Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 2524-2527
Received: 22-11-2018
Accepted: 25-12-2018

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Influence of pretreatment on quality and shelf life of fresh cut jack fruit (*Artocarpus heterophyllus* L.) bulbs

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Abstract
An experiment was carried out to investigate the effect of pretreatments on quality and shelf life of fresh cut jackfruit bulbs. The jackfruit bulbs were pretreated with calcium chloride 0.50 and 1.0% alone or in combination with 0.25% ascorbic acid, 10% aloe vera gel, 0.10% potassium metabisulphite. Untreated samples were used as experimental control. Jackfruit bulbs were dipped for 5 minutes and the bulbs were surface dried. Further, 250 g of jackfruit bulbs were packed in cling film wrapped bowls. Both the treated and untreated control jackfruit bulbs were stored under refrigerated condition (6-8°C). The treatments were replicated 3 times in a completely randomized design (CRD). The observations on various physico-chemical and microbial parameters were recorded both prior to storage and at periodic intervals. Jack fruit bulbs pretreated with 1% $CaCl_2$ along with 0.25% ascorbic acid registered better in terms of maintaining quality with extended shelf life. The treatment recorded lower PLW, better retention of ascorbic acid, total carotenoids, total antioxidants and lower microbial load at the end of the experiment up to 3 weeks.

Keywords: Fresh cut jackfruit, pretreatment, refrigerated storage, calcium chloride, ascorbic acid, aloe vera gel

Introduction
Jackfruit *(Artocarpus heterophyllus* L.) is native to parts of South and Southeast Asia and it is believed to have originated in the rainforests of Western Ghats of India and is cultivated throughout the low lands in South and Southeast Asia. India is the second biggest producer of the fruit in the world and it is considered as the motherland of jackfruit. It is the rich source of carbohydrates, minerals, carboxylic acids, dietary fibre, and vitamins such as ascorbic acid (AA), and thiamine (Rahman *et al*., 1999) [7]. The various parts of the jackfruit tree have also been reported as an ingredient in the preparations of different Ayurvedic and Yunani medicines (Mukherjee, 1993) [6]. Jackfruits usually reach 10 to 25 kg in weight at maturity. It is not convenient for the consumer to carry the whole fruit, or it will be more to consume at once for small families. The edible fleshy pericarp amounts to only 35 per cent of the whole fruit, which is often prone to flavor loss, tissue softening, cut-surface browning and postharvest decay owing to the highly perishable nature (Saxena *et al*., 2009) [10].
The postharvest dip pre-treatment of chemical preservatives such as calcium chloride, ascorbic acid, potassium metabisulphite, edible coating with aloe vera gel at minimum levels alone or in combination during minimal processing have been found to be beneficial in minimizing the stress-induced metabolism, maintaining firmness, reducing browning reaction and improving organoleptic quality of various produce along with extension of their shelf-life (Soliva-Fortuny *et al*., 2002; Martinez-Ferrer *et al*., 2002) [12, 4]. Aloe vera based edible coatings improve the quality of minimally processed kiwifruit (Benitez *et al*., 2013) [1]. Chemical additives with various modified atmosphere packaging techniques at low temperature conditions was found beneficial in reducing decay, maintaining quality and extending the shelf-life of minimally processed produce (Cocci *et al*., 2006) [2].
Minimally processed fruits and vegetables have gained rapid popularity among the consumer due their fresh like nature and convenience. Jackfruit bulbs in a pre-cut form can provide convenience for shelf-life extension and facilitate easy transportation from production site to remote locations. It would also offer advantages such as ease in serving portions of large and difficult to peel fruits, reduced cost of packaging, extended shelf –life and quality products.
The present study was undertaken to investigate the effect of different pre-treatments on postharvest quality and shelf-life of jackfruit bulbs.

Material and methods

Sample preparation

Fresh, healthy, matured, uniform sized and good quality ripe jackfruits were selected from the *cv*. Maddur White in College of Horticulture, Kolar, Karnataka. The fruits were cut into convenient halves using sharp stainless steel knife smeared with cooking oil to avoid sticking. The bulbs were separated from rind and core of the fruit.

Pre-treatments

Jackfruit bulbs were subjected to dip pretreatment *viz.*,T_1= With distilled water treatment (Control); T_2= No water treatment (Control); T_3= Calcium chloride ($CaCl_2$) 0.50% with Ascorbic acid (AA) 0.25%; T_4= Calcium chloride 1.0% with Ascorbic acid (AA) 0.25%; T_5 = Calcium chloride 0.50% with Aloe vera gel 10%; T_6= Calcium chloride 1.0% with Aloe vera gel 10%; T_7 = Calcium chloride 0.50% with 0.10% Potassium metabisulphite (KMS); T_8= Calcium chloride 1.0% with 0.10% Potassium metabisulphite (KMS); T_9= Calcium chloride 0.50%;T_{10}= Calcium chloride 1.0%. Jackfruit bulbs were dipped for 5 minute in all the treatments and drained the excess solution, jackfruit bulbs were packed in cling film wrapped bowls of 250 g each and stored under refrigerated condition. All the treatments were analysed for bio-chemical composition during storage at three days interval (total soluble solids, ascorbic acid, total carotenoids, shelf life, microbial load and sensory attributes). The experiment was carried out with ten different treatments and three replications, using completely randomized design.

Minimally processed jackfruit bulbs was analyzed for TSS, ascorbic acid, total carotenoids, shelf life, microbial load and sensory attributes during refrigerated storage. Various physico-chemical characteristics of the minimally processed jackfruit bulbs were analysed as per the standard methods. Total soluble solids (° B) were measured using a hand refractometer (Erma optical works Ltd., Tokyo, Japan (0-32°B). Ascorbic acid was determined by 2, 6-Dichlorophenol-Indophenol visual titration method described by Ranganna (1986) [8]. The capacity of a sample to reduce a standard dye solution is directly proportional to the ascorbic acid content. The vitamin C was expressed as ascorbic acid (mg $100g^{-1}$). Carotenoid content in jackfruit bulb samples were determined by a modified method of the one described by Ranganna (1986) [8] and absorbance was measured at 452 nm using petroleum ether as a blank in spectrophotometer (Model: UV-VIS Spectrophotometer 117, Systronics).

The number of days the minimally processed jackfruit bulbs were in edible condition was taken as the shelf-life or keeping quality of ripe fruits.

The sensory attributes of samples were evaluated in terms of colour, aroma, taste, texture, and overall acceptability by using a nine point hedonic scale (9: Like extremely; 8: Like very much 7: Like moderately; 6: Like slightly; 5: Neither like nor dislike; 4: Dislike slightly; 3: Dislike moderately; 2: Dislike very much; 1: Dislike extremely).

Results and discussion

Total soluble solids (TSS ºB)

The data revealed that, TSS was significantly increased during storage in all the treatments. The treatment (T_4) was found best with lowest TSS (23.87 °B) on 24th day of refrigerated storage, whereas the highest TSS (24.40 °B) was found in T_2 (control) on 9th day of storage. The increase in TSS was due to conversion of starch into sugars *i.e* simple sugars, which has impact on decreased acidity and increased sweetness of the jackfruit bulb as observed during sensory evaluation (Somogyi *et al*., 1996) [13]. As such, increase in soluble solids could be attributed to enhancement in enzymatic depolymerization as well as the conversion of organic acids in to the sugar through the process of gluconeogenesis (Table 1).

Table 1: Influence of pre-treatment on TSS (°B) of fresh cut jackfruit bulbs in refrigerated storage

Treatments	Storage (days)								
	0	3	6	9	12	15	18	21	24
T_1 distilled water treatment (Control)	23.87	23.83	23.70	23.67	23.90	-	-	-	-
T_2 No water treatment (Control)	23.90	23.90	23.83	24.40	-	-	-	-	-
T_3 $CaCl_2$ 0.50% with AA 0.25%	23.13	23.22	23.33	23.41	23.57	23.80	23.77	24.13	24.23
T_4 $CaCl_2$ 1.0% with AA 0.25%	23.06	23.23	23.40	23.23	23.30	23.50	23.67	23.63	23.87
T_5 $CaCl_2$ 0.50% with Aloe vera gel 10%	23.07	23.20	23.27	23.60	23.60	24.47	24.50	24.57	-
T_6 $CaCl_2$ 1.0% Aloe veragel 10%	23.43	23.37	23.47	23.77	24.17	24.43	24.53	24.70	24.83
T_7 $CaCl_2$ 0.50% with KMS 0.10%	23.50	23.30	23.37	23.67	23.70	24.37	24.70	24.80	24.83
T_8 $CaCl_2$ 1.0% with KMS 0.10%	23.63	23.47	23.53	23.50	23.73	24.20	24.43	24.70	-
T_9 $CaCl_2$ 0.50%	23.40	23.67	23.73	24.20	24.50	24.80	25.00	-	-
T_{10} $CaCl_2$ 1.0%	23.70	23.57	23.67	23.80	24.03	24.50	24.80	-	-
CD at 1%	0.657	0.440	0.413	0.247	0.212	0.422	0.198	0.194	0.084
S.Em ±	0.163	0.109	0.102	0.061	0.052	0.104	0.049	0.048	0.021
F test	**	**	**	**	**	**	**	**	**

$CaCl_2$ – Calcium chloride AA – Ascorbic acid KMS – Potassium metabisulphite

** Significant at 1% NS - Non Significant -- Terminated

Ascorbic acid (mg $100g^{-1}$)

Ascorbic acid content in minimally processed jackfruit bulbs deceased significantly in all treatments during storage. The higher ascorbic acid content (32.17) was observed in T_4 (Calcium chloride 1% with ascorbic acid 0.25%) on 24th day of storage, whereas, the lowest ascorbic acid content (14.62) was recorded in T_2 (control) on 9th day of storage. It is inferred that pre-treatment with calcium chloride along with ascorbic acid had resulted in better retention of ascorbic acid during storage. Addition of ascorbic acid during dip pre-treatment resulted in a 3.5 fold increase in ascorbic acid content in pre-treated samples (Saxena *et al*., 2009) [10]. Use of ascorbic acid could maintain the visual quality of the produce with restricted browning (Table 2).

Table 2: Influence of postharvest pre-treatment on the ascorbic acid (mg 100 g $^{-1}$) content of fresh cut jackfruit bulbs in refrigerated storage

Treatments	Storage (days)								
	0	3	6	9	12	15	18	21	24
T_1 distilled water treatment (Control)	22.01	20.90	19.14	17.97	16.22	-	-	-	-
T_2 No water treatment (Control)	22.01	20.22	16.97	14.62	-	-	-	-	-
T_3 $CaCl_2$ 0.50% with AA 0.25%	38.74	37.27	35.83	35.72	32.92	32.00	31.87	31.37	30.00
T_4 $CaCl_2$ 1.0% with AA 0.25%	39.58	39.02	38.10	37.77	36.00	35.00	34.67	32.37	32.17
T_5 $CaCl_2$ 0.50% with Aloe vera gel 10%	22.01	21.72	21.10	20.75	20.00	19.72	19.55	19.47	-
T_6 $CaCl_2$ 1.0% Aloe veragel 10%	22.01	21.70	20.97	20.54	20.22	19.97	19.03	18.86	18.41
T_7 $CaCl_2$ 0.50% with KMS 0.10%	22.01	21.73	21.70	20.69	20.35	20.00	19.98	18.80	18.73
T_8 $CaCl_2$ 1.0% with KMS 0.10%	22.02	21.63	21.85	20.81	20.58	20.24	19.80	18.60	-
T_9 $CaCl_2$ 0.50%	22.02	21.91	20.72	20.21	20.00	19.73	18.60	-	-
T_{10} $CaCl_2$ 1.0%	22.02	20.83	20.63	20.13	19.79	19.26	18.03	-	-
CD at 1%	0.05	0.22	0.21	0.10	0.73	0.01	8.33	0.14	0.05
S.Em ±	0.01	0.05	0.05	0.02	0.18	0.004	2.07	0.03	0.01
F test	**	**	**	**	**	**	**	**	**

Total carotenoids (mg 100g $^{-1}$)

Jackfruits are rich in carotenoids and antioxidants, rendering golden yellowish colour to the bulbs as carotenoids are highly susceptible to oxidative deterioration. The data revealed that the total carotenoid content was differed significantly and there was highest carotenoid content (0.70) was observed in T_4 (Calcium chloride 1% with ascorbic acid 0.25%) on 24th day of storage, whereas, the lowest carotenoid content (0.50) was recorded in T_2 (control) on 9th day of storage. Ascorbic acid as a constituent of pre-treatment could also minimise the carotenoid loss due to the free radical scavenging activity (RSA), resulting in the prevention of total carotenoid oxidation (Mercadante & Rodriguez-Amaya, 1998). Shi and Le Maguer (2000) have reported that reduction in enzymatic oxidation for lycopene in tomatoes. Effective protection of carotenoids against oxidation is highly critical in the case of carotenoids-rich high moisture product, such as minimally-processed jackfruit bulbs (Table 3).

Table 3: Influence of postharvest pre-treatment on carotenoid content (mg 100 g $^{-1}$) of fresh cut jackfruit bulbs in refrigerated storage

Treatments	Storage (days)								
	0	3	6	9	12	15	18	21	24
T_1 distilled water treatment (Control)	0.71	0.66	0.62	0.58	0.48	-	-	-	-
T_2 No water treatment (Control)	0.70	0.65	0.66	0.50	-	-	-	-	-
T_3 $CaCl_2$ 0.50% with AA 0.25%	0.75	0.77	0.77	0.75	0.73	0.67	0.69	0.68	0.66
T_4 $CaCl_2$ 1.0% with AA 0.25%	0.80	0.82	0.77	0.76	0.77	0.73	0.72	0.70	0.70
T_5 $CaCl_2$ 0.50% with Aloe veragel 10%	0.77	0.74	0.74	0.66	0.68	0.62	0.68	0.60	-
T_6 $CaCl_2$ 1.0% Aloe veragel 10%	0.75	0.73	0.70	0.68	0.65	0.63	0.60	0.60	0.59
T_7 $CaCl_2$ 0.50% with KMS 0.10%	0.75	0.74	0.72	0.68	0.70	0.64	0.63	0.62	0.60
T_8 $CaCl_2$ 1.0% with KMS 0.10%	0.77	0.76	0.75	0.70	0.72	0.68	0.68	0.65	-
T_9 $CaCl_2$ 0.50%	0.71	0.69	0.70	0.65	0.66	0.65	0.65	-	-
T_{10} $CaCl_2$ 1.0%	0.73	0.69	0.64	0.65	0.65	0.60	0.58	-	-
CD at 1%	0.037	.049	.021	.015	.014	.014	.013	.007	.004
S.Em ±	0.009	.012	0.005	.003	.003	.003	.003	.001	.001
F-test	**	**	**	**	**	**	**	**	**

Sensory quality and shelf-life

Table 4: Influence of postharvest pre-treatment on overall acceptability (9 point hedonic scale) of fresh cut jackfruit bulbs in refrigerated storage

Treatments	Overall acceptability scores Storage (weeks)			
	0	1	2	3
T_1 distilled water treatment (Control)	9.00	6.67	5.67	-
T_2 No water treatment (Control)	9.00	6.00	5.33	-
T_3 $CaCl_2$ 0.50% with AA 0.25%	9.00	7.33	7.33	7.00
T_4 $CaCl_2$ 1.0% with AA 0.25%	9.00	8.67	8.67	8.33
T_5 $CaCl_2$ 0.50% with Aloe veragel 10%	7.00	6.67	7.00	7.00
T_6 $CaCl_2$ 1.0% Aloe veragel 10%	6.33	6.33	6.00	6.33
T_7 $CaCl_2$ 0.50% with KMS 0.10%	8.33	7.33	6.33	5.67
T_8 $CaCl_2$ 1.0% with KMS 0.10%	8.33	7.33	7.00	6.00
T_9 $CaCl_2$ 0.50%	8.00	6.00	6.33	5.67
T_{10} $CaCl_2$ 1.0%	7.33	6.67	6.67	5.33
CD at 1%	1.12	1.40	1.12	1.79
S.Em ±	0.278	0.349	0.278	0.447
F test	**	**	**	**

Dip pre-treated samples has showed significantly delay in sensory scores in terms of overall acceptability of minimally processed jackfruit bulbs during storage (Table 4) sensory attributes of minimally processed jackfruit bulbs showed higher ratings by the sensory panel for T_4 (calcium chloride 1% with ascorbic acid 0.25%) samples due to better retention

of colour, texture, flavour, taste and overall acceptability. However, the sensory panel has observed that calcium chloride with ascorbic acid dip pre-treated bulbs had little sour taste. Saxena *et al*. (2008) [9] reported that the use of preservatives in minimally processed jackfruit bulbs should be at minimum levels not to alter the sensory attributes of the product. The sensory score for texture was influenced by calcium chloride, as the bulbs had retained better texture, similar results was reported by Kubasa *et al.* (2011). Whereas, T_2 and T_1 (control) samples had lowest scores after 9 days and 12 days respectively in refrigerated storage. Based on sensory evaluation, the shelf-life of pre-treated jackfruit bulbs was 24, 23, 22.33, 22.33, 21.33, 21.33, 20.33, 20.33, 12 and 9 days, in T_4, T_3, T_5,T_6,T_7,T_8, T_9, T_{10}, T_1 and T_2 respectively (Table 5).

Table 5: Influence of pre-treatment on shelf life of fresh cut jackfruit bulbs in refrigerated storage

Treatments	Shelf life (days)
T_1 distilled water treatment (Control)	12.00
T_2 No water treatment (Control)	9.00
T_3 $CaCl_2$ 0.50% with AA 0.25%	23.00
T_4 $CaCl_2$ 1.0% with AA 0.25%	24.00
T_5 $CaCl_2$ 0.50% with Aloe veragel 10%	22.33
T_6 $CaCl_2$ 1.0% Aloe veragel 10%	22.33
T_7 $CaCl_2$ 0.50% with KMS 0.10%	21.33
T_8 $CaCl_2$ 1.0% with KMS 0.10%	21.33
T_9 $CaCl_2$ 0.50%	20.33
T_{10} $CaCl_2$ 1.0%	20.33
CD at 1%	1.039
S.Em ±	0.258
F test	**

Conclusion

The pre-treatment constituting of anti-respiratory, anti-stress, anti-browning and preservative functions minimized the loss of quality in the fresh-cut bulbs. The jackfruit bulbs dip pre-treated with 1% calcium chloride with 0.25% ascorbic acid (T_4) was found to be best when compared to all the other treatments which was followed by T_3 (calcium chloride 0.5% with ascorbic acid 0.25%) as compared to other treatments. Whole jackfruit bulbs can be utilised for minimal processing, which slow down the respiration rate, loss in colour, firmness, flavour and physiological loss in weight of minimally processed jackfruit bulbs under refrigerated storage.

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