COMBUSTION PROPERTIES OF BRIQUETTES PRODUCED FROM MAIZE COB OF DIFFERENT PARTICLE SIZES.

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ABSTRACT

Maize cobs sieved into three different mesh sizes of 2.36mm, 4.75mm, and 6.36mm were densified into briquettes using starch as binder. Combustion related properties namely percentage volatile matter, percentage ash content, percentage fixed carbon and calorific or heating value of the briquettes were determined. Results showed that different mesh sizes produced briquettes of different properties. Densities of the briquette produced ranged from 0.15-0.27g/cm^3 with particle size 2.36mm having a percentage volatile matter of 57.82%, 4.75mm had 59.37% respectively while 6.30mm had the highest volatile matter of 62.90. The higher the particle size the higher the heating values which ranged from 20.93 to 24.97kj/kg. There is significant difference (P<0.05) in the heating values of the briquette produced from the three particle sizes. Assessment of the burning characteristics showed that briquette produced with particle size 6.30mm gave the highest energy value (24.97) and percentage volatile (62.91%) matter with moderate ash content.

Keywords: Briquette, maize cob, combustion properties, mesh sizes, binding agent

INTRODUCTION

Biomass particularly agricultural wastes have become one of the most promising energy sources. The idea of utilizing the residue from agricultural sectors for primary or secondary energy source is attractive due to their availability, indigenous and also environmental friendly nature.

Enormous quantity of agricultural residues and wastes are generated in Nigeria but they are poorly utilized and badly managed, since most of these wastes are left to decompose or they are burned in the field resulting in environmental pollution and degradation (Jekayinfa and Omisakin, 2005). Agro-residues are waste generated either at post-harvest point or after consumption, which are indiscriminately disposed and used inefficiently thereby causing extensive pollution and menace to the environment. Agro-residues like many other combustible materials are often not useable in the way they freely exist, due to their low density and sizes. There is need to compress these agricultural residues to briquette for a social fuel product of any convenient shape that can burn like wood. Its development results in a cleaner environment through the recycle of the agricultural wastes to briquette, which solves the country environmental problem and waste disposal (Akande, 2002).

Due to the high cost and shortage of conventional fuel such as kerosene and cooking gas, it has become necessary to diversify the energy and economic powers of individual households through the use of briquettes by reducing over-reliance on kerosene and cooking gas (in urban areas). The conversion of agro residues to briquette would reduce problem of carbon dioxide pollution due to the use of conventional fuels (kerosene and gas) and help in converting the waste to wealth.

Briquetting is a process of binding together pulverized materials (such as sawdust, groundnut shell, maize husk, bamboo and other combustible materials.) into a solid block of compressed material under pressure, often with the aid of a binder such as cassava starch. Briquetting ensures maximum utilization of resources such that waste is converted to wealth thereby contributing to socio-economic development. Briquettes exhibit great potentials over fuel wood in terms of heat intensity, cleanliness, convenience in use and relatively smaller space requirement for storage (Yaman *et al.*, 2000 and Olorunnishola, 2004). Improving the production technology helps in enhancing the potentials of the briquettes (Grover and Mishra, 1996) and this can be achieved through densification process (Ogunsanwo, 2001).

It is known that agriculture produce high rate of waste from the harvesting of maize; maize cob is an example of this waste. These wastes if left unattended to can cause environmental degradation, pollution, obstruct visuals and bio-degradation. There is, therefore, need to convert these wastes into useful materials that will be environmental friendly and cost less. Since determination of the combustion characteristics is crucial to evaluating the briquetting potential of a biomass or agro- waste, this study aimed at evaluating the potentials maize cob, of different mesh sizes for briquette production.

MATERIALS AND METHODS

Study Area

This study was carried out at the Department of Forestry and Wildlife Management premises, 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 Area at latitude 3^0 to 20^0 E to 37^0W. The region enjoys an average annual temperature of 31.8^0C. It has annual rainfall of about 1300mm with peaks in June and July and dry season of two to three months.

Materials Used

Maize cob which is an agricultural residue was used. Cassava starch was used as binder and a locally fabricated briquetting mould was used to mould the briquette.

Sample Collection

The maize cobs were collected from TREFAD Farm of Federal University of Agriculture, Abeokuta at disposing unit near the maize crib where the maize is normally stored. The cassava starch was also gotten from the Federal University of Agriculture, Abeokuta premises.

Sample Preparation

The maize cob collected was dried for 7 days to reduce excess moisture after which it was grinded, and the grinded maize cob was sieved into three different mesh sizes (2.36mm, 4.75mm, and 6.36mm) respectively. The sieved maize cob was par boiled and left for 24 hours to reduce the extraneous materials with an attempt to produce a smokeless briquette. The maize cob was again dried after which 300g of each particle sizes was weighed and mixed with 150g (2:1) of starch and molded using the locally fabricated mould. The briquette was finally dried and packaged.

Laboratory Analysis

Briquettes produced were taken to the Laboratory of Nigeria Institute of Science Laboratory Technology (NISLT) Ibadan where the burning characteristics such as; ash content, calorific value, volatile matter, fixed carbon were determined.

Proximate Analysis

Proximate analysis was carried out to determine the following combustion related properties of the briquette produced:

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

Determination of Percentage Ash Content

2g of oven dried briquette sample were placed in the furnace at temperature of 550^0C for 4hours and weigh after cooling.

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

Where D = Weight of Ash

And B = Weight of oven dried sample

Percentage Volatile Matter

The volatile matter was determined by placing 2g of pulverized briquette sample in a crucible oven to obtain constant weight after it was kept in the furnace at temperature of 550^0C for 10minutes and brought out to be cooled in the dessicator and weighed to determine the percentage volatile matter.

Percentage Volatile Matter = $\frac{B - C}{B} \times 100$

Where B = weight of oven dried samples

C = weight of sample after 10minutes in the furnace at 550^0C.

Determination of Percentage Fixed Carbon

This was calculated by subtracting the sum of percentage volatile matters and percentage ash content from 100%

Percentage Fixed Carbon = **100 – (%V + %A)**

Where %V = Percentage Volatile Matter

And %A = Percentage Ash Content

Heating Value

Heating value was calculated using the formula:

HV = 2.326(147.6C + 144V)kj/kg

Where:

HV = Heating Value

C = Percentage Fixed Carbon

V = Percentage Volatile Matter

Determination of Briquette Density

Density is defined as mass per unit volume of a sample (g/cm^3). Meter balance was used to determine the mass of each sample. For accurate readings, there were four replicates of each sample. The volume was estimated from the dimension. The length, breadth and height of each samples were measured and used in calculating the volume (m^3) which is length x breadth x width.

$$\text{Density} = \frac{\text{Mass of a sample}}{\text{Volume of a sample}}$$

DATA ANALYSIS

The data obtained were analyzed using 3 X 3 Factorial in a completely randomized design. Mean separation was carried out by Duncan Multiple Range Test (DMRT). This was done to know the difference between two means and to choose the best treatment combinations for the briquettes produced.

RESULTS AND DISCUSSION

The different mesh sizes produced briquettes of different properties. This was an indication that mesh sizes had effects on the properties. Densities of the briquette produced ranged from 0.15-0.27g/cm^3. Table 1 revealed that briquette produced with particle size 2.36mm had a density of 0.15, 4.75mm had 0.16 while 6.30mm had a density of 0.27g/cm3. This agrees with Grover and Mishra, (2006) that biomass material of 6-8mm size with 10-20% powdery component gives the best result. Results from ANOVA showed that there is significant difference ($P<0.05$) in the density of the briquette produced (Table 2).

Results of the proximate analysis performed on the briquette produced revealed that particle size 2.36mm had a percentage volatile matter of 57.82%, 4.75mm had 59.37% while 6.30mm had the highest volatile matter of 62.91% (Table 1). There was no significant difference (P>0.05) in the volatile matters of the briquette produced. Percentage fixed carbon of the briquette on the other hand ranged from 5.75-8.28%. The 2.36mm briquette had a fixed carbon of 5.75%, 4.75mm had 5.62% while 6.30mm had 8.28%. Though the briquette produced from particle size 6.30mm had the highest percentage fixed carbon yet there was no significant difference (P>0.05) in the percentage fixed carbon of the briquette produced from the 2.30mm, 4.75mm and 6.30mm particle sizes respectively.

The low ash content recorded for the maize cob is of immense importance to its maximum utilization. Briquette produced with particle size 2.36mm had the lowest ash content of 1.06%, 6.30mm had a moderate ash content of 1.20% while 4.75mm had the highest ash content of 1.23%. The values are lower than values reported for various agroforestry residues (FAO, 2003b) The percentage ash content is also lower than 2.35 and 1.63% reported for palm kernel cake (PKC) and sawdust and sawdust only respectively (RESTSASIA,2005) though higher than 0.7% recommended by 51731. The statistical analysis showed that there was no significant difference (P>0.05) between the ash content of the briquette produced from 2.36mm, 4.75mm and 6.30mm particle sizes respectively.

Results from this study showed that maize cob which is mainly regarded as a waste is very suitable for briquette production. The higher the particle size the higher the heating values. This contradicts the report of Aina *et al* (2007) on *Cederela odorata*, *Terminalia superba* and *Cordia millenii*. The heating value ranged from 20.93-24.97kj/kg. Particle size 2.36mm had a heating value of 20.92kj/kg, 4.75mm had 23.97kj/kg while mesh size 6.30mm had 24.94kj/kg. The average heating value is higher than values (19,534Kj/Kg) recorded for briquettes from a mixture of palm kernel cake (PKC) and sawdust and 18,936Kj/Kg recorded for sawdust of some hardwood species (RETSASIA, 2005). The heating values obtained in this study compare favourably with those recorded for coconut husk (Jekayinfa and Omisakin, 2005). It was equally above the recommended standard of 17,500Kj/Kg for a material to be regarded as having adequate calorific value (DIN 51731). There is significant difference (P<0.05) in the heating values of the briquette produced from the three particle sizes.

CONCLUSION

Waste in terms of maize cob which is generated in large quantity and disposed indiscriminately can be utilized for the production of solid fuel called briquettes. This will serve as a measure in curbing the environmental hazard posed by poor methods of agricultural waste disposal as well as converting waste to wealth. Assessment of the burning characteristics of briquettes produced from maize cob sieved with different sizes of mesh showed that briquette produced with particle size 6.30mm gave the highest energy value and percentage volatile matter with moderate ash content while the least energy and ash content was produced by briquettes produced from 2.36mm mesh size. Since the most important fuel property is its calorific or heating value and 6.30mm briquette gave this, a mixture of 6.30mm and 2.36mm particle sizes is advocated to enhance maximum output.

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Table 1: Mean of proximate analysis, heating value and density of different particle size of briquette produced from maize cob.

Sieve size	% Ash	% Volatile matter	% Fixed carbon	Heating value	Density
2.36	1.06±0.0621[a]	57.82±1.8893[a]	5.75±2.7585[a]	20.92±0.6833[b]	0.15±0.0030[b]
4.75	1.23±0.0896[a]	59.37±1.7312[a]	5.62±2.7039[a]	23.97±0.6863[a]	0.16±0.0004[b]
6.30	1.20±0.0959[a]	62.91±2.3358[a]	8.28±2.4389[a]	24.97±0.3569[a]	0.27±0.0024[a]

Mean (± Standard error) with the same superscript alphabets in the same column are not significantly different at 5% probability level

Table 2: Analysis of Variance (ANOVA) of the combustion properties of briquettes produced from maize cob

Parameters	Sources of Variation	SS	DF	MS	F Cal	F Tab ($p<0.05$)
Density (kg/m^3)	Treatment	0.033	2	0.16	1600.00*	4.257
	Error	0.001	9	0.0001		
	Total	0.034	11			
% Volatile matter	Treatment	54.316	2	27.193	1.096ns	4.257
	Error	144.268	9	16.030		
	Total	198.654	11			
% Fixed carbon	Treatment	17.994	2	8.997	0.323ns	4.257
	Error	250.26	9	27.825		
	Total	6243.5972	11			
% Ash content	Treatment	0.063	2	0.032	1.125*	4.257
	Error	0.253	9	0.028		
	Total	0.316	11			
Calorific value (kcal/kg)	Treatment	35.486	2	17.43	12.491*	4.257
	Error	12.784	9	1.420		
	Total	48.269	11			

Ns = not significant at $p>0.05$

* = significant at $p<0.05$