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Comparative analysis of the physiochemical properties of the seed of native pear (*Dacryodes eclulis*) and pimpkin pulp (*Telfairin occidentalis*)

Chukwudi-Madu Etanuro[*], Chime Charles C, Ajah Doris N, Okwesili Lotanna C
Department of Industrial Chemistry, Enugu State University of Science and Technology, Enugu, Nigeria

Abstract
The rising level of agricultural waste deposits in the environment has become a growing concern to environmentalist, Scientist and World governing bodies. There-fore in the recent times researchers have turned their focus into evaluating the potentials in these agro-waste for further application. This study examines the physiochemical properties of Pumpkin Pulp and Native pear seed. The results revealed higher values in the moisture content (5.724 %), Hausner ration (0.765), WAC (0.446), volatile matter (37.362 %) and Ash content (2.918%) in Pumpkin pulp compared with values of Native pear. Higher values were seen in bulk density, tapped density and fixed carbon content as 0.411%, 0.638%, and 61.431% accordingly in Native pear seed compared with the values observed in Pumpkin pulp. The chemical composites results showed that both samples were of soft wood origin as the values of their lignin content were 46.573% and 42.109% for Pumpkin pulp and Native pear seed respectively. Native pear seed had higher values in its hemicelluloses and holocellulose content as 67.695% and 29.915% accordingly compared with values of Pumpkin Pulp while higher values was observed in Pumpkin pulp alpha cellulose result as 50.293% compared with the value seen in Native pear. Conclusively, the result of this study highlights the nature of Pumpkin pulp and Native pear seed for a potential application of these materials in various fields.

Keywords: pumpkin pulp, native pear seed, physiochemical properties

Introduction

The management of agricultural waste has caught the focus of world governing bodies, therefore receiving the necessary attention it deserves especially in the developing world.

Agricultural waste can be defined as by-products from growing and processing raw agricultural products such as fruits, vegetables, meat poultry and crops (Obi, Ugwuishiwu & Nwakaire). This by-product may be essential to man but its economic values are less than the cost of collection, transportation and processing them (Obi, Ugwuishiwu & Nwakaire). The build-up of these agricultural wastes has impacted negatively on the environment, economy and society (Martínez & Pachón-Ariza 2014) [20].

United Nations Environment program's (UNEP) reported food waste index amounting to 1.3 billion tonnes per year, therefore producing 3.3 billion tonnes of CO_2, in 2021 (FAO, 2020). Plant based agro-waste and animal based agro waste are a major fraction of this agricultural waste.

Recycling of these agro-wastes can be found in the area of fertilizer application (Timbers & Downing, 1977) [36] thus impacting positively on the growth and production of crops (Mokwunye, Oct 9-12, 2000) [23]. Agricultural waste has also been a source of methane gas produced from the anaerobic digestion of manure; this gas is very suitable for heating purposes (Obi, Ugwuishiwu & Nwakaire). Pollution problems has also been adequately addressed with the use of these agricultural based sorbents from agro-waste, pollutants like heavy metals (Gupta, Gupta & Sharma, 2001) [14] from industrial waste, crude oil spillage and other industrial and household waste have be treated using these agro-waste based sorbents. Its suitability in the area is majorly as a result its low-cost and biodegradability. Some of the agro-waste that have been applied in treatment procedures are; sugarcane bagasse (Mohan & Singh, 2002) [22], rice husk (Ayub, Ali & Khan, 2002) [3], sawdust (Ajmal, Rao & Siddiqui, 1996) [2], coconut husk (Tan, Ooi & Lee, 1993) [35], oil palm shell (Khan, Shaaban & Hassan, 2003), neem bark (Ayub, Ali & Khan, 2001) [4], etc.

In some developing countries the agricultural waste converted to animal feed with the addition of protein supplements (Leng, Choo & Arreaze, 1992) [18].

This study evaluates the physiochemical properties of Pumpkin pulp and Native pear seed as agro-waste for potential application in various fields.

Materials and Methods

1. Sample collection/Preparations

The samples, Native pear and Pumpkin Pulp were purchased from a local market (New market) in Enugu Metropolis. The samples were prepared by first washing and extracting the seeds and pulp of the respective samples. Then they were thoroughly washed with water to removed dust, fungus, foreign materials and other water-soluble components before sun drying for 28hours (4hours for 1 week) and also in the oven at 60^0 C for 4hours. This is to reduce the moisture content of the samples before been processed to powder form and then sieved using British Standard Sieve (BSS).

2. Determination of the various physiochemical properties.

(i). Determination of Moisture Content.

(Hameed, Tan & Ahmad, 2006)

A portion of the sample W_2 (2g) was measured into a beaker with known weight W_1, then placed in the oven to dry for 24hours at 105^o C, the sample was then reweighed and recorded as W_3. Moisture content evaluated using the following formula;

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (1)$$

W_2 is weight of wet sample
W_3 is weight of oven dried sample.

(ii). Determination of Bulk Density
(Ekpete & Horsfall, 2011) [9]
A portion of the sample 10g was carefully measured and transferred to a 100 ml capacity cylinder of known weight and the reweighed to determined its new weight. It bulk density was then determined using;

$$\frac{weight\ of\ cylinder + sample - weight\ of\ empty\ cylinder}{volume\ of\ cylinder} \quad (2)$$

(iii). Determination Tapped density
(Ekpete & Horsfall, 2011)
10g of the weighed sample was carefully transferred to a pre weighed 100ml cylinder, the bottom of the cylinder and then gently tapped 100 times against the laboratory bench until no more dominating of the sample level. The weight and density was then determined.

(iv). Determination of water absorption capacity (WAC)
(Remya, Jyothi, & Sreekumar, 2018) [29]
A weighed portion of the sample (1g) was put into a pre weighed centrifuge bottle, with 20 ml water added, thereafter shook for 1hour before centrifuged for another 10 minutes at 2200rpm, then decanted and drained for 10 minutes, the new weight with the sample was taken again. WAC was then determined thus;

$$WAC\ (\%) = weight\ of\ drained\ sample - weight\ of\ bottle\ used \times 100 \quad (3)$$

(v). Determination of volatile matter, fixed carbon and Ash Content
(Onochie, Obanor, Aliu, & Igbodaro, 2017) [].
A portion of the sample was added to pre weighed empty crucible (W_1) and placed on a weighing balance to get the new weight as W_2. The crucible with sample was half covered and placed in a furnace to be heated for 10 minutes at a temperature 300° C. It was then removed and allowed to cool before been weighed again to obtain W_3.
The crucible was thereafter placed again in the furnace for another 2hours at 600° C, then removed and weight W_4 recorded.

To calculate the ash content; $\frac{W_4 - W_1}{W_2 - W_1} \times 100$ (4)

To determine volatile matter; $\frac{W_3 - W_1}{W_2 - W_1} \times 100$ (5)

To determine fixed carbon; $100 - (ash\ content + volatile\ matters)$ (6)

(vi). Determination of Lignin Content
(Fagerstedt, Saranpää, Tapanila, Immanen, Alonso Serra, & Nieminen, 2015) [10].
2g (W_1) of the extracted sample was added into a 500ml conical flask then 15 ml of 72% Sulphuric acid was also added and stirred for 2hours 30 minutes at 25° C temperature. 200ml of distilled water was then added and boiled for 2hours at 80° C, it was kept to cool for 24 hours before it was then transferred to a crucible and washed with hot water repeatedly until it was acid free. It was then oven dried at 105° C for 3hours and allowed again to cool in a dessicator and then it weight taken again as W_2.
Lignin

Lignin content is determined thus; $\frac{W_2}{w_1} \times 100$ (7)

(vii). Determination of holocellulose content
(Bledzki, Mamun, Lucka-Gabor, & Gutowski, 2008) [6]
The dried sample with weight 3g was added to 500 ml conical flask where 160 ml of distilled water was also added, 0.5 ml glacial acetic acid and 1.5g sodium chloride were added successively and then placed in a water bath and heated at 75° C for 1 hour, another 0.5 glacial acetic acid and 1.5g of NaCl were then added again repeated at intervals of 30 minutes. it was then placed in the water bath to cool below 10° C before it was filtered and washed with acetone, ethanol and water respectively, before allowed to dry in the oven at 105° C, then cooled in a dessicator and weight taken again.

Holocellulose content is obtain thus; $\frac{weight\ after\ drying}{weight\ of\ sample\ used} \times 100$ (8)

(viii). Determination of alpha cellulose
(Bledzki, Mamun, Lucka-Gabor, & Gutowski, 2008) [6]
2g of the holocellulose sample was placed in a 500 ml beaker, 10 ml of 17.5% Sodium hydroxide also added to it and stirred with a glass rod vigorously, more 17.5% sodium hydroxide solution was also added to the mixture periodically at an interval of 5 minutes for 30 minutes. This mixture was then kept at 20°C before adding 33 ml of water to the beaker and allowed to stand for 1 hour.
The mixture was thereafter filtered and transferred into a crucible before been washed with 100 ml of 8.3% sodium hydroxide, 200ml of water and 15 ml of 10% acetic acid before adding water again. The residue was dried and weighed.

Alpha cellulose is determined thus; $\frac{weight\ after\ drying}{weight\ of\ holocellulose\ used} \times 100$ (9)

(xi). Determination of hemicellulose content
(Bledzki, Mamun, Lucka-Gabor, & Gutowski, 2008) [6] It is simply

It is simply $holocellulose - alpha\ cellulose\ content$ (10)

Results and Discussion

Table 1: The Results of Physiochemical Properties

Physiochemical properties	Pumpkin Pulp	Native Pear seed
Moisture %	5.724	4.817
Bulk Density %	0.287	0.411
Tapped Density (g/cm^3)	0.375	0.635
Hausner Ratio	0.765	0.648
Water absorption capacity (25)	0.446	0.292
Volatile matter %	37.362	35.792
Ash content%	2.918	2.777
Fixed Carbon	59.727	61.431
Lignin	46.573	42.109
Holo Cellulose	66.390	67.695
Alpha- Cellulose	50.293	37.78
Hemi-Cellulose	16.097	29.915

(i). Moisture Content

Table 3.1 shows the results of the Physiochemical properties of Pumpkin pulp and the Native pear seed where its moisture content values are 5.724% and 4.817% respectively. These values represent the amount of water present in the sample after drying at 105^{0}C in the oven for 24 hours. This means that complete or near complete moisture removal is almost impossible and also these values are within the limit of 5% needed for proper acetylation of a sorbent material, (Nwadiogbu, Ajiwe, & Okoye, 2016) [25]. It was also observed that Pumpkin has a higher value compared with Native pear seed, thus it is expected to contain more hydroxyl groups that native pear. (Adeyi, 2010) [1] revealed results of Coconut Husk as 5.43% which is closer to those in this study but a much lesser result compared with those of Coco pods, Kola nut pods, Plantain peels (ripe), plantain peels (unripe), having moisture content ranging from 11.99% to 8.22% with kola nut pods the highest value while plantain peels (unripe) the least value.

(ii). Bulk density, tapped density and Hausner ratio

The results of Bulk density and Tapped density seen in Table 3.1 gave values of 0.287 / 0.375 and 0.411/ 0.635 for pumpkin pulp and native pear seed respectively. Bulk density is described as the density of a powdered sample poured into a cylinder (Coucoulas L., 2003) [7] while Tapped density is said to be the density measured after the container has been disturbed or shaken and the powder has consolidated. The results of both samples are closely related to some values recorded in literatures. The value of Pumpkin is moderately lower than Native pear seed, so higher porosity is expected in the pumpkin sample and also with both values below the value one, this reveals the tendency of these materials to float on water (Soyoye, Ademosun, & Agbetoye, 2018) [33]. Hausner ratio relates to the ratio of the difference between the tapped density and bulk density and also reveals the flow ability of the material as it is noted that values below 1.20 indicates materials with good flow ability while above 1.50 indicates materials with poor flow ability (Nwadiogbu, Ajiwe, & Okoye, 2016) [25]. The Hausner ratio of the Pumpkin and Native pear seed has values of 0.765 and 0.648 respectively, these values are lower than 1.20, therefore these values reveals that both materials have good flow ability. Hausner ratio of Corn cob as 0.896 recorded by (Azubuike & Okhamafe, 2012) [5] gave a value very close those recorded in this study.

(iii). Water absorption capacity. (WAC)

This relates to the adsorbent's hydrophilic nature and the existence of OH groups, adsorbent with higher WAC would have stronger water-water bond than water-material bond, however it also relates to the nature of the pore of the material as pore with larger pore would require more water to create a bridge between clusters of water in each pore (Mikšík, *et al*., 2020) [21]. This study reveals the WAC values for Pumpkin Pulp and Native pear seed as 0.446 and 0.292 accordingly, thus higher porosity and adsorption capacity is expected with Pumpkin pulp as a result of its higher value. This in correlation with the values of the Bulk density observed in this study. (Lv, Wang, Peng, Zhang & Luo; 2018) [19] rapid and saturated water sorption capacity analysis on modified jute fiber gave values of 0.55g/g and 0.92g/g respectively, thus within the range of the results in this study.

(iv). Volatile matter, ash content and fixed carbon

The results of volatile matter, ash content and fixed carbon as seen in Table 3.1 above gave values of 37.362%, 2.918 % and 59.727% for Pumpkin of pulp and 35.792%, 2.777 and 61.431 % as values for Native pear Seed. Volatile matter which is the amount of unstable material in an organic material that easily transits state when subjected to higher temperature. The values for volatile matters revealed in this study showed that pumpkin pulp has higher volatile content compare with native pear seed. (Falemara, Joshua, Aina, & Nuhu, 2018) [11] Recorded for corn cobs 32.4 % and Anogesis Leiocarpus 34.9% as their values, which are closer to those recorded in this study. Ash content is the measure of the mineral and other inorganic matter in a biomass. (Sluiter, Hames, Ruiz, Scarlata, Sluiter, & Templeton, 2008) [32]. The value of the ash content relates to the soft texture of the material hence from this study Pulp of pumpkin is seen to have higher ash content, thus translating to a higher mineral content and a softer texture when compared with that of the seed of native pear. (Falemara, Joshua, Aina, & Nuhu, 2018) [11] are value 3.4% and 4.9% for leicocarpus and corn cob respectively, these values are slightly higher than those in this study. fixed carbon content elicits more bond breaking within the carbon formation thus releasing more organic matters in forms of gases and liquids as a result of high temperature applied hence the values of in this study reveal higher values with Native pear seed than Pumpkin pulp. (Veeresh & Narayana, 2012) [37] reported values for fixed carbon in Sawmill Dust, groundnut shell, press dug, tamarind fruit shell, caster seed cake, jalropha seed cake and it ranged from 8.99% to 20.53%, which lower than those obtained for the adsorbents in this study, however (Tan, I. A. W, 2008) [34] reported values of 58.75% and 54% for the activated carbons of palm fiber and empty fruit bunch which closer to the values as seen in this study for fixed carbon content.

(v). Lignin, holocellulose, alpha-cellulose and hemi-cellulose

The chemical composition analysis for Pumpkin pulp and Native pear seed reports the values for lignin content, holocellulose, alpha and hemicelluloses contents as; 46.573% / 66.39% / 50.293 / 16.097% and 42.109% / 67.695% / 37.78 % / 29.915% as seen in Table 3.1 above. Lignin content relates to how the plant responses to biotic and abiotic factors around it, thus revealing the strength of the supporting tissue of the material studied (Pérez, Munoz-Dorado, De la Rubia, & Martinez, 2002) [28]. From the results of Lignin content, it classifies both Pumpkin and Native pear as softwood, as it is known that Lignin content varies from species to species, generally its range s between 5% to 12% in monocotyledons, 30% to 60% in softwoods and 15% to 30% in hardwood (Kumar, Parikh, & Pravakar, 2016) and (Diez & Urena, 2020) [8]. This study also suggested that the both materials are of a softwood bark as the values of their lignin are much higher than the range for hardwood bark with lignin range of 16 -24 % (González, 2018) [13] and (Saini, Saini, & Tewari, 2015) [31]. Holocellulose content which is referred to as the carbohydrate fraction of the biomass (lignocellulose) puts Native pear seed as material with higher carbohydrate content compared with Pumpkin pulp based on its higher value seen in the result above. Hemicellulose content that tells of the structurally complex polymer containing a variety of monomers in the material shows that native pear is of a higher hemicelluloses content compared with Pumpkin pulp while the value of the Alpha cellulose puts Pumpkin pulp of a higher Alpha cellulose content compared with Native pear as seen the values shown on Table 3.1. (Saffe, Fernandez, Mazza, & Rodriguez, 2019) [30] reported values for lignin content of peach pt, marc, stalk and sawdust as 27.53, 37.97, 30.79 and 26.8 respectively using standard methods, only Marc recorded values closest to those in this study. Holocellulose values recorded by (Pacheco, Bustos, Reyes, Aguayo, & Rojas, 2018) [27] for residue of Blueberry branches and Trunk; 63.8% and 72.8% respectively, these values are close to those in this study but also recorded Alpha-cellulose values on the pruning residue of the Blueberry branches and Trunks as, 51.9% and 51.4% respectively thus closer to that of Pumpkin pulp. Although (Johar, Ahmad, & Dufresne, 2012) [16] gave value for rice husk as 35% which is closer to value of Native pear seed. A review from (Ndika, Chidozie, & Ikechukwu, 2019) [24] indicated Hemi-cellulose values for palm kernel deoiled cake as 14.6, which is of closer value to that of Pumpkin pulp while (Saffe, Fernandez, Mazza, & Rodriguez, 2019) [30] gave value for peach pit as 21.02% which is slightly lower than that Native pear.

Conclusion

This study analyzed the physiochemical properties of Pumpkin Pulp and Native pear seed and the results obtained showed moisture content for both materials as suitable for modification with better porosity in pumpkin pulp as seen from the results of its Bulk density, tapped density and water adsorption capacity compared with the values seen for Native pear seed. Pumpkin pulp also had higher volatile matter and mineral contents compared with Native pear seed but higher value was seen in the fixed carbon content of Native pear seed compared to Pumpkin pear seed. Both materials were observed to originate from softwood as seen from the results of lignin content. Native pear seed was seen to have higher carbohydrate content compared with Pumpkin pulp. The result of this study would enable a critical examination of the nature of these materials for adequate application translating to their recycling, therefore reducing its negative impact on the environment.

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