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Research Article

DETERMINATION OF THE SHELF LIFE AND THE RESIDUAL EFFECT OF CALCIUM CARBIDE OF THE SAMPLED FRUITS CULTIVATED IN TELANGANA, INDIA

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A B S T R A C T

This study was carried out to determine the effects of calcium carbide as a fruit ripening agent where calcium carbide was administered to 15 samples [mango (M1-M3), citrus (C1-C3), banana (B1-B3) guava (G1-G3), and papaya (P1-P3)] at three different concentrations (1 g/kg, 5 g/kg and 10 g/kg of calcium carbide per kilogram of fruit) and control (0 g/kg). The results obtained revealed that calcium carbide is a very good ripening agent with a ripening time of 2 days (48 hours) among all the fruits (mango, citrus, banana, guava and papaya at 10 g/kg). The proximate analysis of the fruits indicated that the administration of calcium carbide may result in the increase of some food contents such as ash C3 (10 g/kg) 10.50%, fibre C3 (10 g/kg) 4.20%, and lipid C3 (10 g/kg) 12.68% while the moisture C3 (10 g/kg) 78.25%, Vitamin C C1 (10 g/kg) 78.25%, protein G1 (1 g/kg) 7.60% and carbohydrate G1 (1 g/kg) 52.97% were found to decrease with increased calcium carbide administration. The moisture, vitamin C, and protein contents of the fruits showed that calcium carbide administration results in reduction of these nutrients, while the administration of calcium carbide resulted in increased of ash, fibre and lipids in the fruits studied. These results showed that even though calcium carbide may have significant fruit ripening ability, it also causes significant reduction in the fruit nutrients for the Telangana people.

INTRODUCTION

Fruits are the naturally occuring staple food of humans. They contain considerable quantities of essential nutrients in a major proportion prevent diseases and keep a person energetic throughout his life. Fruits contain high amounts of chemically active compounds in particular phenolic compounds. They also contain polysaccharides, sugars, vitamins, minerals and organic acids which provide their wonderful taste and excellent health properties. The presence of antioxidants and other biologically active ingredients in fruits makes them effective in treatment of numerous diseases [1].

Fruits are an excellent source of essential vitamins and minerals, and they are high in fiber. Fruits also provide a wide range of health-boosting antioxidants, including flavonoids. Eating a diet high in fruits and vegetables can reduce a person's risk of developing heart disease, cancer, inflammation, and diabetes.

Quality of fruit includes nutritional properties (for example, vitamins, minerals, dietary fiber) and health benefits (for example, antioxidants) and these are attractive factors in consumer preferences. Fruits and vegetables are wealthy sources of phytochemicals, which are known as potentially bioactive compounds. Research exposed that the health promoting factors of fruits are due to the additive and synergistic combinations in a complex mixture of phytochemicals, a lot of them possessing strong antioxidant capacity including ascorbic acid, flavonoids, carotenoids, and others. Fruits include many structures that are not commonly considered as "fruits", such as bean pods, tomatoes and wheat grains. The section of a fungus that produces spores is also called a fruiting body [2] Fruits are widely distributed in nature, commercially important and nutritionally indispensable food commodity. Fruits also play a vital role in human nutrition by supplying the necessary growth regulating nutrients essential for maintaining normal health. They are the seed-bearing structures in flowering plants (also known as angiosperms) formed from the ovary after flowering. Edible fruits, in particular, have propagated with the movements of humans and animals in a symbiotic relationship as a means for seed dispersal and nutrition; in fact, humans and many animals have become dependent on fruits as a source of food. Accordingly, fruits account for a substantial fraction of the world‟s agricultural output. In the process of hastening fruit ripening, chemicals and ripening agents are used by retailers

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and farmers in most developing countries such as India, Bangladesh, Pakistan, Ghana, Cameroon. Natural taste and nutritional value becomes a casualty of the process. The fast ripening of fruits means they may contain various harmful substances [3].

Calcium carbide is a commonly used agent in the ripening process of fruits, though it is primarily used in welding purposes. Calcium carbide for the treatment of food is considered extremely hazardous, because it contains traces of heavy metal arsenic and phosphorous. Acetylene gas may affect the neurological system by inducing prolonged hypoxia. Calcium carbide causes various health hazards like, headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral oedema and seizures. Other commonly used ripening agents are acetylene, ethylene, propylene, ethrel (2-chloroethylphosphonic acid), glycol or ethanol.

The main objective of this paper is to determine the shelf live and the residual effect of calcium carbide as an artificial ripening agent on the quality (moisture, lipid, vitamin C e.t.c) of the sampled fruits viz; mango, citrus, banana, guava and papaya fruits.

MATERIALS AND METHODS

Study Area

The samples were collected at Triangle farms, Hyderabad, Telangana, India.

Sample Collection and Preparation

Fifteen (15) samples consisting of green but matured unripe mango, citrus, banana, guava and papaya were collected from Triangle farms, Hyderabad, Telangana, India. These samples were washed with clean water, dried, weighed and kept in clean polyethylene bags before treatment with calcium carbide to induce the ripening process as described by [4]. The calcium carbide was obtained from fruit sellers in Railway Station market, secunderabad. The core of the fruits was cut into small pieces. After that, the fruits were dried in a hot-air oven operated at 50 °C until the mass of the fruits became constant. The dried fruits were pulverized using a mixer grinder [5]. The pulverized fruits (mango, citrus, banana, guava and papaya fruits) were divided into four parts through random sampling and then subjected to three levels of calcium carbide treatment concentrations of 1 g/kg, 5 g/kg and 10 g/kg of fruits/calcium carbide to induce ripening and the fourth group served as the control (0 g/kg).

Artificial Ripening of Fruits, Ripening Time and Shelf Life

The calcium carbide was weighed using a weighing balance (Mettler AE 166 model) and divided into the weight requirement of each treatment group (1 g/kg, 5 g/kg, 10 g/kg and 0 g/kg calcium carbide per fruit) and then wrapped in a paper and kept at the bottom of a plastic container. The fruits (mango, citrus, banana, guava and papaya) were packed according to treatment and covered tightly with a newspaper to prevent leakage of the acetylene produced. The calcium carbide was then moistened with a drop of water before placing the fruits in the container to release the gas. After 24 hours, the packets of calcium carbide were removed from the containers, and the fruits were uncovered and allowed to ripen. The fruit ripening time was measured as the time it took the whole fruits (mango, citrus, banana, guava and papaya) to change colour from green to yellow [6]. The shelf life of the fruits was determined as described by [7] and calculated as the period (in days) after ripening and the commencement of spoilage (appearance of shrinkage, wrinkles and discolouration). Equation 1 gives summary of the reaction between calcium carbide and water.

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g) \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Proximate Analysis

After the fruits (mango, citrus, banana, guava and papaya) in the various treatment groups have ripened, their nutrition contents were analyzed using proximate analysis which include determination of moisture, ash, lipid, protein, fibre, carbohydrates and vitamin C contents of the fruits.

Determination of Moisture Content

For each of the fruits samples (mango, citrus, banana, guava and papaya), 2 g was weighed into a crucible and heated at 105^0C until a constant weight was attained. The moisture content was then calculated as loss in weight of the original sample and expressed as percentage moisture content [8].

$$\%\ Moisture = \frac{W2-W3}{W2-W1} X\ 100$$

Where:
W1 = initial weight of empty crucible
W2 = weight of crucible +sample before drying
W3= final weight of crucible + sample after drying

Determination of Ash Content

For the ash content determination, 2 g of each sample (mango, citrus, banana, guava and papaya fruits respectively) was weighed into a crucible and burnt in a muffle furnace at 600^0C for two hours to ensure complete ashing. The crucible was then removed, cooled in a desiccator and reweighed. Repetition of the ashing process was done to obtain a constant weight [8] after which the percentage ash content was calculated as follows:

$$\%ash\ content = \frac{W3-W1}{W2-W1} \times 100$$

Where:
W3= weight of crucible + ash
W1 = weight of crucible
W2= weight of sample before ashing

Determination of Lipid Content

A round bottom flask (250 mL) was dried in an oven at 105 oC, cooled and weighed after which 2 g of each fruit (mango, citrus, banana, guava and papaya) was wrapped in a clean white handkerchief and then placed in the thimble holder of a soxhlet apparatus. The thimble with its content was then connected to the soxhlet extraction column with water passing through condenser inlet and outlet. 200 mL of extracting solvent (n-hexane) was transferred into the flask fitted on the extracting unit and the whole setup was heated with heating mantle for 6 hours [9]. The solvent was recovered by distillation and oil obtained was weighed to obtain the percentage crude fat by the formula below:

$$\%\ Crude\ Fat = \frac{Weight\ of\ oil\ in\ gm}{Weight\ of\ sample\ in\ gm} \times 100$$

Determination of Protein Content

Using the Kjedahl method, 2 g of each fruit sample (mango, citrus, banana, guava and papaya) was heated in 25 mL concentrated H_2SO_4 in a 250 mL conical flask in the presence of a selenium catalyst and an anti-bumping agent. The mixture was heated until all the carbon and hydrogen were oxidized (indicated by clear solution). The nitrogen at this stage was also reduced and transformed into ammonium sulphate. The sample solution was transferred into 100 mL volumetric flask and topped up to the mark with distilled water. 25 mL of 2 % boric acid was transferred into a 250 mL conical flask and two drops of phenolphthalein indicator was added. The conical flask and its content were placed under a condenser with the tip completely immersed in the solution. 10 mL of the digested sample solution and 18 mL of 40 % NaOH were transferred into the steam jacket and the stopcock of the funnel was closed to drive the liberated ammonia into the collection flask. The boric acid then changed to bluish-green on contact with ammonia. The flask was removed and the content titrated against 0.1M HCl using phenolphthalein indicator to detect the end point (colourless) in duplicate. A blank was prepared using the same amount of all reagents to correct for traces of nitrogen in the reagents [8].

Percentage total nitrogen in the fruit samples was calculated as follows:

%N=(Va-Vb)x Ma x MN x 100 \ 1000cm3 x W
Where:

Va = volume in mL of standard acid used in titration
Vb = volume in mL of standard acid used in blank titration
Ma = Molarity of acid (HCl)
W = weight in gram of sample
MN = Molar mass of Nitrogen= 14.007 g/mol

On the basis of early determinations, the average nitrogen (N) content of proteins was found to be about 16 percent, which led to use of the calculation N x 6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content.

The protein content of the fruits was calculated from the formula below:

% protein = F × % total nitrogen (F = 6.25)

Determination of Fibre Content

In the determination of the fibre content, 5 g of each fruit was defatted by placing the fruit sample in a soxhlet apparatus and heated for 2 hours with n-hexane as solvent. 2 g of each defatted fruit sample (mango, citrus, banana, guava and papaya) was transferred to 250 mL conical flask after washing and drying and then boiled with 200 mL of 1.25 % (H^2SO^4) solution over a hot plate for 30 minutes. The sample solution was immediately filtered on linen cloth and washed with distilled water until the washings were no longer acidic (using pH meter). The sample was then returned to the heating mantle and boiled with 1.25 % NaOH solution. The boiled fruit sample was washed with 15 mL ethanol then transferred into a dried crucible and heated in an oven at 105^0C for one hour. The dried fruit sample was then ashed for 30minutes at 550^0C in the muffle furnace. The ash was then cooled in a desiccator and reweighed [8]. The loss in weight represents the content of fibre as calculated below:

$$\% \text{ Crude Fibre} = \frac{\text{Loss of weight after final ashing}}{\text{Weight of sample before defatting}} \times 100\%$$

Determination of Carbohydrate Content

The carbohydrate content of the fruit samples (mango, citrus, banana, guava and papaya) was determined by subtracting the summed up percentage compositions of moisture, protein, lipid, fibre, and ash contents from 100 [8].

%Carbohydrate = 100 – (%Protein + %Moisture + %Ash + %Fibre+ % + Lipid%)

Determination of Vitamin C Content

In the determination of the vitamin C content of the fruits in this study, iodometric titration with reference to a standard ascorbic acid solution was used as described by [10]. The mass vitamin C in sample was calculated using the formula below
Mass of vitamin C in sample=Mass of Standard Vitamin C × Titre value of Sample/Titre value of Standard vitamin c

RESULTS AND DISCUSSIONS

Table 1 Ripening Time of Artificially Ripened mango, citrus, banana, guava and papaya with Calcium Carbide at Different Inclusion Levels.

Samples	Conc.(gm)	Ripening time (days)	Shelf life (days)
M	**Control**	**7**	**15**
M1	1	2	8
M2	5	2	6
M3	10	2	7
C	**Control**	**6**	**18**
C1	1	2	10
C2	5	2	8
C3	10	2	8
B	**Control**	**5**	**11**
B1	1	3	5
B2	5	2	5
B3	10	2	5
G	**Control**	**10**	**20**
G1	1	5	10
G2	5	4	10
G3	10	2	8
P	**Control**	**6**	**12**
P1	1	3	6
P2	5	2	5
P3	10	2	5

Key: M= mango, C=Citrus, B= banana G=Guava and P= papaya, 1 g/kg of calcium carbide per fruit, 5 g/kg of calcium carbide per fruit, 10 g/kg calcium carbide per fruit.The ripening time of the artificially ripened mango, citrus, banana, guava and papaya fruits with calcium carbide at different inclusion levels are presented in Table 1. The results showed that all the fruits (mango, citrus, banana, guava and papaya) treated with 10 g/kg calcium carbide ripened within 2 days (48 hours) while the controls (0 g/kg calcium carbide) had the longest ripening time of 7 days (168 hours), 6 days (144 hours), 5 days (120 hours), guava 10 days (240 hours) and 6 days (144 hours) for mango, citrus, banana, guava and papaya fruits respectively. The mango and citrus fruits were observed to ripen quicker when treated with calcium carbide with ripening observed after 2days (48 hours) after calcium carbide treatment (1 g/kg, 5g/kg and 10 g/kg of calcium carbide per fruit). These findings concur with the results presented by Adewole and Duruji [11], when examining the effects of biological and chemical ripening agents on the nutritional and metal composition of some fruits. Similarly, Sogo-Temi *et al,* [12], demonstrated that calcium carbide ripens banana fruits quicker than when done naturally. These findings show that calcium carbide is a very good ripening agent especially at higher concentration. However, from the observation of the shelf-life period for the naturally and artificially ripened fruit, it was observed that the naturally ripen fruits have a longer shelf-life than the artificially ripened fruit.

Table 2 Proximate Analysis of Natural and Artificially Ripened mango, citrus, banana, guava and papaya Fruits with Calcium Carbide.

Samples	Conc. (g/kg)	Moisture (%)	Ash (%)	Liquid (%)	Fibre (%)	Protein (%)	Carbohydrate (%)	Vitamin C (mg/g)
M	**Control**	**77.80**	**6.50**	**2.5**	**o.74**	**4.5**	**7.40**	**57.80**
M1	1	77.72	7.23	3	1.21	3.68	6.39	50.14
M2	5	76.3	8.20	4	1.68	3.76	6.36	46.43
M3	10	78.36	9.02	4.2	2.40	3.41	5.53	33.98
C	**Control**	**76.20**	**7.10**	**10.68**	**1.90**	**6.40**	**8.60**	**80.64**
C1	1	76.12	8.04	11.43	2.46	5.80	7.78	78.25
C2	5	75.40	9.52	11.90	2.98	5.04	7.10	75.70
C3	10	78.25	10.5	12.68	4.20	4.52	6.35	62.45
B	**Control**	**77.43**	**8.34**	**5.4**	**0.710**	**1.94**	**5.95**	**13.90**
B1	1	77.43	9.25	6.2	0.820	1.92	1.86	11.20
B2	5	76.98	9.36	7.4	0.900	2.18	2.75	10.48
B3	10	77.20	9.50	8.8	0.960	1.74	3.82	9.74
G	**Control**	**57.42**	**6.30**	**3.70**	**1.20**	**8.00**	**56.80**	**55.80**
G1	1	57.18	6.90	3.98	1.77	7.60	53.08	52.97
G2	5	56.02	8.20	4.68	2.65	7.05	52.85	50.22
G3	10	55.84	10.35	4.95	4.15	6.25	50.25	48.84
P	**Control**	**41.60**	**6.90**	**4.70**	**0.760**	**0.98**	**45.72**	**50.15**
P1	1	42.00	6.45	4.90	0.810	0.79	44.96	45.20
P2	5	45.10	6.14	5.35	0.870	0.61	42.00	43.75
P3	10	47.5	5.50	5.70	0.920	0.79	39.62	42.35

Key: M= mango, C=Citrus, B= banana G=Guava and P= papaya, 1 g/kg of calcium carbide per fruit, 5 g/kg of calcium carbide per fruit, 10 g/kg calcium carbide per fruit

Moisture content

The results presented in Table 2 showed that the lowest and highest moisture contents were P1 (1 g/kg) and M3 (10 g/kg) samples varied between (42.1-78.34 %) respectively. The results obtained showed that calcium carbide affects fruit moisture content especially in mango fruits and this is in agreement with the findings of Joon *et al,* [13] on mango fruits where they concluded that calcium carbide treatments at 2 or 4 g /kg fruits resulted in higher moisture content loss during the ripening period compared with untreated fruits. Reduction in moisture content may be mainly due to water loss through transpiration process, while some weight loss is due to loss of carbon in respiration process.

Ash content

Table 2 present the lowest and highest ash contents for the artificially ripened fruits P3 (10 g/kg) and C3 (10 g/kg) as (5.50 and 9.48%). These findings are in conflict with the general assumption that fruits lose their weight through respiration where significant carbon is lost. Calcium carbide clearly increases the metabolism of the fruits [14].

Lipid content

The results obtained in Table 2 showed the lowest and highest lipid content for M1 (1 g/kg) and C3 (10 g/kg) ranged between 3.0 and 12.68%. The crude lipid content (3.0 and 12.68%) of the fruits was less than the range (8.3–27.0%) reported for some fruits consumed in Nigeria and Republic of Niger [15]. Amounts of lipid content in mango, citrus, banana, guava and papaya Fruits in our study were compared with the results of the study of Ali A. (2011), and it is observed that amounts of lipid, in our study were less than the results of the study of [16]. The lipid content suggests that there is increase in lipids in the fruits with increase in calcium carbide administration. This can be related to the fact that calcium carbide increases the lipid biosynthesis pathway through provision of precursor substrates obtained from the increased respiratory processes [17].

Fibre content

The results presented in Table 2 showed the lowest and highest fibre content for P1 (1 g/kg) and C3 (10 g/kg) were 0.810 and 4.20 % respectively. In terms of fibre contents, the fruits generally showed increase in fibre contents with increase in administered calcium carbide. The crude fibre content in P1 and C3 fruits (0.810 and 4.20 %) was lower than the reported values (8.50–20.90%) of some Nigerian fruits [18]. The fibre-recommended dietary allowance values for children, adults, pregnant and breast-feeding mothers are 19–25%, 21–38%, 28% and 29%, respectively. Thus, mango, citrus, banana, guava and papaya Fruits could be a valuable source of dietary fibre in human nutrition. According to Sajib *et al*, [19], in his work found out that dietary fibre is an important constituent of fruit ranges from 1.38 ± 0.09% to 2.99 ± 0.10%. Most health advisory groups provide guidance for obtaining the recommended levels of fibre consumption from foods, especially fruits, vegetables, and whole grains [20].

Protein content

Table 2 revealed that the calculated protein content for P2 (5 g/kg) and M2 (5 g/kg) ranged between 0.61 to 7.60 %. According to Elegbede, [21], food plants that provide more than 12% of their calorific value of protein are a good source of protein. In that context, mango, citrus, banana, guava and papaya fruits are a relatively good source of protein. Similarly, the protein content showed increase in amino acid production through the protein biosynthesis pathway due to the fact that ethylene signals transduction pathway in plants which is attributed to the increased uptake of NH4+, in part through stimulation of pyruvate kinase which brings about increased production of amino acids at the expense of carbohydrate production during photosynthesis [22].

Carbohydrate content

Table 2, showed that there is significant decrease in carbohydrate levels with increase of calcium carbide administration except in B1 (1 g/kg) and P1 (10 g/kg) having the lowest (1.86 %) and highest (44.96 %) percentage carbohydrate levels. This can be attributed to the increased rate of respiration caused by the acetylene availability due to the reaction between calcium carbide and water. The respiration tends to promote the removal of carbon from the fruits as carbon dioxide [27]. These findings are similar to those presented by Mahajan *et al*, [23], when examining ethrel treated banana fruits.

Vitamin C

Similarly, in Table 2 the lowest and highest level of vitamin C in the calcium carbide administered fruits for B3 (10 g/kg) and C1 (1 g/kg) were ranged between 9.74 to 78.25%. According to Prakash *et al*, [38], Polyphenols, carotenoids (pro-vitamin A), vitamins C and E present in fruits have antioxidant and free radical scavenging activities and play a significant role in the prevention of many diseases. The North American Dietary Reference Intake recommends 90 mg/day and no more than 2 g (2,000 milligrams) of vitamin C per day [24]. Small amounts of micronutrients (minerals and vitamins) are required for good physical condition along with energy food and protein. Sodium, potassium, iron, calcium and many trace elements together with antioxidant vitamins and minerals are vital for the body. Fruits and vegetables, particularly leafy, have noteworthy amounts of calcium, iron and potassium along with vitamins C [25].

CONCLUSION

From the findings of this study, the following conclusions were drawn. Calcium carbide is a very good ripening agent with a ripening time of 2days among all the fruits (mango, citrus, banana, guava and papaya) in this study. It was observed that the naturally ripened fruits have a longer shelf-life than the calcium carbide artificially ripened fruits and the proximate analysis of the fruits indicated that the administration of calcium carbide for fruit ripening may result in the reduction of some food nutrients such as ash content, protein and carbohydrate contents while the moisture and fibre contents were found to increase with higher calcium carbide administrations.

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