibility and the fuel that cooked food faster. 2 litres of water was used for the test. The temperature reading was taken after every 2 minutes with mercury in glass thermometer (Kim *et al.*, 2001) until the water boil. The time taken by each sample to boil water was monitored using stop watch.

Results and Discussion

Table: 1 Proximate Analysis of the Raw Samples

Parameter	Maize Husk%	Millet Husk %
Moisture Content	1.5±0.9	2.5±0.3
Ash Content	1.6±0.3	1.5±0.3
Lipid Content	1.0±0.6	1.5± 0.2
Fibre Content	1.0±0.4	1.0±0.3
Nitrogen Content	27.0±1.7	31.10±1.7
Volatile Matter	5.5.0±0.4	6.6±0.4
Carbon Content	21.0±1.7	30.0±1.6

Values above are mean value standard deviation of triplicate result

Table: 2 Physico – Chemical Results of Briquette Samples

Sample	Moisture%	Ash %	Volatile Matter%	Fibre Content%	Lipid Content %	Nitrogen Content%	Carbon Content%
MH ₁	2.5±0.6	4.0±0.5	4.0±0.4	1.5±0.6	5.0±0.8	1.7±0.5	90.5±14.9
MH ₂	2.8±0.5	5.0±0.5	5.0±0.5	1.0±0.5	4.5±1.2	1.6±0.3	87.5±10.9
80:20	1.0±0.5	4.5±0.6	4.0±0.5	1.5±0.6	24.5±1.8	1.7±0.4	90.5±16.9
70:30	13.0±1.3	4.5±0.6	4.0±0.5	1.0±0.8	24.0±0.5	8.0±0.4	88.0±12.1
60:40	3.5±0.8	3.5±0.4	4.0±0.5	1.5±0.3	4.5±1.0	2.1±0.1	89.5±9.3
50:50	3.0±0.4	5.0±1.7	5.8±0.6	1.5±0.2	24.0±0.6	2.1±0.1	77.0±17.0

Values above are mean value standard deviation of triplicate result

Key: MH₁-Maize Husk, MH₂- Millet Husk

Table 3: Viability and Combustion Results of the Briquettes

Sample	Compressive Strength	Density (g/dm ³)	Ignition time (sec)	Afterglow(cm/sec)	Combustion test
MH ₁	1.01	0.34	42	0.04	32
MH ₂	0.50	0.40	44	0.06	30
80:201.60	40.14	36	0.01	30	
70:301.22	0.75	22	0.04	30	
60:400.60	0.49	18	0.07	26	
50:50	0.64	0.38	34	0.03	24

Values above are mean value standard deviation of triplicate result

Key: MH₁-Maize Husk, MH₂- Millet Husk

Discussion:

The proximate analysis of the raw sample indicated that millet husk has the highest values of moisture content, volatile matter, carbon content, nitrogen content and lipid content compared to the maize husk briquettes. The high moisture content in the briquettes affects its combustibility, though the moisture content of both the samples are within the accepted range of the recommended values of 10- 15% (Chezhanbin *et al.*, 2003). Moisture content is an important property that can greatly affect burning characteristic of the briquettes. Hence, low moisture content is required to avoid decomposition and disintegration of briquettes during storage and handling. Generally, when the moisture content is low, the briquettes will easily be ignited, no slagness during burning will occur. A further disadvantage of high moisture content is the facilitation of a breeding ground for fungi and microorganisms (Ollet *et al.*, 1993).

The results of the volatile matter is shown in Table 2, millet husk has the highest amount of 5.0 ± 0.5 than maize husk having 4.0 ± 0.4 , the blend of MH₁/MH₂ (80:20) has the same value as that of the millet husk. The blend of MH₁/MH₂ (50:50) has the highest amount of the volatile matter of 5.8 ± 0.6 . The high amount of volatile matter is attributed to the high organic matter in the material. Oloruunisola (2007) noted that, the higher the organic matter of a fuel briquette, the higher its combustibility when the ash content is low. High volatile matter of a briquette is an indication of easy ignition, fast burning and proportionate increase in flame length. Generally, the higher the volatile matter, the better the briquette (Oladeji *et al.*, 2009). It was observed that, high volatile matter briquettes ignite easily, but burn with smoky flame while low volatile charcoal briquettes are difficult to ignite but burn with less smoke. The blended briquettes MH₁/MH₂ (60:40) has the lowest ash content compared to other ratios. The recommended level of ash content is 4% (Grover and Mishra, 1995). The amount of ash content correlated with the amount of fixed carbon and combustion substance such as volatile matter, low ash content offers higher heating value for briquettes but high ash content results into dust emission which lead to air pollution and affect combustion volume and efficiency (Akowuah *et al.*, 2012). The higher the ash content, the lower its calorific value and vice versa, this is because ash content influence

the burning rate. Therefore, high ash content in briquette minimized the heat transfer to fuels interior parts and diffusion of oxygen to the briquette surface during char combustion (Chaney, 2010).

The combustibility test indicated that biomass reduces the time required for the briquettes to boil a specific quantity of water (Elinge *et al.*, 2011). The maize husk briquettes took longer time than millet husk briquettes. Hence, blended briquettes of MH₁/MH₂ (50:50) enhanced the boiling efficiency of maize briquettes. The higher the heat and energy released and the lesser the time required to boil a given specific amount of water. The blended briquettes of MH₁/MH₂ (50:50) are the best followed by MH₁/MH₂ (80:20) which boil 2 liters of water within 28 and 30 minutes.

The blended briquette of ratio (80:20) has the higher compressive strength value 1.46 while that of the maize husk briquettes have less value of hardness of 0.64. The compressive strength of fuel briquettes is one of the qualities used to assess its ability to be handled, packed and transported without breaking (Onuegbu *et al.*, 2010). Since, the low compressive strength can cause the briquettes to crumble faster during transportation, burning at very short time and generates less heat in the process. The highest compressive strength of blended briquette of ratio (80:20), indicates more volume displacement, which is good for packaging, storage and transportation and above all, it is an indication of good quality briquette because of the strong inter-particle bonds that exist Kaliyan and Morey (2009). The density of fuel determines how long it would burn and also the amount of fly ash it will release while burning (Wailopon, 2008), (Olawale, 2009). The densities of the briquettes shows that the blended briquette of ratio (70:30) has the highest value of 0.75 g/cm³ followed by blended value of (60:40) which contained 0.49 g/cm³. It could be as the result of the coarse nature of the sample maize husk while the low value could be attributed to the fine texture of the millet husk samples (praveena *et al.*, 2014). The higher the density of the briquette, the higher the energy value as reported by Ayahan and Ayse (1998). High quality briquettes should have high density and strength in order to burn for a longer time and have higher energy content. The higher the density, the higher the compressive strength (Ingwold and Gerold, 2004).

The afterglow time shows that maize husk briquettes have shorter ignition time compared to the millet husk briquettes. Biomass has shorter ignition time and would catch fire easily as the value blend increase, the value of the ignition time also reduces. Densification leads to decrease in ignition time (delay the ignition time) of the briquettes consequently (Davies and Abolude, 2013). The ignition time was therefore a comparison of how fast the briquettes achieve steady burning. It is apparent that particle sizes of the briquettes have a negative impact on the ignition time of the briquettes. This observation might be adduced to the fact that bigger particle size could have more spaces in between the particle than fine particles thus, increase in porosity index of the briquettes to be ignited (Davies and Abolude, 2013).

The flame propagation of the briquettes samples: The millet husk briquettes have higher flame value of 44 minutes before it extinguished itself, the blended briquettes of (80:20) has 36 minutes and (50:50) blend has 34 and (60:40) 18 minutes, this shows that the ratio contains less amount of volatile matter which enhances the combustibility of any fuel. Therefore, (80:20) and (50:50) blends are better ratios to consider.

CONCLUSION: In conclusion, this can be drawn on the possibility of using maize husk and millet husk as biomass in the production of briquettes. The chemical composition of the biomass samples contributed less to their burning properties since they contain few non-combustible matters such as moisture, ash etc. But the particle nature contributes much to their burning properties. This enhanced the burning rate of maize husk and millet husk briquettes. Densification increases burning efficiency and reduces the ash content, cooking time, ignition time, exhaust gas and smoke emission. From the analysis, maize husk briquettes are a better biomass for production of fuel briquettes than millet husk briquettes, therefore should be utilized.

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