Effect of calcium carbide induced ripening on the vitamin C and mineral composition of banana (Musa acuminata) and papaya (Carica papaya) fruits sourced from Benin city, Nigeria.

Patrick O. Igbinaduwa[1], Uchenna B. Okeke[2], Kimberly C. Dike[1], Ageloisa E. Olohigbe[1]

[1]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Benin, Benin City, Nigeria
[2]Department of Pharmaceutical and Medicinal Chemistry, College of Pharmacy, Afe Babalola University, Ado-Ekiti, Nigeria

Corresponding author: Uchenna B. Okeke
Email: okeke.uchenna@abuad.edu.ng
Phone: +234-8037886318

ABSTRACT

Background: Due to increase in demand of banana fruits, vendors have resulted to hastening the ripening process by subjecting unripe fruits to the action of calcium carbide.

Objectives: The study sought to investigate the possible effect of calcium carbide induced fruit ripening on the vitamin C and mineral composition of banana and papaya fruits.

Methods: Two types of fruits (banana and papaya) were ripened using calcium carbide, while fruits in the control group were allowed to ripen naturally. The vitamin C content of the fruits was determined by iodometric titration; Atomic Absorption Spectrophotometry and Flame Spectrophotometry were used in the determination of mineral elements (sodium, calcium, potassium and magnesium).

Results: The vitamin C content of calcium carbide ripened banana and papaya fruits was found to be 4.5mg/ml and 2.78mg/ml respectively. Vitamin C content was lower in the calcium carbide ripened fruits than in the fruits that were allowed to ripen naturally. The sodium, potassium and magnesium concentrations in the calcium carbide ripened banana and papaya fruits were found to be lower than those of the control. The concentration of calcium in the calcium carbide ripened banana and papaya fruits was found to be lower (5.30±0.01) in the case of papaya and higher (3.05±0.35) in banana fruit when compared with those of the control which ripened naturally.

Conclusion: Artificial ripening causes harmful effects on the body and also affects the nutritional quality of fruits. Thus the use of artificial ripening agents must be strictly monitored and controlled.

Keywords: Vitamin C, calcium carbide, minerals, banana, ripening

Effet du mûrissement induit par le carbure de calcium sur la composition en vitamine C et en minéraux des fruits de la banane (Musa acuminata) et de la papaye (Carica papaya) provenant de Benin city, Nigeria.

Patrick O. Igbinaduwa[1], Uchenna B. Okeke[2], Kimberly C. Dike[1], Ageloisa E. Olohigbe[1]

[1]Département de chimie pharmaceutique, Faculté de pharmacie, Université du Bénin, Benin City, Nigeria
[2]Département de chimie pharmaceutique et médicinale, Collège de pharmacie, Université Afe Babalola, Ado-Ekiti, Nigeria

Auteur correspondant :Uchenna B. Okeke
Courriel : okeke.uchenna@abuad.edu.ng
Tél : +234-8037886318

RÉSUMÉ

Contexte : En raison de l'augmentation de la demande de bananes, les vendeurs ont décidé d'accélérer le processus de maturation en soumettant les fruits non mûrs à l'action du carbure de calcium.

Objectifs : L'étude visait à examiner l'effet possible du mûrissement des fruits induit par le carbure de calcium sur la composition en vitamine C et en minéraux des fruits de banane et de papaye.

Méthodes : Deux types de fruits (banane et papaye) ont été mûris en utilisant du carbure de calcium, tandis que les fruits du groupe témoin ont été laissés mûrir naturellement. La teneur en vitamine C des fruits a été déterminée par titrage iodométrique ; la spectrophotométrie d'absorption atomique et la spectrophotométrie de flamme ont été utilisées pour la détermination des éléments minéraux (sodium, calcium, potassium et magnésium).

Résultats : La teneur en vitamine C des bananes et des papayes mûries au carbure de calcium était de 4,5 mg/ml et 2,78 mg/ml respectivement. La teneur en vitamine C était plus faible dans les fruits mûris au carbure de calcium que dans les fruits que l'on a laissé mûrir naturellement. Les concentrations de sodium, de potassium et de magnésium dans les bananes et les papayes mûries au carbure de calcium étaient inférieures à celles des fruits témoins. La concentration de calcium dans les fruits de banane et de papaye mûris au carbure de calcium s'est avérée plus faible (5,30±0,01) dans le cas de la papaye et plus élevée (3,05±0,35) dans le cas de la banane, par rapport aux fruits témoins qui ont mûri naturellement.

Conclusion : Le mûrissement artificiel provoque des effets néfastes sur l'organisme et affecte également la qualité nutritionnelle des fruits. Ainsi, l'utilisation d'agents de mûrissement artificiels doit être strictement surveillée et contrôlée.

Mots clés : Vitamine C, Carbure de calcium, minéraux, Banane, Mûrissement.

INTRODUCTION

Fruits are common staple foods which supply vitamins (mainly vitamin C or ascorbic acid) and minerals.[1] Fruits also contain considerable quantities of essential nutrients such as sugars, fibres, protein, vitamins, water, cellulose, that protect the body against different diseases, keep a person energetic and produce their wonderful taste and excellent health properties.[2] Fruits contain a high amount of chemically active phytochemicals, in particular phenolic compounds. The consumption of fruits has been linked to a number of health benefits. Eating fruits has also been linked to a decrease in the risk of several diseases.[3]

Banana (Musa acuminata) belongs to the family Musaceae and is an important component of a healthy diet, as it offers great medicinal benefits. Banana aids in the retention of calcium, nitrogen and phosphorus in the body, all of which aid in the building and regeneration of body tissues.[4] Bananas are an excellent source of potassium. A single banana provides 23% of the daily potassium requirement. Potassium helps to maintain the proper functioning of muscles and prevents muscle spasms.[4] Recent studies have shown that potassium can help decrease blood pressure in potassium deficient individuals and it also reduces the risk of stroke.[5]

Papaya or pawpaw (Carica papaya), belongs to the family Caricaceae, is a highly nutritious fruit, and contains a high amount of vitamins and minerals, which contribute to its health benefits.[6] It is high in vitamins, and minerals, such as magnesium, iron, copper and several essential amino acids, and also contains significant amounts of riboflavin, niacin, calcium, phosphorus and Zinc.[6] The leaves have numerous medicinal properties in ethnomedicine.[7]

Ripening is a process which involves structural, physiological and organoleptic changes, making the fruit attractive and edible.[8] Among these changes, the most desirable is textural changes which are important and a major indicator for fruit ripening. These textural changes differ with species where some fruits such as banana, mango, and papaya undergo substantial softening and fruits such as apple normally exhibit less softening.[9] Change in turgor pressure and degradation of cell wall polysaccharides and enzymatic degradation of starch are determinant mechanisms of fruit softening.

Fruit ripening is the initiation of fruit maturity which is a genetically programmed and highly coordinated process of organ transformation from unripe to ripe stage to yield an attractive edible fruit. Ripening is the final stage of development of a fruit which involves a series of physiological and biochemical events leading to changes in colour, flavour, aroma and texture that make the fruits both attractive and tasty.[9] It is an irreversible phenomenon involving a series of biochemical, physiological, and organoleptic changes.[8]

Artificial ripening of fruits with calcium carbide involves application of calcium carbide on the fruits surfaces and then enclosure of the fruits in an airtight environment. Calcium carbide react with water moisture in the air tight environment releasing acetylene gas, which has fruit ripening characteristics similar to ethylene.[10]

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

The reaction of Calcium carbide with water was discovered by Friedrich Wohler in 1862.[11]

Acetylene acts like ethylene and ripens the fruits and vegetables by a similar process. Industrial grade calcium carbide generally contains impurities of arsenic and phosphorus that pose a number of health problems. This is the reason why its use is banned in most of the countries. But because of cheap prices and easy availability, it is still in use in many parts of the world.[12]

Acetylene is believed to affect the nervous system by reducing oxygen supply to the brain. In acute stage, it causes headache, vertigo, dizziness, delirium, seizure and even coma. In the long term, it may produce mood disturbance and loss of memory.[12]

MATERIALS AND METHODS

Mature unripe banana and papaya, were purchased from Uselu market, Benin City, Edo State. Calcium carbide was purchased from Oba market, Ring road, Benin City Edo State.

Experimental design

Sample preparation for the determination of vitamin C

Banana group

Group NB (Natural Banana): Three (3) fruits were placed in an air-tight sack to ripen.

Group CB (Calcium carbide Banana): Three (3) fruits were exposed to calcium carbide. The method of exposure was as described by Igbinaduwa and Aikpitanyi-Iduitua, (2016).[13] This was done by applying the calcium carbide powder (2g/kg weight of fruit) on the surface of the

banana. It was then placed in a polythene sack and the sack was tied up and covered in a plastic container.

Papaya group

Group NP (Natural Papaya): Three (3) fruits were placed in an air-tight sack to ripen.

Group CP (Calcium carbide Papaya): Three (3) fruits were exposed to calcium carbide. The method of exposure was as described by Igbinaduwa and Aikpitanyi-Iduitua, (2016).[13] This was done by applying the calcium carbide powder (2g/kg weight of fruit) on the surface of the papaya. It was then placed in a polythene sack and the sack was tied up and covered in a plastic container.

After a period of thirty six hours, the banana and papaya from the two groups were completely ripe. They were blended with an electric blender with about 50ml of distilled water and kept in distinctly labeled plastic containers for both the naturally ripened papaya and calcium carbide ripened banana and papaya.

Sample preparation for the determination of mineral content

The same method of ripening as described above was applied for the banana and papaya fruits. After a period of thirty six hours, the banana and papaya in the two groups (natural and calcium carbide ripened) were completely ripe. The banana and papaya were carefully peeled and left to air dry for 78 hours and then oven dried at 105°C for three hours for AAS and Flame Spectrophotometric determination of mineral elements.[13]

Determination of vitamin C

Vitamin C (ascorbic acid) concentration was determined by iodometric titration using standardized iodine solution.[14] In this method, ascorbic acid in the fruit reacts with iodine to produce dehydroascorbic acid and iodide ions (Equation (1). Excess iodine then reacts with the starch indicator to produce a violet color and indicate the end point of titration. [14]

$$IO_3 + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$$

$$C_6H_8O_6 + I_2 \longrightarrow C_6H_6O_6 + 2I^- + 2H^+$$

Ascorbic acid dihydroascorbic acid

Determination of mineral composition

The method described by AOAC (2002)[15] was employed for the determination of mineral contents of the fruit samples (banana and papaya). Two grams (2g) each of the dried samples were blended and digested using 20ml of a mixture of concentrated nitric acid and hydrochloric acid in a freshly prepared ratio of 3:1, the mixture was heated slowly until sample dissolved totally to yield a clear sample. Magnesium and calcium composition were determined using an atomic absorption spectrophotometry while Flame spectrophotometry was used for the determination of sodium and potassium contents in the sample.

Statistical analysis

Graph Pad Instat version 2.05 software (UK) was used for the analysis. The values were expressed as mean ± Standard Error of Mean. The data was subjected to Analysis of Variance (ANOVA), and significance accepted at $p>0.05$ level.

RESULTS

The vitamin C content of calcium carbide ripened banana and papaya fruits was found to be 4.5mg/ml and 2.78mg/ml respectively. The Vitamin C content was lower in the calcium carbide ripened fruits than in the natural ripened fruits as shown in Figure 1 below.

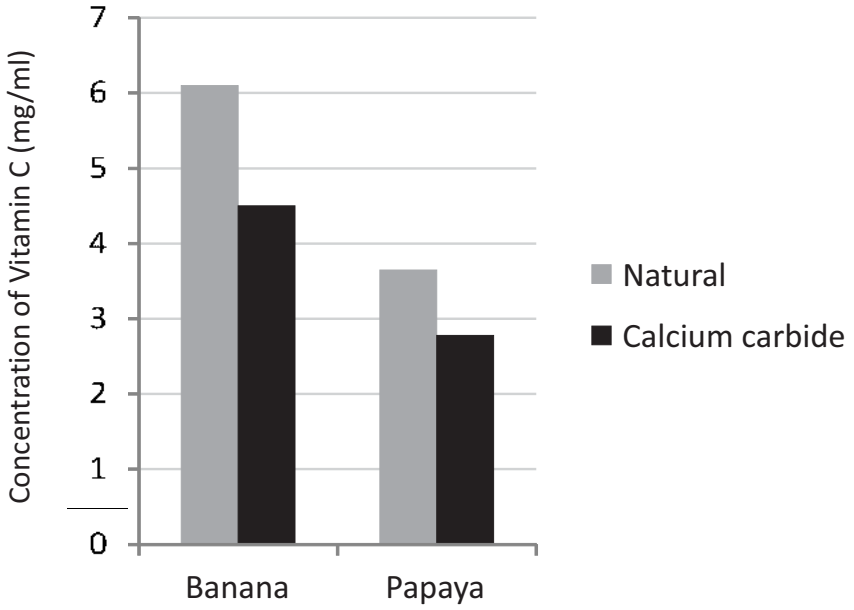

Figure 1: Concentration of Vitamin C in natural and calcium carbide ripened banana and papaya fruits.

Table 1: Mineral composition of calcium carbide and natural ripened banana and papaya fruits

Macro elements	Natural (mg/kg)		Artificial (mg/kg)	
	Banana	Papaya	Banana	Papaya
Sodium	15.35±0.15	37.75±0.85	19.06±1.00	24.55±0.85
Potassium	66.20±0.40	109.65±0.10	80.30±1.00	112.05±0.10
Magnesium	1.75±0.01	0.12±0.85	1.93±0.17	2.04±0.85
Calcium	1.50±0.1	10.01±0.01	3.05±0.35	5.3±0.01

DISCUSSION

The changes in vitamin C and mineral contents of calcium carbide ripened banana and papaya fruits were investigated in this study. The results showed a substantial difference in vitamin C and some mineral elements in the calcium carbide ripened banana and papaya fruits samples.

From the study, it was shown (Table 1) that the vitamin C content was lower in calcium carbide ripened banana and papaya fruits. Adeyemi *et al* (2018)[16] reported higher level of vitamin C in naturally ripened papaya than in calcium carbide ripened papaya at 50mg/g and 45.21mg/g respectively. Lee and Kader (2000)[17] reported that the vitamin C content of papaya increases during natural ripening than in artificially induced ripened fruits. The result of the study shows that calcium carbide inhibits the production of vitamin C.

For sodium, the sodium level in the calcium carbide ripened banana and papaya fruits were found to be lower than those of the control (Table 1). This shows that there are higher levels of sodium in natural ripened banana and papaya fruits. When compared with previous studies, the result obtained on the sodium content observed in this study was lower. Iroka *et al* (2016)[18] reported higher sodium content which was 7.810±0.014 in calcium carbide ripened papaya. Sodium is the main cation outside cells and one of the primary electrolytes

responsible for maintaining fluid balance.

From the study, the concentration of calcium in the calcium carbide ripened banana and papaya fruits was found to be lower (5.30±0.01) in the case of papaya and higher (3.05±0.35) in banana fruit when compared with those of the control which ripened naturally. The result did not agree with the works of Iroka et al (2016)[18] which reported higher calcium content in calcium carbide ripened papaya than in natural ripened papaya. Studies by Myat *et al* (2016)[19] on natural ripened papaya and ethephon ripened papaya showed higher calcium level in naturally ripened papaya at 48.78 mg/L than in ethephon ripened papaya at 34.69mg/L and 46.76mg/L (for dipping and touching respectively). It is thus more beneficial to consume natural ripened fruits such as papaya as high calcium levels is needed in formation of healthy teeth and bones. Consumption of calcium carbide ripened papaya will result in a deficiency of calcium in the body, as observed in this study.

The result further revealed that Potassium and magnesium levels of calcium carbide ripened banana and papaya were higher. This was similar to results obtained from Iroka et al (2016)[18] which correlated high level of potassium and magnesium in calcium carbide ripened papaya. High level of potassium in the body was reported to increase iron utilization[20] and beneficial to controlling hypertension through body fluid regulation.[21]

CONCLUSION

Banana and papaya contain several important essential nutrients that provide the body with high amount of energy and vitality. Most fruits are readily available and affordable in the market. It can be concluded that ripening of fruits with deleterious ripening chemicals used by fruit sellers affects the nutrient contents. Some of the traders have little or no knowledge about the harmful effects of using such chemicals. The reduced vitamin C content as observed in the study in artificially ripened banana and papaya fruits is a source of worry and health concern. The use of artificial ripening agents must be strictly monitored and controlled. Consumer protection agencies and organizations should as a matter of urgency create awareness on the part of buyers to avoid consuming artificial ripened fruits.

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