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Research Paper

Physico-Chemical Composition of *Telfairia Occidentalis* (Fluted Pumpkin Fruit) Pulp

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ABSTRACT
This study investigated the chemical composition of Telfairia occidentalis (Fluted pumpkin fruit) pulp, an agricultural waste. Results revealed that fluted pumpkin fruit pulp contains: 9.34% moisture, 2.10% protein, 1.89% crude lipid, 60.28% carbohydrate, 11.12% crude fibre, 15.27% ash, 1.40% Lignin, 38.60% Hemicelluloses and 20.30% Cellulose. It is a promising alternative to fossil fuels. The utilization of agricultural residues and wastes in the chemical industry is a cost effective and environmentally friendly approach for sustainable development. Considering the recent research progress in the fields of biofuel, utilizing agricultural wastes will certainly prove to be a feasible technology to achieve energy security in the nearest future.

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I. INTRODUCTION

Agricultural wastes are created in large quantities from cocoa, plantain, banana, palm bunches, pumpkin fruit, etc. Inappropriate dumping and burning of these wastes lead to the release of probable harmful volatile compounds into the environment (Kuponiyi and Amuda, 2013). Similarly, fruit and vegetable wastes like tomato pomace, bottle gourd pomace, citrus pulp, carrot pulp, corn husk, cabbage and pineapple waste, etc. are perishable and highly fermentable, mainly because of their high moisture, crude protein and total soluble sugar contents. During the processing season, vegetable wastes are generated in huge quantities but are not consumed at the same pace, thus, surplus quantities of these are discharged which can cause environmental pollution. These wastes usually contain high levels of organic matter, nutrients, moisture and sometimes salts and are not suitable for disposal in municipal landfills because of their physical, chemical and biological properties. Land application is the method most widely used by the food processing industry for disposal of vegetable wastes (Saini *et al*, 2015; Sunday, Israel, and Odey, 2016).

Among other agricultural wastes, fluted pumpkin fruit (*Telfairia occidentalis*) pulp is scarcely used or not utilized at all. Fluted pumpkin fruit pulp is a member of the cucurbitacase family. It is a dioecious and perennial plant that is characterised by greenish leafy vegetables and fleshy fluted gourds with hard edible seeds. When cultivated, the plant develops tendrils that usually creeps and spreads on the surface of the ground if left unattended to and coil through stakes. The broad leaves are locally referred to as “ugu” (Igbo) or “ikongubong” (Ibibio) and is used for cooking soups, stews, yam and vegetable sauces and even for medicinal purposes.

Figure 1: Fluted pumpkin fruit (TOF)

The seeds are also edible. However, they are to be properly cooked before consumption. The cooked seeds can be dipped in palm oil or local sauces before eating and can be used for making soaps. Also, the seeds are an excellent source of protein and oil and thus, are highly beneficial to human health. Interestingly, the seeds can last for months or up to a year in the gourd if left uncut and whole. There has been an overwhelming increase in the consumption of fluted pumpkin leaves and seeds over the past years due to all the nutritive benefits obtainable from them. The most used part of the plant includes the leaves, shoots and seeds. The fruit pulp (Figure 1) is not edible and is regarded as a waste.

Utilization of biomass as energy sources may enhance the economy of rural communities, increase farmer's income and market diversification, reduce agricultural commodity surpluses, enhance international competition and reduce negative environmental impacts. This additional source of income could accrue to farmers and rural populace, improve the material welfare of rural communities thus, resulting in the further activation of the local economy. This will ultimately reduce the emigration rates to urban environments (Jekayinfa and Omasakin, 2005). Exploiting biomass as an alternative to petrochemicals for the production of commodity plastics is vitally important in building a sustainable society, hence, the reason for this research.

II. MATERIALS AND METHOD

Sample Collection and Treatment

Fluted pumpkin fruit (*Telfairia occidentalis* fruit; TOF) was collected from a dumpsite at Akpan Andem Market, Uyo, Akwa Ibom State. The sample was washed, oven-dried, ground to powder and stored in an airtight container prior to analysis.

Proximate Analysis

The chemical composition of the sample was determined using the standard methods of analysis approved by the Association of Official Analytical Chemists (AOAC, 1995). Crude protein, crude lipid, carbohydrate, moisture and ash contents in the samples were analysed. The methods are described below:

a. Moisture Determination

Exactly 5 g of the ground sample was placed in an oven at 105^0C for 6 hours. On cooling, the sample was weighed again and the weight loss was recorded. The moisture content was then calculated using equation 1.

$$\text{moisture content } (\%) = \frac{(B-A)-(C-A)}{(B-A)} \text{ X } 100 \qquad \text{Equation 1}$$

where A = weight of clean dry pan (g); B = weight of pan + wet sample (g); C = weight of pan + dry sample (g).

b. Determination of Crude Protein

Ground sample of 1 g was weighed and placed in a Kjeldahl flask containing 1.5 g $CuSO_4$,1.5 g of Na_2SO_4 and 20 ml of concentrated H_2SO_4. The flask was placed on an electric cooker, boiled and allowed to stand until the solution became clear. On cooling, 90 ml distilled water and 2 g of Na_2SO_4 was added, stirred and allowed to stand until a green colouration was observed. To aid the formation of two layers, one glass bead and 80 ml of 40% NaOH solution was added to the flask. The flask was then connected to a distillation unit. The distillate was then titrated against 0.1 M HCl until the solution changed from blue to reddish brown. The crude protein was then calculated using equation 3.

$$\text{Nitrogen in sample (\%)} = 100\left(\frac{A \times B}{C} \times 0.014\right) \quad \text{Equation 2.}$$

Crude protein (%) = Nitrogen in sample X 6.25 Equation 3.

Where A = volume of acid used in the titration (ml); B = concentration of acid; C = weight of the sample (1 g); 6.25 = conversion factor (equivalent to 0.16 g nitrogen per gram of protein).

c. Lipid Determination

The ground sample of weight, 5 g, was poured in an extraction thimble of a Soxhlet extractor containing petroleum ether and placed in the extraction unit. This was heated with refluxing for 6 hours. Thereafter, the ether was evaporated in a rotary evaporator. On cooling, the sample was reweighed and the loss in weight was recorded as the crude lipid.

d. Determination of Crude Fibre

The defatted sample in step 3.2.3 was weighed and placed in a flask containing 200 ml of 2 M H_2SO_4, boiled for 2 minutes and filtered. The residue was washed with hot water and transferred to a flask containing 200 ml of warm NaOH solution and reheated for another 2 minutes. The resulting solution was filtered with boiling water, 1 M of HCl solution, boiling water again and petroleum ether. A crucible was dried in the oven and weighed. The crucible with the residue was weighed and placed in a furnace at 550°C for 1 hour. On cooling, the crucible was weighed again. The weight loss was recorded as the fibre content of the sample.

3.2.5 Determination of Total Ash

Total ash content was determined by igniting 5 g of the dried samples in a muffle furnace at 500°C for 4 hours. The difference in weight served as the ash content.

3.2.6 Total Carbohydrate Content Determination

Available carbohydrate content in the sample was determined following the method described by Ashraf *et al.* (2013). This was calculated as the difference obtained after subtracting the lipid, ash and fibre values from the total dry matter as given in equation 4.

Carbohydrate (%) = 100 – (a + b + c + d) Equation 4

Where a = amount of crude protein, b = lipid, c = ash, d = crude fiber.

3.3 Determination of Lignin, Cellulose and Hemicelluloses (Ververis *et al.* 2006)

Lignin, cellulose and hemicelluloses contents of the sample was determined according to the method of Ververis *et al.* (2006). Sample of weight 5 g was boiled with 10 ml of 18 M H_2SO_4 solution for 2 hours in order to hydrolyse the cellulose and hemicelluloses. The suspension remaining after the above treatment was filtered through a crucible and the solid residue was dried at 105°C for 2 hours and weighed (W_1). The residue was then transferred to a pre-weighed dry porcelain crucible and heated at 100°C for 1 hour. On cooling, it was reweighed (W_2). The lignin content was determined using equation 5.

Lignin = $W_1 - W_2$ Equation 5

The defatted sample obtained during lipid determination (step) was boiled in 80% methanol solution, allowed to cool and filtered. After filtration, the solvent (methanol) was evaporated and the soluble component was weighed in grams and labeled C_1while the residue left after filtration was equally weighed in grams and labeled C_2. Following these values, the cellulose content in the samples was calculated using equation 6.

$$\text{Cellulose content (\%)} = \frac{0.9}{0.96} \times C_1 \frac{V}{M} \times 100 \quad \text{Equation 6}$$

Where: 0.9 = the coefficient that results from the molecular weight ratio of the polymer and the monomer hexose; 0.96 = the monosaccharide yield; C_1= the glucose concentration (mol/dm^3); V= the total volume of sugar solution (L); M = the dry weight of the samples (g)

The hemicelluloses content was calculated from equation 3.7.

$$\text{Hemicellulose(\%)} \frac{0.88}{0.93} \times (C_1 - C_2) \times \frac{V}{M} \times 100 \quad \text{Equation 7}$$

Where 0.88 = the coefficient that results from the molecular weight ratio of the polymer and the monomer pentose; 0.93 = the conversion yield of xylane to xylose;C_1= the glucose concentration (g); C_2= the determined reducing sugar concentration (g); V = the total volume of sugar solution (g); M = the dry weight of the defatted sample.

III. RESULTS AND DISCUSSION

Results of the proximate analysis of oven-dried TOF is presented in Table 1. TOF contained 9.34% moisture, 2.10% protein, 1.89% crude lipid, 60.28% carbohydrate, 11.12% crude fibre and 15.27% ash.

Table 1:Proximate Composition *Telfairia Occidentalis* Fruit (TOF)

Moisture (%)	Protein (%)	Crude lipid (%)	Carbohydrate (%)	Crude fibre (%)	Ash (%)
9.30 ± 0.002	2.10 ± 0.007	1.90 ± 0.003	60.30 ± 0.003	11.10 ± 0.004	15.30 ± 0.002

Moisture Content

The moisture content of any food is an index of its water activity and can be used as a measure of stability and resistance to microbial contamination. High moisture content may imply short life shelf as moisture enhances fast deterioration of plants.

According to Appoldt and Raihani (2017), moisture content influences the taste, texture, weight, appearance and shelf life of any material. Even a slight deviation from a defined standard can adversely impact the physical properties of a material. The American Association of Cereal Chemist recommends moisture content for plant materials within the range of 14% or lesser. This is because any material with moisture greater than 14% will not be stable at room temperature as organisms naturally present in the material will start to grow, producing off odours and flavours.

Moisture content of dry TOF pulp obtained in this study is within the acceptable range. The moisture content observed in this study was 9.30%. This suggets that *T. occidentalis* fruit pulp may not be susceptible to microbial attack and thus, both can withstand long storage and transportation. When dried, the samples can be stored for a long time without deterioration. However, Moisture content of TOP is in line with 9.63% reported by Verla *et al.* (2014).

In comparison to other works, dried TOF pulp has low moisture contents that compares favourably with other lignocellulosic biomasses; 9.53% in plantain stem (Adeolu *et al*, 2013), 10.04% in cocoa pods and 8.71% in plantain peels (Oladayo, 2010).

Protein Content

Proteins in form of amino acids are nutrients needed by the human body for growth and maintenance (Akinwunmi and Omatoya, 2016). Protein is needed to form blood cells, protect, rebuild, maintain and grow tissue, hair, muscle, bone marrow and other vital organs (Lal, 2008). Protein deficiency can lead to mental retardation while excess consumption of protein leads to a higher risk of kidney stone formation (Lal, 2008).

The protein content in TOF was 2.10%. This result showed that this agricultural waste is not a good source of protein. This explains why the use of these wastes in animal feed has not been reported.

Protein content in *Telfairia occidentalis* fruit pulp (TOF) was lower than 26.33% present in *T. occidentalis* leaves (Akinwunmi *et al.*, 2016) and 32.86% present in *T.occiendtalis* seeds (Kwiri *et al.*, 2013). Low protein content in TOF has also been reported by Fedha *et al.* (2010); Adebayo *et al.* (2013) and Verla *et al.* (2014) as 3.90%, 3.00% and 5.23% respectively. When compared to some commonly consumed biopolymeric plant materials in Nigeria; 20.72% in Moringa, 11.47% in plantain peels and 15.00% in *Lasianthera Africana* (Adeolu *et al*, 2013). The low amount of protein content in TOF indicates that it does not qualify as a protein source and cannot contribute to the nutritional value of animal feed if used.

Crude Lipid

Crude lipid evaluates the free fatty lipids of a product. This property can be used as the basis in determining processing temperatures as well as auto-oxidation which can lead to rancidity (Adeolu *et al.*, 2013).

Lipid content in TOF was 1.90%. This value is low and indicates that the sample may not be good sources of fat-soluble vitamins and cannot contribute significantly to energy content of feeds that are prepared with them. Crude lipid content obtained in TOF was lower than 7.55% present in the leaves (Akinwunmi *et al.*, 2016) and 43.46% present in the seeds (Kwiri *et al*, 2014; Elinge *et al.*, 2012).

Carbohydrate

Carbohydrate is a principal source of energy. Our results revealed that the sample had high carbohydrate contents of 60.30%. Therefore, the plant wastes can serve as an alternative source of carbohydrate.

The carbohydrate content of TOF was higher than 12.16% present in the seeds (Kwiri *et al.*, 2014; Elinge *et al.*, 2012 but lower than 74.0% reported for the leaves (Fai *et al*,2013).

Crude Fibre

Crude fibre measures the cellulose, hemicelluloses and lignin content of food. Lignin comprises polymers of phenolic acids and hemicellulose made up of hetero-polymers of polysaccharides (Zakpaa, Makmensah and Adubofour, 2010).

High fibre content in diets have been reported to result in increased removal of carcinogens, potential mutagens, steroids, bile acids and xenebiotics by binding dietary fibre components.
TOF had high fibre contents of 11.10%. This suggests that the samples may have health promoting benefits for ruminants and non-ruminants. Since the biopolymers contained high amount of crude fibre, it could help to reduce the level of cholesterol in the body and also aid digestion. In addition, it could also help to reduce the level of glucose in the body, thus, it may be used for the treatment of some diseases in ruminant animals (Fai *et al.,* 2013).
TOF had a fibre content of 11.10%. This value agrees with 13.23% present in the leaf (Akinwunmi *et al.,* 2016).

Ash

The ash content of any plant material provides an estimate of the quality of the product. The ash content was 15.30% in TOF. The high content of ash is an indication that the waste is rich in mineral elements which are expected to speed up metabolic processes as well as improve growth and development of the body (Elinge *et al.,* 2012). Nevertheless, 15.30% ash content in TOF agrees with 12.20% present in the leaves (Akinwunmi *et al.,* 2016).

Ash content is a measure of plants mineral contents. High values indicate that the biopolymers contain appreciable amount of mineral element and that they are rich in organic matter which is convertible to oxides and water on heating. Compared to other biopolymeric biomass, ash contents of TOF was higher than 5.80% in oil palm frond (Mohamad *et al,* 2015).

Lignin, Hemicellulose and Cellulose Content of *Telfairia Occidentalis* Fruit (TOF)
The result for lignin, hemicelluloses and cellulose contents in the sample are summarized in Table 2.

Table 2: Lignin, hemicellulose and cellulose content of *Telfairia Occidentalis* Fruit (TOF)

Sample	Lignin (%)	Hemicelluloses (%)	Cellulose (%)
TOF	1.40± 0.002	38.60± 0.002	20.30± 0.007

Lignin

Lignin content in this study was 1.40% for TOF. Chemically, lignin is a cross-linked phenolic polymer which fills the spaces in the cell wall between cellulose, hemicelluloses and pectin components and confers mechanical strength to the cell wall (Lebo, Gargulak and Mcnally, 2001). The lignin in plants also works as a barrier against attack by insects and fungi. It can be used as an alternative raw material for plastics. Lignin in plants also works as a barrier and burns very effectively; it can be used as bio-based alternative to petroleum. The other uses of lignin are animal feed, coatings, agricultural chemicals, micronutrients, natural binders, adhesives, resins and in the manufacturing of vanillin and textile dyes. Lignin is hardly degraded by microorganisms including fungi and bacteria (Tien and Kirk, 1983). In other words, material composed of lignin is associated with reduced digestibility of the overall plant biomass; this gives the material high resistance to microbial attack and helps to defend against pathogens and pests.

Hemicellulose
Results from our study revealed that hemicelluloses contents in TOF was 38.60%.. This shows that TOF contained a greater amount of fermentable sugars. The values of hemicelluloses obtained from TOF is higher than 15.07% reported for ripe plantain peel (Oladayo, 2010).

Cellulose
The cellulose composition of TOF was 20.30%. This value is higher than 13.87% in ripe plantain and 0.52% reported for coconut husk (Oladayo, 2010).

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