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Induced Ripening Agents and Their Effect on Fruit Quality of Banana

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Abstract**—** *This study was carried out to determine the effects of induced ripening agents on the quality of Banana ripened with Apple fruit and calcium carbide. Five batches of banana samples were administered with different concentrations of calcium carbide (5g, 10g, 15g, 20g and 25g) and labeled samples C, D, E, F and G respectively. A separate batch of banana was wrapped with one apple in a polythene bag and was labeled sample B while another batch of banana was left to ripe naturally on its own at room temperature without any ripening agent's and was labeled sample A (control). The results obtained revealed that naturally ripened banana samples took 5 - 7 days to ripe, the apple induce ripened banana took 2 – 5 days to ripe, while the banana ripened with calcium carbide at 5 grams took 2-6 days to ripe, with 10 grams and 15 grams took 2-5 days to ripe, with 20 grams and 25 grams 2 - 4 days to ripe. Vitamin-C content in naturally ripened banana samples and the apple ripened banana were higher than those ripened with calcium carbide. The moisture increased as the concentration of calcium carbide was increased in the calcium carbide induced ripened bananas. The crude fiber content in the naturally ripened banana was higher than in the apple ripened banana. Firmness is greater in naturally ripened and apple-ripened banana samples. The sensory evaluations of naturally ripened banana samples and that of apple ripened were higher than the calcium carbide ripened banana samples. The study concluded that apple induced ripened banana compares favourably with natural method of banana ripening as it is faster and do not contain arsenic. The apple induced ripening is a non toxic alternative to calcium carbide induced ripening method of banana.*

Keywords**—** *Induced ripening, Calcium carbide, Apple, banana*.

I. INTRODUCTION

Significant health advantages of bananas. It improves the body's immune system, lowers cholesterol, supports kidney health, lowers the risk of high blood pressure, stroke, and other illnesses, is crucial for strong teeth and bones, promotes brain and heart health, and lowers the risk of high blood pressure [1].

Fruit and vegetable-rich diets are highly recommended for their ability to promote health. Due to their concentrations of vitamins, particularly vitamins C and A, minerals, particularly electrolytes, and more recently phytochemicals, including antioxidants, fruits and vegetables have historically maintained a role in nutritional advice. As a source of dietary fiber, fruits and vegetables are also advised [2].

Fruits go through three stages of development: fruit set, fruit growth, and fruit ripening. Fruit ripening is the beginning of fruit senescence, a genetically designed, highly coordinated process of organ transition from the unripe to the ripe state that results in an appealing edible fruit [3].

It is an ongoing phenomena that involves biochemical, physiological, and gustatory changes [4]. These modifications include variations in the amount of carbohydrates, an increase in the amount of sugar, variations in color and texture, volatile aroma components, favor compounds, phenolic compounds, and organic acids. The process of ripening, which is the last stage of fruit development, necessitates a series of physiological and biochemical reactions that change the fruit's color, flavor, aroma, and texture, making it more aesthetically pleasing and tastier. Most individuals inadvertently eat fruits that have been ripened by dangerous substances like calcium carbide. This poses a serious threat to the consumers' health. Fruit starch transforms into sugar during ripening. The fruit's green skin turns brilliant crimson or yellow as it ripens. Birds, animals, and shoppers are all drawn to these changes. A fruit's ripening is dependent on the season [5].

There are many artificial ways to tear fruits, mostly done for commercial advantage and to satisfy customer demand. Therefore, people may eat fruits that have been exposed to dangerous substances like calcium carbide, which pose serious health concerns to consumers [6].

Due to high demand and huge profit margins, fruit vendors use artificial ripening agents. Instead of using naturally ripened fruits, which may become overripe and inedible, the sellers typically prepare to harvest the fruits before they are fully matured, which could save them a significant amount of loss due to the time required to transport and distribute fruits from the farmers' orchards to consumers' baskets [7].

Chemicals like formalin are also used to extend the shelf life of fruits, which are reported to cause several health issues like dizziness, weakness, ulcers, heart disease, skin disease, lung failure, kidney failure, and cancer, in addition to using calcium carbide as a fruit ripening and damage-prevention agent. The increasing use of formalin and other chemicals for fruit preservation has raised significant public concern. Fruits are beautiful thanks to the chemicals employed in spray solutions [8].

Calcium carbide is a chemical compound with the formula CaC_2. It is also referred to as phenyl glyceryl ether diacetate, glycerol phenyl ether diacetate, and calcium acetylide. At room temperature, calcium carbide has a rock-like structure and appears in its pure form as an inert, crystalline solid. However, depending on the impurities present, commercial calcium carbide can display a fairly wide range of colors (usually calcium, magnesium, and other oxides). Calcium carbide is known to contain minute amounts of phosphorous and arsenic, making it extremely dangerous to use on fruits. By causing prolonged hypoxia over time and eventually leading to headache, dizziness, mood swings, sleepiness, mental confusion, memory loss, cerebral edema, and seizures, the

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acetylene gas produced by calcium carbide may have an adverse effect on the nervous system [9].

The fruit's final step of development is ripening. Throughout the ripening process, numerous physiological and biochemical changes take place. Numerous changes in quality traits, such as color, taste, aroma, and texture, occur throughout ripening. Fruit can become more palatable, sweeter, more appetizing to consume through this natural process [10].

II. METHODOLOGY

Samples of Banana were purchased directly from a farm on 18th July 2022, in Edo State, Nigeria. The bananas were divided into three groups, namely; group I, group II and group III. Group I was ripened with different concentrations of calcium carbide, group II was ripened with apple and group III was ripened naturally. All the groups of ripened bananas were compared and analyzed for the following physicochemical parameters such as: time taken for the banana to ripe, Moisture content, Dry matter, Total soluble solid, Peel colour, Vitamin C, Sugar contents, Texture/firmness, Taste, Flavour and analysis of the ripening agent diffusion of sulfur.

Group I samples were divided into five and placed into 5 different sacks labeled samples C, D, E, F and G, with 5 grams, 10 grams, 15 grams, 20 grams and 25 grams of calcium carbide added to each of the sacks respectively. Group II samples were placed in a sack together with an apple labeled sample B. And group III samples were kept in a room with temperature of about 20°C - 26°C and allowed to ripe naturally and labeled sample A.

Experimental Techniques

Ripening condition, moisture content, TSS, Dry matter, Peel color, Vitamin C content, Sugar contents, texture, taste, and flavor of the banana samples, as well as toxicity and diffusivity of ripening agents, are some of the physico-chemical characteristics of the treated samples that can be determined through experimental methods.

Determination of Ripening Condition

The starch-iodine test was used to determine the level of ripening. The starch-iodine test, which uses amylase present as starch in the unripe fruits to create violet color in the presence of iodine, is frequently used to detect the ripeness of fruits. The starch content in the ripe samples of bananas did not change color after being dipped into an iodine solution. This is due to the fact that as the ripening process advances, starch is transformed into sugar. So, when strained with iodine, a mature apple will not exhibit any color.

Determination of Moisture Content

The oven-dry method was used to determine the moisture content. Banana samples that had been naturally and artificially ripened were dried in a National NB-7500E oven at 110°C until a constant weight was achieved. The quantity of moisture in the samples was determined by comparing the weight of the samples before and after drying. The amount of moisture present in a sample of 100g fruit is measured in grams of moisture (g of moisture/100g of fruit stem).

Determination of Vitamin C

Redox titration was used to measure the content of vitamin C (ascorbic acid) using a standardized iodine solution. According to this process, iodine and ascorbic acid in fruit react to form dehydro ascorbic acid and iodine ions. The starch indicator and excess iodine subsequently combine to generate violet hue, which marks the titration's end point. The outcomes are presented in ppm.

Determination of Sugar Content

By calculating the samples' refractive indices, the sugar content of the samples was ascertained. The refractive index of the banana solutions (10wt%) was determined using a KRUSS (Germany) refractometer. The reading was then taken to determine the sugar content (wt%) using the refra100s that had been placed into the beaker. Before and after each reading, the electrode was cleaned with distilled water and dried with a fresh tissue.

Determination of Peel Color

The colors of the external peel were measured with a Minolta CR-300 tristimulus Colorimeter. On the opposing sides of each banana, values were recorded.

Determination of Texture

The texture parameter of the banana sample firmness was measured using the texture analyzer (Model TA- XT, Stable Micro System Ltd, UK). The data loaded into the connected computer was recorded using the Exponent software program.

Determination of Firmness

This was done by puncturing the sample, which created a force versus time graph, the firmness of the banana samples was tested. The working conditions used to measure firmness value included the mode of measuring force in compression, test speed of 1.0 mm/s, pre-test speed of 1.5 mm/s, post-test speed of 10 mm/s, trigger type-auto 5 kg, data acquisition rate, and accessory of 5 mm.

Determinations of Taste and Flavour

Mouth feel was used to compare the taste and flavor of bananas that were ripened naturally and artificially.

Analysis of Ripening Agents

The elemental analysis of calcium carbide was performed using a Shimadzu XRF-1800 X-ray fluorescence spectrometer. In calcium carbide samples, a significant amount of sulfur was discovered during elemental analysis. Samples of calcium carbide were examined using energy-dispersive X-ray spectroscopy (EDS, JSM-7600F SEM) to confirm the amount of elemental sulfur present.

Analysis of Diffusion of Sulfur from Ripening Agent to the Banana

Using a HACH DR-6000 UV-Vis spectrophotometer, the sulfate and sulfide content of fresh and carbide-treated banana samples (flesh and peel) were examined to better understand the diffusion of sulfur from calcium carbide to the meat and peel of bananas (USEPA).

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Sensory Quality Characteristics

A panel of 10 judges evaluated the descriptive sensory qualities of ripe banana fruits, including texture, scent, color, appearance, flavor, mouth feel, taste, and overall quality.

III. RESULTS

After evaluating the ripening process, it was discovered that the calcium carbide-ripened banana batches had different ripening abilities (table 1). It took 5 to 7 days for batch A to ripen, 2 to 5 days for batch B, 2 to 6 days for batch C, 2 to 5 days for batches D and E, 2 to 4 days fir batch F and 2 to 5 days for batch G.

TABLE I. Ripening Time Evaluation

Batches	Ripening method	Ripening started	Fully Ripened
Batch A	Natural (Control)	5 days	7 days
Batch B	1 Apple	2 days	5 days
Batch C	Calcium Carbide (5 g)	2 days	6 days
Batch D	Calcium Carbide (10 g)	2 days	5 days
Batch E	Calcium Carbide (15 g)	2 days	5 days
Batch F	Calcium Carbide (20 g)	2 days	4 days
Batch G	Calcium Carbide (25 g)	2 days	4 days

TABLE II. Results of Analysis of Physical Properties of Banana

Physical properties	Naturally ripened (Control)	Banana ripened with Apple	Artificially ripened with Calcium Carbide
Peel color	Yellow with brown spot color	Yellow with brown spot color	Yellow
Texture	Soft and tender	Soft and tender	Tender
Appearance	Most acceptable	More acceptable	Acceptable

TABLE III. Proximate Composition of Apple Induced Ripened and Calcium Carbide Ripened Banana

Parameter	Sample A (Control)	Sample B (Apple)	Sample C (5g)	Sample D (10g)	Sample E (15g)	Sample F (20g)	Sample G (25g)
Moisture (%)	52.1	56.4	69.2	71.8	72.3	74.6	74.8
Crude protein	6.9	8.2	4.1	3.8	3.4	3.4	2.9
Crude fiber	4.9	3.6	4.2	4.0	3.5	3.5	3.1
pH	5.4	6.0	5.8	6.0	5.9	5.8	5.8
Sugar content (%)	12.0	12.8	11.6	12.0	11.0	10.5	10.1
Vitamin-C (mg 100g)	26.00	28.00	26.00	27.00	23.00	21.00	18.00

TABEL IV. Elemental Analysis of Banana Ripened with Apple and Ripened with Calcium Carbide

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Arsenic (As)	N.D	N.D	0.08	0.09	0.12	0.13	0.15
Phosphorous (P)	69.2	70.1	184.3	187.1	192.8	198.5	201.0
Calcium (Ca)	0.10	0.10	0.12	0.10	0.12	0.13	0.14
Magnesium (Mg)	0.12	0.13	0.12	0.12	0.14	0.13	0.14
Potassium (K)	38.0	39.0	39.2	39.8	40.0	40.6	41.2
Sodium (Na)	0.08	0.09	0.10	0.10	0.12	0.12	0.12

TABLE V. Sensory Analysis of Apple Induced Ripened Banana and Calcium Carbide Induced Ripened Banana

Parameters	Natural ripened Banana (control)		Banana ripened with Apple		Banana Ripened with Calcium Carbide	
	Like %	Dislike %	Like %	Dislike %	Like %	Dislike %
Taste	70	30	90	10	50	50
Flavor	80	20	90	10	64	36
Texture	60	40	80	20	66	34
Firmness	80	20	80	20	56	44
Acceptability	70	30	90	10	66	34

TABLE VI. Ripening Condition of Natural Ripened, Apple ripened And Calcium Carbide Ripened Banana Fruit

Physical properties	Naturally ripening (Control)	Banana ripened with Apple	Banana ripened with Calcium Carbide
Peel color	Yellow with brown spot	Yellow with brown spot	Yellow
Texture	Soft and tender	Soft and tender	Softer and tender
Appearance	Most acceptable	More acceptable	Acceptable

IV. DISCUSSIONS

Peel Color

The color change during the ripening stage, the green color is shown by the unripe banana; fully ripened banana is yellow

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in color with brown color spots in naturally ripened and the apple induced ripened bananas, while the Calcium Carbide ripened became yellow. This result is in agreement with the results revealed by [11].

Vitamin C

Samples A, revealed 26.0 mg/100g vitamin-C content (naturally ripened banana samples) while sample B (the apple ripened banana) revealed 28.0 mg/100g vitamin-C. The remaining samples C, D, E, F and G (ripened with 5 g, 10 g, 15 g, 20 g and 25 g of calcium carbide respectively) revealed decreasing vitamin-C concentration as the concentration of calcium carbide was increasing. These results were similar to the results obtained by [12] where decreasing vitamin C concentration was recorded as calcium carbide concentration was increased.

Sugar Content

The apple ripened banana sample B had the highest sugar content of 12.8% followed by the naturally ripened sample A 12.0%, while the calcium carbide ripened (samples C, D, E, F and G) revealed sugar contents ranging from 12.0% to 10.1% decreasing as concentration of calcium carbide was increased.

Moisture Content

The moisture content in the banana ripened with apple (56.4%) was higher than in the naturally ripened (52.1%). The moisture increased as the concentration of calcium carbide was increased showing moisture contents ranging from 69.2 % to 74.8%. These results are in agreement with the results obtained by [12].

Crude Protein Content

The crude protein content in the banana ripened with apple (8.2) was higher than in the naturally ripened (6.9). The crude protein decreased as the concentration of calcium carbide was increased showing protein contents ranging from 4.1 to 2.9. The study by [12] revealed decreasing crude protein contents as the concentration of calcium carbide was increased.

Crude Fiber Content

The crude fiber content in the naturally ripened banana (4.9) was higher than in the apple ripened banana (3.6). The crude fiber decreased as the concentration of calcium carbide was increased showing crude fiber contents ranging from 4.2 to 3.1.

Texture

In comparison to calcium carbide-ripened banana samples, the change in firmness is greater in naturally ripened banana and apple-ripened banana samples. This may be due to the breakdown of insoluble protopectin to produce soluble pectin, which is then followed by cellular breakdown that may cause membrane permeability. Chemical ripening agents cause the cellular fragmentation of the insoluble protopectin in the samples that were ripened using various doses of calcium carbide, which causes a gradual loss in fruit firmness. [13].

V. CONCLUSION

The peel color change during the ripening stage, the green color is shown by the unripe banana; fully ripened banana is yellow in color with brown color spots in naturally ripened and the apple induced ripened bananas, while the Calcium Carbide ripened banana became yellow. Vitamin-C content in naturally ripened banana samples and the apple ripened banana were higher than those ripened with calcium carbide. And it is further revealed that increase in concentration of calcium carbide resulted in decreasing concentration of vitamin-C. The apple ripened banana samples B had the highest sugar content followed by the naturally ripened banana sample. Calcium carbide ripened samples revealed decreasing sugar content as the concentration of calcium carbide was increased. The moisture content in the banana ripened with apple was higher than in the naturally ripened. The moisture increased as the concentration of calcium carbide was increased in the calcium carbide induced ripened bananas. The crude protein content in the banana ripened with apple was higher than in the naturally ripened. The crude protein decreased as the concentration of calcium carbide was increased in the case of bananas ripened with different concentrations of calcium carbide. The crude fiber content in the naturally ripened banana was higher than in the apple ripened banana. The crude fiber decreased as the concentration of calcium carbide was increased in the case of samples of bananas ripened with calcium carbide. Firmness is greater in naturally ripened and apple-ripened banana samples. The sensory evaluations of naturally ripened banana samples and that of apple ripened were higher than the calcium carbide ripened banana samples. It was observed that banana ripened naturally compared favorably with the bananas ripened with apple without any toxicity, whereas bananas ripened with Calcium carbide are softer, less tasty and have a shorter storage life. The study concluded that apple induced ripened banana compares favourably with natural method of banana ripening as it is faster and do not contain arsenic. The apple induced ripening is a non toxic alternative to calcium carbide induced ripening method of banana.

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