Environment and Ecology 39 (2) : 482—488, April—June 2021
ISSN 0970-0420

Effects of Pre-StorageTreatments on Shelf Life and Biochemical Quality Parameters of Minimally Processed Jackfruit (*Artocarpus heterophyllus* L.) Bulbs

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Received 21 September 2020, Accepted 2 March 2021, Published on 5 April 2021

ABSTRACT

Consumer demand for minimally processed products has shown an increasing trend over the past decades due to its health benefits, fresh like quality and convenience they offer. Jackfruit has a high potential for minimal processing as its edible portion makes up only 30-35% of the whole fruit. It also contains a lot of essential nutrients and antioxidants which imparts to its nutritional benefits. The study was conducted to investigate the effects of pre-storage treatments on chemical quality and shelf life of minimally processed jackfruit bulbs. After surface sanitizing the whole fruit using 100 ppm sodium hypochlorite followed by removal of the inedible portions, the de-seeded bulbs were subjected to different pre-storage treatments viz.,0.1% ascorbic acid, 0.1% citric acid, 1% calcium chloride for 10 minutes and untreated bulbs as control. The bulbs were air dried, kept in aluminium foil trays wrapped with cling film and stored under refrigerated conditions (5-6^{0}C). Biochemical parameters recorded at the time of storage and at regular intervals revealed that the shelf life and biochemical quality parameters of the jackfruit bulbs were significantly influenced by the pre- storage treatments. 1% calcium chloride treated jackfruit bulbs were superior to the bulbs treated with 0.1% ascorbic acid, 0.1% citric acid and the untreated control. The treatment recorded high TSS, vitamin C and carotenoid content along with low acidity and phenolic content.

Keywords Jack fruitbulbs, Minimal processing, Pre-treatments, Calcium chloride.

INTRODUCTION

Jackfruit is a tropical fruit, which is a rich source of carbohydrates, proteins, vitamins, minerals, dietary fiber and phytochemicals (Rahman *et al.* 1999). It provides various health benefits including anticarcinogenic, antimicrobial, antifungal, anti-inflammatory, wound healing and hypoglycemic properties. Despite thenutritional values and enormous health benefits, the jackfruit is underutilized primarily due to its exceedingly large amount of inedible portion

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and short shelf life. Its edible portion makes up only 30-35% of the whole fruit resulting in more waste generation. Bulky nature, handling difficulties like peeling, separating the bulbs and lack of knowledge about the post-harvest handling practices hinders the consumption and utilization of jackfruit by the consumers. It has a high potential for minimal processing and conversion of jackfruit into minimally processed products may encourage more population towards the consumption of jackfruit. Declaration of jackfruit as Kerala's official fruit has also helped it in giving a real boost in production and sale.

The post-harvest dip pre-treatments using anti-browning agents, firming agents, preservatives and antimicrobials help 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). The consumer demand for high quality foods requiring only minimum amount of effort and time for preparation has led to the introduction of ready-to-use, convenience foods preserved by mild methods (so-called minimal processing methods) only. Minimally processed fruits and vegetables have gained rapid popularity among the consumer due their fresh like nature and convenience. Jackfruit bulbs in fresh cut form can provide convenience for shelf-life extension and facilitate easy transportation. Hence the present study was undertaken to investigate the effect of different pre-treatments on shelf-life and biochemical quality of jackfruit bulbs.

MATERIALS AND METHODS

Good quality, fresh, optimum mature Jackfruit cv MuttomVarikka, free from visual defects, relatively uniform size, weight and color were collected from Instructional Farm, College of Agriculture, Vellayani, allowed to ripe and used for the study. The ripe fruits were dipped in 100 ppm sodium hypochlorite solution for 15 minutes for surface de-contamination.Good quality bulbs were extracted from the sanitized fruits, seeds removed and dipped in different pre-treatment solutions viz., 0.1% ascorbic acid (T_1), 0.1% citric acid (T_2) and 1% calcium chloride (T_3) for 10 minutes along with untreated bulbs (T_4) as controlso as to analyze the comparative efficiency of the different solutions in extending shelf life and maintaining biochemical quality of minimally processed jackfruit bulbs. The solutions were drained, treated bulbs were air dried, kept in aluminium foil trays wrapped with cling film and stored under refrigerated conditions.

Shelf life jackfruit bulbs were assessed as number of days from extraction or storage till they remain in fresh and marketable condition, based on physical appearance as judged by retention of quality, color variation, level of pathogenic decay, glossy appearance without any desiccation and juiciness of bulbs (Nanda *et al.* 2001). Total Soluble Solids (TSS) of the bulbs were assessed using Erma hand refractometer (range $0\text{-}32^0$B) and was expressed in degree brix (^{0}B). Titrable acidity, total sugar, reducing sugar and non-reducing sugar of the jackfruit bulbs were determined in percentage as per the procedure described by Ranganna (1986). Ascorbic acid content was measured by DCPIP (2, 6 –dichlorophenol indophenol) dye method and expressed as mg 100 g^{-1}. The carotenoid content was analyzed using the method suggested by Saini *et al.* (2001) and expressed in mg 100 g^{-1}. The data generated from each experiment were tabulated and analyzed statistically using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Jackfruit bulbs treated with 1% calcium chloride recorded the highest shelf life (5.00 days) followed by the bulbs treated with 0.1% ascorbic acid and 0.1% citric acid (4.00 days) (Table 1). All the pre-treated bulbs had shown a better chemical quality parameters compared to untreatedbulbs. Jackfruit bulbs pre-treated with 1% calcium chloride recorded least

Table 1. Effect of pre-treatments on shelf life of jackfruit bulbs.

Treatments	Shelf life (Days)
T_1 (0.1% Ascorbic acid)	4.00
T_2 (0.1% Citric acid)	4.00
T_3 (1% Calcium chloride)	5.00
T_4 (Absolute control)	3.00
CD	0.002
SE±(m)	0.001

Table 2. Effects of pre-treatments on acidity of jackfruit bulbs.

Treatments	Acidity (%) At the time of storage	Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	0.46	0.39	0.35	0.40	-
T_2 (0.1% Citric acid)	0.46	0.43	0.39	0.43	-
T_3 (1% Calcium chloride)	0.43	0.33	0.31	0.36	0.26
T_4 (Absolute control)	0.43	0.43	0.38	0.41	-
Day mean	0.45	0.39	0.36		
	SE±(m)		CD (0.05)		
Treatment (T)	- 0.009	0.026			
Days (D)	- 0.008	0.023			
Treatment (T)× Days (D)	- 0.016	NS			

acidity (0.36%), followed by the bulbs treated with 0.1% ascorbic acid (0.35%) after 3rd day of storage (Table 2). This is in accordance with the findings of Bhat *et al*. (2011), who had reported reduced acidity in calcium treated pear fruits during the storage period. Highest acidity (0.43) was observed in 0.1% citric acid treated bulbs. 1% calcium chloride treated bulbs had recorded 0.26% acidity on 5th day of storage. Acidity decreased from 0.45% at the time of storage to 0.39% and 0.36% on 3rd and 5th day of storage respectively. Titratable acidity is directly related to the concentration of organic acids present in the fruit. Decrease in acidity may be due to utilization of stored acids in respiration process as reported by Chulaki *et al.* (2017) in jackfruit bulbs.

Highest mean TSS (20.45) was recorded in untreated jackfruit bulbs which was at par with the bulbs treated with 1% calcium chloride (20.20) after 3 days of storage (Table 3). Increased TSS has been reported by Rajkumar (2005) in papaya fruit when it was treated with calcium chloride at 2% along with gibberllic acid at 100 ppm. 0.1% citric acid treated bulb recorded the lowest mean TSS which was at par with the bulbs treated with 0.1% ascorbic acid (19.53). TSS increased with days of storage from 19.39^{0}B at the time of storage to 20.04^{0}B and 20.28^{0}B on 1st and 3rd days respectively. Increase in Total Soluble Solids with increase in storage period may be due to conversion of starch in to sugars during storage which has impact on decreased acidity and increased sweetness of the jackfruit bulb. Increased TSS can also be attributed to the conversion of organic acids into sugar through the process of gluconeogenesis as reported by Prathibha *et al.* (2019). 1% calcium chloride treated bulbs had recorded a TSS of 20.85^{0}B on 5th day of storage.

Untreated bulbs recorded the highest mean total sugar (34.29%) (Table 4) and reducing sugar content (14.99%) (Table 5) after three days of storage. This was at par with the bulbs treated with 1% calcium chloride, which recorded 34.14% of

Table 3. Effects of pre-treatments on TSS of jackfruit bulbs.

Treatments	Total Soluble Solids (0B) At the time of storage	Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	19.23	19.58	19.78	19.53	-
T_2 (0.1% Citric acid)	19.28	19.45	19.60	19.44	-
T_3 (1% Calcium chloride)	19.50	20.48	20.63	20.20	20.85
T_4 (Absolute control)	19.55	20.68	21.13	20.45	-
Day mean	19.39	20.04	20.28		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.094	0.269			
Days (D)	- 0.081	0.233			
Treatment (T)× Days (D)	- 0.162	0.467			

Table 4. Effects of pre-treatments on total sugar of jackfruit bulbs.

Treatments	At the time of storage	Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	32.47	33.22	34.25	33.31	-
T_2 (0.1% Citric acid)	32.47	33.11	34.19	33.26	-
T_3 (1% Calcium chloride)	32.47	33.45	36.50	34.14	36.50
T_4 (Absolute control)	32.47	33.96	36.43	34.29	-
Day mean	32.47	33.43	35.34		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.058	0.167			
Days (D)	- 0.050	0.144			
Treatment (T)× Days (D)	- 0.100	0.289			

Table 5. Effects of pre-treatments on reducing sugar content of jackfruit bulbs.

Treatments	At the time of storage	Reducing sugar (%) Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	13.15	14.09	14.72	13.99	-
T_2 (0.1% Citric acid)	13.33	14.10	14.50	13.98	-
T_3 (1% Calcium chloride)	13.24	14.92	16.27	14.81	16.40
T_4 (Absolute control)	13.33	15.24	16.39	14.99	-
Day mean	13.26	14.59	15.47		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.094	0.271			
Days (D)	- 0.082	0.235			
Treatment (T)× Days (D)	- 0.163	0.470			

total sugar and 14.81% of reducing sugar after three days. The result is in accordance with Velankanni (2012) who had reported a high total and reducing sugar in jackfruit bulbs, pre-treated with 10000 ppm calcium chloride. Non-reducing sugar was significantly influenced by days of storage and interaction between days and treatment, whereas no significant variation was noticed among the treatments (Table 6).

Total sugar content increased from 32.47% at the time of storage to 33.43% and 35.34% on 1st and 3rd days of storage respectively. Reducing sugar increased from 13.26% at the time of storage to 14.59% and 15.47% on 1st and 3rd day respectively. Non-reducing sugar decreased from 19.21% at the time of storage to 18.85% on first day of storage and then increased to 19.87% on 3rd day of storage. The increase in sugars

Table 6. Effects of pre-treatments on non-reducing sugar contentof jackfruit bulbs.

Treatments	Non-reducing sugar (%) At the time of storage	Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	19.32	19.13	19.53	19.33	-
T_2 (0.1% Citric acid)	19.14	19.01	19.69	19.28	-
T_3 (1% Calcium chloride)	19.23	18.53	20.23	19.33	20.10
T_4 (Absolute control)	19.14	18.72	20.04	19.30	-
Day mean	19.21	18.85	19.87		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.102	NS			
Days (D)	- 0.089	0.255			
Treatment (T)× Days (D)	- 0.177	0.511			

Table 7. Effect of pre-treatments on vitamin C content of jackfruit bulbs.

	Vitamin C (mg 100 g^{-1})				
	At the time of storage	Days after storage			
Treatments		1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	31.58	28.95	26.32	28.95	-
T_2 (0.1% Citric acid)	26.32	19.74	17.11	21.05	-
T_3 (1% Calcium chloride)	26.32	22.37	22.37	23.69	21.05
T_4 (Absolute control)	26.32	18.42	11.85	18.86	-
Day mean	27.64	22.37	19.41		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.705	2.030			
Days (D)	- 0.611	1.758			
Treatment (T) × Days (D)	- 1.221	3.516			

may be the result of hydrolysis of starch to sugars during storage. The increase in reducing sugar may be due to the conversion of sucrose into glucose and fructose, there by resulting in reduction of non-reducing sugar at the beginning of storage period. Non-reducing sugar increased towards the end of storage period due to metabolism of the cell wall polysaccharide producing sugars as suggested by Chulaki *et al*. (2017).

Lowest total sugar (33.26%) and non reducing sugar (13.98%) were reported by 0.1% citric acid treated bulbs after three days of storage which was at par with the bulbs treated with 0.1% ascorbic acid with 33.31% of total sugar and 13.99% of reducing sugar. All jackfruit bulbs except those treated with 1% calcium chloride were discarded by 5 days of storage and it recorded 36.50%, 16.40% and 20.10% of total sugar, reducing sugar and non-reducing sugar respectively.

Mean vitamin C content was highest for 0.1% ascorbic acid treated bulbs (28.95) after 3 days of storage followed by the bulbs treated with 1% calcium chloride (23.69) (Table 7).This is in line with the findings of Sakimin *et al.* (2017) who reported that ascorbic acid pre-treatment positively influence the ascorbic acid content of minimal processed jackfruit in both ambient and cold storage. Addition of ascorbic acid as a dip pre-treatment resulted in a 3.5 fold increase in ascorbic acid content in pre-treated samples during storage as reported by Saxena *et al.* (2012). 1% calcium chloride treated bulbs retained ascorbic acid next to 0.1% ascorbic acid treated bulbs. Calcium has been proven to be effective in retaining ascorbic acid as reported by Ali *et al.* (2011). This might be due to the delayed rapid oxidation of ascorbic acid by higher concentration of calcium chloride as reported by Akhtar *et al*. (2010). Vitamin C of jackfruit bulbs decreased from 27.64 mg100g^{-1} at the time of storage to 22.37 mg100g^{-1} and 19.41 mg100 g^{-1} on 1st and 3rd days of storage respectively.The decrease in vitamin C may be due to the oxidation of ascorbic acid during storage period as reported by Sally *et al.* (2011).

Table 8. Effect of pre-treatments on carotenoid content of jackfruit bulbs.

	Total carotenoids (mg 100 g^{-1})				
	At the time of storage	Days after storage			
Treatments		1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	0.86	0.79	0.77	0.81	-
T_2 (0.1% Citric acid)	0.86	0.78	0.75	0.80	-
T_3 (1% Calcium chloride)	0.86	0.83	0.79	0.83	0.76
T_4 (Absolute control)	0.86	0.75	0.75	0.79	-
Day mean	0.86	0.79	0.76		
	SE±(m)	CD (0.05)			
Treatment (T)	- 0.005	0.015			
Days (D)	- 0.004	0.013			
Treatment (T)× Days (D)	- 0.009	0.025			

Table 9. Effect of pre-treatments on total phenol content of jackfruit bulbs.

Treatments	Total phenolic content (mg100g-1) At the time of storage	Days after storage 1	3	Treatment mean	5
T_1 (0.1% Ascorbic acid)	42.59	40.74	39.81	41.15	-
T_2 (0.1% Citric acid)	42.59	41.66	38.42	40.90	-
T_3 (1% Calcium chloride)	42.59	40.28	36.43	39.77	35.83
T4 (Absolute control)	42.59	42.13	42.13	42.29	
Day mean	42.59	41.20	39.20		
	SE±(m)	CD (0.05)			
Treatment(T)	- 0.528	1.520			
Days (D)	- 0.457	1.316			
Treatment (T)× Days (D)	- 0.914	NS			

Bulbs treated with 1% calcium chloride recorded the highest mean total carotenoid content (0.83) (Table 8) and lowest total phenols (39.77) after 3 days of storage (Table 9) indicating its superiority in maintaining the colour of the jackfruit bulbs. The result is in accordance with the findings of Prathibha *et al.* (2019) who had reported that bulbs treated with 1% calcium chloride and 0.25% ascorbic acid retained maximum carotenoid content during the storage period. Similar findings were also reported by Krishna *et al.* (2018) in fresh cut papaya cubes. Lowest phenol content was observed in fresh cut cabbage, beans, carrot and beetroot that were treated with calcium chloride as reported by Chandran (2013).Total carotenoid content of the jackfruit bulbs decreased from 0.86 mg100 g^{-1} at the time of storage to 0.79 mg100$g^{-1}$and 0.76 mg100g^{-1} on 1st and 3rd days of storage respectively. The decrease in carotenoid content in minimally processed jackfruit bulbs is attributed mainly due to its oxidative deterioration ass reported by Prathibha *et al.* (2019). Total phenol content decreased from 42.59 mg100 g^{-1} at the time of storage to 41.20 mg100 g^{-1} and 39.20 mg100 g^{-1} on 1st and 3rd day respectively. Decrease in phenolic content may be due to post-harvest fruit metabolic processes, such as respiration, ethylene production and enzyme activity as reported by Ghasemnezhad *et al.* (2011). All jackfruit bulbs except those treated with 1% calcium chloride were discarded by 5th day of storage. It had recorded a vitamin C content of 21.05 mg 100 g^{-1}, carotenoid content of 0.76 mg100g^{-1} and 35.83 mg100 g^{-1} of total phenols on 5th day of storage.

CONCLUSION

1% calcium chloride treated jackfruit bulbs were found to have a higher shelf life and superior-biochemical quality parameters compared to the bulbs treated with 0.1% ascorbic acid, 0.1% citric acid and the untreated control. Calcium chloride treatment resulted in bulbs with high TSS and low acidity for better palatability. High carotenoid and vitamin C along with low phenolcontent made it attractive and nutritionally superior to other treatments. 0.1% ascorbic acid treated bulbs had highest vitamin C content and maintained these quality parameters next to 1% calcium chloride treated bulbs.

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