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# Effect of Binder on Physico-chemical Properties of Fuel Briquettes Produced from Watermelon Peels

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**Abstract:** Biomass fuels are potential source of renewable energy and can be easily obtained from agricultural waste. In this context, this article presents the preparation steps and characterization of watermelon peels for the production of briquettes. The chemical compositions with physical characteristics of the waste briquettes were evaluated. The moisture content of the both briquette samples were 11.20±0.40% and 16.18±0.20% respectively are less than 20% of recommended standard. The briquette sample using cassava starch as a binder has a fixed carbon content and ash content values of 15.00±0.5% and 18.00±0.2% respectively, while that of gum Arabic are 13.50±0.20% and 18.50±0.40% respectively. The calorific values of the sample briquettes with cassava starch binder and also that of gum Arabic binder are 11.99±0.10MJ/Kg and 11.27±0.28MJ/Kg, respectively. It showed that the binder types had effect on physicochemical properties and it was concluded that briquettes bonded with starch had better characteristics.

**Keywords:** Briquette, Watermelon, Biomass Fuel, Physic-Chemical, Starch, Gum Arabic

## 1. Introduction

Energy is the key factor in economic and environmental development of a country; also global energy use is increasing very rapidly [1]. There is need to diversify the supply of energy from biomass due to uncertainties to oil prices and environmental concern, which are some of the reasons that make the various biomass types more interesting fuels in industrial countries [2].

Biomass fuels are potential source of renewable energy and can be easily obtained from agricultural waste [3], [4]. The production and the use of briquettes from abandoned resources like biomass and urban wastes are getting more attention in terms of usage due to increase in fuel price. Converting them into briquettes helps in disposing wastes and also makes the environment clean from unwanted wastes. It also reduces greenhouse gas emissions and provide alternative livelihood to the urban and rural communities [5].

Several kinds of promising briquette fuels such as, groundnut shell, bagasse, castor seed shell, saw dust, cotton stalks, bamboo dust, coffee husk, tobacco waste tea, paddy straw, mustard straw, mustard shell, sugarcane, wood chips and others were investigated [6]. The advantages of using briquettes are; production of cheaper energy, reduction of environmental impact caused by the wastes and reduction of deforestation [4].

Watermelon *[Citrullus Lanatus (thun.). Matsum and Nakai]* belongs to the family *cucurbitaceae*. Its centre of origin has been traced to both Kalahari and Sahara desert in Africa [7] and these areas have been regarded as part of diversification to others parts of the world [8]. In Nigeria, though there are no official figures recorded for its production, the crop has a wide distribution as a garden crop, while as a commercial vegetable production; its cultivation is confined to the drier savanna region of the Nigeria [9]. The aim of this work is to study the physicochemical analysis of briquettes produced from waste of watermelon peels.

# 2. Materials and Methods

## 2.1. Sample Preparation

Sample of watermelon peels was obtained from Aliero, in Kebbi state, Nigeria. It was dried to remove the largest percentage of water and the coarse particles were crushed by domestic electric grinder after drying. The grinded particles were sieved with a 2mm mesh. Cassava starch and gum Arabic were used as binders in this study.

## 2.2. Briquetting of Wastes

The watermelon peels and binders were thoroughly mixed in order to obtain a uniformly blended mixture with 30% of binders with fixed weight of 200g of watermelon peels. The briquettes were produced in a fabricated hydraulic press.

## 2.3. Moisture Content

Various methods could be used to determine the moisture content, the moisture content as loss in weight in a drying oven, in this research the percentage moisture content of the briquette samples were determined based on sample weight measurement before and after oven drying. The initial weight of the samples were determined ($W_1$), and placed in an oven set at 105±3°C for 24hours. The samples were removed and cooled in a desiccator, reweighed ($W_2$). Percentage moisture content was calculated according to [10] procedure, using equation 1.

$$percentagemoisture = \frac{W_1 - W_2}{W_2} \times 100 \tag{1}$$

Note: $W_1$ = weight of sample before oven drying, (gram)
$W_2$ = weight of oven dried sample, (gram)

## 2.4. Volatile Matter

The briquettes percentage volatile matter content was determined using Lenton furnace. The residue of dry sample from moisture content determination preheated at 300°C for 2hrs to drive off the volatiles, the resulting sample was further heated at 470°C 2hrs, to ensure complete elimination of volatiles, just before the materials turns to ashes, and then cooled in desiccator, based on the [10] procedure. The crucible with known weight and its content was weighed and expressed as the percentage weight loss, the Percentage volatile matter was computed using equation 2.

$$Volatilematter\% = \frac{finalweight}{originalweight} \times 100 \tag{2}$$

## 2.5. Fixed Carbon Content

Fixed carbon was determined by using the data previously obtained in the proximate analysis and according to [11] using the formula was computed using equation 3

$$\%FC \equiv 100 - (\%Ash + \%Volatilematter) \tag{3}$$

## 2.6. Ash Content

Ash content of the samples briquettes were determined using a furnace residue from fixed carbon determination were heated in a furnace at 590°C, for two hours and transferred into a desiccators to cool down the materials turned into white ash and weighed. Same procedure was repeated three time at 1hr interval until the weight was constant. The weight was recorded as the final weight of the ash, according on [10]. The percentage ash content was then calculated using equation 4.

$$Ashcontent = \frac{Weightofash}{Originalweightofsample} \times 100 \tag{4}$$

## 2.7. Density

Density as physical property of the briquette is defined as structural packing of the molecules of the substance in a given volume. The density was determined using a weighing balanced in the laboratory by taking the weight of briquette sample and the dimension measurement using vernier caliper based on [12], the volume was evaluated using the relation $\pi r^2 h$ and the density was computed using equation 5

$$Density\left(\frac{g}{cm^3}\right) = \frac{Mass}{Volume} \tag{5}$$

## 2.8. Compressive Strength

Each sample of the rectangular briquettes with dimension 3.0cm x 2.5cm and thickness of 2.0cm were loaded into the ELE tritest 50 compression machine, and the shear load was determined at 20% at 0.38mm/minute. The load dial per division (R) was noted for every change in strain (AL). The stress (in $kN/m^2$) and % strain was calculated using the formula [12] in equation 6 and 7.

$$Stress = \frac{force(F)}{unitarea} = \frac{LoadDial \times Calibration(CR)}{Lenght \times Breathofsample}$$

$$= \frac{R \times 2.11 \times 10kN}{7.5m^2} = \frac{2.81RkN}{m^2} \tag{6}$$

$$\%Strain(a) = \frac{AL}{L_o} \times 100 \tag{7}$$

($L_0$ = original thickness of sample)

## 2.9. Calorific Value

Leco AC-350 oxygen bomb calorimeter interfaced with a microcomputer was used to assess the heat values of the briquettes produced. The calorific value was determined following procedure [13].

## 2.10. Combustibilty Test

About 200g of each set of briquettes was stacked into an improved stove. It was lightened with a match after application of little absolute ethanol to initiate combustion. The fire was allowed to assume a steady combustion. One litre of water in an aluminum pot whose initial temperature was recorded and was placed on the stove and a stop watch was initiated. A digital thermometer was inserted into the water inside the pot and readings taken after every two minutes interval and the corresponding temperatures recorded until water boiled [14].

## 3. Results

***Table 1.*** *Shows the average moisture, volatile matter, and fixed carbon and ash contents for the samples.*

| Samples | Moisture content (%) | Volatile matter (%) | Ash (%) | Fixed carbon (%) |
|---|---|---|---|---|
| A | 11.20±0.40 | 67.00±0.30 | 18.00±0.20 | 15.00±0.50 |
| B | 16.18±0.20 | 68.00±0.10 | 18.50±0.40 | 13.50±0.20 |

Values are mean standard deviation of triplicate results
Key: A = Watermelon and Starch
B = Watermelon and gum Arabic

***Table 2.*** *Shows the results of mechanical compressive strength, density, calorific value and combustibity test.*

| Samples | Compressive strength ($N/mm^2$) | Density ($g/cm^3$) | Calorific value (MJ/Kg) | Combustibility test (Sec) |
|---|---|---|---|---|
| A | 0.67±0.36 | 0.590±0.13 | 11.99±0.10 | 22 |
| B | 0.49±0.40 | 0.397±0.20 | 11.27±0.28 | 24 |

Values are mean standard deviation of triplicate results
Key: A = Watermelon and Starch
B = Watermelon and gum Arabic

## 4. Discussion

The values of 11.20±0.40% and 16.18±0.20% were obtained for moisture content for the both briquette samples A and B respectively. The moisture content values obtained are less than the 20% of the recommended standard by [15]. Moisture content in excess of 20% would result in considerable loss of energy required for water evaporation during combustion at the expense of the calorific value of the fuel. Such a briquette may also not be stable in storage [15].

The ash contents of 18.00±0.20% and 18.50±0.40% were recorded for both briquette samples A and B respectively. The lower the ash content the better the quality of fuel briquettes. Hence, the sample A of lower level is of best quality than that of sample B and they are in agreement with 18.60%of ash content for rice husk briquette as reported by [16]. High ash content results in high dust emissions which lead to air pollution and affects the combustion volume and efficiency [17]; [18] and according to [11] general values of ash content may appear in a range of 5-20%.

The volatile matter of 68.00±0.30% and 67.00±0.10% were obtained for both briquette samples B and A respectively. The volatile matters from briquettes of both samples are numerically comparable with 67.98% of rice husk briquette reported by [16]. It is noted that the higher the volatile matter of a fuel briquette the higher the combustibility of the fuel briquette when the ash content is low [19]. The sample A briquette with lower volatile matter has an incomplete combustion which contributes to release of significant amount of smoke and gases [20].

The fixed carbon of the briquette, gives a rough estimate of the heating value of a fuel and acts as the main heat generator during burning [20]. The result of the fixed carbon shows that the briquette produced from sample B has a lower fixed carbon content of 13.50±0.20% which indicates prolonged cooking time but with low heat release [21]. The briquettes are better with higher fixed carbon because the corresponding calorific value is usually higher as reported by [22].

The compressive strength for the two samples were found to be reasonable with the briquette from sample A having the higher value of 0.67±0.36 $N/mm^2$. The implication of this is that briquette from sample A will suffer less damage during packaging, storage and transportation [23] and above all; it is an indication of good quality briquettes because of the strong inter particle bonds [14].

The values of 0.397±0.20$g/cm^3$ and 0.590±0.13$g/cm^3$ were obtained for the density for both samples. The density values obtained compare well with density of notable biomass fuels such as coconut husk briquette -0.63$g/cm^3$ [21] and banana peel -0.60$g/cm^3$ [24]. It is also expected that it will take a longer time for the sample A briquette to burn and may release less fly ash than the other briquette [25].

Calorific value is the most important combustion property for determining the suitability of a material as fuel. The slightly higher heating value of 11.99±0.10MJ/Kg obtained from sample A briquette compared to 11.27±0.28MJ/kg obtained in sample B briquette could be attributed to its higher density, lower volatile matter, higher fixed carbon and low ash content. It was observed that, the starch binder in sample A briquette improved the calorific value of the sample. The values obtained are less than those obtained from previous findings, for example; groundnut shell briquette – 12.6MJ/kg [26]; cowpea – 12.37 MJ/kg and soyabeans 12.95MJ/kg [27]. It was also observed that, the briquette of sample A has a high bulk density and energy value of the briquette is influenced by its density. The higher the density the lower the energy value [28].

The result of combustibility test in table 2, shows that the samples A briquette took 22 minutes to boil one litre of water and also took 24 minutes for sample B briquette to boil one litre of water under similar condition. These indicates that the burning rate (how fast the fuel burns) and the calorific value (how much heat released) are two combined factors that controlled the water boiling time [14].

## 5. Conclusion

The effects of binders on the physicochemical properties of watermelon peel briquettes have been investigated. The results obtained for all the parameters showed that the briquette bonded with starch had a better performance than the other and the calorific value of the produced briquettes makes the fuel briquettes suitable to be used for household cooking and can also serve as supplementary fuel in small scale industries.

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