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Comparative Analysis of Briquettes Burning Efficiency and Characteristics of Coal *(Briquette)*, Rice Husk & Coal (*Briquette)* and Maize Cob, Rice Husk & Coal (*Briquette)*

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Abstract:- Maize cob, rice husk and coal (agricultural waste) were collected, grounded and sieved thoroughly and mixed with Arabic Gum (binding agent) and water in different composition and compressed into cylindrically shaped briquettes then sun dried.Based on the composition used in this research work, the briquettes produced were classified as: Pure briquettes and mixed briquettes. Pure briquettes are briquettes produced with pure agricultural waste (100% composition) i.e pure Coal briquette and pure Rice husk briquette. These was represented as briquettes A and B respectively. Mixed briquettes were produced by mixing together two or more agricultural waste (50-50% composition) i.e mixed rice husk and maize cob; mixed maize cob, rice husk and coal; briquettes respectively. These were represented as briquettes C and D respectively.Tests were carried out on the briquettes A, B C and D respectively to determine their efficiency based on boiling duration.The results showed that 5 minutes, 6.5 minutes were taken to boil (98.5^{o}C) 0.5 litres of water with briquettes A and D with no soot deposit on the pot, compared with briquettes B and C which boil 0.5 litres of water after 7minutes and 7.5 minutes with soot deposit on the pot. It was concluded that the Coal briquette; Rice husk, maize cob& Coal briquettes were efficient solid fuels for domestic cooking and heating and are environmentally friendly.

Keywords:- *Agricultural waste, Arabic gum, Briquettes,Smoke and Flames.*

I. INTRODUCTION

Fuel is expensive and the developing countries are confronted with the dilemma of increasing their food production and decreasing their energy consumption. Twice as much as this energy goes into cooking food than required for growing and harvesting it. The incessant search of wood for cooking is threatening the ecosystem and already has denuded forest in many countries (Gallagher, 1999). Certainly, fuel wood as it is commonly known is by far the most widely used household fuel (for cooking and heating) in Nigeria as in other developing countries.

The insufficient or non- availability supply of kerosene or other fuel sources (alternative cooking and heating fuels) in Nigeria has further compounded the problems of deforestation (Ilechieet al, 2005). Therefore, the use of agricultural wastes as fuel is at present being adopted in Nigeria as well as in many other developing countries, though the progress towards increasing their use as fuel is rather slow. Many of the countries have substantial quantities of agricultural waste which have not been utilized to the greatest economic advantage (Ajayi and Lawal, 1995).

In order to combine old tradition with modern technologies (briquetting) to achieve sustainable development, agricultural and domestic wastes should be treated as by-product. The conversion of such wastes into uniformly shaped models that are easy to use, transport and store is known as Briquetting.

The idea of briquetting is to use materials that are otherwise not usable due to lack of density, compressing them into a solid fuel of a convenient shape that can burn like wood or charcoal (Salah et al, 2006).

Briquettes were discovered to be an important source of energy during the first and Second World War for heat and electricity production using simple storage of waste as they have a uniform shape and free from insect and disease carriers. The raw materials suitable for briquettes are Rice straw or husk; cotton stalk; corn cob or stalk; sugar cane waste and fruit branches. Briquetting process decrease the volume of waste, serve as an efficient solid fuel of high thermal value, protects the environment from pollution and also get rid of insects (Sala et al, 2006).

II. MATERIALS AND REAGENTS

- **Materials used in the production of the briquette include:** Maize cob, Rice husk, Coal, Arabic gum (binding agent), Briquette moulder, Graduation cylinder, Sieves, Measuring scale and Water.
- **Method:** A Quantity of maize cob, rice husk, coal and Arabic gum were collected dried, milled and then sieved with 2mm sieve to obtain an overall uniform particle size. The pulverized materials were then mixed with water (measured quantity) in different compositions and densified in to cylindrical shaped briquettes.

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Based on the composition used in this research work, the briquettes produced were classified as:

- **PURE BRIQUETTES: -**Pure briquettes are briquettes produced with pure agricultural waste (100% composition) i.e pure Coal briquette and pure rice husk briquette. These was represented as briquettes A and B.
- **MIXED BRIQUETTES: -**mixed briquettes were produced by mixing together two or more agricultural waste (50-50% composition) i.e mixed maize cob and rice husk; maize cob rice husk and coal; briquettes respectively. These were represented as briquettes C and D respectively.

Briquettes A comprised of coal and Arabic gum in the ratios of 2.0:1.6 kg and briquette B comprised of Rice husk and Arabic gum in the ratios of 1.8: 1.6 which were mixed vigorously with 2000ml of water for it to form a homogeneous paste and densified into cylindrical shape briquette. While briquettes C and D which comprised of maize cob, rice husk and Arabic gum; and maize cob, rice husk, coal and Arabic gum in the ratios of 0.8:0.8:1.6 and 0.8:0.8:0.8:1.6 kg respectively which were mixed vigorously with 3000ml of water for each of the mixture to form a homogeneous paste and densified into cylindrical shape briquette. The cylindrical shaped briquettes so obtained were sun dried to minimum moisture content.

III. TESTING, RESULT AND DISCUSION

A. Test Procedure

Eight tests were carried out simultaneously in the open-air in front of the Soil Laboratory complex of the department of Agricultural Technology Hussaini Adamu Federal Polytechnic Kazaure. This was done to stimulate the traditional approach to cooking in Nigeria and also to allow free flow of air into combustion chamber of the briquette burning stove.

B. Testing Materials

The materials used in conducting the test are:

- Briquette moulder
- Briquette burning stove
- A weighing balance
- An aluminium pot
- A stop watch
- A thermometer
- Water
- Graduation cylinder
- Kerosene
- Matches

C. Testing Procedure

Initially, the weight of the dried briquettes was taken and recorded. An aluminium pot was then filled with half a litre of water. The initial temperature of the water was recorded using a thermometer, before the pot was placed on the stove. The briquette was then loaded into the briquette stove and ignited with matches. As soon as the briquettes was fully ignited, the flame and smoke colour was observed. The pot containing water was placed on the stove and the subsequent temperature up to boiling point was recorded with a thermometer deep into the pot and a stop watch was “on” to note the time taken to reach the boiling point. At boiling point, the pot was removed from the stove and the fire was put off immediately with the aid of dry sand. The remaining solid fuel briquette was then weighed and recorded. The test was repeated twice for each of the briquettes A, B, C and D.

D. Results And Discussion

The results obtained from the comparative tests were presented in the tables below;

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Table 1: water boiling test

S/N	Briquettes	Weight of dry briquettes (Kg)	Average weight of briquettes (kg)	Volume of water used (litres)	1st time duration (Min)	2nd time duration (Min)	Average time duration (Min)	Average weight of briquette left (kg)
1.	Coal A; A1 A2 A3	 0.8272 0.8284 0.8250	0.4695	0.5	5	5	5.0	0.6269
2.	Rice husk B; B1 B2 B3	 0.4680 0.4700 0.4700	0.4695	0.5	7	7	7	0.2938
3.	Maize cob + rice husk C; C1 C2 C3	 0.3810 0.3820 0.3800	0.3810	0.5	8	7	7.5	0.1021
4	Maize cob + rice husk + coal D; D1 D2 D3	 0.4150 0.4262 0.4100	0.4171	0.5	6	7	6.5	0.3210

Table 2: Density test

S/N	Briquettes	Average weight of dry briquettes (kg)	Average height of briquettes (m)	Average thickness of briquettes(m)	Volume (m^3)	Density (kg/m^3)
1	A	0.8269	0.08	0.12	0.0007	1181.29
2	B	0.4693	0.08	0.12	0.0007	670.43
3	C	0.3810	0.08	0.12	0.0007	544.29
4	D	0.4171	0.08	0.12	0.0007	595.86

NB:
Volume computed using

$$V = \frac{\pi h}{4}(D^2 - nd^2)m^3$$

Where;
V = Volume of the briquette (m^3)
D = Briquette average thickness (m)
d = Hole average thickness (m)
n = Number of holes = 12
π = constant = 3.142

Therefore,

$$V = \frac{\pi \times 80 \times 10^{-3}}{4}[120 \times 10^{-3})^2 - 12\,(15 \times 10^{-3})^2\,]\ m^3 = 0.0007\ m^3$$

Table 3: Flame Test

S/N	Briquettes	Flame colour	Smoke colour
1	A	Yellowish Blue	White
2	B	Yellowish	Black
3	C	Yellowish	Black
4	D	Yellowish Blue	White

Table 4: Average Temperature (^{O}C) of Boiled Water

Time (Min)	Briquette A	Briquette B	Briquette C	Briquette D
0	31	31	31	31
1	53	50	50.5	55.5
2	68	59	62.5	70.5
3	82	69.5	70.5	80
4	86	75	80.5	83
5	98	87.5	87.5	92.5
6	100	94	92.5	100
7	-	97	97	-
8	-	100	100	-

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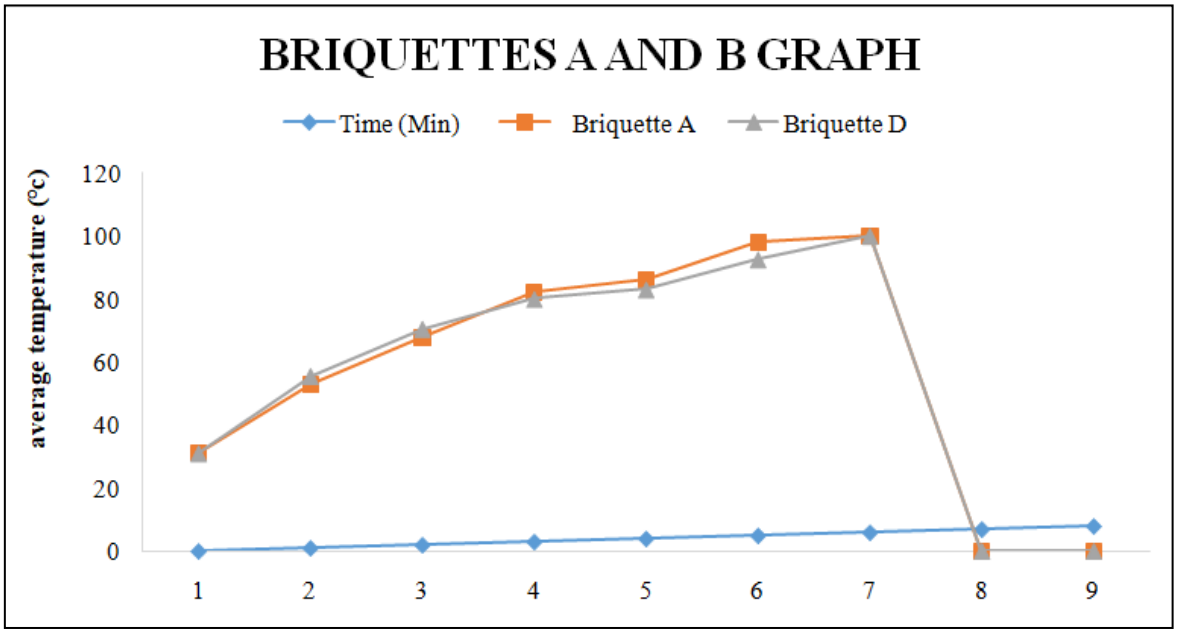

Fig. 1: Rate in temperature rise in water with time

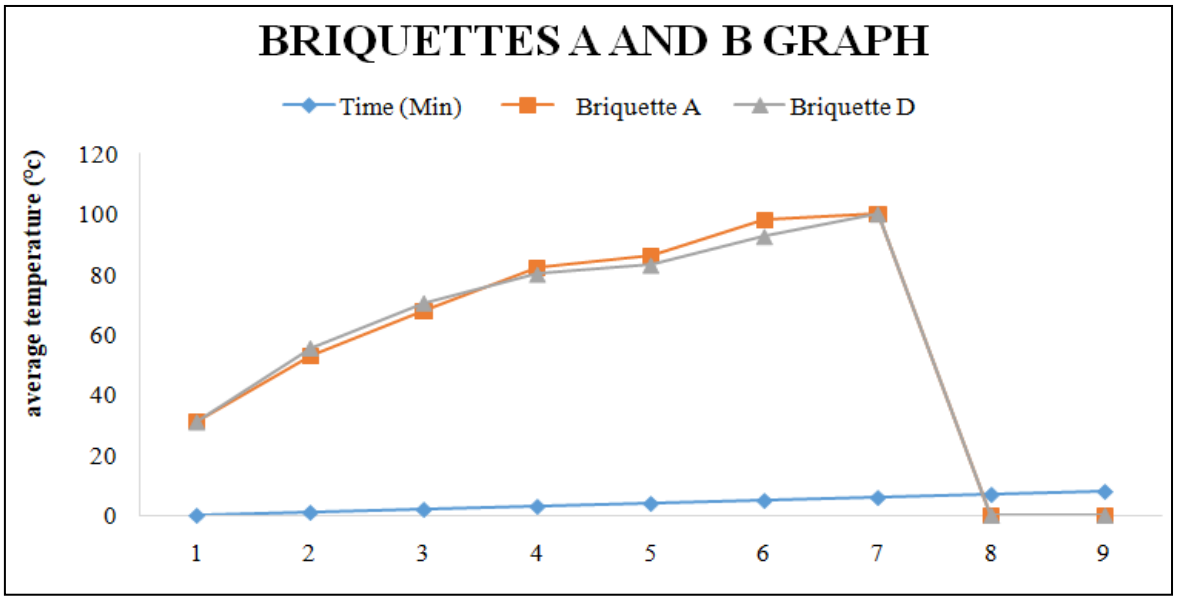

Fig. 2: Rate in temperature rise in water with time

E. Discussion

Figure 1 and 2 above represent the data obtained from the boiling test conducted with Briquettes made from Coal; Rice husk; Maize cob and Rice husk; and Maize cob rice husk and coal which are represented as briquettes A, B, C and D respectively. The time taken to boil 0.5 litres of water varied from 5.0minutes for briquette A, 7minutes for briquette B, 7.5minutes for briquette C, and 6.5minutes for briquette D.

The result showed that the efficiency of each briquette is responsible for the trend in the boiling duration and the densities. This implies that briquette A (coal) and D (Maize cob, Rice husk & coal) has the highest efficiency (in terms of heat energy). They tend to burn slowly and eventually because of their higher density as shown in Table-2. Briquette C (Maize cob + Rice husk) has probably the least efficiency, it tends to burn quickly as a result of its lower densities.

A study of smoke and flames in table-3 revealed that briquette B and C produced a yellowish flame and black smoke indicating that the samples of the solid fuels have a low quality heat with sooty deposit on the pot. While briquettes A and D produced a blend of yellowish blue flame, thus indicating that the samples of the solid fuel has high quality heat with little or no sooty deposit on the pot.

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