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Effects of Postharvest Ripening by Calcium Carbide on Mango and Pineapple

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Abstract

The experiment was carried out to determine the effect of applying calcium carbide as a ripening agent on mango and pineapple. The study was performed in the laboratory of the department of Applied Food Science and Nutrition, Department of

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Food Processing and Engineering, Department of Applied Chemistry and Chemical Technology of Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh. Selected mango and pineapple were divided into two experimental groups namely control (non-treated) and ripened by calcium carbide. Calcium carbide treated fruits ripen quickly with attractive surface color and had shorter shelf life than non-treated fruits (control). Physico-chemical properties including total soluble solid was found higher amount and titratable acidity lower in amount significantly ($P<0.05$) in treated group (15±0.02°B and 0.32±0.04% respectively in mango; 11±0.00°B and 0.59±0.04% respectively in pineapple) than control (14±0.57°B and 0.68±0.01% respectively in mango; 9±0.57°B and 0.81±0.03% respectively in pineapple). Moisture content also observed significantly ($P<0.05$) higher amount in carbide ripened fruits (83.18±0.47g/100g in mango; 88.59±0.43g/100g in pineapple) than non-treated (79.37±0.54g/100g in mango; 87.05±0.65g/100g in pineapple). But significantly lower amount of carbohydrate, ash, crude fibre were recorded in artificially ripened fruits by carbide than naturally ripened. Apparently protein and fat content were found insignificantly less amount in artificially ripened mango and pineapple. The significant lower concentration of vitamin C and β-carotene were observed in calcium carbide ripened mango (19.76±0.12mg/100g; 400±1.1μg/100g respectively) and pineapple (33.94±0.09mg/100g; 26.93±0.09μg/100g respectively). Sodium, potassium and magnesium contents also found fewer amounts in carbide ripened than control fruits except calcium content. Therefore, fruits those were ripened with calcium carbide indicated less nutritional quality than untreated samples.

Keywords: Calcium carbide; mango; pineapple; ripening time; shelf life; physico-chemical parameter; nutritional quality.

1. INTRODUCTION

Bangladesh is a tropical country with many fruit varieties throughout the year. About 5,018 thousand metric tons of fruit are produced each year in Bangladesh [1]. Being a part of balanced diet, fruits play a vital role in human nutrition by providing the necessary growth regulating factors essential for maintaining normal health. Increasing consumption of fruits and vegetables significantly reduces the incidence of chronic diseases such as cancer, cardiovascular disease and other age related diseases. Polyphenols, carotenoids (provitamin A), vitamin C and E present in fruits have antioxidant activity, eliminates free radicals and play an important role in the prevention of many diseases [2]. Small amounts of micronutrients (minerals and vitamins) are necessary for good physical condition along with energy, fat and protein. Many of the bioactive compounds also give colour to plant foods and, therefore, especially coloured varieties of fruits and vegetables are recommended. As a result of this and other initiatives, people are becoming aware of the nutritional and health benefits of fresh fruit and vegetables [3].

Mango is one of the most popular fruits due to its delicacy, pleasant aroma and nutritional composition. It is also known as "the king of all fruits". It is the second most important tropical fruit in the horticulture sector in the world [4]. The energy value per 100g of mango is 250 kj (60 kcal). Fresh mango contains a variety of nutrients but only vitamin C and folate are found in significant amounts of daily value, at 44% and 11%, respectively [5]. It is a good source of ß-carotene which accounts for the yellow-orange colour of mango [6]. In Bangladesh 12,88,315 metric tons mango is produced with in an area of 61,997 acres [1].

Pineapple is the main edible component of the Bromeliaceae family now known botanically as *Ananas comosus*. It has now grown in almost all Bangladesh districts, although Sylhet, Tangail, Dhaka and Rangamati have a more cultivated area. Approximately 33,687 hectares of land are now grown in pineapples with a total production of around 2,11,833 tons [1]. It is a good source of nutrients (water, carbohydrate, sugar, vitamin A, vitamin C, ß-carotene) [7]. However, it is a source of several unique compounds that are essential for optimal health. It contains Bromelain, a proteolytic enzyme that digests food by breaking down proteins [8].

Natural fruit ripening is a combination of physiological, biochemical and molecular processes. It involves coordination of different metabolisms with activation and deactivation of various genes which leads to changes in colour, sugar content, acidity, texture, and aroma volatiles [9]. Ethylene increases the intracellular levels of certain enzymes in fruit [10].

Artificial ripening is done to obtain a more rapid and uniform maturation. The use of calcium carbide as an artificial ripening agent for fruit ripening has been known for many years [11]. The ripening agents increase the speed of the ripening process. In the artificial ripening of the fruits, calcium carbide is used as a source of acetylene which is an artificial ripening agent similar to ethylene, the natural ripening agent [12]. Quick ripening fruits contain harmful properties because calcium carbide contains traces of arsenic and phosphorus and the production of acetylene has a dangerous effect on humans. It affects the neurological system by inducing prolonged hypoxia that causes headaches, dizziness, mood disorders, drowsiness, mental confusion, loss of memory, cerebral edema and convulsions [11].

Food safety is essential to maintain nutrition, combat food or waterborne diseases. It is important to maintain food quality and stop food adulteration, which is rampant in Bangladesh [13]. Fruits treated with ripening agent contain lower nutritional quality and their dangerous effect increases the weight of health in society. It has longstanding impact on economic development of a country [14]. To combat these unexpected situations the studies on the effects of ripening agents on nutritive values of selected fruits and vegetables are demand of current instances. This research was conducted to determine the effects of calcium carbide on the changes of ripening time, shelf life, physico-chemical properties and nutritional composition (moisture, carbohydrate, protein, fat, ash, crude fibre, vitamin and mineral content) in mango and pineapple.

2. MATERIAL AND METHODS

2.1 Collection of Sample

Mango and Pineapple were freshly collected from Rajshahi, Rangamati and local areas such as Anowara, BARI (Bangladesh Agricultural Research Institute), Oxygen areas of Chattogram and transported to the laboratory for analysis.

2.2 Experimental Design

The experiment was organized in completely randomized design (CRD). Selected fruits were divided into two experimental groups namely control (non-treated) and ripened by calcium carbide. Each experiment was replicated for three times.

2.3 Pre-treatment of Samples

The skin (body) of fruits were washed gently with distilled water and then cleaned properly with cotton cloth to remove dust, adhered particles and different types of agricultural chemicals. Then these fruits were stored in a cool and dry place.

2.4 Treatment by Calcium Carbide

Selected mature mango and pineapples were packed in cardboard boxes with newspaper as cushioning material. Each box was packed with calcium carbide 1g/kg in a small paper pouch which was kept in the cardboard/cartoon in the center [15].

2.5 Analysis of Ripening Time

To record the ripening time, mango and pineapple were daily observed for their colour and the time (days) required to reach light yellow to 60% - 90% fully yellow for mango and pineapple [16].

2.6 Analysis of Shelf Life

The shelf life was estimated by counting the days necessary to reach the last stage of ripening of fruits but up to the stage when the fruits were still acceptable for marketing [16].

2.7 Analysis of Physicochemical Parameter

2.7.1 Determination of total soluble solid (TSS)

The total soluble solid (TSS) content of fruit pulp was recorded by using a portable refractrometer. A drop of pulp solution was placed in the prism. The percentage of TSS was observed from direct reading of the refractrometer through the eyepiece of the refractometer. The readings were corrected for temperature changes at 20°C and the results were expressed in °Brix (°B) [17].

2.7.2 Determination of titratable acidity

A known weight of the minced fruit sample was taken in a 100 ml volumetric flask and the volume was completed by adding distilled water and filtered. After filtration, 10 ml of the filtrate were taken in a separate flask and then titrated against 0.1 N of sodium hydroxide. Percentage of titrable acidity was calculated by using the following formula [17]

$$\text{Titratable acidity \%} = \frac{\text{Eq. wt of acid} \times \text{Normality of NaOH} \times \text{Volume made up} \times \text{Titre value}}{\text{wt of sample} \times \text{Volume of extract taken} \times 1000} \times 100$$

2.8 Analysis of Nutritional Composition

2.8.1 Determination of Proximate composition

The moisture content, protein, fat, ash, crude fibre of the experimental groups was measured in triplicate using the standard AOAC methods [18]. The moisture was measured by drying into hot air oven at 105°C to constant weight, crude protein content by following the Kjeldahl procedure (6.25 × N), total fat content by the extraction of ether using the Soxhlet system, ash content by incineration at 550°C to constant weight and crude fibre content was measured by digesting the sample. Carbohydrate content were calculated by difference method i.e

%Carbohydrate = 100 - (%Moisture + %Protein + %Fat + %Ash +%Fiber)

2.8.2 Determination of Mineral

Sodium (Na) and potassium (K) content were determined by using flame photometric method [19]. Sodium and potassium that present in fruit sample solution was atomized into an oxy-hydrogen flame that exits atoms of sodium or potassium and causing them to unit radiation to specific wavelength. The amount of radiation emitted is measured on a flame photometer, under standard condition which is proportional to the concentration of sodium or potassium in sample. Calcium (Ca) and magnesium (Mg) content were analyzed by using titrimetric method as described by Rangana [17].

2.8.3 Determination of Vitamin C

Vitamin C was determined by using UV visible spectrophotometric method, as described by Rahman et al. [20]. In this method, by the action of bromine solution ascorbic acid is oxidized to dehydroascorbic acid and then L-dehydroascorbic acid reacts with 2,4-dinitrophenylhydrazine (2,4-DNPH) and produces an osazone which on treatment with 85% H_2SO_4 forms red colored solution whose absorbance was taken at 521 nm.

2.8.4 Determination of β-Carotene

ß-carotene was analyzed by UV-spectrophotometric method. UV absorption was performed in a range of 200-800 nm on a UV-Visible spectrophotometer, as described by Karnjanawipagul et al. [21].

2.9 Statistical Analysis

Data collected in this study was analyzed by using MS Excel, 2007 and SPSS (Statistical Package for the Social Sciences) version 22.0 software. *P* value was used to understand the significant difference of all parameters. The level of significance was set at $P<0.05$.

3. RESULTS AND DISCUSSION

3.1 Effect of Calcium Carbide on Physical Changes in Mango and Pineapple

Naturally ripened mango and pineapple contained dark spots and greenish yellow colour but carbide treated mango and pineapple had less dark spots on peel. Uniform colour was appeared at the carbide treated mango and pineapple than control. Fresh physical appearance and colour of carbide treated mango and pineapple were more perceptible than those of naturally ripened. Artificial ripening agents provide more acceptable colour in fruits than naturally ripened fruits [14].

3.2 Effect of Calcium Carbide on Ripening Time and Shelf Life in Mango and Pineapple

Significant differences *(P*<0.05) were observed in ripening time and shelf life of mango and pineapple those were ripened artificially with calcium carbide than those were ripened naturally. Effect of calcium carbide on ripening time and shelf life of mango and pineapple has been graphically represented in figure 1 and 2.

3.2.1 Ripening time

The period of ripening is usually determined by the change in color of the mango and pineapple peel. For mango control took 6 days while carbide treated mango ripened in 3 days. In case of pineapple, control ripened within 7 days where carbide treated took 2 days to ripe. Both carbide treated mango and pineapple ripened earlier than control group. When calcium carbide comes in contact with moisture in the atmosphere, it produces acetylene gas, which accelerates the ripening process. This result agrees with most research work in literature that ripening agents do accelerate ripening faster than when done naturally [14, 22, 23, 24].

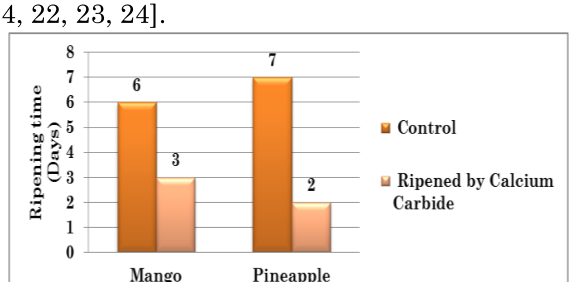

Figure 1: Comparison on ripening time (days) between control and calcium carbide treated fruits

3.2.2 Shelf life

Application of CaC_2 as a ripening agent affects hardly on the shelf life of fruits [25]. According to the observation, the shelf life of control mango and carbide treated mango were 10 days and 8 days respectively. In case of control and carbide treated pineapples the shelf life were 13 days and 6 days respectively. It showed that control group or naturally ripened fruits had higher shelf life than carbide treated fruits. Similar results were reported in pear [25]. The artificial ripening agent is responsible for a faster rate of respiration in the fruits, which causes excess softening and deterioration of the fruit [26] and, therefore, a reduced shelf life in the fruits treated with carbide.

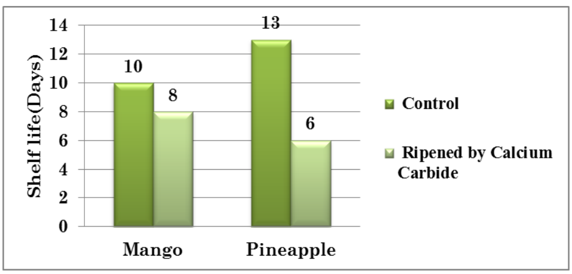

Figure 2: Comparison on shelf life (days) between control and calcium carbide treated fruits

3.3 Effect of Calcium Carbide on Physicochemical Parameter in Mango and Pineapple

In the present study, the TSS and titratable acidity content of control mango and carbide treated mango as well as control pineapple and carbide treated pineapple was represented at table 1.

3.3.1 Total soluble solid content

Total soluble solid (TSS) content of mango and pineapple pulp varied significantly (P<0.05) in control and calcium carbide treated. The calcium carbide treated fruits recorded higher TSS content (15±0.02°B in mango, 11 ±0.00°B in pineapple). The control fruits recorded the lower TSS content (14±0.57°B in mango, 9 ±0.57°B in pineapple). TSS content is higher at carbide treated fruits than control fruits. During ripening, organic solutes concentrates as a consequence of water loss; Starch and other polysaccharide hydrolyzed into soluble form of sugar [27]. So TSS content increased at the ripening stage. Higher TSS indicates more ripeness of fruits [28].

3.3.2 Titratable acidity content

Titratable acidity of mango and pineapple was recorded to be maximum (0.68±0.01% in mango, 0.81±0.03% in pineapple) in control groups. The minimum acidity was found in the carbide ripened fruits (0.32±0.04% in mango, 0.59±0.04% in pineapple). Titratable acidity content was significantly (*P* <0.05) decreases in carbide treated mango and pineapple than control. During the fruit ripening process, the organic acid is utilized in the pyruvate decarboxylation reaction [29]. So titratable acidity may be reduced.

Table 1. Comparison on physicochemical parameter between control and calcium carbide treated fruits

Sample	**Variable**	**Control**	**Ripened by CaC_2**	***P*-value**
Mango	TSS (°B)	14 ±0.57	15±0.02	0.017*
	Titratable acidity (%)	0.68 ±0.01	0.32±0.04	0.000*
Pineapple	TSS (°B)	9±0.57	11 ±0.00	0.007*
	Titratable acidity (%)	0.81±0.03	0.59 ±0.04	0.002*

**Statistically significant at 5% level*
Results are means ± standard deviation (SD) of triplicate

3.4 Effects of Calcium Carbide on Nutritional Composition of Mango and Pineapple

Effects of calcium carbide on nutritional composition of mango and pineapple were presented in table 2.

3.4.1 Proximate composition

The moisture content was found higher in mango and pineapple those were artificially ripened after the treatment by calcium carbide; other proximate compositions were found lower in calcium carbide treated mango and pineapple. The results were significant (*P*<0.05) for the moisture, carbohydrate, ash and crude fibre in mango and pineapple ripened by the calcium carbide.

Moisture content in carbide ripened mango and pineapple were recorded higher in amount than control fruits. Moisture content in pulp is observed to increase because of respiratory breakdown of starch to sugar, migration of water from peel to pulp and excess moisture formation [14, 30, 31]. The high moisture content of fruits contributes to its short storage life and high post harvest loss of fruits. The protein content of the control or naturally ripened mango was 0.36±0.01 g/100g. This reduced in calcium carbide ripened mango was

0.34±0.01 g/100g. In case of naturally ripened pineapple, the protein content was 0.51±0.02 g/100g that was reduced into 0.50±0.01 g/100g in carbide treated pineapple. Similar results of protein content were observed in mango [22], banana [24, 32, 33] and pineapple [34]. Sogotomi et al. [32] revealed that naturally ripened banana contains 3.68% protein that reduces into 1.25% in carbide treated banana. Reduction in the protein content in fruits during ripening which may be due to reduction of nitrogen [24].

The carbide treated fruits recorded lower carbohydrate content than non treated. Similar observations also found in banana [32]. Biochemical changes occurring during ripening is responsible for lower carbohydrate content in carbide treated fruits. The starch is degraded by starch degrading enzymes α and β amylases which convert starch to simple sugars [24, 31].

Fat, ash and crude fibre content in control or naturally ripened mango and pineapple was found higher in amounts in control samples than carbide treated samples. Similar findings also found in banana [33] and pineapple [34].

3.4.2 Mineral content

The analysis of data revealed that application of artificial ripening agent calcium carbide lowers the mineral content in mango and pineapple than naturally ripened. The content of sodium, potassium, and magnesium were lower amount in carbide treated mango and pineapple than control samples. Similar observation was recorded in pear [25], banana [31] and pineapple [34]. Fruits ripened by artificial ripening agents contain less mineral contents then naturally ripened fruits [25].

Calcium concentration increased in carbide treated mango and pineapple. The results were significant ($P<0.05$) for both mango and pineapple. Similar results were observed in pineapple [34].

3.4.3 Vitamin C and β-carotene content

Results reflected that non treated control group contained the highest quantity of vitamin C (26.44±0.42 mg/100g in mango, 36.72±0.07 mg/100g in pineapple) while the artificially ripened fruits by calcium carbide contained the lowest quantity of vitamin C (19.76±0.12 mg/100g in mango and 33.72±0.07 mg/100g in pineapple). Vitamin C was decreased significantly ($P<0.05$) in mango and pineapple after ripened artificially by calcium carbide. Similar results also found in mango [22] and pineapple [34].

In this research ß-carotene content were 412±2.0 µg/100g and 400±1.1 µg/100g respectively in naturally ripened and artificially ripened mango. In case of pineapple, ß-carotene content was found that 28.48±0.39µg/100g in naturally ripened and 26.93±0.09 µg/100g in carbide treated pineapples. The findings in this study is in consonance with the results were observed in pineapple, banana and tomato [14]. The decrease in the ascorbic acid and ß-carotene content may be due to the lower synthesis of some metabolic intermediary substances which contributed to the synthesis of the precursor of ascorbic acid and ß-carotene [35]. Application of calcium carbide in fruits may be interrupted the synthesis of these metabolic intermediary substances.

Table 2. Comparison on nutritional composition between control and calcium carbide treated fruits

Sample	Variable		Control	Ripened by CaC_2	*P* value
Mango	Proximate composition (g/100g)	Moisture	79.37±0.54	83.18 ± 0.47	0.001*
		Protein	0.36 ± 0.01	0.34±0.01	0.350
		Fat	0.26±0.01	0.24± 0.02	0.219
		Carbohydrate	19.51±0.52	15.51±0.19	0.000*
		Ash	0.47±0.04	0.38±0.02	0.024*
		Crude fibre	1.66± 0.02	1.59± 0.01	0.013*
	Mineral content (mg/100g)	Sodium	1.92±0.09	0.87±0.04	0.000*
		Potassium	151.44±0.49	148.81±.33	0.003*
		Calcium	10.31±0.46	11.47±0.38	0.028*
		Magnesium	0.25±0.19	0.04±0.01	0.139
	Vitamin C (mg/100g)		26.44±0.42	19.76±0.12	0.000*
	ß-carotene (µg/100g)		412±2.0	400±1.1	0.001*
Pineapple	Proximate composition (g/100g)	Moisture	87.05± 0.65	88.59± 0.43	0.028*
		Protein	0.51±0.02	0.50± 0.01	0.422
		Fat	0.08±0.04	0.04 ±0.03	0.341
		Carbohydrate	12.30±0.73	10.58±0.44	0.026*
		Ash	0.22±0.05	0.09±0.06	0.046*
		Crude fibre	1.34±0.01	1.29±0.01	0.007*
	Mineral content (mg/100g)	Sodium	1.04±0.04	0.89±0.06	0.231
		Potassium	108.17±0.40	105.40±0.41	0.001*
		Calcium	12.45±0.38	13.49±0.36	0.027*
		Magnesium	11.61±0.34	11.12±0.44	0.205
	Vitamin C (mg/100g)		36.72±0.07	33.94±0.09	0.000*
	ß-carotene (µg/100g)		28.48±0.39	26.93±0.09	0.003*

4. CONCLUSION

This study revealed that, selected mango and pineapple ripened with calcium carbide provides attractive uniform color, quick ripening time but lower shelf life. Physicochemical parameters also varied in carbide ripened fruits and control group. Most of the nutrients are significantly found in low in amount in carbide treated fruits. Apart from this, artificially ripened fruits by calcium carbide have poor nutritional quality as compared to naturally ripened fruits. Furthermore, artificially ripened fruits are most harmful for human beings. Governmental and non-governmental authorities should take appropriate measures to stop this unhealthy practice of using calcium carbide as artificial ripening agent in fruits.

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