

Effects of Induced Ripening Methods on the Proximate, Biochemical and Mineral Compositions of *Ananas Comosus* (Pineapple Fruit)

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Abstract

The effects of induced ripening methods on the proximate, biochemical and mineral compositions of *Ananas comosus* (Pineapple fruit) was carried out. A total of six fruits were collected, the fruits were cleaned and taken to the laboratory for further treatments. Each of the pineapple fruit 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 pineapple fruit was 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 that smoked pineapple fruit gave highest percentage composition of dry matter (18.620 ± 0.028), crude fiber (0.750 ± 0.000), carbohydrate (16.532 ± 0.042) and higher TTA (0.230 ± 0.000). Plantain leaf treatment gave higher percentage composition of moisture content (84.520 ± 0.255) and Iron (0.351 ± 0.409). Calcium carbide treatment gave higher calcium (2.810 ± 0.014) and magnesium (2.780 ± 0.028), while the control fruit had higher percentage composition of ash (0.450 ± 0.000), ether extract (0.850 ± 0.014) and crude protein (1.190 ± 0.099), higher pH (12.790 ± 0.014), reducing sugar (3.620 ± 0.000) and Vitamin C (46.520 ± 0.255) and then phosphorus (7.510 ± 0.127), potassium (5.180 ± 0.028) and sodium (3.790 ± 0.014). There is significant difference in the percentage composition of moisture content, dry matter, ash, crude fibre, ether extract, crude protein and carbohydrate of the pineapple between fruit ripening ($p < 0.05$). There is also significant difference in the percentage composition of the TTA, pH, Reducing sugar and vitamin C of the pineapple between treatments ($p < 0.05$) and then there is significant difference in the composition of phosphorus, potassium, calcium, magnesium and sodium of the pineapple between treatments ($p < 0.05$). 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 process are irreversible. 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.

Keywords: Proximate, Biochemical, Mineral, *Ananas comosus*, Pineapple, Ripening.

1. Introduction

Pineapple (*Ananas* sp.) belongs to the family Bromeliaceae which encompasses about 50 genera and 2000 species mostly epiphytic [1]. It is a tropical fruit native to Central and South America specifically southern Brazil and Paraguay where wild relatives occur [2]. The world-wide total pineapple production is between 16 to 19 million tons [2, 4]. Pineapple mainly contains water, carbohydrates, sugars, vitamins A, C and beta-carotene [5]. It contains low amounts of protein, fat, ash and fiber and antioxidants namely flavonoids in addition to citric and malic acids and moderate amounts of ascorbic acid [6]. Pineapple also helps several enzymes present in the body to produce energy as it contains magnesium and vitamin B1 which are essential for the normal functioning of some enzymes [7].

Pineapple has the enzyme complex protease (bromelain). Bromelain contains peroxidase, acid phosphatase and several protease inhibitors and organically bound calcium and have anti-inflammatory properties as it blocks the formation of kinins which are responsible for inflammations [8]. Bromelain is used for relieving pains, sprains, swelling, bruises, and

arthritis and assist in diluting mucous and thus is beneficial for treating sinusitis, bronchitis, sore throat and tuberculosis [9]. Pineapples offer additional advantages for a whole utilization, in particular as a dietary fiber source. Among the qualities of the fiber is the texture, its length (60 cm), high water and dye holding capacity, high whiteness, brightness, resistance to salt and tension strength. The dietary fiber helps alleviate constipation as an indigestible portion of plant food that pushes through the digestive system, absorbs water and ease defecation and changes the nature of the gastrointestinal tract by changing how other nutrients and chemicals are absorbed [10, 11].

The consumption of pineapple is largely as canned pineapple slices, chunk and dice, juice, fruit salads, sugar syrup, alcohol, citric acid, chips and puree. It is also exported to other countries as fresh produce. Sixty percent of fresh pineapple is edible and average yield in processing ranges from 45% to 55% [7]. Processing residuals ranges from 45% to 65%, an indication of serious organic-side streams disposal challenges, which causes environmental pollution if not successfully utilized [12]. Pineapple peel is rich in cellulose,

hemicelluloses and other carbohydrates. Ensilaging of pineapple peels produces methane as a biogas. Anaerobic digestion occurs and the digested slurry is used as animal, poultry and fish feeds or organic fertilizers [13]. In studies by [14], *Rhizopus oligosporus* was used to produce enhanced levels of free phenolics from pineapple residue in combination with soy flour as potential nitrogen source. Using Reverse Micellar Extraction (RME) technique [6] extracts and purifies bromelain from pineapple wastes. De-juiced pineapple pulps, which are fruit fibers important for human health including boosting satiety, slowing glucose absorption, and functioning as prebiotics fruit fibers often ends up being thrown away or used as animal feed. [12] Successfully incorporated de-juiced pineapple pulps fibers incorporated into human food as carriers for fruit flavours. 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. Even though the acidity of fruit increases as it ripens, the higher acidity level does not make the fruit seems. Fruits 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 [15, 16, 17]. Owing to their anti-oxidant, anti-carcinogenic and anti-mutagenic activities, carotenoid and other photochemical provide protection against chorine disease states, different types of cancers, macular and cardiac vascular diseases and age related ailments [18, 19, 20, 21, 22]. Apart from regular consumption, different types of fruits have varying processing approaches for different applications. Fleshy fruits like apple, peach, pear, pineapple, watermelon and mango are commercially valuable as human food, eaten both fresh. Fruits are also used in manufactured 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 lack of proper post-harvest preservation. Fruits are generally expensive because of the post-harvest spoilage of fruits in supply cycle and costly preservation procedure. People pertinent to the fruit business are not familiar with effective methods or techniques of food preservation that can contribute towards better post-harvest management and less spoilage. 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 [23]. The aim of this study was to compare the effect of induced ripening methods on the proximate, mineral and biochemical contents of *A. comosus*.

Materials and Method

Collection and Preparation of fruits

Unripe *Ananas comosus* (Pineapple) was collected in June, 2015 from a market in Orlu Imo State Nigeria. A total of six fruits were collected, the fruits were cleaned and taken to the laboratory for further treatments. Each of the pineapple fruit was subjected to the following treatments: one of the pineapple 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 pineapple fruit was soaked in hot water (100°C) for 15mins; the fruit was wiped dry and covered with a thin cotton cloth.

The third pineapple fruit was placed on dried plantain leaves which were also spread over it. Another pineapple fruit was smoked for two days to induce ripening. The fifth pineapple fruit was put in a Polythene bag and was tied for three to four days before it ripened. The control pineapple fruit was 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 [15] 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 60°C 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:

$$\% \text{ fat} = \frac{W1 - W2}{\text{sample wt}} \times \frac{100}{1}$$

Determination of Crude Fibre

The Wended Method described by [24] 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 105°C for 3hours after cooling in a dessicator, they were reweighed (W2) and then put in a muffle furnace and incinerated at 550°C for 2hours (until they turned into ash), again they were cooled in a dessicator and weighed. The crude fibre content was calculated gravimetrically as:

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

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 [24] 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°C 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.

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

Determination of Moisture Content

The moisture content was determined gravimetrically as described by [25]. 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 105°C 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

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

$$\% \text{ dry matter} = 100 - \% \text{ moisture content}$$

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:

$$\% \text{ CHO} = 100 - \% (\text{Protein} + \text{Fat} + \text{Fibre} + \text{Ash} + \text{Moisture content}).$$

Determination of protein

Semi-micro Kjeldahl method was used for the protein determination. A measured weight of the test sample 2g was mixed with 10ml of conc. H₂SO₄ in a Kjeldahl 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 H₂SO₄ 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

$$\% \text{ protein} = \% N_2 \times 6.25$$
$$\% N_2 = \frac{100}{w} \times \frac{14 \times N}{1000} \times vdx - b$$

Where:

W= weight of sample analyzed

N= Normality (conc) of titration (0.02-H₂SO₄)

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-molybdate (yellow) spectrometry described by [25]. 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.

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

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 [26] calcium and magnesium content of the test samples was determined by the versanale EDTA complexometric 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 solochrome dark blue (calcon) was used as indicator in place of erichrome black.

Calcium and magnesium contents were calculated separately using the formula below.

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

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 [27] 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 jets 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 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:

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

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:

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

Biochemical Content Determination

Determination of Vitamin C

About 0.5g of the sample was weighted macerated with 10mls of 0.4% oxalic acid in a test tube for 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 [27] 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 [27]. A known weight of sample was diluted with neutralised 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 dealeded 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.

$$\text{Reducing sugar (\%)} = \frac{\text{Mg. of invert sugar} \times \text{Vol. made up} \times 100}{\text{TR} \times \text{Wt. of sample} \times 1000}$$

Result

Table 1: Proximate analysis of Pineapple fruit

Treatment	Moisture	Dry matter	Ash	Crude fibre	Ether extract	Crude protein	Carbohydrate
C. Carbide	82.780±0.28 ^c	17.220±0.028 ^b	0.410±0.014 ^b	0.620±0.000 ^c	0.075±0.000 ^b	0.790±0.014 ^c	15.325±0.057 ^b
Hot water	83.760±0.198 ^b	16.240±0.198 ^c	0.360±0.000 ^d	0.620±0.028 ^c	0.074±0.002 ^b	0.750±0.000 ^c	14.437±0.228 ^c
Poly bag	83.490±0.297 ^b	16.235±0.092 ^c	0.380±0.000 ^c	0.540±0.000 ^d	0.071±0.001 ^b	0.770±0.014 ^c	14.749±0.313 ^c
Smoked	81.380±0.028 ^d	18.620±0.028 ^a	0.420±0.014 ^b	0.750±0.000 ^a	0.068±0.000 ^b	0.850±0.000 ^c	16.532±0.042 ^a
Plantain leaf	84.520±0.255 ^a	15.480±0.255 ^d	0.420±0.000 ^b	0.630±0.000 ^c	0.418±0.484 ^a	1.060±0.000 ^b	12.952±0.229 ^d
Control	83.780±0.028 ^b	16.220±0.028 ^c	0.450±0.000 ^a	0.690±0.014 ^b	0.850±0.014 ^a	1.190±0.099 ^b	13.040±0.042 ^d
p-value	**	**	**	**	**	**	**

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

The effect of different induced ripening methods on the proximate composition of pineapple revealed that smoked pineapple fruit gave highest percentage composition of dry matter (18.620±0.028), crude fiber (0.750±0.000), and carbohydrate (16.532±0.042), plantain leaf treatment gave higher percentage composition of moisture content (84.520±0.255), while the control fruit had higher percentage

composition of ash (0.450±0.000), ether extract (0.850±0.014) and crude protein (1.190±0.099). There is significant difference in the percentage composition of moisture content, dry matter, ash, crude fibre, ether extract, crude protein and carbohydrate of the pineapple between fruit ripening ($p<0.05$)(Table 1)

Table 2: Biochemical composition Pineapple

Treatment	TTA(gms)	pH	Reducing sugar (%)	Vitamin C
C. Carbide	0.220±0.014 ^a	10.790±0.014 ^d	3.450±0.000 ^e	43.760±0.057 ^c
Hot water	0.200±0.000 ^b	11.340±0.085 ^c	3.510±0.014 ^d	40.565±0.049 ^e
Poly bag	0.190±0.000 ^b	11.480±0.028 ^b	3.530±0.014 ^c	42.820±0.028 ^d
Smoked	0.230±0.000	8.450±0.000 ^c	3.490±0.014 ^a	35.820±0.028 ^f
Plantain leaf	0.180±0.000 ^b	11.850±0.000 ^a	3.600±0.000 ^b	45.820±0.028 ^b
Control	0.180±0.014 ^b	12.790±0.014 ^a	3.620±0.000 ^f	46.520±0.255 ^a
p-value	**	**	**	**

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

The effect of different induced ripening methods on the biochemical composition of pineapple fruit revealed that smoke treated pineapple fruit gave higher TTA (0.230±0.000), while the control gave higher pH (12.790±0.014), reducing sugar (3.620±0.000) and Vitamin C

(46.520±0.255). There is significant difference in the percentage composition of the TTA, pH, Reducing sugar, vitamin C of the pineapple between treatment ($p<0.05$)

Table 3: Mineral composition of Pineapple

Treatment	Phosphorus	Potassium	Calcium	Magnesium	Iron	Sodium
C. Carbide	6.845±0.007 ^c	4.490±0.014 ^c	2.810±0.014 ^a	2.780±0.028 ^a	0.045±0.000 ^a	3.340±0.085 ^c
Hot water	6.780±0.000 ^d	4.280±0.000 ^d	1.940±0.000 ^c	2.570±0.042 ^c	0.048±0.000 ^a	3.260±0.000 ^d
Poly bag	6.920±0.000 ^b	4.630±0.099 ^b	2.625±0.247 ^b	2.610±0.014 ^c	0.052±0.000 ^a	3.240±0.000 ^d
Smoked	6.700±0.028 ^d	4.250±0.000 ^d	1.390±0.014 ^d	2.260±0.000 ^d	0.036±0.000 ^a	3.240±0.000 ^d
Plantain leaf	6.910±0.014 ^c	4.620±0.000 ^b	2.465±0.021 ^b	2.680±0.000 ^b	0.351±0.409 ^a	3.380±0.028 ^b
Control	7.510±0.127 ^a	5.180±0.028 ^a	2.610±0.014 ^b	2.770±0.000 ^a	0.064±0.001 ^a	3.790±0.014 ^a
p-value	**	**	**	**	** ns	**

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

The effect of different induced ripening methods on the mineral composition of pineapple revealed that Calcium carbide treatment gave higher calcium (2.810±0.014) and magnesium (2.780±0.028). Plantain leaf treatment gave higher Iron (0.351±0.409), while the control gave higher phosphorus (7.510±0.127), potassium (5.180±0.028) and sodium (3.790±0.014). Therefore, there is significant difference in the composition of phosphorus, potassium, calcium, magnesium, sodium of the pineapple treatment between ($p<0.05$).

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, texture changes, volatile and aroma development and finally abscission of fruits [23].

Fruits play a vital role in nutrition and they are rich source of vitamins, mineral, dietary fibers, different important carotenoid, flavonoids, phenol and other phytochemical [16, 17]. Owing to their anti-oxidant, anti-carcinogenic and anti-mutagenic activities, carotenoids and other phytochemicals provide protection against chorine disease states, different types of cancers, macular and cardiac vascular diseases and age related ailments [18]. Numerous reports have shown that high temperature applications as well as gas treatments are

very effective in decay control, enhancing fruit resistance to chilling injury as well as enhancing ripening processes. However, information about the beneficial effects on health promoting phytochemicals in fruit and vegetables during postharvest are scanty and has to be investigated in more detail.

The result in table 1 above showed the effect of different induced ripening methods on the proximate composition of pineapple. It however, revealed that smoked pineapple fruit gave highest percentage composition of dry matter, crude fiber, and carbohydrate and then the pineapple fruit that was covered with plantain leaf gave higher percentage composition of moisture content, while the control fruit had higher percentage composition of ash, ether extract and crude protein. In table 2 also these different induced ripening methods had varying effects on the biochemical composition of pineapple fruit. Smoke treated pineapple fruit gave higher TTA, while the control gave higher pH, reducing sugar and Vitamin C. And table 3 as well showed the effect of different induced ripening methods on the mineral composition of pineapple and this revealed that Calcium carbide treatment gave higher calcium and magnesium. And then the pineapple fruit that was covered with plantain leaf gave higher Iron, while the control gave higher phosphorus, potassium and sodium.

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 flavylum cation, and with rising pH mainly the colorless carbinol and the blue quinonoidal bases are synthesized leading to a scarlet color [28]. More so, in some fruits, mostly berries, high CO₂ concentrations (20 kPa) increased the pH due to the enhanced decomposition of organic acids [29]. The degradation of organic acids in altered environmental or physical conditions was also found in lettuce and fennel [29, 30]. Similar effects were documented for radish stored in modified atmosphere [31]. In pomegranates, [32] also found reduced pigment levels with rising CO₂ concentrations (10 and 20 kPa), which were correlated with decreased phenylalanine ammonia-lyase activity. This indicates a suppression of pigments biosynthesis by elevated CO₂ concentrations.

However, 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 process are irreversible. 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. Usually fruits produce ethylene gas, a plant hormone, naturally that ripens the fruits.

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 [33]. [34] 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.

[28] Has suggested that phenols and flavonoid were increased during storage. Changes in phenol and flavonoid during fruit ripening have been associated with pigment development of anthocyanin in fruit tissue. Also the antioxidant activities always correlate with the total phenolic and flavonoid content in the fruits. It indicated that the phenolic and flavone compounds could be the main cause of antioxidant in fruit.

Conclusion

Fruits are the best natural food usually consumed raw. Now-a-days fruits are deliberately being contaminated by chemicals causing serious health hazard. Among the pre-treatments, which are mostly followed for fruits intended for better consumer acceptance and facilitating better marketing is artificial fruit ripening. Artificial ripening is done to achieve faster and more uniform ripening characteristics. Although the cosmetic quality of such artificially ripened fruits was found to improve, organoleptic quality was

impaired especially when harvested fruits are subjected to treatment without considering their maturity status.

To date, the effectiveness of postharvest treatments on ripening has been assessed mainly by the quality maintenance of harvested fruit and vegetables. However, with rising 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 phytochemicals and minerals. Therefore, to obtain fruit and vegetables enriched with phytochemicals, 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 induced ripening treatments should be coordinated with crop management strategies. Such phytochemical enriched fruit and vegetables 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 phytochemicals. However, investigations on the beneficial effects of physical and chemical postharvest ripening treatments on health promoting phytochemicals and minerals in fruit and vegetables have to be extended. Plant response in terms of physiological, biochemical, and molecular biological processes have to be studied in more detail for the optimization of elicitor application.

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