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Effects of ascorbic acid and calcium chloride on chemical properties of firm flesh jackfruit bulbs

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Abstract
The present investigation on "Effects of ascorbic acid and calcium chloride on chemical properties of firm flesh jackfruit bulbs" was carried out during 2014-15 at College of Agriculture, DBSKKV, Dapoli. A known quantity of jackfruit bulbs were treated with 12 different combinations of ascorbic acid (0.0, 0.5, 1.0 and 1.5 %) and calcium chloride (0.0, 0.5 and 1.0 %) along with 100 ppm KMS, 0.5 percent citric acid and packed in themocole tray, covered with permissible film and refrigerated. The treated jackfruit bulbs were analyzed for different chemical properties at two days interval. The treatment of 1.5 percent ascorbic acid, 0.5 percent calcium chloride with 100 ppm KMS, 0.5 percent citric acid and surface sterilized with chlorine water (30 ppm) resulted in extending the storage life of jackfruit bulbs upto 6 days (increase in acidity, sugars and TSS and decrease in pH and ascorbic acid).

Keywords: Ascorbic acid, calcium chloride, citric acid, chlorine water, chemical properties, KMS

Introduction
Jackfruit (*Artocarpus heterophyllus* Lam.) one of the unexploited nutritious fruit indigenous to the rainforests of Western Ghats of India [1]. It was probably taken by Arab traders to the East African coast. Major producers are Bangladesh, India, Myanmar, Thailand, Vietnam, China, Philippines, Indonesia, Malaysia and Sri Lanka. India is the second biggest producer of the fruit in the world and is considered as the motherland of jackfruit.

The jackfruit, *Artocarpus heterophyllus* Lam. is also called as jack-fruit, jak and jaca. In Malaysia and Philippines called as *nangka*; in Thailand, *khanun;* in Combodia, *Khnor;* in Laos, *mak mi* or *may mi* and in Vietnam, *mit.* An edible portion of 100 g of (fresh weight) ripe jackfruit contains 72.0-94.0 g water, 1.2-1.9 g protein, 0.1-0.4 g fat, 16.0-25.4 g carbohydrate, 1.0-1.5 g fibre, 0.87-0.9 g total minerals, 20.0-37.0 mg calcium, 175-540 IU vitamin A, 88-410 Kj energy [2] and [3].

Jackfruit is climacteric fruit having high degree of perishability. To minimize the postharvest losses and extend shelf life of jackfruit bulbs, minimal processing and treatment with chemicals like potassium metabisulphite (KMS), citric acid, calcium chloride and ascorbic acid helps to extend shelf life of fruits. Hence, the present i.e., "Effects of ascorbic acid and calcium chloride on chemical properties of firm flesh jackfruit bulbs" was undertaken to investigate the chemical properties of minimally processed jackfruit bulbs under refrigeration condition.

Material and methodology
For this study, ripe jackfruits of firm flesh type were collected purchased from the farmer Mr. Milind Phatak and were kept for ripening at ambient temperature. All the chemicals used in this investigation were of analytical grade Thermocole tray and permissible film was used for packaging of jackfruit bulbs. All the chemicals used in this investigation were procured from Shree Chemicals, MIDC, Ratnagiri. All the chemicals used in this investigation were of analytical grade. Thermocole tray and permissible plastic film was purchased from Vashi market, Navi Mumbai.

The ripe fruits were surface sterilized with 100 ppm chlorinated water for 5 minutes and then cut opened. The jackfruit bulbs without removal of seeds were separated and whole, sound bulbs were used for experimentation. These bulbs were treated with 30 ppm chlorinated water for 5 minutes. Again these bulbs were dipped in solution containing 100 ppm KMS, 0.5 percent citric acid, along with ascorbic acid (0.0, 0.5, 1.0 and 1.5%) and calcium chloride (0.0, 0.5 and 1.0 %) treatment combination, for 5 minutes. These bulbs were blotted dry and 9 bulbs were packed per thermocole tray and covered with permissible plastic film.

The packed bulbs were kept at refrigerated condition (6-7 ºC) and observed for chemical changes at every 3rd day).

Chemical properties of jackfruit bulbs during storage

Total Soluble Solids (^{0}Brix)

Total soluble solids (T.S.S.) were determined with the help of hand refractrometer [4] and expressed in °Brix.

Sugars (%)

The reducing and total sugars were determined by the method of [5] as modification suggested by [6].

Titratable acidity (%)

In case of jackfruit carpels, a known quantity of sample was blended in pestle and mortar with 20-25 ml distilled water. The sample was boiled for 10 minutes, replacing water lost by evaporation and it was then transferred to 100 ml volumetric flask and volume was made. The sample was filtered and known volume of aliquot was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The results were expressed as percent anhydrous citric acid [6].

pH

The pH was determined by potentiometric method.

Ascorbic Acid

The ascorbic acid was determined and expressed as mg/100 g fresh weight using 5 g of fruit tissues were homogenized in 100 ml 3 % metaphosphoric acid, the extraction was filtered and 2 ml was titrated against 2, 6- dichlorophenol indophenols dye and ascorbic acid was calculated using following formula.

$$\text{Ascorbic acid (mg/100 gm)} = \frac{\text{Titre reading} \times \text{Dye factor} \times \text{Volume made up}}{\text{Wt of the sample} \times \text{Volume of sample taken for estimation}} \times 100$$

Statistical analysis

The data obtained during the present investigation were analyzed statistically in Factorial Completely Randomized Design (F.C.R.D) as per the method described by [7].

Results

Total soluble solids (ºBrix)

The data presented in Table 1. It could be seen from the data that, total soluble solids of jackfruit bulbs increased from 0 day (23.31 °Brix) to 6th day (25.42 °Brix) and thereafter decreased at 9th day (24.50 °Brix) of storage, irrespective of ascorbic acid and calcium chloride treatments. With respect to ascorbic acid, the TSS was found to be decreased with increase in ascorbic acid concentration at 0 (except A_3), 6th (except A_3) and 9th day of storage, irrespective of calcium chloride treatments. At 9th day it decreased from A_1 (25.33°Brix) to A_4 (23.83°Brix). In case of calcium chloride treatment, TSS of jackfruit bulbs increased till C_2 treatment and decreased at C_3 treatment during 3, 6 and 9th day of storage. At 6 and 9th day of storage, A_1C_1 recorded maximum TSS i.e., 27°Brix and 26°Brix, respectively. This interaction was at par with A_1C_2 (26.7°Brix) at 6th day of storage.

Reducing sugars (%)

Significant increase in reducing sugars was observed (Table 2) till 6th day of storage and then decreased at 9th day of storage, irrespective of ascorbic acid and calcium chloride treatments. Reducing sugars content of jackfruit bulbs did not show fixed trend with respect to ascorbic acid concentration till the end of storage period. With respect to calcium chloride treatment, there was significant increase in reducing sugars till C_2 treatment and then decreased at C_3 treatment throughout storage period. With respect to interaction of ascorbic acid and calcium chloride treatments, at 6th day of storage highest reducing sugars were found in A_3C_1 (5.60 %) and it was at par with A_1C_2 (5.54 %), A_2C_1 (5.12 %), A_2C_2 (5.24 %) and A_4C_1 (5.34 %) and at 9th day A_1C_3 (4.29 %) recorded highest reducing sugar and was at par with A_1C_1 (4.26 %), A_1C_2 (4.06 %), A_3C_1 (4.13 %) and A_4C_1 (4.26 %) interaction.

Total sugars (%)

Total sugar significantly increased (Table 3) till 6th day of storage and then decreased at 9th day storage, irrespective of ascorbic acid and calcium chloride treatments. With respect to ascorbic acid concentration total sugars content did not show fixed trend till the end of storage period. There was significant decrease in total sugars at 0 and 6th day of storage with increase in calcium chloride concentrations. At 6th day of storage highest total sugars were found in A_4C_1 (11.90 %) and were significantly superior over other treatments.

Acidity (%)

The data (Table 4) revealed that, there was significant increase in acidity till 6th day of storage and then decreased at 9th day with advancement of storage, irrespective of ascorbic acid and calcium chloride treatments. With respect to ascorbic acid treatment, at 6th day of storage acidity increased till A_4 treatment. At 9th day of storage acidity did not show fixed trend. At 9th day of storage acidity decreased at C_2 (0.35 %) treatment and then increased at C_3 (0.40 %) treatment. The results were non significant with respect to calcium chloride and interaction treatments at 6th day of storage.

pH

The data presented in Table 5. There was significant decrease in pH till 6th day of storage and then increased at 9th day with advancement of storage, irrespective of ascorbic acid and calcium chloride treatments. At 6th day of storage pH decreased till the end of ascorbic acid treatment. At 6 and 9th day of storage pH decreased till C_3 treatment. It is revealed from the data that interaction of ascorbic acid and calcium chloride, highest pH at 6 and 9th day was observed in A_1C_1 (5.43) and A_2C_2 (5.53) interactions.

Ascorbic acid (mg/100g)

The data presented in Table 6. There was decrease in ascorbic acid till end of storage, irrespective of ascorbic acid and calcium chloride treatment. Ascorbic acid content did not show fixed trend with respect to ascorbic acid treatment, irrespective of calcium chloride treatment. Ascorbic acid decreased till C_2 treatment and then increased at C_3 treatment during storage at 0, 3 and 6 day except at 9th day where it increased till C_2 treatment and then decreased at C_3 treatment, with respect to calcium chloride treatments. At 6th day of storage highest ascorbic acid was recorded in A_1C_3 (19.2 mg/100g) and it was significantly at par with A_2C_1, A_2C_2, A_4C_1 and A_4C_3. At 9th day of storage highest ascorbic acid was recorded in A_1C_3 (14.8 mg/100g).

Table 1: Effect of ascorbic acid and calcium chloride on TSS (ºBrix) of jackfruit bulbs during refrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	23.40	24.60	23.56	23.85	23.50	25.50	24.00	24.33	27.00	26.70	25.25	26.31	26.00	25.00	25.00	25.33
A_2	24.80	22.80	22.00	23.20	25.45	24.35	23.60	24.46	24.50	25.50	25.00	25.00	24.50	25.00	24.00	24.5
A_3	22.60	24.85	23.20	23.55	24.15	25.00	25.50	24.88	24.70	25.96	25.50	25.38	24.00	25.00	24.00	24.33
A_4	22.95	21.50	23.55	22.66	23.30	23.50	23.60	23.46	24.10	25.70	25.20	25.00	23.00	24.50	24.00	23.83
Mean	23.43	23.43	23.07	23.31	24.10	24.58	24.17	24.28	25.07	25.96	25.23	25.42	24.37	24.87	24.25	24.50
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.154		0.450		0.127		0.371		0.198		0.578		0.159		0.465	
Calciu Chloride	0.133		NS		0.110		0.321		0.171		0.501		0.138		0.403	
AxC	0.267		0.780		0.220		0.643		0.343		1.002		0.276		0.806	

A1: 0.0 % Ascorbic Acid A2: 0.5 % Ascorbic Acid A3: 1.0 % Ascorbic Acid A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride C2: 0.5 % Calcium Chloride C3:1.0 % Calcium Chloride

Table 2: Effect of ascorbic acid and calcium chloride on Reducing Sugar (%) of jackfruit bulbs during refrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	3.38	2.89	3.96	3.41	3.48	3.41	4.08	3.65	4.73	5.54	4.65	4.97	4.26	4.06	4.29	4.20
A_2	3.58	2.89	3.50	3.32	3.71	3.25	3.84	3.60	5.12	5.24	4.95	5.10	3.95	3.47	3.99	3.80
A_3	2.95	3.40	3.82	3.39	3.49	3.59	3.91	3.66	5.60	3.71	4.20	4.50	4.13	3.34	3.73	3.73
A_4	3.41	3.16	3.43	3.33	3.38	3.31	3.55	3.41	5.34	4.03	4.81	4.73	4.26	3.84	3.83	3.97
Mean	3.33	3.08	3.68	3.36	3.51	3.39	3.84	3.58	5.20	4.63	4.65	4.82	4.15	3.67	3.96	3.93
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.019		0.057		0.043		0.125		0.104		0.304		0.050		0.147	
Calcium Chloride	0.016		0.049		0.037		0.108		0.090		0.263		0.043		0.127	
AxC	0.033		0.098		0.074		0.217		0.180		0.526		0.087		0.255	

A1: 0.0 % Ascorbic Acid A2: 0.5 % Ascorbic Acid A3: 1.0 % Ascorbic Acid A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride C2: 0.5 % Calcium Chloride C3:1.0 % Calcium Chloride

Table 3: Effect of ascorbic acid and calcium chloride on Total Sugar (%) of jackfruit bulbs during refrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	7.46	6.64	6.59	6.89	7.88	6.75	7.81	7.48	9.23	10.51	10.27	10.00	7.68	8.89	8.62	8.39
A_2	7.72	6.53	7.75	7.33	7.99	7.91	8.05	7.98	10.29	9.43	9.29	9.67	7.64	7.45	7.89	7.66
A_3	7.24	7.78	6.64	7.22	7.33	7.84	8.29	7.82	10.94	9.49	8.86	9.76	7.84	8.35	8.02	8.07
A_4	7.58	7.06	6.92	7.19	7.68	7.82	6.93	7.48	11.90	9.04	9.24	10.06	7.14	7.97	6.95	7.35
Mean	7.50	7.00	6.97	7.16	7.72	7.58	7.77	7.69	10.59	9.61	9.41	9.87	7.57	8.16	7.87	7.87
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.081		0.238		0.045		0.133		0.084		0.246		0.113		0.331	
Calcium Chloride	0.070		0.206		0.039		0.115		0.073		0.213		0.098		0.286	
AxC	0.141		0.412		0.078		0.230		0.146		0.426		0.196		0.573	

A1: 0.0 % Ascorbic Acid A2: 0.5 % Ascorbic Acid A3: 1.0 % Ascorbic Acid A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride C2: 0.5 % Calcium Chloride C3:1.0 % Calcium Chloride

Table 4: Effect of ascorbic acid and calcium chloride on Acidity (%) of jackfruit bulbs duringrefrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	0.32	0.32	0.31	0.31	0.32	0.36	0.33	0.33	0.47	0.47	0.48	0.47	0.37	0.35	0.40	0.37
A_2	0.36	0.38	0.34	0.36	0.40	0.44	0.37	0.40	0.48	0.49	0.5	0.49	0.38	0.28	0.38	0.34
A_3	0.38	0.39	0.39	0.38	0.45	0.45	0.46	0.45	0.50	0.52	0.52	0.51	0.36	0.37	0.46	0.39
A_4	0.41	0.38	0.32	0.37	0.47	0.43	0.47	0.45	0.53	0.52	0.53	0.53	0.33	0.41	0.37	0.37
Mean	0.36	0.36	0.34	0.35	0.41	0.42	0.41	0.41	0.49	0.50	0.51	0.50	0.36	0.35	0.40	0.37
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.006		0.018		0.007		0.022		0.007		0.020		0.009		0.026	
Calcium Chloride	0.005		0.015		0.006		NS		0.006		NS		0.007		0.022	
AxC	0.010		0.031		0.013		0.038		0.012		NS		0.015		0.045	

A1: 0.0 % Ascorbic Acid, A2: 0.5 % Ascorbic AcidA3: 1.0 % Ascorbic Acid, A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride, C2: 0.5 % Calcium Chloride, C3:1.0 % Calcium Chloride

Table 5: Effect of ascorbic acid and calcium chloride on pH of jackfruit bulbs during refrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	5.6	5.53	5.60	5.57	5.55	5.49	5.49	5.51	5.43	5.42	5.4	5.41	5.45	5.5	5.41	5.45
A_2	5.43	5.37	5.49	5.43	5.46	5.32	5.45	5.41	5.39	5.31	5.31	5.33	5.41	5.53	5.44	5.46
A_3	5.34	5.28	5.25	5.29	5.25	5.26	5.25	5.25	5.24	5.19	5.22	5.21	5.48	5.46	5.25	5.40
A_4	5.21	5.39	5.57	5.40	5.23	5.38	5.19	5.26	5.16	5.2	5.12	5.16	5.52	5.25	5.48	5.41
Mean	5.39	5.39	5.49	5.42	5.37	5.36	5.34	5.36	5.30	5.28	5.26	5.28	5.46	5.43	5.39	5.43
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.033		0.097		0.038		0.113		0.008		0.025		0.013		0.038	
Calcium Chloride	0.028		NS		0.033		NS		0.007		0.021		0.011		0.033	
AxC	0.057		NS		0.066		NS		0.015		0.043		0.022		0.066	

A1: 0.0 % Ascorbic Acid, A2: 0.5 % Ascorbic Acid, A3: 1.0 % Ascorbic Acid, A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride, C2: 0.5 % Calcium Chloride, C3:1.0 % Calcium Chloride

Table 6: Effect of ascorbic acid and calcium chloride on Ascorbic Acid (mg/100g) of jackfruit bulbs during refrigerated storage.

Treatments	Storage Days															
	0				3				6				9			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
A_1	24.00	22.80	25.20	24.00	21.60	21.60	24.00	22.40	15.66	15.26	19.20	16.71	10.80	13.20	14.80	12.93
A_2	25.20	24.00	26.40	25.20	20.40	22.80	24.00	22.40	18.00	18.00	16.80	17.60	14.40	13.20	12.00	13.20
A_3	25.20	20.40	26.40	24.00	21.60	19.20	24.00	21.60	16.80	16.80	15.60	16.40	13.20	14.40	10.80	12.80
A_4	30.00	24.00	27.60	27.20	22.80	21.60	24.00	22.80	18.00	15.60	18.00	17.20	12.00	10.80	13.20	12.00
Mean	26.10	22.80	26.40	25.10	21.60	21.30	24.00	22.30	17.11	16.41	17.40	16.97	12.60	12.90	12.70	12.73
	SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%		SEm±		C.D. at 1%	
Ascorbic Acid	0.333		0.972		0.220		0.643		0.241		0.704		0.072		0.212	
Calcium Chloride	0.288		0.842		0.190		0.557		0.209		0.610		0.062		0.183	
AxC	0.577		1.685		0.381		1.114		0.418		1.220		0.125		0.367	

A1: 0.0 % Ascorbic Acid, A2: 0.5 % Ascorbic Acid, A3: 1.0 % Ascorbic Acid, A4: 1.5 % Ascorbic Acid
C1: 0.0 % Calcium Chloride, C2: 0.5 % Calcium Chloride, C3:1.0 % Calcium Chloride

Discussion

Total soluble solids (ºBrix)

Increase in TSS with increase in storage period may be due to conversion of starch in to sugars during storage. Similar findings have been reported by [8] when used calcium chloride of 1, 2, 3 and 4 percent in papaya fruit. [9] reported contradictory results in guava fruit. He found increase in TSS of guava fruit with increase in ascorbic acid concentration. The increase in TSS and then sharp decline thereafter may be due to the role of calcium in delaying metabolic activity of fruits during storage. Similar findings have been reported by [10] in guava fruits. During his studies he found that with increase in calcium chloride treatment at concentration of 1, 2 and 3 percent TSS content of guava fruits increases upto 3 weeks of storage and then decreased steadily.

Reducing sugars (%)

The increase in reducing sugars may be due to hydrolysis of starch to sugars during storage. As on complete hydrolysis of starch no further increase occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrates for respiration and hence decrease in reducing sugars is observed at 9th day of storage [10]. when used 1, 2 and 3 percent of calcium chloride found similar results in guava fruits [11]. treated guava fruits with 1 and 2 percent of calcium chloride and reported that there was decrease in reducing sugars with increase in calcium chloride treatment.

Total sugars (%)

Increase in total sugars during storage may be due to the reasons as given under 4.3.3.1 in reducing sugars [10]. when used calcium chloride at 1, 2 and 3 percent have shown similar findings with advancement of storage period in guava fruits. There was significant decrease in total sugars at 0 and 6th day of storage with increase in calcium chloride concentrations may be due to increased level of calcium in fruits which can retard ripening and senescence process resulting in slower hydrolysis of polysaccharides into monosaccharides [12]. reported decrease in total sugars with increase in calcium chloride concentration (0, 0.5, 0.75 and 1.0 %) in pear cv. Bartlett.

Acidity (%)

Decrease in acidity at 9th day of storage may be due to utilization of stored acids in respiration process [10]. while using calcium chloride treatment at concentration of 1, 2 and 3 percent found similar results in guava fruits during storage [12]. in pear fruit reported decrease in acidity with increase in calcium chloride concentration.

pH

Increase in pH with increase in storage period may be due to decrease in acidity with increase in storage period. At 6th day of storage pH decreased till the end of ascorbic acid treatment. This may be due to corresponding increase in acidity with increase in ascorbic acid concentration. The result was in accordance with [13] in jackfruit.

Ascorbic acid (mg/100g)

Decrease in ascorbic acid during storage may be due to oxidation of ascorbic acid during storage [14]. found decrease in ascorbic acid during refrigerated condition in jackfruit [15]. noticed decrease in ascorbic acid with increase in calcium chloride treatment in pomegranate fruits by using 2 or 4 percent calcium chloride concentration [16]. found decrease in ascorbic acid content in mango cultivars throughout storage period when used ascorbic acid 2 percent, calcium chloride 1

percent and citric acid 2 percent. Oxidative reactions seem to be the main cause of vitamin C deterioration, and therefore the antioxidant treatment may prevent such losses, leading to a fresh-cut product with a final ascorbic acid content as high as the fresh fruits.

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