International Journal of Innovative Mathematics, Statistics & Energy Policies
12(2):72-80, April-June, 2024

 www.seahipaj.org ISSN: 2467-852X

Some Handling Characteristics Of Cassava Peels Bonded Water Hyacinth Briquettes

Tariebi Karikarisei[1] & Davies Rotimi Moses[2]

PhD Scholar: [1]Department of Agricultural and Environmental Engineering,
Faculty of Engineering,
Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria
[1]Corresponding Author: Karikarisetariebi@gmail.com, Phone: +2348063289501

Professor: [2]Department of Agricultural and Environmental Engineering,
Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria

ABSTRACT
Water hyacinth, which falls into the invasive category of aquatic plants, blooms heavily in the Niger Delta region, all year round due to its endowment with network of rivers and streams. The Government often spends millions of naira to clear off the streams, because their presence encourages flooding, disrupt: fishing, navigation and recreational activities on streams and normal hydropower operation. A sustainable and more economical solution to the aquatic plants menace on our water bodies and also dependence on fossil fuels for heat generation, is their densification, using agro-waste binder (cassava peels) which often also are indiscriminate disposed causing environmental concerns. The study investigated the effect of binder concentration on the physical properties of water hyacinth briquettes. The briquettes were produced using: Cassava peelings (CA) as binding agents with water hyacinth grinds. The cassava peels were collected, cleaned, sun-dried and milled to particle sizes 1.18 mm using Disk mill and Tyler sieves. The water hyacinth plants were harvested manually from river using drag net, and sun-dried before milled and sieved to particle size of 1.18 mm. Cassava peel grinds at levels of 20% (B1), 40% (B2), 60% (B3), and 80% (B4) of a constant weight of water hyacinth grinds were evenly mixed together, with the addition of 200ml of boiled water, before it was fed into a steel cylindrical die of dimension 14.21cm height and 2.14cm diameter, and compressed by hydraulic press at pressure level of 5 MPas with dwell time of 20 second before ejected for further experimentation. From the results of the study, all the physical parameters investigated showed improvement with increment in binder concentration. The Durability of water hyacinth briquettes ranged from 81.58 to 98.12%. Briquettes below the binder level of B2 (40%) are not recommended for production as they do not meet the threshold minimum strength for handling, transportation and storage by standard (DIN 51731). This work provides valuable insight on the handling characteristics of cassava peels bonded water hyacinth briquettes, and highlighted the need to investigate their suitability for sustainable energy generation in rural communities.
Keywords: Biomass, cassava peels, energy, briquette, water hyacinth, cassava peels

1.0 INTRODUCTION

The development of any nation is closely linked with his energy sector progress. Nigeria with its epileptic power supply has made the country to develop at a very slow pace. But Nigeria as a nation is endowed with several network of rivers and creeks especially in the Niger Delta region of the country. Water hyacinth, which clogs ditches and drainage systems and shades out other aquatic vegetation, is a concern for this river and its creeks. It also causes issues for commercial activities including fishing, recreation, and water transportation. Physical, chemical, or biological methods have not been successful in controlling these aquatic weeds. Its quick growth rate in comparison to other agricultural plants may be the cause of this. However, this might be the most effective way to collect and manage water hyacinth when it comes to using it to produce biofuel. Additionally, this will improve farmers' income, the growth of rural economies, the mitigation of adverse environmental effects, and the establishment of job possibilities related to production, harvesting, and consumption. Wastes from agriculture have the potential to be a large supply of materials for energy (Emerhi, 2011).

One of the most potential energy sources for developing nations appears to be biomass, especially agricultural wastes. The concept of turning agricultural sector leftovers into primary or secondary energy resources is highly appealing. Wastes of this nature can be used as renewable, locally produced, and ecologically beneficial energy sources. Additionally, efforts must be taken to efficiently utilize agricultural wastes due to the declining availability of firewood (Patomsok, 2008).

The briquetting of water hyacinth weeds with cassava peels as binding agent is a sustainable way of tackling both the aquatic plants' menace on our rivers and creeks as well indiscriminate disposal of cassava peels on the environment. A number of biomass resources, including sawdust, rice husk, peanut shells, coconut fiber, and palm fruit fiber, have been experimentally investigated to be converted into densified fuels due to the benefits of densification (Davies and Davies, 2014).The current work offers important insights into a few handling characteristics of the briquettes made from 1.18 mm water hyacinth waste particles with cassava peel binder at various binder ratios and 5 MPa compaction pressure.

2.0. MATERIALS AND METHODS

2.1 Water Harvest and Preparation

For this investigation, samples of water hyacinth (*Eichornia crassipes*) plants were collected from the Agbura River in the Yenagoa Local Government Area of Bayelsa State then transported to the Power laboratory in the Department of Agricultural and Environmental, Faculty of Engineering, Niger Delta University Wilberforce Island Bayelsa State, Nigeria. They were thoroughly washed for them to be void of foreign matter (mud,stone etc.) before sun drying to reduce moisture, after the water hyacinth had dried, it was chopped into pieces and then comminuted to 1.18mm shown in Plate1 just to increase surface area and promote densification by reducing particle size content by the recommendations of (Kaliyan and Morey, 2009).

Plate 1: Water Hyacinth grinds of size 1.18mm.

Plate 2: Cassava peelings grinds of size 1.18mm

2.2 Cassava Peels collection and preparation

Samples of cassava peelings were collected from the neighborhood, where they are normally disposed indiscriminately. After giving them a thorough washing to get rid of any dirt or stone, they were sun-dried and ground into smaller pieces to speed up the densification process. Tyler sieves were used to isolate size particles of 1.18mm see plate 2 which were used for the experiment. In line with procedures followed by (Nkemdirim, 2014; Davies and Davies, 2014). The chosen particle sizes at levels of 20% to 80% with discrepancy of 20% of the residue weight of the aquatic plant were hydrated by addition of predetermined amount of hot water. The resulting mixture was stirred constantly together with the weighed bulk of aquatic plant powder until a homogeneous mixture is produced before it was fed into the die (Plate 3) for densification on a hydraulic as shown in Plate 4. The briquette was expelled and taken for additional research after a 20-minute dwell period.

Plate 4: Hydraulic press Plate 3: Mould for Briquette Production

2.3 Physical properties sample briquettes

In relation to briquetting the indices such as compressed density, relaxed density, compaction and relaxation ratios are useful in the investigating the physical properties of briquettes (Sotande and Alandele, 2010).

2.4 Compressed or maximum density.

As soon as the briquette was ejected from the die, as a ratio of the observed mass in grams to the volume in cubic centimeters. The mass was gotten with help of the weighing balance given above while the volume was calculated after the dimensions of the briquette was obtained. It was then calculated as follows (Olorunnisola, 2007)

$$\text{Compressed Density} = \frac{MEASURED\ MASS\ (g)}{CALCULATED\ VOLUME\ (cm^3)} \qquad 1$$

2.5 Relaxed density.

Relaxed density was determined after ensuring that the briquette produced has been dried and has reached a stable state, as the ratio of the mass (g) of the dried briquette over the calculated new volume based on the dimension of the sun dried stable briquette measured in line with the procedure adopted by (Olorunnisola, 2007)

$$\text{Relaxed Density} = \frac{MASS\ OF\ DRIEDBRIQUETTE\ (g)}{NEW\ VOLUME\ OF\ DRIED\ BRIQUETTE\ (cm^3)} \qquad 2$$

2.6 Compaction ratio.

This was evaluated as division of compressed density by initial density. When reduced to its most basic form, is equal to the ratio of the compacted briquette's height to the depth of the mold used to produce the briquettes. (Sotande and Alandele, 2010; Olorunnisola, 2007; Oladeji and Oyetunji, 2013; Bolufawi and Bamgboye, 2014;),

$$\text{Compaction Ratio} = \frac{DEPTH\ OF\ MOULD}{HEIGHT\ OF\ COMPRESSED\ BRIQUETTE}. \qquad 3$$

2.7 Relaxation ratio.

This was calculated as the ratio of compressed density to relaxed density after the briquette had been sun dried to a stable state. (Bolufawi and Bamgboye, 2014).

$$\text{Relaxation Ratio} = \frac{COMPRESSED\ DENSITY}{RELAXED\ DENSITY} \qquad 4$$

2.8 Determination of Water Resistance Capacity of Briquette.

A dried sample of the briquette was pre-weighed before hydrated in a water bath for sixty seconds and then rescaled again to get a final weight. This procedure was repeated thrice and the mean evaluated using Equation (5), water resistance capabilities using equation 6 (Kpalo *et al*., 2020)

Water absorption Capacity (W) = $\frac{M_f - M_i}{M_i} * 100$ 5

Water Resistance Capacity (W_R) =100 – W 6

Where: M_f = weight of briquette after hydration, M_i = weight of briquette before hydration.

2.9 Briquette's Durability.

Durability gives a picture of the briquette's interaction with material handling equipment and was evaluated based on ASTM D440-86 (ASTM 2002) Standard. The relaxed briquette was pre-weighed and then allowed to fall gravitationally from a height of 1.5meter onto a concrete base. After that, a sieve with a 2.36 mm aperture was used to filter the material, taking record of the mass that was retained on the sieve (Kpalo *et al*. 2020; Suprin *et al*, 2008). This was done in triplicate and the mean recorded using equation 7.

$D = (M_a / M_b)x100$ 7

Where, M_a – mass of briquette after dropping and that was retained on sieve, M_b – mass of briquette before dropping and D – durability in percentage.

3.0 RESULT AND DISCUSSION.

Plate 5. Samples cassava peel bonded water hyacinth Briquettes and Table 1 shows the averages of physical properties results.

Plate 5: Water hyacinth briquettes

3.1: Effect of binder level on Relaxed and compressed densities of water hyacinth briquettes.

This section establishes the impact of binder quantity on the relaxed and compressed densities of water hyacinth briquettes, which are displayed in table 1. In cassava peel (CA) bonded briquettes for binder levels of B1(20%) to B4(80%) of the residue weight of water hyacinth plant, the relaxed density ranged from 0.310 g•m–3 to 0.327 g•m–3. The compressed density of the briquettes was found to have a range of 0.554 to 0.640 g•m–3. All of the binder levels used in this investigation showed that the compressed density consistently had a greater value than the relaxed density. Significant elastic recovery and stress relaxation processes take place after the briquette is taken out of the die in order for it to reach its stable state, as evidenced by the observed decrease in the relaxed density. Figure 1 and figure 2 shows an increase in the binder ratio showed an increase in the compressed and relaxed densities of the briquettes respectively, this is consistent with briquettes made from municipal waste (Singh and Singh, 1982; Prasityousila and Muenjina 2013; Park *et al.*, 2014; Davies and Davies, 2014; Thabuot *et al.*, 2015 and Rajaseenivasan *et al.*, 2016). All briquettes produced met the minimum standard required for strength to withstand handling, storage, and transportation by DIN 51731 (1996). When compared to other organic and inorganic binders reported in the literature, the cassava peel (CA) binder utilized in this work performed well in briquette formation (Rajaseenivasan *et al.*, 2016).

Table 1: Means of physical properties of water hyacinth briquettes with cassava (CA) peels as binding agent.

Mean of Physical Properties	Sample Replication Value	0% of CA	20% of CA	40%of CA	60% of CA	80% of CA
Compaction Ratio	3	3.837	3.695	3.639	3.585	3.543
Compressed Density (G/Cm3)	3	0.5	0.554	0.593	0.632	0.64
Relaxed Density (G/Cm3)	3	0.294	0.31	0.312	0.324	0.327
Relaxation Ratio	3	1.701	1.79	1.9	1.95	1.96
Water Resistibility (%)	3	70.18	82.97	92.84	97.45	98.06
Durability (%)	3	79.64	81.58	95.42	97.37	98.12

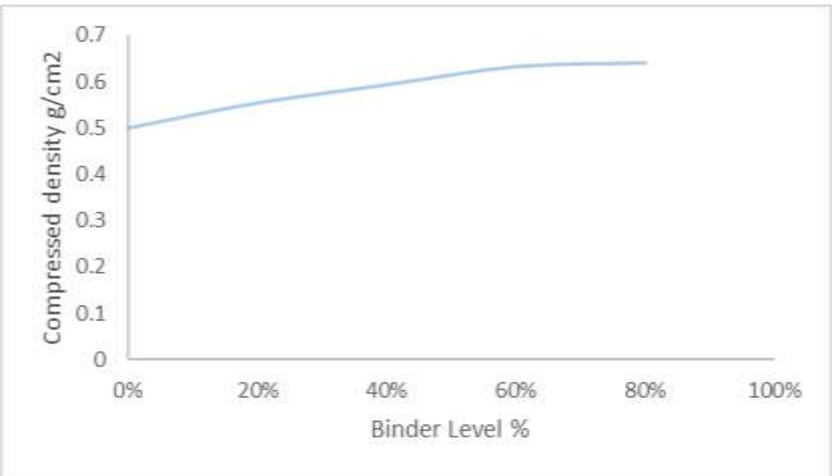

Figure 1: The effect of binder level on compressed density

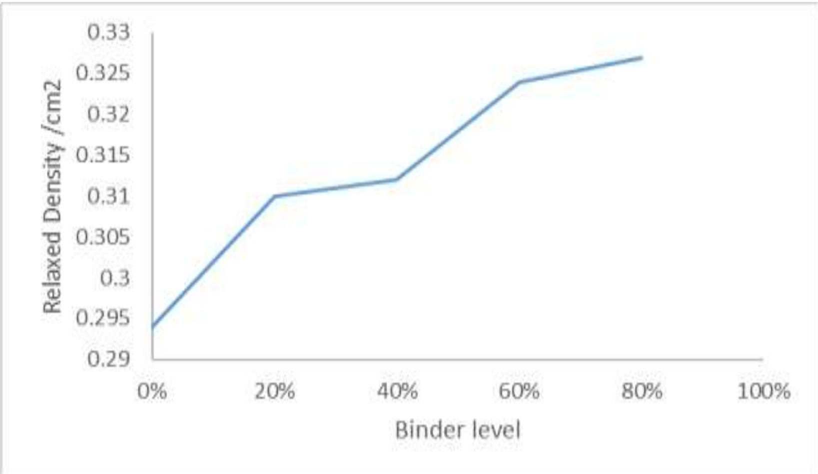

Figure 2: The effect of binder level on relaxed density

3.2 The effect of binder level on the Compaction and Relaxation Ratios of Water Hyacinth Briquettes.

According to Table 1 and Figure 4, the relaxation ratio for cassava peel (CA) bonded briquettes varied from 1.79 to 1.96 depending on the binder level, with a mean value of 1.9 for binder levels of B1 (20%) to B2 (80%) of the residue weight of water hyacinth. Figure 4 demonstrates a positive correlation between Relaxation ratio and the binder level, i.e., an increasing trend of Relaxation ratio with increment in the binder level, this is in conformity with a researched works that was previously reported by Bolufawi, (2011) for coconut husk briquettes and by Oladeji *et al.*, (2009) for groundnut and melon shell briquettes. Given that lower relaxation ratio values indicated a lower tendency of elastic property and more stability and higher relaxation ratio values indicated a higher tendency of elastic property and less stability, the observed relaxation ratio values obtained for this study across all binder levels suggest that the briquettes have good packaging, storage, and transportation qualities. With binder levels ranging from B1 (20%) to B4 (80%) of the residue weight of the water hyacinth grinds under consideration, the findings for compaction ratio, as displayed in Table1, varied from: 3.695 to 3.543 for cassava peel bonded briquettes. Greater vacancy in the compressed materials was indicated by a higher compaction ratio. A higher number denotes greater volume displacement, which is advantageous for transportation, storage, and packaging—but most importantly, it shows high-quality briquettes. Figure 3 shows that when binder concentration increased with decreased in the compaction ratio. This is in agreement with some studies (Oladeji *et al.*, 2009) and (Bolufawi, 2011) for the production briquettes using rice husk; groundnut shells and guinea corn briquettes respectively.

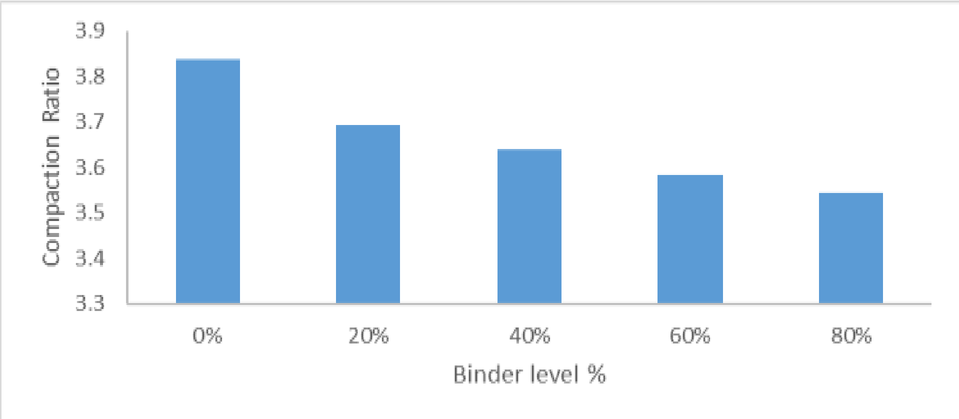

Figure 3: Effect of binder level on compaction Ratio

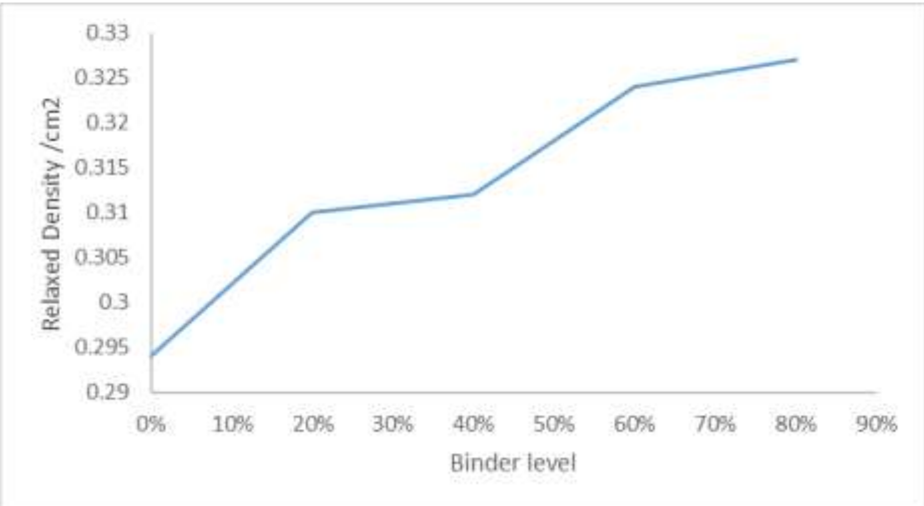

Figure 4: Effect of binder level on Relaxation Ratio

3.3 The effect of binder level on the Durability of water Hyacinth briquettes

The shattering index of the cassava peelings bonded water Hyacinth briquettes ranged from 81.58 to 98.12% for binder levels of 20% to 80% of the residue weight of water Hyacinth grinds. These values showed that the briquettes were able to maintain their shape after being subjected to an impact force, as they are higher than the recommended value of 90% same as investigated by these researchers (Borowski 2007; Borowski and Hycnar 2013; Gwenzi *et al.*, 2020) on sawdust briquette mixed with neem powder and (Rajaseenivasan *et al*., 2016; and (Kpalo *et al*., 2020) studied on a maize cob and oil palm trunk bark briquette. they yielded a shattering index range that is comparable to that of the cassava peeling bound water hyacinth briquette. As illustrated in Figure 5, the briquettes' shattering index exhibits an increasing trend as the binder is added. A possible explanation for the increase in the shattering index with higher binder concentration could be the amalgamation of the constituent components, leading to a strong bonding of particles with more binding agent present. Briquettes made by mixing lignite with leftover paper had an equivalent outcome (Yaman *et al*., 2001).

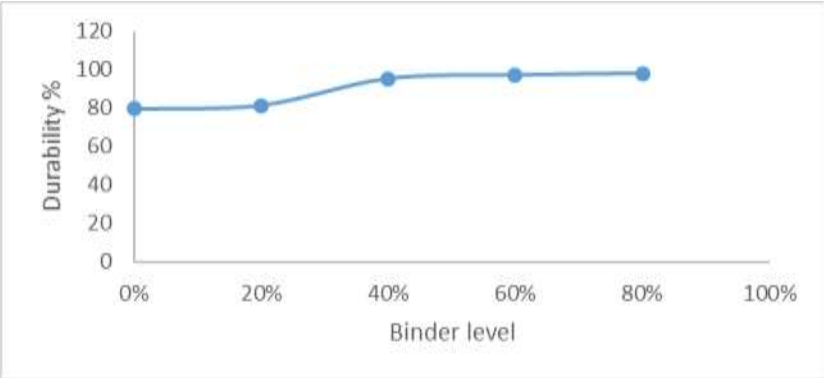

Figure 5 Effect of binder level on the durability of water hyacinth briquettes

4.4 The effect of the binder level on the Water Resistance capacity of water hyacinth briquettes.

The water resistance test is a simulation of the briquette's interaction with the environment while in storage or being transported. When water Hyacinth grinds were bound using cassava peelings, the water resistance of the resulting briquettes ranged from 82.97 to 98.06% for binder amounts ranging from B1 (20%) to B4 (80%) of the residual weight, as shown in Table 1. Similar values for a neem and sawdust briquette were reported by (Rajaseenivasan, 2016). The study found a direct association between the water resistance of the briquettes and the degree of binder used. As indicated by Figure 6, the water resistance of the briquette increases as the amount of binder increases. The reduced particle sizes of the dried water hyacinth plant, which improved its inter-particle bonding with insignificant pore spaces may be the cause of the rise in water resistance with binder quantity. The briquette's high-water resistance capacity with binder increment might be attributed to the applied binder's ability to increase the briquette's resistance to water absorption when exposed.

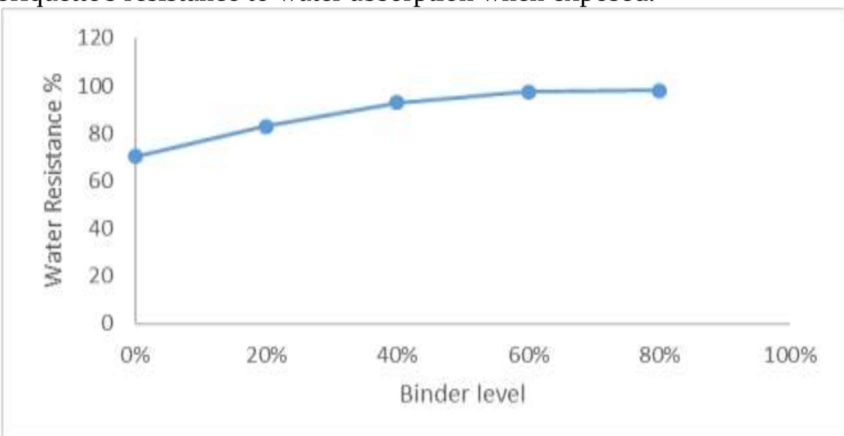

Figure 6 effect of binder level on water resistance of water hyacinth Briquettes

CONCLUSIONS

The production of water hyacinth briquettes with cassava peel binder is feasible and sustainable, because the aquatic plants as well as the binder are readily accessible and inexpensive, and has the potential for employing thousands of unemployed youths in the affected areas, because it does not necessarily require complicated expensive equipment for their production. The percentage of binder added to the feedstock had a substantial impact on the physical properties of the water hyacinth briquettes, according to this study. According to the study's findings, every physical property examined showed improvement as the binder level increased; however, because briquettes below B2 (40%) binder level do not satisfy the minimal requirements for handling by standard (DIN 51731), production of such briquettes is not advised. The handling characteristics of this variant of water hyacinth briquettes competed favorably with those of other biomaterials based on reports. Water hyacinth briquettes using Cassava peel as binder are optimally recommended to be produced at 40% binder level and above as briquettes below those levels of the binder do not meet handling requirement. Thermal characteristics of cassava bonded water hyacinth briquettes should also be studied to know their suitability for household and small-scale industrial heating applications.

REFERENCES.

ASTM standard E711-87, (2004). Standard test method for gross calorific value of refuse –derived fuel by the bomb calorimeter. Annual book of ASTM standard, 11.04. ASTM International, http//www.astm.info/standard/E711.htm.

ASTM (2002): ASTM D440-86. Standard Test Method of Drop Shatter Test for Coal; ASTM International: West Conshohocken, USA.

Borowski, G. (2007). The possibility of utilizing coal briquettes with a biomass. *Environment Protection Engineering*, 33: 79.

Borowski, G. and Hycnar, J.J. (2013). Utilization of fine coal waste as a fuel briquette. *International Journal of Coal Preparation and Utilization*. 33: 194–204.

British Standards Institution, (2004). “Solid biofuels- terminology, definitions and descriptions.” draft biomass standard, DD CEN/TS 14588.

Bulufawi, S. J and Bamgboye, A. I. (2014). Evaluation of some handling and processing parameters for briquetting of guinea corn (Sorghum bi-color) residue. *African journal of biotechnology*. 13(46): 4320-4329.

Davies Rotimi Moses, Davies Onome Augustina (2014). Some Physical and Mechanical Properties of Water Lettuce (*Pistia stratiotes*) Briquettes. *American Journal of Science and Technology*.1(5): 238-244.

Davies and, R. M. and Davies, O. A. (2013). Physical and Combustion Characteristics of Briquettes Made from Water Hyacinth and Phytoplankton Scum as Binder. *Hindawi Publishing Corporation Journal of Combustion*: 2013.

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.

Kpalo S.Y., Zainuddin M.F., Manaf L.A.and Roslan A.M. (2020): Production and characterization of hybrid briquettes from corncobs and oil palm trunk bark under a low pressure densification technique. *Sustainability*, 12: 2468

Nkemdirim, Ogechi Vivian (2014). Effects of Different Binders on the Physical and Combustion Properties of Dried Leaves Briquettes. M.Eng. Thesis, Department of Agricultural andBio-resources Engineering, Faculty of Engineering University of Nigeria, Nsukka, Nigeria.

Olorunnisola, A. O. (2007). Production of Fuel Briquettes from Waste Paper and Coconut Husk Admixture. *Agricultural Engineering International*: the CIGR E-journal. Manuscript EE 06 006 Vol. IX : 1-10.

Oladeji, J. T.; Enweremadu, C.C. and Olafimihan, E. O. (2009). Conversion of Agricultural Wastes into Biomass Briquettes. *IJAAAR* 5 (2): 116-123.

Prasityousila, J. and Muenjina, A. (2013). Properties of solid fuel briquettes produced from rejected material of municipal waste composting. *Procedia Environmental Sciences* 17: 603–610.

Thabuot, M., Pagketanang, T., Panyacharoen, K., Mongkut, P., Wongwicha, P. (2015).Effect of applied pressure and binder proportion on the fuel properties of holey bio-briquettes. *Energy Procedia*, 79: 890–895.

Park, J., Lee, Y., Ryu, C. and Park, Y. (2014). Slow pyrolysis of rice straw: Analysis of products properties, carbon and energy yields. *Bio-resource Technology*.155: 63–70.

Rajaseenivasan, T., Srinivasan, V., Qadir, G.S.M. and Srithar, K. (2016). An investigation on the performance of sawdust briquette blending with neem powder. *Alexandria Engineering Journal*. 55: 2833–2838.

Bolufawi, S.J. (2011). Briquetting Characteristics in Relation to Fuel Values of Guinea Corn (Sorghum bicolor) Residue. An Unpublished Ph.D Thesis of the Department of Agricultural and Environmental Engineering, University of Ibadan, Nigeria.

Gwenzi, W.; Ncube, R.S. and Rukuni, T. (2020). Development, properties and potential applications of high-energy fuel briquettes incorporating coal dust, bio-wastes and post-consumer plastics. *SN Applied Sciences*.2: 1006.

Yaman, S.; Sahan, M.; Haykiri-Acma, H.; Sesen, K. & Kucukbayrak, S, (2001). Fuel Briquettes from Biomass-Lignite Blends. *Fuel Processing Technology*.72: 1-8.

Suprin, R. (2008). Test for physical properties of Briquettes. *International Journal of Engineering Research*. 25(5):234-245.

Sotande, P. and Alandele, A. (2010). Wood and Waste Biodiversity. *IISTE Journal on Briquettes*.15 (3):57-60.

Oladeji, J. T. and Oyetunji, A. (2013). Investigation into physical and fuel Characteristics of briquettes produced from Cassava and Yam peels. Mechanical Engineering Dept, Ladoke Akintola University of Technology,Oyo. *Journal of Energy Technologies and Policy*. 3(7).