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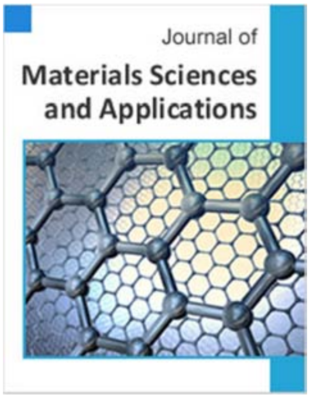

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Proximate Analysis of Smokeless Briquettes Using Agro-waste (Rice Chaff, Maize Cob and Saw Dust)

Agu Matthew Onyema[1], Hotton Joseph Anthony[2], Ukwubile Cletus Anes[1], Yakubu Shedrack[1]

[1]Department of Science Laboratory Technology, Science and Technology, Federal Polytechnic Bali, Nigeria
[2]NAFDAC, Office Complex, Chemical Evaluation and Research Directorate, Oshodi-Lagos, Nigeria

Email address
mataguonyema@gmail.com (A. M. Onyema)

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Abstract
This period of economic recession and hike in the price of petrol, diesel and electricity in many countries for daily usage have called for alternative fuel source. One of the major driving forces behind this research is the need to address the environmental consequences and health hazards associated with the use of solid fuels such as fuel wood and coal [11] and also to develop an effective means of recycling and managing agro-waste. Therefore in this research work, briquettes of Rice Chaff, Maize Cob and saw dust were produced and evaluated for use. The different briquettes produced were made by blending 120 g of the different Agro-waste each using 20 mL of gelatinous Cassava starch as a binder and Calcium Hydroxide ($Ca(OH)_2$), as the desulphurising agent. The Briquettes were produced manually in a calved mold and a G-shaped clamp was used as a press to apply pressure on the compacted Agro-waste in the mold. The result of the proximate analysis indicates that the different briquettes have reasonable calorific value. The Rice Chaff has - Ash content 17.5%, porosity index 94.4%, Burning time 35 minutes, ignition time 30s, Volatile matter 18.6%, moisture content 14.8%. The maize cob has - Ash content 43.2%, Porosity index 91.8%, Burning time 25 minutes, Ignition time 12s, Volatile matter 7.98%, moisture content 6.91%. Finally saw dust has - Ash content 11.6%, porosity index 98.7%, Burning time 8 minutes, Ignition time 9s, Volatile matter 4.23%, moisture content 3.70%. The analysis gave a contrasting combustible quality when the three samples were compared. Based on the above result, use of briquettes like rice chaff, maize cob and saw dust can effectively substitute the existing source of fuel like firewood and petroleum products/electricity because of the reasonable calorific value and other parameters obtained from the proximate analysis.

1. Introduction

Life is a continuous process of energy conversion and transformation. Thus, access to energy is necessary to harness human life and to achieve overall economic, social and environmental aspect of human development. About half of the world's household [9] still use solid fuel for cooking on a daily basis especially in the rural area of developing countries like Nigeria.

Compaction of bulky combustible materials for fuel making purposes has been a technology widely used by many countries. There have been several researches carried out on production of fuel briquettes for both domestic cooking and industrial application. One of the major driving forces behind these researches is the need to address the environmental consequences and health hazards associated with the use of solid fuels such as fuel wood and coal [11] and also effective means of recycling and managing agro-waste.

Among the common types of briquettes widely used in some countries are biomass briquettes, coal briquettes and charcoal briquettes etc. however, blending coal with biomass (Agro waste) gives rise to a briquettes with better combustion properties and pollutant emission compare to the conventional coal briquettes. This briquettes known as Bio-coal briquettes which is a type of solid fuel prepared by compacting pulverized coal, biomass (Agro-waste such as Rice chaff, maize cob, and saw dust), and binder [2]. According to [8] Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. It can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is the main component of particleboard. Sawdust has a variety of other practical uses, including serving as a mulch, as an alternative to clay cat litter, or as a fuel.

The high pressure involved in the process ensures that the coal and the biomass particles are sandwiched and adhere together, as a result do no separate during transportation, storage and combustion. Bio-coal briquettes has a favorable ignition, better thermal efficiency, emits less dust and soot [1]. However, preserving the forest resources by substituting fuel wood with bio-coal, along with the use of the ash from these briquettes for soil treatment will compensate for the briquette. Therefore, Bio-coal and also agro-waste briquetting is considered to be a clean technology.

Characteristics and uses of agro waste briquettes

From traditional point of view, waste is potentially a resource and can be classified into various categories based on its sources such as municipal wastes, residential wastes, commercial wastes, industrial wastes, agro-wastes, hazardous wastes and other waste [5]. The daily wastes are generally regarded as worthless but can be recovered, recycled and reused.

The following are qualities of a good solid fuel as enumerated by [6].

i. A good fuel should have a low ignition point
ii. It should have a high calorific value.
iii. It should freely burn with a high efficacy once it is ignited.
iv. It should not produce harmful gases.
v. It should produce least quantity of smoke and goes.

These qualities are part of what is investigated in this work so as to achieve an increased energy density. The main purpose of briquetting material is to reduce the volume and thereby increasing energy density [4]. The energy characteristics associated with briquettes are how it act and what it produces when burned are important issues or parameters looked at when describing and comparing briquettes with other fuels. The calorific value varies with ash content and moisture content. Different ash and moisture contents in briquettes result in different calorific values [4]. Normally, the ash content of wood briquettes is about 0.7%, the resulting calorific value is 17 – 18KJ/kg as the normal moisture content in Swedish production is about 10% [3].

2. Methods

a Materials

Materials required for fuel briquetting are classified into the following:

Agro-waste which comprises of Saw Dust, Rice Chaff and Maize Cob, Hand mould, Binding Materials (Prepared Gelatinous Cassava Starch), Others are Calcium Hydroxide [$Ca(OH)_2$], Electronic Weighing balance, Stop Watch, Oven and G – Clamp, Sodium Hydroxide (NaOH), Crucible, Lighter

b Methods

2.1. Biomass Collection and Drying

2.1.1. Biomass Collection

Saw Dust, Rice Chaff and Maize Cob are selected as raw materials because of their availability, low cost and abundance. The rice chaff were collected from different Rice milling houses in Bali town, Maize cob were collected from houses at angwuan Daniel – Bali and Saw dust were collected from carpenter work-shop at Baruwa road Bali, Taraba State.

2.1.2. Drying

Saw Dust, Rice Chaff and Maize Cob were broken into smaller sizes by hammer and sun dried for a period of ten (10) days until its moisture content was found to reduce to 5-10% of the original content. Later, the samples were pulverized (ground) using corona hand grinder to pass through 1mm sieve and stored for use.

2.2. Production of the Briquette Sample

The modified method of [4] was used for the production of the briquette sample. The briquettes were produced using an improvised mould of 1.5kg. Briquettes of Rice chaff, maize cob and saw dust were produced with a specific amount of $Ca(OH)_2$ added based on the mass of the waste to serve as the desulfurizing agent. Certain amount of gelatinized cassava starch was introduced based on the entire mass of the mixture to serve as the briquette binder. During the production, specific quantity of water was added to the mixture to attain cohesion and homogeneity. A binding pressure was maintained throughout the production time using a G - clamp. After production, the briquettes were sun dried for one week (7 days) before analysis. The number of days of sun drying depends on the season and the geographic nature of the area.

Figure 1. Picture of saw dust briquette.

Figure 2. Picture of a maize cob briquette.

Figure 3. Picture of a Rice Chaff briquette.

2.3. Proximate Analysis of the Briquettes

The following parameters were investigated using the produced briquettes as described by [4] with modifications were necessary.

2.3.1. Calorific Value

The calorific value was determined in line with the moisture content, ash content, ignition time, burning time, porosity index and volatile matter on the briquettes. The calorific value (KJ/Kg) of the samples under test was calculated from the temperature rise of the briquettes when burnt and its heat capacity [10]. A calorimeter was used for this process.

2.3.2. Moisture Content

A portion (18 g) each of the samples was weighed out in a wash glass. The samples were placed in an oven for 4 hours at 205°C the moisture content was determined using:

$$MC = \frac{w_1 - w_2}{w_1} \times 100. \quad (1)$$

Where, W_1 = initial weight
W_2 = Weight after drying
MC = Moisture content

2.3.3. Ash Content

A portion (4 g) were placed in a preweighed porcelain crucible and transferred into a preheated oven set at a temperature of 400°C for 3 hours after which the crucible and its content were transferred to a desiccator and allowed to cool. The crucible and its content were reweighed and the new weight noted. The percentage ash content was calculated thus:

$$AC(\%) = \frac{W_2}{W_1} \times 100 \quad (2)$$

Where, W_2 = weight of ash cooling
W_1 = Original weight of dry sample
AC = Ash content

2.3.4. Volatile Matter

A Portion (18 g) of the sample was heated to about 300°C for 30 minutes in a partially closed crucible in an oven. The crucible and its content were retrieved and cooled in a desiccator. The difference in weight was recorded and the volatile matter was calculated thus.

$$VM = \frac{W_1 - W_2}{W_1} \times 100 \quad (3)$$

Where, VM = Volatile Matter
W_1 = Original Weight of sample
W_2 = Weight of the sample after cooling

2.3.5. Ignition Time

The different samples were ignited at the edge of their bases with a Bunsen burner. The time taken for each briquette to catch fire was recorded as the ignition time using a stopwatch.

2.3.6. Burning Time

This is the time taken for each briquettes sample to burn completely to ashes. Subtracting the time it turned to ashes completely from the ignition time gives the burning rate.

$$\text{Burning rate} = \text{Ashing time} - \text{ignition time} \quad (4)$$

2.3.7. Water Boiling Test/Burning Efficiency

This was carried out to compare the cooking efficiency of the briquettes. It measures the time taken for each set of briquettes to boil an equal volume of water under similar condition

2.3.8. Porosity Index

The porosity index of the briquettes was determined based on the amount of water each sample was able to absorb. The porosity index was calculated as the ratio of the mass of water absorbed to the mass of the sample immersed in the water.

$$Porosity\ index = \frac{mass\ of\ water\ absorbed}{mass\ of\ the\ sample} \times 100 \quad (5)$$

3. Results

3.1. Result for Proximate Analysis

The result for the proximate analysis of the three (3) produced briquettes of the agro wastes were carried out following the procedure as described by [4] with modifications as shown below.

3.2. Determination of Moisture Content

Table 1. *Shows the Moisture content value of the different briquettes.*

S/N	Briquette Sample	Initial Weight M_1 (g)	Final Weight M_2 (g)	M C (%)
1	Rice Chaff	18.3	15.6	14.8
2	Maize Cob	18.8	17.5	6.91
3	Saw Dust	18.9	18.2	3.70

3.3. Determination of the Volatile Matter

Table 2. *Shows the Volatile matter of Rice Chaff, Maize Cob and Saw Dust briquettes.*

S/N	Briquette Sample	Initial Weight M. (g)	Weight on Cooling M_2(g)	Volatile matter (%)
1	Rice Chaff	18.3	14.9	18.6
2	Maize Cob	18.8	17.3	7.98
3	Saw Dust	18.9	18.1	4.23

3.4. Determination of Ash Content

Table 3. *Shows the Ash content of Rice Chaff, Maize Cob and Saw Dust briquettes.*

Briquette Sample	Weight of ash after cooling (g)	Original weight of dry sample (g)	Ashcontent (%)
Rice chaff	0.7	4	17.5
Maize cob	1.9	4.4	43.22
Saw dust	0.5	4.3	11.6

3.5. Determination of the Porosity Index

Table 4. *Shows the porosity Index for Rice chaff, Maize cob and Saw dust briquettes.*

S/N	Briquette Sample	Weight of Sample (g)	Weight of Sample and Absorbed H_2O (g)	Weight of H_2O Absorbed(g)	P I (%)
1	Rice Chaff	7.2	14.3	6.8	94.4
2	Maize Cob	7.3	14.0	6.7	91.8
3	Saw Dust	7.8	15.5	7.7	98.7

3.6. Determination of Ignition Time/Burning Time/Burning Rate

Table 5. *Shows the Ignition time/Burning time/ Burning rate of Rice chaff, Maize cob and Saw dust.*

Briquette Sample	Mass (g)	Ignition Time (sec)	Burning time (minute)	Burning Rate (minute)
Rice Chaff	2.8g	30	35	34.5
Maize Cob	2.8g	12	25	24.8
Saw dust	2.6g	9	8	7.85

Table 6. *Summary Table for all the analyzed parameters.*

S/N	Sample	MC%	VM%	P.I%	AC%	I.T(Sec)	B.T(Min)	B R (Min)
1	Rice Chaff	14.8	18.6	94.4	17.5	30	35	34.5
2	Maize Cob	6.91	7.98	91.8	43.2	12	25	24.8
3	Saw Dust	3.70	4.23	98.7	11.6	9	8	7.85

Table 7. *Shows the Statistical relation of the coefficient of variance of the briquettes.*

S/N	Sample	$\bar{x}$	d^-	S	V	CV%
1	Rice Chaff	160.6	29.28	36.08	1301.8	22.5
2	Maize Cob	159.4	35.12	43.1	1358.8	27.0
3	Sa dust	209.8	24.24	31.7	1005.2	15.1

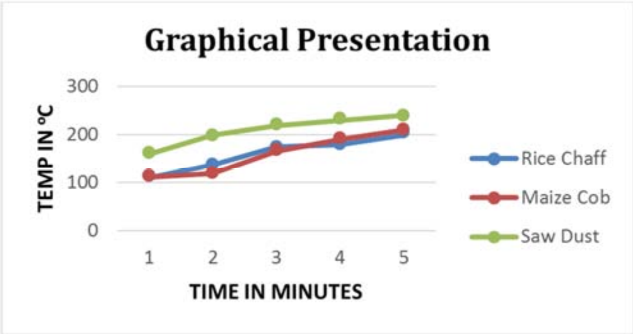

Figure 4. *Shows the graphical representation of calorific value the briquettes produced.*

4. Discussion

The result of the proximate analysis shows that Rice Chaff briquette has the highest moisture content (14.8%) while Saw Dust briquette has the lowest moisture content of 3.70%. The Saw Dust briquette has the highest porosity index (98.7%), indicating that the briquette sample absorbs more liquid under humid condition which subsequently reduces the burning rate. The Maize Cob briquette has the lowest porosity index (91.8%) which implies that it can withstand humid environment to some tolerable range.

Furthermore, in terms of ignition and burning time, Saw Dust briquette tends to burn faster while Rice Chaff briquette ignite slowly and also burn at a lower rate. The Maize Cob briquette has the highest Ash Content of 43.2% while the Saw Dust briquette has the lowest ash content of 11.6%.

In term of temperature and energy relation, the Saw Dust briquettes tend to release a very high energy at the initial time of ignition. This behavior may depend on the moisture content as shown in the result. The Rice Chaff and Maize Cob briquettes releases lower energy as compared to the Saw Dust briquette this may be as a result of their individual moisture content and density.

From the statistical summary (Table 7), Saw Dust has the highest central tendency of energy released (209.8°C) but yet having the lowest coefficient of variance (15.1%). Maize Cob has the lowest central tendency (159.4) but with the highest coefficient of variance (27.0%). This implies that the higher the mean of energy released the lower the coefficient of variation and vise-versa.

5. Conclusion

Based on the result obtained from this work, Saw dust gave the highest calorific value within the time limit as shown in the figure 1 and Rice Chaff the lowest. The study provides information about the comparison by proximate analysis of the three sample collected in Bali Local Government Area, Taraba State which gave 14.8% M.C., 17.5% A.C. for R.C.; 6.91% M.C., 43.2% A.C. for CC and finally 3.70% M.C., 11.6% A.C. for S.D. From the result obtained and the view of [12] moisture content plays a vital role in the burning characteristics of the briquettes. Based on the result obtained, use of briquettes like Rice Chaff, Maize Cob and Saw Dust may effectively substitute the existing source of fuel like firewood and petroleum products/electricity because of the reasonable calorific value obtained. The quality of the studied briquettes depends on their ability to provide enough heat at all times, generate less/little ash, and capable of igniting easily without causing damage to nearby materials. They may be used as a flammable material in brick kilns, paper mills, chemical plants, distilleries, pharmaceutical units, dyeing houses, food processing units, oil mills etc.

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