

Production of Biomass Briquettes using coconut husk and male inflorescence of *Elaeis guineensis*.

Abstract

Aims: The decreasing availability of fuel wood coupled with the increasing prices of kerosene and cooking gas in Nigeria has drawn attention on the need to consider alternative sources of energy for domestic and industrial use in the country. The study was undertaken to evaluate the combustion properties (percentage volatile matter, percentage ash content, percentage fixed carbon, heating value) of briquette produced from coconut husk and male inflorescence of *Elaeis guineensis*.

Study Design: The experiment was laid down using the Randomized Complete Block Design (RCBD). The study involves three particle sizes of coconut husk, male inflorescence of oil palm tree and cassava starch used as binder.

Methodology: The coconut husk and male inflorescence of *Elaeisguineensis* were varied into (25:30:40:50:60) respectively and binded together with starch at same ratio. Proximate analysis were carried out on ash content, percentage fixed carbon, percentage volatile matter and heating value to determine the properties of the briquette produced.

Results: All processing variables in this study were significantly different except for heating value at $P>0.05$. From the result of the percentage ash content, briquette produced from coconut husk, male inflorescence and starch at (20:20:60) has the least fixed carbon (6.5%) with better performance. The highest percentage volatile matter 74.6% was obtained from coconut husk, male inflorescence and starch at (20:20:60) while low fixed carbon (18.8%) was obtained from male inflorescence and starch at (60:40).

Conclusion: In conclusion, large quantities of wastes generated in terms of coconut husk and male inflorescence which are disposed indiscriminately can be utilized to produce briquette with enhanced performance.

Keywords: Biomass, Briquette, Coconut Husk, Inflorescence, *Elaeis guineensis*, Fuel

1. Introduction

The importance of energy especially renewable energy for a nation's development cannot be overemphasized and this is because energy is the cornerstone of economic and social development [1]. Globally, 140 billion metric tons of biomass is generated every year from agriculture of which can be converted to useful resources such as biofuel [2]. Numerous agricultural residues and wastes are generated in Nigeria which are poorly utilized and badly managed, since most of these wastes are left to decompose or burned in the field resulting in environmental pollution and degradation contributing to the negative impacts of climate change [3]. In Nigeria, a large quantity of rice husks and corncobs are produced annually, and these residues are left to rot away or burned like other agricultural wastes. These residues could however, be used to generate energy for domestic and industrial cottage applications [4]. The decreasing availability of fuel wood coupled with the ever-rising prices of kerosene and cooking gas in Nigeria has drawn attention on the need to consider alternative sources of energy for domestic and industrial use in the country. Such energy sources should be renewable and accessible to everyone especially those in rural and vulnerable settlements.

Briquetting is a process of binding together pulverized materials (such as sawdust, groundnut shell coconut husk, male inflorescence oil palm, rice husk, maize cob, bamboo and other combustible materials) into a solid block compressed material under pressure, often with the aid of binder such as cassava starch. The use of briquette can reduce the demand for fuel wood and therefore reduce the over-exploitation of forest resources by rural dwellers. Briquette production has the potential to meet the additional energy demands of urban and industrial sectors, thereby making a significant contribution to the economic advancement of countries especially the developing countries and also the advances in technology has made the waste resources from different production line form new basis of energy production. Furthermore, briquettes have advantages over fuel wood in terms of greater heat intensity, clean production, convenience, and relatively smaller space requirement for storage [5]. The amount of energy required for various purposes keep on increasing due to the increase in demand. Majority of these waste materials constitutes a form of nuisance to the environment which are left to decompose, or they are burned in the field resulting in environmental pollution and degradation and thereby contributing to unclean environment. Hence, the utilization of coconut husk and male inflorescence of oil palm which are known to be waste should therefore be encouraged which in turn helps to produce briquette from waste materials.

2. Materials and Method

2.1 Study Area

The study was conducted at the Federal University of Agriculture, Abeokuta. The university is located at Alabata road in the north Eastern part of the town, Abeokuta in Odeda local government of Ogun state Nigeria at latitude 3 to 20° E to 30° W. The region enjoys an average temperature of 31.8° C. It has annual temperature of about 1300mm with peaks in June and dry season of two or three month.

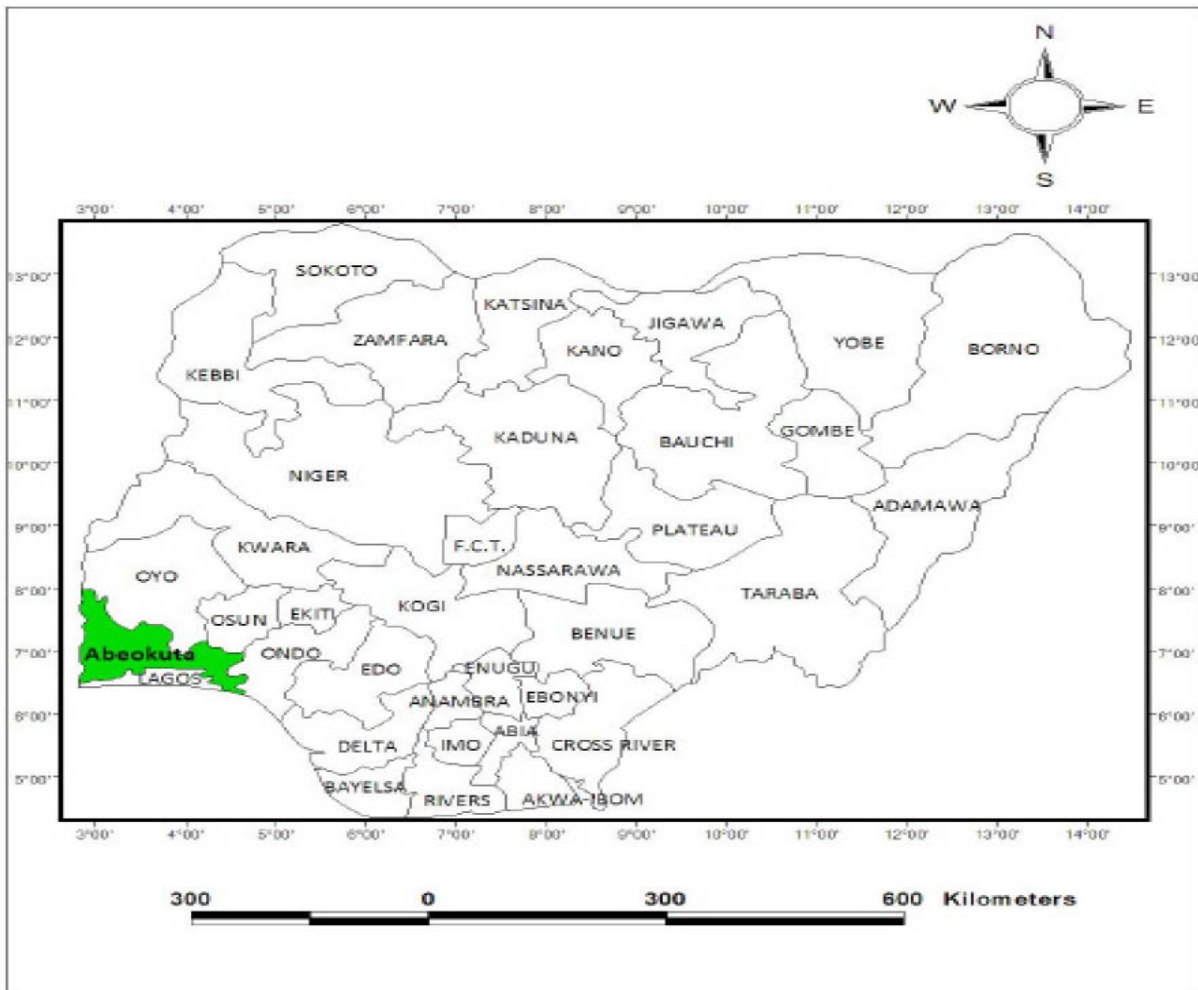


Image. 1: Map of the study location

2.2 Material Collection and Preparation

Coconut husk and Male Inflorescence Oil Palm tree were used for this study. Cassava Starch was used as binder while weight top screw presser was used to form briquette. The Male Inflorescence Oil Palm tree was collected from Oil Palm tree along Federal University of Agriculture Abeokuta (FUNAAB) gate via Alabata and the coconut husk was collected around the Ogun State environs.

Collected male inflorescence was sundried and shredded into powdery form as well as the coconut husk to reduce the moisture content before been grinded into powdery form. The grinded samples were then sieved with 2mm mesh sizes to obtain uniformity in their particle sizes. The particles obtained from the mixture of male inflorescence and coconut husk were weighed into varied proportions (20:25:30:50:60) and were produced with the aid of a locally fabricated mould. Cassava starch (40:50:60) which is the binding agent was mixed to each sample in a different proportion and molded using weight screw molder presser to form the briquette. After the production, the briquette was weighed to determine their weight.

2.3 Place of study

The briquette produced was taken to the laboratory of Forest Research Institute of Nigeria (FRIN) Ibadan, Nigeria where the analysis on burning characteristics of the briquette were determined such as percentage volatile matter, ash content, calorific value, and percentage fixed carbon.

2.4 Proximate Analysis

Proximate analysis was carried out on the following combustion related properties of the briquette produced

- Ash content
- Percentage fixed carbon
- Percentage Volatile matter
- Gross Calorific/ Heating value.

2.4.1 Determination of Percentage Ash Content

2g of oven dried briquette sample would be placed in the furnace at temperature of 550⁰C for 4hours and weigh after cooling

$$\text{Percentage Ash content} = \frac{D}{B} \times 100$$

Where D = Weight of Ash

B= Weight of oven dried sample

2.4.2 Determination of Percentage Volatile Matter

The volatile matter would be determined by placing 2g of pulverized briquette sample in a crucible oven to obtain constant weight after it would have been kept in the furnace at temperature of 550⁰C for 10minutes and be brought out to be cooled in the desiccators and weighed to determine percentage volatile matter.

$$\text{Percentage Volatile matter} = \frac{D-C}{B} \times 100$$

Where B=weight of dried samples

D =weight of Ash

C = weight of sample after 10 minutes in the furnace at 600⁰C.

2.4.3 Determination of Percentage Fixed Carbon

The percentage fixed carbon would be calculated by subtracting the sum of percentage volatile matters and percentage ash content from 100%.

$$\text{Percentage Fixed Carbon} = 100 - (\% V + \% A)$$

Where % V= percentage volatile matter

% A= percentage Ash Content

2.4.4 Determination of Heating Value/Energy Mj/kg

Heating value would be calculated using this formula:

$$HV = 2.326(147.6C + 144V) \text{ kJ/kg}$$

C=Percentage Fixed carbon

V=Percentage Volatile Matter.

2.5 Data analysis

The experiment was laid down using the Randomized Complete Block Design (RCBD). The data were subjected to one-way Analysis of Variance (ANOVA) at 0.05 probability level. Where significant differences were encountered, the means were separated using Duncan Multiple Range Test (DMRT). Descriptive statistics that includes mean and standard error of estimates was also used to describe the data. All analysis was done using the SPSS software Version 20.0 (IBM, Chicago).

3. Results and Discussion

3.1 Percentage Ash Content

Knowledge of the ash content tells the extent of clogging up of the burning medium. High ash content decreases the burning rate and reduces the heating value of fuel. The result of percentage ash content shows that briquette produced with 20% coconut husk, 20% male inflorescence of oil palm and 60% starch has the least ash content 6.5%. The result of the percentage ash content observed in this study was lesser when compared to previous work reported [6] with ash content (6%) obtained on briquetting of palm fibre and shell from the processing of palm nuts to palm oil. Briquettes with lower ash content are considered the best in the production; this is because it produces less smoke. According to [7] biomass residues normally have much lower ash content (except for rice husk with 20% ash), but their ashes have a higher percentage of alkaline minerals, especially potash. High ash content results into dust emissions which lead to air pollution and affects the combustion volume and efficiency. [8] revealed that the higher the fuel's ash content, the lower its calorific value since it influences the burning rate due to minimization of the heat transfer to fuel's interior parts and diffusion of oxygen to the briquette surface during char combustion. The ash content of different types of biomass with lower ash content will not show any slagging behaviour of the biomass. [9] also noted that low ash content offers higher heating value for briquettes but high ash content results into dust emissions which lead to air pollution and affects the combustion volume and efficiency. Generally, the greater the ash content the greater the slagging behavior, but this does not mean that biomass with lower ash content will not show any slagging. The mineral composition of ash and their percentage combined determine the slagging behaviour. Hence, briquettes made from 20% coconut husk, 20% male inflorescence of oil palm and 60% will be more suitable for domestic uses like cooking.

3.2 Percentage Volatile matter

The result of percentage volatile matter shows that briquette produced with 20% coconut husk, 20% male inflorescence of oil palm and 60% starch has the highest volatile matter (74.6%) but lower to that of briquette which is in accordance with previous studies [10] and were higher than those obtained by other researchers in their works [11, 12, 13] which explained that the materials and binders which were selected are better for briquetting. The percentage volatile matter of the briquettes was higher than normal value of 20% as reported [14]. High volatile matter in the results of this research is an indication of easy ignition,

fast burning and proportionate increase in flame length. [15] noted that biomass generally contains high volatile matter of around 70% and 80% with low char content.

3.3 Percentage fixed carbon

The fixed carbon of the briquette is a percentage of carbon (solid fuel) available for char combustion after volatile matter is distilled off or lost to the atmosphere. Therefore, fixed carbon gives a rough estimate of the heating value of fuel and acts as the main heat generator during burning [11]. The result in table 1 is further illustrated on a bar chart in figure 2. Table 1 shows the result of comparison in the number of fixed carbon observed among the 9 different samples. The result shows that the average number of fixed carbon in the 9 samples ranged from 18.8133 to 24.0000 with the highest number of fixed carbon recorded in sample CH/MI/S (20:20:60) while the least number of fixed carbon was recorded in sample MI/S (60:40). The result shows further that the average number of fixed carbon varied significantly among the 9 different samples at 1% ($p < 0.01$) level (Table 1). The result in table 1 is further illustrated on a bar chart in figure 3. This result shows that briquette produced with 60% male inflorescence and 40% starch has the least percentage fixed carbon 6.5% hence, has a better performance for briquette production. The result of this study contradicts the work done in the past [16] which stated that the higher the fixed carbon content 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.

3.4 Heating value

The result of the analysis of variance (ANOVA) showing comparison in heating value among the 9 different samples was reported (Table 1). The result shows that the average heating value for the 9 samples ranged from 21.6467 to 25.5667 with the highest heating value observed in sample CH/MI/S (20:20:60) while the least heating value was recorded in sample CH/S (60:40). However, the result shows that the average heating value did not vary significantly among the 9 different samples at 5% ($p > 0.05$) level (Table 1). The result in table 1 is further illustrated on a bar chart in figure 4. The result of heating value obtained from this research was higher than the briquette produced from groundnut shell using cassava peel as binder (33.70MJ/kg) in previous studies [16]. The result was also higher than the durian peel conducted in previous work [17] with the heating value of 20.265MJ/Kg and also lower to that of 33.09 MJ/kg reported in the past [10, 12], this may be as a result of the treatments composition or different treatment used in the study. The result of this study also compares well with that of the calorific value of charcoal and sawdust briquette observed in previous studies [18].

Table 1: ANOVA showing comparison in the ash content, volatile matter, fixed carbon and heating value among samples.

Samples	Ash content (%)	Volatile matter (%)	Fixed carbon (%)	Heating value (MJ/kg)
CH/S (50:50)	7.0000±0.200 ^b	63.3333±5.1316 ^a	21.4333±2.45832 ^{ac}	24.4133±1.37 ^a
CH/S (60:40)	6.7333±0.665 ^a	59.6667±3.0550 ^a	20.3100±0.90570 ^{ab}	21.6467±1.70 ^a
CH/S (40:60)	6.8333±0.208 ^a	64.0900±1.2674 ^a	21.2633±1.87538 ^c	22.7167±1.24 ^a
MI/S (50:50)	8.7367±0.439 ^d	62.9833±4.6111 ^a	19.7900±1.72357 ^a	23.9100±1.59 ^a
MI/S (60:40)	9.3467±0.566 ^d	58.9933±0.9308 ^a	18.8133±0.85582 ^a	23.6933±2.72 ^a
MI/S (40:60)	9.8333±0.763 ^d	59.3500±3.4967 ^a	19.1333±0.28431 ^a	21.7400±1.01 ^a
CH/MI/S (25:25:50)	8.2667±1.418 ^c	61.6667±2.5166 ^a	21.3033±2.20123 ^c	24.2500±0.85 ^a
CH/MI/S (30:30:40)	7.1833±1.284 ^b	70.5000±1.32288 ^b	23.0000±0.86603 ^{bc}	25.3333±1.04083 ^a
CH/MI/S (20:20:60)	6.5000±0.500 ^a	74.6667±4.64579 ^b	24.0000± 1.00000 ^c	25.5667±2.10079 ^a

Values represent mean ± standard deviation.

Values of ash content, volatile matter and fixed carbon with different superscripts are significantly different at 1% ($p < 0.01$) level. Values of heating value represent mean ± standard deviation. Values with the same superscript are not significantly different at 5% ($p < 0.05$) level.

CH = Coconut Husk, MI = Male Inflorescence of Oil Palm, ST = Starch

Table 2: Analysis of variance result for ash content, volatile matter, fixed carbon and heating value

		Sum Squares	of df	Mean Square	F	Sig.
Ash	Between Groups	37.195	8	4.649	7.555	.000
	Within Groups	11.077	18	.615		
	Total	48.272	26			
Volatile Matter	Between Groups	685.089	8	85.636	7.609	.000
	Within Groups	202.591	18	11.255		
	Total	887.679	26			
Fixed Carbon	Between Groups	70.665	8	8.833	3.829	.009
	Within Groups	41.520	18	2.307		
	Total	112.185	26			
Heating Value	Between Groups	48.097	8	6.012	2.295	.068
	Within Groups	47.160	18	2.620		
	Total	95.257	26			

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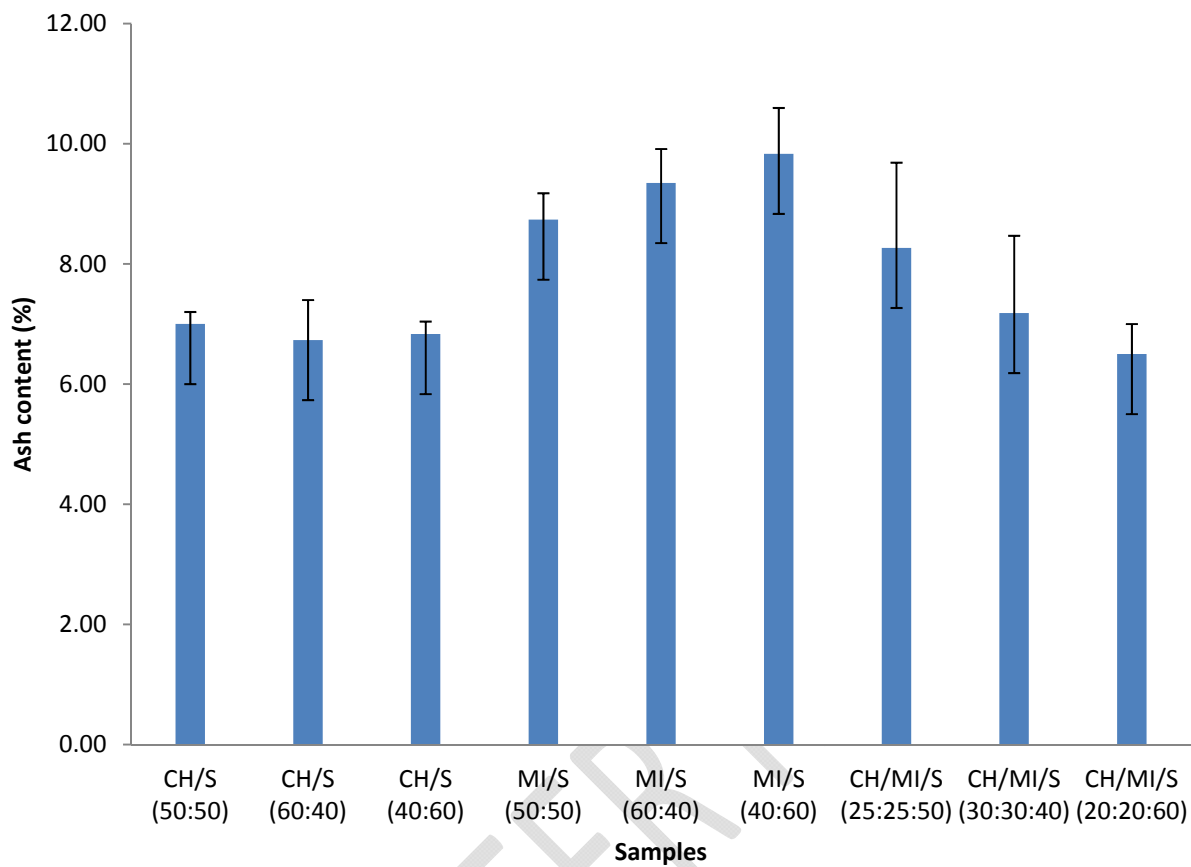


Fig. 1: Bar chart showing the ash content of the samples

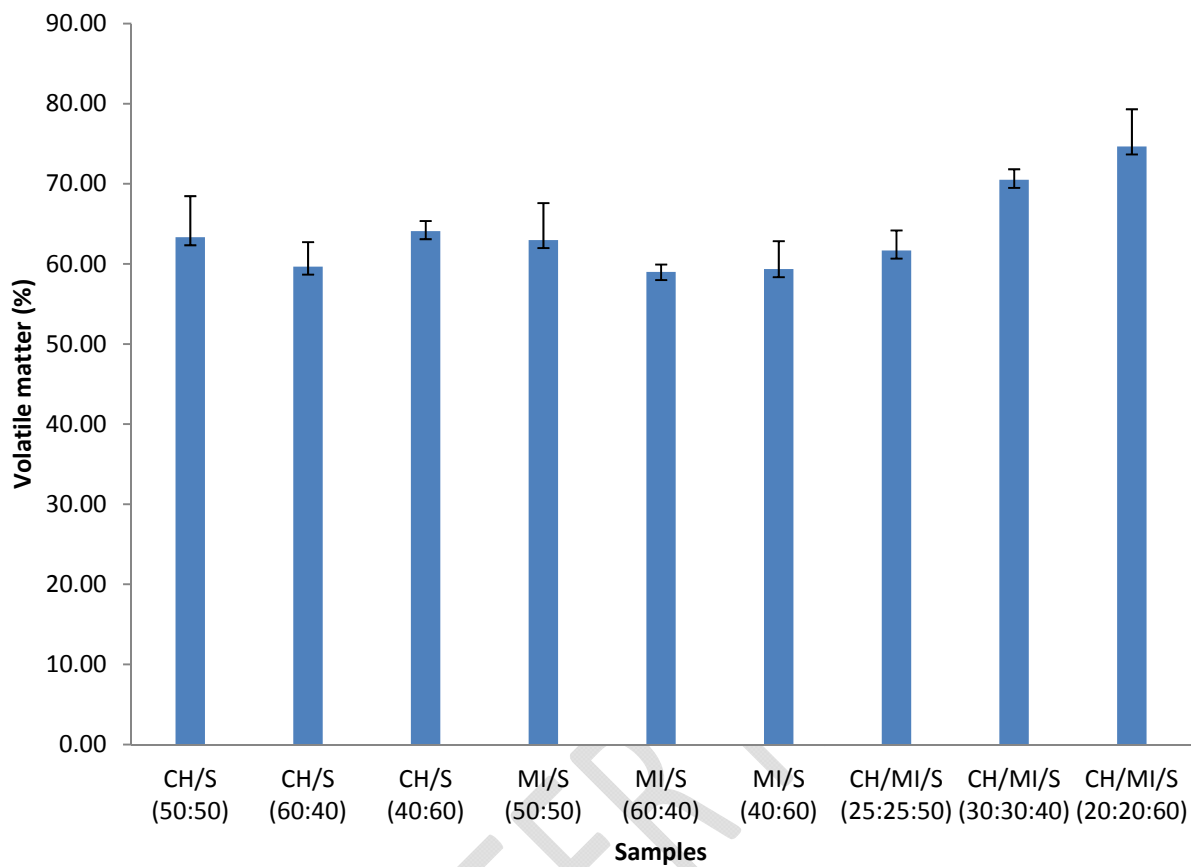


Fig. 2: Bar chart showing the volatile matter of the samples

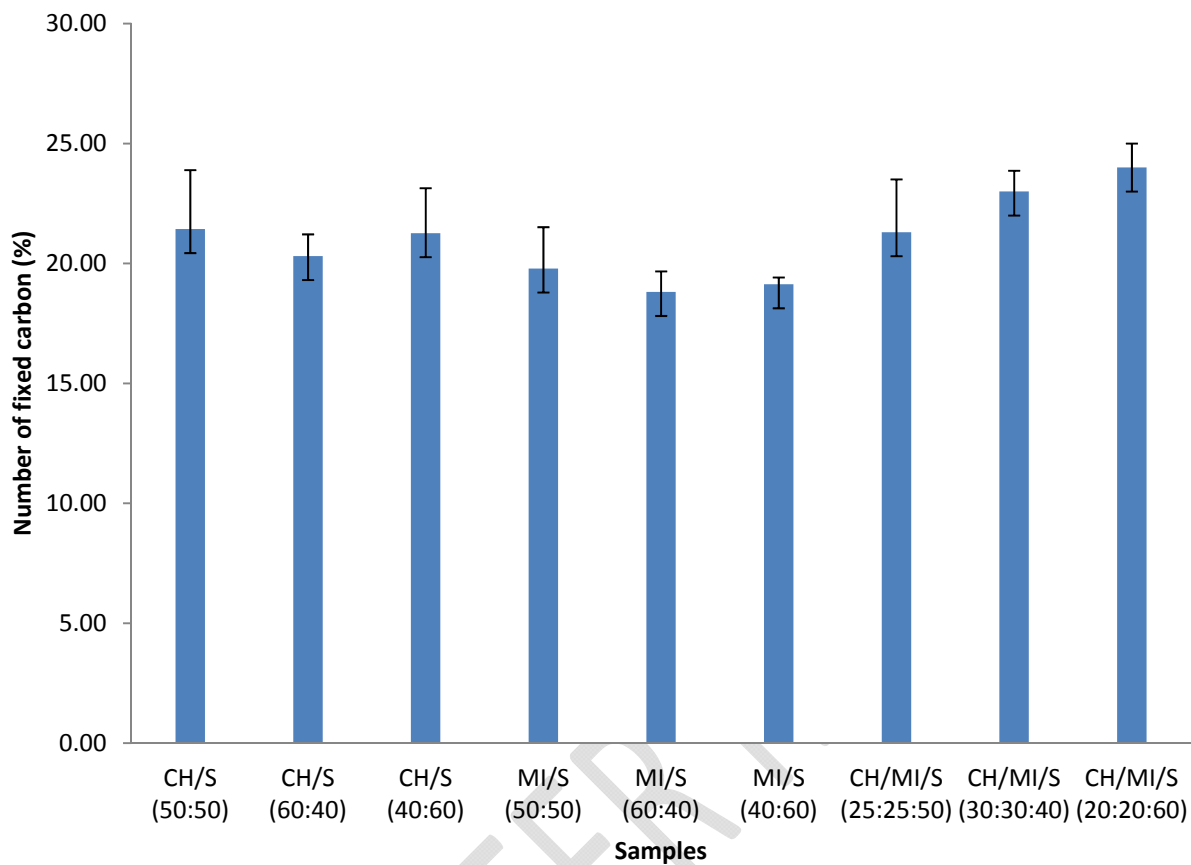


Fig. 3: Bar chart showing the number of fixed carbon in the samples

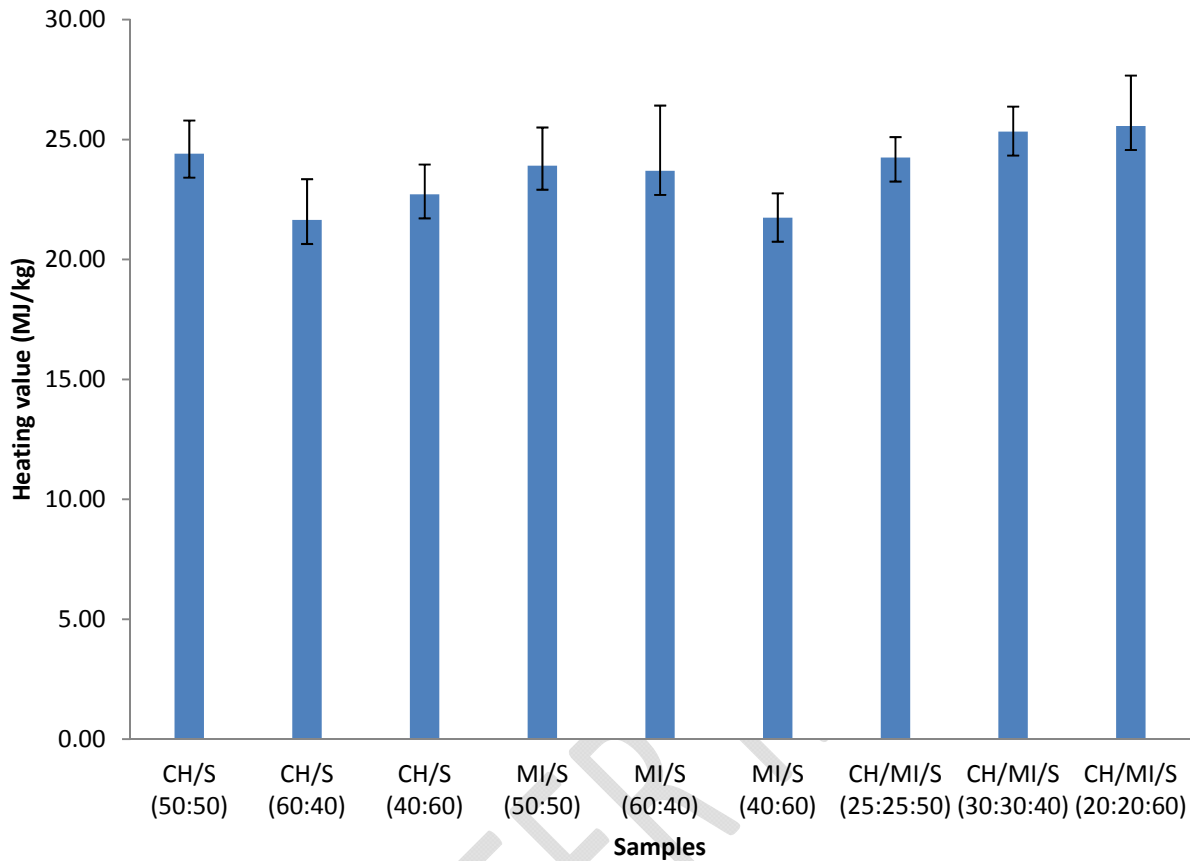


Fig. 4: Bar chart showing the heating value of the samples

4. Conclusion

Waste in terms of coconut husk and male inflorescence which are generated in large quantities and disposed indiscriminately can be utilized to produce solid fuel called briquettes. The biomass briquettes are very efficient since the quality of solid fuel depends on the following factors; providing enough heat at a time necessary, easy ignition without danger, less smoke generation and gases that is harmful to the environment. From the result of this research, it was evident that the briquette can be satisfactorily produced from coconut husk and male inflorescence of oil palm. Therefore, the use of briquette should be promoted in Nigeria so as to the reduce pressure on fuel wood for energy generation.

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