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**COMPARATIVE ANALYSIS OF CALORIFIC VALUE OF BRIQUETTES PRODUCED FROM SAWDUST PARTICLES OF *DANIELLA OLIVERI* AND *AFZELIA AFRICANA* COMBINATION AT BINARY AND TERTIARY LEVELS WITH RICE HUSK**

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**ABSTRACT**

*Comparative performance in calorific value was determined from the binary and tertiary combination of briquettes produced from biomass materials (sawdust) of Afzelia africana, Daniella oliveri and Rice husk at 20% 30%, and 40% starch binder levels. From the proximate analysis of the samples, it was observed that there were significant differences ( $p < 0.05$ ) between the densities, Percentage Ash content, Percentage Volatile matter and Percentage Fixed carbon of the samples. A progressive increase in heating value was observed among briquettes produced as the starch level increased. Briquettes produced at the tertiary combination of Afzelia africana + Daniella oliveri + Rice husk biomass recorded the highest heating value of 4827.20kcal/kg at 40% starch level while Daniella oliveri + Rice husk briquettes at binary level recorded the least heating value of 4586.72kcal/kg at 20% starch level. Among the various starch levels the tertiary combination had the least Ash content of 4.30% at 40% starch level while Daniella oliveri + Rice husk briquettes at 20% starch level had the highest Ash content of 9.29%. It is therefore recommended that 40% starch level be used for briquettes production at binary and tertiary combinations using Afzelia africana, Daniella oliveri and Rice husk biomass.*

**Key Words:** Briquettes, Rice husk, *Daniella oliveri*, *Afzelia Africana*, starch

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**INTRODUCTION**

The decreasing availability of fuel- like wood, coupled with the ever-rising prices of kerosene and cooking gas in Nigeria, has drawn attention to the need to consider alternative sources of energy for domestic and cottage level industrial use in the country

(Lucas and Akinoso, 2001). As rightly noted by Stout and Best (2001), a transition to a sustainable energy system is urgently needed in the developing countries such as Nigeria. Renewable energy sources are being sought for domestic cooking in developing countries due to the fact that their non-renewable

counterpart such as kerosene, cooking gas etc., are not keeping up with peoples' demand (Olawole *et al.* 2008). Also the high cost of non-renewable energy sources has made people to start deviating to the use of renewable energy sources for domestic cooking. The use of biomass fuel such as composite sawdust briquette has been proposed to be a good source of renewable energy for domestic cooking (Kuti and Adegoke, 2008). This is due to the fact that sawdust, i.e., the chief raw material in the production of composite sawdust briquette is readily available in large quantities as wastes in majority of the wood processing industries. It has been proposed that the conversion of sawdust wastes through briquetting process will go a long way in reducing waste disposal problems in majority of the wood processing industries. Furthermore, deforestation which promotes pollution will be drastically reduced if the use of sawdust waste is enhanced. Before promoting the use of any

new type of fuel, it is expedient to have good understanding of its performance. However, research had shown that most of these agricultural residues, rice husk residues inclusive contain enormous amount of energy and if properly harnessed with other wastes can go a long way to mitigate the problem of global energy shortage (Jekayinfa and Scholz, 2000, 2009; Oladeji, 2011). However, rice husk in its present form, just like any other agricultural residues, cannot be effectively used for energy conversion. This is because utilization of agricultural residues is often difficult due to their uneven characteristics. It is widely accepted that the majority of the residues in their natural forms have lower density, higher moisture content and lower energy density. Besides, the low bulk density and dusty characteristics of the biomass also cause problems in transportation, handling and storage (Husan *et al.* 2002). The application of biomass briquetting i.e. transforming the loose

biomass into briquettes is an effective way to solve these problems and contribute towards alleviation of energy shortage and environmental degradation (El-Saeidy, 2004). The objective of the study is therefore to compare the calorific values of briquettes produced from sawdust particles of *Daniella oliveri* and *Afzelia africana* combinations at binary and tertiary levels with rice husk in the different percentages of starch binder.

## **MATERIALS AND METHOD**

**Study Area:** The briquettes were produced in the Forestry, Fisheries and Mechanical Engineering laboratories of the University of Agriculture, Makurdi, Benue state of Nigeria. Makurdi, the study area is located in the Guinea savannah region of north central Nigeria.

**Sample Collection:** Sawdust particles of *Daniella oliveri* and *Afzelia africana* were collected at the Timber shade in Industrial layout while Rice husk was collected at Rice mill in Makurdi town of Benue state.

**Particle Preparation:** Sawdust of *Daniella oliveri*, *Afzelia africana*, and Rice husk were air dried to reduce moisture content to between 8-12% which is within the acceptable operating limit for briquetting. A sieve of 1.18mm was used to obtain uniform grain size distribution for the samples (Elaigwu *et al.* 2010 and Imeh *et al.* 2011).

**Binder ratio:** Cassava starch was used as binder for the briquettes and 3 starch ratios notably: 20%, 30% and 40% of the weight of sample was used to determine the effect of binder concentration on physical and chemical characteristics of briquettes produced.

**Briquette production processes:** The sawdust materials from *Daniella oliveri*, *Afzelia africana* and Rice husk collected were sundried to reduce moisture content to approximately 12% (Elaigwu *et al.* 2010 and Imeh *et al.* 2011). Grinding machine was used to reduce the sawdust and rice husk materials to smaller sizes after which a

1.18mm sieve was used to obtain uniform sizes. Starch binder was prepared using 250 ml of boiled water at binder ratios of 20%, 30%, and 40% of the bulk weight of briquette materials. The briquettes were produced in binary combination using *Daniella oliveri* sawdust + Rice husk and *Afzelia africana* with rice husk in 1:1 ratio. For tertiary combination the 3 briquette materials; *Daniella oliveri* + *Afzelia africana* + Rice husk were mixed in ratio of 1:1:1. The binary and tertiary combinations were thoroughly mixed with cassava starch at 20%, 30% and 40% binder levels and handfed into rectangular shaped metallic briquette mould (10cm x 5cm x 5cm) which was compacted using a hydraulic press at a pressure of 19.62KN/m<sup>2</sup>. The compacted briquettes were air dried for 21 days and used for proximate analysis. The parameters investigated were as stated below:

**Percentage Moisture Content (%MC):**

This was determined by measuring 2g of

pulverized briquettes into a crucible (w<sub>1</sub>). The content was dried in an oven at 105°C for 3hrs to obtain oven dry weight (w<sub>2</sub>). Moisture Content was then calculated as:

$$\%MC = \frac{\text{Wet weight (w}_1) - \text{Dry weight (w}_2)}{\text{Dry weight (w}_2)} \times 100$$

**Volatile matter (%Vm):** Percentage Volatile matter was determined by keeping the substance in crucible with oven dry weight (w<sub>2</sub>) in the furnace for 10mins at 550°C to obtain weight (w<sub>3</sub>) after which the Volatile matter in it have escaped, the method was used by Carrel *et al.* (1981) and Fuwape and Shobanke (1998). This was used in calculating percentage Volatile Matter (%VM) thus:

$$\%Vm = \frac{\text{Dry weight (w}_2) - \text{Weight of sample (w}_3)}{\text{Dry weight (w}_2)} \times 100$$

**Ash Content (%Ash):** 2g of oven dried pulverized briquettes were weighed in a crucible (w<sub>2</sub>), this was placed in the furnace

for 4hrs at 550<sup>o</sup>c to obtain the ash weight ( $w_4$ ). Percentage Ash Content (%Ash Content) was calculated as:

$$\% \text{Ash} = \frac{\text{Weight of ash } (w_4) \times 100}{\text{Dry Weight } (w_2)}$$

**Fixed carbon (%Fc):** This was calculated by subtracting the sum of % Volatile matter and % Ash content from 100.

$$\% \text{Fc} = 100\% - (\% \text{Vm} + \% \text{Ash})$$

**Specific Heat of Combustion (Hc):**

Specific Heat of Combustion (HC) was calculated using the formula  $H_c = 0.35[(147.6 \times Fc) + (144 \times Vm) + (\% \text{Ash})]$  kcal/kg (Carre *et al.* 1981).

The data collected for sample tests was subjected to analysis of variance using the factorial designed in Completely Randomized Design (CRD) while the Least Square Difference (LSD) was used in

separating means with high levels of significance.

## RESULTS

### Effect of 20% starch level on Combustion Properties of Briquettes produced.

*Azelia africana* + Rice husk briquettes had the highest heating value of 4718.45kcal/kg at 20% starch binder and least % ash content of 6.66% (Table 1). *Daniella oliveri* + Rice husk briquettes had the least heating value of 4586.72kcal/kg, % ash content of 9.29% and high fixed carbon percentage of 9.95%. The heating values of the briquettes ranged from 4586.72 - 4718.45 kcal/kg was is higher than that of Elaigwu, (2010) and Imeh, (2011) who got 3215.25 and 4010.0.8 kcal/kg respectively in their work on *Khaya senegalensis* and *Daniella oliveri*.

**Table 1: Combustion Properties of Briquettes at 20% Starch Level**

Biomass materials	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Heating Value (%)
<i>Daniella oliveri</i> + Rice husk	80.76 ± 0.06 <sup>a</sup>	9.29 ± 0.01 <sup>a</sup>	9.95 ± 0.05 <sup>a</sup>	4586.72 ± 0.87 <sup>a</sup>
<i>Afzelia africana</i> + Rice husk	83.98 ± 0.02 <sup>b</sup>	6.66 ± 0.01 <sup>b</sup>	9.35 ± 0.01 <sup>b</sup>	4718.45 ± 0.46 <sup>b</sup>
<i>Daniella oliveri</i> + <i>Afzelia africana</i> + Rice husk	77.16 ± 0.18 <sup>c</sup>	9.19 ± 0.01 <sup>c</sup>	13.64 ± 0.21 <sup>c</sup>	4596.89 ± 0.12 <sup>c</sup>

**Note:** means with different alphabets are significantly different

**Effect of 30% Starch level on Combustion Properties of Briquettes produced.**

The result in Table 2 shows that the specific heat of combustion values of the species at 30% starch level ranged from 4616.02 kcal/kg to 4747.43kcal/kg. *Daniella oliveri* + *Afzelia africana* + Rice husk briquettes had the highest heating value of 4747.43kcal/kg with

least ash content of 6.01%. The result was however lower than 5210kcal/kg for *Anoëissus leiocarpa* and 4908 kcal/kg for *Gmelina arborea* briquettes as reported by Egbewole *et al.* (2009).

**Table 2: Combustion Properties of Briquettes at 30% Starch Level**

Biomass material	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Heating Value (%)
<i>Daniella oliveri</i> + Rice husk	85.60 ± 0.40 <sup>a</sup>	8.62 ± 0.01 <sup>a</sup>	5.78 ± 0.29 <sup>a</sup>	4616.02 ± 0.35 <sup>a</sup>
<i>Afzelia africana</i> + Rice husk	79.36 ± 0.35 <sup>b</sup>	8.45 ± 0.01 <sup>b</sup>	12.19 ± 0.43 <sup>b</sup>	4632.60 ± 0.38 <sup>b</sup>
<i>Daniella oliveri</i> + <i>Afzelia africana</i> + Rice husk	87.32 ± 0.20 <sup>c</sup>	6.01 ± 0.01 <sup>c</sup>	6.60 ± 0.39 <sup>c</sup>	4747.43 ± 0.52 <sup>c</sup>

**Note:** means with different alphabets are significantly different

### Effect of 40% starch level on Combustion Properties of Briquettes produced

The heating values of all briquette combinations at 40% starch levels were not significant (Table 3). Tertiary combination produced the highest heating value of 4827.20kcal/kg at 40% starch level. The highest heating value observed in the tertiary

combination of *Daniella oliveri* + *Afzelia africana* + Rice husk may be due to the high concentration of exudates coupled with lignin content and density of *Afzelia africana* as it tends to show higher heating value in almost all the starch percentage level.

**Table 3: Combustion Properties of Briquettes at 40% Starch Level**

Biomass material	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Heating Value (%)
<i>Daniella oliveri</i> + Rice husk	87.03 ± 0.01 <sup>a</sup>	6.54 ± 0.01 <sup>a</sup>	6.44 ± 0.03 <sup>a</sup>	4720.95 ± 0.38 <sup>a</sup>
<i>Afzelia africana</i> + Rice husk	89.08 ± 0.46 <sup>b</sup>	5.85 ± 0.02 <sup>b</sup>	5.07 ± 0.58 <sup>b</sup>	4720.10 ± 0.34 <sup>b</sup>
<i>Daniella oliveri</i> + <i>Afzelia africana</i> + Rice husk	91.78 ± 0.48 <sup>c</sup>	4.30 ± 0.01 <sup>c</sup>	3.91 ± 0.80 <sup>c</sup>	4827.20 ± 0.35 <sup>c</sup>

Note: means with different alphabets are significantly different

### CONCLUSION

The heating values of briquettes produced at binary and tertiary levels using *Daniella oliveri*, *Afzelia africana* and rice husk biomass were high at the different starch binder levels. The calorific value was not inhibited by increase in starch levels at

binary and tertiary combinations of briquettes from *Daniella oliveri*, *Afzelia africana* and rice husk. The high volatile matter discharge from the briquettes could pose high health and climate risks when used in closed environments.

## RECOMMENDATIONS

Production of briquettes at binary and tertiary combinations using *Daniella oliveri*, *Afzelia africana* and Rice husk samples was a more efficient way of utilizing the biomass materials due to the higher heating values generated.

- The briquettes produced at binary and tertiary combinations using *Daniella oliveri*, *Afzelia africana* and Rice husk samples at between 20-40% starch

binder should be used in well aerated environment instead of closed chamber due to the high discharge of volatile matter which may pose health risks to end users.

- Research on the user friendliness of the briquettes should be undertaken to ascertain the ease of burn, ignition and CO<sub>2</sub> emission of the briquettes since the starch content was high.

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