Density, Shatter Index and Heating Value of Briquettes Produced from the Leaves of Terminalia Mentalis and Sawdust of Daniela Oliveri

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ABSTRACT

This study investigated some qualities of briquettes produced from the leaves of Terminalia mentalis and sawdust of Daniela oliveri as alternative to the conventional fuelwood resources used for domestic cooking. The leaves of Terminalia mentalis and sawdust of Daniela oliveri was collected and sundried to equilibrium moisture content. The samples were sieved into uniform fractions and used to produce briquettes at 25% of starch to sample as binder. The experimental design was a 2 x 3 factorial in Completely Randomised Design (CRD). Densities, Shatter index and Combustion related properties such as % moisture content, % volatile matter, % fixed carbon, % ash content and Specific heat of combustion (Heating value) were investigated from the produced briquettes. Terminalia mentalis briquettes recorded a highly significant relaxed density of 0.668 g/cm3 in seven (7) days. Terminalia mentalis briquettes recorded a higher weight loss of 2.00% and lower shatter resistance of 98% which was significantly lower than Terminalia mentalis + Daniela oliveri briquettes with weight loss of 0.02% and higher shatter resistance of 99.98%. The specific heat of combustion value ranged from 9704.0 kcal/kg to 11053.0 kcal/kg for Terminalia mentalis and Terminalia mentalis + Daniela oliveri respectively. The percentage Ash content was significant, for Terminalia mentalis briquettes which recorded a higher %Ash content of 12.56% , 30.93% fixed carbon and 56.52% volatile matter while there was no significant difference in %moisture content. The effect of particle size also showed that there was no significant difference in % Volatile matter and heating value. The relatively high heating values of the briquettes indicate that the materials can be a very good alternative source of energy for cooking.

Keywords: *Briquettes, Density, Weight loss, Shatter resistance, Combustion properties.*

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1. INTRODUCTION

Nigeria is faced with a major task of finding a means of expanding its energy services especially to the rural households without jeopardizing the health and environmental conditions of the rural communities (Philip, 2007). Attention is therefore drawn to the enormous biomass resources of Nigeria which include wood, forage, grasses, shrubs, animal wastes, wastes arising from agricultural, municipal, as well as industrial activities, etc. The potential for the use of alternative biomass resources is very high because about 80% of Nigerians depend on wood biomass for their energy needs. Fuel wood accounts for about 90% of the total wood demand from the forest and the demand is still on the increase due to population increase and lack of alternative energy (source) (Onuegbu *et al.*, 2010).

The leaves of *Terminalia mentalis* and sawdust of *Daniela oliveri are useful* biomass resources which can be processed into a useful energy source instead of burning to pollute the environment. The burning of biomass leads to bushfires thereby causing more havoc to soil biodiversity, geomorphic process and volatilizes large amount of the nutrients accumulated in the soil including organic matter, however, conversion of these wastes into fuel briquette is a good opportunity for Nigeria (Tembe, 2015). The main objective of this study therefore is to determine the density, shatter index and heating value of briquettes produced from the leaves of *Terminalia mentalis*.and sawdust of *Daniela oliveri*.

2. MATERIALS AND METHODS

2.1. Study Area

The study was carried out in the University of Agriculture, Makudi, Benue State, situated at North bank side of the River Benue covering an area of 46 squares km and lies between longitude 08°36'E and 08°41'E, latitude 07°52'N.

2.2. Sample Collection

The leaves of *Terminalia mentalis* were collected in Makurdi area of Benue State where the tree shades its leaves in large quantities for briquette production. Sawdust from *Daniela oliveri* was also collected from sawmill in Makudi town. Cassava starch was used as the binding agent.

2.3. Particle Preparation

The leaves of *Terminalia mentalis* and sawdust of *Daniela oliveri* were sundried for 7days to remove excess moisture content. A mortar and pestle was used to pound *Terminalia mentali s*leaves. while sieve sizes of 1.7mm,2.36mm and 3.35mm were used to sieve the pounded *Terminalia mentalis* leaves into 3 different particle sizes. The pounded leaf particles were weighed, labelled and stored ready for briquetting. Cassava starch was prepared by mixing 25g of starch in 100ml of water. Starch solution of 25% was mixed with 100g of the pounded leaves and sawdust samples.

2.4. Briquette Production and Quality Evaluation

The experimental design for the project involved a 2x3 factorial design in completely Randomised Design (CDR). The leaves of *Terminalia mentalis* alone (100%) and sawdust of *Daniela oliveri*(50:50) were used to produce briquettes. The sample-binder mixture was hand-filled into the steel mould and compressed manually at both ends with a covered disk. The compressed briquettes were kept under pressure from a hydraulic press and compacted at 20.0kN/m^{2}for a dwell time of 60seconds. For each sieve sizes; 1.70mm, 2.36mm and 3.35mm 10 replicates were produced. Data was collected to determine physical (compressed and relaxed density of briquettes, Shattered index) and Combustion properties of the produced briquettes.

2.5. Determination of Physical Properties

i. **Density**

Four briquettes were randomly selected from each production batch for evaluation. The mean compressed density of the briquettes was determined immediately after removal from the mould as a ratio of measured weight to calculate volume (Olorunnisola, 2007). The weights of the produced briquettes were determined using digital weighing balance, while the average diameters and heights of the briquettes was taken. The volume of the cylindrical shaped briquettes was determined using the formula

$$V = \frac{\Pi D^2 \times H}{4}$$

Where:

D= diameter

H=height

$\Pi = 3.14$

The compressed density (0 minute) and relaxed densities of the briquettes were determined at 30 minutes, 1hour, 24hours and 7days using the dimensions and ASTM Standard E711_87 (2004) standard method of determining densities. Density was determined for each briquette as ratio of briquette weight to volume.

$$Density = weight\ of\ briquettes/Vol.\ of\ briquate \quad \text{................. Equation 1}$$

ii. Determination of Shattered Index of Briquettes

The durability of the briquettes was determined in accordance with the Shattered Index described by Suparin *et al.* (2008). The briquette samples were dropped repeatedly from a specific height of 1.5m onto a solid base. The fraction of the briquette retained was used as an index of briquette breakability. The durability rating of the briquette was expressed as a percentage of the initial mass of the material remaining on the solid bass (Ghorpade and Moule, 2006).

$$\text{Percentage weight loss} = \frac{\text{Initial weight before shatter} - \text{weight after shatter} \times 100}{\text{Initial weight of briquette before shattering}} \quad \text{.......equation 2}$$

$$\text{Shatter resistance} = 100 - \%\text{weight loss} \quad \text{.........equation 3}$$

iii. Determination of Combustion properties

The combustion properties included the percentage; Moisture content, Ash content, Volatile matter, fixed carbon, and the heating value.

iv. Percentage Moisture content (%Mc)

The Moisture content of samples was measured by oven dry method. Two (2)g of pulverized briquette samples (w_1) was measured and kept in oven at 103 °C for 3hours (Sengar *et al.*, 2012) to obtain oven dry weight (w_2). The oven dry sample was kept in the dessicator to cool at room temperature without absorbing moisture from the atmosphere.

The moisture content of sample was calculated by using following formula:

$$\%MC = \underline{W_1 - W_2} \times 100 \quad \text{..........equation 4}$$

W_1

Where:

W1 = Initial weight of sample (g),

W2 = Dry weight of sample (g),

v. Determination of the % volatile matter in the samples

Volatile matter is defined as those products, exclusive of moisture, given off by a material as gas or vapour. The volatile matter of the sample was determined by measuring 2g of the oven dry weight (W_2) to be preheated in the furnance for 4minutes at 400^{0}c to obtain charred weight, this method was used by Egbewole *et al.* (2009). The percentage volatile matter (%VC) was calculated thus;

%Vm = [Dry weight (w_2) – weight of sample (w_3)/ Dry weight (w_2)] x 100 ......equation 5

vi. Percentage Ash content

This was determined by placing the charred weight (w_3) in the furnance for 3 hours at 600^{0}c to obtain ash weight (W_4). Percentage ash content was estimated using the formula below by Carre *et al.* (1981).

%Ash content = [Ash weight (W_4)/ Dry weight (W_2)] x 100 ....equation 6

vii. Percentage Fixed Carbon (%FC)

This was calculated by subtracting the sum of %Volatile matter and %Ash content from 100 as stated by Bailey and Blankenhorn (1982).

%FC= 100% - (%Vm + %Ash) ....e quation 7

viii. Specific Heat of Combustion (HC)

Specific heat of combustion was calculated using the formula by Carre *et al.* (1981).

HC = 0.35((147.6 x FC) + (144 x Vm) + (%Ash)) Kcal/kg ....equation 8

3. RESULTS AND DISCUSSION

3.1. Effect of Briquette Type on Density of Briquettes

The result of analysis of variance (ANOVA) (Table 1) showed that briquette type had significant effect on compressed and relaxed densities of briquettes at 0minutes, 30minutes, 1hour, 24hours and 7days of drying. The density of *Termianlia mentalis* briquettes was higher than that of *Terminalia mentalis* + *Daniela oliveri* briquettes. *Terminalia mentalis* briquettes had a higher density of 1.06g/cm^3 in 0minute and 0.668 g/cm^3 in 7days, there was a general trend in reduction of density of briquettes as drying time increased. The moisture loss due to drying of the briquette from 30 minutes to 7days resulted in reduction in density values as drying progressed (Tembe, 2015). The relaxed density of 0.668 g/cm^3 for *Terminalia mentalis* briquettes in 7 days was less than 0.7269 g/cm^3 obtained by Obi *et al.* (2013) in their work on sawdust briquettes and 0.80 g/cm^{3}obtained by Tembe (2015) in his work on puck shaped bambara briquettes.

Table-1. Effect of Briquette Type on Density of Briquettes

Briquette type	Compressed Density (0min) g/cm³	Relaxed Density (30min)g/cm³	Relaxed Density (1hr) g/cm³	Relaxed Density (24hrs) g/cm³	Relaxed Density (7days) g/cm³
Terminalia mentalis	1.0625	1.0001	0.979	0.877	0.668
Terminalia mentalis + *Daniela oliveri*	1.0242	0.965	0.965	0.820	0.5942
LSD	0.035	0.054	0.046	0.047	0.031

3.2. Effect of particle size on Density of Briquettes

The ANOVA result for effect of particle size on density of briquettes was significant in 0minute, 30minutes, 1hour, 24hours and 7days (Table 2). However, the smaller the particle sizes, the higher the density of briquettes produced. Density of briquettes with particle size of 1.70mm recorded the highest value of 1.068g/cm³ in 0minute and the highest value of 0.638 g/cm³ in 7days. This result is in agreement with Maninder *et al.* (2012) who reported that finer the particle sizes of briquette materials the higher the ease of compaction.

Table-2. Effect of Particle Size on Density of Briquettes

Particle size (mm)	Compressed Density (0min)g/cm³	Relaxed Density (30min)g/cm³	Relaxed Density (1hr)g/cm³	Relaxed Density (24hrs)g/cm³	Relaxed Density (7days)g/cm³
1.70	1.068	1.007	0.993	0.880	0.638
2.36	1.013	0.954	0.927	0.824	0.619
3.35	1.050	0.987	0.964	0.841	0.636
LSD	0.048	0.0631	0.057	0.0577	0.038

3.3. Effect of Briquette Type on Shatter Index and Shatter Resistance

The result of the analysis of variance (ANOVA) was significant on shattered index of briquettes as shown in (Table 3). However, *Terminalia mentalis* + *Daniela oliveri* briquettes recorded a higher shatter resistance of 99.98% and weight loss 0.02%, while, *Terminalia mentalis* briquettes recorded a lower shatter resistance of 98.00% and weight loss of 2.00%. The high resistance of *Terminalia mentalis* + *Daniela oliveri* briquettes indicates high durability of the briquettes and the ability to withstand handling stresses especially in packaging and transportation. The briquettes with low shatter resistance should be handled with care to reduce the possibility of disintegration during packing and long distance transportation (Sotannde *et al.*, 2010; Obi *et al.*, 2013).

Table-3. Effect of Briquette Type on Shatter Index and Shatter Resistance

Briquette type	Weight loss%	Shatter resistance%
Terminaliamentalis	2.00	98.00
Terminaliamentalis + *Daniela oliveri*	0.02	99.98
LSD	2.902	2.902

3.4. Effect of Briquette Type on Combustion Properties of Briquettes

Effect of briquette type was not significant on percentage moisture content, however, there was significant effect on percentage ash content, percentage fixed carbon and specific heat of combustion. *Terminalia mentalis* briquettes had higher % Ash content of 12.56%, 30.93% fixed carbon but *Terminalia mentalis*+ *Daniella oliveri* briquettes recorded a higher specific heat of combustion of 11053 kcal/kg as shown in (Table 4). This could be linked to the variation in density of the briquette materials since density has significant effect on combustion properties of briquettes (Egbewole *et al.*, 2009; Obi *et al.*, 2013). The result was higher than Tembe (2015) who obtained 3980kcal/kg for groundnut briquettes and also higher than 5210kcal/kg for *Anogeissus leocarpa* and 4908kcal/kg for *Gmelina arborea briquettes* as reported by Egbewole *et al.* (2009). The result is lower than 23991kcal/kg for *Terminalia superba* briquettes as reported by Emerhi (2011). This indicates also that any of the 2 briquette types could serve as an efficient briquette fuel (Table 4).

Table-4. Effect of Briquette Type on Combustion Properties of Briquettes

Briquette type	%Mc	%Ac	%Fc	%Vm	SHkcal/kg
Terminaliamentalis	7.08	12.56	30.93	56.52	9704
Terminaliamentalis + *Daniela oliveri*	7.00	6.81	25.63	67.55	11053
LSD	NS	0.759	3.922	3.880	353.9

4. CONCLUSION AND RECOMMENDATIONS

The study showed that briquettes produced from *Terminalia mentalis* had relaxed density of 0.668 g/cm^3 in 7 days, while briquettes produced from binary combination of *Terminalia mentalis* + *Daniela oliveri* had relaxed density of 0.594g/cm^{3}in 7days. The effect of particle size was significant on the density of briquettes at 1.70mm. Briquettes produced from *Terminalia mentalis* + *Daniela oliveri* had a higher shatter resistance of 99.98% and a lower weight loss of 0.02% while, briquettes from *Terminalia mentalis* had a lower shatter resistance of 98.00% and weight loss of 2.00%. *Terminalia mentalis* briquettes had a lower heating value of 9704kcal/kg while, *Terminaliamentalis* + *Daniela oliveri* briquette gives a higher heating value of 11053kcal/kg.

The use of the leaves of *Terminalia mentalis* and *Terminalia mentalis* + *Daniela oliveri* sawdust to produce briquettes is hereby recommended because of its high heating value. Long distant transportation of briquettes for use should be encouraged as briquettes will not easily dismember because of it high resistance to shatter.

REFERENCES

ASTM Standard E711_87, 2004. Standard test method for gross calorifc value of refuse-derived fuel by the bomb calorimeter. Annual Book of ASTM Standards ASTM International. pp: 105.

Bailey, R.T. and P.R. Blankenhorn, 1982. Calorific and porosity development in carbonized wood. Wood Science, 15(1): 19-28. *View at Google Scholar*

Carre, J., L. Lacrosse and J. Herbert, 1981. Critical Analysis of the dry process improvement of lignocellulosic for energy producing purpose. A Final Report Submitted to the Commission of the European Communities general directorate of Development and Ministries, Belgrade L. Agriculture centre de Reseaeches Agronomiques de IE tat de Gembloux (CRN) France. pp: 25.

Egbewole, Z.T., O.A. Sotannde and K.S. Aina, 2009. Combustion efficiency of briquettes produced from wood sawdust; an alternative for energy generation. Proceedings of the 2nd Biennial National Conference of the Forests and Forest Products Society, 11: 385-400.

Emerhi, E.A., 2011. Physical and combustion properties of briquettes produced from sawdust of three hardwood species and different organic binders. Advances in Science Research Journal, 2(6): 236-246. *View at Google Scholar*

Ghorpade, S.S. and A.P. Moule, 2006. Performance evaluation of deoiled cashew shell waste for fuel properties in briqutted form. B. Tech. Thesis (Unpublished.), Dapoli. pp: 15.

Maninder, S.K. Rupinderjit and G. Sonia, 2012. Using agricultural residues as a biomass briquetting: An alternative source of energy. Journal of Electrical and Electronics Engineering, 12(2): 303-307.

Obi, O.F., C.O. AKubuo and W.I. Okonkwo, 2013. Development of an appropriate briquetting machine for use in rural commuties. International Journal of Engineering and Advanced Technology, 2(4): 578-582. *View at Google Scholar*

Olorunnisola, A., 2007. Production of fuel of briquettes from waste paper and coconut husk admixtures. Agricultural Engineering International E- Journal, 6(1): 27-35.

Onuegbu, T.U., I.M. Ogbu, N.O. Ilochi, I. Okafor, O.F. Obumselu and U.E. Ekpunobi, 2010. Enhancing the efficiency of coal briquette in rural Nigeria using pennisetum purpurem. Advances in Natural and Applied Sciences, 4(3): 299-305. *View at Google Scholar*

Philip, F., 2007. Nigeria looking for firewood alternatives, palm/deforestation watch. Retrieved from www.//deforestationwatchorg.org.

Sengar, S.H., A.G. Mohol, Y.P. Khandetod, S.S. Patil and A.D. Chendake, 2012. Performance of briquette machines for briquette fuel. International Journal of Energy Engineering, 2(1): 28-34. *View at Google Scholar*

Sotannde, O.A., A.O. Oluyege and G.B. Abah, 2010. Physical and combustion of briquettes from sawdust of azadirachta indica. Journal of Forestry Research, 21(1): 63-67. *View at Google Scholar* | *View at Publisher*

Suparin, C., S. Suwit and K. Prattana, 2008. Development of fuel briquettes from biomass lignite blends. Chiangi Journal of Science, 35(1): 43-50. *View at Google Scholar*

Tembe, E.T., 2015. Heating value of briquettes produced from bambara groundnut shells. An Unpublished Ph.D Thesis. pp: 30-205.