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Effects of Induced Ripening on the Proximate, Biochemical and Mineral Compositions of *Carica papaya* (Pawpaw Fruit)

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Authors' contributions

This work was carried out in collaboration between all authors. Author CFI designed the study, wrote the protocol, managed the analyses of the study and wrote the first draft of the manuscript. Authors EEA and RNA carried out the laboratory work. Authors NCO, CON and CFI performed the statistical analysis, wrote the final draft and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The effects of ripening acceleration methods on the proximate, biochemical and mineral compositions of *Carica papaya* (Pawpaw) was carried out. 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 replica of the fruits was subjected to the following treatments respectively: Dipped into a Calcium carbide solution for about 60 secs; soaked in hot water (100℃) for 15 mins; placed on dr ied plantain leaves which were also spread over it to completely cover it; and then smoked for two days to induce ripening; the last replica was put in a Polythene bag and was tied for three to four days to accelerate ripening. The control pawpaw fruits were left in the open at room temperature without any treatment whatsoever and

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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. The result of the study showed that hot water treatment gave higher percentage of moisture (90.840±0.100); the control gave higher dry matter (14.680±0.113) and carbohydrate (13.435±0.134), while smoke treatment gave higher vitamin C (46.520±0.255), phosphorus (16.810±0.014), calcium (33.625±0.247), magnesium (13.625±0.247) iron (0.850±0.014) and sodium (9.525±0.106). And then poly bag treatment gave higher TTA (0.160±0.011), Plantain leaf treatment gave higher pH (5.060±0.068), reducing sugar (27.960±0.23) and Vitamin C (43.795±0.4). While calcium carbide treatment gave higher potassium composition (24.780±0.028). There was significant difference in the percentage composition of moisture content, dry matter, ash, crude fibre, ether extract, crude protein and carbohydrate of the pawpaw fruit between fruit ripening ($p<0.05$). There is also significant difference in the TTA, pH, vitamin C of the pawpaw fruit between treatment ($p<0.05$). There is significant difference in the composition of phosphorus, potassium, calcium, magnesium, iron, sodium of the pawpaw fruit between treatments ($p<0.05$).

Keywords: Carica papaya; pawpaw; proximate; biochemical; mineral; ripening.

1. INTRODUCTION

Carica papaya commonly known as pawpaw belongs to the genus *Carica*. It is native to the tropics of American and was first cultivated in Mexico [1,2]. *Carica papaya* contains the enzyme papain, which is present in the fruits, stem and leaves [3]. Meat can be tenderized by wrapping it in a papaya leaf before cooking. It contains biologically active compounds such as chymopain and papain which aids in digestion [4,5]. Hasheen [5] points out that *Carica papaya* is a large, tree-like plant with a single stem growing from 5 to 10 m [16 to 33 ft] tall, with spirally arranged leaves confined to the top of the trunk. The lower truck is conspicuously scarred where leaves and fruit were borne. The leaves are large, 50-70 cm, [20-28 inches] in diameter, deeply and palmately lobed with seven lobes. Practically, every part of *Carica papaya* is of economic value ranging from nutritional to medicinal uses. The fruits are popularly processed into juice and wine, while some people cook the fruits as vegetable [6]. The seeds are medically important in the treatment of sickle cell diseases and poisoning related disorder. The leaf tea or extract has been implicated as a tumor destroying agent [1]. The fresh green tea is an antiseptic whilst, the brown dried pawpaw leaves are best served as a tonic and blood purifier [7]. Due to its antioxidant and fiber contents, it is therefore, used in the treatments of digestion and other ailments such as chronic indigestion, overweight, obesity and high blood pressure and weakening of the heart [1].

Ripening is a process in fruits that brings about their becoming more palatable. Generally, a fruit becomes sweeter, less green and softer as it ripens. Fruits therefore, play a vital role in nutrition and they are rich source of vitamins, mineral, dietary fibers, different important carotenoid (lycopene, beta- carotene, xanthophylls etc.), flavonoids, phenol and other phytochemical [8,9,10]. Apart from regular consumption, different kinds of fruits have various processing approaches for varying applications. Fleshy fruits like pawpaw, apple, peach, pear, pineapple, watermelon and mango are commercially valuable as human food, eaten both fresh and processed. Fruits are also used in the production of foods like Cookies, Muffins, yogurt, Salad, Ice Cream etc. Unfortunately, consumption of fruits is not as high as it is supposed to be because of unavailability during off season and inadequate post-harvest preservation. Fruits are generally expensive because of the post-harvest spoilage of fruits in supply cycle and expensive preservation procedure. Most people in the fruit business are not familiar with effective methods or techniques of food preservation that can contribute towards better post-harvest management, less spoilage and preservation of the nutritional value. 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 [11]. Therefore, this study was conducted to determine the effects of induced ripening method on the proximate, biochemical and mineral compositions of *Carica papaya*.

2. MATERIALS AND METHODS USED IN THE STUDY

2.1 Collection and Preparation of Fruits

Unripe *Carica papaya* (Pawpaw) was collected from a village in Orlu locality of 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 pawpaw fruits was subjected to the following treatments: Three of the pawpaw fruits were dipped into a Calcium carbide solution for about 60 secs and wiped dry; the fruit was then placed on a newspaper and covered with a thin cotton cloth. Another replica of pawpaw fruit was soaked in hot water (100℃) for 15 mins; the fruit was wiped dry and covered with a thin cotton cloth. The third replica of pawpaw fruit was placed on dried plantain leaves which were also spread over it to completely cover it. And then three other pawpaw fruit was smoked for two days to induce ripening. The fifth replica of pawpaw fruit was put in a Polythene bag and was tied for three to four days to accelerate ripening. The control pawpaw fruits were left in the open at room temperature 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.

2.2 Proximate Analyses

2.2.1 Determination of fat content (lipids)

Continuous Solvent Extraction Gravimetric Method using Soxhlet Apparatus as described by [12] was used to determine the fat content in the plant sample. About 5.0 g of each sample was wrapped in a porous paper (Whatman NO 45 Filter paper) the wrapped sample was put in a soxhlet flask containing 200 ml 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 60℃ for 3 mins 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:

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

2.2.2 Determination of crude fibre

The Wended Method described by Hunter Laboratory Manual [13] was used for the determination of the crude fiber content. A measured weight of the defatted sample 5 g from the fat analysis was boiled under reflux for 30 mins. 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 20 ml 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 105℃ for 3 hours after cooling in a desiccator, they were reweighed (W2) and then put in a muffle furnace and incinerated at 550℃ for 2 hours (until they turned into ash), again they were cooled in a desiccator and weighed. The crude fibre content was calculated gravimetrically as:

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

Where

W1 = weight of sample analyzed
W2 = weight of crucible and sample after boiling and drying
W3 = weighed of crucible and sample after ashing

2.2.3 Determination of total ash

Furnace Incineration Gravimetric Method described by Hunter Laboratory Manual [13] 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 550℃ until only ash content was left of it. The crucible and its ash content was cooled in a desiccator and then weighed, total ash was given by the formula.

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

2.2.4 Determination of moisture content

The moisture content was determined gravimetrically as described by Hunter Laboratory Manual [13]. A 5.0 g weight of each sample was weight was weighed into a pre-

weighed moisture can, each can with its sample content were dried in the oven at 105℃ for 3 hours in the first instance. It was cooled in desiccators 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

2.2.5 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).

2.2.6 Determination of protein

Semi-micro Kjedahl method was used for the protein determination. A measured weight of 2 g of the test sample was mixed with 10 ml 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 100 ml volume flask and made up to mark with distilled water. An aliquot 10 ml of the digest was mixed with equal volume 10 ml of 45% NaOH solution in a machine distillation apparatus. The mixture was distilled and the distillate connected into 10 ml of 4% boric acid solution containing three drops of mixed indicator solution (methyl red and bromocressol green), a total of 50 ml of distillate was collected and titrated against 0.02 N 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

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

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

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

2.3 Mineral Content Determination

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

2.3.1 Determination of phosphorus

Phosphorus in the samples was determined by using the vanado-mohybdate (yellow) spectrometry described by James [14]. 1 ml 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 420 nm. Measurement was given with the blank at zero.

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

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

2.3.2 Determination of calcium and magnesium

This method was described by James [14] calcium and magnesium content of the test samples was determined by the versanale EDTA complexometric titration. 20 ml of each extract was dispersed into a conical flask; pinches of the

masking agent's hydroxyl tannin, hydrochlorate, potassium cyanide were added followed by 20 ml 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 0.02 N of EDTA solution titration was from a mauve colour to a permanent blue colouration. A reagent blank consisting of 20 ml 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.

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

Where:

W = Weight of sample analyzed
EW = Equivalent weight
VF = Total volume of extract
N = Normality of EDTA = 0.02 n
VA = Volume of extract titrated
T = Titer value less blank.

2.3.3 Determination of potassium and sodium

Method of Pearson [15] 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 10 minutes. The gas and air lets were opened as the start knob was turned on. The equipment being self-igniting and the flame were 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 10 ppm 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 100 ml. Thereafter, starting with least concentration i.e. 2 ppm, 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:

$$Na/100 \text{ g} = \frac{100}{W} \; x \; \frac{VT}{1} x \frac{N}{10^5} \; x \; X \; x \; D$$

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:

$$K/100 \text{ g} = \frac{100}{W} \; x \; \frac{VT}{1} x \frac{N}{10^5} \; x \; D$$

2.4 Biochemical Content Determination

2.4.1 Determination of vitamin C

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

2.4.2 Determination of pH Value

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

2.4.3 Determination of total titratable acid (TTA)

Total titratable acid was determined using standard methods by AOAC [16]. A known weight of sample was diluted with neutralized water and titrates to just before end point with 0.1

N 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 1.0 N alkali can be easily observed and readings were taken.

2.4.4 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.

Reducing sugar (%) = (Mg. of invert sugar x Vol. made up / TR x Wt. of sample x 1000) x 100

2.5 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).

3. RESULTS

3.1 Proximate Analysis of Pawpaw

The effect of different ripening acceleration method on the proximate composition of pawpaw revealed that hot water treatment gave higher percentage composition of moisture (90.840±0.100), control has higher percentage composition of dry matter (14.680±0.113), carbohydrate (13.435±0.134), while smoke treatment gave higher percentage composition of ash (0.380±0.024), crude fibre (0.600±0.032), ether extract (0.285 ± 0.021), and crude protein (0.450±0.015). There is significant difference in the percentage composition of moisture content, dry matter, ash, crude fibre, ether extract, crude protein and carbohydrate of the pawpaw fruit between fruit ripening ($p<0.05$).

3.2 Biochemical Composition Pawpaw

The effect of different ripening acceleration method on the biochemical composition of Pawpaw revealed that Poly bag treatment gave higher TTA (0.160±0.018), while plantain leaf treatment gave higher pH (5.060±0.068) Reducing sugar (27.960±0.23) and Vitamin C (43.795±0.50). There is significant difference in the TTA, pH and Vitamin C of the pawpaw fruit between treatments ($p<0.05$).

3.3 Mineral Composition of Pawpaw

The effect of different ripening acceleration method on the mineral composition of Pawpaw revealed that Calcium carbide treatment gave higher Potassium (24.780±0.028), while smoke treatment gave higher Phosphorus (16.810±0.014), Calcium (33.625±0.247), Magnesium (13.625±0.247) Iron (0.850±0.014) and Sodium (9.525±0.106). There is significant difference in the composition of Phosphorus, Potassium, Calcium, Magnesium, Iron, Sodium of the pawpaw fruit between treatments ($p<0.05$).

4. DISCUSSION

The effect of different ripening acceleration method on the proximate composition of pawpaw revealed that hot water treatment gave higher percentage composition of moisture. The moisture content of fruits and their processed products provides an indication of their freshness and shelf life, also high moisture content exposes food items to increased microbial spoilage and short shelf life, which can lead to its deterioration [17]. The control sample had higher percentage composition of dry matter and carbohydrate; however, previous study showed that the carbohydrate content was found to be decreased in the fully ripe papaya which is not in agreement with the present study [18]. While smoke treatment gave higher percentage composition of ash, crude fibre, ether extract and crude protein. Increase in crude protein during ripening in ripe papaya is attributed to the increase of the conversion of enzymes or protein synthesis. It has been reported that protein synthesis is required for the ripening of fruits [18]. Also, the high value of ash content suggests that pawpaw would provide essentials minerals to the body.

Table 1. Proximate analysis of pawpaw

Treatment	Moisture content	Dry matter	Ash	Crude fibre	Ether extract	Crude protein	Carbohydrate
Plantain leaf	90.660±0.576^{a}	9.340±0.057^{d}	0.350±0.020^{b}	0.420±0.006^{c}	0.280±0.028^{b}	0.420±0.016^{b}	7.870±0.085^{c}
C. carbide	90.660±0.198^{a}	9.340±0.198^{d}	0.335±0.021^{c}	0.410±0.014^{c}	0.200±0.020^{a}	0.410±0.014^{c}	7.885±0.247^{c}
Hot water	90.840±0.100^{a}	9.160±0.024^{d}	0.310±0.014^{d}	0.390±0.014^{d}	0.250±0.021^{c}	0.390±0.014^{c}	7.820±0.042^{c}
Poly bag	88.280±0.150^{a}	10.220±0.028^{b}	0.346±0.020^{c}	0.440±0.014^{b}	0.280±0.022^{b}	0.440±0.014^{b}	10.214±0.198^{b}
Control	85.320±0.113^{c}	14.680±0.113^{a}	0.280±0.021^{d}	0.365±0.021^{d}	0.240±0.024^{c}	0.360±0.012^{d}	13.435±0.134^{a}
Smoke	90.525±0.106^{b}	9.475±0.106^{c}	0.380±0.024^{a}	0.600±0.032^{a}	0.285±0.021^{b}	0.450±0.015^{a}	7.760±0.127^{c}
p-value	**	**	**	**	**	**	**

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

Table 2. Biochemical composition pawpaw

Treatment	TTA	pH	Reducing sugar	Vitamin C
C. carbide	0.150±0.016[a]	4.380±0.054[d]	10.780±0.057[a]	41.780±0.40[c]
Hot water	0.120±0.014[b]	4.760±0.057[b]	10.660±0.057[a]	40.360±0.40[d]
Poly bag	0.160±0.018[a]	4.350±0.052[d]	8.590±0.056[a]	35.320±0.20[e]
Control	0.090±0.010c	5.040±0.068[a]	11.325±0.10[a]	42.570±0.30[b]
Plantain leaf	0.090±0.010[c]	5.060±0.068[a]	27.960±0.23[a]	43.795±0.50[a]
Smoke	0.130±0.015[b]	4.560±0.057[c]	9.790±0.014[a]	41.720±0.40[c]
p-value	**	**	Ns	**

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

Table 3. Mineral composition of pawpaw

Treatment	Phosphorus	Potassium	Calcium	Magnesium	Iron	Sodium
C. carbide	14.310±0.042[b]	24.780±0.028[a]	30.365±0.120[d]	11.225±0.035[c]	0.750±0.014[b]	7.810±0.014[d]
Hot water	13.820±0.028[d]	19.560±0.057[e]	30.770±0.042[d]	11.340±0.085[c]	0.665±0.012[c]	7.810±0.014[d]
Poly bag	14.180±0.028[c]	21.775±0.035[c]	31.720±0.170[c]	12.460±0.057[b]	0.640±0.014[c]	8.230±0.082[c]
Control	11.540±0.085[e]	18.360±0.085[f]	27.880±0.028[e]	9.450±0.030[d]	0.610±0.012[c]	6.790±0.014[e]
Plantain leaf	14.560±0.339[b]	21.310±0.156[d]	32.480±0.453[b]	12.585±0.091[b]	0.790±0.014[b]	8.660±0.085[b]
Smoke	16.810±0.014[a]	23.780±0.028[b]	33.625±0.247[a]	13.625±0.247[a]	0.850±0.014[a]	9.525±0.106[a]
p-value	**	**	**	**	**	**

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

The effect of different ripening acceleration method on the biochemical composition of Pawpaw revealed that Poly bag treatment gave higher TTA, while plantain leaf treatment gave higher pH, Reducing sugar and Vitamin C. As compared to previous studies, the result obtained on vitamin C content observed in this study was lower compared to other reports. Souza et al. [19] reported higher vitamin C content which were 90.7 mg/100 g and 71.3 mg/100 g in two different species of papaya which are Sunrise Solo 783 and Tainung 01 hybrid respectiv-eely. However Vinci et al. [20] reported vitamin C mean values of 54.0 mg/100g for ripe pawpaw and these findings were quite similar to the present study. Wall [21] suggested that pawpaw fruits are a good supply of vitamin C and A. It ranks first among 13-17 fresh fruits for vitamin C content [22]. 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 [23]. Halcroft and Kader [24] 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.

The effect of different ripening acceleration method on the mineral composition of Pawpaw showed significant difference in the composition of all the elements and between treatments.

The result further revealed that calcium carbide treatment gave higher potassium, while smoke treatment gave higher phosphorus, calcium, magnesium, iron and sodium. High amount of potassium in the body was reported to increase iron utilization [25] and beneficial to control hypertension through body fluid [26]. Sodium is the main cation outside cells and one of the primary electrolytes responsible for maintaining fluid balance. As recommended by Institute of Medicine [27] the adequate intake of sodium is 1500 mg/day for adults.

5. CONCLUSION

Although all the ripening induced treatments had an effect in quickening the ripening of pawpaw fruits but there was no striking difference in the nutritional value of the fruit. Ripening in general is a physiological process which makes the fruit edible, palatable and nutritious. Naturally, fruits ripen after attainment of proper maturity by a sequence of physiological and biochemical events and these processes are irreversible. But whether fruit ripens on the plant or after harvest, the resultant changes associated with ripening process is softening of fruit, change in colour and development of characteristic aroma and flavour. There may also be a reduction in sourness and increase in sweetness of the fruit. Usually fruits produce ethylene gas, a plant hormone naturally that ripens the fruits. From this study, it is recommended that a more natural means of induced ripening such as smoking method or

plantain leaf method be used rather than using chemicals such as calcium carbide which may have an adverse effect on the consumers resulting to allergic conditions. Natural methods remain safer since they have reasonably high proximate, biochemical and mineral compositions.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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