Global Scientific JOURNALS

GSJ: Volume 7, Issue 11, November 2019, Online: ISSN 2320-9186

www.globalscientificjournal.com

Combustion Potentials of Briquettes Produce Sawdust: Alternative Energy Source

David-Sarogoro, N.

Department of Forestry and Environment, Rivers State University, Nkpolu, Port Harcourt, Nigeria
P.M.B. 5080

nwiisuator@yahoo.com **david.nwiisuator@ust.edu.ng**

Phone No. 07030447559 & 08051862240

ABSTRACT

The study aimed at aggregating pulverized sawdust from Marine and Illoabuchi sawmills in Port Harcourt into briquette for energy generation and evaluating the physical, chemical and combustion characteristics of the briquettes. The experimental design was 2 x 3 Factorial Experiment arranged in Completely Randomized Design (CRD) with three replications, and the data collected were subjected to one-way analysis of variance (ANOVA), *t-test* and regression analysis using the SPSS version IBM 21 and MS-Excel 2013. The sawdust was oven dried at temperature of 105^{o}C for 30 minutes to moisture content of 7% and binding agent-starch at different concentration of 30% and 40% in ratio 1:3 and 1:4 respectively. The results showed that *t-test* of bulk density (BD) was significant difference ($P \geq 0.05$: P-value=0.00879) between briquettes from Illoabuchi and Marine: mean BD of Illoabuchi sawmill (0.207g/ml) was higher than BD (0.146g/ml) MB sawmill. Briquette densities of 30% and 40% starch showed that there was significant difference ($P<0.05$:0.047761) between them from Illaobuchi but no difference ($P>0.05$:0.265129) between 30% and 40% starched briquette from Marine Base. Result on combustion properties showed that percent volatile matter (VM) was highest in briquette of

Marine Base (14.791±1.34%) followed by sawdust from same source with 13.845±0.91%, and lowest %VM (11.531±1.54%) was observed in briquettes from Illaobuchi. Similar trend was observed in %AC as it was highest in briquettes of Marine Base (1.046±0.07%) followed by sawdust from MB with 0.996±0.08% and sawdust from Illoabuchi and lowest %AC of 0.745±0.07. The result also showed that briquettes formed from sawdust of Illaobuchi and Marine Base sawmills contained protein 0.52% and 2.27% respectively. Combustion of briquettes indicated that it is less choky and smoky, cheap, ubiquitous, environmentally friendly and organic thus may mitigate the duo of climate change and global warming by reuse and recycle of wood waste reduce deforestation and degradation if utilized on large scale. The pulverized sawdust should be moulded or packaged in order to aggregate, enhance and maximize its potentials as an alternative for fossil fuel and automated briquetting machines should be sourced.

Keywords: Briquette, starch, protein, environmental friendly

Introduction

Wood waste and residues, although useful have been neglected in Nigeria because the average Nigerian considers them useless and of no importance; in almost all sawmills industries within Port Harcourt particularly Illoabuchi sawmills, wood wastes are dumped around its premises causing environmental pollution in form of dust nuisance and fire hazards (Nwiisuator, *et al.*, 2011).These wood wastes are of different sizes, forms and classes-sawdust and wood shavings which seem useless and constitute environment concerns;1500kg (1.5Tonnes) and 3 tons per month of these sawdust. The sawdust is divided into macro and micro wastes (David-Sarogoro, 2016). It is estimated that about 55% of wood waste generated in the country in 1988 was estimated to be 1.72 million m^3 (Badejo, 1990). Also reported that the average world production of wood residues comprises 250 million tonnes of sawdust, 200 million tonnes of bark and over 400 million tonnes of crooked logs (FPRDI, 1982). The slabs and barks are collected and used as firewood while the saw dust is mostly burnt at the saw mill sites or used in land filling or land reclamation by dwellers living near the various creeks in Port Harcourt (Nwiisuator, *et al.,* 2011). The continuous processing activities and churning out innumerable and copious volume of sawdust which contribute to environmental pollution, particularly releases carcinogenic particulate matter which constitutes health hazards to dwellers within sawdust heap (Nwiisuator, *et al.*, 2011).

The sawdust lining the various coastlines of watersides within the creeks where they are deposited has high economic value if harnessed. Sawdust heaps found near every saw mill in Port Harcourt shows that they are put to little or no use beneficial to people. The problems of acute scarcity and deficit in fuel wood have resulted in energy crisis in arid and semi-arid regions of developing countries (Fuwape, 1985). There has being an unprecedented increase in demand for fuel wood in response to high rate of production growth in tropical areas. With repeated bush burning and overgrazing are seriously affecting the rate and environmental degradation. In a country where there is a serious desert encroachment problem as a result of deforestation and issues of greenhouse effect and global warming, it is pertinent that other sources of energy are developed. More than 80% of people in Nigeria use fuel wood as a source of energy (Adesola, 1986). In 1992, the Federal Ministry of Budget reported that, the total fuel wood consumption in

Nigeria was expected to increase to 87,58710m^3 in 2000 (Federal Ministry of Budget and Planning, 1992).

One factor that has contributed enormously to the rapid depletion of the country's timber resources is wastage of wood during log processing. If wood waste is minimized in the country's sawmills, number of tree cut per annum for lumber production would be reduced (FAO, 1972). One of the major factors contributing in Nigeria and Rivers State in particular is the waste of wood during log conversion especially in sawmills (Aina, *et al*., 2004). Another notable source of wood waste occurs in the forest during timber harvesting. This has constituted a setback to the sustainable management of the forest and sustainability of the forest industries. In Sarawak, the number of damaged trees varied from one to nine (Noack, 1995), while in Nigeria, there are two problems associated with product harvesting and utilization. These are wastages during harvesting and conversion.

The study explored and transformed sawmill sawdust into briquette for energy generation as alternative to fossil fuel consumption and evaluated the physical and chemical characteristics of produced briquettes.

Methodology

The sawdust was sourced from Marine and Illoauchi sawmills in Port Harcourt, Rivers State on Latitude 4.5^{o}N, and longitude 7.01^{o}E and average rainfall of above 2000m. The sawdust was oven dried at temperature of 105^{o}C for 30 minutes to moisture content of 7%. The binding agent-starch at different concentration of 30% and 40% in ratio 1:3 and 1:4 respectively and mixed in boiling water.

A simple metal hand press (4"x6"x2") was fabricated used as a moulder (Plate 3.1) and the mixture put in and by application of pressure for formed the briquettes. The output briquettes were oven dried in Food Science and Technology Departmental Labouratory at temperature of 105oC for 48 hours. This was done repeated for the various sets of briquettes.

The physico-chemical properties of sawdust were analysed in Food Science and Technology Departmental Labouratory before and after composition (bonding) of the sawdust as knowledge of quality of a substance enhances utilization.

Determination of Briquette Density

The electronic weighing balance was used to measure the weight; volume determined by briquette dimension measurement. Density is defined by as the mass per unit volume of a sample (kg/m^3). The briquette volumes dimensions; length, breadth and height taking the shape of the fabricated hand press in 4"x6"x2"of metal box.

Density $= \frac{M}{V}$ (Avery &Burhart, 2002)

Where D=Density

M=Mass of sample

V=Volume of sample

Impact Strength Determination

Briquette samples were sent to Labouratory of Food Science and Technology Department, Rivers State University, Port Harcourt where friability or pliability test of the briquette samples were done repeatedly (20 times) by dropping them from a specific height of 1.8m into a solid base (25mm thick metal plate) and a fraction retained was used as an index of briquette friability. This adopted method was described by Sanner and Eckert (1957) as follows:

1. Weight of briquette
2. Dried samples shaped
3. Calculation of weight loss after test
4. Repetition of test 20 times on the specimen briquette if not yet destroyed

Water Boiling Test

Water boiling test in assessing combustion efficiency of briquette. A fixed volume of water (1 litre) was boiled by combustion of the briquettes and time taken with a stop watch to get the best starch-briquette amalgam that produced the best result or efficiency. The burning characteristics of briquettes were assessed by comparing the time taken to boil the water which is important in evaluating both the performance and likely acceptance for domestic use.

Combustion Properties Analysis

The combustion analysis or properties of produced briquettes were carried out to determine the following Percentage Volatile Matter, Ash Content of Samples, Percentage Fixed Carbon and Heating Value.in labouratory, Department of Food Science and Technology, Rivers State University, Port Harcourt.

Percentage Volatile Matter (PVM)

Blocks of briquetted samples were put in a crucible and oven dried to constant weight after which kept in the furnace at temperature of 550^{o}C for 10 minutes and calculated from the formula.

$\% \, Volatile\ Matter = \frac{B-Cx100\%}{B}$ (Adegoke and Fuwape, 2008)

Where B=Weight of oven dried samples

C=Weight of sample after 10 minutes in the furnace at 550^{o}C

Percentage Ash Content (PAC)

Block of oven dried briquette sample were placed in the furnace at temperature of 550^{o}C for 4 hours and weighed after cooling.

$\% \, Ash \, Content = \frac{Dx100\%}{B}$ (Adegoke and Fuwape, 2008)

Where D=Weight of Ash

B=Weight of oven dried sample

Percentage Fixed Carbon (PFC)

This was calculated by subtracting the sum of Percentage Volatile Matter (PVM) and Percentage Ash Content from 100%.

$PFC = 100 - (\%V + \%A)$

Where %V= Percentage Volatile Matter (PVM)

%A= Percentage Ash Content from 100%

Heating Value

Heating value was calculated using formula

$HC = 2.326(1447.6 + 144V)KJ/kg$ (Adegoke and Fuwape, 2008)

Where HV=Heating Value, C= Percentage Fixed Carbon (PFC), V= Percentage Volatile Matter

Experimental Design/Data Analysis

The experimental design was 2 x 3 Factorial Experiment arranged in Completely Randomized Design (CRD) with three replications, and the data collected were subjected to one-way analysis of variance (ANOVA), t-test and regression analysis using the SPSS version IBM 21 and MS-Excel 2013.

RESULTS AND DISCUSSION

Sawdust Bulk Density

The *t-test* result on bulk density (BD) showed a significant difference ($P \geq 0.05$: P-value=0.00879 and 0.017581 at one-tailed and two-tailed respectively) between briquettes from Illoabuchi and Marine. The mean BD of Illoabuchi sawmill (0.207g/ml) was higher than BD (0.146g/ml) MB sawmill (Figure 1). These results are far lower than the bulk density (g/cm3) of flour without the influence of any compression ranged from 0.762 g/cc to 0.820 g/cc (www.wikipedia.com).

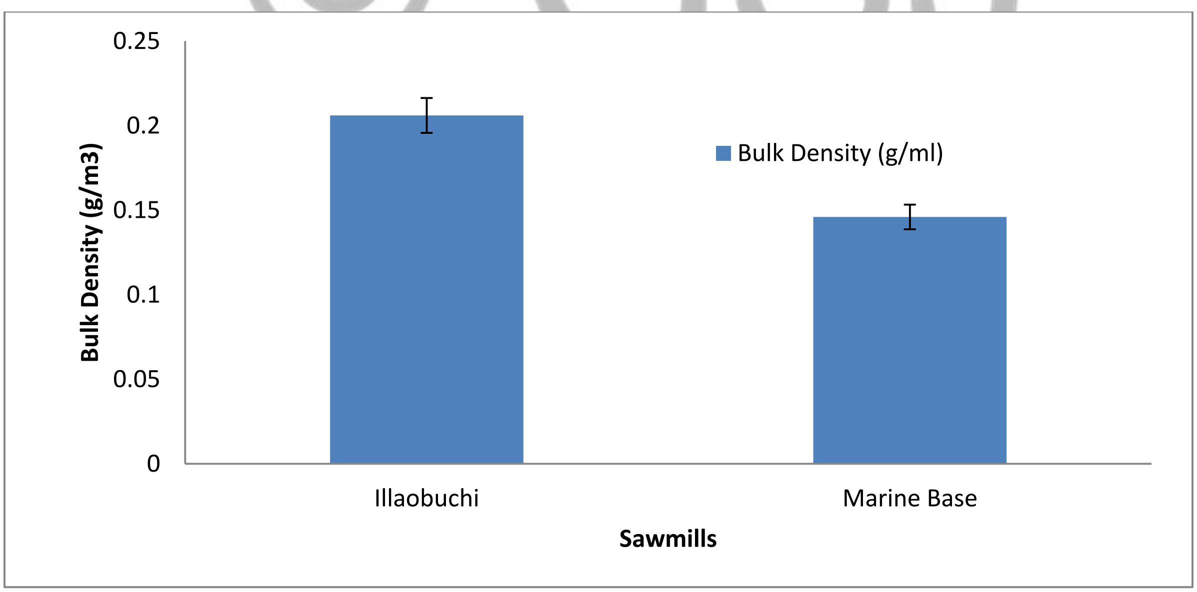

Figure 1: Bulk density of briquettes from Illoabuchi and Marine Base

Plate 1: Produced Briquettes from Marine Base Sawmill, Port Harcourt

Briquette Density

The result on the briquette densities showed that there was significant relationship (P<0.05:1.96E-08) between briquettes from Illaboachi and Marine Base: the former ranged from 0.37g/cm^3 to 0.52g/cm^3 while latter ranged from 0.15g/cm^3 to 0.28g/cm^3. Thirty percent (30%) starch had mean of 0.47±0.048g/cm^3 and 40% starch had 0.41±0.045g/cm^3 from Illaobuchi while 30% starch from Marine Base was 0.23±0.054g/cm^3 and the 40% starch was 0.26±0.018g/cm^3 (Table 1). From the foregoing it was observed the briquettes from Marine Base had lower densities than those from Illaobuchi which is due to the lower bulk densities of the sawdust therefrom (0.146g/cm^3), the wood source composition of the sawdust, kind of machine saw used in processing, compaction during briquetting, binder-sawdust ratio.

Similarly, the briquette densities of 30% and 40% starch showed that there was significant difference (P<0.05:0.047761) between them from Illaobuchi but no difference (P>0.05:0.265129) between 30% and 40% starched briquette from Marine Base (Table 2)..

Table 1: Density and Starch Content of Briquettes from Illaobuchi and Marine Base

Starch Content	Illaobuchi (Mean ± SD) n=10	Marine Base (Mean ±SD) n=10
30%	0.47±0.048^a	0.23±0.054^a
40%	0.41±0.045^b	0.26±0.018^a

Means with different letters superscripted are significant different (P<0.05)

The result on regression of density on heating values of briquettes showed a direct relationship between them: the higher the former, the higher the latter with correlation coefficient (r2) equal 0.9821 which means 98% relationship between them (Figure 2).

GSJ: Volume 7, Issue 11, November 2019
ISSN 2320-9186

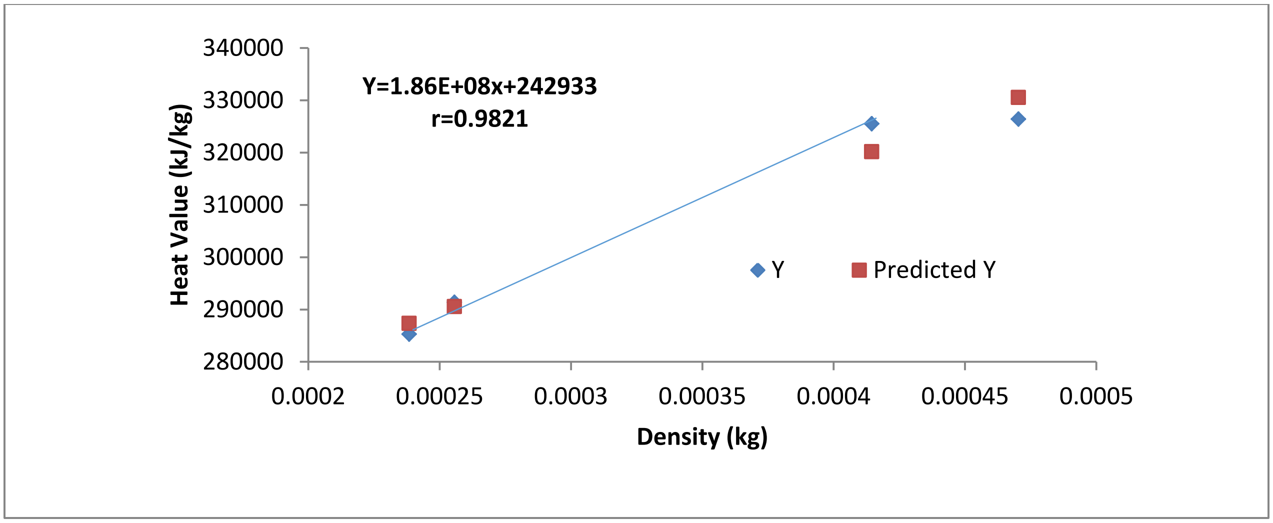

Figure 2: Regression of briquette density on heat values

Table 2: ANOVA of Regression of Density on Heat Values of Briquettes

	df	*SS*	*MS*	*F*	*P-value*	*Significance F*
Regression	1	1.38E+09	1.38E+09	54.43191	0.001389	0.01788
Residual	2	50866394	25433197			
Total	3	1.44E+09				

Impact Strength Determination

The result on impact strength determination showed a significant relationship (P<0.05: P-value=0.0004) between 30% and 40% starched bonded briquettes but none from the two sawmills (P≥0.05: P-value=0.3184). The average IM of 30% briquettes was 2.52Nmm^2 while 40% was 1.30Nmm^2. This implies that the former was stronger and tougher than the latter because there was higher consistency and adhesion within the starch molecules and sawdust particulates. The finding agrees with Aleru and David-Sarogoro (2016) observed mean strength ranged from 1.49-2.15Nmm^2 and 1.89-2.21Nmm^2 at wet and dry basis respectively.

Water Boiling Test

The result on boiling water showed that there is no significant difference (P≥0.05: P-value=0.17744 and 0.35488 at one-tailed and two-tailed respectively) between the 30% and 40% binding agent used, however, 30% starch took the overall lowest time of 4.15minutes to 5.20minutes while 40% took 4.20minutes to 5.30minutes (Figure 1)

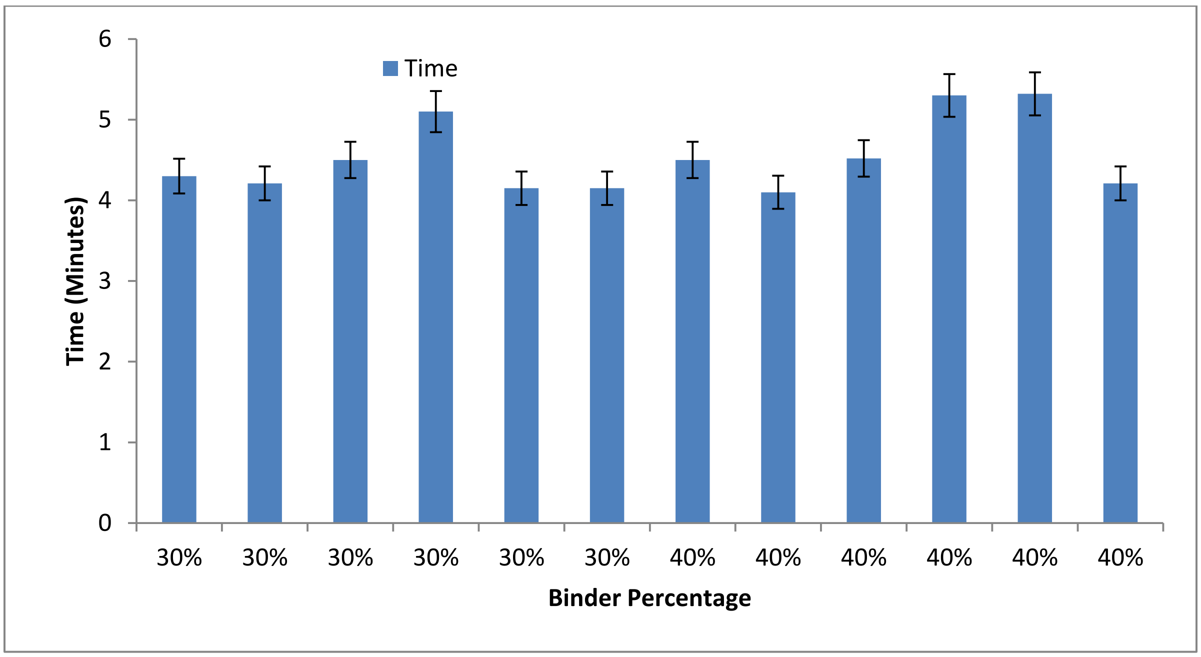

Figure 1: Boiling time and binder percentage

Combustion Properties Analysis

The result of the combustion properties showed that there no significant difference (P≥0.05) amongst most of them particularly percentage volatile matter (%VM), percentage fixed carbon (%FC) and heat values (HV) of sawdust and briquette from Illaobuchi and Marine Base sawmills while there was significant difference (P≤0.05) between the percentage ash content (%AC) of sawdust/briquettes from the two sawmills. Though, %VM was highest in briquette of Marine Base (14.791±1.34%) followed by sawdust from same source with 13.845±0.91%, lowest %VM

(11.531±1.54%) was observed in briquettes from Illaobuchi (Table 3). Similar trend was observed in %AC as it was highest in briquettes of Marine Base (1.046±0.07%) followed by sawdust from MB with 0.996±0.08% and sawdust from Illoabuchi and lowest %AC of 0.745±0.07% (Table 3). Contrariwise, %FC was lowest in briquettes with 84.163±1.41%, followed by sawdust (85.159±1.52%) all of MB and sawdust of Illaobuchi with 86.581±1.53% while briquette of Illaobuchi with 87.724±1.62% had the highest %AC (Table 3). Similarly, HV was lowest in briquettes with 288,340.09±4294.67 kj/kg, followed by sawdust (288,340.09±4294.67kJ/kg) all of MB and sawdust of Illaobuchi with 295,756.74±402.41kJ/kg while briquette 239.10±4924.79kJ/kg of Illaobuchi was highest (Table 3). This implies that briquettes and sawdust from Marine Base contained higher volatile matter and ash content but lower fixed carbon and heat values from both sawmills. This findings agrees with Emerhi (2010) that Cassava starch is a good organic binder and its efficiency in briquette production has been demonstrated and Sotannde, O. A. Oluyege, A. O. & Abah, G. B. (2010) observed a better performance with briquettes bonded with starch based on the heating value of 33.09 $MJ \cdot kg^{-1}$, percentage of fixed carbon of 84.70% and low ash and volatile matter of 3.35% and 11.95%, respectively.

It could be deduced from above results that the higher the %FC and HV, the lower the %VM and %AC of the sawdust and the resultant briquettes formed which to kinds of cellulose of the wood processed. The carbon fixed here might be due to amorphous carbon inbuilt in wood which on pyrolysis of the producing wood formed carbonless ashes and charcoal.

This result disagrees with Nwiisuator and Azuokwu (2013) that coconut shell with high % VM with corresponding HV but lower %FC, %AC burnt with low smoke, choke and faster; the lower %VM and HV, the higher the %FC and %AC.

GSJ: Volume 7, Issue 11, November 2019
ISSN 2320-9186

The variations amongst the combustion properties of sawdust and briquettes from both sawmills agrees with Fuwape (2008) that pyrolysis of any material is dependent on the %VM: process of wood charcoal production which involves thermal separation of volatile matter from solid residue: proportion of FC and VM in charcoal which varies with type of plant material used as feedstock, pyrolytic technique, heating rate, residence time, particle size, temperature, chemical position, moisture content of species and final pyrolysis temperature.

Table 3: Combustion Properties of Briquettes and Sawdust from Illaobuchi and Marine Base

Location	Waste Type	% volatile matter	% ash content	% fixed carbon	Heating Value (kJ/kg)
Illaobuchi	Briquette	11.531±1.54[a]	0.745±0.07[a]	87.724±1.62[a]	299,239.10±4924.79[a]
	Sawdust	12.624±1.01[a]	0.795±0.08[a]	86.581±1.53[a]	295,756.74±402.41[a]
Marine Base	Briquette	14.791±1.34[a]	1.046±0.07[b]	84.163±1.41[a]	288,340.09±4294.67[a]
	Sawdust	13.845±0.91[a]	0.996±0.08[b]	85.159±1.52[a]	291,377.67±4916.51[a]

Means with different letters within same column are significantly different (P≤0.05)

Protein Content of Sawdust from Illaobuchi and Marine Base Sawmills

The result showed that briquettes formed from sawdust of Illaobuchi and Marine Base sawmills contained protein 0.52% and 2.27% respectively (Figure 4.2). Marine Base sawdust had the higher protein content of 2.27% which means it could be used in soil fertilization as there was significant difference ((P<0.05: P-value=0.0132) between PC of Illaobuchi and Marine base sawmills. This implies that the trees processed influenced the composition of sawdust and the briquettes therefrom. This agrees with Panshin and Dezeeuw (1980) that wood constituents are determined by factors inherent in its structural organization reflect in the resultant wood sawdust or wood shaving in micro or macro forms.

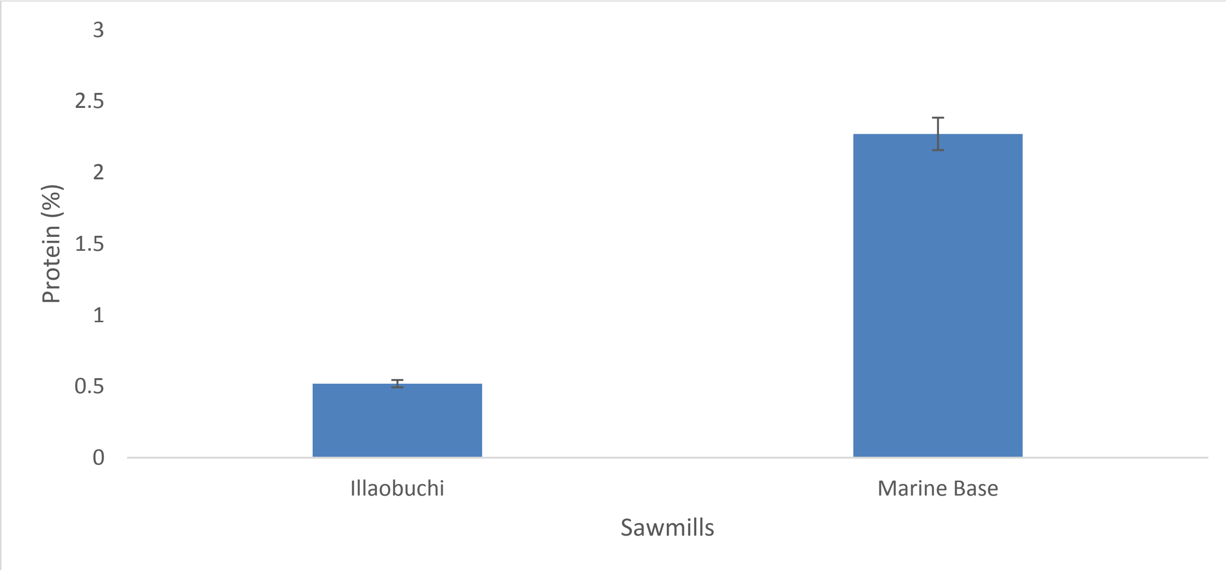

Figure 2: Protein content of sawdust from sawmills

Conclusion

The study has shown that heaped sawdust or micro-wood particles or non-carbonized biomass that generated energy as biomass fuel with outstanding combustion, physical and chemical properties which could be used as alternative to conventional fossil fuel: the sawdust contained some percentage of Nitrogen which fertilizes the soil hence used as organic fertilizer and growing medium for raising seedlings in nursery beds. The combustion of briquettes indicated that it is less choky and smoky, cheap, ubiquitous, environmentally friendly and organic thus may mitigate the duo of climate change and global warming by reuse and recycle of wood waste reduce deforestation and degradation if utilized on large scale.

The pulverized sawdust should be moulded or packaged in order to aggregate, enhance and maximize its potentials as an alternative for fossil fuel and automated briquetting machines should be sourced from other climes.

Acknowledgement

This is to acknowledge Tertiary Education Trust fund (Tetfund) for the grant given me hence the sponsor of this research.

References

Adegoke, I.A. and Fuwape, J.A. (2008). Combustion properties of briquettes as affected by production process. In research for development in forest products and natural resources management (eds. Onyekwelu, J.C., Adekunle, V. A.J. and Oke, D,O.) Proceedings of First National Conference of the and Forest Products Society, Federal University of Technology, Akure, Nigeria. 16th – 18th, April, 2008. Pp. 193 – 197.

Adesola, J. (1986). Investigation of composite sawdust briquette as a source of fuel for domestic cooking, P2.

Aina, O.M., Adetogun, A.C., Ogunsanwo, O.Y and Ajala, O.O. (2004). Comparative rate of distortion in three indigenous Nigerian hardwood lumber species under different drying conditions. *Journal of Agricultural and Environmental Engineering Technology*. 1(1): 69-76.

Badejo, S.O. (1990). Sawmill wood residues and their utilization: invited paper presented at the national Forestry Workshop Management Strategies for self-sufficiency in wood production held at Ibadan, June, 1990.

David-Sarogoro N. and Chukunda, F.A. (2016). Dormancy breaking and Disease Incidence in *Hevea brasiliensis* (Muell, Arg.) Seeds after Pre-germination treatments. Journal of Forestry and Environment Sustainable Development (JOFESD). 2 (2). Pp. 69-74.

FAO, (1972). Forestry advisory Commission, Western State of Nigeria. A report on the Review of Assessment and evaluation of wood-waste owing to bad sawing and poor saw doctoring series No. 1.

Forestry Product Research and Industrial Development (FPRDI, 1982). Magazine for Forestry Product research and Industrial Development. Forestry Pride Digest. Vol (x) No 1 and 2, June 1982. Pp 2-8.

Fuwape, J.A. (1985). Heat of combustion of twenty Savanna tree species in the changing character of Nigerian forest resources implications for future development, Proceedings of 1995 Annual Conference of Forestry Association of Nigeria (FAN) Gongalo, Nigeria. Pp 70-78.

Noack, D. (1995). Making better use of tropical Forest Update. 5(2): 12-14.

Nwiisuator, D., Emerhi, E.A. Ariwaodo, J.O. and Aleru, K. (2011). Wood waste generation and lumber conversion efficiency of selected sawmills in Port Harcourt, Nigeria. *Acta Agronomica Nigeriana.* 11(1&2): 8-14.

Sanner, D. and Eckert, C. (1957). Resources for the National Academy of Science Washington DC. Kewbell. 32(2):52-53.

Panshin, A.J. and Dezeeuw, C. (1980). *Textbook of Wood Technology.* McGraw-Hill Book Company.