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Estimation of the Moisture Content, Volatile Matter, Ash Content, Fixed Carbon and Calorific Values of Palm Fruit Shell Briquettes

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ABSTRACT: Briquettes from agro-residues are been used as replacement for firewood, charcoals and fossil fuels for heating, cooking and for other domestic and industrial applications. This research investigates the potentials of using palm fruit shell to produce briquettes as an alternative to firewood, charcoals and fossil fuelswith the intention ofreducing the menace of deforestation and excessive dependence on fossil fuels which depletes the ozone layer and mitigating the effect of greenhouse gas emission generated by the use of fallen trees as fuel wood. The binder used wascassava starch in proportions of 100:15 by weight. Selected heating values of the palm fruit shell briquettes produced: moisture content, volatile matter, ash content, fixed carbon and calorific value were determined. Results indicated that the average percentage moisture content, the average percentage volatile matter, the average percentage ash content, the average percentage fixed carbon and the average calorific value for the palm fruit shell briquette produced are 7.56%, 17.45%, 6.68%, 68.28%, 9717.74KCal/Kg respectively. These rresults indicate that the briquettes made from palm fruit shell have high heating value enough for domestic, small-scale industrial cottage applications. This research has established the potential ofpalm fruit shell briquettes as alternative material for firewood, charcoals and fossil fuels.

KEYWORDS: briquettes, palm fruit shell, heating values, domestics use, cottage applications

I. INTRODUCTION

"The primary source of energy for such vital activities as cooking and space heating is burning wood and other agricultural products. An increasing population using dwindling resource of combustible biomass materials will eventually result in the shortage of those materials unless urgent steps are taken to reverse the trend. One way of making efficient use of existing resources is briquetting. Briquetting involves collecting combustible materials that are not usable due to lack of density, compressing them into solid fuels of convenient shape that can burn like wood or charcoal" (Khadatkar and Gangwani 2016).

Mordi, 2007 "defined biomass briquetting as the densification of loose agro residues with or without binding agents to produce compact solid composites of different sizes with the application of pressure. A briquette is the product formed from the physic-mechanical conversion of dry, loose and tiny particle size material with or without the addition of an additive into a solid state characterized by a regular shape. Briquettes are mainly used for heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes and for domestic uses".

Agidi et al., (2015) "reported that developing countries are faced with the huge problem of waste management and agro residues. We usually see agro and sawmill residues burnt on roadside or dump yards, which results in pollution. There is a need to convert these residues into fuels they noted. However, these residues are very difficult to handle, store and if they are burnt directly results in very poor thermal efficiency and create lots of air pollution. They however concluded that these problems could be avoided by briquetting the waste biomass into a usable energy generating fuel. This will make biomass briquettes an alternative for fossil fuels, improve waste management and reduced air pollution".

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Biomass briquettes are a proven way of generating energy from waste. Different types of waste have been utilized in order to develop biomass briquettes. Recently, Romallosa and Kraft (2017) revealed that the simulated fabrication of biomass briquettes derived from the municipal waste stream could result in feasible on-site fuel production. In another report, Garrido et al. (2017) produced briquettes from sawdust, date palm trunk and different plastic wastes, lacking an external binding agent.

DahamShyamalee et al., 2015 prepared briquettes with binding agents like cow dung, wheat flour and paper pulp. These briquettes were tested for calorific value and compressive strength by varying percentage by volume of binders. They also calculated the minimum energy cost for production.

Onuegbu et al., 2011 had prepared bio briquettes from elephant grass, spear grass and bio coal at moderate pressure and temperature. They did proximate analysis and compared the results with wood samples. Their efforts was to substitute firewood to briquettes in the rural households in Nigeria.

In this research work, I estimated the calorific value of the briquettes produced from palm fruits shells.

II. MATERIALS AND METHODS

Biomass-binder Mixture

“Palm Fruits Shell samples were mixed with an already prepared cassava starch in proportions of 100:15 by weight in line with the works of (Sotannde et al 2010), (Martin et al, 2008)” and compacted using an appropriate briquetting machine of the screw type.

Determination of Moisture Content of the Briquettes

The percentage moisture content (PMC) determined by weighing 1.5g of the briquette sample put in a crucible of known mass and placed in an oven set at 105°C ± 5°C for 1 hour. The crucible and its content were removed from the oven allowed to cool to room temperature and reweighed. This process was repeated until the weight after cooling became constant and this was recorded as the final weight. The sample's moisture content was determined using equation (1).

$$PMC = \frac{W_1 - W_2}{W_2} \times 100\% \quad (1)$$

Where, W_1 is the initial weight of briquette sample and W_2 is the final weight of briquette sample.

Determination of Volatile Matter of the Briquettes

The percentage volatile matter (PVM) was determined by placing 1.5g of the briquettes sample in a crucible and kept in a furnace for 8 minutes, at temperature of 550^{o}C ± 5°C and weighted after cooling. The percentage volatile matter of the sample was determined using equation (2)

$$PVM = \frac{W_2 - W_3}{W_3} \times 100\% \quad (2)$$

Where, W_2 is the weight of the oven-dried sample (g); W_3 is the weight of the sample after 8 min in the furnace at 550 °C (g)

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Determination of Ash Content of the Briquettes

1.5g of the briquettes samples are kept in a closed furnace and burnt completely. The weight of the residue was taken with an electronic balance. The percentage weight of residue gives the ash contained in the sample and its determined using equation (3).

$$PAC = \frac{W_4}{W_2} \times 100\% \quad (3)$$

Determination of Fixed Carbon of the Briquettes

Akowuah*et al.* (2012), gave the percentage fixed carbon (PFC) as equation (4).

$$PFC = 100\% - (PMC + PVM + PAC) \quad (4)$$

Determination of Calorific Value of the Briquettes

The calorific value of the briquettes were determined using a bomb calorimeter. 1.5g of the briquettes sample was burnt completely in oxides of oxygen. The liberated heat was absorbed by the water and calorimeter. The heat lost by burning briquette was the heat gained by water and calorimeter. The calorific value (CV) of the fuel was calculated from the measured data (Obi *et al.*, 2013) using equation (5)

$$CV = \frac{BFx\ \Delta t - 2.3\ length\ of\ wire}{W} \quad (5)$$

Where: BF = Burn Factor; Δt = Change of temperature $(t_2 - t_1)^oC$; t_2 = final temperature; t_1 = initial temperature; W = mass of the sample used and BF = constant = 13,257.32

III. RESULTS AND DISCUSSION

The physico-chemical properties of the briquettes produced from Palm fruit shell were limited to determination of the percentage moisture content, percentage volatile matter, percentage ash content, percentage fixed carbon and calorific value.

Table 1: Percentage Values of Moisture Content for Palm Fruit Shell Briquettes

Sample	PMC (%)
1	7.65
2	7.52
3	7.60

Results from Table 1, showed that the average percentage moisture content for the palm fruit shell briquette produced is 7.56%. Moisture content of briquette increased with increase in binder concentration and decreased with increase in compaction pressure for all briquettes (Akintaroa et. al., 2017). Results obtained agreed with Pallavi*et al.*, (2013) recommendation of 5 – 10% moisture content for quality briquettes. When moisture content is low, briquettes will easily ignite, and higher calorific values are expected from the briquette (Akowuah*et al.*, 2012).

Table 2: Percentage Values of Volatile Matter for Palm Fruit Shell Briquettes

Sample	PVM (%)
1	17.45
2	17.48
3	17.42

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Results from Table 2, showed that the average percentage volatile matter for the palm fruit shell briquette produced is 17.45%. High volatile matter of a briquette indicates ease of ignition, rapid burning and proportionate increase in flame length but low heating values. The palm fruit shell briquette produced has a percentage volatile matter that falls within the range 10 to 25% for good quality briquettes (Akintaroa et. al., 2017).

Table 3: Percentage Values of Ash Content for Palm Fruit Shell Briquettes

Sample	PAC (%)
1	6.58
2	6.98
3	6.47

Knowledge of the ash content tells the extent of clogging up of the burning medium. Results from Table 3, showed that the average percentage ash content for the palm fruit shell briquette produced is 6.68%. Low ash content offers higher heating value for briquettes but high ash content results in dust emissions that lead to air pollution. It affects the combustion volume and efficiency (Obi *et al*. 2013). High ash content results in lower calorific value and vice versa, because ash content influences burning rate as a result of minimization of heat transfer to fuel's interior parts and diffusion of oxygen to the briquette surface during char combustion (Chaney, 2010).

Table 4: Percentage Values of Fixed Carbon for Palm Fruit Shell Briquettes

Sample	PFC (%)
1	68.32
2	68.02
3	68.51

Results from Table 4, showed that the average percentage fixed carbon for the palm fruit shell briquette produced is 68.28%. This result agrees with the result of Pallavi*et al*. (2013) who reported the suitability of briquettes with fixed carbon as 80.5% for domestic applications. Moore and Johnson, (1999) reported that, the higher the fixed carbon of a fuel, the greater the calorific value, the smaller the volatile matter, the lower the ash and moisture content and the better the quality of the fuel.

Table 5: Calorific Values for Palm Fruit Shell Briquettes

Sample	CV (Kcal/Kg)
1	9,710.53
2	9,721.12
3	9,721.56

The calorific value determines the amount of heat energy present in a material. Results from Table 5, showed that the average calorific value for the palm fruit shell briquette produced is 9717.74KCal/Kg. The briquette samples produced were of high heating value enough for domestic use and small-scale industrial cottage applications.

IV. CONCLUSION

Fossil fuels and wood fuels are the major source for energy in Nigeria today. The excessive use of these fuels will lead to serious environmental issues like global warming, air pollution and deforestation. It is high time we convert biomass wastes to useful briquettes, which will be the substitute for these fuels. This work focused on estimating the heating values of palm fruit shell briquettes to ascertain its suitability for domestic use and small-scale industrial cottage application. Results obtained indicate that the briquettes made from palm fruit shell have high heating value enough for domestic use and small-scale industrial cottage applications.

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