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A study of the effects of induced ripening on the proximate, biochemical and mineral compositions of *Musa sapientum* (Banana)

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Abstract
The effects of ripening acceleration methods on the proximate, biochemical and mineral compositions of *Musa sapientum* (Banana) was carried out. A total of eighteen fruits were collected, three for each replica of the five treatments and then the three control samples. The fruits were cleaned and taken to the laboratory for further treatments**.** Each of the replica was subjected to the following treatments; Calcium carbide treatment, hot water treatment, dried plantain leaves treatment, smoked treatment and then polythene bag treatment. The control banana fruits were left in the open without any treatment whatsoever and allowed to undergo natural ripening which took about five to six days. For the statistical analysis, systems version 9.1 software package was used to statistically analyze the data obtained for all treatments. Significance of treatment means was tested at $P<0.05$ probability level using Duncan's New Multiple Range Test (DNMRT). The result of the study showed smoke treatment gave higher phosphorus (11.335±0.021), potassium (8.770±0.042), calcium (18.525±0.106), magnesium (18.525±0.106), Iron (2.140±0.000) and Sodium (6.150±0.042). For the biochemical composition of banana, the control treatment gave higher composition of TTA (0.078±0.000), plantain leaf treatment gave higher composition of Vitamin C (9.610±0.014) while smoke treatment gave higher composition of pH (5.700±0.000) and Reducing sugar (11.375±0.000). The effect of ripening acceleration method on the proximate composition of banana revealed that plantain leaf treatment gave higher percentage of ether extract (0.490±0.000); control gave higher percentage composition of dry matter (41.475±0.106), crude fibre (0.510±0.014) and carbohydrate (38.220±0.156) while smoke treatment gave higher percentage of moisture (64.790±0.014), ash (1.050±0.014) and crude protein (2.540±0.085). Whether fruit ripens on the plant or after harvest, the general changes associated with ripening process is softening of fruit, change in colour and development of characteristic aroma and flavour. There is also reduction in sourness and increase in sweetness of the fruit. Ripening in general is a physiological process which makes the fruit edible, palatable and nutritious. In nature fruits ripen after attainment of proper maturity by a sequence of physiological and biochemical events and the processes are irreversible.

Keywords:*Musa sapientum,* Plantain, Proximate, Biochemical, Mineral, Ripening.

Introduction

The word "banana" is said to have its roots in the Arabic word "banan" which means "finger" [1]. Banana is a general term embracing a number of species or cultivars in the genus *Musa* of the family *Musaceae*. Most edible fruited bananas are usually seedless and belong to the species *Musa acuminata*, *Musa sapientum*, *Musa cavendishi, Musa paradisiaca* etc. Other species include *Musa balbisianocolla*of southern Asia which bears a seeded fruit. *Musa basjoosieb*of Japan and *Musa ornate* from Pakistan are grown mainly as ornamental plants and for fibre. *Musa textiles Nee* of the Philippines is grown for its fibre and for making tissue thin tea bags. *Musa enseta Gmel* is cultivated in Ethiopia for fibre and for the foods derived from the young shoot, base of the stem and the corm [2]. Banana plant is an herb but is often mistaken for a tree because of its size and structure [1]. Banana fruit is technically a false berry made up of a peel (pericarp) and inner edible portion (mesocarp). The pericarp is usually glossy deep green, firm and sticks to the mesocarp when the fruit is unripe. When the fruit is ripe, the pericarp turns yellow, light green or dull green with black speckles. The pericarp of the unripe fruit sticks firmly to the mesocarp but peels off easily when the fruit is ripe. The flavor may be mild and sweet or sub acid with a distinct apple tone. Wild banana fruits are nearly filled with black hard round or angled seeds and have scant fleshy portion. The commonly cultivated and consumed domesticated types are generally seedless with just minute vestiges of ovules visible as brown speckles in slightly hollow or faintly pithy centre which is especially evident when the fruit is over ripe [1, 2]. Bananas are important food crops in the humid forest and mid altitude zones of sub-saharan Africa. It has been estimated that bananas provide nearly 60 million people in Africa with more than 200 calories (food energy) a day [3]. In tropical America and the Caribbean, bananas are of great nutritional and socio-economic significance generating considerable export earnings and employment. Bananas and plantains together constitute the fourth most important global food commodity after rice, wheat and maize in terms of gross production and consumption [4]. Banana flour is an important raw material in the confectionery industry and complementary infant food formulation in Nigeria [5]. Ripe banana fruit is utilized in a multiple of ways in the diet, from simply being peeled and eaten out of hand to being sliced and served in fruit drinks, and salads, sandwiches, custards etc. Banana fruits are also smashed and incorporated into ice cream, bread and cream pies. The fruit is used in making jam, sauce or jelly. Banana Puree is an important component of most infant food. Matured unripe banana fruits are boiled or baked and eaten with soups or stews; or the fruit

is thinly sliced and fried till crisp to make banana chips [1]. Eating ripe banana fruit is reported to help relief problems of constipation. Banana fruit is also used as the dietary food against intestinal disorders because of its soft texture and smoothness. Ripe banana fruit when eaten neutralize acidity and reduce irritation by coating the stomach lining [2].Banana leaves, being large, flexible and water proof are used in wrapping food for cooking or storage, and also for thatching. The fibre obtained from the pseudostem of banana is used for diverse purposes like fabrics, teabags, paper, shoe soles etc [2]. Although various studies have been carried out on banana fruit, most of these were on the mineral element concentration of the matured and ripe fruit. Hence, the aim of this study was to determine the effects of induced ripening method on the proximate, biochemical and mineral compositions of *Musa sapientum*.

Ripening is a natural process that brings a series of biochemical changes which are responsible for the change of color, pigment formation, starch breakdown, textural changes and aroma development and finally abscission of fruits [6]. Ripening is a process in fruits that causes them to become more palatable. In general, a fruit becomes sweeter, less green and softer as it ripens. Nutritional changes upon ripening are very complex and depend on a number of factors, including light and temperature. It is important to realise that this is occurring in the mature fruit tissue and very little phloem activity occurs in a mature fruit that can ripen off the plant. While the mature tissue may not be growing, it is still functioning biochemically. Various studies have shown that changes in cell pH by altered environmental condition affect the mineral, biochemical and proximate contents of plant since the vacuolar acidity influences the formation of the various chemical forms. For instance, in fruits the acid pH range of anthocyanins are predominantly present as red flavylium cation, and with rising pH mainly the colorless carbinol and the blue quinonoidal bases are synthesized leading to a scarlet color [7]. More so, in some fruits, mostly berries, high CO_2 concentrations (20 kPa) increased the pH due to the enhanced decomposition of organic acids [8]. The degradation of organic acids in altered environmental or physical conditions was also found in lettuce and fennel [8, 9]. Similar effects were documented for radish stored in modified atmosphere [10].

Materials and Method

Collection and Preparationof fruits

Unripe *Musa sapientum* (Banana) was collected in June, 2015 from Imo State. A total of eighteen fruits were collected, three for each replica of the five treatments and then the three control replica. The fruits were cleaned and taken to the laboratory for further treatments. Each of the banana fruit was subjected to the following treatments: three of the banana fruits was dipped into a Calcium carbide solution for about 60secs and wiped dry; the fruit was then placed on a newspaper and covered with a thin cotton cloth. Another three banana fruit was soaked in hot water (100°C) for 15mins; the fruit was wiped dry and covered with a thin cotton cloth. The third replica of banana fruit was placed on dried plantain leaves which were also spread over it. And then three other banana fruit was smoked for two days to induce ripening. The fifth replica of banana fruit was put in a Polythene bag and was tied for three to four days before it ripened. The control banana fruits were left in the open without any treatment whatsoever and allowed to undergo natural ripening which took about five to six days.

The fruit samples were washed and peeled, the fruits were sliced and the slices were used for the various analyses.

Statistical Analysis

The Statistical Analysis Systems version 9.1 software package was used to statistically analyze the data obtained for all treatments. Significance of treatment means was tested at $P < 0.05$ probability level using Duncan's New Multiple Range Test (DNMRT).

Determination of Fat Content (lipids)

Continuous Solvent Extraction Gravimetric Method using Soxhlet Apparatus as described by [11] was used to determine the fat content in the plant sample. About 5.0g of each sample was wrapped in a porous paper (Whatman NO 45 Filter paper) the wrapped sample was put in a soxhlet flask containing 200ml of petroleum ether. The upper end of the reflux flask was conducted to a condenser. By heating the flask through electro-thermal heater, the solvent vaporized and condensed into the flux flask such that the wrapped sample was completely immersed in the solvent and remained in contact with it until the flask filled up and siphoned over thus carrying oil extract from the sample down to the boiling flask. The defatted sample was removed and reserved for crude fibre analysis. The solvent was recovered and the extraction flask with its oil content was dried in the oven at 60ºC for 3mins so as to remove any residual solvent. After cooling in a dessicator, the flask was reweighed. By difference, the weight of fat (oil) extracted was determined and expressed as a percentage of the sample weight. It was calculated as:

$$\% \, fat \; = \frac{\mathrm{W1} - W2}{sample \; wt} x \frac{100}{1}$$

Determination of Crude Fibre

The Wended Method described by [12] was used for the determination of the crude fiber content. A measured weight of the defatted sample 5g from the fat analysis was boiled under reflux for 30mins. After that, the samples were washed with several portions of hot boiling water using a two-fold muslin cloth to trap the particles. The washed samples were carefully transferred quantitatively back to the flask and 20mls of 1.25% sodium hydroxide (NaOH) solution was added to it. Again, the samples were transferred to a weighed porcelain crucible and dried in an oven at 105ºC for 3hours after cooling in a dessicator, they were reweighed (W2) and then put in a muffle furnace and incinerated at 550ºC for 2hours (until they turned into ash), again they were cooled in a dessicator and weighed. The crude fibre content was calculated gravimetrically as:

% crude fibre = $\frac{w1-w3}{w2} x \frac{100}{1}$

Where

W1 = weight of sample analyzed

W2= weight of crucible and sample after boiling and drying

W3 = weighed of crucible and sample after ashing

Determination of Total Ash

Furnace Incineration Gravimetric Method described by [12] was used to estimate the total ash content. A measured weight of

the sample was put in a previously weighed porcelain crucible and allowed to incinerate in a muffle furnace at 550ºC until only ash content was left of it. The crucible and its ash content was cooled in a dessicator and then weighed, total ash was given by the formula.

$$\% \text{ Ash} = \frac{W3}{w2} - \frac{W1}{w1} x \frac{100}{1}$$

Determination of Moisture Content

The moisture content was determined gravimetrically as described by [13]. A five gram 5.0g weight of each sample was weight of each was weighed into a pre-weighed moisture can, each can with its sample content were dried in the oven at 105ºC for 3 hours in the first instance. It was cooled in dessicator and reweighed. The weight was recorded while the sample was returned to the oven and dried further. The drying, cooling and weighing was continued repeatedly until a constant weight was obtained. The weight of moisture lost was determined by difference and expressed as a percentage. It was calculated as

$$\% \text{ moisture} = \frac{W2}{w2} - \frac{W3}{w1} x \frac{100}{1}$$

%dry matter = 100- % moisture content

Determination of Carbohydrate

The carbohydrate content was determined by calculating the difference of Nitrogen Free Extractive (NFE). It was given as the difference between 100 and a sum total of the other proximate components. Hence it was calculated using the formula below:

% CHO= 100-% (Protein + Fat + Fibre + Ash + Moisture content).

Determination of protein

Semi-micro Kjedahl method was used for the protein determination. A measured weight of the test sample 2g was mixed with 10ml of conc. H_2SO_4 in a Kjedahl digestion stand in addition to a tablet of selenium catalyst and heated strongly under a film cupboard as the digestion process. A reagent blank was digested as well but without any sample. All digest were carefully diluted with distilled water and transferred quantitatively to a 100ml volume flask and made up to mark with distilled water. An aliquot 10ml of the digest was mixed with equal volume 10ml of 45% NaOH solution in a machine distillation apparatus. The mixture was distilled and the distillate connected into 10ml of 4% boric acid solution containing three drops of mixed indicator solution (methyl red and bromocressol green), a total of 50ml of distillate was collected and titrated against 0.02N H_2SO_4 solution. The end point was marked by a colour change from green to deep red colour both the sample and the reagent blank digest were distilled and titrated. The formula below was used to calculate the nitrogen and protein content

$$\% \, protein \; = \; \% \, N_2 x \; 6.25$$

$$\% \, N_2 = \frac{100}{w} x \frac{14 \, xN}{1000} xvdxt - b$$

Where:

W= weight of sample analyzed
N= Normality (conc) of titration (0.02-H_2SO_4)
VD= total volume of digest
Va = volume of digest analyzed
T= titre value of sample
B= Titre value of blank

Mineral Content Determination

The mineral content of the test samples were determined by the dry ash extraction method. Here 2.0g of the samples were burnt to ashes in a furnace (as in ash determination) the resulting ash was dissolved in 100ml of dilute hydrochloric acid and then diluted to 100ml in a volumetric flask using distilled water. The digest obtained was used for the various analyses.

Determination of Phosphorus

Phosphorus in the samples was determined by using the vanado-mohybdate (yellow) spectrometry described by [14]. 1ml extract from each sample was dispensed into a test tube, similarly the same volume of standard phosphorus solution as well as standard and blank respectively. The content of each tube was mixed with equal volume of the vanado-molybdate for 15 minutes at room temperature before their absorbance was taken in Jenway electronic spectrophotometer at wavelength of 420nm. Measurement was given with the blank at zero.

$$\text{Phosphorus} = \frac{100}{W} x \frac{AU}{AS} \text{ x C x } \frac{VF}{VA}$$

Where:

W	=	Weight of sample analyzed
AU	=	Absorbance of test sample
AS	=	Absorbance of standard solution
VF	=	Total volume of filtrate
VA	=	Volume of filtrate analyzed
C	=	Total volume of extract

Determination of Calcium and Magnesium

This method was described by [15] calcium and magnesium content of the test samples was determined by the versanale EDTA complexiometric titration.20ml of each extract was dispersed into a conical flask; pinches of the masking agent's hydroxyl tannin, hydrochlorate, potassium cyanide were added followed by 20ml of ammonia indicator solution pH 10.0. The pinch of the indicator-Erichrome black was added and the mixture was shaken very well, it was titrated against 0.02N of EDTA solution titration was from a mauve colour to a permanent blue colouration. A reagent blank consisting of 20ml distilled water was also treated as described above. The titration gave a reading for combined Ca and Mg complexes in samples. A separate titration was then conducted for calcium alone. Titration for calcium alone was a repeat of the previous one with slight change 10% NaOH solution at pH 12.0 was used in place of the ammonia buffer while solchrome dark blue (calcon) was used as indicator in place of erichrome black. Calcium and magnesium contents were calculated separately using the formula below.

$$\% \text{ calcium or magnesium} = \frac{100}{W} \text{ x EW x } \frac{N}{100} \text{ x } \frac{VF}{VA}$$

Where:

W	=	Weight of sample analyzed
EW	=	Equivalent weight

VF = Total volume of extract
N = Normality of EDTA = 0.02n
VA = Volume of extract titrated
T = Titer value less blank.

Determination of Potassium and Sodium

Method of [16] was used potassium and sodium in the samples was determined by flame photometry. The instrument was set up according to the manufacturer's instruction. The equipment was turned on and allowed to stay for about 10miuntes. The gas and air lets were opened as the start knob was turned on. The equipment being self-igniting and the flame was adjusted to a non-luminous level (i.e. blue colour flame). Meanwhile, standard K and Na solutions were prepared separately and each was diluted to concentration and each was diluted to concentration of 2,4,6,8 and 10ppm respectively. When analyzing for specified element say k, the appropriate filter was selected and the instrument flushed with distilled water. The highest concentrated standard solutions were put in place and the reading adjusted to 100ml. Thereafter, starting with least concentration i. e. 2ppm, all the standard solutions were sucked into the instrument and caused to spray over the non-luminous flame. The readings were recorded and later plotted into a standard curve used to extrapolate the k level in the sample. After the standard, the sample digest were carefully siphoned in turns into the instrument, their readings recorded. The samples were repeated with sodium (Na) standard and the place of the k filter. The concentration of the test mineral in the sample was calculated and obtained as follows:

$$\text{Mkmg/100g} = \frac{100}{W} \times \frac{VT}{1} \times \frac{N}{10^5} \times X \times D$$

Where:
W = Weight of sample used
Vt = Total extract volume since 1m was siphoned into the instrument.
X = Concentration from the graph
D = Dilution factor where applicable similarly.

For sodium concentration it was given:

$$\text{Kmg/100g} = \frac{100}{W} \times \frac{VT}{1} \times \frac{N}{10^5} \times D$$

Determination of Vitamin C

About 0.5g of the sample was weighted macerated with 10mls of 0.4% oxalic acid in a test thefor 10mins, centrifuged for 5mins and the solution filtered. 1ml of the filtrate was duplicates, 9mls of 2, 6- dichlorephenol-indophenols was added and absorbance was taken at 15sec and 30sec interval at 520nm.

Determination of pH Value

For the pH value, method by [16] was used. Measurement of the electrode potential between glass and reference electrodes was done; pH meter was standardized using standard pH buffer.

Determination of Total Titratable Acid

Total titratable acid was determined using standard methods by [16]. A known weight of sample was diluted with neutralized water and titrates to just before end point with 0.1N alkali, using 0.3 ml phenolphthalein for each 100 ml solution being titrated. Measured volume 2-3 ml of solution was transferred into about 20 ml of neutral water in small beaker.Extra diluted solution was poured back into original solution to make up to end point; more alkali was added and titration was continued to end point. By comparing dilutions in small beakers differences produced by a few drops of 1.0N alkali can be easily observed and readings were taken.

Determination of Reducing Sugar

Exactly 25 ml of filtrate was titrated with mixed Fehling A and B solution using Lane and Eynon volumetric method. Inversion was carried out at room temperature. Also 50 ml aliquot clarified and deleaded solution was transferred to a 100 ml volumetric flask and 10 ml HCl was added and let to stand at room temperature for 24 hours. The sample was neutralized exactly with conc. NaOH solution using phenolphthalein and dilute to 100 ml. It was later titrated against mixed Fehling A and B solution to determine total sugar as invert sugar.

$$\text{Reducing sugar (\%)} = \frac{\text{Mg. of invert sugar x Vol. made up x100}}{\text{TR x Wt. of sample x 1000}}$$

Result

Table 1: Proximate analysis of Banana

Treatment	Moisture content	Dry matter	Ash	Crude fibre	Ether extract	Crude protein	Carbohydrate
Plantain leaf	63.770±0.042^{b}	26.280±0.113^{e}	0.950±0.000^{b}	0.480±0.000^{b}	0.490±0.000^{a}	2.380±0.028^{b}	31.930±0.071^{d}
C.Carbide	63.795±0.078^{b}	36.205±0.078^{c}	0.920±0.000^{c}	0.450±0.000^{c}	0.420±0.000^{c}	1.960±0.028^{d}	32.455±0.049^{c}
Hot water	62.375±0.106^{c}	37.625±0.106^{b}	0.900±0.000^{c}	0.420±0.000^{d}	0.390±0.000^{d}	1.850±0.000^{e}	34.065±0.106^{b}
Poly bag	64.780±0.028^{a}	35.220±0.028^{d}	0.940±0.014^{b}	0.460±0.000^{c}	0.400±0.000^{d}	2.130±0.014^{c}	31.290±0.057^{e}
Control	58.525±0.106^{d}	41.475±0.106^{a}	0.905±0.021^{c}	0.510±0.014^{a}	0.390±0.014^{d}	1.450±0.000^{f}	38.220±0.156^{a}
Smoke	64.790±0.014^{a}	35.210±0.014^{d}	1.050±0.014^{a}	0.480±0.014^{b}	0.450±0.000^{b}	2.540±0.085^{a}	30.690±0.127^{f}
p-value	**	**	**	**	**	**	**

** $p<0.05$, column followed by the same letter are not significantly difference

The effect of ripening acceleration method on the proximate composition of banana revealed that plantain leaf treatment gave higher percentage of ether extract (0.490±0.000); control gave higher percentage composition of dry matter (41.475±0.106), crude fibre (0.510±0.014) and carbohydrate (38.220±0.156) while smoke treatment gave higher percentage of moisture (64.790±0.014), ash (1.050±0.014) and crude protein (2.540±0.085). There is significant difference in the percentage composition of the moisture content, dry matter, ash, crude fibre, ether extract, crude protein and carbohydrate of the plantain between treatment ($p<0.05$).

Table 2: Biochemical composition of Banana

Treatment	TTA	pH	Reducing sugar	Vitamin C
C. Carbide	0.062±0.000[b]	5.610±0.014[e]	9.810±0.014[c]	8.540±0.085[c]
Hot water	0.075±0.000[e]	5.360±0.000[b]	8.610±0.014[e]	8.420±0.000[c]
Poly bag	0.065±0.000[d]	5.410±0.014[a]	8.775±0.035[d]	9.380±0.028[b]
Control	0.078±0.000[f]	5.310±0.014[c]	5.395±0.078[f]	5.720±0.170[d]
Plantain leaf	0.070±0.000[c]	5.450±0.000[d]	10.540±0.085[b]	9.610±0.014[a]
Smoke	0.059±0.000[a]	5.700±0.000[f]	11.375±0.000[a]	9.225±0.035[b]
p-value	**	**	**	**

** $p<0.05$, column followed by the same letter are not significantly difference.

The effect of ripening acceleration method on the biochemical composition of banana revealed that control treatment gave higher composition of TTA (0.078±0.000), plantain leaf treatment gave higher composition of Vitamin C (9.610±0.014) while smoke treatment gave composition of pH (5.700±0.000), and Reducing sugar (11.375±0.000) There is significant difference in the percentage composition of the TTA, pH, Reducing sugar, Vitamin C of the Banana between treatment ($p<0.05$).

Table 3: Mineral composition of Banana

Treatment	**Phosphorus**	**Potassium**	**Calcium**	**Magnesium**	**Iron**	**Sodium**
C. Carbide	10.525±0.106[c]	8.190±0.014[c]	16.710±0.014[c]	16.710±0.014[c]	1.835±0.021[c]	5.710±0.042[c]
Hot water	9.450±0.000[e]	7.250±0.000[e]	16.850±0.014[c]	16.850±0.014[c]	1.790±0.014[d]	4.870±0.071[e]
Poly bag	9.820±0.028[d]	7.325±0.035[d]	16.615±0.233[c]	16.615±0.233[c]	1.790±0.014[d]	5.960±0.000[b]
Control	9.310±0.014[f]	7.170±0.014[e]	16.660±0.198[c]	16.660±0.198[c]	1.640±0.014[e]	5.780±0.028[c]
Plantain leaf	10.750±0.042[b]	8.320±0.113[b]	17.525±0.106[b]	17.525±0.106[b]	1.940±0.028[b]	5.340±0.085[d]
Smoke	11.335±0.021[a]	8.770±0.042[a]	18.525±0.106[a]	18.525±0.106[a]	2.140±0.000[a]	6.150±0.042[a]
p-value	**	**	**	**	**	**

** $p<0.05$, column followed by the same letter are not significantly difference.

The effect of ripening acceleration method on the mineral composition of Banana revealed that smoke treatment gave higher phosphorus (11.335±0.021), potassium (8.770±0.042), calcium (18.525±0.106), magnesium (18.525±0.106), Iron (2.140±0.000) and Sodium (6.150±0.042).There is significant difference in composition of the Phosphorus, Potassium, Calcium, Magnesium, Iron, Sodium of the Banana between treatment ($p<0.05$)

Discussion

Ripening is a natural process that brings a series of biochemical changes which are responsible for the change of color, pigment formation, starch breakdown, textural changes and aroma development and finally abscission of fruits [6]. It has been suggested that during storage, fruit utilize organic acids for metabolic activities and resulted in decrease in the titratable acidity. Various organic acids have been reported in fruits and which included citric, malic, acetic, fumaric, tartaric and lactic acids [17, 18] reported that a slow decrease in acidity, with increased total soluble solids and total sugar content is an intrinsic process during ripening of fruits to impart the flavor.

Effect of ripening acceleration methods on the proximate, biochemical and mineral composition of banana was shown in Table 1, Table 2 and Table 3 respectively. Moisture content was high in all the samples which are in agreement with values obtained by [19] where the moisture level of most fresh fruits was in the range of 75-90%. Plantain leaf treatment gave higher percentage of ether extract; the control gave higher percentage composition of dry matter, crude fibre and carbohydrate while smoke treatment gave higher percentage of moisture, ash and crude protein. The relatively high content of these nutrients explains why *Musa sapientum* is taken as staple in some communities [2, 20] reported higher values for crude protein in *Musa parasidiaca*fruits. Thus, the crude protein in *Musa parasidiaca*is higher than that in *Musa sapeintum*. Also, [20] gave higher ash values for *Musa paradisiaca.*

Table 2 showed the composition of biochemicals in the banana ripened by induced methods. The results indicated that the vitamins were relatively high in the ripened *Musasapientum*. This result indicated that banana fruit is likely to be a good source of ascorbic acid and folic acid, given the average recommended daily intake for the acids to be 400 µg/day [21, 22]. [22, 23] gave the recommended daily intake for ascorbic acid to be 90 mg per day for an adult. Various studies have shown that changes in cell pH by altered physical conditions affect the mineral, biochemical and proximate contents of plant since the vacuolar acidity influences the formation of the various chemical forms. For instance, in fruits the acid pH range of anthocyanins are predominantly present as red flavylium cation, and with rising pH mainly the colorless carbinol and the blue quinonoidal bases are synthesized leading to a scarlet color [7]. More so, in some fruits like tomatoes, high CO_2 concentrations (above 20 kPa) increased the pH due to the enhanced decomposition of organic acids [8]. The degradation of organic acids in altered physical conditions was also found in lettuce and fennel [8, 9]. Similar effects were documented for radish stored in modified atmosphere [10]. In pomegranates, [24] also found reduced pigment levels with rising CO_2 concentrations (10 and 20 kPa), which were correlated with decreased phenylalanine ammonia-lyase activity.

Table 3 showing the effect of ripening acceleration method on the mineral composition of Banana revealed that smoke treatment gave higher phosphorus, potassium, calcium, magnesium, Iron and Sodium. Calcium and phosphorus are very important in the formation of strong bones and teeth, for growth, blood clotting, heart function and cell metabolism [25, 26]. Potassium is an important raw material in soap production and in soil neutralization [27]. Being rich in macrominerals, it can also be formulated into instant flours for convalescence and in the formulation of baby foods as these categories of humans require high levels of minerals for growth and repair.

Conclusion

The effectiveness of accelerated treatments on ripening has been used only on the quality maintenance of harvested fruit. However, with increasing consumer interest in foods that promote health, attention has shifted from quality maintenance to quality assurance with particular emphasis on the enhancement of health-promoting biochemicals and nutients. Therefore, to obtain fruit enriched with nutrients, induced ripening treatments might be used either singularly or in combination to elicit the desired effect. To ensure an efficient and consumer-oriented supply chain, these ripening acceleration treatments should be coordinated with crop management strategies. Such nutrient enriched fruit could be served as fresh products or used as raw material for functional foods and supplements and would act as a complementary or synergistic strategy to human nutrition programs and nutrition policy for enhancing the consumption of health friendly fruit.

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