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EFFECT OF DIFFERENT COATING MATERIAL ON THE STORAGE BEHAVIOR OF CUSTARD APPLE (*ANNONA SQUAMOSA* L.)

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ABSTRACT

Custard apple, being a climacteric fruit, has short shelf-life because of fast ripening followed by senescence accompanied with quality changes and decay loss. The physiological weight loss of fruits, irrespective of treatments, increased with advancement of storage period but, the minimum (20.99%) physiological weight loss was recorded in the fruits treated with sago 5 per cent and maximum (39.11%) was observed under untreated fruits at 8 days of storage. The fruits treated with fine coating of sago (10%) retained excellent fruit quality with highest TSS (30°Brix) and higher sugar (total and reducing sugar) (31.19 and 17.28) at 8 days of storage. The minimum sugar (total and reducing sugar) percentage *i.e.* 21.11 and 9.10 per centage, respectively and maximum vitamin 'C' content (47.10 mg/100g of pulp) was recorded in the fruits treated with $Cacl_2$ (1.5%) whereas, control treated fruits recorded the least (23.10 mg/100g pulp) at 8 days of storage and marketable fruits were available even up to eight days of storage. Therefore, identification of natural products which produces desirable coating material with necessary amendment is the appropriate technology that can be explored for improving post-harvest storage and marketing efficiency.

INTRODUCTION

Custard apple (*Annona squamosa* Linn.) popular in the Deccan plateau is one of the most important fruit due to its nutritional and medicinal values. The fruits of Custard apple are very delicate and highly perishable. Being climacteric in nature, the biochemical changes in the fruit after harvest occur at a faster rate. The mature fruits after harvest ripen quickly and become excessively soft within 2 to 3 days at ambient condition and become unfit for consumption. The increase in shelf life of custard apple fruit would, therefore, be an advantage to the growers.

Fruit coatings are one such alternative as they not only improve external appearance, but also modify the internal atmosphere of fruits (Saftner, 1999). It is a comparatively newer technique of post-harvest treatment for fruits and vegetables to increase shelf-life which has virtually replaced old commercial methods of post-harvest treatments due to its obvious advantage. Use of coatings has gained importance in reducing the moisture loss and maintaining firmness (Farooqhi *et al.,* 1988; Chauhan *et al.,* 2005; Patel *et al*., 2011). Coatings make good oxygen and lipid barriers at low to intermediate RH, because the polymers can effectively make hydrogen bonds.

The present investigation was planned with the hypothesis that deterioration in custard apple fruits is triggered from the sites of weak attachments at the junctions of cohering carpels. Several naturally available sources, which are edible and produce a fine coating, have the capacity to retard the rate of ripening. Keeping the above facts in view, an experiment was planned and executed.

MATERIALS AND METHODS

Fresh and fully matured uniform sized, free from diseases and mechanical injury custard apple fruits were collected for the study. The fruits were coated with various concentrations of $CaCl_2$ (0.5%, 1%, 1.5%), $CaNO_3$ (4%, 6%, 8%), aloevera gel (50%, 75%, 100%), sago (5%, 10%, 15%) and arrowroot (5%, 10%, 15%) for 5 minutes and equal portion was taken with distilled water to be taken as control. Thereafter, the coated custard apple fruits were placed on newspaper sheet for air drying in shade at room temperature. The duration for experiment was 9 days and observations were recorded on alternate days up to last day of storage, however, records of sampling on 2nd, 4th, 6th and 8th day have been mentioned. The experiment was laid out in completely randomized design with three replications. The physiological loss of weight (PLW) was recorded on weight basis, TSS was determined by hand refractrometer and expressed in °Brix, acidity of fruits by AOAC method (Anon, 1984), ascorbic acid levels in fruits by a method suggested by Ranganna, 1986, and total and reducing sugars levels were determined by Nelson Somogyi's method (Nelson, 1994). Data were recorded periodically and analyzed statistically following the complete randomized design as outlined by Panse and Sukhatme, 1967.

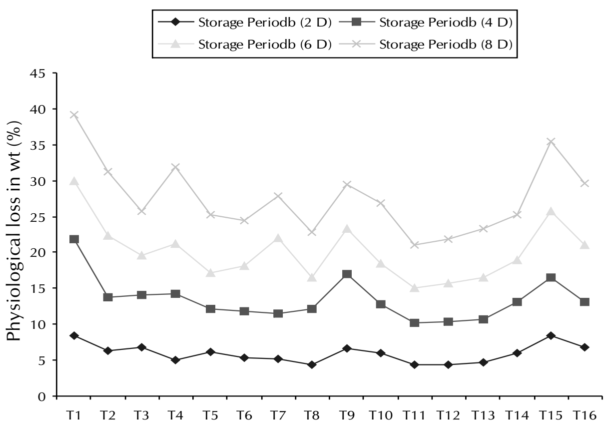
RESULTS AND DISCUSSION

Physical characteristics

Perusal of the results obtained in the present investigation indicated that post harvest treatment of sago influenced the physical characteristics of custard apple fruit during storage at room temperature and are presented in Table 1.

The physiological Loss in weight of custard apple fruit increased with the increase in storage period (Fig. 1). Minimum weight loss (20.99 per cent) was recorded with sago 5% closely followed by sago 10% (21.82 per cent) as compared to control in which the maximum weight loss (39.11 per cent) was recorded up to 8 days of storage. Higher weight loss of untreated fruits may be due to increased storage breakdown associated with higher respiratory rate as compared to sago treated fruits. These results are in conformity with the findings of Kumar *et al.* (2004). It was interesting to note that among the coating material, fruits treated with sago, a starch rich polysaccharide (Nene *et al.* 1996) showed maximum resistance for physiological weight loss. This observation may be attributed to the provision of physical barriers by coating material to transpirational losses from fruit surface. Application of sago, in particular, formed a fine coating around the fruit retarding the rate of physiological weight loss, which may be due to plugging of grooves in between the carpels of the fruits, as they are the potential sites for excessive transpirational loss. Retardation in transpirational losses on treatment of permeable edible coating has been reported in custard apple (Patel *et al.*, 2011) and banana (Lowings and Cutts, 1982).

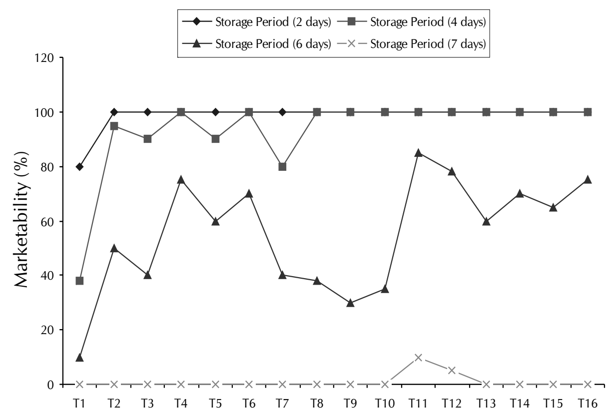
From Fig. 2, it is clear that the marketable fruit (%) of the fruit decreased continuously with the increase in storage period. The present investigation showed that maximum percent of marketable fruits were retained under sago 5 per cent followed by sago 10 per cent coating after 2, 4, 6 and 8 days of storage period. The cause of extended shelf life of fruits under sago coating may be due to reduction in the rate of water loss with lesser ripening of the fruits and slowing down of the change in colour. Whereas, minimum retention of marketable fruits was recorded under control. This might be due to the unsealing of lenticels' that are responsible for higher rate of transpiration and respiration, which are subjected to the physiological activities. This finding was in line with Haribabu *et al.*, 1990 in custard apple.



T1: Control (distill water); T2: $CaCl_2$(0.5%); T3: $CaCl_2$(1%); T4: $CaCl_2$(1.5%);T5 $CaNO_3$(4%); T6: $CaNO_3$(6%); T7: $CaNO_3$(8%); T8: Aloevera (75%); T9: Aloevera (75%); T10: Aloevera (100%); T11: Sago (5%);T12: Sago (10%); T13: Sago (15%); T14 Arrowroot (5%); T15: Arrowroot (10%); T16: Arrowroot (15%)

Figure 1: Effect of different post harvest treatments on physiological loss in weight (%)

Chemical characteristics



T1: Control (distill water); T2: $CaCl_2$(0.5%); T3: $CaCl_2$(1%); T4: $CaCl_2$(1.5%);T5 $CaNO_3$(4%); T6: $CaNO_3$(6%); T7: $CaNO_3$(8%); T8: Aloevera (75%); T9: Aloevera (75%); T10: Aloevera (100%); T11: Sago (5%);T12: Sago (10%); T13: Sago (15%); T14 Arrowroot (5%); T15: Arrowroot (10%); T16: Arrowroot (15%)

Figure 2: Effect of different post harvest treatments on marketability (%)

Table 2: Bio-chemical changes in custard apple fruits as influenced by different coating materials under ambient storage

Treatments	Total soluble solids (^{0}Brix)				Acidity (%)				Ascorbic acid (mg$^{-100g\ pulp}$)			
	Days of storage				Days of storage				Days of storage			
	2	4	6	8	2	4	6	8	2	4	6	8
T_1:Control (distill water)	20	22	23	24	0.30	0.27	0.24	0.21	39.16	37.50	31.12	23.10
T_2: $CaCl_2$ (0.5%)	21	23	26	27	0.30	0.29	0.27	0.22	59.18	65.80	56.78	45.00
T_3: $CaCl_2$ (1%)	21	23	25	27	0.32	0.30	0.28	0.25	65.89	61.00	54.50	37.90
T_4: $CaCl_2$ (1.5%)	22	24	27	29	0.33	0.31	0.28	0.25	60.87	51.90	43.50	31.19
T_5: $CaNO_3$ (4%)	23	24	25	27	0.32	0.32	0.30	0.25	42.10	40.60	32.20	28.98
T_6: $CaNO_3$ (6%)	21	23	25	27	0.34	0.32	0.30	0.26	43.10	42.00	35.40	30.12
T_7: $CaNO_3$ (8%)	23	24	24	26	0.34	0.31	0.30	0.26	45.17	42.00	39.10	35.89
T_8: Aloevera (50%)	20	22	24	25	0.39	0.33	0.32	0.31	56.18	51.90	48.12	35.00
T_9: Aloevera (75%)	20	23	24	25	0.30	0.28	0.25	0.24	49.50	45.80	35.18	30.41
T_{10}: Aloevera (100%)	21	23	25	25	0.35	0.33	0.30	0.28	47.00	43.21	32.00	28.20
T_{11}: Sago (5%)	21	23	26	28	0.31	0.28	0.27	0.24	61.60	55.90	48.10	41.80
T_{12}: Sago (10%)	23	25	28	30	0.40	0.34	0.32	0.31	70.70	61.12	58.17	45.21
T_{13}: Sago (15%)	23	24	27	28	0.39	0.34	0.32	0.28	79.31	69.20	65.33	47.10
T_{14}: Arrowroot (5%)	21	23	26	28	0.30	0.28	0.27	0.23	71.90	62.00	59.80	46.60
T_{15}: Arrowroot (10%)	22	22	24	25	0.32	0.31	0.29	0.29	72.10	69.00	60.17	43.00
T_{16}: Arrowroot (15%)	23	25	26	27	0.36	0.32	0.32	0.30	63.70	58.18	49.12	40.29
CD at 5% level	1.22	NS	NS	1.62	0.019	0.026	0.021	0.023	2.50	4.43	4.46	3.50

Table 3: Transformation of carbohydrates in fruits of custard apple as influenced by different coating materials under ambient storage

Treatments	Total sugar (%) Days of storage				Reducing sugar (%) Days of storage			
	2	4	6	8	2	4	6	8
T_1:Control (distill water)	27.46	28.00	30.14	25.19	21.70	22.53	24.67	14.15
T_2: $CaCl_2$ (0.5%)	21.06	23.23	25.45	22.18	15.15	16.66	17.19	11.81
T_3: $CaCl_2$ (1%)	20.92	24.12	29.14	23.99	13.14	18.91	19.09	12.43
T_4: $CaCl_2$ (1.5%)	18.80	19.18	23.67	21.11	11.65	14.15	15.96	9.10
T_5: $CaNO_3$ (4%)	23.22	28.45	29.18	23.14	17.77	19.30	20.50	11.33
T_6: $CaNO_3$ (6%)	23.89	28.67	28.41	26.59	17.01	20.21	20.93	11.55
T_7: $CaNO_3$ (8%)	26.98	29.15	30.54	28.80	19.54	22.13	23.67	14.51
T_8: Aloevera (50%)	30.07	32.94	32.11	30.58	21.07	24.58	26.17	16.95
T_9: Aloevera (75%)s	27.84	30.19	31.11	29.51	19.98	22.91	24.59	14.73
T_{10}: Aloevera (100%)	29.00	30.66	31.15	29.10	20.50	23.19	25.28	15.43
T_{11}: Sago (5%)	30.91	31.10	31.87	27.15	20.92	24.15	25.00	15.83
T_{12}: Sago (10%)	31.05	31.99	33.18	31.19	22.69	25.16	26.79	17.28
T_{13}: Sago (15%)	30.98	31.91	32.15	29.16	21.64	24.81	26.53	16.74
T_{14}: Arrowroot (5%)	23.21	25.25	26.31	22.40	17.21	20.89	22.67	12.19
T_{15}: Arrowroot (10%)	23.70	23.91	25.17	21.66	18.14	20.97	22.81	13.34
T_{16}: Arrowroot (15%)	25.98	26.87	28.61	23.41	19.17	21.13	23.88	13.92
CD at 5% level	0.15	0.13	0.12	0.17	0.083	0.080	0.068	0.070

Increase in total soluble solids with different post harvest treatments was recorded in the present investigation (Table 2) but the effect of sago 10 per cent (30° Brix) was more pronounced as compared to control (24° Brix) up to 8 days of storage. The increase in TSS might be due to conversion of reserved starch and other polysaccharides to soluble form of sugar with the advancement of storage period. These results are in agreement with the result of Kaur *et al*., 2005. The changes brought about in total soluble solids of fruits during ripening are mainly due to degradation of starch and accumulation of sugar. Application of coating to fruits showed a marked effect on the rate of carbohydrate metabolism and the concomitant changes in TSS. The gradual increase in TSS of fruits treated with coating material may be justified by the twin role of coating material acting as a physical barrier for transpirational losses, thus creating a modified atmosphere resulting into building of internal CO_2 and depletion of O_2. This might have led to slow down in the carbohydrate metabolism reflected in delayed starch depletion (Jholgiker and Reddy, 2007). On the other hand, untreated fruits recorded minimum increase in TSS, which was probably due to the less concentration of juice as a result of dehydration.

During storage period, the acidity of custard apple fruit reduced with all chemicals registering minimum reduction (0.31 per cent) with sago 10 per cent up to 8 days of storage. In the present study (Table 2), decrease in acidity could be explained with the fact that organic acid might be utilized rapidly in respiration or conversion of acid into sugar from pre-climacteric to post-climacteric stage. These results are in close view to that of Sihag *et al.* (2005) as he stated that the higher acidity content might be due to anaerobic respiration and higher evapotranspiration rate. Minimum acidity was observed in untreated fruits. Acidity (%) and storage period followed a linear declining trend on account of conversion of organic acid into sugars. Similar findings have been also advocated by Paull, 1982; Tuwar and Ughreja, 1999 and Patel *et al.*, 2011 in custard apple and Mahajan *et al.* (2005) in kinnow.

It was observed that the ascorbic acid content decreased significantly during storage with the post harvest treatments of sago 10 per cent (45.21 $mg^{-100g\ pulp}$) up to 8 days of storage (Table 2). The decrease in vitamin 'C' content on prolonged storage might be mainly due to oxidation phenomenon (Mapson, 1970). These results are in close proximity with the findings of Singh *et al.* (1982) and Patel *et al.*, 2011. The highest ascorbic acid was recorded under sago 10 percentage. Maximum vitamin 'C' content may be due to metabolic changes and increase in percentage of acidity. The minimum ascorbic acid content of fruit was recorded under control (distill water) which, possibly might be due to rapid conversion of ascorbic acid into dehydro ascorbic acid in the presence of enzyme ascorbinase in over ripen fruits with injured skin. The result corroborates with the findings of Yokohoma and Honda (1998) in mango fruits.

The total and reducing sugar increased significantly during storage of custard apple fruit with sago 10 per cent (31.19 per cent total sugars and 17.28 per cent reducing sugars) up to 8 days of storage (Table 3). The sugar (total and reducing sugar) percentage of fruits showed a increasing trend up to 6th day of storage and thereafter declined up to 8th day. Increase in total sugar might be due to partial hydrolysis of complex carbohydrates. The increase in reducing sugar as well as total sugar corresponded to the increase in total soluble solids and ultimate decrease in non reducing sugar in the storage period. The variation in different fraction of sugar might be due to hydrolysis of polysaccharides like starch, pectin and inversion of non-reducing sugar into reducing sugar, as increase in reducing sugar was correlated with the decrease in non-reducing sugar (Sharma and Singh, 2005). The increased level of total sugar was probably due to conversion of starch and pectin into simple sugar, which decline later on during storage might be due to their rate of consumption for respiration and other energy sources. Such information has been reported by Patel *et al.* (2011) in custard apple.

From the present study, it is concluded that post-harvest treatment to custard apple fruits with edible coating material like sago at 5 per cent and 10 per cent concentration resulted in increase in shelf-life by 8 days as compared to untreated fruits (control) satisfactorily. This technology can be explored for improving post harvest storage and market efficiency.

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