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Comparative Study on the Physicochemical Properties of Naturally and Artificially Ripened Banana

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Abstract A comparative study on the physico-chemical properties of naturally ripened and artificially ripened bananas was carried out. Calcium carbide was chosen as ripening agent. The banana samples were collected and ripened naturally and artificially in the laboratory by dividing the banana samples into batches A, B and C. Batch A was ripened naturally and batch B was ripened with 5 grams calcium carbide and batch C using 10 grams calcium carbide. The results revealed that naturally ripened banana samples took 6 - 8 days to ripe, whereas those ripened with calcium carbide at 5 grams and 10 grams respectively took 2 - 4 days to ripe. Total soluble solids, moisture, sugar content, firmness, texture and taste were found higher in the naturally ripened banana samples than the artificially ripened banana sample. The Vitamin C content of artificially ripened banana sample was lower than the naturally ripened samples. The overall sensory evaluations of naturally ripened banana samples were higher than the calcium carbide ripened banana samples. The study concluded that natural method of banana ripening is better than artificial method of banana ripening and it gives beneficial effects without toxicity.

Keywords: *artificial ripening, calcium carbide, ripening agent, banana*

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1. Introduction

There are three phases of life of a fruit; fruit set, fruit development, and fruit ripening. Fruit ripening is the initiation of fruit senescence (the condition or process of deterioration with age) which is a genetically programmed highly coordinated process of organ transformation from unripe to ripe stage to yield an attractive edible fruit [1]. It is an irreversible phenomenon involving a series of biochemical, physiological, and organoleptic changes [2]. These changes include changes in carbohydrate content, increment of sugar content, changes in colour, texture, aroma volatiles, favour compounds, phenolic compounds, and organic acids. Ripening is the final stage of development of a fruit which requires chains of physiological and biochemical processes resulting in various changes like, colour, flavour, aroma and texture that make the fruits both attractive and tasty. Most people consume fruits, ripened with hazardous chemicals like calcium carbide unknowingly. This is highly hazardous to the health of the consumers. During ripening, the starch in the fruit breaks down to sugar. The fruit skin color changes green to bright red or yellow. These changes attract birds, animals and consumers. The ripening of a fruit depends on the season [3].

There are numerous artificial methods of fruits ripping, mainly for financial gains and meet consumers' demand. Hence, people may consume fruits ripened using hazardous chemicals like calcium carbide which are of great health risks to consumers [4]. Fruit sellers use artificial ripening agents due to high demand and high profit margins. The sellers normally prepared to harvest the fruits before they are fully matured, which could save them great deal of loss as a results of time taken to transport and distribute fruits from the farmers' orchards to consumers' baskets, instead of the naturally ripened fruits which may become over ripen and inedible [5]. Besides using calcium carbide as fruit ripening and protection agent against damage, chemicals like formalin are also used for extending the shelf life of fruits which are reported to cause several health problems such as dizziness, weakness, ulcer, heart disease, skin disease, lung failure kidney failure and cancer etc. The widespread use of formalin and other chemicals for preservation of fruits has become a great concern among the people. The chemicals used as spray solution make fruits attractive [6]. "Calcium carbide CaC_2 is a chemical compound with a chemical name Calcium Carbide. It is also known as *calcium acetylide, phenyl glyceryl ether diacetate, and glycerol phenyl ether diacetate.* Calcium Carbide in its pure form appears as a colourless crystalline solid and is a rock-like structure at room temperature. Commercial Calcium Carbide, however, may present a relatively wide range of colours depending on the impurities present (usually calcium, magnesium, and other oxides). However,

treatment of fruits with calcium carbide is extremely hazardous because the chemical is known to contain traces of arsenic and phosphorous. Acetylene gas produced by calcium carbide may affect the neurological system by inducing prolonged hypoxia gradually culminating to headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral edema and seizures [7]. This study was aimed at determining the effects of calcium carbide on banana as an artificial ripening agent and comparing its physico-chemical properties with that of naturally ripened banana.

2. Methodology

Banana samples were collected on 8th February 2021, from a farm in Benin City, Edo State, Nigeria and were divided into three batches A, B and C. Batch A was ripened naturally and batch and B and C were ripened artificially using calcium carbide. The naturally and artificially ripened bananas were compared and analyzed for the following physicochemical parameters such as: Ripened time, Moisture content, Dry matter, Total titratable acidity, Total soluble solid, Peel colour, Vitamin C, Sugar contents, Texture/firmness, Taste, Flavour and analysis of the ripening agent diffusion of sulfur.

The samples were divided into batches A, B and C. Batch A was kept in a room with temperature of about 20°C - 26°C and allowed to ripe naturally. Batch B was placed in a sack with the application of 5 grams of calcium carbide and Batch C was also placed in a sack bag with the application of 10 grams of calcium carbide. Batch B and C were allowed to ripened artificially.

2.1. Experimental Techniques

Experimental techniques to determine the physico-chemical properties of the treated samples which include: Ripening condition, moisture content, TTA, TSS, Dry matter, Peel colour, Vitamin C, Sugar contents, texture, taste and flavor of the banana samples, and toxicity and diffusivity of ripening agents.

2.2. Determination of Ripening Condition

The degree of ripening was determined using starch-iodine test. Starch-iodine test is widely used to determine the maturity of fruits in which amylase present as starch in the unripe fruits produces violet color in the presence of iodine. After dipping the banana samples into iodine solution; the starch content in the ripe samples showed no color change. This is because starch is converted to sugar with the progression of ripening process. So a ripe fruit will show no color when strained with iodine.

2.3. Determination of Moisture Content

The moisture content was determined by oven-dry method. Naturally and artificially ripened banana samples were dried in an oven (National, NB-7500E) at 110°C until a constant weight was reached. Weight readings of the samples were taken before and after drying; the weight difference denoted the amount of moisture in the samples. The moisture content is expressed in gram of moisture available per 100g of fruit sample (g of moisture/100g of fruit stem).

2.4. Determination of Total Titratable Acidity (TTA)

Total Titratable Acidity (TTA) was measured using the method. The Juice from banana samples was titrated with standardized 0.1M NaOH solution using phenolphthalein indicator. The resultant acid content from the titration is multiplied by the citric acid factor and the result is expressed in gram citric acid per 100 g of fruit stem.

2.5. Determination of Vitamin C

Vitamin C (ascorbic acid) concentration was determined by redox titration using standardized iodine solution. In this method, ascorbic acid in fruit reacts with iodine to produce dehydro ascorbic acid and iodine ions. Excess iodine then reacts with the starch indicator to produce violet color and indicate the end point of titration. The results obtained are expressed in ppm.

2.6. Determination of Sugar Content

The sugar content of the samples was determined by measuring the refractive index of the samples. A KRUSS (Germany) refractometer was used to measure the refractive index of the banana solutions (10wt %). Afterwards, sugar content (wt %) was determined from this refra100s inserted into the beaker and the reading was taken. The electrode was rinsed with distilled water and wiped dry with a clean tissue before and after each reading.

2.7. Determination of Peel Color

External peel colors were quantified using a Minolta CR-300 tristimulus Colorimeter. And values were taken on opposite sides of each banana.

2.8. Dry Matter

Pulp dry matter was determined by placing 10 g of pulp in a Petri dish and drying it at 70˚C for 48 hours using an Excalibur® Food Dehydrator (Excalibur Dehydrators, Sacramento, CA). The weight of the sample was recorded before (Wt_o) and after (Wt_f) drying and the following equation were used to obtain dry matter values:

$$Dry\ Matter\ (\%) = \left(Wt_o / Wt_f - 1\right) * 100$$

2.9. Determination of Total Soluble Solid (TSS)

Total Soluble Solids (TSS) was determined using a digital table refractometer at room temperature (25˚C). A drop of 1:5 homogenized pulps: ultrapure water solution was placed on the prism glass. Readings were multiplied by the dilution factor to obtain original TSS.

2.10. Determination of Texture

The texture analyzer was used to measure texture parameter of the banana samples firmness (Model TA- XT, Stable Micro System Ltd, UK). The Exponent software program was used to record the data loaded in the linked computer.

2.11. Determination of Firmness

The firmness of the banana samples was carried out by puncturing the sample that generated a force vs. time graph. The measurement of firmness value was done with the working conditions such as mode measure force in compression, pre-test speed 1.5 mm/s, test speed 1.0 mm/s, post-test speed 10 mm/s trigger type-auto 5 kg, the data acquisition rate, and accessory were 5 mm.

2.12. Determinations of Taste and Flavor

Taste and flavor of the naturally and artificially ripened banana were determined by mouth feel.

2.13. Analysis of Ripening Agents

X-ray fluorescence spectrometer (Shimadzu, XRF-1800) was used for the elemental analysis of calcium carbide. During elemental analysis, high amount of sulfur was found in calcium carbide samples. Energy-dispersive X-ray spectroscopy (EDS, JSM-7600F SEM) was used to cross-check the value of elemental sulfur in calcium carbide samples.

2.14. Analysis of Diffusion of Sulfur from Ripening Agent to the Banana

To understand the diffusion of sulfur from calcium carbide to the flesh and peel of fruits, sulfate and sulfide content of fresh and carbide-treated banana samples (flesh and peel) were measured using HACH DR-6000 UV-Vis spectrophotometer (USEPA).

2.15. Sensory Quality Characteristics

Descriptive sensory quality of ripe banana fruits, texture, aroma, colour, appearance, flavor, mouth feel, taste and overall quality were assessed by a panel of 10 judges.

3. Results

The evaluation of the ripening time and it was observed that he banana batches ripened with calcium carbide differ in the ripening ability (Table 1). Batch A took 6 to 8 days to ripen while Batch B took 3 to 4 days to ripen and batch C took 2 to 3 days respectively. Table 2, represents the analysis of physical properties of banana samples. The appearance of natural ripening is acceptable while the appearance artificially ripening were more acceptable.

Table 1. Ripening Time Evaluation

Batches	Ripening Method	Ripening Started	Fully Ripened	Scenerosis Happened
Batch A	Naturally	Day 6	Day 8	Day 9
Batch B	Artificially using (5 grams calcium carbide)	Day 3	Day 4	Day 5
Batch C	Artificially using (10 grams calcium carbide)	Day 2	Day 3	Day 4

Table 2. Results of Analysis of Physical Properties of Banana

Physical properties	Naturally (Batch A)	Artificially. Ripened with calcium carbide (Batch B)	Artificially ripened with calcium carbide (Batch C)
Peel Color	Yellow with brown color spot	Yellow	Yellow
Texture	Soft and tender	Soft and tender	Soft and tender
Appearance	Acceptable	More acceptable	Most acceptable

Table 3. Results of Analysis of Chemical Properties

Chemical Properties	Naturally (Batch A)	Artificially Ripened with Calcium Carbide (Batch B)	Artificially Ripened with Calcium Carbide (Batch C)
Total Titratable Acidity (TTA) (%)	0.12	0.14	0.15
Vitamin C (mg/100g)	26.83	25.01	24.23
Sugar Content (%)	11.89	10.10	10.40
Total Soluble Solid (TSS) (mg/100g)	19.20	15.70	17.90
Moisture Content (%)	67.80	62.50	61.40
Dry Matter (%)	32.20	37.50	38.60

Table 4. Elemental Analysis of Calcium Carbide Samples X-ray fluorescence spectroscopy analysis of calcium carbide sample

Samples	Cac_2 (g)	Arsenic Acid (As)	Prosperous (P)	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Sodium (Na)
B	5	80.4	50.2	0.11	0.2	40.3	0.20
C	10	102.8	62.4	0.08	0.09	41.6	0.18

Table 5. Analysis of Diffusion of Sulfur from Ripening Agent to the Banana

Sample	Peel mg/kg	Flesh mg/kg	Peel mg/kg	Flesh mg/kg
5gram Calcium Carbide	2.92	1.74	0.21	0.16
10gram Calcium Carbide	3.71	1.95	0.38	0.26

Table 6. Sulfate and Sulfide Content in Banana Samples

	Naturally Ripened Banana		5g Calcium Carbide Ripened		10g Calcium Carbide Ripened	
Parameters	Like (%)	Dislike (%)	Like (%)	Dislike (%)	Like (%)	Dislike (%)
Taste	80	20	60	40	60	40
Flavour	90	10	60	40	60	40
Texture	60	40	50	50	60	40
Firmness	80	20	60	40	40	60
Acceptability	80	20	60	40	30	70

Key:
CaC_2 = Calcium carbide
TSS = Total Solute Solid
TTA = Total Titratable Acidity.

4. Discussions

4.1. Peel Color

The color change during the ripening stage, the green color is shown by the unripe banana and fully ripe banana is yellow in color with brown color spots in naturally ripen while the artificially ripened became yellow. This result is in consonant with the results obtained by [8].

4.2. Texture

The rate of change of firmness is higher in the naturally ripened banana as compare to artificially ripened banana samples. The changes in the fruit firmness could be due to the production of soluble pectin by the breakdown of insoluble protopectin followed by cellular breakdown results in the membrane permeability. In the case of the artificial ripening, chemical ripening agents trigger the cellular fragmentation of the insoluble protopectin and result in a gradual decrease in fruit firmness.

4.3. Total Titratable Acidity (TTA)

TTA content was found comparatively higher in artificially ripened banana samples (0.14 and 0.15) than in the naturally ripened samples (0.12). Naturally ripened banana showed lowest titratable acidity (0.09%) [8].

4.4. Vitamin C

Vitamin C content in naturally ripen banana samples during the experiment ranged was higher than the artificially ripened samples. This was in agreement with results obtained by [9] where decreasing vitamin C concentration was recorded as calcium carbide concentration was increased.

4.5. Sugar Content

The artificially ripened banana sample had low sugar content varied from 10.10% to 10.40%.

4.6. Total Soluble Solids (TSS)

Calcium carbide treated banana sample have lower TSS as compared to natural ripened banana. The reaction of the breakdown of starch into soluble sugars responsible for the increase in the TSS values in Batch A. Chemical ripening agents decrease the rate of starch breakdown, thus gives lower TSS values than the natural banana sample.

4.7. Moisture Content

Moisture content values of the calcium carbide ripened samples ranged from 62.50 to 61.40 wt%. The moisture content is higher in the naturally ripened samples.

4.8. Dry Matter

Dry Matter values of the calcium carbide ripened samples are higher than the naturally ripened samples.

The Sensory evaluation of the banana samples and the calcium carbide treated banana sample found highly acceptable in sensory evaluation. The sensory evaluation revealed that the artificial ripening agent helps in increasing the consumer acceptability of banana fruit. The naturally ripened banana sample showed lowest acceptability in comparison to artificially ripened banana. The estimated values were found similar with literature [11].

5. Conclusion

Total soluble solids, moisture, sugar content, firmness, texture and taste were found higher in the naturally ripened banana samples than the artificially ripened banana sample. However, the titratable acidity of calcium carbide ripened banana was higher than the naturally ripened banana. The Vitamin C content of artificially ripened banana sample was lower than the naturally ripened samples. The overall sensory evaluations of naturally ripened banana samples were higher than the

calcium carbide ripened banana samples. It was observed that banana ripened naturally gives beneficial effects without toxicity, whereas banana ripened with Calcium carbide are often soft, less tasty, and they also have a shorter storage life and It also contains traces of arsenic and phosphorus hydride, which could result in several acute and chronic health effects. The study concluded that natural method of banana ripening is better than artificial method of banana ripening.

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