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INVESTIGATION OF THE COMBUSTION CHARACTERISTICS OF BRIQUETTES PRODUCED FROM CASSAVA PEELS, MANGO NUTS AND ORANGE PEELS

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ABSTRACT

It was discovered that particle size, compaction pressure and percentage composition have effects on the briquette qualities. Higher compaction pressure increases the shattering index (durability) of the briquettes. Reduction in particle size increases the compaction ratio. The lower the burning rate the longer the briquette will burn compare to other samples and the higher particle size, there is increase in the burning rate, the lower the compaction pressure, higher volatile content and larger particle size decrease the ignition time of the briquette samples, it was also observed that increase in the particle size and reduction in the compaction pressure reduces water boiling time. It was concluded that 30 % mango nuts, 35 % cassava peels and 35 % orange peels have the lowest specific fuel consumption and has the highest calorific value.

Keywords: Investigation, Combustion, Briquettes, Characterize, Fuel Consumption, Calorific Value.

I. INTRODUCTION

Energy availability, supply and consumption are very important indicators for technological and social economic development of every nation. It plays a vital role in synergizing the three pillars of sustainability (economy, social and environment). Sustainable energy development entails the exploitation, processing and utilization of energy resources in such a way that it meets human needs while preserving the environment (Akinola, 2012)

Sustainable development is very important to developing countries like Nigeria. Every sector of the Nigerian economy (agriculture, industry, transport, commercial and domestic) needs inputs of energy. This makes energy one of the most important necessities of life. Ever increasing consumption of fossil fuels and rapid depletion of known reserves are matters of serious concern in the country. This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as oil and gas. Rising prices of oil and gas and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased use of fossil fuels also causes environmental problems both locally and globally. Thus, a need to consider alternative sources of energy for domestic and industrial use in the country strongly exists.

In this respect, biomass is of great interest because of its miscellaneous advantages such as easily finding, low priceand carbon dioxide neutral feature. However, direct combustion of biomass is not preferable because of the negative aspects coming from the intrinsic properties of biomass such as low density, low calorific value in a unit volume, and high moisture, etc.From this point of view, it is important to develop strategies by which biomass is converted to secondary fuels which have better characteristics in comparison to the parent material.

Nigeria still relies heavily on traditional sources of energy to meet its energy demand which have health and environmental implications, as most Nigerians living in the rural areas have depended solely on fuel wood for their energy needs for the past decades. Continual exploitation of fuel wood used in domestic heating applications would lead to deforestation, which causes soil erosion, floods, landslides etc. Meanwhilea lot of agricultural residues and wastes are generated in the country from agricultural activities, but they are poorly utilized and badly managed, since most of these wastes are left to decompose or they are burnt, resulting in environmental pollution and degradation (Jekayinfa and Omisakin, 2005). These problems can be minimized by converting these agricultural residues to biomass briquettes to fill energy needs and also serve as a waste management strategy.According to Kenechukwu and Kevin, (2013), briquettes are flammable materials formed from the compression or densification of matter in solid form to be used as fuel. Briquetting technology is the high pressure densification of flammable materials that improves the handling characteristics of raw materials and enhances volumetric calorific value (Ndaganaet *al.,* 2014). Densification of agricultural residue is one way of upgrading combustion and mechanical characteristics. Through briquetting of agricultural residues, the produced briquettes will supplement existing energy sources hence reduce the pressure on wood based biomass in the country.

Amongst the several agro-residue generated in the country are Mango nuts (*MangiferaIndica*), Cassava (*ManihotEsculenta*) and Orange (*Citrus Sinensis*) peels which are existent in large quantities as Nigeria is the world's largest producer of cassava and among the top ten producers of Mango fruit (https://www.worldatlas.com). This study is aim of this paper is to carry out comparative analysis on briquettes produced from mango nuts, cassava and orange peels.

II. METHODOLOGY

Materials

Cassava peels, mango nuts, orange peels, hydraulic press, mild steel mould, stop watch, cassava starch, digital weighing balance, water, briquette stove, milling machine,300μm standard sieve, cookingpot, muffle furnace, meter rule, venier caliper.

Methods

The biomass samples used for this study were cassava peels,mango nuts and orange peels. These samples were obtained from dump sites in Makurdi, Benue state. The samples were screened to remove impurities and sun dried for 7 days to reduce the moisture content after which they were pulverized with a milling machine to obtain sample reduction. The pulverized samples were screened using standard sieve to particle size of 300μm.

Briquetting of raw materials

The briquettes were produced by thoroughly mixing the pulverized biomass materials - mango nuts, orange peels and cassava peels, in various percentage compositions by mass as shown in Table 1 below. 20 % cassava starch of the entire mass of the mixture was used as binder for all samples as adopted by Shuaibu*et al.*, (2015);Wakchaure and Mani (2015).A mild steel mould of rectangular cross-sectional dimension (45 mm by 42 mm by 80mm) was completely filled with each sample mixture and kept under a manual hydraulic press machine for compaction. The biomass briquette samples were subjected to a compaction pressure of 10 MPa.A dwell time of 60 seconds was allowed (Davies et al., 2017). The briquette formed was extruded and labeled for identification. Extruded briquettes were left to dry at atmospheric temperature until stable moisture content was obtained.

Table 1: Percentage Composition of briquette samples

Briquette Sample	Composition of Cassava Peels (%)	Compositionof Mango nut (%)	Compositionof OrangePeel (%)
A	100	-	-
B	-	100	-
C	-	-	100
D	35	35	30
E	30	35	35
F	35	30	35

Analysis of briquette samples

Determination of density

Density is an important physical property of a solid fuel. High density briquettes are desirable so as to make transportation, storage and handling easier. The bulk density of the briquette samples produced were determined by measuring dimensions andweighing the briquette samples.

$$Density = \frac{mass}{volume} \qquad (1)$$

Determination of Shattering Index

The shattering index is a measure of the durability of the briquettes (Shuaibu*et al.*, 2015). The briquettes shattering index was measured according to ASTM D440-07 (2012) as adopted by Oladeji and Oyetunji

(2013).The shattering index was determined by weighing the briquettes before and after dropping the briquettes from a height of 1320 mm using a digital weighing balance. After the briquette was dropped from the height, the mass of the largest part of the briquette that holds together was then measured.

$$Shattering\ index = \frac{mass\ after\ dropping}{mass\ before\ dropping} \times 100 \qquad (2)$$

Determination of percentage moisture content

The moisture content of the biomass briquette was determined based on ASTM standard (ASTM D-3173). 2g of the briquette sample was kept in oven at 105 ºC for one hour. Then the oven dried sample was weighed and moisture content of sample calculated by using following formula:

$$\%M.C = \frac{m_2 - m_3}{m_2 - m_1} \times 100 \qquad (3)$$

Where, m_1= mass of crucible

m_2= mass of crucible + sample

m_3= mass of crucible + sample after drying

Determination of percentage ash content

The percentage ash content was determined based on ASTM standard (ASTM-D3174) as adopted by Emerhi (2011). 2g of the briquettes sample were weighed in a crucible, this was placed in the furnace for 4hrs at 550ºC to obtain the ash weight. Percentage ash Content (PAC) was calculated as:

$$PAC = \frac{weight\ of\ ash}{original\ weight\ of\ sample} \times 100 \qquad (4)$$

Determination of percentage volatile matter and percentage fixed carbon

The Percent volatile matter (PVM), percentage fixed carbon (PFC), and heating value (HV) were determined according to the method used by Emerhi (2011). To determine the PVM, 2g of pulverized briquettes sample in a crucible were placed in the oven until a constant weight was obtained after which the briquettes were kept in the furnace at a temperature of 550°C for 10 minutes and weighed after cooling. The PVM was determined using the formula below:

$$PVM = \frac{B - C}{B} \times 100 \qquad (5)$$

Where,

B = the weight of oven dried sample.

C = the weight of sample after 10 minutes in the furnace at 550°C.

The PFC was calculated by subtracting the sum of the percentage volatile matter (PVM) and percentage ash content (PAC) from 100.

$$PFC = 100 - (PVM + PAC\ ) \qquad (6)$$

Calorific value

Heating value (HV) or calorific value was calculated from equation 7:

$$HV = 2.326\ (\ 147.6\ C + 144\ V\ ) \qquad (7)$$

Where C is the percentage fixed carbon and V is the percentage volatile matter (Bailey *et al.*, 1982).

Determination of ignition time

The ignition time was determined following the method used by Onuegbu*et al.*, (2010). Each briquettes sample was ignited at the base with a cigarette lighter in a drought free environment. The time required for the flame to ignite the briquettes was recorded as the ignition time using a stop watch.

Determination of Water Boiling Time and Burning Rate

Test was carried out on water boiling time according to the method used by Onuegbu*et al.,* (2010). The test was carried out in order to compare the boiling efficiency of the briquettes. The time taken for each set of briquettes to boil 100 cm^3 of water using domestic briquette stove. Burning rate was also determined during this test from equation (8).

$$Burning\ rate = \frac{mass\ of\ fuel\ burnt}{total\ time\ taken} \qquad (8)$$

Determination of specific fuel consumption (SFC)

In the experiment, the specific fuel consumption was taken to be the ratio of the quantity of fuel consumed in term of its mass, to the quantity of the boiling water in term of its volume in litres.

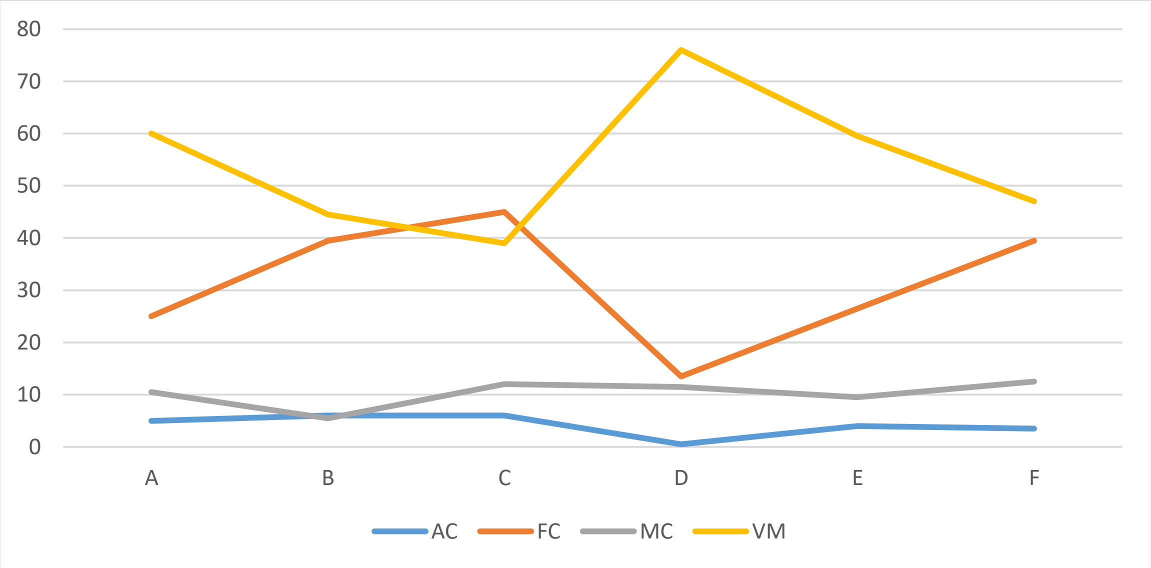
$$SFC = \frac{mass\ of\ fuel\ consumed}{quantity\ of\ boiling\ water} \qquad (9)$$

Table 2: Results and Discussion

Briquette sample	Density	Shatter index
A	0.83	0.81
B	0.81	0,97
C	0.86	0.95
D	0.85	0.94
E	0.80	0.85
F	0.86	0.76

Briquette sample	MC (%)	AC (%)	VM (%)	FC (%)	CV (MJ/kg)
A	10.50	5.0	60.00	25.00	32.11
B	5.50	6.0	44.50	39.50	32.00
C	12.00	6.0	39.00	45.00	31.94
D	11.50	0.5	76.00	13.50	33.36
E	9.50	4.0	59.50	26.50	32.37
F	12.50	3.5	47.00	39.50	32.73

Briquette sample	Ignition time (sec)	Water boiling time (min)	Burning rate (g/min)
A	60.70	5.05	2.97
B	33.30	3.08	5.52
C	58.60	3.83	4.18
D	23.50	5.63	4.42
E	85.00	6.33	3.32
F	26.70	3.92	5.61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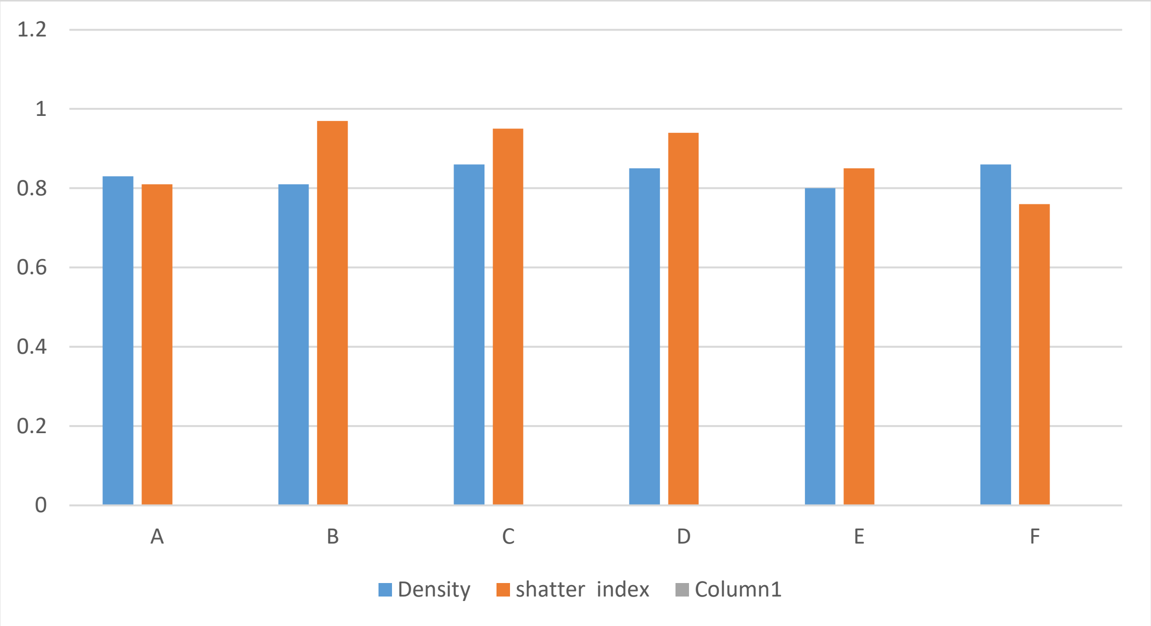
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shatter index
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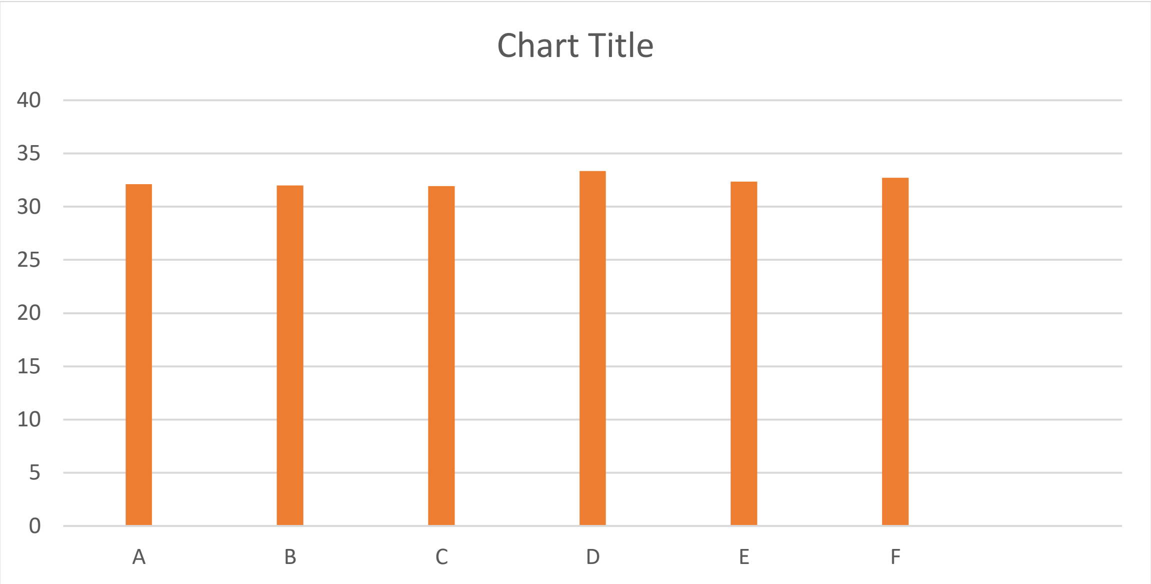
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D
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F

III. CONCLUSION

In the study, it was discovered that particle size, compaction pressure and percentage composition have effects on the briquette qualities. Samples C42 (0.6 mm particle size, 8 MPa, and 100 % mango nuts) and C43 (0.6 mm particle size, 10 MPa, and 100 % mango nuts) have the highest durability (0.99 or 99 %).Higher compaction pressure increases the shattering index (durability) of the briquettes. Sample A43 (0.3 mm particle size, 10 MPa, and 100 % mango nuts) has the highest compaction ratio (1.5). Reduction in particle size increases the compaction ratio. Sample B13 (0.425 mm particle size, 10 MPa, and 30 % mango nuts, 35% cassava peels and 35 % orange peels) has the lowest burning rate, which means it can burn for longer time compared to the rest samples. Higher particle size increases the burning rate. Sample A42 (0.3 mm, 8 MPa, and 100 % mango nut) has the lowest ignition time (12.5 sec.). Lower compaction pressure, higher volatile content and larger particle size decrease the ignition time of the briquette samples. Sample C31 (0.6 mm particle size, 5 MPa, and 35 % mango nuts, 35 % cassava peels, and 30 % orange peels) has the lowest water boiling time (1.97 min.). Increasing particle size and reducing compaction pressure reduces water boiling time. Samples B11(0.425 mm particle size, 5 MPa, and 30 % mango nuts, 35 % cassava peels, and 35 % orange peels) and B13 (0.425 mm particle size, 10 MPa, and 30 % mango nuts, 35 % cassava peels and 35 % orange peels) have the lowest specific fuel consumption (10 g/ltr). Sample A33 (0.3 mm particle size, 10 MPa, and 35 % mango nuts, 35 % cassava peels and 30 % orange peels)has the lowest percentage ash content (0.5 %). Samples B53 (0.425 mm particle size, 10 MPa, and 100 % cassava peel) and A33 (0.3 mm particle size, 10 MPa, and 35 % mango nuts, 35 % cassava peels and 30 % orange peels) has the highest calorific value (33356.24 Kj/Kg), which is well above the DIN 51731 minimum of 17500 Kj/Kg before a material can be regarded as having adequate calorific value.

IV. REFERENCES

[1] Aina, O. M., A. C. Adetogun, and K. A. Iyiola. 2009. Heat energy from value-added sawdust Briquettes of albiziazygia. Ethiopian Journal of Environmental Studies and Management, 2(1): 42–49.

[2] Arogba, S. S. 1997. Physical, Chemical and functional properties of Nigerianmango (*Magnifera indica*) kernel and its processed flour. Journal of the Science of Food and Agriculture, 73: 321-328.

[3] ASTM E897-88. 2004. Standard test method for volatile matter in the analysis sample of refuse-derived fuel. Available at: http//www.astm.org/standards/E897.htm

[4] ASTM standard E1358-9. 2013. Standard test method for determination of moisture content of particulate wood fuels using a microwave oven. Available at: http://www.astm.org/standards/E1358.html

[5] ASTM standard E711-87. 2004. Standard test method for gross calorific value of refuse derived fuel by the bomb calorimeter. Available at: http://www.astm.info/standard/E711.html Chaney, J. 2010. Combustion Characteristics of Biomass Briquettes. PhD. Dissertation. Univ of Nottingham.

[6] ASTM standard E830-87. 2004. Standard test method for ash in the analysis sample of refus derived fuel. Available at: http//www.astm.org/standards/E830.htm.

[7] Bamboye, A. I. and Bolufawi, S. J., Physical characteristics of briquettes from guinea corn(*sorghum bi-colour*) residue. Agricultural Engineering International: CIGR E-journal, 1-10.

[8] Chaney, Joel O. (2010): Combustion characteristics of biomass briquettes. PhD thesis, University of Nottingham. Access from the University of Nottingham repository: http://eprints.nottingham.ac.uk/11732/1/

[9] Davies, R. M. and Abolude D. S., (2013). Mechanical handling characteristics of briquette produced from hyacinth and plantain peel as binder. Journal of Scientific Research and Report, 2(1): 93-102.

[10] Egbewole, Z.T., Sotande, O.A. and Aina, K.S. (2009): Combustion Efficiency of Briquette Produced from Wood Sawdust: An Alternative for Energy Generation. Proceedings of the 2nd Biennial National Conference of the Forests and Forest Products Society. Pp 385-400.

[11] El-Saeidy, E.A. (2004).“Technological Fundamentals of Briquetting Cotton Stalks as a Biofuel”.An Unpublished Ph.D.Thesis. Faculty of Agriculture and Horticulture, Umboldt University: Germany Pp 56-70.

[12] Emerhi, E. A. (2011). Physical and combustion properties of briquettes produced from sawdust of three hardwood species and different organic binders. Advances in Applied Science Research, 2(6): 236-246.

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[13] Hamish, F. 2012. Briquette Business in Uganda. The potential for briquette enterprises to address the sustainability of the Ugandan biomass fuel market. Available at: http://www.gvepinternational.org/sites/default/files/briquette_businesses_in_uganda.pdf.Accessed 18 May 2013.

[14] IFAD/ FAO (2000). The World Cassava Forum. International Fund for Agricultural Development/ Food and Agricultural Organization of the United Nations, Rome. Jekayinfa, S. O., and O. S. Omisakin. 2005. The energy potential of some agricultural wastes aslocal fuel materials in Nigeria. The Agricultural Engineering International: theCIGR E-journal of Scientific Research and Development. 7: 1–10.

[15] Kaliyan, N., Vance Morey, R., 2009. Factors affecting strength and durability of densified biomass products. Biomass and biomass energy, 33(3): 337-359.

[16] Kaur, M., and R. S. Kathunia, S. Grover. 2012. Using agricultural residues as a biomass briquetting, an alternative source of energy. Journal of Electrical and Electronics Engineering, 1(5): 11–15.

[17] Kenechukwu U., Kevin A. (2013). Evaluation of binders in the production of briquettes from empty fruit branch of *Elais Guinensis*. International Journal of Renewable and Sustainable Energy, 2(4): 176-179.

[18] Mishra, S. K., and P. D. Grover. 1996. Biomass Briquetting:Technology and Practices. Available at :http://ces. iisc.ernet.in/energy/HC270799/RWEDP/fd46.html. Accessed 5 March 2013. National Planning Commission (NPC) (2008). Nigeria's Crop Production for 1999 - 2006.

[19] The Fifth National Development Plan (2008-2011). Federal Republic of Nigeria, Abuja. P 38 Oladeji, J. T. 2010. Fuel characterization of briquettes produced from corncob and rice husk resides. *Pacific Journal of Science and Technology*, 11(1): 101-106.

[20] Olorunnisola, A. 2007. Production of fuel briquettes from waste paper and coconut husk admixture. *CIGR Journal,*9: 123-128.

[21] Onuegbu T.U., Ogbu, I. M., Ilochi N.O., Okafor I., Obumselu O. F. and Ekpunobi U. E.(2010). Enhancing the efficiency of coal briquette in rural Nigeria using *Pennisetum Purpurem*. Advances in Natural and Applied Sciences, 4(3): 299-304.

[22] Onuegbu T.U., Ogbu, I. M., Ilochi N. O., Ekpunobi, E., and Ogbuagu, A. S. (2010). Enhancing the properties of coal briquettes using spear grass. Leonado Journal of Sciences, 47-58.

[23] Oladeji, J. T. and Enweremadu, C. C. (2012). The effects of some processing parameters on physical and densification characteristics of corncob briquettes. International Journal of Energy Engineering, 2(1): 22-27.

[24] Shuaibu, N., Dandakouta, H. and Bello, A. (2015). Studying the effect of binder ratio on relaxed density, compressive strength and and durability of sawdust briquettes. International Institute of Academic Research and Development, 1 (3): 1-6.