Journal of
Petroleum Engineering & Technology

https://journals.stmjournals.com/jopet

ISSN: 2231-1785 (Online)
ISSN: 2321-5178 (Print)
Volume 15, Issue 2, 2025
May–August
DOI (Journal): 10.37591/JoPET

Combustion Characteristics of Waterlily (*Nymphaea lotus* Linn.) Briquettes

Karikarisei T.[1],*, Davies R.M.[2]

Abstract

The effect of binder types (bananas, yams, and cassava) and binders' proportion on thermal properties of waterlily (Nymphaea lotus Linn.) briquettes were investigated. Peels from bananas, yams, and cassava were collected from agro processing cottage industry. The peels were washed, sun-dried, and ground using a disk mill and Tyler sieves to a particle sizes of 0.50 mm. The waterlily plants were collected from the river using a drag net, sun-dried, then ground and sieved to a 1.18 mm particle size. Respective agro-waste grinds at 20% (B1), 40% (B2), 60% (B3), and 80% (B4) of a constant weight of water lily grinds were blended together after addition of 200 ml of boiled water. The resulting homogenous feedstock was then fed into a steel cylindrical die of dimension 14.21 cm height and 2.14 cm diameter, and compressed by hydraulic compression machine at pressure level of 5 MPa with dwell time of 20 sec before ejected for further experimentation. From the results of the study, calorific value of waterlily briquettes ranged from 24751 to 26717 kJ/kg. The values obtained in this study are above 17000 kJ/kg threshold minimum calorific value by standard (DIN 51731:1996-10) for fuel sources, hence they are suitable for household and for small industrial heating applications. Because the ash content increased and the calorific value decreased beyond 60%, it can be concluded that the ideal amount of binder recommended across the binders for the production of waterlily briquettes is at 60% and below, even though the combustion properties generally improved with an increase in binder concentration.

Keywords: Biomass, densification, agro wastes, aquatic plants, density, briquette

INTRODUCTION

It appears that one of the most promising energy sources for developing nations is biomass, especially agricultural waste. The concept of using agricultural waste materials as primary or secondary energy sources is quite alluring. Waste of this type can be used as free, locally produced, and ecologically friendly energy sources. Furthermore, efforts must be taken to efficiently utilize agricultural wastes due to the declining supply of firewood. They have gained significant significance as fuels for a variety of applications, including power production, industrial process heating, and home cooking. Certain agricultural wastes, like wood chips, coconut shells, and wood debris, are suitable for direct use as fuel. However, without an adequate procedure, most of these heavy minerals are not suitable for direct use as fuel. Their low density, high moisture content, and low energy density are the reasons for this. All of these concerns could lead to issues with handling, storage, transportation, and entrained particulate emission management, including direct combustion [1]. The development of any nation is closely linked with his energy sector progress. Nigeria with its epileptic power supply has

***Author for Correspondence**
Karikarisei T.
E-mail: Karikariseitariebi@gmail.com

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

Received Date: February 04, 2025
Accepted Date: March 07, 2025
Published Date: April 05, 2025

Citation: Karikarisei T., Davies R.M. Combustion Characteristics of Waterlily (*Nymphaea lotus* Linn.) Briquettes. Journal of Petroleum Engineering & Technology. 2025; 15(2): 12–21p.

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. Aquatic plants like waterlily and water hyacinth plague this river and its creeks, obstructing ditches and drainage systems and obscuring other aquatic vegetation. This causes issues for commercial enterprises, fishing, recreation, and water transportation. It has been challenging to control these aquatic weeds using physical, chemical, or biological methods. Their rapid growth rate in comparison to other agricultural plants may be the cause of this. However, this might be the most effective way to harvest and control aquatic weeds when they are utilized to produce biofuel. Additionally, this will improve farmers' income, rural economic growth, the environment, and the creation of jobs in the production, harvesting, and use sectors. Waste from agriculture has the potential to be a significant source of resources for energy production. These consist of animal waste, crop and forest residues, wood, and aquatic and herbaceous plants. Each year, Nigeria produces a significant amount of these wastes, which are either indiscriminately disposed of or severely underutilized [2].

A mechanical compaction method called briquetting is used to make bulky materials denser. This process can be utilized for forming fine or granular materials into a designed shape, hence improving their handling characteristics. 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. The benefits of densification have led to the experimental conversion of a number of biomass resources, including sawdust, rice husk, peanut shell, coconut fiber, and palm fruit fiber, into densified fuels [3].

The current study offers useful details on a few thermal characteristics of the briquettes made using 1.18 mm water lily residue particles and, respectively, cassava, yam, and banana peels as binders at various binder ratios and a compaction pressure level of 5 MPa.

MATERIALS AND METHODS

Waterlily Harvest and Preparation

Waterlily (*Nymphaea lotus* Linn.) are commonly found in slow-moving streams, shallow marshes, bogs, pond etc. But for this study, they were harvested at a stream in Azikoro Village, off Goodnews street, in Yenagoa Local Government Area of Bayelsa State, Nigeria. The water lilies were cleaned to remove interference of foreign matter such as mud, stone etc., prior to drying them in order to lower the moisture content in line with Kaliyan and Morey [4]. After drying they were still scrutinized to avoid the presence of foreign matter which will adversely affect the properties of briquettes produced. The dried material was chopped into pieces and finally comminuted to enhance surface area by decreasing particle size to improve its densification. The comminuted material of size 1.18 mm for the experiment, was determined with the help of Tayler sieves (Plate 1). The milling of the materials was achieved with disk mill and weighing was done with table top digital balance with 0.01 g precision (Plate 1).

Agro-waste Collection and Briquette Production

Cassava, yam and banana peels are in abundance in many states in Nigeria, especially in the Southern part of the country. They are occasionally used as feeds for domestic animal such as goat and others, but majorly indiscriminately disposed, creating environmental problems. This study is done in a bid to curb or mitigate: the challenges created by the indiscriminate disposal of Agro-wastes (cassava, yam and banana peels); and create employment opportunity for the unemployed as well as provide an alternative renewable easily accessible energy source for low income earners. Samples of cassava peels were collected from the neighborhood, where they are normally disposed indiscriminately, while banana and yam peels were gotten from table top vendors. They were thoroughly washed to remove mud and stone to prevent contrary interference of their presences in the mixture for briquetting and then sun dried and ground to reduce their particle size to enhance the densification process. Tyler sieves were used to isolate particles of size 1.18 mm of each of the binders, which were used for the experiment. In line with procedures followed by Tariebi and Davies, the chosen particle size in 20, 40, 60 and 80% respectively of the residue weight of the aquatic plant, were hydrated by addition of 200 ml of boiled water [5]. The resulting mixture was stirred constantly together with the weighed bulk of waterlily grinds until a homogeneous mixture was produced, which was then fed into the die for densification on a hydraulic compression machine at the farm structures laboratory of Agricultural and environmental Engineering of Niger Delta University, Amasomma, Bayelsa State, Nigeria. A dual time of 20 min was observed before the briquette was ejected and taken for further experimentation.

Burning rate Evaluation

This is the rate of combustion of a given volume of fuel in air [6]. This was determined in line with the procedure followed by Tariebi and Davies and Onuegbu *et al.* [7, 8]. A Bunsen burner was ignited and controlled to attain a blue flame, a tripod stand holder was then carefully used to hold a sample briquette after it has been pre-weighed, and placed over the flame ensuring only the base of the Briquette was in touch with the flame and in a drought free corner. The sample briquette was left over the gas flame until it was thoroughly ignited, after which it was removed and allowed to burn until it went off on its own. The ignition time, burning time and weight loss were recorded and burning rate evaluated by the following expression:

$$B.R=M_f/t \tag{1}$$

Where,
B.R: is burning rate, in (g/s),
M_f: is total weight of burnt briquette in (g), and
t: is total time taken in (s).

Ignition Time Evaluation

This was calculated in accordance with the methodology used by Onuegbu *et al.* [8]. As previously mentioned, a sample of the briquette was lit at the base in a corner free of drought. Using a stopwatch, the average time it took the briquette to produce a continuous glowing flame was determined to be the ignition time.

Moisture Content (MC)

The fuel's moisture content serves as a gauge for its water content. According to Borman and Ragland, there are two types of moisture that can be found in solid fuels: bound water that is a component of the material's chemical structure, and free water that is present in the fuel's pores and interstices [9]. A fixed mass of briquette sample was employed to evaluate the moisture composition, by oven drying it at 105°C to achieve mass uniformity. Consequently, the moisture content was then computed on dry basis, as follows:

$$(MC)\%=\frac{M_{i-M_f}}{M_f} * 100 \tag{2}$$

Where,
M_i: initial mass briquette sample,
M_f: final mass of briquette sample after drying.

Volatile Matter (VM)

As indicated in Plate 1, a muffle furnace was used to heat 2 gm of crushed, oven-dried briquette sample in a crucible to 600°C for 10 min. After letting the sample cool in a desiccator as shown in Plate 1, the proportion of volatile matter was determined by Eq. (3):

$$PVM=\frac{B-C}{B} x\ 100 \tag{3}$$

Where,

C: represents the weight of the sample after it has been in the furnace for 10 min at 6000°C, and
B: represents the weight of the oven-dried sample.

Ash Content (AC)

Ash either inherent or entrained is inversely correlated with a fuel's calorific value and are created when dirt and clay particles are added to fuel during harvest, transportation, and processing [10]. In order to quantify ash content, 2 gm of the pulverized sample briquettes were measured with weighing balance into crucible and heated in a furnace for 4 h at 600°C in the Reactions and Kinetics laboratory of the department of chemical Engineering, Faculty of Engineering, Niger Delta University, Wilberforce Island, Wilberforce Island, Amassoma, Bayelsa State, Nigeria. The sample was then weighed after cooling in a desiccator and PAC calculated as follows:

$$\text{PAC}=\frac{D}{B}\times 100 \quad (4)$$

In this case, D represents the weight of ash and B represents the weight of the oven-dried sample.

Fixed Carbon (FC)

By deducting the total of the moisture content (MC), percentage of volatile matter (PVM), and percentage of ash content (PAC) from 100, the percentage fixed (PFC) was calculated as follows:

$$\text{PFC}=100\%–(\text{MC}+\text{PAC}+\text{PVM}) \quad (5)$$

The Heating Value (Calorific Value)

The heating value (HV) was evaluated with the empirical expression below [11].

$$\text{HV}=2.326\ (147.6\text{C}+144\text{V}) \quad (6)$$

Where,

V: stands for the volatile matter in percentage,
C: for the fixed carbon proportion, and
HV: represents the heating value ($\text{kJ}\cdot\text{kg}^{-1}$).

RESULTS AND DISCUSSION

Thermal Properties of Waterlily Briquettes

The thermal characteristics of water lily briquettes bonded with different binders at various binder proportions were investigated as shown in Plate 1.

Plate 1. Waterlily briquettes.

The Impact of Binder Type and Level on the Burning Rate and Ignition Time of Waterlily Briquettes (WL-B)

Ignition time gives a picture of how easily a fuel source can be activated to start burning, while burning rate indicates how a given mass of fuel will last. This section clarifies the impact of binder inclusion in the feedstock on these aforementioned parameters as highlighted in Figures 1 and 2.

The average amount of time needed to produce a stable, brilliant flame was used as the ignition time in this investigation. The results of thermal properties of briquettes made of water lily, with (yam, cassava and banana) peels binders at levels of B1 (20%) to B4 (80%) incorporated with a constant weight of water Lily grinds. It can be inferred that higher binder concentration across all binders result in longer ignition times. The ignition time was 123 sec for the controlled briquettes, but increased to 258 sec. for Cassava peels' bonded briquettes, and to 253 sec for yam peels' bonded briquettes, and to 233 sec for banana peels' bonded briquettes respectively at B4 (80%) binder level. Due to improved bonding, the density increased, potentially resulting in low porosity and decreased oxidant infiltration and combustion product outflow during combustion which resulted in an extended ignition time as shown in Figure 3. The findings of Olugbade and Ojo support the theory that the amount of binder lengthens the ignition period because it increases density and showed that this affects the flame propagation in the briquettes [12]. The variations in outcomes for each type of binder used are comparable to the values for bio-coal briquettes produced by combining components at different coal concentrations of 10 to 50%, which range from 19 to 186 sec [8].

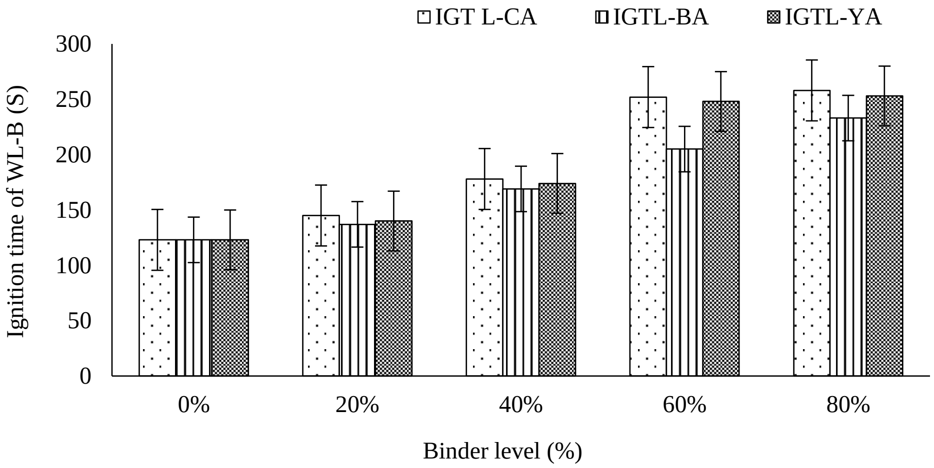

Figure 1. The Effect of binder type and level on ignition time of waterlily briquettes.

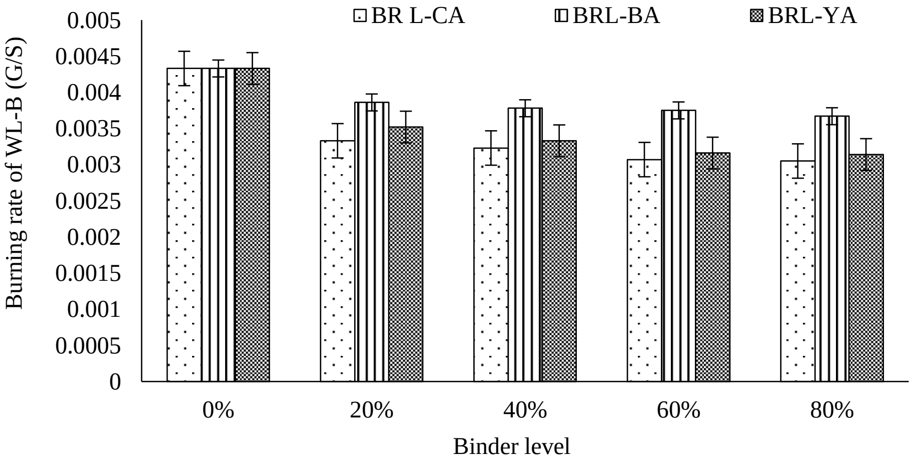

Figure 2. The Effect of binder type and level on burning rate of waterlily briquettes.

Burning Rate, as of the waterlily briquettes indicates an inverse correlation with increment in binder concentration across all binder types, though at different degrees of response as shown in Figure 2. The mean burning rate was 0.00357 g/sec at 20% binder level, but reduced to 0.00337 g/sec at 80% binder level. An increase in density that led to a decrease in porosity may have caused the burning rate to drop as the binder was added. Due to limited heat conductivity, a reduction in the air gap between neighboring particles may have prevented the spread of the flame. Chaney validates the notion that density affects briquette combustion rate because of decreased porosity, which slows the pace at which oxidant infiltrates and combustion products exit the briquette during burning [13]. The Burning rate indicated statistical significance in relation to binder level and type at $p<0.05$, but ignition time was observed to be statistically significant only in terms of binder concentration at $p<0.05$.

Moisture Content of Waterlily Sample Briquettes

Because moisture content significantly influences the burning characteristics of biomass fuel, the briquette samples were dried to a moisture level of 8.32% on a dried basis prior to performing proximate analysis on them. Chin and Siddiqui suggested a lower moisture content of between 5 and 12% for better combustion and briquette stability [14, 5].

Ash Content of waterlily Sample Briquettes

The content of ash as seen in Figure 3, took a slightly downward trend with increment in the binder level across all the three binders used for this study. This can be attributed to the agglomeration of particles enhanced by the binder, leading to the formation of more compact structure, resulting in less ash production during the burning process. For yam peelings bonded water lily briquettes, the ash content ranged from 14.7 to 18.2%, while cassava peels and banana peels bonded water lily briquettes recorded ash values that ranged from 12.6 to 16.8 and 15.45 to 18.2% respectively. The range of values of ash content across types and levels of binder used are lower compared to the ash level of 19.4% of the controlled briquettes (at 0% binder level), which is a testimonial of their effectiveness to function as binders. The slight increment of ash after 60% binder level for banana and yam peelings bonded briquettes may be explained by influence of mineral matter bound into the carbon structure of the binders and water lily playing out (inherent ash). The ash content values found in this study are lower than those found in studies by Emerhi on briquettes made from sawdust from three hard wood species (19.07±4.80–21.72±3.99%) [2], and Onuegbu on coal briquettes (18.27%) [8], however, they remain larger than the values mentioned for different agroforestry residues (Figure 3) [15]. The Ash content values recorded for this study indicated statistical significance across binder levels and types used for this study at $p<0.05$.

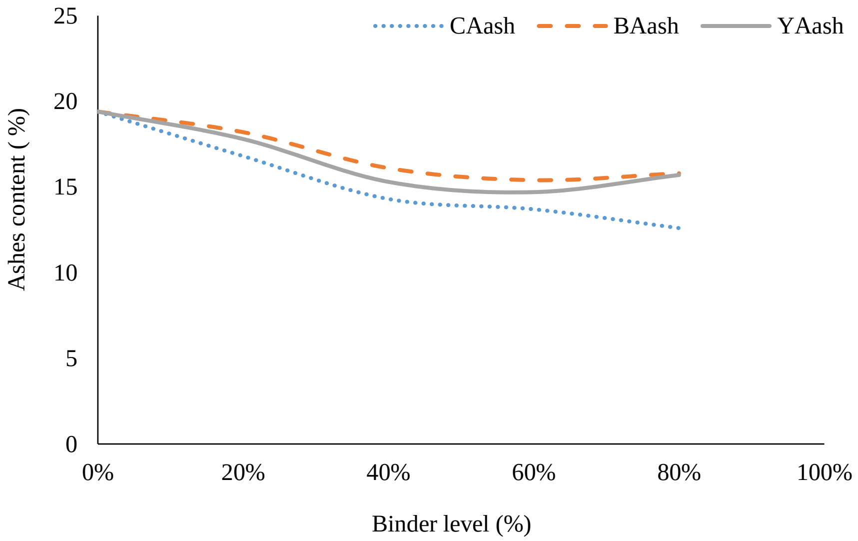

Figure 3. Effect of binder level on Ash content of briquette samples.

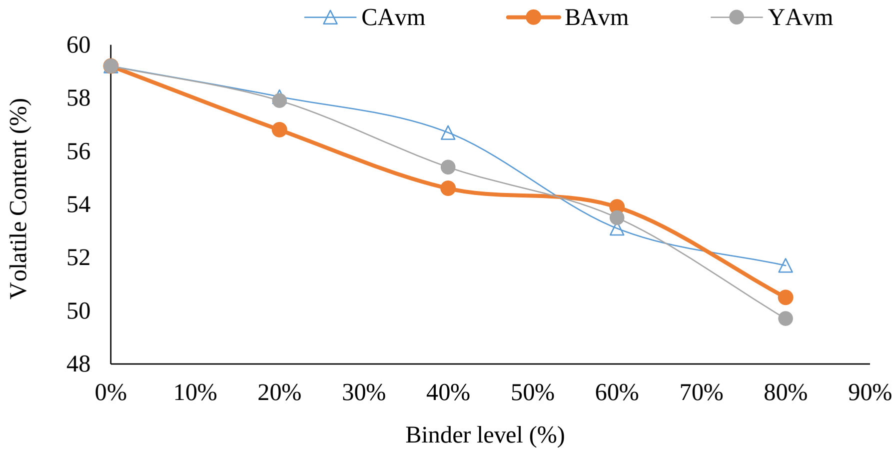

Figure 4. Effect of binder level on volatile content of WL-Briquette samples.

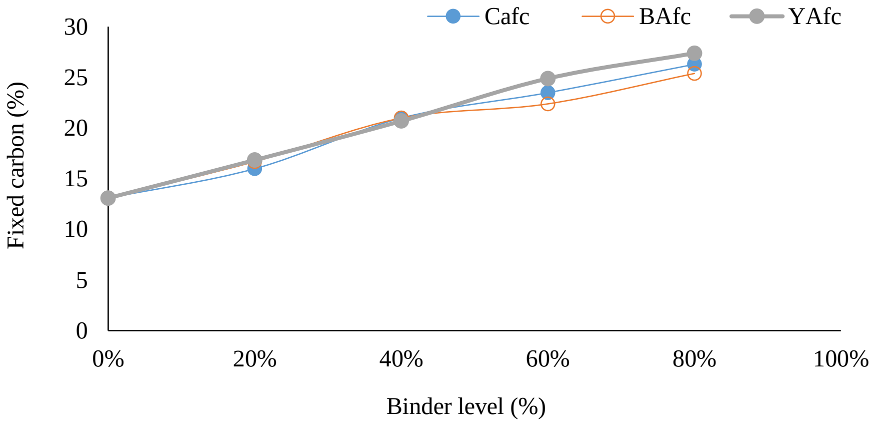

Figure 5. Effect of binder level on fixed carbon content of Waterlily briquette samples.

Volatile Content of Waterlily Sample Briquettes

The volatile content of a fuel source hints us on how it can be easily ignited especially at lower temperature. A mean value of volatile content of 54.89% was observed for cassava peelings bonded waterlily briquettes, while of yam peels and cassava peels bonded briquettes were respectively observed 54.13 and 53.93% as mean values of volatile content, all across binder inclusion level of B1 20%) to B4 (80%) of the residue weight of waterlily grinds (being kept at a constant mass). The higher volatile content value of 59.2% observed for the controlled waterlily briquettes is a reflection of the rapidity of combustion of the dried uncompressed water lily plant, during, burning. Generally, across binder types and levels, an increment in binder proportion led to decrease in volatile content of the respective water lily briquettes, though at different pace as can be seen in Figure 4 respectively. This can be attributed to higher degree of bonding provided by the binding agent which could have resulted in reduced pore spaces and enhanced structural integrity, consequently preventing or reducing the escape of volatile matter during combustion. Volatile content values obtained from this study compete favorably with 89.47±0.22% reported by Emerhi for starch bonded sawdust briquettes from three hard wood species [2], and 70.810% reported by Nkemdirim [16], concerning gum bonded dried leave briquettes. The volatile matter values recorded for this study indicated statistical significance across binder levels, but not across binder types at $p<0.05$.

Fixed Carbon Content of Waterlily Sample Briquettes

A fuel's fixed carbon is essentially the portion of carbon that can be burned to produce char [5]. This section introduces the findings of binder's influence on the fixed carbon content of the feedstock and it is illustrated in Figure 5.

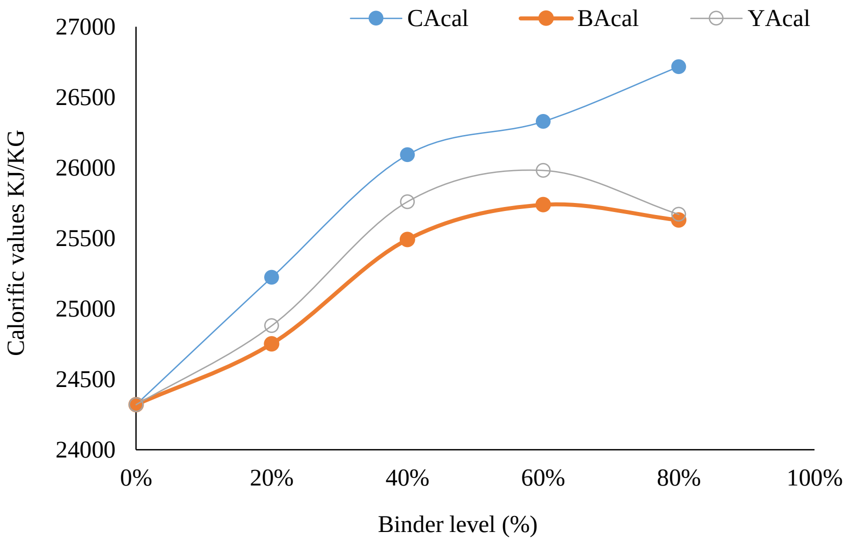

Figure 6. Effect of binder level on calorific value of waterlily briquette samples.

The content of fixed carbon for this study improved from 13.08% of samples of the controlled waterlily briquettes with zero binder inclusion to 27.38% for cassava peelings bonded water lily briquettes with binder level at B4 (80%) of the residue weight of the aquatic plant. Likewise, banana peelings and yam peelings bonded water lily briquettes recorded fixed carbon content improvement with increment in binder level as can be inferred from Figure 5. This can be attributed to improved carbonization or char formation during the burning process, which enhances the stability and combustion efficiency of the fuel. The findings are consistent with reports of Nkemdirim concerning starch bonded dried leave briquettes [16]. The study's three binders: cassava, yam, and banana peelings, improved the water lily briquettes' fixed carbon content, notably at $p<0.05$, and they performed favorably with organic as well as inorganic binders that have been documented in the literature for the production of briquettes [17].

Calorific Value of Waterlily Sample Briquettes

The calorific values of comminuted cassava peelings bonded waterlily briquette samples increased with increment in binder concentration to a peak value of 26717 kJ/kg at B4 (80% binder level), while comminuted yam peelings and banana peelings bonded water lily briquette samples, also recorded increase in calorific value with increment in binder concentration to peak values of 25981 and 25737 kJ/kg respectively both at B3 (60% binder level) and slightly declined with further increment up to (80% binder level). This can be attributed to the slight increment in ash content beyond those binder levels due to inherent ash coming into play (Figure 6) [10]. But generally, the calorific value of waterlily briquette samples improved across all binder types used for this study with increment in their concentration. Sawdust and palm kernel shell-mixed briquettes showed an increase in calorific value from 19.91 to 20.54 MJ/kg, according to Adegoke [18]. The heating values gotten from this investigation agree with those found for coconut husk [19]. It was also more than the 17,500 kJ/kg threshold that is suggested in order for a material to be considered to have an adequate calorific value (DIN 51731:1996-10) [20–22]. The calorific values observed for this study indicated statistical significance across binder levels and types at $p<0.05$ [23–27].

CONCLUSION

Cassava peel bonded briquettes performed best in terms of thermal properties, followed by yam peel bonded briquettes and banana peel bonded briquettes being the least performing based on this study’s results. They recorded peak values of 94.24, 93.03 and 90.29% respectively in terms of shattering index, but recorded peak calorific values of 26716, 25980 and 25736 kJ/kg respectively. This can be attributed to the fact that cassava peel contains more starch compared to the other two binders. Starch gelatinizes with application of water and heat. This is because Amylose and Amylopectin, the major polysaccharides in starch form hydrogen bond among themselves with a resultant disruption of its granular structure giving rise to the formation of starch paste or gel which increases in viscosity while cooling. This increase in viscosity that accompanies the conversion of starch from its granular form to paste form, is expressed by significant resistance to deformation and improved bonding strength. This improvement in bonding strength leads to better agglomeration among particles, increase in density and structural integrity and consequent improvement in calorific value.

REFERENCES

1. Patomsok Wilaipon. Density Equation of Bio-Coal Briquettes and Quantity of Maize Cob in Phitsanulok, Thailand. Am J Appl Sci. 2008; 5(12): 1808–1811.
2. Emerhi EA. Physical and combustion properties of briquettes produced from sawdust of three hardwood species and different organic binders. Advances in Applied Science Research. 2011; 2(6): 236–246.
3. Davies RM, Davies OA. Some Physical and Mechanical Properties of Water Lettuce (Pistia stratiotes) Briquettes. American Journal of Science and Technology. 2014; 1(5): 238–244.
4. Ajit Kaur, Madhuka Roy, Krishnendu Kundu. Densification of Biomass by Briquetting: A Review. Int J Recent Sci Res. 2017; 8(10): 20561–20568.
5. Tariebi Karikarisei, Davies Rotimi Moses. Some handling characteristics of cassava peels bonded briquettes. International Journal of Innovative Mathematics, Statistics and Energy Policies (IJIMSEP). 2024a; 12(2): 72–80.
6. Bintu Grema Mustafa, Yaumi Ali L, Mohammed Modu Aji, Bitrus Kwaji Highina, *et al*. Comparative studies on the combustion performance of briquettes produced from selected biomass residues in Maiduguri. World Journal of Energy Sciences & Engineering. 2015; 1(1): 1–8.
7. Tariebi Karikarisei, Davies Moses Rotimi. Some thermal characteristics of Yam Peels bonded Water lily (Nymphaea Odorata) briquettes. RSU Journal of Biology and Applied Sciences. 2024b; 4(1): 24–32.
8. Onuegbu TU, Ekpunobi UE, Ogbu IM, Ekeoma MO, Obumselu FO. Comparative Studies of Ignition Time and Water Boiling Test of Coal and Biomass Briquettes Blend. Int J Recent Res Appl Stud. 2011; 7(2): 153–159.
9. Borman GL, Ragland KW. Combustion Engineering. McGraw-Hill Science/Engineering/Math; 1998.
10. Loo SV, Koppejan J. A Handbook of Biomass Combustion and Co-firing. Routledge; 2012 May 16.
11. Bailey RT, Blankenhorn PR. Charcoal production, improvement for rural development. Vol. 1. 1982; 61–70.
12. Olugbade TO, Ojo OT. Binder-less briquetting technology for lignite briquettes: A review. Energy Ecol Environ. 2021; 6: 69–79.
13. Chaney JO. Combustion Characteristics of Biomass Briquettes. Ph.D. Thesis. UK: University of Nottingham; 2010.
14. Chin OC, Siddiqui KM. Characteristics of some biomass briquettes prepared under modest die pressures. Biomass Bioenergy. 2000; 18: 223–228.
15. FAO. The briquetting of Agricultural waste for fuel. FAO corporate document. 2003. Repository: www.fao.org/docre/T0275E/T0275E03htm
16. Nkemdirim Ogechi Vivian. Effects of Different Binders on the Physical and Combustion Properties of Dried Leaves Briquettes. M.Eng. Thesis, Department of Agricultural and Bio-resources Engineering, Faculty of Engineering. Nsukka, Nigeria: University of Nigeria; 2014.
17. Demibas A. Yield of hydrogen–rich gaseous products via pyrolysis from selected biomass samples. Fuel. 2001; 80(13): 1885–1891.
18. Adegoke CO. Preliminary investigation of sawdust as high grade solid fuel. J Renew Energy. 1999; 1–2: 102–107.

19. Jekayinfa SO, Omisakin OS. The energy production of some agricultural wastes as local fuel materials in Nigeria. Agricultural Engineering International: the CIGR E-Journal of Scientific Research and Development, Manuscript EE 05 003. 2005; 7: 10–19.
20. Ai Y, Jane JL. Understanding starch structure and functionality. In: Starch in food. Woodhead Publishing; 2024; 55–77.
21. Zobel HF. Gelatinization of starch and mechanical properties of starch pastes. In Starch: chemistry and technology. Academic Press; 1984; 285–309.
22. ASTM standard E711-87. Standard test method for gross calorific value of refuse–derived fuel by the bomb calorimeter. Annual book of ASTM standard, 11.04. ASTM International; 2004. http//www.astm.info/standard/E711.htm.
23. Davies RM, Davies OA. Physical and Combustion Characteristics of Briquettes Made from Water Hyacinth and Phytoplankton Scum as Binder. Hindawi Publishing Corporation: J Combust. 2013; 2013(1): 549894.
24. Davies OA, Tawari CC. Season and tide effects on sediment characteristics of trans-okpoka creek, upper bonny Estuary, Nigeria. Agriculture and Biology Journal of North America (ABJNA). 2010; 1(2): 89–96.
25. Davies RM, Davies OA. Effect of briquetting process variables on hygroscopic property of water hyacinth briquettes. J Renew Energy. 2013; 2013(1): 429230.
26. Davies RM, Abolude DS. Mechanical handling characteristics of briquettes produced from water hyacinth and plantain peel as binder. Journal of Scientific Research and Reports (JSRR). 2013; 2(1): 93–103.
27. Sotande P, Alandele A. Wood and Waste Biodiversity. IISTE Journal on Briquettes. 2010; 15(3): 57–60.