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Chemical changes in custard apple fruits hybrid atemoya x balanagar packed in polypropylene bags to improve shelf life of fruit

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Abstract
In present investigation the results revealed that, significantly lowest acidity was observed in Polypropylene bags without pores (T_7) (0.12) and highest acidity was recorded in Polypropylene bags with 50 pores (T_5) (0.19).
The interaction between treatments and storage period on acidity was found to be significant. Significantly lowest Brix-acid ratio was recorded in Polypropylene bags with 50 pores(T_5) (140.95).But it was on par with treatment T_3.Highest brix-acid ratio was observed in T_6 (191.93) which was on par with T_7.
Polypropylene bags without Pores (T_7) was recorded highest reducing pores (T_7) was recorded highest reducing sugars (13.89) which was significantly superior over rest of treatment and significantly lowest reducing sugars was recorded in T_3 (11.44).
The interaction between Treatment X Storage periods on reducing sugar was significant. Polypropylene bags with 60 pores (T_6) recorded significantly highest non reducing sugars (2.77) and significantly lowest non reducing sugar was recorded by treatment (T_8) (0.74).
Significantly highest Ascorbic acid was recorded in treatment T_3 (35.00) The interaction effect between Treatment and storage period on Ascorbic acid of Custard apple fruits was found to be significant.

Keywords: Custard apple, polypropylene bag, titrable acidity, brix-acid ratio, reducing sugars, ascorbic acid

Introduction
Custard apple is a small, more or less evergreen shrub or tree, grows to a height of 5 to 9 m. It starts bearing at the age of 4 to 6 years and the bearing declines after 12 to 15 years. Harvesting may extend from August to November depending on the climatic condition of the region. An average tree yields about 100 to 150 fruits per year but bigger and vigorous tree may yield more. Each fruit weighs about 120 to 230 g (Aziz and Yusouf, 1994) [1]. Custard apple is considered as one of the delicious table fruit and is valued mainly for its sweet, mild flavoured pulp. The fruit has a scale like thick fragile non-edible peel outside. The fruit is botanically referred as syncarpium and aggregate of fruit lets, each processing edible fleshy mass of soft, juicy and granular textured pulp surrounding a non-edible black seed. Apart from fruit, the leaf, seeds and roots of custard apple are reported to have medicinal properties (Pareek and Sharma, 1993) [14].
Extension of shelf life in custard apple even for a day or two will go a long way in increasing the shelf life and thus making it much easier to handle the fruit. The practice as reported by Salunkhe and Kadam (1995) [21] and Reddy (2000) [19] suggest that the fruits of custard apple after harvesting are either loaded directly or packed in bamboo baskets with paddy straw or leaves of custard apple as cushioning material and transported to markets. During this process, the fruits experience high mechanical stress, thereby reducing their shelf life. The sensitivity of fruit to minor bruises results into enzymatic browning which further aggravates the problem of marketing. Normal ripening of custard apple was reported by Broughton and Guat (1979) [2] at temperature ranging from 15 to 30 °C. Prasanna *et al*. (1997) [17] reported that the safe range of storage temperature of custard apple was found to be between 15 and 20 °C, with maximum shelf life at 15 °C.
Modified atmosphere packaging (MAP) is intended to create an appropriate gaseous atmosphere around a commodity packed in film packages to enhance shelf life and conserve the quality of packed produce (Deepak Raj Rai *et al*., 2002) [5].

Typically, initial atmospheric conditions are established for a transient period, and the interplay of the commodities physiology and the physical environment maintain those conditions within broad limits (Zagory and Kader, 1988) [9]. Modified atmosphere can be created either passively by the commodity or internally. Passive or commodity generated MA is defined as if the commodity characteristics are properly matched to film permeability characteristics, an appropriate atmosphere can passively evolve within a sealed package as a result of the consumption of O_2 and the production of CO_2 through respiration (Smith *et al*., 1987) [24]. Active MA can be done by pulling a slight vacuum and replacing the package atmosphere with the desirable gas mixture (Kader *et al*., 1988) [9]. Gas flushing establish modified atmosphere quickly and increases the shelf life and quality of fruits and vegetables (Sudheer and Indira, 2007) [26]. In India, no studies have been reported on the effect of polypropylene packing with ventilation, hot water treatments and the combination of both on the shelf life of custard apple stored at low temperature (13 ºC±1).

Materials and Methods

In present investigation, we tried seven packaging (MAP) materials having different number of pores and one control treatment without using any packaging material tested for Hybrid Atemoya X Balanagar. Lab Experiment was laid in Completely Randomized block design with three replications. In each treatment 6 units containing 4 fruits were tested and observations were recorded at 4 days interval for Titrable acidity, Brix acid ratio, Reducing sugar, Non reducing sugar and Ascorbic acid (Vitamin C). Statistical analysis was carried out in Windostat 8.5 for recording correlation in period span with Titrable acidity, Brix acid ratio, reducing sugar, Non reducing sugar and Ascorbic acid and modified atmospheric packaging (MAP).

The Titrable acidity of custard apple pulp samples were determined by titration method (Ranganna, 1986) [18]. Brix-Acid ratio was calculated by dividing the TSS value by the acid value. Reducing sugars present in the custard apple pulp samples were determined by the method of Lane and Eyon (AOAC, 1965).

The non-reducing sugar content of the custard apple pulp samples were determined by the method of difference as: Non-reducing sugars = Total sugars - Reducing sugars.

Ascorbic acid content of custard apple pulp samples were determined by 2,6-dichlorophenol indophenol titration method (Ranganna, 1986) [18].

Treatment Details

T_1- Packing of fruits in polypropylene bag with 10 pores
T_2- Packing of fruits in polypropylene bag with 20 pores
T_3- Packing of fruits in polypropylene bag with 30 pores
T_4- Packing of fruits in polypropylene bag with 40 pores
T_5 - Packing of fruits in polypropylene bag with 50 pores
T_6 -Packing of fruits in polypropylene bag with 60 pores
T_7 -Packing of fruits in polypropylene bag without any pores
T_8 -control (No packing)

Results and Discussion

Titrable acidity (%)

The data pertaining to titrable acidity of custard apple fruits cv. Atemoya X Balanagar packed in polypropylene bags and stored at low temperature are presented in Table 1.

There were significant differences among the treatments with respect to acidity. Significantly lowest acidity was recorded in polypropylene bags without pores (T_7) (0.12). Significantly highest acidity was recorded in polypropylene bags with50 pores (T_5) (0.19).

Significant differences were observed in acidity of custard apple fruits due to storage period. The acidity increased from '0' day (0.06) to 12th day (0.28) of storage period.

The interaction between treatments and storage period on acidity of custard apple fruits was significant. From 4th day and 12th day of storage lowest acidity was recorded in polypropylene bags without pores (T_7) (0.07 and 0.14 and 0.20) respectively. From 4th day to 12th day of storage highest acidity was recorded in polypropylene bags with 50 pores (T_5) (0.14, 0.20 and 0.38) respectively.

In the present investigation, it was observed that the acidity of custard apple fruits initially increased with increase in storage period and later decreased in all the experiments at low temperature. There was an initial increase in acidity upto few days of storage and then showed a decreasing trend at the end of shelf-life, which was in conformity with the findings of Barnell (1941) who suggested that changes in acidity, may be connected with changes in mechanism of respiratory process. Further, the decrease in acidity may be due to conversion of acids to sugars (Pool *et al.*, 1972) [16] and utilization of organic acid during respiration (Singh and Mathur, 1954 and Srivastava *et al*., 1961) [23, 25].

In MAP, fruits packed in polypropylene bags recorded significantly higher acidity irrespective of pores. This is in conformation with the results of Kumar and Gupta (1985) [11]. The increase in acidity can be ascribed to the production of organic acids as reported by Paull *et al*. (1983) [15] and Gutierrez *et al*. (1994) [7] during ripening of soursop and cherimoya fruits respectively. Buescher (1975) [3] and Sankat *et al*. (1993) [22] also observed an increase in acidity at low temperature on tomato and mangoes, respectively. Acidity content in edible ripe stage in custard apple varied among the varieties and it ranged from 0 to 2.5 per cent (Rajput, 1985) [20].

Brix-acid ratio

The data pertaining to brix-acid ratio of custard apple fruits cv. Atemoya X Balanagar packed in polypropylene bags and stored at low temperature are presented in Table 2.

There were significant differences among different treatments with respect to brix-acid ratio. Significantly lowest brix-acid ratio was recorded in polypropylene bags with 50 pores (T_5) (140.95), which is on par with polypropylene bags with 30 pores (T_3) (151.19). Significantly highest brix-acid ratio was recorded in polypropylene bags with 60 pores (T_6) (191.93), which is on par with polypropylene bags without pores (T_7) (187.78).

Significant differences were observed in brix-acid ratio of custard apple fruits due to storage period. The brix-acid ratio decreased from '0'day (283.02) to 12th day (85.96) of storage period.

The interaction between treatments and storage period on brix-acid ratio of custard apple fruits was significant. On '0' day and 8th day of storage lowest brix-acid ratio was recorded in polypropylene bags with 30 pores (T_3) (265.45 and 93.40) respectively. On 8th day and 12th day of storage highest brix-acid ratio was recorded in polypropylene bags with 10 pores (T_1) (117.22 and 122.89) respectively.

In the present investigation, it was observed that the brix-acid ratio of custard apple fruits initially decreased with increase in storage period and later increased in all the experiments at low temperature. The brix-acid ratio in fruits followed decreasing trend initially and increased at later stages of storage period. Though both TSS and acidity had shown initial increase followed by decrease but an increase acidity is very less, therefore the brix-acid ratio increase initially and decrease later indicate that the magnitude of increase or decrease in TSS are more as compared to acidity during storage. In all the experiments control recorded highest brix-acid ratio and it may be due to control fruits recorded the highest TSS and lowest acidity.

In MAP, fruits packed in polypropylene bags recorded significantly higher acidity irrespective of pores. The brix-acid ratio decreased from '0' day to 12th day of storage period. Significantly the highest brix-acid ratio recorded in polypropylene bags with 60 pores. Kramchote *et al*. (2008) [10] also found controlled atmosphere storage at 3% O_2 + 5% CO_2 maintained TSS/TA ratio in 'Nam Dok Mai' mango stored at 13 °C.

Reducing sugars (%)

The data pertaining to reducing sugars of custard apple fruits cv. Atemoya X Balanagar packed in polypropylene bags and stored at low temperature are presented in Table 3.

There were significant differences among the treatments with respect to reducing sugars. Significant highest reducing sugars were recorded in polypropylene bags without pores (T_7) (13.89), which is on par with polypropylene bags with 60 pores (13.77) (T_6), and control (T_8) (13.47). Significantly lowest reducing sugars was recorded in polypropylene bags with 30 pores (T_3) (11.44).

There were significant differences among the treatments with respect to reducing sugars. The reducing sugars increased from '0' day (9.69) to 12th day (15.36).

The interaction between treatments and storage period on reducing sugars of custard apple fruits was significant. On 4th day and 12th day of storage highest reducing sugars was recorded in polypropylene bags without pores (T_7) (15.66 and 16.49) respectively. From 4th day to 12th day of storage lowest reducing sugars was recorded in polypropylene bags with 30 pores (T_3) (11.32, 11.11and 13.33) respectively.

Ascorbic acid or Vitamin C (mg per 100 g)

The data enunciated on ascorbic acid of custard apple fruits cv. Atemoya X Balanagar packed in polypropylene bags and stored at low temperature are presented in Table 4.

There were significant differences among the treatments with respect to ascorbic acid. Significantly with lowest ascorbic acid was recorded in control (T_8) (28.25), which is on par with polypropylene bags with 20 pores (T_2) (28.50). Significantly highest ascorbic acid was recorded in polypropylene bags with 30 pores (T_3) (35.00).

Significant differences were observed in ascorbic acid content of custard apple fruits due to storage period. The ascorbic acid content decreased from ''0' day (37.00) to 12th day (19.62) of storage.

The interaction between treatments and storage period on ascorbic acid of custard apple fruits was significant. On 4th day and 8th day of storage lowest ascorbic acid was recorded in control (T_8) (30.00 and 28.00) respectively. From '0' day to 8th day of storage highest ascorbic acid content was recorded in polypropylene bags with 30 pores (T_3) (42.00, 40.00 and 40.00) respectively.

Ascorbic acid content of custard apple fruits increased with storage upto certain period and decreased at the end of storage period in all the experiments. The decrease in ascorbic acid in later stage of storage may be due to higher rates of respiration and oxidation (Mapson, 1970) [12]. The loss in ascorbic acid content on prolonged storage might be mainly due to rapid conversion of L-ascorbic acid into dehydroascorbic acid in the presence of enzyme ascorbinase (Mapson, 1970) [12]. These findings are in agreement with the results of Chaudhary and Farooqui (1969) and Tripathi (1989) [27]. The decline in ascorbic acid during storage may be attributed to conversion of ascorbic acid into dehydroascorbic acid (Gustafson and Cooke, 1952) [6].

Among the different MAP treatments, significantly lowest ascorbic acid was recorded in fruits packed in polypropylene bags with 30 pores. In custard apple, vitamin C concentration was very low, and the maximum concentration occurred at the harvest-mature stage (120 days after flowering) then decreased (Pal and Sampath Kumar, 1995). Similar decline of ascorbic acid content in Dwarf Cavendish banana was earlier reported by Padmavathi (1999) [13].

Table 1: Effect of modified atmosphere packaging on titrable acidity (%) of custard apple fruits cv. Atemoya x Balanagar at low temperature (13 °C±1).

Treatments	Days				Mean
	0	4	8	12	
T_1-Polypropylene bag with 10 pores	0.06	0.20	0.19	0.13	0.14^b
T_2-Polypropylene bag with 20 pores	0.06	0.33	0.19	0.14	0.18^d
T_3-Polypropylene bag with 30 pores	0.06	0.26	0.20	0.12	0.16^c
T_4-Polypropylene bag with 40 pores	0.06	0.32	0.20	0.13	0.17^c
T_5-Polypropylene bag with 50 pores	0.06	0.38	0.20	0.14	0.19^d
T_6-Polypropylene bag with 60 pores	0.06	0.26	0.19	0.06	0.14^b
T_7-Polypropylene bag without pores	0.06	0.20	0.14	0.07	0.12^a
T_8-Control	0.06	0.33	0.19	0.13	0.17^c
Mean	0.06^A	0.28^D	0.19^C	0.12^B	

	CD at (0.05)	S.Em ±
Factor A (Days)	0.008	0.003
Factor B (Treatments)	0.01	0.004
For A x B	0.02	0.008

Table 2: Effect of modified atmosphere packaging on brix-acid ratio of custard apple fruits cv. Atemoya X Balanagar at low temperature (13 ºC±1).

Treatments	Days				Mean
	0	4	8	12	
T_1-Polypropylene bag with 10 pores	281.07	147.47	117.22	122.89	167.16^b
T_2-Polypropylene bag with 20 pores	281.07	151.34	120.02	78.30	159.80^b
T_3-Polypropylene bag with 30 pores	265.45	156.15	115.02	89.78	147.08^c
T_4-Polypropylene bag with 40 pores	312.30	151.18	93.40	80.16	165.90^b
T_5-Polypropylene bag with 50 pores	281.07	127.15	112.12	57.25	150.64^c
T_6-Polypropylene bag with 60 pores	249.84	309.70	98.32	96.04	168.37^a
T_7-Polypropylene bag without pores	296.68	254.30	117.22	87.12	201.63^b
T_8-Control	296.68	158.99	113.02	76.14	162.26^b
Mean	283.02^D	182.03^C	110.79^B	85.96^A	

	CD at (0.05)	S.Em ±
Factor A (Days)	9.92	3.51
Factor B (Treatments)	14.04	4.96
For A x B	28.08	9.93

Table 3: Effect of modified atmosphere packaging on reducing sugars (%) of custard apple fruits cv. atemoya X balanagar at low temperature (13 ºC±1).

Treatments	Days				Mean
	0	4	8	12	
T_1-Polypropylene bag with 10 pores	10.42	12.56	13.34	15.00	12.83^c
T_2-Polypropylene bag with 20 pores	8.93	13.16	14.06	14.91	12.76^c
T_3-Polypropylene bag with 30 pores	10.00	11.32	11.11	13.33	11.44^d
T_4-Polypropylene bag with 40 pores	9.61	12.50	15.63	16.26	13.50^a
T_5-Polypropylene bag with 50 pores	9.26	13.90	14.71	15.58	13.36^b
T_6-Polypropylene bag with 60 pores	10.42	15.60	13.89	15.16	13.77^a
T_7-Polypropylene bag without pores	8.93	15.66	14.51	16.49	13.89^a
T_8-Control	10.00	13.49	14.57	16.14	13.47^a
Mean	9.69^A	13.49^B	13.98^C	15.36^D	

	CD at (0.05)	S.Em ±
Factor A (Days)	0.30	0.10
Factor B (Treatments)	0.42	0.15
For A x B	0.85	0.30

Table 4: Effect of modified atmosphere packaging on ascorbic acid (mg/100g) of custard apple fruits cv. Atemoya X Balanagar at low temperature (13 ºC±1).

Treatments	Days				Mean
	0	4	8	12	
T_1-Polypropylene bag with 10 pores	38.00	35.00	35.00	20.00	32.00^c
T_2-Polypropylene bag with 20 pores	35.00	34.00	32.00	13.00	28.50^e
T_3-Polypropylene bag with 30 pores	42.00	40.00	40.00	18.00	35.00^a
T_4-Polypropylene bag with 40 pores	42.00	40.00	32.00	19.00	33.25^b
T_5-Polypropylene bag with 50 pores	36.00	35.00	30.00	17.00	29.50^d
T_6-Polypropylene bag with 60 pores	35.00	36.00	38.00	20.00	32.25^c
T_7-Polypropylene bag without pores	33.00	34.00	34.00	30.00	32.75^b
T_8-Control	35.00	30.00	28.00	20.00	28.25^e
Mean	37.00^D	35.50^C	33.62^B	19.62^A	

	CD at (0.05)	S.Em ±
Factor A (Days)	0.57	0.20
Factor B (Treatments)	0.81	0.28
For A x B	1.63	0.57

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