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Valorization of waste cassava peel into biochar: An alternative to electrically-powered process

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ABSTRACT

Cassava production and consumption in its raw or processed form have experienced a rise in recent times globally, with Nigeria being the major producer of cassava in the world. However, the increased consumption of this crop has resulted in an increase in its peels, which if not properly disposed of or recycled, would burden the environment. Previous studies have only been able to engage electrically-powered reactors for the thermochemical conversion of these peels, which is a challenge as these reactors cannot be used in regions with an insufficient supply of electricity. In this study, the authors utilized a top-lit updraft reactor with retort heating for the conversion of waste cassava peels into biochar. The reactor, which is relatively cheap, simple to use, and environmentally friendly and modified for biochar production, is biomass-powered. The carbonization process, which lasted for 160 min, obtained a peak reactor temperature of 338 ℃, and gave rise to a biochar yield of 55.13 %. FTIR analysis revealed that the cassava peel biochar consists of similar functional groups in relation to its precursor, but consists of more oxygenated functional groups. The BET surface area and BJH pore diameter of the biochar were obtained to be 319.784 m^2/g and 2.447 nm, respectively. EDX analysis showed the biochar is majorly made up of carbon (56.93 %) and silver (22.97 %). SEM micrographs revealed that the biochar has a rough and porous surface. The DTA/TGA results showed that the carbonization process improved the thermal efficiency of the cassava peel material.

1. Introduction

The rise in population and its direct proportional increase with the trio; rate of industrialisation, energy need, and waste generation, has been an age long global challenge (Saliu et al., 2022; Aisien and Aisien, 2020). Its direct impact on sustainable development has been a major focus in research and development. In pursuit of economic, energy and environmental sustainability, the re-usage of solid waste has been identified as a potential solution to provide alternative make-up in the shortage of energy (Ismanto et al., 2010; Adeniyi et al., 2021), and also facilitate an environmental and cost effective route to material production (Eletta et al., 2020). Furthermore, the burden of the solid waste volumes in agro centres and municipals centres across the globe will be lifted (Santos et al., 2022). Agro-waste has recently been discovered as a potential source of secondary raw material for energy and material recovery (Santos et al., 2022). Their suitability for energy and material recovery is traceable to their lignocellulosic content (Santos et al., 2022; Adeniyi et al., 2022). Their thermal and non-thermal valorisations are enormously reported (Bull et al., 2011; Adejumo et al., 2013; Adelodun et al., 2020; Adeniyi and Ighalo, 2022). They have been variously explored because they constitute zero threat to food security, except for their negative impact on the environment (Odetoye et al., 2020; Onifade et al., xxxx). Moreover, the need for balance between food and biofuel production is a strong call for concern as the population rises and energy needs can no longer be satisfied within the limit of fossil fuel (Jansson et al., 2009; Marx, 2019; Ighalo et al., 2022). Cassava peel has been recently projected as the candidate agro-waste to meet the need (Pipitpukdee et al., 2020; Widiarto et al., 2017).

A recent report by the International Institute of Tropical Agriculture (IITA) has confirmed that the production of cassava in Nigeria stands at over 59 million tons per year (Garba et al., 2020). This makes

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Nigeria one of the major producers of cassava globally. Cassava peel is about 8–15 % of cassava root, on a dry basis (Howeler, 2000). Its suitability for fuel production is confirmed by its composition of hemicellulose at 20 – 31 wt%, cellulose at 14–42 wt% and lignin at 6–8 wt% content (Kongkiattikajorn and Sornvoraweat, 2011). Its mineral contents were also reported in satisfactory proportion, with a carbon content of 48.7 wt% and a significant percentage of sodium, calcium, potassium, and nitrogen. The cassava peel waste is considered a viable agro waste for energy recovery (Adelekan and Bamgboye, 2009). Thermo-chemical and non-thermo-chemical valorisation of cassava has been variously reported, with application of its carbon-based derivatives in capacitors (Ismanto et al., 2010), biogas (Aisien and Aisien, 2020), and adsorbents (Simate and Ndlovu, 2015). The usage of retort heated carbonisation facilities has been recently explored in the production of carbon-based products like biochar and hybrid biochar (Adelodun et al., 2020; Adeniyi et al., 2020; Adeniyi et al., 2021). It has been adjudged to be the modular concentric chambers for biomass and biomass-plastic waste carbonisation to biochar and hybrid biochar, respectively (Amoloye et al., 2022; Ighalo et al., 2021). This is achieved without the use of electricity or any environmental pollution because of its carbon capture feature.

Studies on the valorisation of cassava peel for energy and material recovery are widely reported in the open literature (Okudoh et al., 2014; Ubalua, 2007; Kayiwa et al., 2021; Iwuozor, 2019). Recently, its co-pyrolysis with synthetic polymer content was reported by Adeboye et al. (Adeboye et al., 2021). The study employed the pyrolytic temperature range of 0 to 800 ℃. The calorific value of the cassava was found lower than other synthetics polymer components; the eventual affected the thermal and kinetic behaviours of the cassava-plastic mix. The lowered values of the activation energy and residue were found when compared with a similar report by Adeboye et al. (Adeboye et al., 2021). This position was further reinforced with optimisation studies (Adeboye et al., 2021). Okekunle et al. (Okekunle et al., 2016) also carried out the pyrolysis of cassava peel in a fixed reactor. The operation was performed at a differential temperature of between 400 ℃ and 700 ℃. The maximum yields of tar, char, and pyrogas were reported at 44 wt%, 34 wt%, and 64 wt% at respective temperatures of 500 ℃, 400 ℃, and 700 ℃. This implies that gaseous products are favoured at high temperatures, while solid products are favoured at low temperatures. This is in line with the similar study of cassava peel valorisation conducted by Ighalo, Adeniyi (Ighalo and Adeniyi, 2021). One of the major drawbacks in the valorisation of cassava peel waste is the cost and availability of energy for its thermo-chemical conversion. This has contributed to the mounting volume of cassava peel available in the urban and agro-centres; this obviously confirms the need for greener and cleaner renewable energy for its thermal recycling scheme.

In this study, the authors utilized a biomass-powered carbonization reactor for the valorisation of cassava peel into biochar. The relative cost-effective reactor used in this study, which operates on the principle of top-lit updraft technology, is self-regulating, modified for biochar production, and is a sustainable alternative to electrically-powered carbonization reactors, which may not be suitable for electricity-deficient parts of the globe. The synthesized cassava peel biochar as well as the precursor material were characterized to obtain more information on their functional groups, elemental composition, surface morphology, surface area, pore characteristics, and thermal properties.

2. Methodology

2.1. Material collection

The cassava peels utilized in this study were obtained from Ganmo market, located in the Ifelodun local government area of Kwara state. The peels were cut with the aid of a scissors into small sizes, sun-dried for three days to reduce its moisture content, and were used for biochar production without any form of purification. Dried African balsam stems (utilized as the biomass fuel for this study) were hand-picked within the environs of the University of Ilorin, also in Kwara state, located in North-central Nigeria.

2.2. The carbonization process

The cassava peels (CP) were converted into biochar (CPB) with the aid of a biomass-powered gasification reactor (gasifier). The reactor is made up of two cylindrical-shaped aluminum compartments; the inner and smaller compartment, also referred to as the carbonization chamber, houses the CP feedstock and is the space where carbonization occurs. This compartment has a radius of 9.8 cm and a height of 18.3 cm. The other compartment, the outer and larger one, also referred to as the heating space or chamber, houses the carbonization chamber as well as the biomass fuel, which occupies the space between the two compartments. The heating space has a radius of 19.9 cm and a height of 20.8 cm.

A weighed sample of CP (150 g) was weighed and transferred into the inner compartment, which was then properly closed with its lid to avoid the passage of gases. Thereafter, the inner compartment was placed at the centre of the outer compartment, and the biomass fuel was carefully lined around the inner compartment in a concentric manner, until it covered the remaining volume of the heating space, up to the top, leaving just enough space for the lid of the outer compartment to sit comfortably on it. Then, the biomass fuel was ignited from the top and allowed to combust in the open air for about three minutes to allow for proper circulation of the combustion within the chamber, after which the heating chamber was covered by the lid fitted to an exhaust to cut off further supply of oxygen into the reactor.

With the aid of a CASON CA380 infrared thermometer, the temperatures of different sections of the reactor were recorded (Adeniyi et al., 2022). The sections include the base, middle, top, and center of the reactor, as shown in Fig. 1. In addition, the temperature reading for each section was taken in triplicate, covering equal distances around the reactor (Emenike et al., 2022; Adeniyi et al., 2022). These points were marked with tiny openings around the reactor to allow for the injection of oxygen to support the combustion. The readings were taken at a time interval of ten minutes around these points. The temperature for each section of the reactor was plotted against the different times at which the reading was taken to form a temperature–time profile graph. At the completion of the carbonization process, the reactor was allowed to cool, after which the weight of CPB was taken and used to calculate the char yield with the aid of the equation as stated by Adeniyi et al. (Adeniyi et al., 2022).

2.3. Material characterization

The samples, i.e., CP and CPB, were characterized for their functional groups, elemental composition, surface morphology, surface area, pore characteristics, and thermal properties. The Fourier transform infrared (FTIR) spectroscopy (Shimadzu, FTIR-8400S, Japan) was used to qualitatively ascertain the functional groups and complexes present in the samples, with the spectra obtained in the transmittance range of 4000–650 cm^{-1}. Differential thermal analysis/thermogravimetric analysis (DTA/TGA) was carried out on the samples to determine their thermal characteristics using the PerkinElmer simultaneous thermal analyser. Scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDX) (Phenom proX, Phenom-World BV, Netherlands) was used to examine the surface morphology of the samples. The Branueur-Emmett-Teller (BET) analysis (Quantachrome NovaWin ©1994-2013, Quantachrome Instruments v11.03) was performed to evaluate the specific surface area, pore vol-

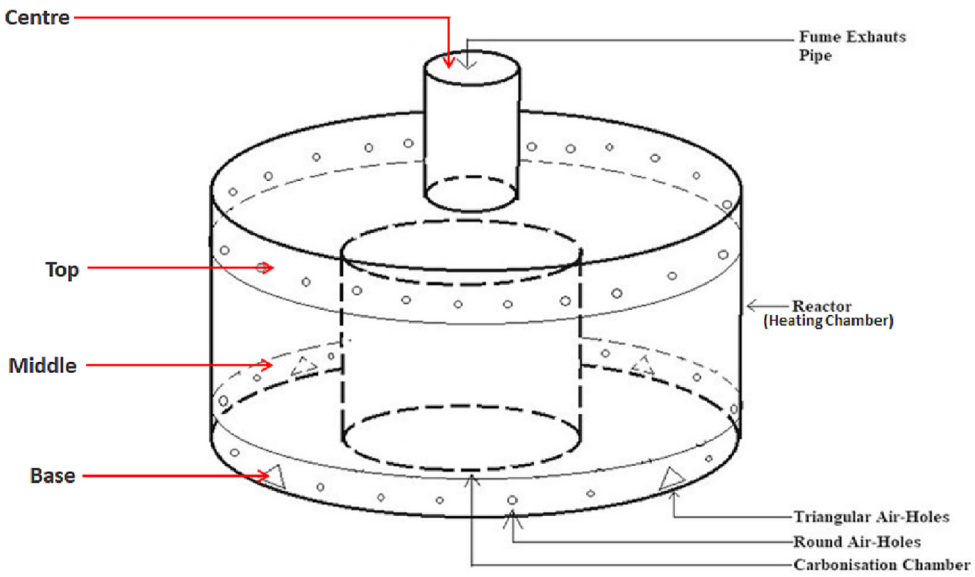


Fig. 1. An schematic diagram of the biomass-powered carbonization reactor used in this study (Adeniyi et al., 2022).

ume, and average size of the samples (Adeniyi et al., 2022; Adeniyi et al., 2022).

3. Results and discussion

3.1. The biochar production process

The carbonization process in the reactor lasted for a duration of 160 min. This duration is higher than that performed with the aid of a similar reactor for sugarcane bagasse (Iwuozor et al., 2023), oil palm fibre (Adelodun et al., 2020), elephant grass (Adeniyi et al., 2022), and almond leaves (Ighalo et al., 2021), but has a similar duration for the carbonization of orange albedo (Adeniyi et al., 2022). The variation in carbonization duration is based on the self-regulating nature of the reactor. From the temperature–time profile graph for the carbonization of CP into its biochar (CPB) as seen in Fig. 2, it can be observed that for most of the different sections of the reactor, the temperature rose gradually to a peak, and thereafter started decreasing. However, a few deviations from this were observed before the temperature reached its peak, such as the temperature at the base of the reactor from time 30 min (145.37 ℃) to 40 min (133.4 ℃), the temperature at the middle of the reactor from time 50 min (167.3 ℃) to 60 min

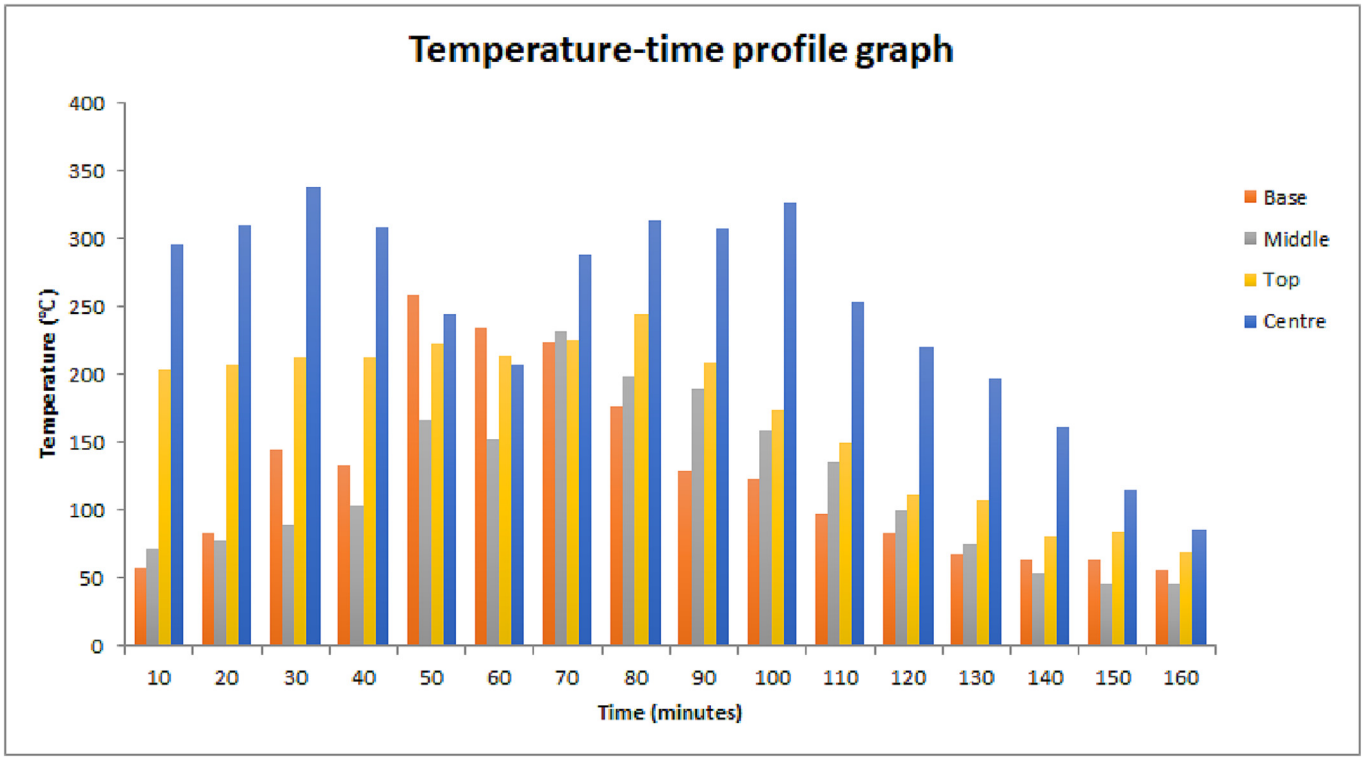


Fig. 2. Temperature-time profile graph for the carbonization of cassava peel.

(151.97 ℃), and the temperature at the top of the reactor from time 50 min (223 ℃) to 60 min (214.33 ℃). A similar deviation was also observed at the centre of the reactor after its peak temperature at 30 min (337.6 ℃) was reached. The cause for this deviation is due to the interaction of external agents on the reactor, since the reactor is self-regulating. Such agents or factors which may have caused such deviations include the direction and strength of wind flow and changes in the humidity of the environment.

It is important to state that the peak of the different sections of the reactor was obtained as follows: at 50 min for the base of the reactor (258.7 ℃), at 70 min for the middle of the reactor (232.4 ℃), at 80 min for the top of the reactor (245.83 ℃), and at 30 min for the centre of the reactor (337.6 ℃). Of these, it can be observed that the temperature at the centre of the reactor (337.6 ℃) gave the highest temperature in comparison with the other parts of the reactor. A similar observation was also made, that the temperature at the centre was the highest recorded temperature in comparison with the other parts of the reactor for the different times the temperature was recorded. However, two deviations were made at 50 min and 60 min only, where the temperature at the base of the reactor was observed to be higher than that at the centre (at 50 min, 258.7 ℃ for the base > 245 ℃ for the centre; and at 60 min, 234.8 ℃ for the base > 206.8 ℃ for the centre). According to Ighalo et al. (Ighalo et al., 2021)and Adeniyi et al. (Adeniyi et al., 2020), a higher temperature at the centre of the reactor implies a synergistic effect of the heating around the reactor, which translates to a better transfer of thermal energy from the biomass fuel to the carbonization chamber, situated at the centre of the reactor.

At the expiration of the carbonization process, the weight of the carbonized material was weighed and noted to be 82.7 g, thereby achieving a material yield of 55.13 %. In comparison with other researchers, da Silva et al. (da Silva et al., 2022) obtained a maximum biochar yield of 36.7 % for the conversion of cassava peel into biochar. In comparison with studies where a similar reactor configuration has been utilized, Ighalo et al. (Ighalo et al., 2021)obtained a yield of 28 % for the carbonization of almond leaves after a duration of 120 min. Adeniyi et al. (Adeniyi et al., 2019)obtained a yield of 14 % for the carbonization of elephant grass after a duration of 120 min. Adeniyi et al. (Adeniyi et al., 2021)obtained a yield of 6.9 % using plantain fibers after a duration of 150 min. This implies that the carbonization reactor utilized in this study is efficient for biomass to biochar conversion and that cassava peel is a good feedstock for making high-yield biochar.

3.2. FTIR analysis

FTIR analysis was performed on CP and CPB to determine the functional groups inherent in them. This was done to study the impact and effect that the carbonization process had on the original material (cassava peel). The FTIR spectra of the two materials are shown in Figs. 3 and 4. The FTIR spectra of CP at characteristic peaks of 3250.2 cm^{-1} and 2929.7 cm^{-1} showed the presence of hydroxyl groups (Anas et al., 2021). The characteristic peak at 2109.7 cm^{-1} corresponds to the C≡N stretching vibration, observed in inorganic cyanide (Monga et al., 2022). The characteristic peak at 1636.3 cm^{-1} speaks of the presence of the alkene functional group (Anas et al., 2022). While the peak at 1420.1 cm^{-1} was assigned to C—O in-plane bending (Adeniyi et al.,), and 1338.1 cm^{-1} was assigned to the stretching vibration of S═O (Anas et al., 2021), the peaks at 1148 cm^{-1} and 1077.2 cm^{-1} were assigned to C—O in-plane stretching (Anas et al., 2022; Anas et al., 2021). These oxygenated groups represent the presence of the lignin faction of the cassava peel (da Silva et al., 2022). The bands at 861 cm^{-1}; 764.1 cm^{-1}, and 704.5 cm^{-1} correspond to the presence of alkene hydrogen in out-of-plane bending mode (Adeniyi et al., 2022; Emenike et al., 2022).

The FTIR spectra of CPB showed that the carbonization process introduced new peaks into the biochar observed at 3801.9 cm^{-1}, 3548.4 cm^{-1}, 3116.1 cm^{-1}, and 1230 cm^{-1}. The loss of some peaks in CP, such as 704.5 cm^{-1}, 928.1 cm^{-1}, and 1077.2 cm^{-1}, was also observed. Shifts in peaks were also observed from 3250.2 cm^{-1} to 3343.4 cm^{-1}, 2929.7 cm^{-1} to 2918.5 cm^{-1}, 2109.7 cm^{-1} to 2102.2 cm^{-1}, 1636.3 cm^{-1} to 1558 cm^{-1}, 1338.1 cm^{-1} to 1375.4 cm^{-1}, 861 cm^{-1} to 872.2 cm^{-1}, and 764.1 cm^{-1} to 752.9 cm^{-1}, for CP and CPB, respectively. In general, it was observed that CPB and CP have similar functional groups, but the peaks representing oxygenated groups in CPB are more than those in CP. In addition to aiding in water retention and pH regulation, the presence of oxygenated groups functions as a conditioner in the soil because of the chelating influence that these groups have on minerals (da Silva

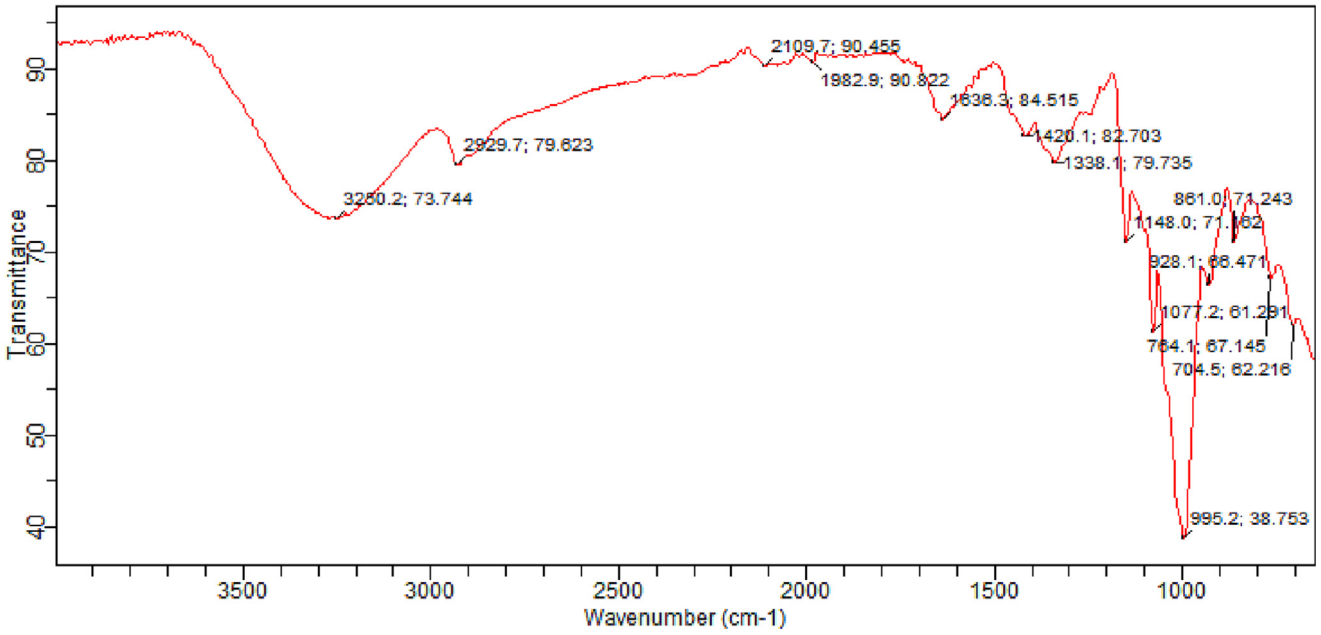


Fig. 3. FTIR spectra of Cassava peel (CP).

et al., 2022). Also, the existence of double bonds between carbon atoms in aromatic rings enhances the stability of biochar when applied to soil, making it less sensitive to the operations of microbes and, as a result, having greater environmental stability (da Silva et al., 2022).

3.3. Elemental composition

The elemental composition of CPB was determined with the aid of an Energy Dispersive Spectrophotometer (EDX). The result as shown in Fig. 5, depicts carbon as the major constituent of CPB, with a weight concentration of 56.93 %. This is unsurprising as carbon has been shown in several studies to be the major component of biochar. In comparison with other studies, a carbon content of 64.1 %, 64.13 %, and 70.22 % was obtained by Anas et al. (Anas et al., 2020); Anas et al. (Anas et al., 2021), and Anas et al. (Anas et al., 2022), respectively, for carbon peel biochar. In addition to biochar, the presence of silver (22.97 wt%) was also noted in CPB. The high concentration of silver could be due to the composition of the soil where the cassava was planted. An oxygen concentration of 8.99 % was obtained for CPB. This observation is in line with the FTIR spectra of CPB in **section 3.2,** which depicts the presence of oxygenated functional groups in the biochar. In another study, Anas et al. (Anas et al., 2022) obtained a higher oxygen content of 29.87 % for cassava peel biochar. While nitrogen concentrations of less than 2 % have been obtained from cassava peel biochar (Anas et al., 2020; Anas et al., 2021), a higher nitrogen content of 5.81 % was obtained in this study. The presence of nitrogen, which is also reflected in the FTIR spectra of CPB, is related to the presence of cyanide. Several studies have also shown the presence of cyanide in

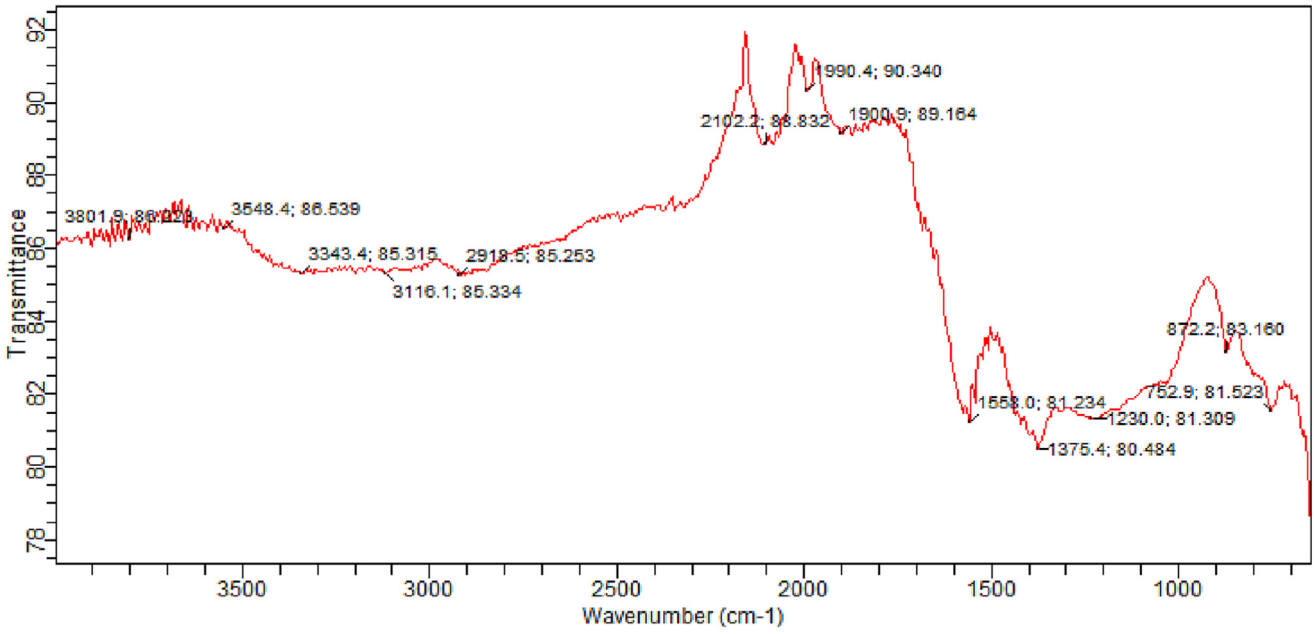


Fig. 4. FTIR spectra of Cassava peel biochar (CPB).

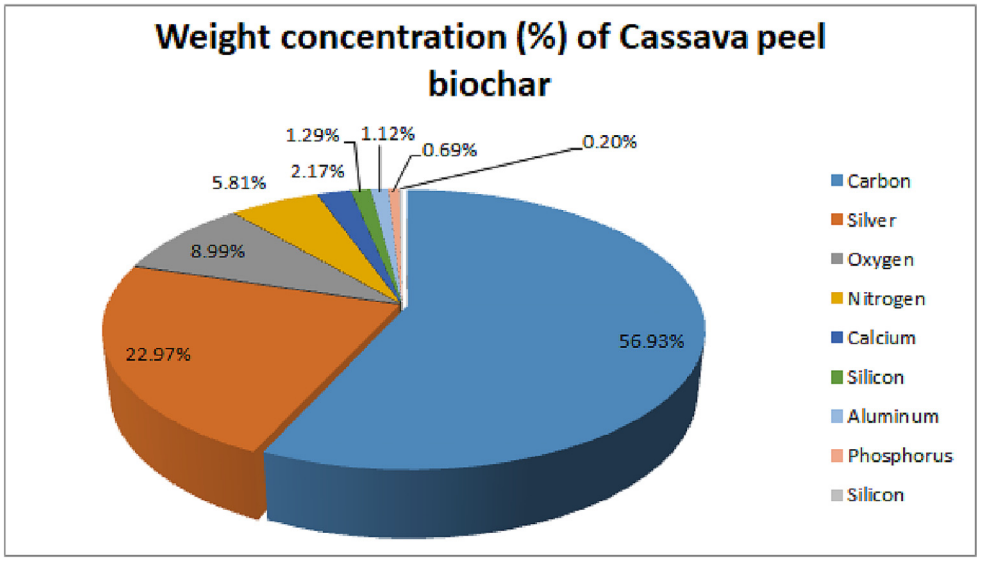


Fig. 5. Elemental composition of Cassava peel biochar.

harvested cassava (Zhong et al., 2021; Quinn et al., 2022). The presence of other elements such as calcium, silicon, aluminum, phosphorus, and sulphur were found to be present in CPB in trace quantities.

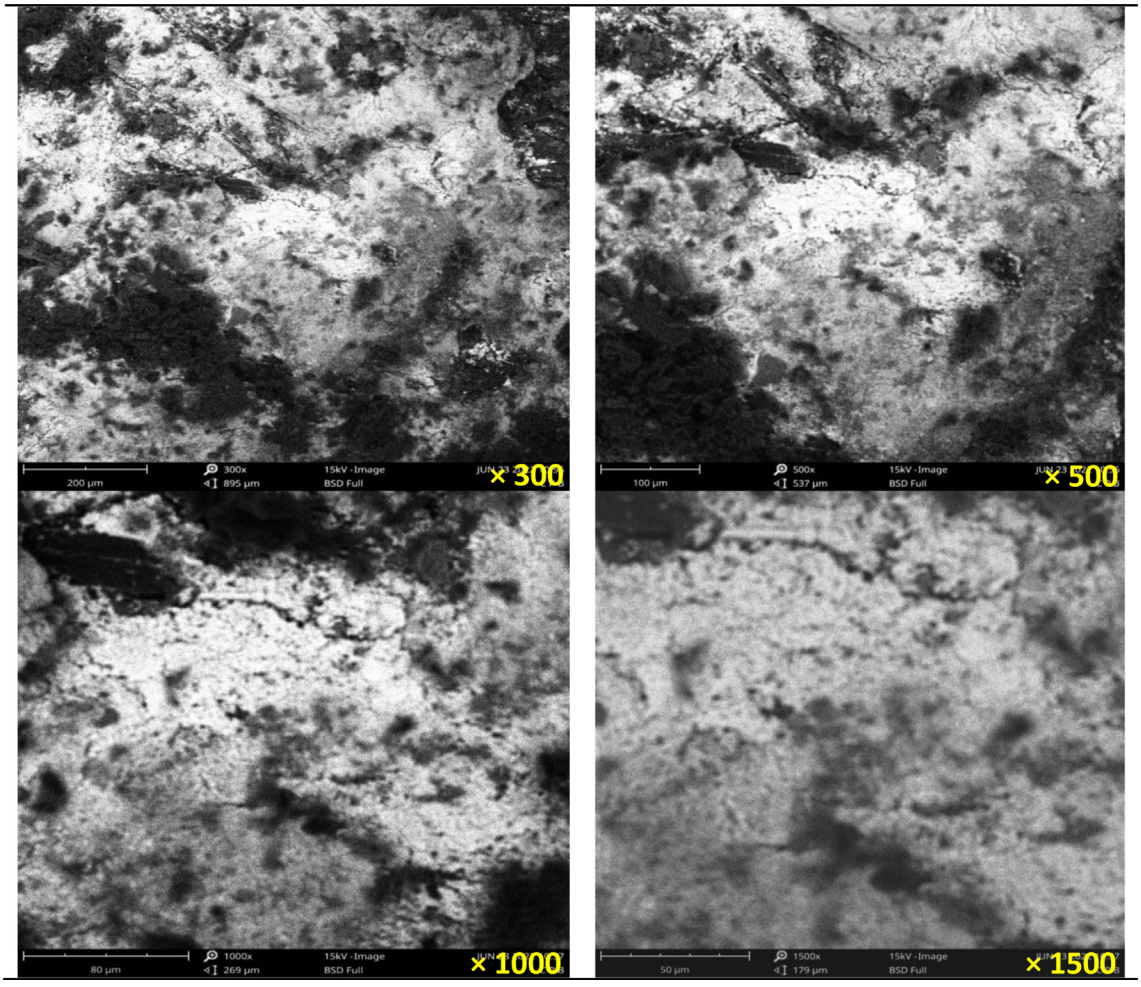
3.4. Surface morphology

The surface morphology of the biochar (CPB) was studied with the aid of a Scanning electron microscope (SEM), and the micrographs are shown in Table 1. The SEM micrographs at lower resolution show the presence of an uneven height and rough surface on the biochar. In addition, it shows the presence of a homogeneous surface in the composition. The surface's heterogeneity allows for a variety of characteristics onto which pollution might be adsorbed. However, adsorption is influenced by factors which may include the adsorbent's SSA, surface functional groups, as well as the surface topology (Ighalo et al., 2021; Adeniyi et al., 2022). At higher resolution, the presence of tiny pores scattered non-uniformly on the biochar's surface is more glaring. Similar pores were observed by Anas et al. (Anas et al., 2021) for cassava peel biochar at a higher magnification of 5000×. The large number of pores on the surface of CPB and its surface heterogeneity support its application as an adsorbent for the sequestration of pollutants from the environment or for the purification of materials (Iwuozor et al., 2022; Iwuozor et al., 2022). CPB can also be used as a soil conditioner due to its pore structure, which could encourage the development of symbiotic microbes.

3.5. Thermal stability

The thermal stability of CP and CPB was studied with the aid of a differential thermal/thermogravimetric analyzer. This was done to study the effects of temperature change on the materials. It can be observed from Figs. 6 and 7, that the thermogravimetric analysis of the materials is divided into four stages. In the first stage, volatile compounds, adsorbed water, and moisture are lost from the material when the temperature is increased. This first stage, which occurred from 27.4 ℃ to 185.49 ℃, and 26.48 ℃ to 132.65 ℃ led to a 2.77 % and 2.15 % mass loss in CP and CPB, respectively. At this stage, da Silva et al. (da Silva et al., 2022) obtained a weight loss of 10.7 % for cassava biochar. The second stage involves the beginning of the decomposition of cellulose and hemicellulose. This stage occurred between 185.49 ℃ to 232.18 ℃ and 132.65 ℃ to 208.52 ℃ for CP and CPB, respectively. da Silva et al. (da Silva et al., 2022)observed this stage from 150 to 250 ℃. Rapid weight loss was observed in the third stage, which involved the beginning of the decomposition of lignin and the conclusion of the decomposition of cellulose. This stage was observed between 232.18 ℃ to 392.71 ℃ and 208.52 ℃ to 459.05 ℃, resulting in a material weight decrease of 84.79 % and 80.57 %, respectively.

Table 1
SEM micrographs of cassava peel biochar at different magnifications.



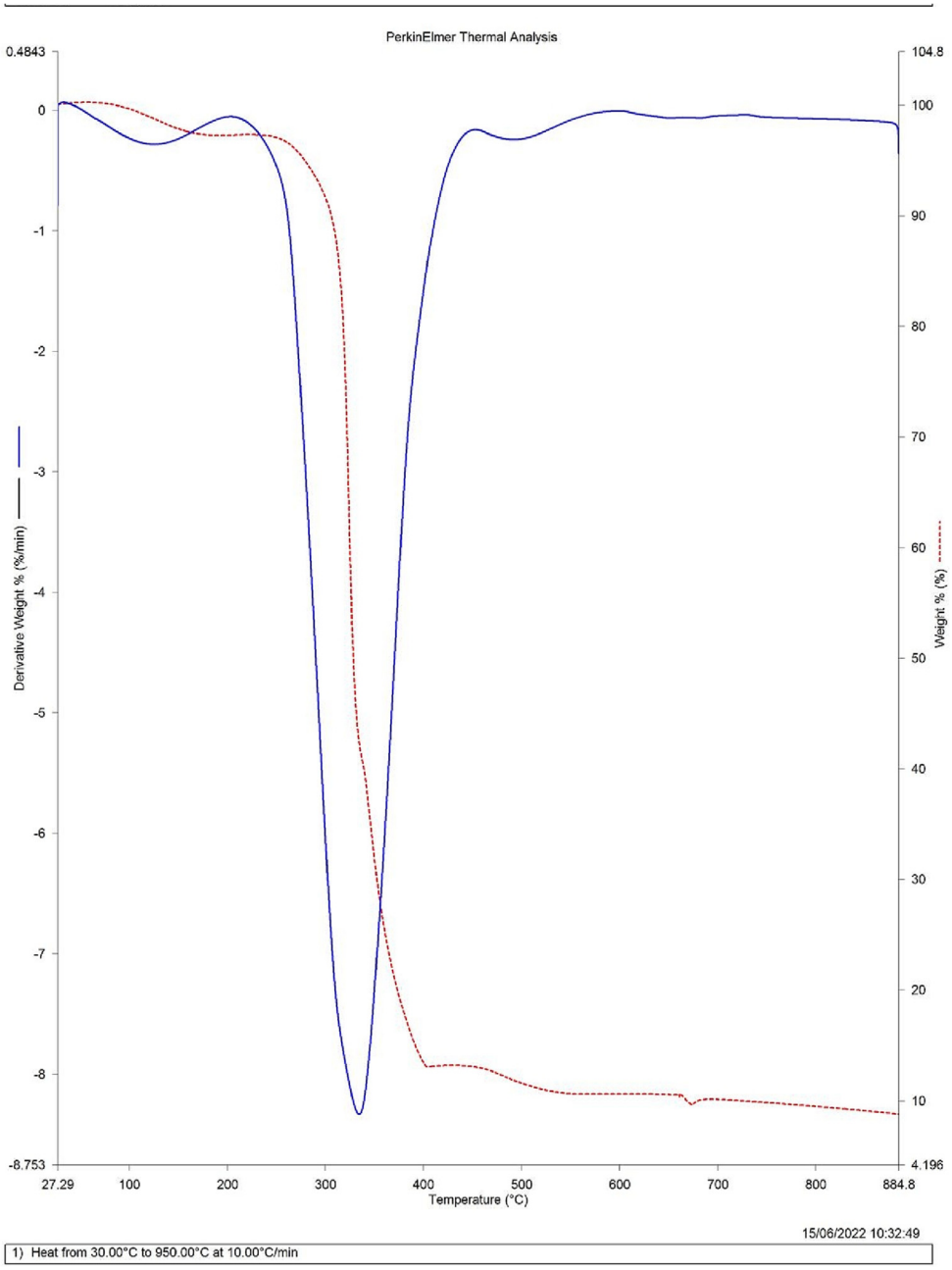


Fig. 6. DTA/TGA curve of CP.

Similar studies have shown an 86 % weight decrease at this stage (da Silva et al., 2022). In the last stage, which occurred above 392.71 ℃ and 459.05 ℃ for CP and CPB, respectively, depicts the decomposition of the remaining lignin not decomposed in the third stage.

The DTA degradation curve of both CP and CPB from Figs. 6 and 7 consists of only one endothermic peak each. The degradation curve's endothermic peak was observed at 336.95 ˚C for CP and 371.58 ˚C for CPB, respectively. The DTA/TGA results have shown that the carbonization process improved the thermal efficiency of the cassava peel, as the cassava peel biochar is more thermally efficient than the cassava peel.

3.6. Surface area and pore characteristics

A range of additional biochar qualities are linked to its porosity and specific surface area (SSA) (Adeniyi et al., xxxx). The accessibility of surface charges, for example, is determined by the surface area, which also regulates its cation exchange capacity (Leng et al., 2021; Liang et al., 2006). The interconnectivity of the pores and their porosity are important elements in influencing the biochars' water-retaining ability (Chakraborty and Mistri, 2015). Biochars' reactivity is strongly linked to active sites, and a wide, accessible surface area is required for a significant number of active sites (Weber and Quicker, 2018). The surface area as well as porosity of cassava biochar (CPB) was studied using various methods, i.e., Langmuir, BET (Brunauer-Emmet-Teller), BJH (Barette, Jovner, and Halenda), DR (Dubinin-Radushkevich), DA (Dubinin-Astakov), and DFT (Density Functional Theory). The surface area of CPB according to the BET, BJH, Langmuir, and DFT methods is 319.784 m^2/g, 397.886 m^2/g, 813.192 m^2/g, and 101.176 m^2/g, respectively. The BET surface area of the CPB, is lower than that reported in the literature for the thermochemical carbonization of waste biomass, such as oil palm fibers (352.9 m^2/g) (Adelodun

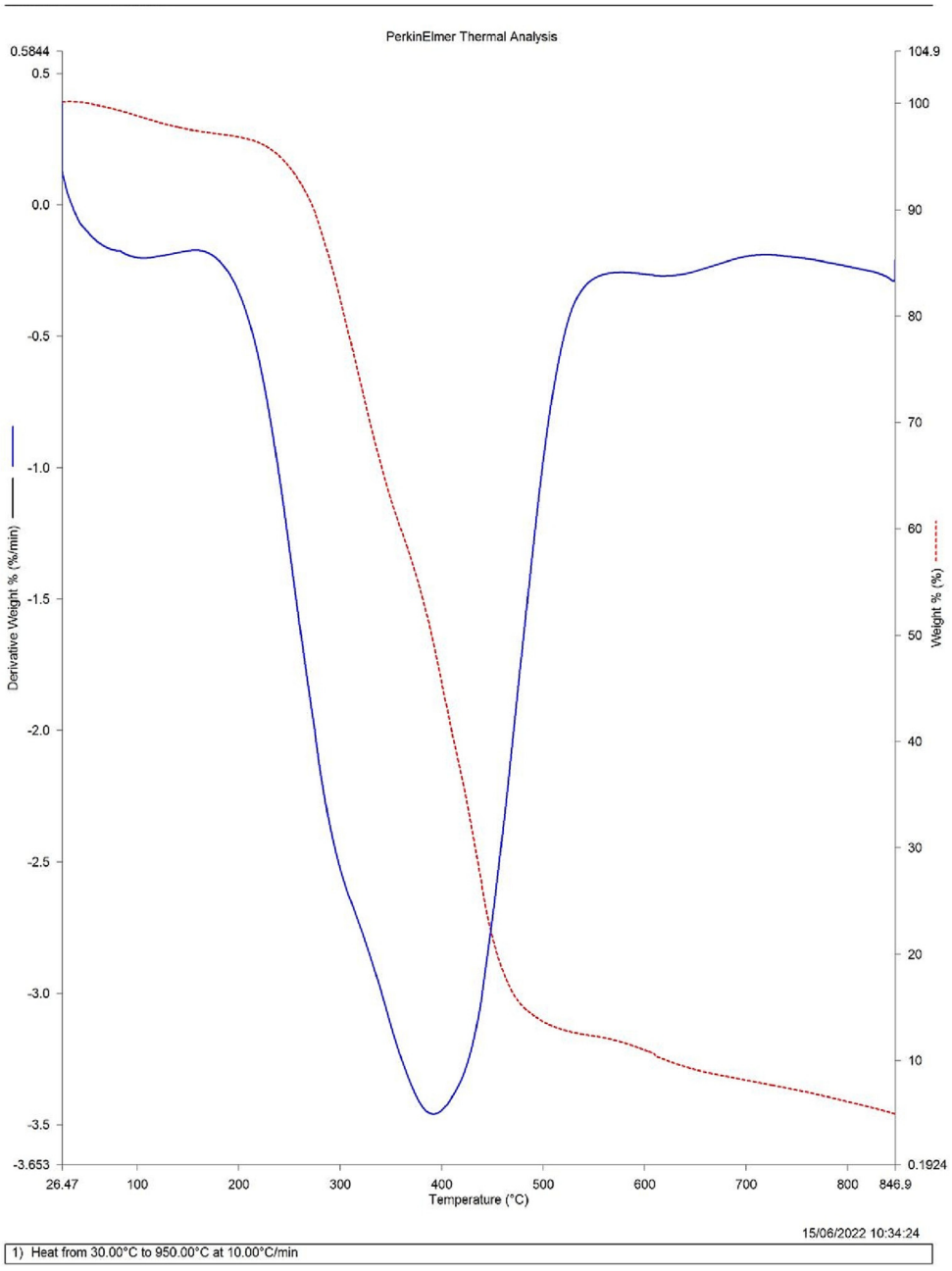


Fig. 7. DTA/TGA curve of CPB.

et al., 2020), and sugarcane bagasse (533.6 m^2/g) (Adeniyi et al., 2021). The pore diameter of CPB according to the DA and BJH methods is 2.720 nm and 2.447 nm, respectively. Its pore volume according to the BJH and DFT methods is 0.196 cc/g and 0.114 cc/g, respectively. As shown by the DA and BJH methods, the pore diameter of CPB is in the mesoporous region. Mesoporous materials have diameters ranging from 2 to 50 nm. Mesoporous materials can be used in a variety of applications, including drug delivery, solar cells, and nucleic acid detection (Liu et al., 2011; Ramasamy and Lee, 2010).

4. Conclusion

In this study, the authors explored the valorisation of waste cassava peel and its conversion into biochar. A biomass-powered top-lit updraft reactor with retort heating was employed for this purpose. The carbonization process, material yield, and properties of the biomass precursor and its biochar were also studied. The carbonization process, which occurred for 160 min, obtained a peak reactor temperature of 338 ℃, and gave rise to a biochar yield of 55.13 %. FTIR analysis revealed that the cassava peel biochar consists of similar functional groups in relation to its precursor, but consists of more oxygenated functional groups. EDX analysis showed the biochar is majorly made up of carbon (56.93 %) and silver (22.97 %). SEM micrographs revealed that the biochar has a rough and porous surface. The DTA/TGA results showed that the carbonization process improved the thermal efficiency of the cassava peel material. The BET surface area and BJH pore diameter of the biochar were obtained to be 319.784 m^2/g and 2.447 nm, respectively. This study shows that waste cassava peels can be thermochemically recycled into biochar in a non-electrically powered reactor, which is relatively cheap, environmentally friendly, and simple to use and maintain, and the resulting biochar can be utilized for environmental applications such as carbon sequestration and greenhouse gas reduction, as well as agricultural applications to improve soil conditions.

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Compliance with ethical standards

This article does not contain any studies involving human or animal subjects.

CRediT authorship contribution statement

Samson O. Odeyemi: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Kingsley O. Iwuozor:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Ebuka Chizitere Emenike:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Omolola Titilayo Odeyemi:** Data curation, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Adewale George Adeniyi:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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