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DETERMINATION OF PHYSICAL AND COMBUSTION PROPERTIES OF BIO-BRIQUETTE PRODUCED FROM GROUNDNUT SHELL AND RICE HUSK AS AN ALTERNATIVE SOURCE OF DOMESTIC COOKING

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Abstract

Biomass briquettes can be considered as one of the cleaned energy source compared to wood fuel understanding that clean energy in homes can be a tool to enhance human health. In this present research, bio briquette was produced from ground nut shell and rice husk. Physical and combustion properties were evaluated using standard analytical methods. The physicochemical properties of the bio briquette are 5.54±0.043, 7.65±0.048, 9.52±0.003, 11.65±0.004, 0.85±0.21, 1.81±0.29, 40.47±0.021, 45.74±0.031, 3892.73±0.151, 4984.73±0.169, for the percentage of moisture, volatile matter, ash content fixed carbon and calorific value (kj/kg) for rice husk and groundnut shell respectively. The combustion test observed in the both briquette produced from is as follow: no spark from rice husk briquette while spark was observed in groundnut shell briquette. No smoke emitted in both briquette, the average ignition time is was 3 minutes and 4 minutes for the both briquette respectively. Both briquettes appeared black in color; their respective density recorded was 0.81g/ml and 1.2 g/ml respectively. The water boiling time is 13 minutes 24 second and 14 minutes 34 second for rice and ground nut shell briquette. It was observed that the fuel burring time for rice husk and ground nut shell briquette was 1.95g/min and 2.05g/min. There are significance difference in the properties and combustion rate of groundnut shell and rice husk briquetted produced. therefore, the agricultural waste such rice husk and groundnut shell has proved to be an alternative cleaned energy for domestic uses.

Keywords: rice husk, groundnut shell, briquette, combustion properties

1. Introduction

Along with negative effects on the environment, the high cost of cooking gas contributes to a high demand for fuel wood, or firewood, for cooking. This is especially dangerous for both women and children who likely disproportionately exposed to the emission smoke [1]. For the past few decades, rural households and some urban residents have relied entirely on fuel woods (such as sawdust, charcoal, and firewood) as their main source of energy [2]. However, biomass, especially agricultural waste such as groundnut shell and rice husk has proved to be one of the most promising energy resources for developing nations [3]. It has become necessary to focus on making effective use of agricultural wastes due to the declining supply of fire wood. These wastes have become more important as fuels for a variety of uses, including industrial heating and home cooking. Certain agricultural wastes, such as wood pulp, coconut shells, and wood debris, can be used straight away as fuels. Biomass, which includes rice husk and groundnut shell is a major agricultural waste that is frequently burned off during the processing of agricultural produce. In addition to wasting valuable raw materials, this approach degrades soil fertility and further pollutes the environment [4].

However, most of the massive minerals require additional processing before they can be utilized directly as fuel. This is most likely the result of improper density and high moisture contents, which can lead to issues during handling, storing, and transportation. The majority of these wastes are burned, which pollutes and degrades the environment, or are left to decay [5],[6].

A bio-briquette is a fuel block composed of charcoal dust, biomass, or compressed coal that is used to start and maintain a fire. This method is used to shape tiny particles into the desired form. One way to think of briquettes made from agricultural waste is as a waste management tool. However, by offering a fuel source dependent on the substance of interest, briquetting might be used as a preventive measure to numerous ecological difficulties [7],[8],[9].The goal of the briquetting process has historically been to produce non smoke solid fuels mostly from agricultural waste. Several ways are available to turn coal fine into smokeless solid fuel. The most widely used method applies light pressure and a roller press with a binder [9]. It should be mentioned that alternative kinds of briquettes that aren't fuel-based are also made from inorganic components like metal ores using the same equipment employed in this procedure. The subject of global warming is spreading worldwide. [10]. One of the primary greenhouse gasses that causes global warming is carbon dioxide. Studies have shown that as the country's afforestation efforts are outpaced by the rate of deforestation, rising CO_2 emissions have dramatically decreased [11], [12] [7].

Despite all the energy sources available in Nigeria, agricultural waste found in abundant are underutilized for energy source such as smokeless biomass briquettes have not been fully utilized, several research showing that they have the highest potential for use as suitable alternatives to coal and fuel wood for thermal application and domestic purposes.

2. Figure in Template Materials and Methodology

2.1 Sample Collection

Groundnut shells were obtained from a groundnut shell milling site in Kaura Namoda, Zamfara The groundnut shell samples were filtered to remove sand and stones from the sample before sun drying.

2.2 Preparation of Starch

A starch powder was obtained from Kaura Namoda market. 10 g of the powder starch was weighed and dissolved in 5ml of distilled water. 20ml of boiled water was later added to form gel and allowed to cool.

2.3 Production of Bio-Briquette Formulation

After 50g of the dried groundnut shell had been weighed, it was divided into five crucibles and heated to a temperature of 1200–1250oC in a muffle furnace. The ash remains were allowed to cool in the absence of air. A uniform paste was formed by weighing and combining 25g of the ash samples with 4g of the produced starch. The paste was then compacted into a solid form and allowed to dry [13], [14].

Fig. 1. Bio- briquette produced from groundnut shell.

3. Characterization of Bio-Briquette

3.1 Proximate Analysis of Briquette:

Moisture content

After 3.0g of the biomass samples were weighed into a cleaned crucible (designated as W1) and another crucible containing samples (designated as W2), the oven was set to 110°C for two hours. Following its removal and cooling in desiccators, the crucible was weighed once again. The % weight loss is equal to moisture content

$$\text{Moisture content (\%)} = \frac{\text{w1} - \text{W2}}{W1} \times 100$$

Where W1 and W2 is initial weight, and final weight respectively

Volatile matter

The volatile matter was determined using the method describe by ASTEM. 3.0 g of the samples was weighed into a cleaned crucible and placed in the muffle furnace; the temperature was set at 920OC for 7 minutes, and then cooled. The crucible was reweighed and percentage weight loss was expressed as volatile matter as shown in the equation below:

$$\text{Volatile matter (\%)} = \frac{\text{Dry weight} - \text{ final weight of smple}}{oven\ druied\ weightt} \times 100$$

Fixed carbon:

Fixed carbon content is the percentage of carbon remaining after removing the volatile matter; it was calculated using the equation below:

$$\text{Fixed carbon (\%)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where, W3=final weight W1= weight of Volatile M crucible

W2= weight of Volatile Matter crucible+1g of sample.

Ash content:

Ash content is the non-combustible residue left after the sample is burnt. It shown the content of mineral left after other sources such as carbon, oxygen, sulfur has been removed. The ash content was determined by weighing 1.0 g of sample in open silica crucibles into muffle furnace for 1 hour at temperature of 800 ± 5 °C.
Calculation was done by using the following formula,

$$\text{Ash content(\%)} = \frac{Weight\ of\ Ash}{Dry\ weight} \times 100$$

Calorific value: Calorific values describe the amount of heat energy present in materials after determined by complete combustion using LECO AC-350 bomb calorimeter. Combustion Test of Bio-Briquette: these were carried out by boiling specific amount of water using the bio-briquette produced. Two liters of water was measured in a kettle and local tripod stoves to enhance the normal cooking condition. The time was monitored using stopwatch [14].

Ignition time: It is the time takes for a flame to ignite the bio-briquette produced the [14]. All the standard test technique for measuring ignition time and flame attributes was followed in estimating ignition time. After setting the briquette to blue flame, the Bunsen burner was used to make sure that the entire bottom surface lit at once. Before the stopwatch was put on to record the ignition time, it was made sure the briquette was properly ignited.

Smoke: The smoke that is released when the briquette burns is this color. It is usually black or white smoke. As less smoke suggests cleaner combustion, less smoke is preferred [14].
Water boiling time: the amount of time it takes for a certain weight of bio-briquette samples about (100g) to bring a given volume of water to a boil. This will show which sample of briquettes will cook meals more quickly. The briquette samples were lit in a briquette burner after one liter of water was added to a kettle. A briquette sample's time to bring the water to a boil was measured and documented [14]
Burning Time: This is the total burning time of the briquette from ignition to complete burnout. Burning time is an essential factor as it determines how long the briquette can sustain its combustion.
Fuel Burning Rate: The fuel burning times was determined According to [14].burning time can be calculated using the formula below:

$$\text{Fuel Burning rate } = \frac{intial\ mass\ of\ briquette - final\ mass\ of\ burnt\ briquette}{Time\ (mins)}$$

Flame: This is the characteristics of the flame produced by the briquette. The color height, stability, and any irregularities in the flame. A stable and consistent flame is preferable for better heat output and safety [14].
Odor: This is the smell produced during the combustion process, as any odors emitted by the briquette. A strong or unpleasant odor could indicate the presence of impurities or inappropriate materials used in the briquette's production [14].
Spark: The briquette was examined for the presence of sparks or popping sounds during ignition and combustion. Sparks can be a safety hazard, especially in indoor or confined spaces, and may also indicate the presence of foreign materials in the briquette [14].

4. Results

The result was expressed in mean± standard deviation

The moisture content of biomass briquettes shown in Table 1 was 7.65±0.048. According to [16] [19], being within the acceptable limit for cooking fuel moisture content. The value found currently is comparable to that found in [20] work. According to [17], cooking fuel typically has a moisture level of 8–12% as standard. As a result, the value found in the current research falls within the standard range. Furthermore, this is thought to be essential for efficient and sustainable burning, which affects fuels' energy value [17]. This value is consistent with the findings of [7] who reported that fuel wood with high volatile matter content, like charcoal, ignites and burns out more quickly.
Ash content of biomass is referred to as a complicated issue. The amount of organic and inorganic stuff, as well as any potential contaminants, determines how much ash is present. The sampling location, harvesting period, and harvest conditions all affect the amount of ash in biomass [17]. The biomass briquette has an estimated ash content of 1.81±0.29%.
Biomass briquettes have a low ash concentration, which is consistent with [2] analysis by that said greater ash values were bad for boiler operations. According to [16], a lot of industries often view

biomass briquette as an excellent fuel for energy source since, when utilized, it produces little amounts of ash, potassium, and chlorine, which reduces ash agglomeration. During burning, fixed carbon serves as the primary source of heat. In the biomass briquette, the result of fixed carbon percentage was 45.74±0.031. The heating value and fixed carbon have a significant relationship that affects how long it takes the water to boil in the combustion test. With a calorific value of 4984.73±0.169 kj/kg, biomass briquettes make an excellent fuel for burning (Table 2). Additionally, the calorific value of the presented product falls within the ASTM standard range for bio-briquette (38 to 53kJ/kg) [14].

Table 1: Result of the physicochemical analysis of briquette produced from biomass.

Proximate analysis	Rice husk briquette	Ground nut shell Briquette
Moisture content (%)	5.54±0.043	7.65±0.048
Volatile matter (%)	9.52±0.003	11.65±0.004
Ash content (%)	0.85±0.21	1.81±0.29
Fixed carbon (%)	40.47±0.021	45.74±0.031
Calorific value (kj/kg)	3892.73±0.151	4984.73±0.169

Table 2: Results of the combustion test of briquette produced form biomass.

Combustion Test	Rice husk briquette	Ground nut shell Briquette
Physical appearance	Black color	Black color
Density (g/ml)	0.81g/ml	1.20g/ml
Average Ignition time (mins)	3 minutes	4 minutes 43 seconds
Smoke	No smoke emitted	No smoke
Water boiling time	13 minutes 24second	14 minutes 34 seconds
Fuel burning rate	Initial mass of briquette = 30.00 g Final mass = 12.48 g Mass of burnt matter = 17.52 g 1.95 g/min	Initial mass of briquette = 30.00 g Final mass = 12.48 g Mass of burnt matter = 17.52 g 1.95 g/min
Odor	no odor	no odor
Flame	Reddish in color	Reddish in color
Spark	no sparks	burnt with sparks

The water boiling tests were estimated to check the suitability of the bio-briquette for domestic fuel. The ignition test result as shown in Table 2, it shows briquettes did not ignited immediately until after 4 minutes 43 seconds. This observation can be attributed to the hard nature of the groundnut shells according to [2]. These observation of ignition time for the biomass briquette (4 minutes, 53 seconds min) did not corresponds to the same value (8 min) obtained by [13]. The difference may be attributed to nature sample sources and the varieties of the ground nut shells as reported by [2].

During ignition, no smoke emission was observed from the briquette. This gives biomass briquette a great advantage as a cooking fuel in homes. This is because smoke is deleterious to health and the environment, the effect of which is well documented [21]. The flame produced by the briquette burned with a reddish color with no odor.

The briquette burnt with sparks and popping sounds during ignition and combustion. Sparks can be a safety hazard, especially in indoor or confined spaces, and may also indicate the presence of foreign materials or contaminates in the briquette [21].

The water boiling times recorded were 14 minutes 23 seconds and its resulting times were used for the calculation of briquette burring rate. From the result as shown (Table 2), the burning rate obtained from the present study is 1.95 g of the briquette fuel burnt per minute during combustion test. The fuel burning rate value obtained for the biomass briquette produced was seen to be less than 3.20 g/min obtained by [20],[21]. The difference maybe as results factors such as briquette's calorific value, briquette density, and raw material. Essentially, the results have proved that biomass briquette, if fully utilized it have efficient and sustainable than the use of charcoal, and fuel wood as an alternative fuel.

5. Conclusions

The production of biomass briquettes was produced from the agricultural waste groundnut shell and rice husk) the resulting biomass briquette after evaluation and combustion properties was found to be environmentally friendly. The parameter of biomass briquettes such as' moisture, ash, volatile matter, fixed carbon, and calorific value were all fall to be within standard limits. Statistically, There are no significance difference in the properties and combustion rate of both briquetted produced. The results of tests and combustion analysis also showed that while the biomass briquette took longer to ignite, once it did, it burned for a longer period of time, produced no ash, and produced steady heat. These findings suggest that the produced briquette has suitable combustion properties for household use because of its low smoke emissions.

Conflict of Interest

The authors declared no conflict of interest.

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