# Comparative Studies Of Water Boiling Test And Ignition Time Of Carbonized Rice Husk Using Starch And Gum Arabic As Adhesives

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***Abstract- In evaluating national development and standard of living of any nation, the supply and consumption of energy are very important. The overdependence of fossil fuels as the major energy source has yielded several environmental disasters such as global climate change, environmental degradation and environmental pollutions which have led to human health challenges. Renewable energy for sustainable development is practically the best alternative means of generating energy. The focused of this research is Briquetting, which is one of the alternatives to fossil fuels, to compare the cooking efficiency of briquettes produced from starch and gum arabic at different ratios. Two sets of solid fuel Briquettes were produced from carbonized rice husk at varying concentration weight of 25:75, 30:70, 35:65, 40:60 and 45:55 respectively in grams. It took (25%) ratio gum arabic briquettes 22 minutes to boil 1litre of water while it took (45%) ratio gum arabic bonded briquettes 18 minutes to boil the same quantity of water. As compared to (25%) ratio starch briquettes that took 20 minutes and (45%) ratio starch took 14 minutes to boil the same quantity of water. It is observed that briquetting has improved the combustion efficiency. This could be attributed to burning rate, fixed carbon, density and calorific value which are the factors combine that determines the water boiling time. Therefore, (45%) ratio starch binder shows better combustion characteristic***

***Indexed Terms- Briquette molder, Biomass utilization, waste to energy, Carbon sink.***

## I. INTRODUCTION

The current energy crisis has become a serious threat to the sustainability of the planet. Since the industrial revolution, fossil fuels have generated many environmental problems such as global warming and cities with heavy air pollution, due to a significant increase of carbon dioxide in the atmosphere. Furthermore, with the increase of the world population and growing demand for energy, the diversification of the energy sources is necessary to prevent power outages (Yahaya and Ibrahim, 2012). Among alternative energy sources, biomasses play the most important role, accounting for about 80% of the energy generated by renewable energy carriers worldwide. The main difference between biomass and other renewable is the possibility of its utilization as a fuel. Biomass is also the only renewable energy source that can be stored and applied to produce heating, electricity and fuels. A briquette is a block of compressed coal, biomass or charcoal dust that is used as fuel (Zubairu and Gana 2014) Briquetting is a high pressure process which can be done at elevated temperature (Moore and Johnson 1999), or at ambient temperature depending on the technology one applies. In some briquetting techniques, the materials are compressed with or without addition of adhesive (Marinder *et al*., 2012).

Generally briquetting are done where charcoal is used as one of the major feed stocks, but the use of charcoal in briquettes brings many problems, one of them is the emission of greenhouse gases like CO2, SOX, NOX, and CH4. To mitigate all these problems biomass briquetting is a better option; it mainly includes rice husk, wheat straw, cotton stalk, bagasse, jute stick etc. Apart from agro wastes the dried leaves are disposed off by burning them in open field, which is a huge loss of potential heat energy. Biomass briquetting has advantages of large accumulation of ash and higher thermal efficiency than loose biomass burning (Maciejewska *et al*., 2006). On the other hand it has higher density and energy content, less moist compared to its raw materials. Apart from these advantages it can be used in domestic purpose (cooking, heating, barbequing), industrial purposes (agro industries, food processing) in both rural and urban areas (Marinder *et al.*, 2012). Those are renewable source of energy and they avoid adding fossil carbon to atmosphere. So being derived from renewable resources biomass briquettes has superior qualities than coal fuels

## II. 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 to remove impurities and the sample was kept in a polythene bag 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 weight of 25:75, 30:70, 35:65, 40:60,45:55 of the substrate. After the production the briquettes were sun-dried for three weeks before analysis as reported by (Elinge *et al.*, 2011)

- Ignition Time: Ignition time was determined as reported by Oladeji (2010). The samples was graduated in centimeters, 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.

$$Ignition\ time = \frac{distance\ burnt\ (mm)}{total\ tme\ taken\ (sec)}$$

- 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).

$$Burning\ Rate = \frac{mass\ of\ total\ fuel\ comsume\ (g)}{total\ time\ taken(\mathrm{min})}$$

- Calorific Value Determination: The calorific or heating value is an important indicator of the quality of the pressed fuel briquettes. It measures the energy content of the briquettes. It is defined as the amount of heat evolved from a pressed fuel briquettes. The procedure of the ASTM standard D5373-02 (2003) was used to determine the calorific values of produced briquettes by using the equation.

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

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.

- Combustibility Test: Water Boiling Tests 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 boil. 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. Values with different superscripts are significantly different at $p<0.05$.

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 Characteristics of the Briquettes

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

Values are presented as mean ± SD (n = 3) of triplicate results analysed using One-way ANOVA followed by Duncan Multiple Comparisons Test using SPSS Version 20.0. Values with different superscripts are significantly different at $p<0.05$.

## III. DISCUSSION

Results in Table 1 and 2 shows the variation of different temperature with time taken for both gum arabic and starch bonded briquettes to boil 1litre of water, 25:75 gum arabic briquettes took 22 minutes to boil 1litre 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 takes longer period of 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 which affected it boiling properties.

Heat value determines the energy content in a material. Is the property of biomass fuel that depends on the moisture content (Santhebennur and Jogttappan, 2012). Fixed carbon is a major contributor to the heating value of fuel briquettes. The calorific values for gum arabic ranged from 1729.3KJ/Kg for (25%) ratio to 2942.2KJ/Kg for (45%) ratio and for starch from 2258.3KJ/Kg for (25%) ratio to 3461.9KJ/Kg for (45%) ratio. The calorific value increased with the increase in binder ratio. This compared favourably with the works of (Adegoke, 2002) who observed an increase in the calorific value of briquettes of palm kernel shell mixed with sawdust from 19.91 MJ/kg (4755.4 kca/kg) MJ/kg to 20.54 MJ/kg (4905.9 kcal/kg). The lowest calorific value observed was 1729.3KJ/Kg for (25%) ratio and the highest calorific value of 3461.9KJ/Kg for (45%) ratio starch. Most of the briquettes produced were found to meet the minimum requirement of (>17500KJ/Kg) in accordance with the standard test method DIN 51731 (1996) for household cooking and small-scale industrial cottage applications. The higher the amount of carbon and density, the higher the calorific value of the briquettes.

(Sotanndes *et al* 2010) reported that cassava starch as a binder has the ability to influence the calorific value of briquettes. Calorific value is the most important fuel property (Ayahan and Ayse 1998). Since the primary aim of briquetting biomass is to produce a good and efficient high energy fuel source that enhance combustion, the (45%) ratio starch have the most outstanding result, that implies that the amount of binder used have a significant influence on the properties of the briquettes, so carbonized rice husk briquettes can provide better alternative to fossil fuel. Therefore, (45%) ratio starch is one of the best mixtures to be considered in producing 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 shows 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 coking, 45:55 starch shows the highest burning efficiency.

The ignition time results decreased with the increased in amount of binders. Gum Arabic ranged from 45 seconds to 36.6 seconds for gum Arabic 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 ingnited 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).

## CONCLUSION

It can be concluded that, waste material like dry leaves, wheat straw & saw dust are potential feed stocks & starch is better binder for biomass briquetting. Among the combination ratios and binders it can be suggested that the combination of starch and 45:55 is better one rather than combination of gum arabic and 45:55. Generally, rice husk are burnt to reduce the waste which causes severe pollution to environment and for fertilizer, but if wisely handled these waste then could be a better option for briquetting. Hence for an agrarian country like India that produces huge amount agriculture waste every year, use of these wastes as briquettes can be an economically viable, sustainable and environment friendly solution.

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