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Minimal processing for short term preservation of jackfruit (*Artocarpus heterophyllus* L.) bulbs

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Abstract
An experiment was carried out to develop minimal processing techniques for short term preservation of jackfruit (*Artocarpus heterophyllus* L.) bulbs in the Department of Horticulture, AAU, Jorhat during the year 2015. Jackfruit bulbs were collected from fields and bulbs were extracted and sprayed with different concentrations of ascorbic acid, citric acid, calcium chloride @ 0.02%, 0.02% and 1% respectively along with a preservative *i.e.,* potassium metabisulphite @ 150ppm in different treatment combinations followed by storage at 6^{o} C. Amongst the treatments, a significant difference on chemical properties and sensory quality of bulbs was observed. Evaluation for development of minimal processing technique for jackfruit bulbs revealed that the bulbs treated with combine solution of ascorbic acid, citric acid and calcium chloride and stored at 6°C (T_2) retained the highest sensory and physico-chemical quality as compared to other treatments. Using this minimal processing technique jackfruit bulbs can be stored for up to 9 days.

Keywords: Antioxidants, bulbs, jackfruit, minimally processed, storage

Introduction
Jackfruit (*Artocarpus heterophyllus*) is one of the most important fruit crop of India belonging to family Moraceae. Consumers prefer attractive golden yellow-coloured ripe bulbs to consume as it is believed to be more delicious and have more aroma. Owing to its bulkiness the consumers generally prefer minimally processed fruits in smaller packets. Minimally processing of Jackfruit is an appropriate post-harvest technology for enhancing shelf life as well as provide convenient option to consumers where they could get a small portion of the fruit for consumption. The issue of the safety of minimally processed foods is also considered looking at the use of hurdle technology and establishing safety criteria for minimally-processed foods (Leistner, 2002) [10]. Now a day Consumers are more health and quality conscious as well as more adverse to use of chemical preservatives. Hence the demand for high quality foods with fresh like and natural characteristics that require a minimum amount of effort and time for processing has led to introduction of ready-to-eat convenience foods preserved by mild technologies. Thus, the minimal processing concept has emerged to satisfy demand of high-quality products (Sudheer and Indira, 2007) [21]. Minimally processed fruits are ready to eat fruits which offers several benefits to the consumers as it reduces preparation time, provide more uniform and consistent quality, require less storage space, easy packing and reduced waste during handling. Quality of the fruits can be ensured which will provide satisfaction to the consumer (Binti, 2003) [3]. Therefore, it is necessary to standardize minimal processing techniques for short term preservation of jackfruit bulbs.

Materials and Method
The experiment was carried out during the year 2015 in the laboratory of the Department of Horticulture, Assam Agricultural University, Jorhat.

Sample preparation
Jackfruits were collected at brownish yellow skin colour of optimum ripening and without any microbial contamination or mechanical crevices, from Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat. The fruit were cleaned to remove foreign matters and washed with 2% chlorinated water. Under the laminar air flow, Jackfruits were cut with sterilized knife and the bulbs were extracted. The extracted jackfruit bulbs were sprayed with Citric Acid (CA), Ascorbic Acid (AA) and Calcium Chloride ($CaCl_2$) at different

concentration @ 0.02%, 0.02% and 1% respectively and with a preservative *i.e.*, potassium metabisulphite @ 150ppm followed by storage at 6° C.

Statistical analysis

The data obtained were analysed through Completely Randomized design with 5 replication and subjected to analysis of variance due to treatments by 'F' test.

If the variance was found to be significant, the corresponding C. D values were calculated at 5% level and the standard error of the mean S.Ed (x) was calculated by using the following expression:

$$\text{S.Ed} = \sqrt{\frac{2 \times \text{Error mean square}}{\text{Total number of replication}}}$$

Statistical calculation was performed using Microsoft Excel. Graphs were prepared in Microsoft Excel (MS-Office ver. 2003).

Description of treatments

The following combination of antioxidants and preservatives were tested:

Control (T_0), Ascorbic acid 0.02% + Citric acid 0.02% + $CaCl_2$ 1.0% + Storage at 6°C (T_1), 150ppm potassium metabisulphite (KMS) + Storage at 6°C (T_2), Ascorbic acid 0.02% + Citric acid 0.02% + $CaCl_2$ 1.0% + 150ppm potassium metabisulphite + Storage at 6°C (T_3)

On 3rd day, 6th day and 9th day after treatment of bulbs, data on bio-chemical and organoleptic changes were recorded.

Results and Discussion

After treatment of jackfruit bulbs, the Physico-biochemical properties exhibits changes which were furnished in the following tables. Total soluble solids (TSS) content of the prepared bulbs followed an increasing trend during storage. On 3rd day and 6th day there was no significant difference among the treatments. However, on 9th day, the highest TSS content was exhibited by the bulbs in T_1 (Table no. 1). Increasing trend of TSS could be ascribed to the increase in sugar content of the bulbs. Similar observations of increasing TSS during storage have been reported by Manolopoulou and Varzakas (2011) [12], Jiang *et al.* (2004) [8] and Gonzalez-Aguilar *et al.* (2000) [7] for cabbage, Chinese water chestnut and mangoes respectively.

Table 1: Effect of various treatment combinations on TSS (°B) of jackfruit bulbs during storage

Treatments	TSS (°B)			
	Initial	3rd day	6th day	9th day
T_0	20.20	-	-	-
T_1	20.20	21.30	23.66	25.80
T_2	20.20	21.66	23.38	24.84
T_3	20.20	21.74	23.48	25.48
S.Ed±		0.302	0.181	0.100
$CD_{0.05}$		NS	NS	0.218

T_0 = Control, T_1= 0.02% AA+0.02% CA+1% $CaCl_2$+ Storage at 6°C, T_2= 150ppm KMS + Storage at 6°C, T_3= 0.02% AA+0.02% CA+1% $CaCl_2$+150ppm KMS + Storage at 6°C, NS= Non-significant

Data presented on table no. 2 represents change in sugar contents of the bulbs. The sugar content followed an increasing trend during storage. There was a significant difference among the treatments on sugar content. However, on 3rd, 6th and 9th day observations; reducing sugar and total sugar contents were the lowest in the bulbs in T_1. Increasing trend of sugar in terms of reducing sugar and total sugars could be ascribed to the conversion of organic acid and starch into sugars. Lima *et al.* (2010) [11] and Damasceno *et al.* (2005) [5] reported similar for guava and honeydew melons respectively.

Table 2: Effect of various treatment combinations on reducing sugar (%) and total sugar (%) of jackfruit bulb during storage

Treatment	Reducing sugar (%)				Total sugar (%)			
	Initial	3rd day	6th day	9th day	Initial	3rd day	6th day	9th day
T_0	5.95	-	-	-	15.92	-	-	-
T_1	5.95	6.88	8.50	9.09	15.92	16.22	19.26	23.37
T_2	5.95	8.23	9.19	11.60	15.92	17.31	20.50	24.62
T_3	5.95	8.67	9.70	13.03	15.92	19.34	20.32	27.42
S.Ed±		0.154	0.266	0.384		0.312	0.308	0.587
$CD_{0.05}$		0.337	0.579	0.836		0.680	0.672	1.279

T_0 = Control, T_1= 0.02% AA+0.02% CA+1% $CaCl_2$+ Storage at 6°C, T_2= 150ppm KMS + Storage at 6°C, T_3= 0.02% AA+0.02% CA+1% $CaCl_2$+150ppm KMS + Storage at 6°C, NS= Non-significant

The ascorbic acid and total carotenoid content of the minimally processed bulbs showed a decreasing trend during storage (Table no. 3). However, bulbs in T_1 retained the highest amount of ascorbic acid and total carotenoid at the end of 9th day. Ascorbic acid content increased at the initial period and then decreased during storage. Rapid increase in ascorbic acid content might be due to the addition of ascorbic acid as treatment and then decreases thereby. This might be due to oxidation of ascorbic acid to dehydroascorbic acid (Miller and Rice-Evans, 1997) [13], This is in agreement with the previous findings, which reported a significant decrease in ascorbic acid content in minimally processed guava (Lima *et al.*, 2010) [11]. Whereas the decrease in total carotenoid content could be the result of oxidative degradation by lipoxygenase enzyme (Blain, 1970; Rosa *et al.*, 1987) [4, 17].

Table 3: Effect of various treatment combinations on ascorbic acid (mg $100g^{-1}$) and of total carotenoid (μg g^{-1}) jackfruit bulbs during storage

Treatment	Ascorbic acid (mg $100g^{-1}$)`				Total carotenoid (μg g^{-1})			
	Initial	3rd day	6th day	9th day	Initial	3rd day	6th day	9th day
T_0	25.29	-	-	-	4.17	-	-	-
T_1	25.29	34.44	22.40	21.72	4.17	3.68	2.93	2.44
T_2	25.29	21.30	19.54	14.10	4.17	3.32	2.17	1.79
T_3	25.29	31.00	20.28	18.13	4.17	2.96	2.79	1.51
S.Ed±		0.357	0.290	0.426		0.108	0.101	0.168
$CD_{0.05}$		0.777	0.633	0.929		0.235	0.220	0.366

T_0 = Control, T_1= 0.02% AA+0.02% CA+1% $CaCl_2$+ Storage at 6°C, T_2= 150ppm KMS + Storage at 6°C, T_3= 0.02% AA+0.02% CA+1% $CaCl_2$+150ppm KMS + Storage at 6°C

However, at the end of 9th day, the highest increase of acidity was observed in the bulbs in T_1 lowest was observed in T_2 whereas in case of pH, lowest pH was exhibited by the bulbs in T_1 and highest in T_2 (Table no. 4). Increase in acidity coupled with decrease in pH might be due to the addition of acids which increases the acidity and decreases the pH of the produce (Bieganska-Marecik and Czapski, 2007) [2]. Similar observations have been reported by Damasceno *et al.* (2005) [5], Lima *et al.* (2010) [11], and Antoniolli *et al.* (2012) [1] for honey dew melon, guava and pineapple respectively. Various treatment combinations have a significant influence on the activity of polygalacturonase enzyme. An increasing trend was observed in polygalacturonase activity in terms of enzyme activity and specific activity. There is a possible role of ethylene in increasing polygalacturonase activity (Karakurt and Huber, 2003) [9]. At the end of 9th day, the enzyme activity and specific activity were the lowest in T_1 (Table no. 5).

Table 4: Effect of various treatment combinations on acidity (%) and pH of jackfruit bulbs during storage

Treatment	Acidity (%)				pH			
	Initial	3rd day	6th day	9th day	Initial	3rd day	6th day	9th day
T_0	0.37	-	-	-	5.16	-	-	-
T_1	0.37	0.44	0.48	0.51	5.16	5.08	5.05	4.98
T_2	0.37	0.27	0.22	0.16	5.16	5.17	5.19	5.23
T_3	0.37	0.38	0.43	0.48	5.16	5.10	5.06	5.00
S.Ed±		0.032	0.004	0.009		0.013	0.010	0.011
$CD_{0.05}$		0.070	0.008	0.019		0.028	0.022	0.024

T_0 = Control, T_1= 0.02% AA+0.02% CA+1% $CaCl_2$+ Storage at 6 °C, T_2= 150ppm KMS + Storage at 6°C, T_3= 0.02% AA+0.02% CA+1% $CaCl_2$+150ppm KMS + Storage at 6°C

Table 5: Effect of various treatment combinations on polygalacturonase activity in terms of enzyme activity and specific activity of jackfruit bulbs during storage

Treatment	Enzyme activity				Specific activity			
	Initial	3rd days	6th days	9th days	Initial	3rd days	6th days	9th days
T_0	1.235	-	-	-	-	0.42	-	-
T_1	1.235	1.64	1.83	2.67	0.352	0.42	0.44	0.56
T_2	1.235	2.43	2.18	3.65	0.352	0.48	0.52	0.60
T_3	1.235	2.17	2.52	2.85	0.352	0.44	0.49	0.58
S.Ed±		0.075	0.052	0.066		0.007	0.003	0.004
$CD_{0.05}$		0.163	0.114	0.145		0.015	0.007	0.009

T_0 = Control, T_1= 0.02% AA+0.02% CA+1% $CaCl_2$+ Storage at 6°C, T_2= 150ppm KMS + Storage at 6°C, T_3= 0.02% AA+0.02% CA+1% $CaCl_2$+150ppm KMS + Storage at 6 °C

Sensory quality, *viz.* colour, texture, flavour and overall acceptability was the highest in the bulbs in T_1 on 3rd, 6th, and 9th day's observations (Fig. 6). Regarding the sensory quality of the produce, better retention of the sensory score in terms of colour, flavour, taste, texture and overall acceptability was observed in treatment solution containing ascorbic acid, citric acid and calcium chloride. This might be due to the properties of ascorbic acid and citric acid in better retention of colour, appearance and flavour, while the better sensory score for texture could be influence by calcium chloride. Similar beneficial effect was also reported for pineapple and jackfruit (Ediriweera *et al*., 2012 [6]; Saxena *et al*., 2012) [18]. This is in agreement with the previous findings which reported that, low temperature storage/refrigerated storage (4-6°C) extended the shelf life as well as retained the health-related characteristics of minimally processed products such as rambutans, tomatoes, jackfruit and orange, (Sirichote *et al*., 2008; Odriozola-Serrano *et al*., 2008; Saxena *et al*., 2009; Plaza *et al*., 2011) [20, 14, 19, 15].

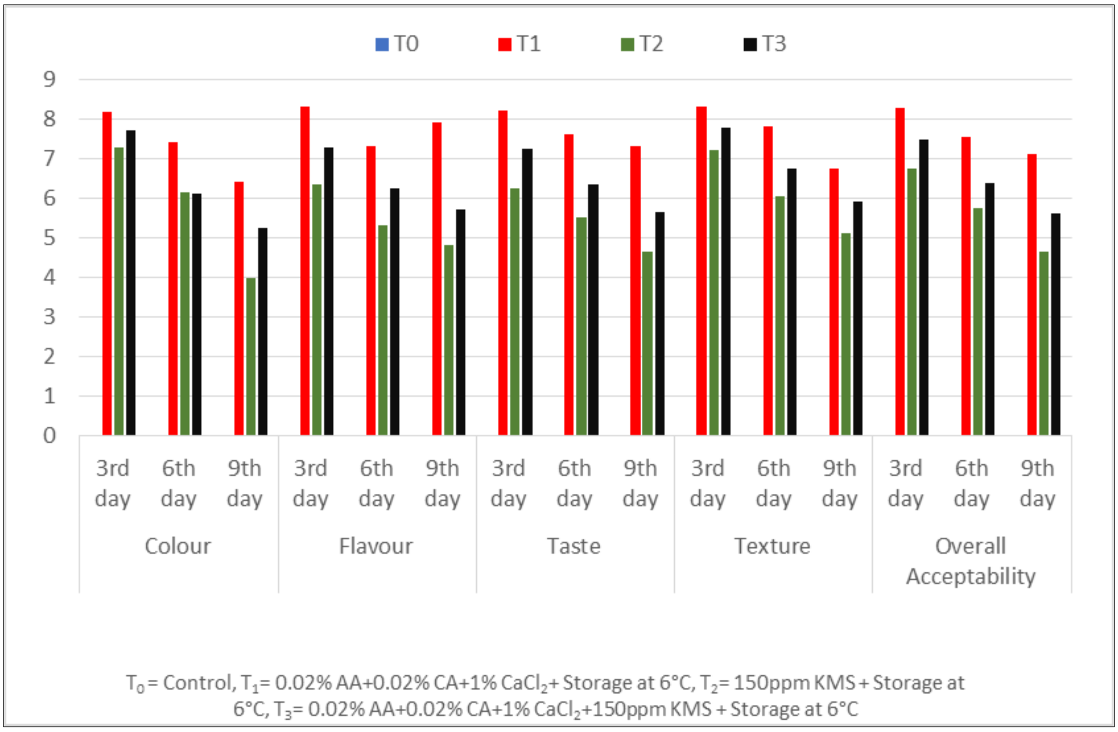

Fig 1: Effect of various treatment combinations on the sensory quality of jackfruit bulbs during storage

Conclusion

Studies on the development of minimal processing technique for short term preservation of jackfruit bulbs reveal that antioxidant treatment along with low temperature storage are beneficial in reducing decay, maintaining quality by slowing down the deterioration of quality and extending the shelf life of the produce. Amongst the different treatments, T_1 have been found to be the most effective treatment for minimal processing of jackfruit bulbs. This might be due to the synergistic effect of combine antioxidant and low temperature that maintained the quality and hence extend the shelf life of the bulbs. This is in agreement with the previous findings which have been reported that dipping in ascorbic acid, citric acid and calcium chloride solution showed better colour retention, bioactive compound and antioxidant activity of fresh cut mangoes stored at 5°C (Robles-Sanchez *et al*., 2009) [16].

For minimal processing of jackfruit bulbs for short term preservation, the bulbs should be sprayed with combine solution of 0.02 per cent ascorbic acid, 0.02 per cent citric acid and 1 per cent calcium chloride and stored at 6°C. By this technique the jackfruit bulbs could be stored for up to 9 days without deterioration in its quality and acceptability.

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Conflict of Interests

The author(s) declare that there is no conflict of interest with respect to the research, authorship, and/or publication of this article to disclose

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