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Production of Briquettes from Sawdust and Palm Frond

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Abstract: *The study was conducted to compare the combustion properties of briquettes produced from sawdust and palm frond using different mixing ratios which will serve as a substitute for kerosene and LPG. In obtaining these results, five different briquettes were produced using locally sourced cassava starch as binder in the sawdust (s): palm frond (p) ratios of 0:1, 1:3, 1:1, 3:1 and 1:0: A 0%S: 100%P, B 25%S: 75%P, C 50%S: 50%P, D 75%S: 25%P and E 100S:0%P. The attainment of each sample with various weight percentages was evaluated using proximate analysis. The biomass combination was changed into compacted form of briquette through a manual screw press machine process. The briquettes attributes were correlated at different weight percentage following standard testing analysis which included proximate analyses such as density, moisture content, volatile matter, ash content and calorific value analysis. The experimental results showed that D -75%S: 25%P sawdust to palm frond gave the optimum results. This also showed that D (3S: 1P) attained a good combustion characteristics. This could serve as a substitute to firewood and other biomass fuel industrially and domestically. It could be deduced that the production of the briquettes is feasible, cheaper than kerosene and environmentally friendly.*

Keywords: ***Briquette, Biomass, Renewable energy, Oil palm frond, Sawdust.***

INTRODUCTION

In In developing countries, renewable energy sources are being sought for domestic cooking due to the fact that their non-renewable counterpart such as Kerosene, LPG, etc are not sufficient enough with people's demand. Also, the high cost of non-renewable energy sources has made people to start deviating to the use of renewable energy sources for domestic cooking and industrial purposes. The use of biomass fuel such as composite sawdust briquette has been proposed to be a good source of renewable energy for domestic cooking and industrial uses (Kuti and Adegoke, 2008). This is due to the fact that sawdust, i.e. the chief raw material in the production of composite sawdust briquette is readily available in large quantities as wastes in majority of the wood processing industries. However, it has been proposed that the conversion of sawdust wastes through briquetting process will go a long way in reducing waste disposal problems in majority of the wood processing industries. Furthermore, deforestation which promotes pollution will be drastically reduced if the use of sawdust waste is enhanced and encouraged.

Consequently, the production and use of briquettes from abandoned resources (Sawdust) are growing as pointed out earlier due to increase in fuel prices. Converting them, among others into briquettes, gives an opportunity to dispose of wastes and at the same time clean the community of unwanted wastes, conserve the forest, reduce greenhouse gas (GHG) emissions and provide alternative/additional livelihood to the urban and rural communities (Chaney,2010). Subsequently, the process of briquetting involves the compression of a material into a solid product of any convenient shape that can be utilized as fuel just like the use of wood or charcoal. The conversion of combustible materials found in the waste stream was found to be a better way of turning waste into wealth (Adegoke, 2002). In addition, if briquettes are produced at low cost and made conveniently accessible and available to consumers, it could serve as substitute to firewood and charcoal for domestic cooking and agro-industrial operations, thereby reducing the high demand for the latter two (Olorunnisola, 2007). Hence, these materials which were of low density prior to being converted into briquettes are compressed to form a product of higher bulk density, lower moisture content and uniform size and shape making these materials easier to package and store, cheaper to transport, more convenient to use, and better in combustible characteristics than those of the original waste material.

MATERIALS AND METHODS

A. Parameters Analyzed

The parameter analyzed in this study are density, ignition time, burning time, water boiling tests, moisture content, volatile matter, ash content, fixed carbon content and calorific value.

B. *Apparatus used for the Experiment*

The apparatus used during the analysis are Triple beam balance model, manually screw press briquetting machine, Bunsen burner, muffle furnace, thermometer, milling machine, measuring cylinder, compaction mould, aluminum kettle, crucibles, conical flask, tripod stand, vernier caliper.

C. Materials

The materials used in this study are as shown below:

- Sawdust (Abura Softwood)
- Palm Fronds
- Tap Water
- Cassava starch (binder)

D. Preparation of Materials

The dry palm fronds used for this experimental analysis were obtained from a palm plantation in Abuja Campus of University of Port Harcourt. The leaves were trimmed off and the fronds cut into smaller sizes. The samples were sundried for two weeks and later oven dried at 105°C for three more days for thorough drying before grinding in a milling machine while the sawdust used was collected and bagged in polythene sacks as the logs were being processed in Rumuosi Timber Market.

E. Briquette Formulation

The briquettes were prepared in the laboratory of Chemical Engineering, University of Port Harcourt, Choba using a manual screw press machine with a cylindrical mould. The briquettes were formulated using different percentages of palm frond and sawdust. The ratio of sawdust to palm frond were 0:100, 25:75, 50:50, 75:25 and 100:0 which were labeled A, B, C, D and E respectively.

Table-1 Briquette Formulation

Raw materials (%)	A 0:100	B 25:75	C 50:50	D 75:25	E 100:0
Sawdust(g)	0	25	50	75	100
Palm Fronds(g)	100	75	50	25	0
Starch (g)	30	30	30	30	30
Water (ml)	100	100	100	100	100

F. Procedure

A specific quantity of milled palm fronds and sawdust based on the stated ratios in Table 1 were weighed out using a triple beam balance into a plastic basin. A measured quantity of water was added to make the starch which was used as a binder. Both the made starch and the sawdust /Palm frond combination were mixed thoroughly using a stirring stick until a homogeneous (uniform) mixture was obtained. The briquetting mould of the manual screw press briquette moulder was filled with the mixture, making sure that the moulder plates were inserted first. The lid of the moulder was closed and the mixture was briquetted by screwing in the manual screw press and applying pressure. This action moved the movable part of the mould up to the immovable part (the lid), causing the mixture in the mould to be compressed, and after 5 minutes of residence time, the briquettes were ejected from the mold and taken to a tray drier for drying at a temperature of 105˚C for 3 days. Thereafter, the briquettes were removed from the dryer and allowed to cool.

2.1. Physical Analysis

A. Determination of Density (Cylindrical Mould)

The height (h) of the briquette was measured using vernier caliper and recorded. The diameter (d) was also obtained from the top using vernier caliper. The volume was evaluated by using the mathematical relationship: $V = \pi r^2 \mathrm{h}$ or $\frac{\pi}{4}\mathrm{D}^2\mathrm{h}$

The mass in grams (g) was measured using a triple beam balance and was recorded. The density was calculated thus (Grover and Mishra, 2006).

$$Density = \frac{Mass(g)}{Volume\ (cm3)} \quad (1)$$

B. Determination of Ignition Time

Ignition time is the time taken for a flame to raise the briquette to its ignition point. The briquette samples were ignited at the edge of their base with a lighter adjusted to give a steady light. The time required for the flame to ignite the briquette was recorded as the ignition time using a stop watch (Eboatu *et al,* 1993).

*C. Determination of the Burning Tim***e**

From the record of the ignition time to the water boiling test, the stop watch was left to keep taking time. The briquette sample was left to keep burning and the stop watch keeps recording until the time the sample was turned into ashes completely (Bailey and Blankenhorn, 1982).

2.2 Proximate Analysis of Briquette Samples

The proximate analysis of the briquette samples analyzed were percentage moisture content, percentage volatile matter, percentage ash content, percentage fixed carbon and calorific (heating) value in order to ascertain its combustion characteristics.

A. Determination of the Moisture Content of the Briquette

The moisture content is the amount of liquid (water) contained in the briquette after drying. The moisture content was determined using ASTM Standard E 711 – 87(2004). Primary oven-drying method was used to determine the moisture content because it has the highest accuracy and degree of precision .During the analysis, a portion of each of the samples of the briquette was weighed out into an aluminum pan. The samples were placed in a tray dryer for 3 days at 105˚C. The moisture content was determined using:

$$\%Moisture = \frac{W0 - W}{W0} \qquad (2)$$

where,
W_0 = Initial mass of briquette before drying (g)
W = Final mass of briquette after drying (g)

B. Determination of the Volatile Matter in the Samples

Volatile matter given off by a material as gas or vapour was determined by definite prescribed methods. In order to determine the percentage volatile matter, 20g of briquettes were kept in the furnace at a temperature of 550˚C for 10 minutes (just before the materials turn black i.e before it ashes) and weighed after cooling. The percentage volatile matter was then expressed as the percentage of loss in weight to the oven dried weight of the original sample (Bailey and Blankenhorn, 1982).

Volatile matter = weight of residual dry sample–weight of dry sample after heating

$$\%\ Volatile\ matter = \frac{wi - wf}{wi}\ x\ 100 \qquad (3)$$

where,
W_i is the weight of oven dried sample
W_f is the weight of sample after 10 minutes in the furnace at 550˚C.

C. Determination of the Ash Content of the Samples

Ash content predicts the purity and gives an indication about the quality of wood sawdust. Thus, the ash content of wood is residue that remains after the wood material is burnt and such residue is referred as the non-combustible residue. The residual samples from the volatile content determination were weighed and allowed to burn into ashes inside the crucibles. It was allowed to cool. The crucibles and their contents were reweighed and the new weight recorded. The percentage ash content was calculated thus (Bailey and Blankenhorn, 1982).

$$Ash\ Content\ (A.C\ \%) = \frac{final\ weight\ of\ sample}{initial\ weight\ of\ sample} \times 100 \qquad (4)$$

D. Determination of the Fixed Carbon Content of the Samples.

Fixed carbon is the solid combustible residue that is present in a biomass sample after the percentages of ash content and volatile matter have been determined. It represents the quantity of carbon that can be burnt by a primary current of air drawn through the hot bed of a fuel (Barnard, 1985). The fixed carbon content of the samples was calculated using the following relation:

$$\%\ Fixed\ Carbon = 100 - (\%\ Volatile\ matter + \%\ Ash\ Content) \qquad (5)$$

E. Determination of the Calorific (Heating) Value

The high heating value is the amount of heat produced by the complete combustion of a unit quantity of fuel. This was calculated using formula (Barnard, 1985).

$$Heating\ Value\ = 2.326(147.6C\ + 144V) MJ/Kg \tag{6}$$

Where C is the percentage fixed carbon and V is the percentage volatile matter (Bailey and Blankenhorn, 1982).

RESULTS AND DISCUSSION

A. *Density of the Briquette Sample*

Based on Fig. 1, it was found that the density of the samples decreases with increase in sawdust. This will help for easy transportation and increase in the burning characteristics of the briquettes.

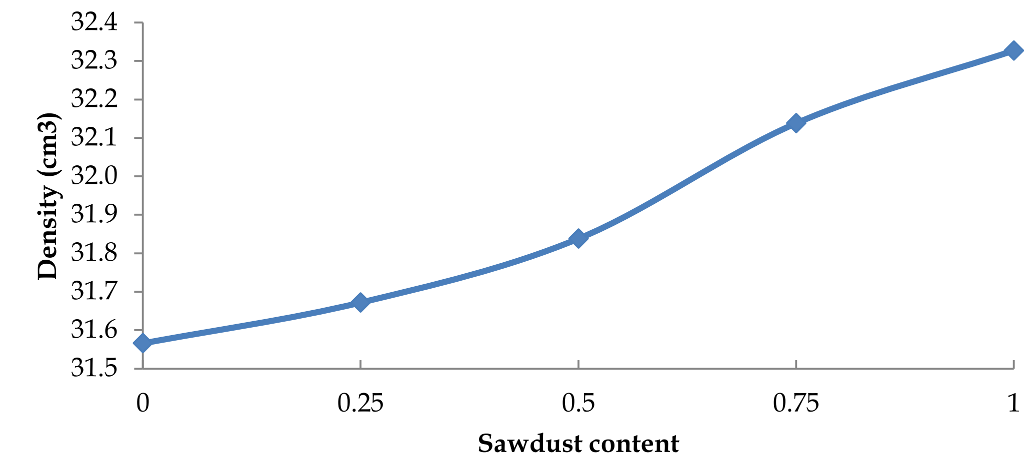

Fig. 1 Variation of Density with Sawdust fractional composition of the Briquette

B *Ignition Time of the Briquette Sample*

Ignition time was taken as the average time taken to achieve steady glowing flame. Fig. 2 is the ignition time for the composite briquettes produced. From the results, it can be seen that ignition time decreases with an increase in the content of Palm fronds. It shows that the more the palm fronds content in the briquette, the more the pores which create opening for the decrease in ignition time observed as palm fronds increases.

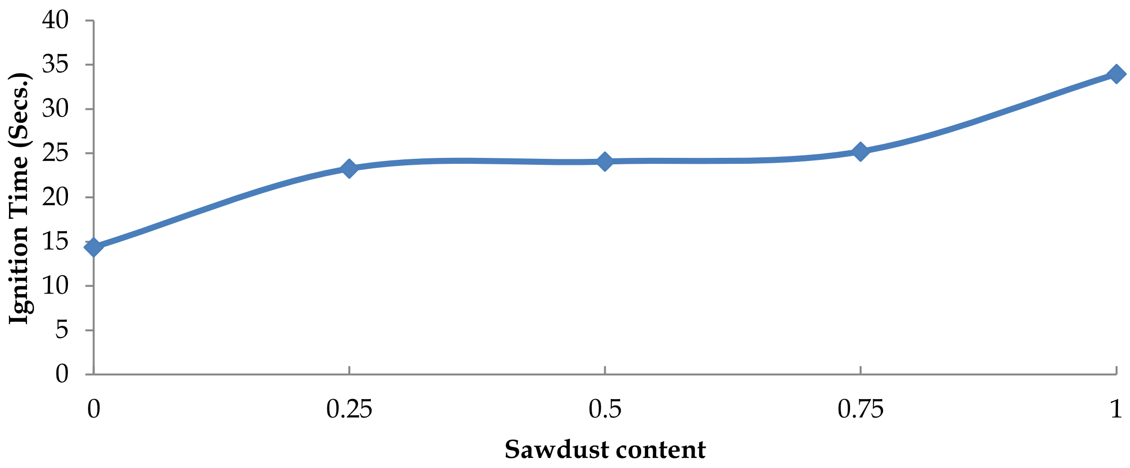

Fig. 2 Variation of Ignition Time (Secs.) with Sawdust fractional composition of the Briquette

C. Burning time of the Briquette Sample

Burning time indicates that the burning duration of briquettes decreased with amount of palm fronds as seen in Fig. 3. The rapid combustion observed as the palm frond increases could be due to increase in pores observed as palm frond content in briquettes increases enables the volatiles to leave more readily and be consumed rapidly. The decrease in the burning time with palm fronds could also be attributed to poorer bonding which might have resulted in relatively high porosity hence promote the infiltration of oxidant and outflow of combustion products during combustion.

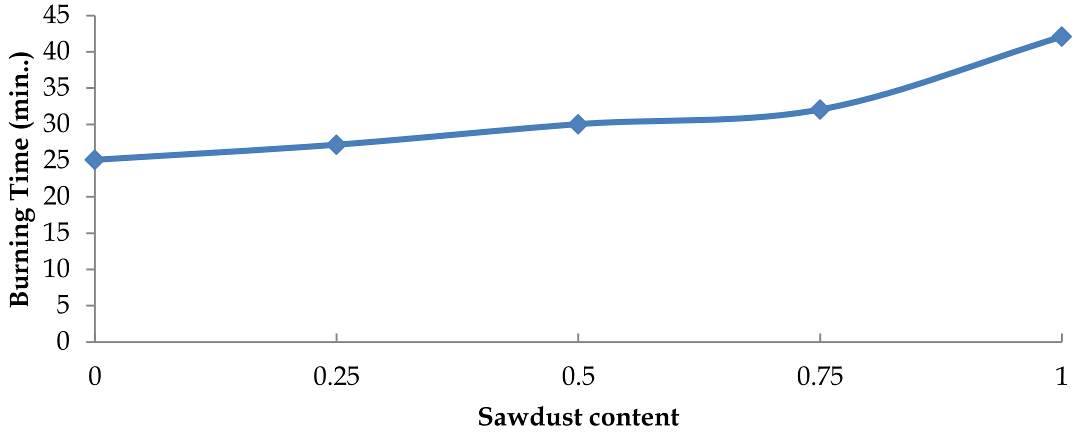

Fig. 3 Variation of Burning Time (mins.) with Sawdust fractional composition of the Briquette

Proximate Analysis of the Briquettes

A. Moisture content of the briquette sample

The moisture content of biomass from literature should be as low as <15% so that there will be complete combustion of the briquette (Grover and Mishra, 2006). The moisture contents obtained during the analysis as shown in Figure 4 were all below 10%. This makes the briquettes good as solid fuel. Low moisture content of biomass also helps in their storage (prevents rotting and decomposition). Fig. 4 shows that the value of moisture content increases with an increase in sawdust and a decrease in palm frond.

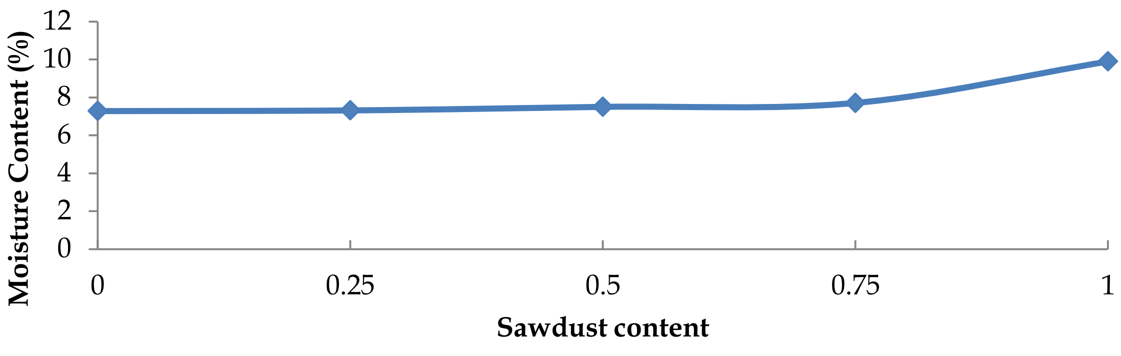

Fig. 4 Variation of Moisture Content (%) with Sawdust fractional composition of the Briquette

B. Volatile matter of the briquette sample

The burning efficiency is directly affected by the level of the volatile matter. The higher the volatile matter, the more the burning efficiency of the briquette. It was noted from Fig. 5 that the volatile matter of the briquettes increases with an increase in sawdust with D- 75:25 Sawdust to Palm Frond showing the highest value. It shows that sawdust contains more volatile matter than palm frond.

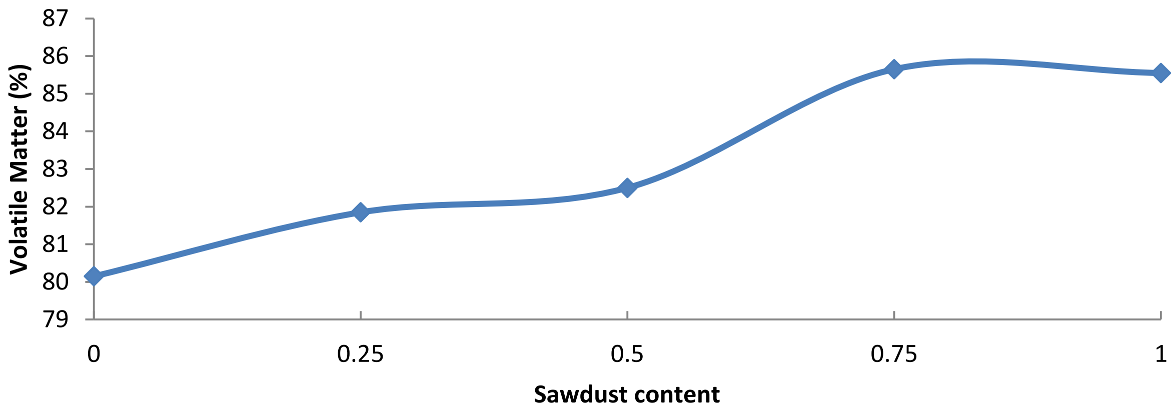

Fig. 5 Variation of Volatile Matter (%) with Sawdust fractional composition of the Briquette

C. Ash Content of the Briquette Samples

The level of ash content in the briquettes directly affects their burning efficiency. The lower the ash content, the more the burning efficiency of the briquette. The effect of biomass on the ash content of the briquette samples are indicated in Fig. 6. The value of the ash content decreases with an increase in sawdust. It therefore shows that palm frond has more ash content than sawdust. While compared to Table 1, the results obtained in Fig. 6 have significant difference. The ash content is less than 7% which makes it suitable as a good solid fuel.

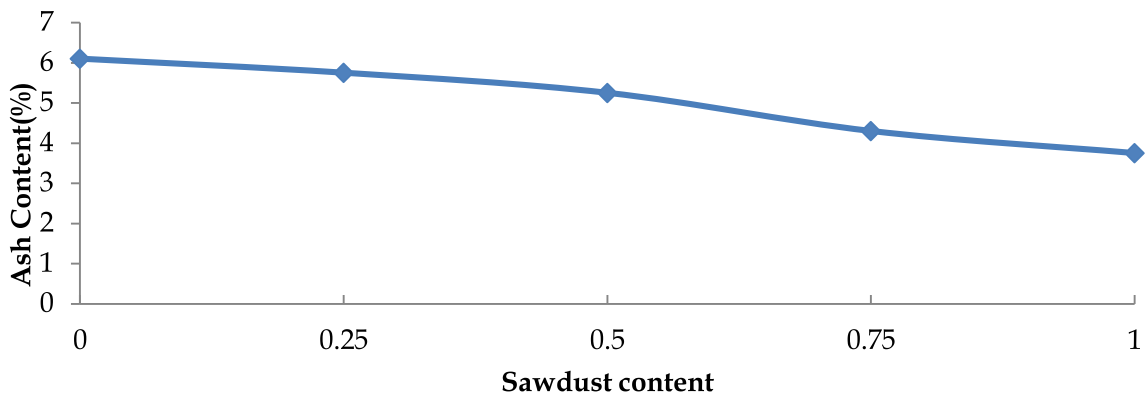

Fig. 6 Variation of Ash Content (%) with Sawdust fractional composition of the Briquette

D. Fixed Carbon of the Briquette Sample

The level of fixed carbon in combustible materials is indicative of its burning efficiency. In contrast to volatile matter, the lower the fixed carbon, and the higher the efficiency of burning. Fig. 7 shows that the value of fixed carbon increases with an increase in palm frond. It therefore shows that briquette sample with more palm frond has a higher carbon content.

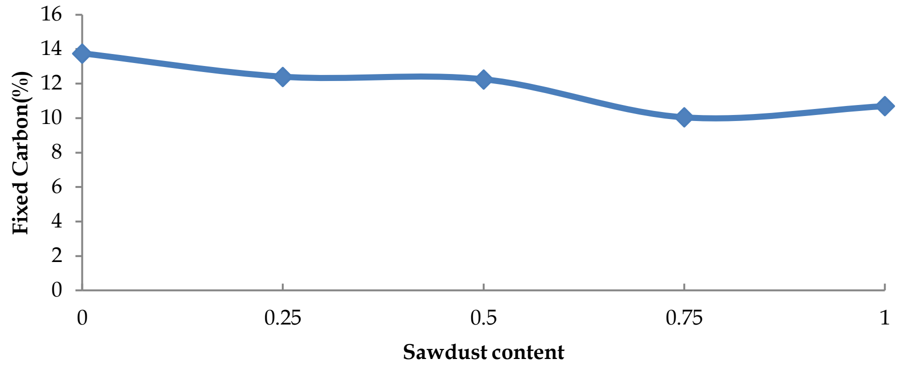

Fig. 7 Variation of Fixed Carbon (%) with Sawdust fractional composition of the Briquette

E. Heat (Calorific) Value of the Briquette Sample

Heat value or calorific value determines the energy content in a fuel. The standard calorific value of the composite briquettes from literature ranges between 33,536 and 17,500 KJ/Kg. From Fig. 8, it was found that the calorific value increases as the percentage of sawdust increases. The composition with 75% sawdust and 25% palm frond has the higher calorific value than that with 25% sawdust and 75% palm frond. The variation was expected since sawdust has higher calorific value than palm frond. The energy value obtained for the various compositions was found to meet the minimum requirement of calorific value for making commercial briquette (>17,500KJ/Kg) (Oyelaran *et al,* 2014). They can therefore produce enough heat required for household cooking and small-scale industrial cottage applications.

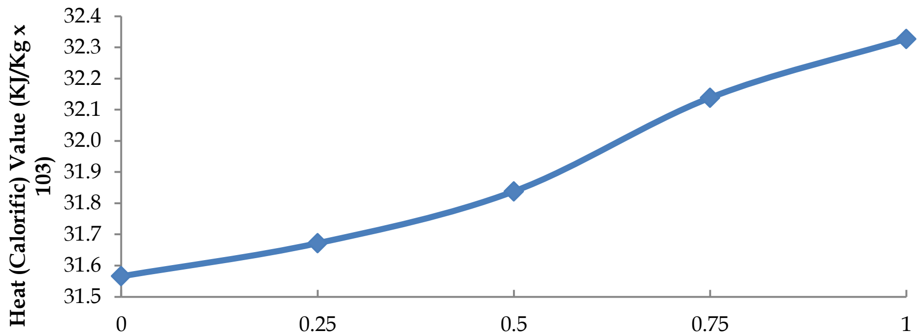

Fig. 8 Variation of Heat (Calorific) Value (KJ/Kg x 10^3) with Sawdust fractional composition of the Briquette

CONCLUSION

From the results obtained during the analyses, the following conclusions were drawn on the possibility of using sawdust and palm frond in different ratios. The sawdust briquette has good attributes compared to the bio-fuel materials currently in use. However, the most viable mixture for the production of sawdust and palm frond briquette of different ratios based on high performance from the analyses was 75% sawdust and 25% palm frond because of the following reasons:

i. It has high volatile matter of 85.65% compared to other briquettes produced which is an important characteristic of a fuel because volatile matter of a briquette greatly influences the combustion behavior of fuel.

ii. Furthermore, it also has high heating (calorific) value of 32,138.295 KJ/Kg. This high calorific value is an important factor that should be considered when selecting raw materials for briquetting. The combination properties of sawdust and palm frond have resulted in the high calorific value for fuel briquettes.

iii. Another reason for preferring 75% sawdust and 25% palm frond over other ratios of the briquette produced was its low ash content of 4.3%.

RECOMMENDATIONS

Based on the above findings and conclusions of the project, the following are the recommendations for the improvement of briquette production from sawdust -palm frond:

i. Firstly, the use of briquette should be given wide publicity in Nigeria due to abundant sawdust, wood shortage due to deforestation and scarcity of other energy sources.

ii. Secondly, improvement should be made in introducing electrically controlled pistons to perform the compaction instead of using manually operated screw press briquetting machine.

iii. Briquettes from sawdust and palm frond should be scaled up for industrial use.

CONFLICT OF INTEREST

This research work was carried out by me and there is no conflict of interest associated with it.

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