Journal of Good Governance and Sustainable Development in Africa (JGGSDA), Vol. 4, No 4, August, 2019
Available online at http://www.rcmss.com/index.php/jggsda; www.academix.ng
ISSN: 2346-724X (P) ISSN: 2354-158X (E)
Abdul Musa, Binfa Bongfa, Ibrahim A. Audu, P.A. Ogakwu, 2019, 4(4):70-79

PROXIMATE ANALYSIS OF BRIQUETTES PRODUCED FROM IDAH-BASED MALAINA TIMBRE SAWDUST AND RICE HUSK USING STARCH AS BINDER

[1]Abdul Musa, [2]Binfa Bongfa, [3]Ibrahim A. Audu, [4]P.A. Ogakwu

[1, 2, 3&4]Department of Mechanical Engineering, Federal Polytechnic Idah, Kogi State, Nigeria

Editorial Comment: *This article is published on the strength of the paper's potential in contributing to technological and sustainable development in Africa*

ABSTRACT
There are significantly high quantities of rice husk (RH) and sawdust (SD) as by-products from the rice mills and wood milling industries in Idah, Kogi state Nigeria. These by-products are virtually being wasted and or constituting environmental pollution as there is no established used made of them. This study proximately analyzes the properties of fuel briquettes produced from these rice husk, saw dust, and their blends using cassava starch as binder. The briquettes were produced from 100% SD, 100% RH and blends of 75%RH + 25% SD, 75% SD + 25%RH, and 50%RH + 50%SD. The proximate analysis and physical properties such as percentage ash content, volatile matter, moisture content, fixed carbon, bulk density, and calorific values of the briquettes were determined. From the results, it was found that, the 100% SD recorded the highest calorific value (29,463.26kJ/kg) with lowest ash content (1.51%), assuring a very high burning efficiency and the highest volatile matter (87.77%), while the 100% RH has the lowest volatile matter. The 100%RH and 100%SD briquettes respectively has the lowest (7.46%) and highest (10.53%) percentage moisture content though within the recommended limit (< 15%). The 75%RH + 25%SD briquettes has the highest value of fixed carbon of 0.70%, ranking it highest in heat generating capacity during burning. The 100%SD and the 75%RH + 25%SD briquettes has the highest bulk density of 0.28 g/cm^3, rating them as having the longest burning time among the briquettes produced in the current work. The use of 100%SD and 75%RH + 25%SD as biomass briquettes can offer several advantages including, reduction of environmental pollution from the use of fossil fuels, and reduction of ecological disaster arising from deforestation.

Keywords: *Briquettes, Proximate analysis, Physical Properties, Sawdust, Rice husk*

Nomenclatures

a = weight of dried crucible + ash
c = weight of dried crucible
m = weight of sample in grams
x = weight of dry matter in grams
y = weight of residue in grams
V = volume of sample in cm^3

1.0. INTRODUCTION

Fuel-wood such as sawdust from wood industries and agricultural waste such as rice-husk maize-husk, sugarcane residues, cassava peels, palm fibres and coconut fruit fibres, peanut shells, and groundnut shells have been viewed as lucrative materials for quantum fuel briquetting (Chaiklangmuang, Supa, & Kaewpet, 2008; Chin & Siddiqui, 2000; Shinde & Singarvelu, 2014). Wherever any of these materials are available in commercial quantity, there is need to explore their viability as fuel briquettes. In countries like Thailand, southern USA, Bangladesh and Nigeria where rice, groundnut, coconut products and timbers are in high production, rice-husk (RH), groundnut shell, and sawdust (SD) can be popular fuel briquetting resources (Akowuah, Kemausuor, & Mitchual, 2012; Chaiklangmuang et al., 2008; Huda, Mekhilef, & Ahsan, 2014).

In Nigeria where electricity is unstable and/or not available in most locations, and kerosene and gas as cooking fuels are very expensive (Idah & Mopah, 2013), non-ecofriendly and non-renewable, the drive towards alternative, renewable and environmentally friendly cooking fuel sources such as briquettes is most encouraged, especially as the use of firewood is being discouraged to reduce the rate of deforestation.

Briquettes are densified biomass materials to improve their handling characteristics and to enhance their volumetric calorific values (Akowuah et al., 2012). The process of producing briquettes involves sorting, sieving, grinding, composting, pressing, and drying (Tumuluru, Tabil, Song, Iroba, & Meda, 2015). Biomass briquettes can be produced from a large range of green sources which include; Saw dust, Rice husk, waste papers, charcoal, coconut husk etc. Some of the social benefits of using biomass briquette have been presented to include saving trees, and thereby protecting the environment from all ecological disasters arising from deforestation, and saves the environment from pollution arising from the use of conventional fuels (Cambero & Sowlati, 2014; Hu et al., 2014). The advantages of using briquettes are that they are concentrated, slow burning, more efficient, smokeless, available, easy to make, easily stored, easily transported, cheaper and renewable materials (Pantuhan, 2011).

Idah, in kogi state of Nigeria is a high industrial base for rice processing and timber production. These endeavor made abundantly available, rice husk and sawdust as waste which are not being so much used. It is here envisaged that the use of this materials as briquettes will reduce deforestation, environmental pollution from fossil fuels, supplement the energy need of the society, and contribute to national economy.

This work aims at using these abandon resources for making briquettes as solid fuels for home and industrial heating. Researches have revealed that performance of briquettes is based on the combustible biomass materials and the binders used. Idah-based sawdust, and rice-husk, and their various mixtures with cassava starch as binder were analyzed to see their performance.

2.0. MATERIALS AND METHODS

The materials and equipment used for the production and analysis of the briquettes are presented in Tables 1 and 2 respectively.

Table 1: Materials used for production of briquettes

S/N	Materials	Specification
1	Sawdust (SD)	400 kg of malaina tree-based timbre wood sawdust obtained from wood sawing industry in Idah metropolis, Kogi state, Nigeria.
2	Rice husk	400 kg of rice husk obtained from rice milling industry in Idah metropolis, Kogi state, Nigeria.
3	Starch	Cassava starch
4	Water	10 liters of locally consumed water in Idah

Table 2. Equipment used in production and analysis of the briquettes

S/N	Equipment	Specification
1	Briquette mould	Locally fabricated 12 number rectangular matrix array 200 x 200 x 300 mm^3 cell wooden mould (Figure 1)
3	Weighing balance	Digital weighing balance
4	Porcelain crucible	Cylindrical shape
5	Oven	Electric oven
6	Desiccators	Electric desiccators
7	Furnace	Electric muffle furnace
8	Bomb calorimeter	Oxygen type
9	Measuring cylinder	25 ml cylinder

2.1. Briquettes Production

The process of producing the briquettes involved mixing 100g of the sawdust (100% SD) with 5g of starch and water. These materials were properly mixed and packed into the wooden mould (Figure 1) and sufficiently densified to a pressure of about 5 psi (0.345 bar) using a hand operated hydraulic press. The densified briquettes were ejected and left to dry under the open sun for 5 days. The processes were repeated for 100%SD, 100%RH, 50%SD + 50%RH, 75%SD + 25%RH and 25%SD + 75%RH. Samples of the produced briquettes are presented in Figure 2.

Figure 1: Briquettes mould showing prepared raw material filling stage.

Figure 2: Samples of the produced briquettes

2.2. Proximate Analysis

2.2.1 Bulk density

A clean empty measuring cylinder was weighed on a digital weighing balance and the weight (w_1) noted. It was then filled with one of the samples, tapped on a wooden table thirty times and then weighed and the weight (w_2) noted. The volume (V) of sample after tapping was noted. The procedure was repeated for all the samples. This experiment was carried out at room temperature.

The bulk density (BD) in g/cm^3 was calculated using equation (1).

$$BD = \frac{m}{V} = \frac{w_2 - w_1}{V} \quad (1)$$

2.2.2 Moisture content

AOAC (1990) official method was used. Porcelain crucibles washed and dried at 100^{0}C for 30 minutes and allowed to cool in desiccators. Porcelain crucibles were each weighed and recorded as *c*, and around 1g of each sample was placed into a separate crucible, reweighed and placed inside the oven of a bomb calorimeter set at 105^{0}C and left inside for 4 hours. The samples were then removed from the oven, allowed to cool and weighed. The moisture content of each of the samples was calculated using equation (2).

$$\text{Moisture content } (MC) = \frac{m-x}{m} \times 100\% \quad (2)$$

2.2.3 Ash content

AOAC (1990) method as in the determination of moisture content was followed after which the briquette samples were placed inside muffle furnace, heated at 600^{0}C for 4 hours, removed and cooled in a desiccator and weighed as a in grams. The ash content (AC) is computed from equation (3).

$$\text{Ash Content } (AC) = \frac{a-c}{m} \times 100\% \quad (3)$$

2.2.4 Volatile matter

The method by Meynell (1982) reported in Moki, E. C., Abubakar, B. Y. U., Bayewa, M. A., & Mu'azu, M. (2018) was used in this test. The dried residue was heated in a muffle furnace at 600^{0}C for 2 hours. The heated residue was cooled in desiccators and weighed. The volatile matter of each briquettes was computed from equation (4).

Volatile Matter, $VM = \frac{x-y}{m} \times 100\%$
(4)

2.2.5 Fixed carbon content
The fixed carbon content of the produced briquettes in this work was analyzed according to method reported in Berkowitz (1994). The fixed carbon content was estimated using equation (5)
$Fixed\ carbon\ content(FCC) = [100 \quad VM + AC + MC]\%$ (5)
2.2.6 Calorific value
The calorific value of each of the produced briquettes was analyzed using an oxygen bomb calorimeter (model XRY-1A). 1g of one of the produced briquettes was pelleted and turned into the said bomb calorimeter and ignited under a high pressure of oxygen gas. The heat energy released was absorbed by the surrounding water inside the bomb calorimeter.
Energy content or calorific value $CV = \frac{E \ T-2.3L-V}{m}$ (KJ/kg) (6)
Where
E= energy equivalent of the calorimeter
T = temperature
L =length of burnt wire
V = volume of briquettes
M = weight of briquettes sample.

3.0 RESULTS AND DISCUSSION

The sawdust / Rice husk briquettes produced has been analyzed and the result is as presented in Figures 3 - 6. Chemically, biomass is plant materials with combination of cellulose (about 60%), lignin (30%), and other organic materials (about 10%) (http://bit.ly/1eG0L8l).
3.1 Bulk Density of the Briquettes
Bulk density of briquette expresses the densification of the briquette.
The bulk density (BD) of the briquettes produced in the current work are presented in Figure 3.

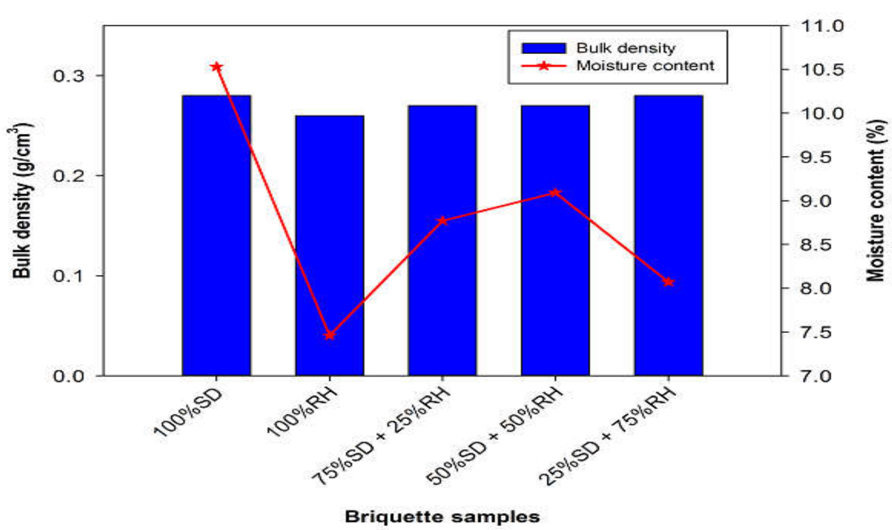

Figure 3: Bulk density (BD) of the produced briquettes

From the results, the 100%RH briquettes has the lowest, while the 100%SD and 75%SD + 25%RH has the same highest value of 0.28g/cm^3 bulk density. These should be that in the current work, the shape, size, surface characteristics, and density of the particles of the 100%RH briquette as well as its moisture content did not favour its densification while these said parameters did favour the densification of 100%SD and 75%SD + 25%RH briquettes. The same arguments have been reported of these parameters in the work by Bhagwanrao and Singaravelu (2014). The use of 100%SD and 75%SD + 25%RH briquettes will contribute meaningfully to energy independence, environmental control, and reduction in deforestation. The latest being from the fact that trees will no longer be fell for firewood.

3.2 Moisture Content of the Briquettes

The moisture contents (MC) of briquettes is the amount of water present in the briquettes, and is always expressed as a percentage of the briquette's weight of dry or wet sample. The moisture contents of the produced briquettes are as shown in Figure 3.

The 100% RH briquettes has the lowest while the 100%SD briquettes has the highest moisture content. The moisture content of the mixed rice husk (RH) and saw dust (SD) samples increased with the increase in the proportion of the saw dust (SD). It can be observed here that the moisture contents of all the produced briquette samples were all less than 15%, which presented then suitable as the values are within the limit (15%) recommended for briquetting of agro residues (Efomah & Gbabo, 2015; Wilaipon, 2008), and within the operating limits (8 -12%), as reported by Li and Liu (2000).

3.3 Ash content of the studied briquettes samples

The residue after all the moisture have been removed and the fats, proteins, carbohydrates, vitamins and organic acids burnt away by ignition at about 600^{0}C is called ash. It is usually taken as the measure of the mineral content of raw waste. The ash contents of the produced briquettes are presented in Figure 4.

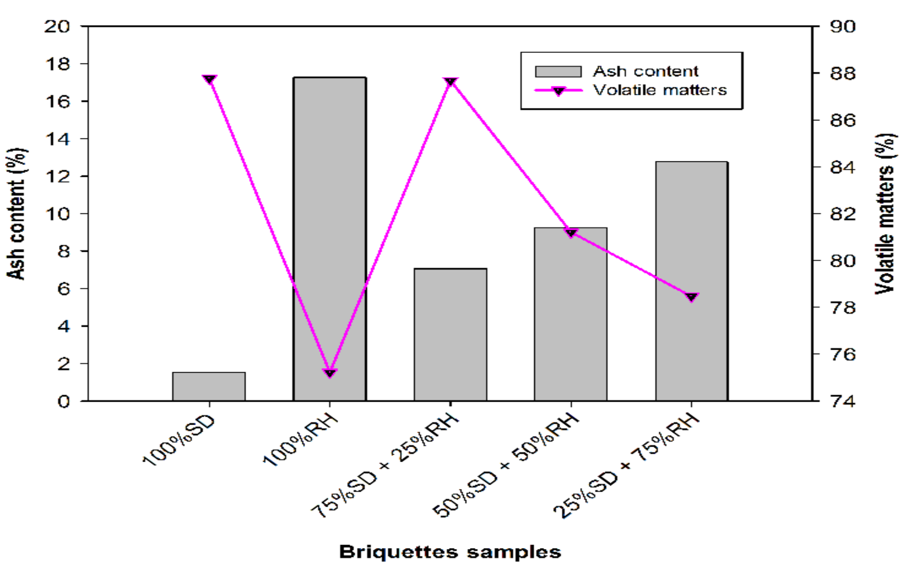

Figure 4: Ash Content of the produced briquettes

From the figure, the 100%RH has the highest while the 100%SD has the lowest ash contents. Higher ash content in a fuel will usually results to higher dust emissions and affects the combustion volume and efficiency while low ash content offers higher heating value for briquettes (Tembe, Otache, & Ekhuemelo, 2014). The graph in Figure 4 depicts that the higher the proportion of sawdust (SD) in the briquette sample, the lower the ash content. Sawdust briquette will make a better solid fuel when stand-alone than the rice-husk and their blend from the stand point of ash content.

3.4 Volatile Matter of the Briquettes

Volatile matters (VM) refer to the products given off by a material as gas or vapour, when the materials (biomass) is heated to about 400 – 500 ^{0}C (Raju, Praveena, Satya, Jyothi, & Rao, 2014). The percentage volatile matters of the produced briquettes are presented in Figure 4. The 100%SD has the highest volatile matters, while the 100% RH has the lowest volatile matters. The results show that the volatile matter content of each of the tested samples falls within the neighborhood of the volatile matter content of biomass reported in previous works (Raju et al., 2014). Percentage volatile matter has a great influence on the thermal decomposition and combustion characteristics of solid fuels. Fuels with higher volatile matters burn faster while those with lower volatile matters such as coals need to be burnt on a grate, because they take a long time to burn if they are not cut in smaller sizes (Raju et al., 2014). By this, the findings in this work is that 100%SD burn fastest, followed by 75%SD + 25%RH, 50%RH + 50%SD, 75%RH + 25%SD, then 100%RH.

3.5 Fixed Carbon Content of the Briquettes

The fixed carbon content of a solid fuel is the mass remaining after the volatiles, ash and moisture have been released (McKendry, 2002). The fixed carbon content of the produced briquettes in this work is as shown in Figure 5.

From the results, the 75%RH + 25%SD has the highest while the 100%RH has the lowest fixed carbon. Raju et al. (2014), reported that, low fixed carbon content of solid fuels would cause it to have prolong cooking time because of its low heat release and calorific energy. That is to say, the higher the fixed carbon the better the briquette. Among the briquette produced, 75% RH + 25%SD briquettes is the highest generator of heat during burning, whereas 100%RH will generate the least heat among the samples. There is synergy in heat release as demonstrated by higher values of the fixed carbon content in the mixed briquettes residues than with the primary residues.

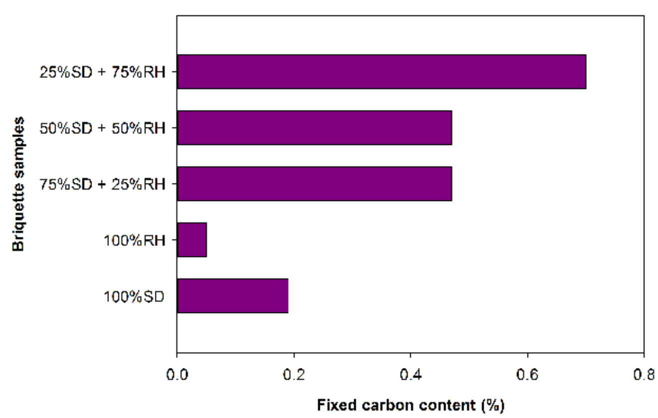

Figure 5: Fixed carbon content of the produced briquettes

3.6 Calorific Value of the Briquettes

Calorific value also known as heat value of a solid fuel expresses the energy content of the fuel (Akowuah et al., 2012) of these samples vary in the same order with their calorific values. The higher the calorific value of the fuel sample the higher the energy content, and of course the better.

The calorific values of the briquette samples tested in this work are reported in Figure 6. The higher the bar the higher and hence the better the calorific value.

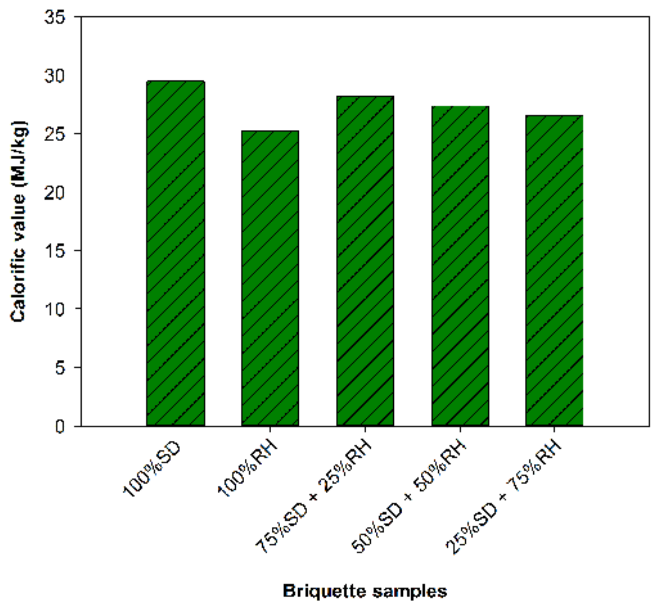

Figure 6: Calorific value (CV) of the produced briquettes

Among all the briquettes produced, the 100%RH (25.21 MJ/kg) has the lowest while the 100%SD recorded the highest (29.46 MJ/kg) calorific value. There was no synergy in energy values through blending of the feed stocks, rather the energy value reduces with reduction in the proportion of the sawdust. The implication of these values is that 100%SD has the lowest ash content, followed by 75%SD + 25%RH, 50%RH + 50%SD, 75%RH + 25%SD then 100%RH, based on the descending order of their calorific values, as reported in the literature that, the higher the calorific value, the lower the ash content (Ogwu, Tembe, & Shomkegh, 2014). However, the calorific values showed that briquettes from either of the two feed stocks or their blends can sufficiently produce heat energy household and small scale industry used.

CONCLUSION

In this work, briquettes were produced from sawdust, rice husk, and sawdust/rice husk blends, with starch as binder. The proportion of sawdust and rice husk in the production varies from 25:75, 75:25, 50:50 and 100%.

All the briquette samples have acceptable value of moisture content which fall within the recommended limit (less than 15%). The 100% SD briquette has the lowest ash content, highest calorific value and volatile matter implying that it has highest burning efficiency, fastest burning rate (though not advantageous) and have the highest heating value.

The 100%RH briquettes has the lowest volatile matter content implying that it has the slowest burning rate. The 75%RH+25%SD briquettes has the highest value of fixed carbon which makes suggesting the highest heat generating capacity during burning. The 100%SD and 75%SD + 25%RH briquettes has the same highest value of bulk density of 0.28g/cm^3 indicating most favoured densification, a parameter very useful in solid fuels.

The researchers hereby conclude that the sawdust has preferred proximate parameters compared to the rice husk. Blends of the two raw materials did not result in visible synergy but still very attractive especially at 77%SD to 25% RH composition which resulted in highest fixed carbon of 0.70% promising a comparable heat generating capacity to 100%SD.

REFERENCES

Akowuah, J. O., Kemausuor, F., & Mitchual, S. J. (2012). Physico-chemical characteristics and market potential of sawdust charcoal briquette. *International Journal of Energy and Environmental Engineering, 3*(1), 20.

AOAC (Association of Official Analytical Chemists). (1990). Official methods of analysis. *Assoc Anal Chem*.

Bhagwanrao, S. V., & Singaravelu, M. (2014). Bulk density of biomass and particle density of their briquettes. *International Journal of Agricultural Engineering, 7*(1), 221-224.

Cambero, C., & Sowlati, T. (2014). Assessment and optimization of forest biomass supply chains from economic, social and environmental perspectives–A review of literature. *Renewable and Sustainable Energy Reviews, 36*, 62-73.

Chaiklangmuang, S., Supa, S., & Kaewpet, P. (2008). Development of fuel briquettes from biomass-lignite blends. *Chiang Mai J. Sci, 35*(1), 43-50.

Chin, O. C., & Siddiqui, K. M. (2000). Characteristics of some biomass briquettes prepared under modest die pressures. *Biomass and Bioenergy, 18*(3), 223-228.

Efomah, A., & Gbabo, A. (2015). The Physical, Proximate and Ultimate Analysis of Rice Husk Briquettes Produced from a Vibratory Block Mould Briquetting Machine. *International Journal of Innovative Science, Engineering & Technology, 2*(5), 814-822.

Hu, J., Lei, T., Wang, Z., Yan, X., Shi, X., Li, Z., . . . Zhang, Q. (2014). Economic, environmental and social assessment of briquette fuel from agricultural residues in China–A study on flat die briquetting using corn stalk. *Energy, 64*, 557-566.

Huda, A., Mekhilef, S., & Ahsan, A. (2014). Biomass energy in Bangladesh: Current status and prospects. *Renewable and Sustainable Energy Reviews, 30*, 504-517.

Idah, P., & Mopah, E. (2013). Comparative assessment of energy values of briquettes from some agricultural by-products with different binders. *IOSR Journal of Engineering, 3*(1), 36-42.

Li, Y., & Liu, H. (2000). High-pressure densification of wood residues to form an upgraded fuel. *Biomass and Bioenergy, 19*(3), 177-186.

McKendry, P. (2002). Energy production from biomass (part 1): overview of biomass. *Bioresource technology, 83*(1), 37-46.

Moki, E. C., Abubakar, B. Y. U., Bayewa, M. A., & Mu'azu, M. (2018). Ignition and Burning Rate of Sheanut Shell Briquettes Produced at Moderate Temperature and Die Pressure. American Journal of Earth and Environmental Sciences, 1(3), 145-149

Ogwu, I., Tembe, E., & Shomkegh, S. (2014). 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. *Journal of Research in Forestry, Wildlife and Environment, 6*(2), 13-21.

Pantuhan, G. (2011). Ten major advantages of briquettes.

Raju, C. A., Praveena, U., Satya, M., Jyothi, K. R., & Rao, S. S. (2014). Studies on Development of Fuel Briquettes using Biodegradable Waste Materials. *Journal of Bioprocessing and Chemical Engineering, 2*(1).

Shinde, V., & Singarvelu, M. (2014). Thermo gravimetric analysis of biomass stalks for briquetting. *Journal of Environmental Research and Development, 9*(1), 151.

Tembe, E., Otache, P., & Ekhuemelo, D. (2014). Density, Shatter index, and Combustion properties of briquettes produced from groundnut shells, rice husks and saw dust of Daniellia oliveri. *Journal of Applied Biosciences, 82*(1), 7372-7378.

Tumuluru, J., Tabil, L., Song, Y., Iroba, K., & Meda, V. (2015). Impact of process conditions on the density and durability of wheat, oat, canola, and barley straw briquettes. *BioEnergy Research, 8*(1), 388-401.

Wilaipon, P. (2008). Density equation of bio-coal briquettes and quantity of maize cob in Phitsanulok, Thailand. *American Journal of Applied Sciences, 5*(12), 1808-1811.