STUDIES ON THE COMBUSTION PROFILE OF BRIQUETTES PRODUCED FROM CARBONIZED RICE HUSK USING DIFFERENT BINDERS AT MODERATE TEMPERATURE AND DIE PRESSURE

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ABSTRACT

The unsystematic utilization of agricultural wastes has resulted into health hazard and environmental pollution. A potential solution to the afore-mentioned problems is to use these waste for sustainable energy production and supply such as renewable energy technologies. This research is carried out to study the combustion properties of briquettes produced from carbonized rice husk using gum Arabic and starch as binders at varying concentration weight of 25%, 30%, 35%, 40% and 45% with the constant weight of 100g of the substrate. A simple extruder briquette machine was fabricated to facilitate the densification of the biomass. The calorific value increased with the increase in binder concentration. The burning rate shows that briquettes with little amount of binder burnt off faster, the rate of burning decreased with the increase in binder amount. The ignition time decreased with the increase in binder amount. Gum Arabic of 45%, boiled 250ml of water in 18 minutes while the same ratio for starch binder boiled the same quantity in 14 minutes; from the results gotten 45% starch binder has the best positive outstanding results compared to other concentrations.

Keywords: Briquette, Rice husk, Densification, Gum Arabic, Starch, Fuel.

INTRODUCTION

The availability of energy is essential for the development of any country. The use of fossil fuel, firewood for energy has negative effect on both human health and the ecosystem causing deforestation which results to soil erosion, desert encroachment, atmospheric pollution and global warming (Elinge *et al.,* 2011). The increasing negative effects on the environment as a result of fossil fuels combustion, in addition to its limited stock have forced many countries to explore and change to environmental friendly alternative energy sources that are renewable to sustain the ever increasing energy demand (Mohyoub and Al Buhairi, 2006). The renewable energy sources include bio-energy, solar, wind, wave and geothermal, which are fairly abundant in Nigeria to complement the conventional energy source and provide adequate security to energy supply of the nation (Ohunakin and Olayinka, 2011).

Biomass may be used directly as a source of energy for heating or can be converted to a cleaner fuel source, for example, conversion of wood to charcoal and biomass to briquettes (Fapetu, 2000). Other energy sources that are produced from biomass are biogas, biodiesel and bio-ethanol. All these energy sources have better combustion performance and are more environmental friendly than direct combustion of biomass (Fapetu, 2000). However, fuel wood is the cheapest energy choice of rural dwellers and the urban poor, which has led to increased pressure on the forest in search of fuel wood while on the other hand, large amount of biomass resources in form of agricultural wastes are wasted either deliberately or ignorantly (Fapetu, 2000). These biomass resources can be converted to better fuel sources compared to fuel wood and can also act as a preventive measure to many ecological problems, such as deforestation and global warming at large.

MATERIALS AND METHODS

Sample Collection: Carbonized rice husk was collected from Labana rice mill industry, Birnin Kebbi, Kebbi State. Cassava starch was purchased at Zuru New Market while Gum Arabic was also obtained from Zuru Local Government Area, Kebbi State, Nigeria.

Preparation of the Sample: The collected carbonized rice husk was sun-dried for two days and sieve with a 2mm mesh to remove impurities that may prevent proper briquette formation and the sample was kept in a polythene bag to avoid absorption of moisture until required for preparation of briquettes. In preparation of binders, heating mantle was switched on and water was poured into the pot and placed on the heating mantle, after boiling, the water was mixed with the respective percentage of starch binder until a sticky gel was produced, cold water was used to prepare gum arabic binder. Six briquettes samples for each binding agent were produced with varying weights of 25:100, 30:100, 35:100, 40:100,45:100 of the substrate. After the production, the briquettes were sun-dried for three weeks before analysis as reported by Elinge *et al.* (2018).

Calorific Value: The calorific value measures the energy content of the briquettes. The procedure of the ASTM standard D5373-02 (2003) was used to determine the calorific values of produced briquettes by using the equation:

$$Qv = \frac{\mathrm{C(Q1 - Q2)}}{\mathrm{Wb}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

Q_v = Heating/ Calorific value (kJ/kg),

C = Calibration of constant for biomass acid (0.6188),

Q_1 = Galvanometer deflection without sample,

Q_2= Galvanometer deflection due to test sample,

W_b= Weight of sample.

Ignition Time: Ignition time was determined as reported by Oladeji (2010). The samples were calculated in centimetres, ignited at the base and allowed to burn until it extinguished itself. The rate at which flame propagated was calculated by dividing the distance burnt by the time taken in seconds.

$$\textbf{Ignition time} = \frac{\boldsymbol{distance\ burnt\ (mm)}}{\boldsymbol{total\ tme\ taken\ (sec)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots . (\mathbf{2})$$

Burning Rate: Briquettes burning rate were determined by recording the briquettes weight before combustion and after the briquettes were completely burnt, the rate at which fire consume the briquette samples were calculated using equation (Onuegbu *et al.*, 2011).

$$BurningRate = \frac{massoftotalfuelcomsume\ (g)}{totaltimetaken(\mathrm{min})} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Combustibility Test

Water Boiling Test was conducted by combusting 100g of briquettes of different percentage of binders (gum arabic and starch) samples respectively using charcoal stove to compare the fuel combustibility and the fuel that cooked food faster. 250ml of water was used for the test. The temperature reading was taken after every 2 minutes with mercury in glass thermometer (Kim *et al.*, 2001) until the water boiled. The time taken by each sample to boil water was monitored using stop watch.

Statistical Analysis: The average of all the parameters analyzed was computed by one-way analysis of variance (ANOVA) using Graph Pad Instant (Version 20) and results were presented as mean ± standard deviation.

RESULTS AND DISCUSSION

Table 1: COMBUSTIBILITY TEST (Gum Arabic)

25:75		30:70		35:65		40:60		45:55	
Time (mins)	(°C)	Time (mins)	(°C)	Time (mins)	(°C)	Time (mins)	(°C)	Time (mins)	(°C)
0	28	0	27.5	0	28.1	0	28	0	28
2	31.5	2	32.2	2	34.1	2	33.5	2	33.6
4	38.2	4	36.0	4	39.0	4	41.7	4	45.9
6	45.1	6	42.3	6	46.5	6	53.8	6	55.9
8	57.6	8	56.9	8	50.6	8	64.4	8	68.1
10	62.3	10	68.2	10	68.6	10	73.2	10	72.6
12	76.4	12	79.6	12	81.0	12	84.1	12	77.8
14	81.1	14	84.1	14	85.4	14	88.4	14	85.7
16	87.5	16	91.6	16	93.2	16	95.1	16	97.2
18	92.9	18	98.5	18	99.4	18	97.8	18	100
20	97.1	20	100	20	100	20	100	20	
22	100	22		22		22		22	

Values are presented as mean ± SD (n = 3) of triplicate results analysed using Dunnett Multiple Comparisons Test.

Table 2: COMBUSTIBILITY TEST (Starch)

25:75		30:70		35:65		40:60		45:55	
Time (mins)	(°C)	Time (mns)	(°C)	Time (mins)	(°C)	Time (mins)	(°C)	Time (min)	(°C)
0	28	0	28.1	0	27.5	0	28	0	27
2	36.2	2	38.3	2	39.6	2	40.1	2	43.5
4	39.5	4	41.6	4	43.5	4	45.3	4	51.9
6	47.7	6	47.8	6	49.8	6	51.0	6	68.7
8	58.5	8	59.5	8	63.5	8	67.8	8	79.9
10	69.2	10	79.2	10	70.2	10	79.8	10	88.6
12	77.7	12	82.3	12	78.9	12	83.9	12	97.5
14	84.1	14	93.1	14	97.8	14	99.8	14	100
16	90.6	16	97.2	16	100	16	100		
18	97.8		100						
20	100								

Values are presented as mean ± SD (n = 3) of triplicate results analysed using Dunnett Multiple Comparisons Test.

Table 3: Combustion Properties of Carbonized Rice husk Briquettes

Binder	Calorific Value (KJ/Kg)		Burning Rate (g/mins)		Ignition Time (s)	
Ratio/Sample	Gum Arabic	Starch	Gum Arabic	Starch	Gum Arabic	Starch
25:75	1729.3 ± 768.28	2258.3 ± 51.56	27.547 ± 0.011	20.757 ± 0.040	45.550 ± 0.580	32.560 ± 0.010
30:70	2578.8 ± 46.821	2728.7 ± 97.12	26.670 ± 0.012	19.347 ± 0.058	41.540 ± 0.528	31.023 ± 0.003
35:65	2768.9 ± 49.170	2927.7 ± 62.91	24.343 ± 0.006	18.670 ± 0.002	38.290 ± 0.036	28.233 ± 0.005
40:60	2854.5 ± 83.003	3226.8 ± 88.18	23.230 ± 0.571	17.583 ± 0.005	37.260 ± 0.017	25.673 ± 0.007
45:55	2942.2 ± 137.03	3461.9 ± 91.19	23.047 ± 0.652	16.263 ± 0.006	36.687 ± 0.012	21.187 ± 0.006

Values are presented as mean ± SD (n = 3) of triplicate results analysed using Dunnett Multiple Comparisons Test.

Discussion

The calorific value determines the amount of heat present in a material (Santhebennur and Jogttappan, 2012). From the results, 45:55 ratio has the highest calorific values, 2942.2KJ/Kg for gum arabic and 3461.9KJ/Kg for starch binder. Calorific value increased with the increase in binder concentration, most of the briquettes contained the minimum requirement of calorific value for commercial briquettes (>17500KJ/Kg) as reported by DIN 51731 (1996). Starch bonded briquettes have higher calorific values which could be due to enhanced characteristics. Cassava starch binder has been reported by Sotanndes *et al.* (2010) as having the ability to increase the calorific value of briquettes.

The burning rate results varied from 27.5g/min to 23g/min for gum arabic and 20.7g/min to 16.2g/min for starch. From the results, it show that briquettes with little amount of binder burnt off faster than those with higher amount of binder. The rate of burning of the briquette decreased with increasing binder concentration. The implication of this results is that more fuel might be required for cooking with fuel produced at 25:75 ratio than 45:55 ratio as they burnout readily. Davies and Abolude (2013) reported that slow burning rate is desirable because less is required for cooking, 45:55 starch shows the highest burning efficiency.

The ignition time results decreased with the increase in amount of binders. Gum Arabic ranged from 45 seconds to 36.6 seconds and 32 seconds to 21.1 seconds for starch binder. The ignition time is the function of the volatile matter. The higher volatile matter is an indication that fuel will be ignited easily and increase in flame length (Elinge *et al.,* 2011). Briquettes with a favorable ignition have a better thermal efficiency with less environmental hazard (Praveena *et al.,* 2014).

Results in Tables 1 and 2 show the variation of different temperature with time taken for both gum arabic and starch bonded briquettes to boil 250ml of water, 25:75 gum arabic bonded briquettes took 22 minutes to boil 250ml of water while 45:55 boil the same quantity of water in 18 minutes. Starch bonded briquettes of 25:75 boil the same amount of water in 18 minutes and 45:55 boil the same quantity of water in 14 minutes. From the two respective binder results, briquettes produced using gum arabic took longer time to boil water compared to starch binder. The reason might be gum arabic briquettes smoked more than starch briquettes; in that case much energy was lost to smoke, therefore affecting its boiling properties.

CONCLUSSION: The findings of this study showed that carbonized rice husk briquettes would serve as a good alternative source to hydrocarbons and fossil fuel. The two binders used in the research; gum arabic and starch are mainly because of their availability in every environment, cheap and having high binding effect. Starch binder shows good combustibility characteristics than gum arabic and can be economically processed into a good fuel briquettes for domestic application because of its better performance.

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