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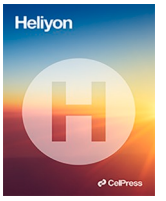

Research article

Utilization of solid residue from hydrothermal liquefaction of breadfruit pulp for the production of bio-briquette using cassava starch as binder

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ABSTRACT

The generation of agro-waste as a result of increase in agro and food processing activities is on the increase due to rapid increase in human population. Hence the need to eliminate these waste by converting them into a useful product or energy source. This work presents the use of bio-char from hydrothermal liquefaction of breadfruit pulp to produce bio-briquettes with cassava starch as a binder. The response surface method using design expert was used to design the experiment with particle size, press pressure and binder dosage as factors, to determine the parameter combination that will produce briquettes of high energy density. The briquette with the highest calorific value 26.75 MJ/kg was produced at the parameter combination of 450 mm^{-6} particle size, 5 MPa press pressure, and 20 % binder dosage. The ultimate analysis carried on the produced briquette gave carbon, hydrogen, nitrogen and sulphur content of 47.22 %, 3.88 %, 0.69 %, and 0.42 % respectively, with oxygen content of 4.79 % by percentage mass difference. While the proximate analysis gave moisture, ash, volatile matter, and fixed carbon content of 7.8 %, 3.9 %, 43.7 %, and 44.6 % respectively. Other characterization test carried out gave combustion rate of 4.5 g/min, ignition time of 3.5 min, density of 0.86 g/cm^3, compressive strength of 8.31 N/mm^2, shatter index of 0.89, and hydrophobicity of 61.3 %. These findings shows that briquettes produced with bio-char from HTL of breadfruit pulp can be used as solid fuel for domestic and mini-industrial heating purposes, as well as eliminate waste from processing of breadfruit.

1. Introduction

The rapid increase in global population and human activities has resulted to high demand for energy and tremendous increase in waste generation [1]. This high demand for energy has resulted to overdependence on fossil to meet the energy demand for both industrial, agricultural and domestic purposes [2,3]. This has caused an adverse effect on the environment due to the release of harmful gases such as, oxides of carbon, nitrogen and sulphur to atmosphere which is the primary cause of global warming, acid rain and health problems like bronchitis, lung cancer, and irritation of eyes [4]. Also the millions of tons of waste generated from human activities especially from agricultural activities for food production, causes a serious pollution on our environment due to the difficulty in

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disposing those wastes [5]. Most of these agricultural wastes from production and processing of crops are mostly dumped on farm site or burnt off at the disposal sites thereby constituting environmental hazards such as global warming and degradation of agricultural soil [6].

Research has shown that 40 % of the energy demand of the world is for heating purposes, ranging from cooking, roasting, bakery and other heating purposes. In rural areas of developing countries such as Nigeria and many other African countries, their major source of fuel for cooking and other heating purposes is wood and woody based fuels, due to the difficulty in sourcing electricity, kerosene, and liquefied natural gas for their cooking and other heating purposes, as a result of unavailability and cost. However, the use of wood fuel is currently becoming unavailable and expensive because the present rate of deforestation is not commensurate to the rate of afforestation due to urbanization and the use of wood for construction and production of woody based products. More so, deforestation as a result of using wood for fuels and other products can lead to climate change, desertification, soil erosion, fewer crops, flooding, and increased greenhouse gases in the atmosphere [7]. Hence the need for alternative sustainable source of energy for heating purposes especially in rural areas.

Currently, biomass especially wastes from agro-activities has been proven to be a good alternative energy source to reduce consumption of fossil fuels and the consequent greenhouse gas emission. The use of these agro-waste for energy generation in large scale can sustain the energy demands in rural areas, and will also help to rid the environment of waste especially from agro-activities, thereby saving the land-space that would've been used as dumping site [8]. These wastes can be converted into solid fuels through briquetting into high-grade solid briquette fuels by improving the calorific value and ensuring a clean smoke-free flame suitable for small scale industrial and domestic applications [9].

Briquetting is a densification process of applying pressure to biomass materials to produce homogenously high bulk density and uniformly sized solid pellets or block known as briquettes, which can be continently used as fuel [10]. This process can be referred to as a waste control method of producing briquettes from agricultural waste [11]. Briquettes can be used to provide fuel source as a preventive measure to ecological challenges [11]. The briquetting of agricultural biomass is normally achieved by direct briquetting of agricultural biomass using additives as binders such as starch and gum arabic. These kinds of briquettes have been characterized by increased smoke generation, low heating value, poor ignition and burning properties, and ultimately not stable under wet condition. These limitations can be improved by carbonization or torrefaction of the biomass before briquetting with or without binders [11].

The utilization of available agro waste materials for briquettes production have been considered and reviewed. These include; the use of rice husk and the combination of rice husk and other agro waste such as wheat straw, and maize stalk ([12]; [7,13]. Some other researcher used sawdust of different woods and the combination of saw dust and other agro-waste for briquette production [9,11, 13–16]. While other work such as Niedziółka et al. [17,18] reported the use of other agro-waste such as rape and oat straw, maize straw and cobs, and its mixture for briquette production. Most of these works reported the use of cassava starch gel as a binder, while some works such as Davies et al. [8]; Mallika et al. [19]; and Helwani et al. [20] densified water hyacinth, palm fiber and empty palm fruit bunches, using plantain peel, molasse and crude glycerol as binder. No work has reported the use of breadfruit pulp which is the major waste from the processing of breadfruit. This waste can undergo pyrolysis or hydrothermal liquefaction for bio oil production while the char or the solid residue from the oil extraction can be used for briquette production, which form the basis of this work.

2. Materials and method

The breadfruit pulp char was used as the parent material, while cassava starch gel was used as the binder for the briquette production. The breadfruit pulp char was the solid residue obtained from the hydrothermal liquefaction of breadfruit pulp carried out at a temperature of 290 °C, biomass-water ratio of 0.1, heating rate of 20 °C/min, and for a reaction time of 50 mins. This liquefaction process was carried out in Chemical Engineering Laboratory of Nnamdi Azikiwe University, Awka, Anambra Nigeria. While the cassava starch was obtained from the waste water pit of a cassava processing plant located at a farm settlement in Ogboji, Anambra, Nigeria.

2.1. Materials' preparation

The solid residue (breadfruit pulp char) was collected after hydrothermal liquefaction of breadfruit pulp and sun dried for 5 days. The dried char was further dried in a memmert oven at a temperature of 105 °C for 1 h, and allowed to cool. The dried char was manually grinded with piston and mortar, and sieved with meshes into different particle sizes ranging from 150 μm to 600 μm particle sizes.

The cassava starch was tied with a linen and kept a load 30 kg for 2 days to allow the water to drain. The starch was sun dried for 5 days until the starch was completely dried. The starch was then gelatinized by dissolving 200 g of starch with 10 g of water at room temperature, before adding 600 g of hot water. The starch was continuously stirred while adding the hot water until the starch was evenly and completely gelatinized.

2.2. Experimental design for briquette production

The experimental design was carried out using a standard Response Surface Method (RSM), known as Central Composite Design (CCD), because of its suitability for fitting a quadratic surface, which usually works well for process optimization. This was done using Design Expert software, version 10. Three factors and seven responses were selected, which gave a total of seventeen runs for the briquette production at different production parameter combinations. The factors are particle size, pressing pressure, and binder dosage, with it's high and low value as shown in Table 1. While the response is calorific value.

2.3. Briquette production procedures

The briquette was produced using the parameter combination generated from the experimental design as shown in Table 2. For each of the runs as generated by the experimental design, 4 g of the solid residue was measured and thoroughly mixed with the corresponding percentage of the binder. The mixture is then poured into the mold and placed in a hydraulic press for compaction. The sample is then allowed to stay under the required pressing pressure according to the experimental design, for 2 min, to allow for adequate formation of the mixture to into a mass of briquette. The press is then disengaged and the briquette extracted from the mold. The produced briquette was sun dried for 3 days and prepared for characterization. The flow chart for the production process of the briquettes and its characterization is shown in Fig. 1. These processes were repeated for all the runs as prescribed in the experimental design.

2.4. Response analysis

The response for the experimental design which was the calorific value was determined for all the briquette samples produced. The calorific value of the sample was determined using the bomb calorimeter according to ASTM D240 [21]. The mass of water in calorimeter (W), mass of water equivalent of calorimeter and stirrer (w), and the initial and final temperature reading of the calorimeter (T_1 and T_2) respectively as well as the mass of the loaded sample (m_s) were recorded and applied in Eq. (1) to determine the calorific value.

$$Calorific\ Value = \frac{(W - w)(T_2 - T_1)}{m_s} \tag{1}$$

The sample with the highest calorific value was chosen as the desired briquette since it possess the highest energy density. The sample was then characterized to determine its fuel and physical properties.

2.5. Characterization

2.5.1. CHNS/O analysis

The CHNS/O analysis was conducted on the samples produced with optimum process condition, with to determine the carbon, hydrogen, nitrogen, and sulphur, content of the samples, while the oxygen contents are determined by mass difference [22]. This was done PerkinElmer 2400 Series II CHNS/O Elemental Analyzer. The analyzer makes use of Helium and oxygen gases to run the analysis, and the oven temperature is allowed to reach 925 °C as prescribed in the manual before the analysis.

2.5.2. H/C and O/C ratio

The carbon, hydrogen and oxygen content of the samples from the CHNSO analysis was used to determine the hydrogen-carbon (H/C) and oxygen-carbon (O/C) ratio of the samples the briquette sample produced at the optimum condition, using Eqs. (2) and (3) respectively, as described by [23].

$$H \Big/ C = \frac{Percentage\ Weight\ of\ Hydrogen / Molar\ weight\ of\ Hydrogen}{Percentage\ weight\ of\ Carbon / Molar\ Weight\ of\ Carbon} \tag{2}$$

$$O \Big/ C = \frac{Percentage\ Weight\ of\ Oxygen / Molar\ weight\ of\ Oxygen}{Percentage\ weight\ of\ Carbon / Molar\ Weight\ of\ Carbon} \tag{3}$$

2.5.3. High heating value

The high heating value is the amount of heat produced by the complete combustion of a unit quantity of the sample. This was determined using Eq. (4) as described by[24].

$$HHV = 0.349C + 1.1783H + 0.1005S - 0.1034O - 0.0151N \tag{4}$$

where HHV is the high heating value of the samples in (MJ/Kg), while C,H,N,S,O represent the percentage content of carbon, hydrogen, nitrogen, Sulphur, and oxygen respectively, within the sample.

Table 1
Experimental design factors with it's high and low values for briquette production.

Factor	Name	Unit	Low Level	High Level
A	Particle Size	μm	300.00	600.00
B	Pressing Pressure	bar	5.00	15.00
C	Binder Dosage	%	20.00	50.00

Table 2
Briquetting experimental factors and responses.

Std	Particle Size	Pressing Pressure	Binder Dosage	Calorific Value
	mm^{-6}	MPa	%	MJ/kg
1	300	5	35	24.35
2	600	5	35	20.97
3	300	15	35	33.00
4	600	15	35	25.15
5	300	10	20	26.45
6	600	10	20	25.45
7	300	10	50	19.06
8	600	10	50	17.69
9	450	5	20	28.54
10	450	15	20	35.70
11	450	5	50	23.01
12	450	15	50	19.41
13	450	10	35	30.39
14	450	10	35	31.05
15	450	10	35	32.98
16	450	10	35	31.05
17	450	10	35	29.76

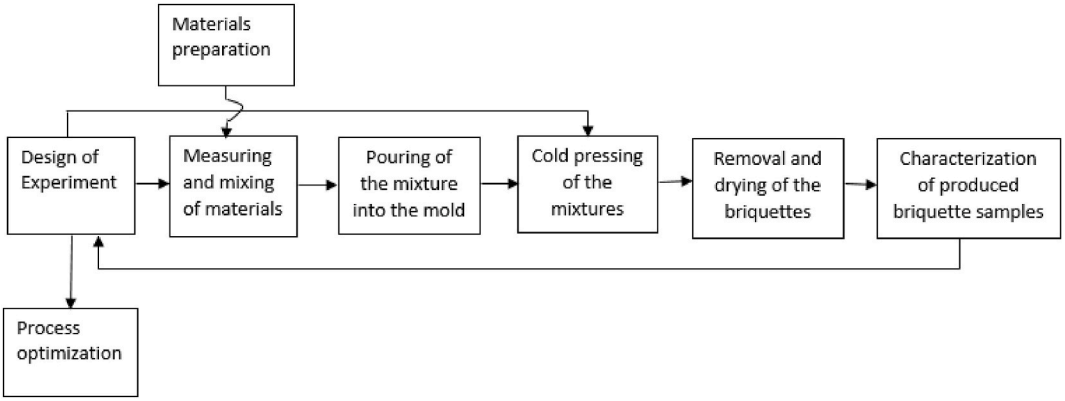

Fig. 1. Flow chart for the production and characterization of the briquettes.

2.5.4. Moisture content

The moisture content of the samples were determined according to ASTM E872-82 as described by Lee et al. [25]. A known weight (W_i) of the samples were placed inside an oven with a dish of known weight, and allowed to dry inside the oven at a temperature 105 °C for 5 h until the weight difference became stable. The weight of the dry sample (W_d) was recorded, and applied in Eq. (5) to obtain the percentage moisture content (%MC).

$$\%MC = \frac{(W_i - W_d)}{W_i} \times 100 \tag{5}$$

2.5.5. Ash content

The ash content was determined according to ASTM E1755- II, as described by Lee et al. [25]. A known weight of the dry sample (W_d) was put inside a crucible and placed inside the furnace, and operated at the temperature of 550 °C for about 8 h until the sample completely turns into ash. The crucible was transferred to a desiccator to cool, and weighed to record the weight of the ash (W_a). The obtained data was applied in Eq. (6) to determine the percentage ash content (%AC).

$$\%AC = \frac{W_a}{W_d} \times 100 \tag{6}$$

2.5.6. Volatile matter

The volatile matter of the sample was determined using ASTM E−872 as described by Basu [26]. The residual dry sample from moisture content determination was placed in a crucible with cover to avoid the interaction of the sample with air. The sample in the crucible was heated at 900 °C in a furnace for 7 min to drive off the volatiles. The weight of the samples before and after heating (W_d and W_h respectively) were measured and applied in Eq. (7) to obtain the percentage volatile matter (%VM).

$$\%VM = \frac{W_d - W_h}{W_d} \tag{7}$$

2.5.7. Fixed carbon content

The fixed carbon according was obtained by subtracting the sum of percentage content of moisture, ash, and volatile matter from 100% of the whole sample as expressed in Eq. (8) [27],

$$\%FC = 100\% - (\%AC - \%VM - \%MC) \tag{8}$$

2.5.8. Combustion rate

Briquette burning rate was determined according to the method reported by Aliyu et al. [7]. The briquette was placed on a Bunsen burner that was arranged and placed on the weighing balance with the insulation pad placed under the burner to prevent the heat from damaging the weighing balance. The briquette was ignited and allowed to burn completely until constant weight was recorded, and the time for complete combustion was recorded. These data were applied in Eq. (9) to obtain the combustion rate of the briquette.

$$Combustion\ rate = \frac{mass\ of\ burnt\ briquette\ (m_{bb})}{total\ time\ taken\ for\ complete\ combustion\ (t_{cc})} \tag{9}$$

2.5.9. Ignition time

Ignition time was determined according to the method described by Aliyu et al. [7]. Each of the briquette was ignited by placing it on a wire gauze placed 3 cm above the Bunsen burner. The Bunsen burner was used to ensure that the entire base of the briquette was ignited simultaneously, and caution was taken to avoid flame spread in the transverse direction. The Bunsen burner was adjusted to blue flame and the briquette was allowed to ignite well until its steady state burn phase is observed. Then the time taken for the complete ignition of the briquette was taken and recorded as the ignition time of the briquette.

2.5.10. Density

The briquettes compressed density of each of the produced were determined after sun drying of the briquettes, as a ratio of measured mass to the volume of the briquettes. The mass of the produced briquettes (m_b) was determined using a digital weighing balance, while the dimensions which include the diameters (d_b), and height (h_b) of the briquettes were measured using a vernier calliper. The measured diameters and height were subsequently used to calculate the volumes (V_b) of the briquettes using Eq. (10), while the corresponding densities (ρ_b) were calculated using Eq. (11) [7].

$$V_b = \pi \frac{d_b}{4} h_b \tag{10}$$

$$\rho_b = \frac{m_b}{V_b} \tag{11}$$

2.5.11. Compressive strength

The axial compressive strength (Nmm^{-2}) of the briquette was measured using Universal Testing Machine with a digital control and display unit for test control and result display. The dimension of the sample was first measured and inputted into the system and the briquette placed directly under the plunger to be pressed. The machine applied load to the briquette until failure occurred on the briquette. The applied force was recorded and displayed until the maximum force that corresponds to the failure is recorded. The compressive strength is then calculated using Eq. (12) [8].

$$Compressive\ strength = \frac{maximum\ force\ aplied}{surface\ area\ of\ the\ briquette} \tag{12}$$

2.5.12. Shatter index

The shattering index or durability index of the produced briquettes was measured according to ASTM D440- 86(2002) method of drop shatter, developed for coal [8]. The test was conducted after sun drying of the briquette samples. The weight of each of the samples were measured and placed in a polythene bag. The bag was dropped from a height of 2 m onto concrete floor four times. After the dropping, the briquettes and its fractions was placed on top of a 35 cm square mesh screen and sieved. The mass of the remaining briquettes was measured, and the shatter index expressed as the ratio of weight of material retained on the screen (m_{bs}) to weight of briquettes before the dropping (m_b), was determined using Eq. (13) [8].

$$Shatter\ index = \frac{m_{bs}}{m_b} \times 100 \tag{13}$$

2.5.13. Hydrophobicity

Hydrophobicity of the produced briquette is its ability to resist water absorption. This was determined by immersing a measured sample of the briquette into 150 ml of water at room temperature for 30 s. The weight of the briquette before and after soaking was determined, and the briquette's hydrophobicity expressed in percent was calculated using Eq. (14) [7].

$$Hydrophobicity = 100 - \left(\frac{m_w - m_b}{m_b} \times 100\right) \quad (14)$$

3. Results and discussion

3.1. Experimental result

The picture of the produced briquette samples are shown in Fig. 2, while the result of the experimental design and the obtained response from the produced briquettes are shown in Table 2.

The experimental result as shown in Table 2, shows that the briquette with highest calorific value of 33.00 MJ/kg was produced at the parameter combination of 300 mm^{-6} particle size, 15 MPa pressing pressure and 35 % binder dosage, while the lowest calorific value 17.69 MJ/kg was obtained from the production parameter of 600 mm^{-6} particle size, 10 MPa pressing pressure and 50 % binder dosage.

3.2. Effect of the factors on calorific value

3.2.1. Interactive effect of press pressure and particle size on the calorific value

Fig. 3 shows that the interaction of particle size and pressing pressure have a significant effect on the calorific value of the briquettes. In Fig. 3(a), it can be seen that increase in press pressure increases the calorific value of the briquettes, while increase in particle size decreases the calorific value of the briquette. That is to say that the briquettes with high calorific value were produced with small particle size at high pressure. This is evident in Fig. 3(b) that showed maximum calorific value within the region of high press pressure and small particle size. This is similar to the reports of Helwani et al. [28]; Niedziółka et al. [17] and Bello et al. [9]. This is because at high press pressure with small particle size, the materials tends to compact together thereby creating more dense materials by eliminating the pores within the briquettes.

3.2.2. Interactive effect of binder dosage and particle size on the calorific value

The interactive effects of particle size and binder dosage on the calorific value of the briquettes are shown in Fig. 4.53(a) and (b). It is seen from the figures that moderate particle size with low binder dosage favours the calorific value of the briquettes. However, at large particle size and high binder dosage, the calorific value decreases. Similarly, the calorific value also decreases at extreme small particle size. This shows that the binder has a lower calorific value compared to bio char used for the briquetting. That is why the calorific value reduces at higher binder dosage, because at that condition, the briquette contains more binder and thereby reducing the quantity of the filler material. Also at large particle sizes, the briquettes tend to more possess pores, thereby reducing energy density of the briquettes. This can be clearly seen in the colour code of Fig. 4.53(b) showing maximum calorific value within the region of low binder dosage with small and moderate particle sizes. This is in agreement with the report of Zakari et al. [29] and Pushkar et al. [30].

3.2.3. Interactive effect of binder dosage and press pressure on the calorific value

The interactive effect of press pressure and binder dosage on the calorific value of the produced briquettes are shown in Fig. 5(a) and (b). The figure shows that the briquettes with high calorific value were produced with low binder dosage at high pressure which is similar to the report of Helwani et al. [28]. In Fig. 5(a), it was seen that at low pressure, high binder dosage reduces the calorific value due to excess of binder which has lower calorific value compared to the bio char used for the briquetting. This tend to increase as the binder content reduces. However at extreme low binder with low press pressure the calorific value begins to reduce due to insufficient binder to hold the filler materials during compaction. At moderate and high press pressure, the calorific value is less with high binder content but increases as the binder content reduces. But in contrast to the condition of low pressure, the calorific value is still high because of the pressure is high enough to compact the material irrespective of the low binder dosage. Hence the reason for maximum calorific value at the region of high press pressure with low binder dosage as seen in Fig. 5(b).

Fig. 2. Picture of the produced briquettes samples.

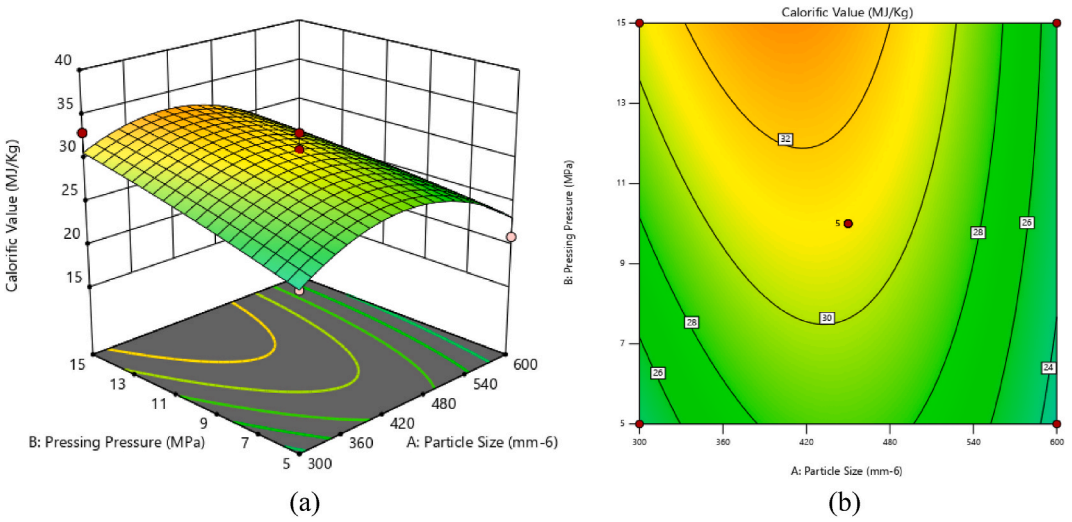

Fig. 3. (a) 3D response surface and (b) contour plot of particle size and press pressure on the calorific value of the briquettes.

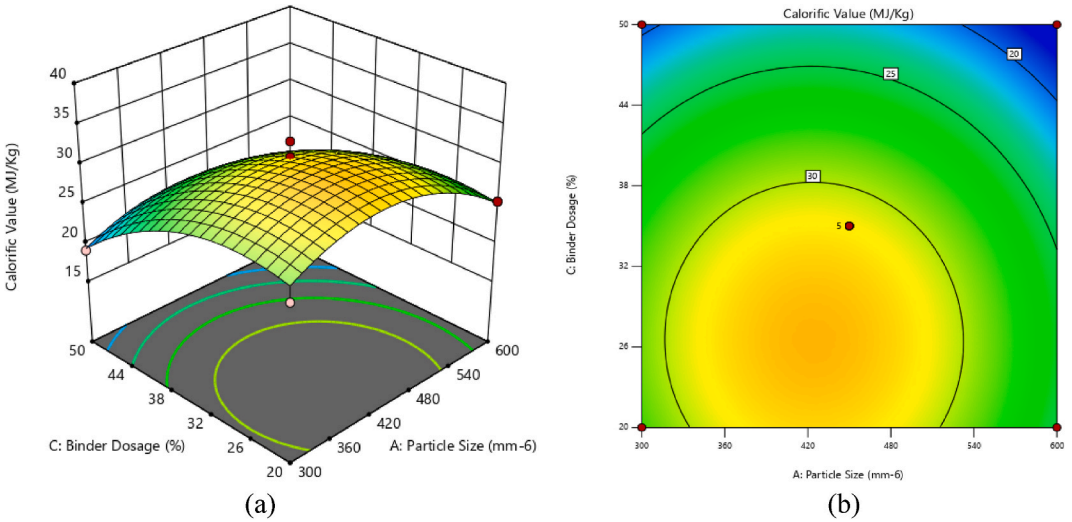

Fig. 4. (a) 3D response surface and (b) contour plot of particle size and binder dosage on the calorific value of the briquettes.

3.3. Characterization result

3.3.1. Ultimate analysis result

The result of the ultimate analysis conducted on the raw material (bio char from HTL of breadfruit pulp) and the produced briquette samples, are presented in Table 3 and compared as shown in Fig. 6. This is to determine the carbon, hydrogen, nitrogen, sulphur, and the oxygen content of the samples, as well as their high heating values, hydrogen-carbon and oxygen-carbon ratios.

Fig. 6 shows that the briquetting process improved the energy content of the products. The higher H/C and O/C ratio obtained for bio-char as compared to the briquette is as a result of the introduction of the binder, which implies that the increase in the binder dosage lowers the energy efficiency of the briquette and increases CO_2 emissions from its combustion. Hence binder dosage should be kept as minimal as possible during briquetting.

3.3.2. Proximate analysis result

The result of the proximate analysis conducted on the raw material and the produced briquette samples, are presented in Table 4 and compared as shown in Fig. 7. This is to determine the moisture, ash, volatile and fixed carbon content of the samples.

Fig. 7 shows that the briquetting process reduced the moisture content and volatile matter, while the ash content and the fixed carbon was increased. The reduction in the moisture content is as a result of the densification process while the increase in the ash content and the fixed carbon is as a result of the binder addition. The minerals in the binder added to the ash content while the carbon

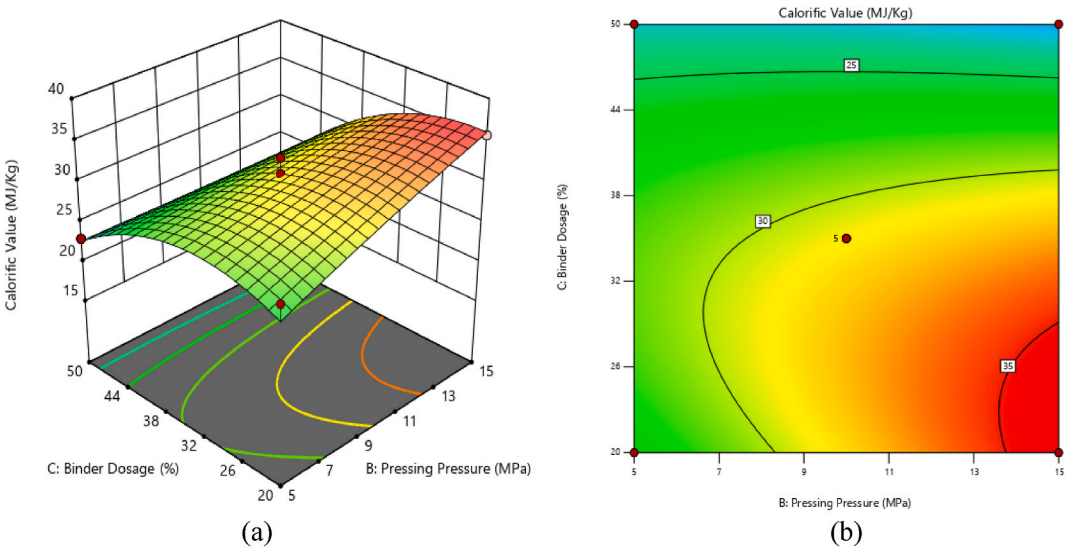

Fig. 5. (a) 3D response surface and (b) contour plot of press pressure and binder dosage on the calorific value of briquettes.

Table 3
Ultimate analysis of the bio-char and briquette.

Samples	Ultimate Analysis (wt % dry basis)					HHV (MJ/kg)	H/C Ratio	O/C Ratio
	C	H	N	S	O			
Solid residue	40.79	3.95	0.31	0.31	54.64	13.23	1.162	1.004
Briquette	47.22	3.88	0.69	0.42	47.79	16.13	0.991	0.759

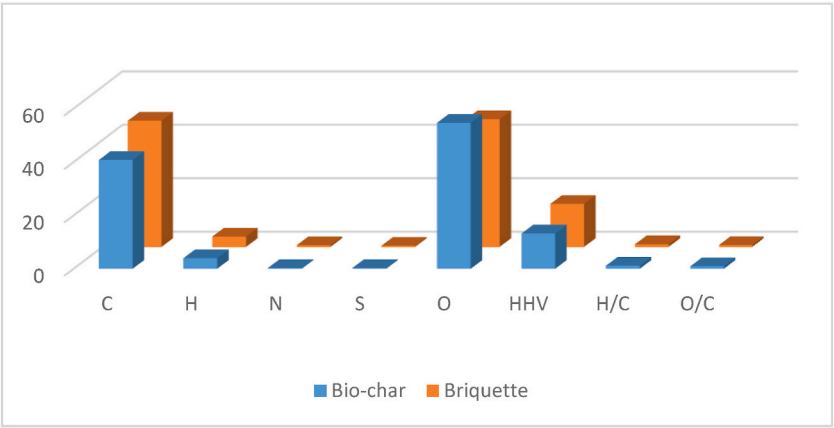

Fig. 6. Comparison of the ultimate analysis of the raw material and produced briquette.

in the binder added to the carbon content of the briquette thereby increasing the energy density of the briquette.

3.3.3. Fuel and physical properties of the briquette

The result from the characterization of the briquette is as shown in Table 5. The result showed the fuel and physical properties of the briquette which includes; calorific value, combustion rate, ignition time, density compressive strength, shatter index and hydrophobicity. The produced briquette showed better calorific value compared to some report literature such as Malika et al. [19] that reported calorific value of 21.26 MJ/kg for Holey bio-briquettes with faster burning rate of 2.01 g/min compared to that of the produced briquette. The produced briquette has better compressive strength and density compared to that of the briquette produced by Mitchual et al. [18]. However, Aliyu et al. [7] reported better shatter index of 90 % for briquettes produced from rice husk and saw dust, as compared to the produced briquette.

Table 4
Proximate analysis of the bio-char and briquette.

Samples	Proximate Analysis (wt % dry basis)			
	Moisture	Ash	Volatile	Fixed carbon
Bio Char	8.9	3.2	48.1	39.1
Briquettes	7.8	3.9	43.7	44.6

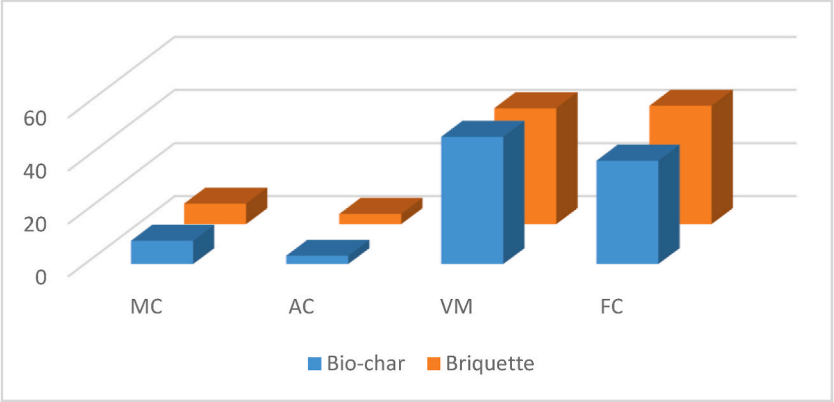

Fig. 7. Comparison of the ultimate analysis of the raw material and produced briquette.

Table 5
Properties of the briquette.

Fuel Properties			Physical Properties			
Calorific Value (MJ/kg)	Combustion Rate(g/min)	Ignition Time (min)	Density (g/cm^3)	Compressive Strength (N/mm^2)	Shatter Index	Hydrophobicity
33.00	4.5	3.5	0.86	8.31	0.89	61.3

4. Conclusion

This work is aimed at converting waste from agro-activity into solid fuels thereby eliminating waste from our environment and producing alternative source of energy for heating purposes. It utilized bio-char from hydrothermal liquefaction of breadfruit pulp for bio-briquette production with cassava starch as binder. An experimental design was carried out to determine the best parameter combination for the production of briquette with high energy density. Highest calorific value of 26.75 MJ/kg at parameter combination of 450 mm^{-6} particle size, and 5 MPa pressing pressure, 20 % binder dosage. The produced briquette was characterized to determine its fuel and physical properties. The result showed better properties compared to some available briquettes produced from other waste. Therefore bio-char from HTL of breadfruit pulp can be used for production of briquettes for domestic and mini-industrial heating applications. However the starch concentration during gelatinization, and the effect of the process parameters on the physical and fuel properties of the briquette should be studied.

Data availability statement

No data was used for the research describe in this article. Hence, no data was deposited into publicly available repository.

CRediT authorship contribution statement

Obiora Nnaemeka Ezenwa: Writing - original draft, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Chinedum Ogonna Mgbemena:** Writing - review & editing, Supervision, Project administration, Conceptualization. **Eyere Emagbetere:** Writing - review & editing, Supervision.

Declaration of competing interest

The corresponding author, on behalf of all the authors hereby declare that there is no conflict of interest in this research work. There is no financial and personal relationships with other people or organizations that could inappropriately influence (bias) this

work.

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