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Comparative Analysis of the Nutritional Content of Ripe and Unripe Plantain (*Musa paradisiaca*) obtained from Nigeria

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Abstract

Plantain is a monocotyledonous and important crop in the tropical and subtropical world regions. It is a staple crop and an important dietary source of carbohydrate in Nigeria and in the humid tropical zones of Africa, Asia and South America. The analyses of such foods provide evidence on nutritional quality and guide to healthy choice. Comparative analyses of phytochemical, proximate, vitamin and mineral content of ripe and unripe plantain were carried out using standard methods. The results showed that plantain (both ripe and unripe) have rich nutritional values. The statistical analysis also showed significant differences existed with phytochemical, vitamin and mineral composition of both ripe and unripe plantain with p-values lower than 0.05. The data obtained showed ripe plantain to have higher nutritional value in phytochemical, proximate, mineral and vitamin contents than the unripe except in crude fibre and carbohydrate content. This could be as a result of the decrease in the starch content as the plantain ripens; which is due to the conversion of starch to sugar that leads to increase in the sugar contents of the ripe plantain. The lower sugar content of the unripe (1.85±0%) compared to the ripe (4.31±0.01%) provided a suitable nutritional energy source for the management of diabetes.

Key words: Plantain, Ripe and unripe, nutritional content, Nigeria.

1. Introduction

Plantain belongs to the genus *Musa* of the family *Musaceae*. Plantain (*Musa paradisiaca* L.) is a tropical fruit that constitute a staple food crop in Central and West Africa. Plantain is a green to yellow boat- shaped fruit

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(shade of colour depends on stage of ripening) of a large shrub called *Musa paradisiaca*. It is a close relative of banana, but it is bigger, longer and has thicker skin and often needs to be cooked before eaten. It is sometimes called plantain banana, excellent for weight control, slow energy release and good for diabetics (unripe plantain), with surpassing nutritional value. Plantain is grown in 52 countries of the world with production capacity of 33 million metric tons per annum [1]. It is a major starchy staple in the sub-Saharan Africa providing more than 25% of the carbohydrates and 10% of the daily calorie intake for more than 70 million people in the continent [2]. Data from FAO [1] sources put the world production of plantain at about 60 million tons. However, in West Africa, plantain production increased at an average annual rate of between 2.3- 2.6% (FAO, 2004). Higher production figures for plantain has been attributed to the cheaper and easier methods of growing once the plant has established vegetative cover [1]. Plantain is often grown alongside other crop plants with similar requirements [3]. In Nigeria annual production is estimated at 2.11 million metric tons [4] thus making Nigeria the world's largest producer and consumer of plantain (10.5 million tones per annum). This accounts for approximately 10% of total global production [5]. In Nigeria and other parts of Africa, plantain (*Musa paradisiaca*) serves as a major staple food and is particularly desired for the variability in its stages of ripeness and cooking methods [6]. In Ghana, plantain is ranked fourth in the agricultural sector and constitutes about 13% of her agricultural gross domestic product with national production of 2.00 million tones [4, 7].

Plantain can be unripe (green), half ripe (yellow green) or ripe (yellow) and can be consumed boiled, roasted, grilled or fried [8]; the ripe plantain can be eaten fresh. Unripe plantain is low in sugar and usually consumed by Nigerian diabetic patients to reduce post pyramidal glucose level. Plantain is employed in the management of diseases such as ulcer, wound healing and have anti-ulcerogenic, antimicrobial, anti-urolithiatic and analgesic properties [9]. Plantain has diversity of minerals like calcium, iron and iodine, but notably high in potassium and low in sodium [10, 11]. This makes it suitable for the control of blood pressure and muscle cramp [12, 13]. Baiyeri *et al* [14] observed significantly high levels of Nitrogen, Phosphorus, Potassium, Magnesium, and Calcium in fully ripe plantain pulp, but low levels of Fe, Cu, Zn, and Na. Plantains are good source of vitamins A, B_1, B_2, B_3, B_6 and C [15], thus, it is often recommended for people who are intolerant to salt. Various literatures have varying chemical compositions of plantains which are associated with the level of maturity, degree of ripeness, soil type, variety and climate [16, 17].

There is literature documentation on high consumption pattern of unripe plantain as a source of energy among people suffering from diabetes mellitus [18-22]. This is because starch is the main component of unripe plantain compared to ripe that has more sugar [16, 17, 23]. Plantain contains a high fibre content, and thus is capable of lowering cholesterol and helps to relieve constipation and hence prevention of colon cancer. Ajasis *et al* [24] observed that both ripe and unripe plantain have some nutritional values as it contains about 3.80% and 3.24% crude protein respectively. Therefore, this study aimed at providing comparative data on nutritional values of ripe and unripe plantains and their benefits in human diet.

2. Experimental

2.1. Materials and Methods

The ripe and unripe plantains were bought from a local market in Okwuta Ibeku in Umuahia, Abia State, Nigeria and identified by a plant taxonomist at National Root and Crop Research, Umudike, Umuahia, Abia State. The plantain samples (ripe and unripe) were washed with distilled water and processed by peeling off the back; then chopped into smaller pieces and dried in an oven pre-set at 105^{o}C for 24 hours to dry off the moisture content. After oven drying, the samples were grinded into fine powder and stored in airtight containers respectively prior to analysis. Each analysis was repeated five times and the mean was calculated and recorded accordingly.

2.3. Determination of Phytochemicals (Quantitative Analysis)

2.3.1. Determination of Alkaloids

The gravimetric method of Harborne [25] was used in determining the alkaloids. About 5 gm of the sample was dispersed in 50 mL of 10% acetic acid solution in ethanol. The mixture was shaken and allowed to stand for four hours before it was filtered. The filtrate was evaporated to quarter of its original volume. Concentrated NH_4OH was added drop-wise to precipitate the alkaloids. The precipitate was filtered off and washed with 1% NH_4OH solution and weighed. The precipitate was dried at 60°C for 30 minutes and reweighed. By weight difference, the weight of alkaloid was determined.

2.3.2. Determination of Saponin

The method used was described by AOAC [26]. About 5 gm of dry sample was weighed inside extractor thimble and transferred into the soxhlet extractor chamber fitted with condenser and a round bottomed flask. Some quantity of acetone enough to cause a reflux was poured into the flask. The sample was exhaustively extracted of its lipid and interfering pigments for 3 h by heating the flask on a hot plate and the solvent distilled off. This is the first extraction. For the second extraction, a pre-weighed round bottomed flask was filled unto the soxhlet apparatus (bearing the sample containing thimble) and methanol poured into the flask. The methanol should be enough to cause the reflux. The saponin is then exhaustively extracted for 3 h by heating the flask on a hot plate after which the difference between the final and the initial weight of the flask represents the weight of saponin extracted.

2.3.3. Determination of Tannins

The methods of Van-Buren and Robinson [27] were employed for the determination of tannin. 0.5 gm of the sample was weighed into a 50 mL plastic bottle. 50 mL of distilled water was added and shaken for 1 h in a mechanical shaker. This was filtered into a 50 mL volumetric flask and made up to the mark. Then 5 mL of the filtrate was pipetted out into a test tube and mixed with 2 mL of 0.1M $FeCl_3$ in 0.1 N HCl and 0.008 M potassium ferrocyanide. The absorbance was measured 120nm within 10 min using a spectrophotometer (Jenway Model 721, Germany).

2.3.4. Determination of Flavonoids

Flavonoid in the sample was determined by the acid hydrolysis gravimetric method of Harborne [25]. Five grams of the sample was mixed with 1mL of diluted HCl in a ratio of 1:10w/v. The mixture was boiled for 30 minutes.

The boiled extract was allowed to cool and filtered. 20 mL of the filtrate was treated with ethyl acetate to precipitate the flavonoids. The precipitate was measured and determined by weight difference.

2.3.5. Determination of Phenols

This was determined using the method described by Oberlease [28]. The sample was first extracted with 0.2 mL of NH_4Cl. 0.5 mL of the extract solution was pipette into a test tube fitted with a ground glass stopper. 1 mL of ferric solution was added and the tube heated in a boiling water bath for 30 minutes. After heating, the tube was cooled in ice water for 15 minutes and allowed to adjust to room temperature. The tube was then centrifuged for 30 minutes at 300 rpm. 1mL of the supernatant was transferred to another tube and 1.5 mL of 2, 2, bipyrindine solution was added and the absorbance measured at 519 nm against distilled water.

2.4. Determination of Proximate Composition

2.4.1. Determination of Moisture Content

Moisture content was determined by gravimetric method described by AOAC [26]. 5 gm of each sample (ripe and unripe plantain) was weighed into a moisture can. The can and its content were dried in the oven at 105°C in the first instance. It was cooled in desiccators and reweighed. The weight was recorded while the sample was retained in the oven for further drying. The drying, cooling and weighing was continued repeatedly until a constant weight was obtained. The moisture content was calculated as shown below:

$$\% \text{ moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1= Weight of empty moisture can

W_2= Weight of can + Sample before drying

W_3= Weight of can + Sample after drying to a constant weight

2.4.2. Determination of Total Ash

This was done using the incineration gravimetric method [29]. 5 gm of each sample was put in a previously weighed crucible. The sample in the crucible was put in a muffle furnace set at 550°C and allowed to burn for 2-3 h. The sample was carefully removed from the furnace and cooled in desiccators. It was reweighed and by difference the weight of ash was obtained and expressed as percentage using the formula given below:

$$\% \text{ Ash} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1= Weight of crucible

W_2= Weight of crucible + Sample

W_3= Weight of crucible + Ash

2.4.3. Determination of Crude Fibre

This was determined by the Wende method [30]. 5 gm of each sample was defatted (during the fat analysis). The defatted sample was boiled in 200 mL 1.25% H_2SO_4 solution under reflux for 30 min. After that, the samples were washed with several portions of hot (boiling) water using two-fold muslin cloth to trap the particles. The washed samples were carefully transferred quantitatively back to the flask and 20 mL of 1.25% NaOH solution was added to it. The samples were boiled again for 30 minutes and washed as before with hot water. They were carefully transferred to a weighed porcelain crucible and dried in the oven at 105°C for 3 h. After cooling in the

desiccators, they were reweighed, put in a muffle furnace and incinerated at 550°C for 2 h until they become ash. Again, they were cooled in desiccators and reweighed. Crude fibre content was calculated gravimetrically as:

$$\% \text{ Crude Fibre} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1= Weight of crucible

W_2= Weight of crucible + Sample before washing and drying in the oven

W_3= Weight of crucible + Sample as ash

2.4.4. Determination of Protein

This was determined by Kjeidahl digestion method described by AOAC [26]. The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. About 0.5 gm of each sample was mixed with 10 mL of concentrated sulphuric acid in a Kjeldahl digestion flask. A tablet of selenium catalyst was added to it and the mixture was digested under a fume cupboard until a clear solution was obtained. The acid and other reagents were digested but without sample to form the blank control. All the digests were carefully transferred to 100 mL volume flask using distilled water and made up to a mark in the flask. A 100 mL portion of each digest was mixed with equal volume of 45% NaOH solution in Kjeldahl distilling unit. The mixture was distilled and the distillate collected into 10 mL of 4% boric acid solution containing 3 drops of mixed bromo cresol green and methyl red. A total of 50 mL distillate was obtained and titrated against 0.02 N H_2SO_4 solutions. The end point is from the initial green colour to a deep red point. The nitrogen concentration was calculated as shown below:

$$\% N_2 = \left(\frac{100}{W} \text{ x } \frac{NX14}{100} \text{ x} \frac{Vf}{Va}\right) T$$

Where: W= Weight of sample analyzed

N= Concentration of H_2SO_4 titrant

Vf= Total volume of digest

Va= Volume of digest distilled

T= Titre value-Blank

% Crude Protein= %N x 6.25

2.4.5. Determination of Fat

The fat contents of the samples were determined by the continuous solvent extraction method using a soxhlet apparatus described by AOAC [26]. 5 gm of each of sample was wrapped in Whatman No 1 filter paper. The wrapped sample was placed in an extraction thimble. The thimble was placed in a soxhlet reflux flask containing 200 mL of diethyl ether. The upper end of the reflux was connected to a water condenser. The solvent (diethyl ether) was heated to boiling point, vaporized and condensed into the reflux flask. The sample remained in contact with the solvent until the reflux flask was filled up and siphoned over, carrying its oil extract down to the boiling flask. This process was allowed to run repeatedly for at least 4 h before the defatted samples were removed, the solvent recovered and the oil extract was left in the flask. The flask containing the oil extract was dried in the oven at 60°C for 30 min to remove any residual solvent. After cooling in desiccators, the flask was

reweighed. By difference, the weight of fat (oil) extract was determined and expressed as a percentage of the sample weight. It was calculated as followed:

$$\% \text{ Fat} = \frac{W_2 - W_1}{W_3} \times 100$$

Where: W_1= weight of flask

W_2= weight of flask + extracted fat

W_3= weight of sample

2.4.6. Determination of Carbohydrate

The carbohydrate content was calculated by difference as nitrogen free extraction (NFE), a method described by James [30]. The NFE was calculated by using the formula below:

$$\% \text{ NFE} = 100 - (\text{MC} + \% \text{ ash} + \% \text{ CF} + \% \text{ EE} + \%\text{CF})$$

Where: MC= Moisture content

CF= Crude fibre

EE= Ether extract

CP= Crude protein

2.4.7. Determination of Minerals/Vitamins

The sample for the determination of the elements was subjected to acid digestion using concentrated hydrochloric acid and subsequently, the different elements were determined using appropriate methods as described by James [30]. 20 gm of each sample was burnt to ashes in a muffle (as in ash determination). The resulting ash was dissolved in HCl (1 mL HCl) and then diluted to 100 mL in a volumetric flask using distilled water. The digest obtained was used for various analyses.

2.4.8. Determination of Calcium and Magnesium

Calcium and magnesium contents of the digested sample were determined by complexiometric titration. 10 mL of the sample was dispensed into a separate conical flask. Pinch of the masking agents, potassium cyanide, potassium ferrocyanide and hydroxyl hydrochloride were measured into the content of each flask. 20 mL of ammonia buffer was added to one of the flasks to raise the pH to 10.0, while 10 mL of NaOH solution was added to the other to raise the pH to 12.0. To the flask at pH 10 (for cacium and magnesium) Erichrome dark black indicator was added and titrated against 0.02 N EDTA solution and the other black was added and titrated against 0.02 N EDTA solution at pH 12.0 (for calcium alone). Selechrome dark blue indicator was added and titrated against 0.02 N EDTA solution at pH 12.0. Calcium form complexes with EDTA at pH 12.0, while both calcium and magnesium form complexes with EDTA at pH 10.0. A reagent blank was titrated as a control. The calcium and magnesium content of the samples were calculated using the standard that 1mL of 1 N EDTA has an equivalence of 24mg magnesium and 20.04 mg calcium.

2.4.9. Determination of Sodium and Potassium

Sodium and potassium were determined by flame photometry method. The instrument (photometry) was set up according to the manufacturer's instruction. 1 mL of the prepared potassium and sodium standard were aspirated into the machine and sprayed over the non-luminous butane gas flame. The sodium and potassium

emission (having been appropriately filtered) from the different concentration were recorded and made into standard curve. Subsequently, the optimal density emission was recorded from each of the sample against those in the curve. Thus using the curve was used to extrapolate the quantity of each (sodium and potassium) in the sample.

2.4.10. Determination of Phosphorus

The phosphorus in the sample was determined by the Vanado-molybdate (yellow) spectrometry. 1 mL extract from the sample was dispensed into the test tube. Similarly, the volume of the standard phosphorus solution as well as water was put into another test tube to serve as standard and blank respectively. The content of each tube were mixed with equal volume of Vanado-molybdate colour reagent. They were left to stand for 15 min at room temperature before their absorbance was measured in Jenway electronic spectrophotometer at wavelength of 420 nm. Measurements were taken with the blank at zero. Phosphorus content was given by the formula:

$$\text{mg/100gm} = \frac{100}{W} \text{ x } \frac{Au}{As} \text{ x C x } \frac{Vf}{Va}$$

Where: W= Weight of sample analyzed

Au= Absorbance of the test sample

As= Absorbance of standard solution

Vf= Total volume of filtrate

Va= Volume of filtrate analyzed

C= Concentration of the standard

2.4.11. Determination of Iron

The iron content of the sample was determined by spectrophotometric method by James [31]. 2 mL of the sample solution was pipetted into a flask before 3 mL buffer solution, 2 mL hydroquinine solution and 2 mL bipyridyl solution were added. The absorbance reading was taken at wavelength of 520 nm and the blank was used to zero the instrument. Also a standard solution of iron was prepared by dissolving 3.512 gm of Fe $(NH_4)_2(SO_4).6H_2O$ in water and 2 drops of 0.5 N HCl was added and diluted to 500 mL with distilled water. 3 mL buffer solution hydroquinone solution and 2 mL bipyridyl solution were also added. Absorbance reading was taken at 520 nm. The readings were extrapolated on a standard iron curve.

2.4.12. Determination of Iodine

This was determined by leucocrystal violet method by Black and Whittle [32]. 10 mL of the digested sample was measured into a test tube and 2 mL of citric buffer was added, then 1 mL of potassium peroxymonosulphate was added. The mixture was mixed and allowed to stand for 1 minute. 2 mL of leucocrystal violet indicator was added and was made up to 50 mL. This was allowed to stay for 5 min and the absorbance taken at 592 nm.

2.4.13. Determination of Vitamin B_1 (Thiamine)

Five grams of each of the samples was homogenized with 50 mL of ethanolic sodium hydracids and filtered into 100 mL flask. 10 mL of the filtrate was pipetted and colour development by the addition of 10 mL potassium dichromate was read at 31 nm wavelength in a spectrophotometer. A standard thiamine solution was prepared

and diluted. 10 mL of the solution was analyzed as discussed above. The readings were made with the reagent blank at zero and thiamine calculated as below:

$$\text{Thiamine (mg/100g)} = \frac{100}{W} \text{ x } \frac{Au}{As} \text{ x C x} \frac{Vf}{Va} \text{ x D}$$

Where: W= Weight of sample analyzed

Au= Absorbance of test sample

As= Absorbance of standard sample

Vf= Volume of filtrate

Va= Volume of filtrate analyzed

C= Concentration of the standard

D= Dilution factor where applicable

2.4.14. Determination of Vitamin B_2 (Riboflavin)

Five grams of each sample was extracted with 100mL of 50% ethanol solution for 1 h and filtered. 10 mL portion was treated with equal volume of 5% $KMnO_4$ solution and 10 mL of 30% hydrogen peroxide (H_2O_2). The mixture was allowed to stand on a steam bath for 30 min, after which 2 mL of Na_2SO_4 solution was added. It was diluted to 5 mL with distilled water and read at 510 nm wavelength. Meanwhile, a standard riboflavin solution was prepared and diluted and 10 mL portion of it was analyzed as discussed above. The readings were taken with the reagent blank at zero and riboflavin calculated as below:

$$\text{Thiamine (mg/100g)} = \frac{100}{W} \text{ x } \frac{Au}{As} \text{ x C x} \frac{Vf}{Va} \text{ x D}$$

Where: W= Weight of sample analyzed

Au= Absorbance of test sample

As= Absorbance of standard sample

Vf= Volume of filtrate

Va= Volume of filtrate analyzed

C= Concentration of the standard

D= Dilution factor where applicable

2.4.15. Determination of Vitamin B_3 (Niacin)

Five grams of the sample was treated with 50 mL of 1N H_2SO_4 and shaken for 30 min. 3 drops of ammonia solution was added to the sample and filtered into a 50 mL volumetric flask and 5 mL of potassium ferrocyanide was added. This was acidified with 5 mL of 0.02N sulphuric acid and absorbance was measured at 470 nm wavelength. A standard niacin solution was prepared and diluted. 10 mL of the solution was analyzed as discussed above. The readings were made with reagent blank at zero and niacin calculated as below:

$$\text{Niacin (mg/100gm)} = \frac{100}{W} \text{ x } \frac{Au}{As} \text{ x C x} \frac{Vf}{Va} \text{ x D}$$

Where: W= Weight of sample analyzed

Au= Absorbance of test sample

As= Absorbance of standard sample

Vf= Volume of filtrate

Va= Volume of filtrate analyzed

C= Concentration of the standard

D= Dilution factor where applicable

2.4.16. Determination of Vitamin C (Ascorbic Acid)

The method used was described by Okwu [33]. 10g of the sample was extracted with 50 mL EDTA/TCA extracting solution for 1 h and filtered through a Whatman filter paper into a 50 mL volumetric flask and made up to the mark with the extracting solution. 20mL of the extract was pipette into a 250 mL conical flask and 10 mL of 10% KI and 50 mL of water were added. This was titrated against 0.01 N $CuSO_4$ solution to a dark end point and Ascorbic acid was calculated as below:

$$\text{Ascorbic acid (mg/100gm)} = 0.88 \times \frac{100}{5} \times \frac{Vf}{20} \times \frac{T}{1}$$

Where: Vf = Volume of extract

T = Sample titre- Blank titre

2.4.17. Determination of Carotene

This was determined by using the method described by Maeko and Delia [34]. 5 gm of the test sample was first homogenized using acetone solution with the aid of pestle and mortar. The solution was filtered after crushing. The filtrate was then extracted with petroleum spirit using separate funnel. Two layers were obtained. The upper layer which contains carotene was washed very well with sodium sulphite in order to remove residual water. It was later poured out to the volumetric flask and made up to the mark.

The absorbance of the solution was read at 450 nm.

2.5. Statistical Analysis

The data was analyzed using descriptive statistics and presented as mean ± standard error of mean of three (3) determinants (mean± SEM) using the statistical software package (SPSS) for window version. Differences between means were separated using the analysis of variance (ANOVA) and multiple comparison tests. The proximate analysis was expressed in percentage (%) while the phytochemical, mineral and vitamin contents were expressed in g/100g.

3. Results

The results of the phytochemicals, proximate, mineral and vitamin contents are shown on the tables below. Table 1 shows the phytochemical composition of the ripe and unripe plantain. Plantain (both ripe and unripe) contains alkaloids, tannin, saponin, phenols and flavonoids. However, the presence of these bioactive agents is higher in the ripe than the unripe, except for tannin where the unripe (0.064±0.02) recorded a higher value than the ripe (0.040±.001). The statistical analysis showed a statistical difference between the ripe and unripe (*p-value* < 0.05).

Table 1. Phytochemical composition of unripe and ripe plantain.

Sample (mg/100g)	Alkaloids	Saponin	Phenols	Tannin	Flavonoids
Unripe	0.46±0.25	1.04±0.01	1.88±0.03	0.064±0.02	0.073±0.057
Ripe	1.47±0.02	1.17±0.02	2.47±0.02	0.04±0.001	0.83±0.01

P-value= 0.006, t= 2.571

The proximate composition of unripe and ripe plantain is shown in Table 2. Plantain has moisture, ash, fat, crude fibre, crude protein carbohydrate and sugar. As observed in the phytochemical contents, the ripe plantain is richer in proximate content than the unripe except in crude fibre and carbohydrate (starch) content. The statistical analysis showed there was no significant difference (*p-value* > 0.05).

Table 2. Proximate composition of unripe and ripe plantain.

Sample (%)	Moisture content	Ash	Crude fibre	Fat content	Crude protein	Carbohydrate content	Sugar
Unripe	50.21±0.29	1.49±0.035	0.84±0.1	0.61±6.15	3.24±0.0	46.02±2.13	1.85±0.0
Ripe	65.77±0.7	1.64±0.1	0.64±0.15	0.71±0.2	3.96±04	27.49±0.16	4.31±0.01

P-value= 0.05976, t= 0.591

The mineral contents of unripe and ripe plantain is shown in Table 3.The result revealed the presence of six (6) minerals which include calcium, magnesium, sodium, potassium, phosphorus and iron. The ripe is richer in mineral content than the unripe. The statistical result showed a significant difference between the two (*p-value* < 0.05).

Table 3. Mineral composition of unripe and ripe plantain.

Sample (mg/100g)	Calcium	Magnesium	Sodium	Potassium	Phosphorus	Iron
Unripe	23.38±0.03	12.80±0.1	8.58±0.125	20.38±0.025	13.30±0.07	2.18±0.02
Ripe	27.87±0.03	14.77±0.03	10.78±0.02	23.57±0,17	13.68±0.08	5.82±0.02

P-value= 0, t=8.436

The vitamin content of unripe and ripe plantain is shown in Table 4. Plantain is rich in vitamins with ripe having higher vitamin content than the unripe. The result revealed the presence of six (6) vitamins which include vitamin B1, B2, B3, C, E and carotene with the ripe being richer than the unripe. The statistical result showed a significant difference between the two (*p-value* < 0.05).

Table 4. Vitamin composition of unripe and ripe plantain.

Sample (mg/100g)	B_1	B_2	B_3	C	E	Carotene
Unripe	0.31±0.01	0.23±0.01	1.49±0.01	5.24±0.01	2.25±0.01	0.41±0.01
Ripe	0.41±0.15	0.27±0.0	1.53±0.01	8.37±0.07	4.14±0.02	0.67±0.35

P-value= 0.015, t=1.713

4. Discussion

In Nigeria and other parts of Africa and in many other places in the world, plantain (*Musa paradisiaca*) serves as a major staple food and is particularly desired for the variability in the stages of ripeness and in cooking methods. In this survey, the comparative study of unripe and ripe plantain was investigated. The phytochemical analysis showed the presence of alkaloids, tannins, saponoids, flevonoids and phenols. These compounds have various pharmacological and nutritional benefits. Although some of these bioactive agents occur in low quantities, saponin and phenols occur in appreciable quantities and were richer in the ripe than the unripe. This result agrees with the findings of Adeolu and Enesi [35] and Akinsanmi *et al* [36] who worked on bract and peels of plantain respectively.

The proximate composition showed ripe plantain is richer than the unripe. This result agrees with findings of Egbebi and Bademosi [23], where the ripe showed higher proximate values than the unripe. However, the carbohydrate in the unripe (46.02±2.13%) is higher than the ripe (27.49±0.16), while the sugar contents in unripe (1.85±0) is lower than that of the ripe (4.31±0.01). This report agrees with the findings of Zakpaa *et al* [16] and Egbebi *et al* [23]. This could be as a result of the decrease in the starch contents as the plantain ripens; which is due to the conversion of starch to sugar that leads to increase in the sugar contents of the ripe plantain. Unripe plantain is very high in starch which makes it useful in industrial production of starch. The ripe plantain on the other hand, is very high in sugar content and because of this; ripe plantain is not recommended for diabetic patients. High moisture content in ripe plantain results in storage problems, thereby limiting its usage in food industry.

Plantain is also rich in minerals and vitamins. The mineral contents include calcium, potassium, magnesium, phosphorus, sodium and iron. The presence of these minerals will play vital roles in the formation of strong bones and teeth, muscle action, blood clotting, proper heart function, cell metabolism and general growth [37-38]. The vitamin contents include thiamine (B_1), riboflavin (B_2), niacin (B_3), tocopherol (E) and carotene (vitamin precursor in plants). These vitamins, apart from helping in growth also play important roles in promoting resistance to diseases and delay in aging. B1, B2 and B3 are required for normal growth and heart function [39]. The mineral and vitamin contents are higher in ripe than the unripe and this agrees with findings of Cohen *et al* [40].

The significant variations that existed in the phytochemicals, proximate, mineral and vitamin contents of the fruit following ripening suggest that nutritional qualities of plantain fruits vary with the stage of ripeness. Other factors that could influence variations in nutritional composition of plantain include variety, cultivar, maturity, climate and geographical condition of production, handling during and post-harvest, processing and storage, species genotype, growing conditions and the interaction between genotype and environmental characteristics. All these directly influence the composition of the fruit.

5. Conclusion

Plantain is a nutritious food that is commonly consumed in Africa and other tropical zones of the world. It is rich in phytochemicals, proximate, mineral and vitamin contents. It could be consumed ripe or unripe. However, the results from this work have shown that ripe plantain has more nutritional values than unripe. Ripening increases the sugar content and thus unfit for diabetics.

6. Conflicts of Interest

The author(s) report(s) no conflict(s) of interest(s). The author along are responsible for content and writing of the paper.

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NA

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