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Comparative Analysis of Nutritional and Proximate Compositions of Peel and Pulp of Unripe Plantain

Ayorinde OJ[1,*], Olu-egbor OG[2], Precious I[3] and God'sfavour OI[3]

[1]*Department of Basic Sciences, Federal Polytechnic Auchi Edo State, Nigeria*
[2]*Department of Science, Auchi Polytechnic Secondary School, Nigeria*
[3]*Department of Physical Science Laboratory, Federal Polytechnic Auchi Edo State, Nigeria*

[*]**Corresponding author:** Ayorinde OJ, Department of Basic Sciences, Federal Polytechnic Auchi, Edo State, Nigeria; E-mail: jejeayorindeoludiya@gmail.com

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Abstract

The nutritional composition of unripe plantain (Musa paradisiacal) was investigated. The various parts of the unripe plantain such as the peel and the fruit were subjected to different preparation processes. The unripe boiled unpeeled plantain flour (UBUPF), the unripe peeled boiled plantain flour (UPBPF), the unripe plantain peeled flour (UPPF), and unripe peeled uncoiled plantain flour (UPUPF). Each sample was characterized using Energy Dispersive X-ray Fluorescence (EDXRF) for the elemental composition while Fourier Transform Infrared spectroscopy (FTIR) was used to investigate the presence of functional groups. Proximate composition of the samples were carried out. The results showed that potassium (K) is the most abundant element present in the entire sample showing UPPF with the highest (3.547 weight %), UBUPF (1.046 weight %), UPUPF (0.981 weight %), and the least was obtained in UPBPF (0.869 weight %) while sodium to potassium ratio (Na/K) was less than one in all the samples an indication of the plantain diet potential to control high blood pressure and also the calcium to phosphorous ratio (Ca/P) was less than one in all the processed samples however, the value obtained in UPPF (0.743) falls within the recommended range since is higher than 0.5 the ratio of Ca/P value adjudged to be poor. The results revealed that ash content was observed to be the highest in UPPF (9.25±0.07 %), followed by UBUPF (3.00±0.01 %), UPBPF (2.31±0.01 %) and UPUPF (2.19±0.01). UPPF has the highest percentage crude fibre (4.78±0.04 %), followed by UPUPF (4.10±0.00 %), UPBPF (3.96±0.08 %) and UBUPF (3.48±0.03). The highest percentage carbohydrate (CHO) was recorded in UPBPF (870.8±0.01) while the least percentage was in UPPF (74.88±0.14). The FTIR spectra revealed breaking of bonds, formation of new bonds and shifting of peaks.

Keywords: *Unripe plantain peel; Mineral composition; proximate composition; Musa Paradisiacal; Fourier Transform infrared analysis*

Introduction

Musa paradisiacal (Plantain) is a fruit crop that is native to tropical regions of Africa, South America, Central America and Asia. Plantain belongs to the family called Musaceae and order; Plantaginaceae [1]. It is a stable fruit cultivated and consumed in sub-saharan Africa particularly in Nigeria. It has been reported by that over 2.11 million metric tons of plantain are produced in Nigeria annually and across the continent of Africa, also according to over 10 % calorie are obtained from consuming plantain [2,3]. Plantain foods are named in different ways according to the method use in preparing them, for example, when the plantain is prepared by mixing with boiling water it is referred to as amala according to Yoruba tribe in the western region of Nigeria. Plantain is a perennial crop that is about 2-9 inches tall with an underground rhizome. They are named by counting the number of fingers in the bunch mostly in the southern part on Nigeria according to [4]. Cultivated plantains found their origin from two wild diploid species and named accordingly: Musa acuminate which has the genome AA and Musa balbisiana refers to as BB [5]. The raw fresh green plantains are edible and suitable for consumption when cooked. Each fruit measures about 3 to 10 inches or more in length depending upon the cultivar type. They tend to have coarser external features with prominent edges and flat surface. Plantain has been the major source of carbohydrates more than 25 % and provide about 10 % of the daily calorie intake for more than 70 million people in Africa both rural and urban populace [6]. Plantain is a potential sources of various food products such as beverages, fermentable sugars, medicines, flavouring, cooked foods, silage, fragrance, rope, cordage, garlands, shelter, clothing, smoking material and numerous ceremonial and religious uses [7]. It has been reported by that the extracts from the flower of plantain ripe and unripe fruits, leaves and stems have been used for the treatment of numerous human ailments due to their medicinal properties [8]. The major pharmacological effects of plantain includes hepatoprotive, diuretic, analgesic, anti-ulcer, wound healing, hair – growth promoter and haemostatic activity [9]. The peels of plantain are used majorly to feed animals, in purification and production of several biochemical products. Plantain peel (plantain skin) is the outer envelopes (covering) of plantain fruit. They are the by-product of plantain consumption and processing. Plantain peels are used as food for animals as reported for manufacturing of several biochemical products and as a result of this removal of the plantain peel, a significant amount of organic waste is generated but there are some concerns over the impact of tannins contained in the peels on animals that consume them as reported [10,11]. Have reported that the potential applications for plantain peel depend on its chemical composition [12]. Apart from the health benefit derived from plantain peel, it has constituted environmental nuisance since they are mostly considered as waste and often disposed of indiscrimately in landfills, drainages, and road sides therefore become a threat to the environment [13]. The Plantain peel is made up of about 40 % of the total fruit weight had reported that plantain peel to have the potential as a promising raw material with numerous important and useful industrial applications especially in agro-based industries. Somalia is one of the countries that has considered and processed plantain peels for use as organic fertilizers and manure to replenish and improve soil fertilities and subsequently enhance better crop yield and production [14]. Plantain peels can be used as a substitute for corn starch in the production of snails' diet and also incorporate with other waste materials in the diet of pigs according. However, plantain peels have been used for the production of important chemicals like ethanol and also alkali for soap manufacturing. In order to achieve a cleaner and safer environment for humans, efforts have been made by scientists to prepare polyphenolic resol resins from the ethanol extract of plantain peels for the adsorption of heavy metals from industrial effluents since the plantain peels show high adsorption capacity and retention affinity for lead (Pb), nickel (Ni), and chromium (Cr) [15]. The aim of this study therefore, is to investigate and compare the nutritional and proximate composition of peel and pulp of unripe plantain.

Materials and Methods

Sample Collection

Bunches of matured unripe plantain fruit were purchased from Uchi market in Auchi, Etsako West Local Government, and Edo State. All the chemicals and reagents used were of the analytical grade.

Sample Preparation

The unripe plantain fruits were washed with tap water and followed with distilled water in order to remove the surface dirt. Four different flour samples were prepared from the unripe plantain.

Preparation of Unripe Boiled Unpeeled Plantain Flour (UBUPF)

The unripe boiled unpeeled plantains were cut into small sizes with a stainless steel knife, and boiled in a stainless cooking pot until it became soft. The boiled plantains were transferred into a thermostatically controlled oven and allowed to dry for 24 hr at 105ºC. The dried sample was ground to fine powder using electric grinder and sieved using 100μm size sieve to obtain a finer particle sizes. The obtained powder was collected and stored in an air tight dry container and labelled unripe boiled unpeeled plantain flour. (UBUPF)

Preparation of Unripe Peeled Boiled Plantain Flour (UPBPF)

The UPBPF was prepared by removing the peel (the bark) and cut into small pieces using a stainless steel knife and boiled in a stainless cooking pot until it became soft. The boiled peeled plantain was transferred into a thermostatically controlled oven and allowed to dry at 105ºC for 48 hr. The boiled peeled plantain was ground using electric grinder and further sieved to finer particles using 100 μm size sieve. The resulted powder was collected and stored in an air tight dry container and labelled unripe peeled boiled plantain flour (UPBPF).

Preparation of Unripe Plantain Peels Flour (UPPF)

The UPPF was prepared by removing the peels using a stainless steel knife. The peels were dried in a thermostatically controlled electric oven at 105ºC for 48 hr, the dried peels were ground to fine particles using a grinder and further sieved into finer particles using 100 μm sieve. The resulted powder was stored in an air tight dry container and labelled as unripe plantain peeled flour (UPPF).

Preparation of Unripe Peeled Uncoiled Plantain Flour (UPUPF)

The procedure in third sample preparation was repeated for the fourth sample, the unripe peeled uncoiled plantain and labelled as unripe peeled uncoiled plantain flour (UPUPF).

Proximate Composition Analysis

Samples were analysed chemically for crude protein, crude fibre, dry matter, ash, fat, and carbohydrate content was determined by difference technique, which is the addition of moisture, fat, crude protein, ash, and crude fibre which was subtracted from 100 %, this is the amount of nitrogen free extract known as carbohydrate (% carbohydrate = 100 – (% Moisture + % Crude protein + % Crude fat + % Crude fibre + % Ash) according to the official methods of analysis described by the Association of Official Analytical Chemist [16]. All analysis were carried out in duplicate.

Elemental composition methods

The samples were characterized for their elemental compositions using x ray fluorescence (XRF) while the Fourier Transform Infrared was used for the identification of functional groups in the samples

Results and Discussion

In their study had reported that trace metals and minerals are group of inorganic substances that occur naturally and account for about 4 % of total human body mass [17]. Table 1 is the elemental composition of the plantain part samples flour (UPBPF, UPUPF, UBUPF and UPPF). Generally, trace elements and minerals are responsible for regulating numerous biological, help in building body structure and also needed for good health. The activities of enzymes as well as electrolytic balance of body fluid are related to the availability of some minerals such as sodium (Na), potassium (K), magnesium (Mg) and zinc (Zn). K has been adjudged as essential and important mineral that has helped to maintain the volume of the body, regulation of muscles and irritability of nerves, control of glucose absorption and enhancement of normal retention of protein during growth had also reported that lack of calcium results in syndrome like rickets and calcification of bone whereas minerals in sufficient quantity ensure the normal physiological functions including the utilization of iron (Fe) [18,19]. The investigation showed that potassium was more than all other elements determined in the samples however has the highest concentration in unripe plantain peel (UPPF, 3.547), followed by the unripe boiled unpeeled plantain (UBUPF, 1.046), unripe peeled unboiled plantain (UPUPF, 0.981) and the lowest concentration was obtained in unripe peeled boiled plantain (UPBPF, 0.869).

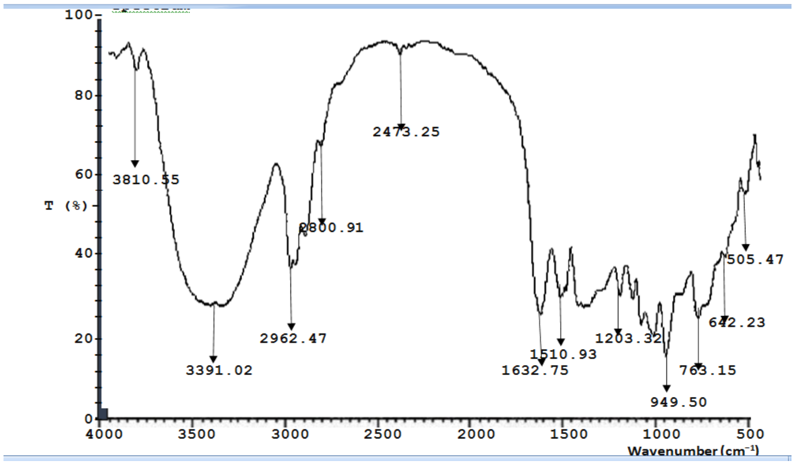

Figure 1: *The Fourier Transform Infrared of UBUPF.*

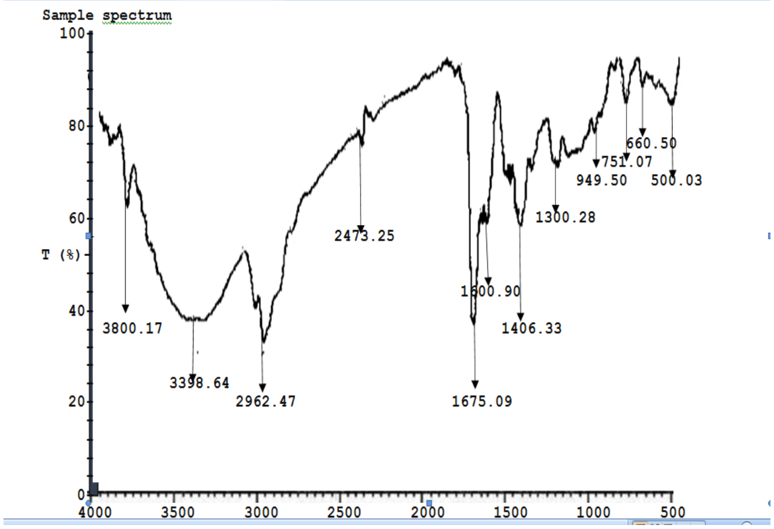

Figure 2: *The Fourier Transform Infrared of UPBPF.*

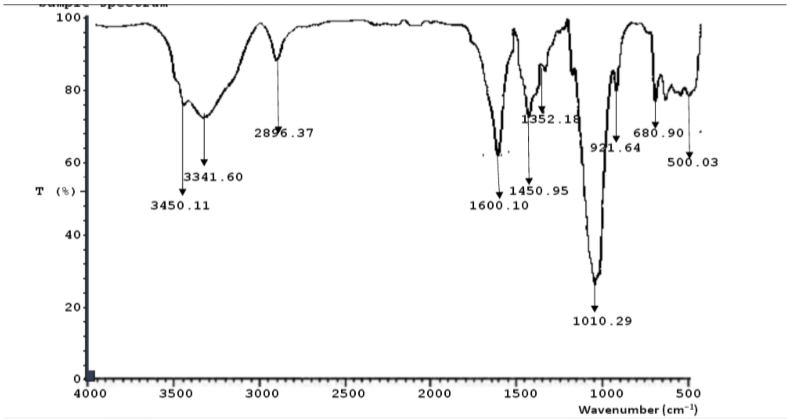

Figure 3: *The Fourier Transform Infrared of UPPF.*

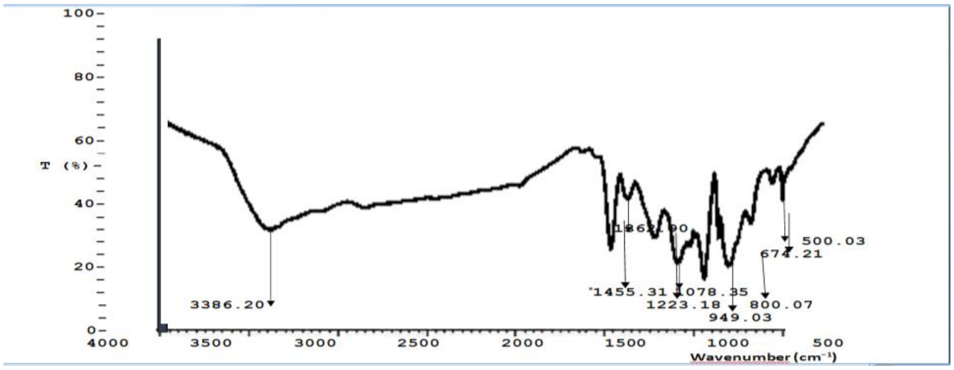

Figure 4: *The Fourier Transform Infrared of UPUPF.*

Table 1: *The Elemental Composition of the Peel and Pulp of Unripe Plantain in Weight Percentage.*

Element	UPBPF	UPUPF	UBUPF	UPPF
		% weight		
Fe	0.004	0.008	0.003	0.014
Cu	0.001	BDL	BDL	BDL
Zn	0.002	0.001	0.001	0.004
Al	BDL	0.030	0.040	0.003
Mg	0.015	0.025	0.027	0.010
Na	0.065	0.178	0.005	0.058
S	0.047	0.089	0.054	0.061
P	0.098	0.073	0.112	0.101
Ca	0.024	0.010	0.011	0.075
K	0.869	0.981	1.046	3.547
Mn	0.001	0.002	0.001	0.006
Mo	BDL	BDL	BDL	BDL
Na/K	0.074	0.181	0.005	0.016
Ca/P	0.245	0.137	0.098	0.743
BDL: Below Detection Limit				

Table 2: *The Proximate Composition of the Peel and Pulp of Unripe Plantain Sample In Weight Percentage.*

Sample	UPBPF	UPUPF	UBUPF	UPPF
		Percentage (%)		
Moisture content	6.84±0.01	7.15±0.01	6.91±0.01	6.90±0.00
Crude protein	2.65±0.02	2.73±0.04	3.07±0.01	5.24±0.01
Ash content	2.31±0.01	2.19±0.01	3.00±0.01	9.25±0.07
Ether extract	4.16±0.08	4.45±0.07	3.68±0.04	6.50±0.01
Crude fibre	3.96±0.08	4.10±0.00	3.48±0.03	4.78±0.04
Dry matter	92.64±03.73	92.86±0.01	92.80±0.42	92.80±0.42
ME(cal/kg)	3522.67±1.43	3530.78±0.71	3494.18±1.37	3386.14±0.77
CHO	87.08±0.01	86.77±0.35	86.75±0.01	74.85±0.14

The obtained values are averages ± standard deviation of duplicate determinations

Table 3: *Fourier Transform Infrared of UBUPF.*

Absorption bands (cm^{-1})	Functional groups
3810.55	OH Stretching (Hydroxyl group)
3391.02	OH Stretching (Hydroxyl group)
2962.47	CH_2 Symmetric and asymmetric stretching vibrations (alkanes)
2800.91	C-H stretching vibration. (alkanes)
2473.25	C=O Stretching (ester group)
1632.75	COOH Stretching (carboxylic group)
1510.93	C-O Stretching vibration (amide I and amide II)
1203.32	C-O-C asymmetric stretching carbonyl (cellulose and hemicelluloses)
949.50	OH bending and C-O-C bond stretching (Hydroxyl ether)
763.15	C-O-C Stretch vibration (carbonyl group)
642.23	C-O Stretching and CH rocking vibration of cellulose (aldehydes)
505.47	CH_2 Scissoring vibrations(alkanes

Table 4: *Fourier Transform Infrared of UPBPF.*

Absorption bands (cm^{-1})	Functional groups
3800.17	OH Stretching (Hydroxyl group)
3398.64	OH Stretching (Hydroxyl group)
2962.47	CH_2 Symmetric and asymmetric stretching vibrations (alkanes)
2473.25	C-H stretching vibration. (alkanes)
1678.09	C=O Stretching (ester group)
1800.90	COOH Stretching (carboxylic group)
1406.33	C-O Stretching vibration (amide I and amide II)
1300.28	C-O-C asymmetric stretching carbonyl (cellulose and hemicelluloses)
949.50	OH bending and C-O-C bond stretching (Hydroxyl and ether)
751.07	C-O-C Stretch vibration (carbonyl group)
660.50	C-O Stretching and CH rocking vibration of cellulose (aldehydes)
500.03	CH_2 Scissoring vibrations(alkanes

Table 5: *Fourier Transform Infrared of UPPF.*

Absorption bands (cm^{-1})	Functional groups
3450.11	OH Stretching (Hydroxyl group)
3341.60	OH Stretching (Hydroxyl group)
2896.37	CH2 Symmetric and asymmetric stretching vibrations (alkanes)
1600.10	C=O and N-H stretching vibrations (amide)
1450.95	C-N stretching vibrations (Cyanide)
1352.16	C-O-C asymmetric stretching carbonyl (cellulose and hemicelluloses)
1010.29	C-O Stretching vibration of amide I and amide II (amide)
921.64	OH bending and C-O-C bond stretching (Hydroxyl and ether)

680.90	C-O Stretching and CH rocking vibration of cellulose (aldehydes)
500.03	C=C Stretching vibration (alkenes)

Table 6: *Fourier Transform Infrared of UPUPF.*

Absorption bands (cm^{-1})	Functional groups
3386.20	OH Stretching (Hydroxyl group)
1455.31	C-N stretching vibrations (Cyanide)
1362.90	C-O-C asymmetric stretching carbonyl (cellulose and hemicelluloses)
1223.18	C=O and N-H stretching vibrations (amide)
1078.35	C-N stretching vibrations (Cyanide)
949.03	C-O-C asymmetric stretching carbonyl (cellulose and hemicelluloses)
800.07	C-O Stretching vibration of amide I and amide II (amide)
674.21	C-O Stretching and CH rocking vibration of cellulose (aldehydes)
500.03	C=C Stretching vibration (alkenes)

In his research had reported that sufficient concentration or quantity of K in the body system increases utilization of iron which is more beneficial to humans taking diuretics to control hypertension and also people suffering from excessive excretion of K through the body system fluid according to the study revealed the various concentrations of sodium in plantain parts [20,21]. The highest concentration of sodium was obtained in (UPUPF, 0.178) followed by (UPBPF, 0.065) then (UPPF, 0.058) and the lowest concentration was obtained in (UBUPF, 0.005). Sodium (Na) as one of the minerals needed in the body as reported by regulates fluid balance in the body and helps in the proper functioning of muscles and nerves [22]. While when the dietary Na concentration is high leads to cardiovascular and renal disorder as reported by The results also revealed that the concentration of calcium was more in (UPPF, 0.075) and the lowest concentration was found in (UPUPF, 0.01) and 0.024 was in (UPBPF). Calcium is a constituent of bones and help greatly in concentration process in the body system, clothing of blood and the nerves to transmit messages. Whenever there is low concentration of calcium in the body, the body on its own extracts the required and needed calcium from the bones. Calcium is one of the essential minerals that has found application in disease prevention and control and therefore play a role in medicinal influence of the plant [23,24]. The concentration of copper in the samples ranged between 0.0003 and 0.0005 with the highest concentration recorded in UPBPF, 0.0005 and the lowest in both (UBUPF) and (UPPF) with the value of 0.0003. Copper plays significant role in helping the body to utilize iron and sugar properly, it also necessary for the growth of bone and nerve function. Manganese plays an important role in the formation of connective tissues, bones, nerves, sex hormones, and clothing of blood. The concentrations of manganese in the plantain various parts ranged between 0.001 and 0.005. The highest percentage concentration recorded was in (UPPF, 0.005) and the lowest in (UPBPF) and (UBUPF) having the same percentage concentration of (0.001). Iron has the highest concentration in UPUPF. 0.008 And the lowest in fresh unripe plantain peel, UPPF, 0.01. Iron is an essential element in the diet of pregnant women, nursing mother and infant to prevent anaemia [25]. The concentration of zinc in various parts of the plantain was comparatively low but may still play a key role in normal body development since is an essential element in protein and nucleic acid synthesis and also is one of the microelements that is required in a small quantity in the body system and the same with molybdenum (Mo) [26]. The highest concentration of phosphorous in the sample was obtained in (UBUPF, 0.11). The mineral ratios were also calculated and presented in table 1. Na/K are less than one (Na/K values < 1) in all the samples investigated. Na/K plays a significant role in the diet which as a result will helps to control high blood pressure in the body system. It has been reported that low concentration of sodium and high concentration of potassium intake helps to reduce high blood pressure in hypertensive patients [27]. The recommended Na/K ratio should be less than one. The Na/K values obtained are 0.074, 0.181, 0.005 and 0.016 in UPBPF, UPUPF, UBUPF, and UPPF respectively. This is an indication that regular consumption of plantain would help in preventing hypertension and also help in lowering of blood pressure in hypertensive patients. Calcium to phosphorous ratio (Ca/P) higher than 1 has been reported to be advantageous for consumption because diet is considered good if the Ca/P ratio is greater than 1 and as poor if less than 0.5 [28]. The results of Ca/P ratio obtained showed that only UPPF (0.743) contained the highest Ca/P ratio and could be regarded as suitable among the samples for consumption. The results of the proximate composition analysis of unripe plantain parts samples were presented in Table 2. The percentage moisture content of various plantain parts; (UPBPF), (UPUPF), (UBUPF), and (UPPF) shows that the highest percentage moisture content was observed in UPUPF while the lowest percentage moisture content was in UPBPF. The results showed that moisture content of the samples were moderate and low, this is an indication that the samples can conveniently be stored for a longer period of time as they will prevent efficiently and effectively the growth of microorganisms therefore increasing the shelf-life. The values obtained in this study are acceptable for the established aim, with stable shelf-life (< 20 % moisture) and agreed with those values previously reported by [29-31]. Ash refers to the concentration of minerals or inorganic residue that remains after either ignition or complete oxidation of organic matter in a foodstuff. Ash content is used for nutritional evaluation. The percentage ash content in unripe plantain various parts; UPBPF, UPUPF, UBUPF, and UPPF ranged from 9.25±0.07 to 2.19±0.01. The highest percentage ash content obtained was in UPPF (9.25±0.07) and the lowest percentage ash content recorded was in UPUPF. However, the low percentage ash content obtained in UBUPF and UPBPF was due to evaporation of some of the volatile minerals as a result of heating. The highest percentage ash content was obtained in UPPF revealed that the bulk of the minerals were concentrated in the peels of the unripe plantain

Carbohydrates are important in foods as a major source of energy, to impact crucial textural properties, and as a dietary fibre which influences physiological processes. Carbohydrate also exhibit other attributes such as bulk, body, viscosity, stability to emulsions and foams water-holding capacity, freeze-thaw stability, flavour, aromas, and a range of desirable textures and also provide safety. The results of carbohydrate obtained for the samples by difference showed that the highest percentage carbohydrate recorded was in unripe peeled boiled plantain flour (UPBPF; 87.08±0.01) while the lowest was in unripe plantain peel (UPPF; 74.85±0.14). Comparatively, the results showed that UPUPF is rich in appreciable quantity of carbohydrate than the UPPF and that the major class of food in unripe plantain is carbohydrate. The dry matter that remains after moisture removal is referred to as total solids. The result showed the percentage dry matter ranged between 92.86±0.01 and 92.64±0.73 with the highest value in (UPUPF; 92.86±0.01) and the lowest in (UPBPF; 92.64±0.73). Dry matter ensures adequate nutrient balance. Those nutrients that are essential and required to maintain the normal growth and development of animals, pregnancy during lactation are part of the dry matter portion of food [32]. Fat are referred to those lipids that are solid at room temperature. The analysis of fats in foods is important for accurate nutritional labelling, determination of whether the food meets the standard of identity, and to ensure that the product meets manufacturing specifications. Fat values obtained for (UPBPF), (UPUPF), (UBUPF) and fresh unripe plantain peel were 4.16±0.08, 4.45±0.07, 3.68±0.04, and 6.50±0.01 respectively. The energy values in various parts of unripe plantain ranged from 3386.14±0.77 to 3530.78±0.71. The highest energy value was obtained in (UPUPF) and the lowest was in (UPPF). The various proportions of energy contribution were as a result of fat, protein and carbohydrates. Proteins are an abundant component in all cells and they are important for biological functions and cell structure except the storage proteins. The percentage crude protein of unripe plantain various parts ranged between 5.24±0.01 and 2.65±0.02. The highest percentage crude protein content obtained was in UPPF, (5.24±0.01) and the lowest percentage crude protein content recorded was in (UPBPF, 2.65±0.02). The percentage crude protein content in the study was comparatively low however, the results revealed that much protein are obtained in (UBUPF) and will enhance protein content of the body system if consumed than (UPBPF). However, the low values of percentage crude protein obtained showed that unripe plantain is not rich in protein and not a good source of protein. In spite of the low protein content, the percentage crude fibre recorded makes unripe plantain of interest from a nutritional point of view. Dietary fibre is essentially the sum of the non-digestible components of a food stuff or food product. Most, though not all dietary fibre is plant cell wall materials such as cellulose, hemicelluloses, lignin and made up of polysaccharides molecules. Foods that the body system cannot digest or absorb are refer to as dietary fibre portion of food according to [33]. In this study, the fibre content of unripe plantain various parts ranged between 4.78±0.04 and 3.96±0.08 with the highest percentage obtained in (UPPF, 4.78±0.04) and the lowest was in (UBUPF, 3.48±0.03). Comparatively, the results showed that (UPUPF) percentage crude fibre was 4.1±0.00 while the (UPBPF) and (UBUPF) were 3.96±0.08 and 3.48±0.03 respectively suggesting that crude fibre quantity in the sample was reduced probably due to evaporation during heating. The percentage quantity of crude fibre obtained in this study showed that unripe plantain meal will protect against colon cancer, keep blood lipids within the normal range, thereby reducing the risk of obesity, hypertension, and cardiovascular disease. It will also help in maintaining and sustaining the normal peristaltic movement of the intestinal tract which is one of the important physiological roles that crude fibre plays in the living system. The results revealed that the fibre was concentrated in the peel which is (UPPF) and its importance as a source of dietary fibre and will be able to regulate the normal bowel function

Fourier Transform Infrared (FT-IR) Analysis

The analytical techniques for the characterization of the plantain parts samples flour was achieved using FTIR spectroscopy. The quality features of infrared spectroscopy have been so useful and of the most effective tools for characterization especially for functional groups [34]. Figure 1 is the spectrum of UBUPF while table 2 shows the absorption bands and functional groups of

UBUPF. The low intensity peak at 3810.55 cm^{-1} and broad peak at 3391.02 cm^{-1} are attributed to hydroxyl group (OH stretching vibrations and also due to hydroxyl surface). The absorption band at 2962.47 cm^{-1} is due to CH2 symmetric and asymmetric stretching from alkyl group while the peak at 2800.91 cm^{-1} is due to CH stretching vibration from alkyl group. The absorption band at 2473.25 cm^{-1} is attributed to C=O stretching of ester group while the peak that appears at 1632.75 cm^{-1} is due to COOH stretching. The absorption band at 1510.93 cm^{-1} is as a result of the presence of C-O stretching vibration of amide group and probably amide I and amide II. The absorption peak at 1203.32 cm^{-1} is attributed to C-O-C asymmetric stretching of carbonyl group likely a characteristic mode of cellulose and hemicelluloses. The peak at 949.50 cm^{-1} represents the characteristic peak of OH bending vibration and C-O-C bond stretching of hydroxyl ester while the peak at 763.15 cm^{-1} is attributed to C-O-C stretching vibration of carbonyl group. However, the absorption peak that appears at 642.23 cm^{-1} is due to the presence of C-O stretching and C-H rocking vibration of cellulose. The peak at 505.47 cm^{-1} is attributed to CH2 scissoring vibrations of alkyl group (alkane). Figure 2 is the spectrum of sample UPBPF and table 3 shows the absorption bands and functional groups of UPBPF. The weak peak at 3800.17 cm-1 and the broad peak that appears at 3398.64 cm^{-1} are the characteristic band corresponding to OH stretching vibrations of hydroxyl group present in the sample. The appearance of a peak at 2962.47 cm^{-1} indicates the presence of CH2 symmetric and asymmetric stretching vibrations of alkane while the peak at 2473.25 cm^{-1} is due to CH stretching vibration of alkanes. The absorption band at 1678.09 cm^{-1} is attributed to C=O stretching of the ester group. However, the peak at 1800.90 cm^{-1} is due to the presence of COOH stretching of carboxylic and the presence of a peak at 1406.33 cm^{-1} corresponds to C-O stretching vibration of amide (amide I and amide II). The absorption band that appears at 1300.28 cm^{-1} is a characteristic peak of C-O-C asymmetric stretching mode of cellulose and hemicelluloses (carboxyl group). The peak at 949.50 cm^{-1} is due to OH bending vibration and C-O-C bond stretching of hydroxyl and ether while the peak at 751.07 cm^{-1} corresponds to C-O-C stretching vibration (carbonyl group). The absorption band at 660.50 cm^{-1} indicates the presence of C-O stretching and C-H rocking vibration of cellulose (Aldehyde) and the peak at 500.03 cm^{-1} is due to CH2 scissoring vibrations of alkanes. Figure 3 is the spectrum sample of UPPF while table 4 highlights the absorption bands and functional groups of UPPF. The peak absorption band at 3450.11 cm^{-1} and weak broad band at 3341.60 cm^{-1} correspond to stretching vibration of OH of hydroxyl group. The peak at 2896.37 cm^{-1} is attributed to the characteristic band of CH2 symmetric and asymmetric stretching of alkyl groups (Alkanes) while the sharp band at 1600.10 cm^{-1} is due to C=O and N-H stretching vibrations of amide. The characteristic absorption band at 1450.95 cm^{-1} is attributed to the presence of C-N stretching vibration (Cyanide). The peak at 1352.16 cm^{-1} is due to C-O-C asymmetric stretching mode of cellulose and hemicelluloses (carbonyl group). However, the sharp absorption band at 1010.29 cm^{-1} corresponds to C-O stretching vibration of amide (amide I and amide II). The observed peak at 921.64 cm^{-1} is attributed to OH bending vibration and C-O-C bond stretching from hydroxyl and ether respectively while the peak at 680.90 cm^{-1} is due to C-O stretching and C-H rocking vibration of cellulose from aldehydes and the absorption band at 500.03 cm^{-1} is an indication of the presence of C=C stretching vibration of alkenes. Figure 4 is the FT-IR spectrum of UPUPF and table 5 shows the absorption bands and functional groups of UPUPF. The peak at 3386.20 cm-1 is due to OH stretching vibrations of hydroxyl group. The peaks at 1455.31 and 1078.35 cm^{-1} correspond to CN stretching vibration of cyanide while the absorption peak that appears at 1362.90 and 949.03 cm^{-1} are due to C-O-C asymmetric stretching mode of cellulose and hemicelluloses (carbonyl group). The absorption peak at 1223.18 cm^{-1} is attributed to C=O and N-H stretching of amide groups. However, the absorption peak at 800.07 cm^{-1} corresponds to C-O stretching vibration of amide (amide I and amide II). The absorption band at 674.21 cm^{-1} is due to C-O stretching and C-H rocking vibration of cellulose (Aldehydes) and the peak at 500.03 cm^{-1} corresponds to C=C stretching vibration of alkenes.

Conclusion

The study shows that different parts of unripe plantain contain appreciable levels of food nutrients. The proximate analysis revealed that unripe plantain peel and pulp are rich in nutrients with high proportion of minerals concentrated in the peel. The high amount of dry matter present in the samples revealed that the consumption of unripe plantain will ensure adequate nutrient balance since the nutrients that are essential and required to maintain the growth of animals and pregnancy during lactation are part of the dry matter portion of food. The level of crude fibre revealed that the consumption will also fight against colon cancer, keep blood lipids within the normal range as a result reducing the risk of obesity, hypertension, and cardiovascular disease, and it will help maintaining and sustaining the normal peristaltic movement of the intestinal tract which is one of the important physiological roles that crude fibre plays in the living system. The result showed that unripe plantain is an excellent source of carbohydrate and not rich in protein as low proportion of percentage crude protein were obtained in all the samples investigated. The peel of unripe plantain contains sufficient concentration of minerals and therefore can be incorporated into animal feeds formulation and if successful by extension will enhance solid waste management and reduce environmental pollution to appreciable level.

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