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Effect of Different Packaging Materials and Chemicals on Shelf Life and Quality of Aonla (*Emblica officinalis* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To extend the shelf life of Aonla fruits and to regulate marketing for acceptability and profit during distant transportation and storage, Aonla fruits can be coated with chemicals and coating materials which are safe for consumption and packed in packaging materials. So, to find out the effect of different packaging materials and chemicals on shelf life and quality of Aonla (*Emblica officinalis* L.); a lab experiment was conducted at the Post Harvest Laboratory, Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) during the year 2022-2023. The experiment comprised 13 treatments of different coating materials, viz. untreated fruits, 5% Chitosan Wax, 1% Calcium Nitrate, 400 ppm Cycocel and 0.1% Sodium Benzoate and packaging materials viz. Nylon

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Net Bags, Poly Ethylene Bags, CFB Box which are replicated three times in a completely randomized design. The objectives of the experiment were to evaluate the effect of different treatments on the shelf life and quality of aonla. From the present investigation treatment T_8 (5% Wax + 400 ppm Cycocel packed in Poly Ethylene Bags) was found best with minimum Physiological weight loss %, minimum rotting of fruits and best in terms of Bio-chemical attributes i.e., Total Soluble Solids (TSS ^{0}Brix), Titrable Acidity (%), Ascorbic Acid (mg/100g) and Organoleptic Qualities i.e., maximum retention of Fruit colour and minimum fruit shriveling till the end of storage period.

Keywords: Shelf life; quality; aonla; chemicals; packaging material.

1. INTRODUCTION

Indian gooseberry or aonla (*Emblica officinalis* L.) also known as the wonder fruit for health and belongs to family Euphorbiaceae. The chromosome number of aonla is 2n=28 and in case of variation from 2n=98 to 104 has also been observed. Aonla fruits are round, globose, or oblate in shape. Fruit colour changes from green to yellow or brick red colour when mature. Aonla is the major constitutes in chayvanprash and trifla preparations and is used in the Ayurvedic and Unani System of Indian medicines. Aonla fruit is useful in curing anemia, artherosclerosis, cough, diarrhea and jaundice [1] and is reported to possess antiviral, antibacterial, anticarcinogenic, antioxidative, cardiovascular [2] expectorant activities. The fruit is rich source of ascorbic acid and contains about 20 times more vitamin C than the citrus fruits. It contains 500-1500 mg of ascorbic acid per 100g of pulp [3].

Aonla fruits have a shelf life of 6 to 7 days and are perishable in nature, it is difficult to store and transport it over long distances. For transportation to distant markets and for minimum losses from spoilage of fruit, it is necessary to prolong shelf life of aonla. Likewise, packaging materials also have a significant impact on the quality and storage life of fruits. Packaging creates a modified atmosphere surrounding the fruits by decreasing O_2 level and increasing CO_2 level as a result, respiration and metabolic activities slow down which ultimately help in maintaining the quality parameters of aonla. Factors like water vapour losses, ripening rates, skin thickness, infestation etc affect the post harvest life of fruits and by checking these factors; the shelf life can be increased up to certain period. Therefore, application of physical barrier such as surface coating may be used to regulate permeability of water vapour and other gases, retard ripening and restricts insect infestation as well as microbial growth [4-7]. Edible coating like chitosan act as an excellent O_2 barrier, CO_2 permeation and antibacterial activity against microorganisms and some other coating materials are also available like Cycocel, Calcium Nitrate and Sodium Benzoate which help to reduce post harvest decay, delay senescence, reduce fruit weight loss and help in maintaining quality.

In order to have good return and to avoid market glut it becomes essential to store the fruits for a considerable period. But very less research has been done for chemicals combined with packing materials for their positive effect on quality and shelf life of fruit. Therefore, this experiment has been proposed with the following objectives:

1. To study the effect of different packaging materials and different level of chemicals on shelf life and quality of Aonla.
2. To study the changes in organoleptic score during storage.

2. MATERIALS AND METHODS

The experiment was laid out during October month of 2022, ripe, uniformly sized, shape and colour Aonla cv. Kanchan were harvested at proper stage of maturity and fruits were plucked carefully and brought to the Post-harvest Laboratory, Department of Horticulture of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad.

2.1 Experiment Details

The experiment was conducted in completely randomized design with thirteen treatments and three replications comprising of different coating materials viz., Chitosan Wax (5%), Calcium Nitrate (1%), Cycocel (400 ppm), and Sodium Benzoate (0.1%) and packed in Nylon net bags, Polyethylene bags and CFB box.

Table 1. Treatment details

Treatment No.	Description
T_0	Control (untreated fruits)
T_1	5% Wax + Nylon Net Bag
T_2	5% Wax + Perforated Poly Ethylene Bag
T_3	5% Wax + Corrugated Fiber Board Box
T_4	5% Wax + 1% Calcium Nitrate + Nylon Net Bag
T_5	5% Wax + 1% Calcium Nitrate + Perforated Poly Ethylene Bag
T_6	5% Wax + 1% Calcium Nitrate + Corrugated Fiber Board Box
T_7	5% Wax + 400 ppm Cycocel + Nylon Net Bag
T_8	5% Wax + 400 ppm Cycocel + Perforated Poly Ethylene Bag
T_9	5% Wax + 400 ppm Cycocel + Corrugated Fiber Board Box
T_{10}	5% Wax + 0.1 % Sodium Benzoate + Nylon Net Bag
T_{11}	5% Wax + 0.1% Sodium Benzoate + Poly Ethylene Bag
T_{12}	5% Wax + 0.1% Sodium Benzoate + Corrugated Fiber Board Box

2.2 Preparation of Coating Material

For coating of fruits with calcium nitrate, 10g of $Ca(NO_3)_2$ was dissolved in a little amount of distilled water and volume was made upto one litre with distilled water to get 1% $Ca(NO_3)_2$ solution and used for dipping the fruits [8-10].

For preparation of cycocel coating, the stock solution was prepared by dissolving one gram of cycocel in little amount of distilled water and diluted it with distilled water to one litre. From this stock solution, desired concentration as per treatment (400 ppm) was prepared by diluting with distilled water and used for dipping the fruits [11].

For coating of fruits with sodium benzoate, one gram of sodium benzoate was dissolved in a little amount of distilled water and emulsion is further diluted with distilled water to one litre and used for dipping the fruits [11,12]. The fruits were dipped for three minutes with particular solution of respective chemical and surface dried in room temperature and to prepare 5% chitosan solution, 50g of chitosan powder was added in aqueous solution of 2% acetic acid (20ml in 1000ml of water) as solvent [12-14]. To facilitate adhesion of the coating, 0.1% Tween 80 was added [15].

2.3 Statistical Analysis

The data collected on different parameters were subjected to statistical analysis of variance technique as described by Panse and Sukhatme [16]. The method of “Analysis of Variance” for completely randomized design was used and treatment effects of all the characters were studied by employing ‘F’ test.

Five percent level of significance was used to test the “null hypothesis” for significance of results. The critical difference was calculated where the difference among the treatments was found significant by ‘F’ test. The C.V. percent was also worked out.

3. RESULTS AND DISCUSSION

3.1 Physical Attributes

3.1.1 Physiological weight loss (%)

It was calculated by subtracting final weight from the initial weight of fruits. The data in Fig. 1 revealed that as the storage period progressed, the physiological loss in weight (%) was increased. Effect of treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded the minimum physiological weight loss % [1.40 (3 days), 2.70 (6 days), 5.65 (9 days), 7.35 (12 days) and 10.05 (15 days)]% over all other treatments whereas Treatment T_0 (control) was found having significantly highest physiological weight loss % [4.95 (3 days), 8.25 (6 days), 11.37 (9 days), 14.19 (12 days) and 17.18 (15 days)]%. Coating in fruit crops may have slowed down respiration and transpiration, which could have helped in lowering fruit weight loss. Similar results were obtained by Yadav and Singh [17] while working on aonla fruits.

3.1.2 Per cent rotting

The number of rotted fruits was counted at three days interval and the per cent rotting was worked out. The data in Fig. 2 revealed that as the storage period progressed, the percent rotting was increased irrespective of storage conditions. Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded lowest per cent rotting [0.65 (9 days), 2.45 (12 days) and 4.90 (15 days)] % over all other treatments whereas treatment T_0 (control) was found having highest rotting percentage [3.70 (9 days), 6.90 (12 days) and 11.45 (15 days)] %. Thus elimination and/or reduction of rotting during storage are crucially important for preserving the good quality of fruits. In the present investigation, application of cycocel allowed minimum rotting during storage.

3.2 Quality Attributes

3.2.1 Total soluble solids (TSS) (^{0} Brix)

Fruits of each replication of a treatment were crushed to form a homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determination of TSS in ^{0}Brix by hand refractometer. The data in Fig. 3 revealed that Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded the minimum TSS (^{0}Brix) [12.50 (3 days), 13.05 (6 days), 14.05 (9 days), 13.10 (12 days) and 12.95 (15 days)] ^{0}Brix over all other treatments whereas Treatment T_0 (control) was found having significantly highest TSS (^{0} Brix) [14.80 (3 days), 15.50 (6 days), 16.05 (9 days), 15.92 (12 days) and 15.15 (15 days)] ^{0}Brix. It was also found that Treatment T_9 (5% Wax + 400 ppm Cycocel + CFB Box) was at par with treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) during the whole storage period of study. However, its effect was found non-significant at 0 days. To sum up, there was significant increase in TSS content till it reached peak followed by gradual decline irrespective of storage treatments. The increase of TSS during storage can be due to breakdown of complex polymers into simple substances by hydrolytic enzymes. The retention of TSS in T_8 might be due to decrease in Physiological loss in weight followed by slow degradation of soluble contents of fruits.

3.2.2 Titrable acidity (%)

The data in Table 2 revealed that Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded the maximum titrable acidity (%) [2.39 (3 days), 2.30 (6 days), 2.12 (9 days), 2.22 (12 days) and 2.35 (15 days)] % over all other treatments whereas Treatment T_0 (control) was found having significantly lowest titrable acidity (%) [1.50 (3 days), 1.38 (6 days), 1.25 (9 days), 1.35 (12 days) and 1.60 (15 days)] %. It was also found that Treatment T_9 (5% Wax + 400 ppm Cycocel + CFB Box) was at par with treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) during the whole storage period of study. However, its effect was found non-significant at 0 days. To sum up, it was found that with advancement of storage there was significant decrease in acidity followed by gradual increase irrespective of storage treatments. This may be due to synthesis of some organic acids due to initiation of process of fermentation and also may be attributed to concentration of cell contents due to loss of moisture in all treatments after prolonged storage.

3.2.3 Ascorbic acid (mg/100g)

It was determined by volumetric method and by using 2, 6-dicholorophenolindophenol dye. The data in Fig. 4 revealed that ascorbic acid dropped steadily throughout the storage period and Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded the maximum ascorbic acid (mg/100g) [300.28 (3 days), 295.41 (6 days), 287.39 (9 days), 280.24 (12 days) and 268.29 (15 days)] (mg/100g) over all other treatments whereas Treatment T_0 (control) was found having significantly lowest ascorbic acid (mg/100g) [283.32 (3 days), 274.39 (6 days), 257.80 (9 days), 241.28 (12 days) and 228.24 (15 days)] (mg/100g). During storage, ascorbic acid was lost due to activation of phenoloxidase and ascorbic acid oxidase enzymes whereas coating could have inhibited O_2 diffusion and slowed respiration rate, delaying deteriorative oxidation reaction of fruit ascorbic acid. Similar results were recorded by Singh et al. [18].

3.2.4 Reducing sugar (%)

Reducing sugars, non-reducing sugars and total sugars of aonla fruit samples were estimated by using copper titration method. The data in Fig. 5 revealed that as the storage period advanced the reducing sugar (%) in fruits increased continuously and Treatment T_{11} (5% Wax + 0.1% Sodium Benzoate + PE Bags) recorded the minimum Reducing Sugar % [1.36 (3 days), 1.52 (6 days), 1.68 (9 days), 1.74(12 days) and 1.91 (15 days)] % over all other treatments whereas Treatment T_0 (control) was found having significantly highest reducing sugar % [2.05 (3 days), 2.15 (6 days), 2.32 (9 days), 2.42 (12 days) and 2.61 (15 days)] %. It was found that Treatment T_8 (5% Wax + 400 ppm Cycocel + PE

Bags) was at par with Treatment T_{11} (5% Wax + 0.1% Sodium Benzoate + PE Bags) during the whole storage period of study. However, its effect was found non-significant at 0 days. Regarding packaging materials the fruits packed in nylon net bags showed the highest reducing sugar percentage and lowest percentage was observed in PE Bags. The rate of hydrolysis of starch to simple sugars might be higher in untreated fruits due to normal respiration whereas in coated fruits it is lower.

3.2.5 Non-reducing sugar (%)

The data in Fig. 6 revealed that as the storage period advanced, the non–reducing sugar (%) in fruits increased continuously and Treatment T_{11} (5% Wax + 0.1% Sodium Benzoate + PE Bags) recorded the minimum non-reducing sugar % [0.38 (3 days), 0.44 (6 days), 0.59 (9 days), 0.68(12 days) and 0.72(15 days)] % over all other treatments whereas Treatment T_0 (control) was found having significantly highest non-reducing sugar % [1.25(3 days), 1.48 (6 days), 1.55 (9 days), 1.62 (12 days) and 1.70 (15 days)] %. It was found that Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) was at par with Treatment T_{11} (5% Wax + 0.1% Sodium Benzoate + PE Bags) during the whole storage period of study. However, its effect was found non-significant at 0 days. Coated fruits having lower level of non-reducing sugar might be due to altered respiration process resulting in slow hydrolysis of starch.

3.2.6 Total sugar (%)

The data in Fig. 7 revealed that Treatment T_{11} (5% Wax + 0.1% Sodium Benzoate + PE Bags) recorded the minimum total sugar % [1.74 (3 days), 1.96 (6 days), 2.27 (9 days), 2.42 (12 days) and 2.63 (15 days)] % over all other treatments whereas Treatment T_0 (control) was found having significantly highest total sugar % [3.30 (3 days), 3.63 (6 days), 3.87 (9 days), 4.04 (12 days) and 4.31 (15 days)] %. Fruits with coating may have lower respiration rate and metabolic activity, leading to a slower breakdown of complex polysaccharides [19]. Similar results are also reported by Gangwar et al. [9] in aonla.

3.3 Organoleptic Quality

3.3.1 Colour

The colour of fresh fruits was recorded by visual observations such as greenish, yellowish, yellowish with pink shade etc. The colour change if any was assessed by panel of five judges using hedonic scale. It was revealed from Table 3 that as the storage period advanced, the fading of colour increased, recording gradual reduction in score. At all stages of storage, Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded best score on hedonic scale [7.95 (9 days), 7.80 (12 days) and 7.60 (15 days)] over all other treatments whereas treatment T_0 (control) was found having lowest score for colour change

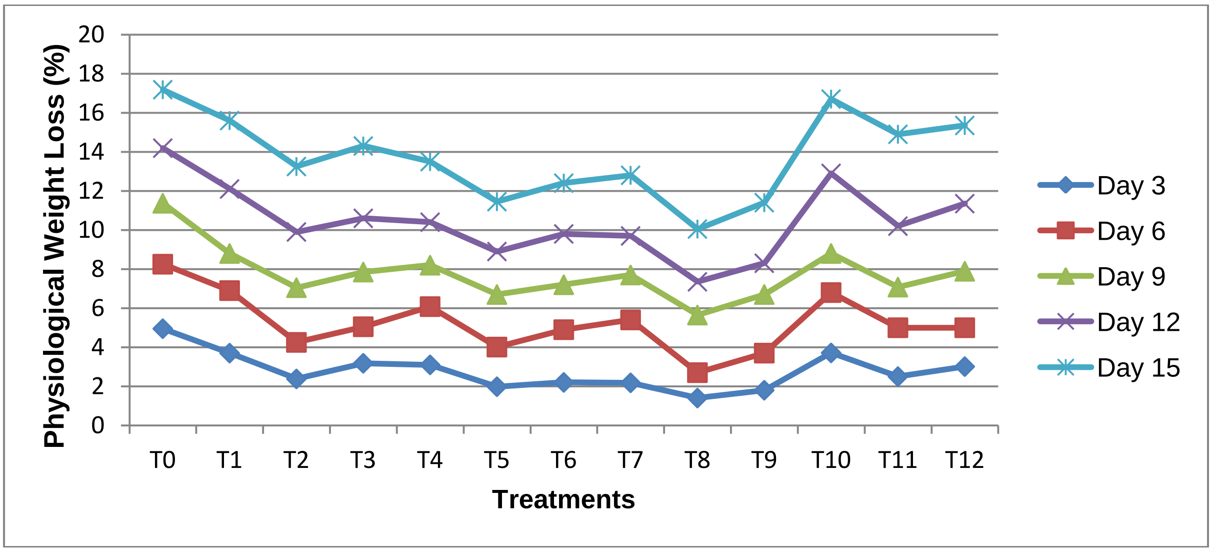

Fig. 1. Effect of different packaging materials and chemicals on Physiological Weight Loss (%) of aonla

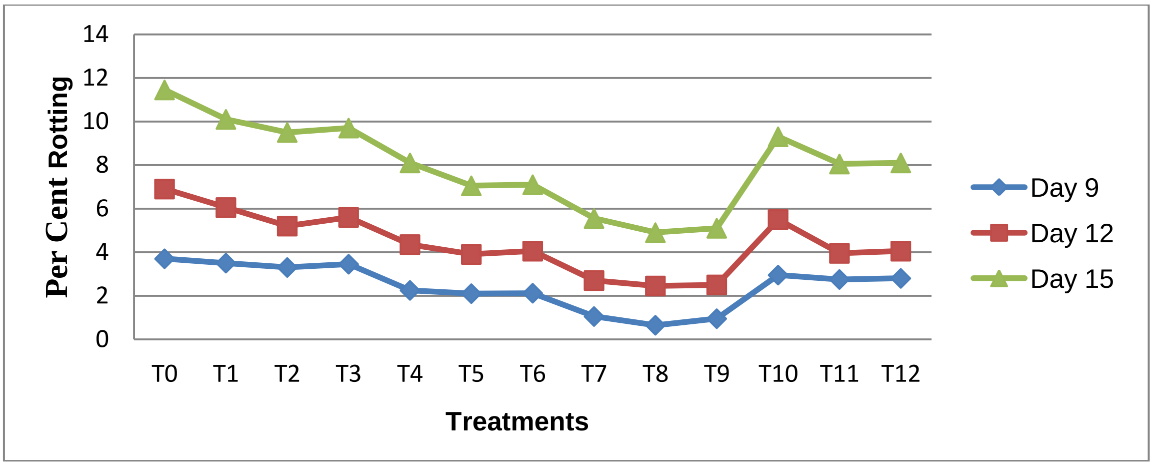

Fig. 2. Effect of different packaging materials and chemicals on rotting (%) of aonla

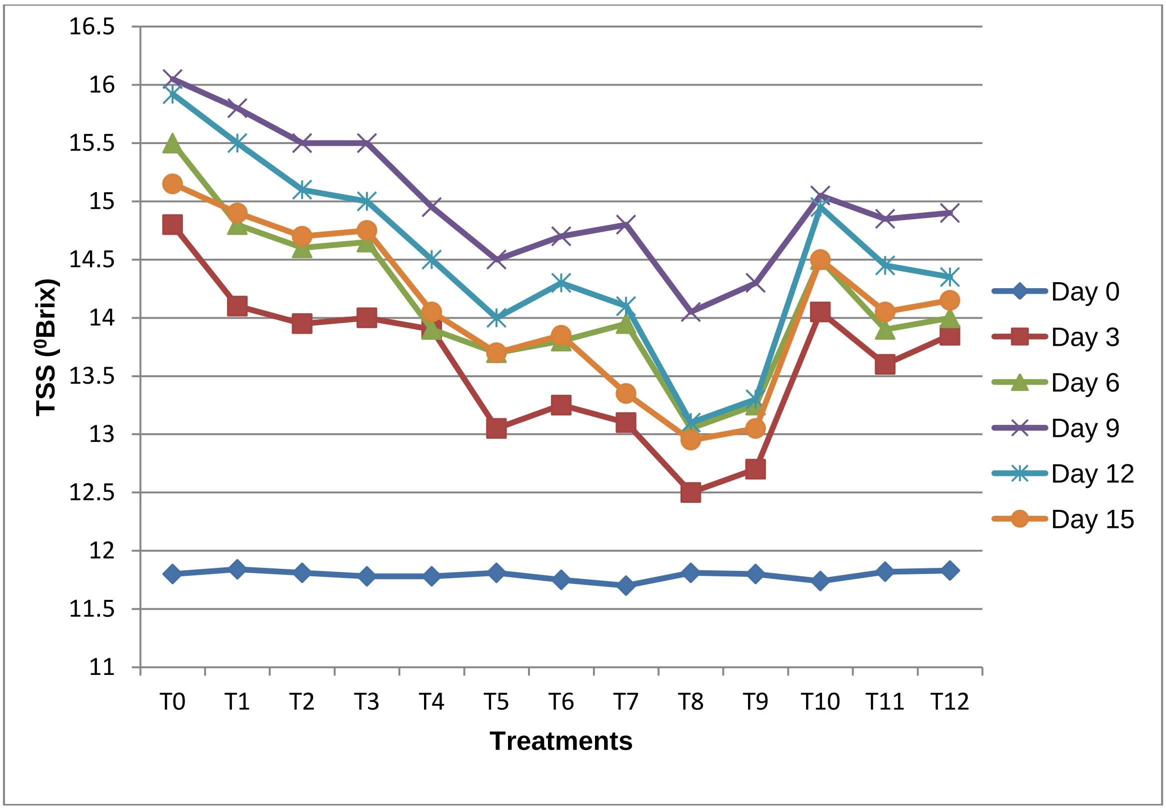

Fig. 3. Effect of different packaging materials and chemicals on TSS (^{0}Brix)

[6.50 (9 days), 5.80 (12 days) and 4.50 (15 days)]. It was also found that Treatment T_9 (5% Wax + 400 ppm Cycocel + CFB Box) was at par with treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) during the whole storage period of study. This could be due to external application of wax which increased glossiness of fruit, while cycocel helped to maintain firmness throughout storage period as reported by Patel et al. [20] in Guava.

3.3.2 Fruit shriveling

The progress of development of fruit skin shrivelling was observed visually at three days interval. The intensity of shrivelling was worked out on 0 to 4 scale. Table 3 depicts that during the course of storage, it was found that with advancement of storage period, fruit shrivelling was increased. Treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) recorded lowest score for shrivelling [0.40 (9 days), 0.90 (12 days) and 1.50 (15 days)] over all other treatments whereas treatment T_0 (control) was found having highest fruit shrivelling [2.0 (9 days), 2.55 (12 days) and 3.55 (15 days)]. It was also found that treatment T_9 (5% Wax + 400 ppm Cycocel + CFB Box) was at par with treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) during the whole storage period of study. Application of wax and chemicals to fruits helps them against excessive moisture loss and in reduction of respiration rate, without affecting the natural appearance of fruits and its quality as reported by Jagadeesh and Rokhade [21] in guava.

Table 2. Effect of different packaging materials and chemicals on titrable acidity (%) of aonla

Treatment symbols	Titratable acidity (%)					
	0 day	**3 days**	**6 days**	**9 days**	**12 days**	**15 days**
T_0	2.46	1.50	1.38	1.25	1.35	1.60
T_1	2.42	1.60	1.52	1.43	1.59	1.70
T_2	2.36	1.85	1.71	1.55	1.70	1.80
T_3	2.40	1.80	1.68	1.50	1.65	1.75
T_4	2.43	2.10	1.98	1.75	1.90	1.98
T_5	2.38	2.34	2.22	1.98	2.04	2.15
T_6	2.42	2.33	2.18	1.92	2.01	2.08
T_7	2.37	2.05	1.95	1.70	1.85	1.93
T_8	2.42	2.39	2.30	2.12	2.22	2.35
T_9	2.43	2.38	2.28	2.05	2.15	2.28
T_{10}	2.34	1.90	1.83	1.62	1.75	1.88
T_{11}	2.39	2.30	2.10	1.85	1.98	2.05
T_{12}	2.38	2.29	2.05	1.82	1.95	2.02
F- Test	**N.S**	**S**	**S**	**S**	**S**	**S**
C.V.	**0.028**	**0.027**	**0.036**	**0.036**	**0.037**	**0.036**
S.E.(m)	**-**	**0.079**	**0.105**	**0.104**	**0.107**	**0.105**
C.D. (5%)	**2.035**	**2.273**	**3.221**	**3.570**	**3.429**	**3.166**

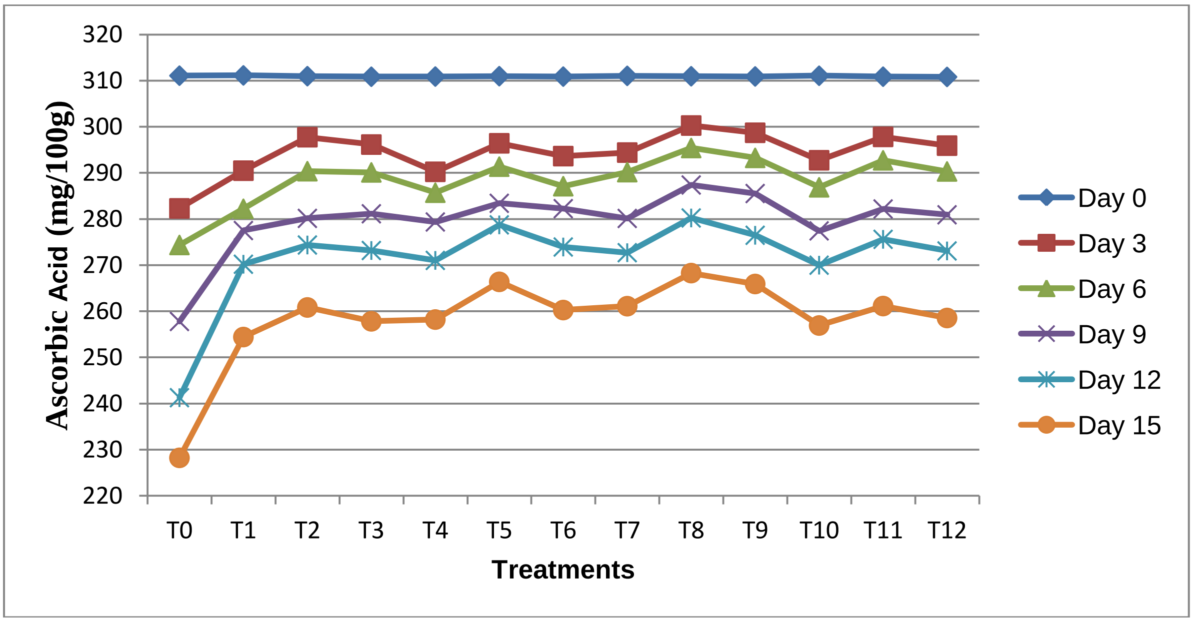

Fig. 4. Effect of different packaging materials and chemicals on ascorbic acid (mg/100g) of aonla

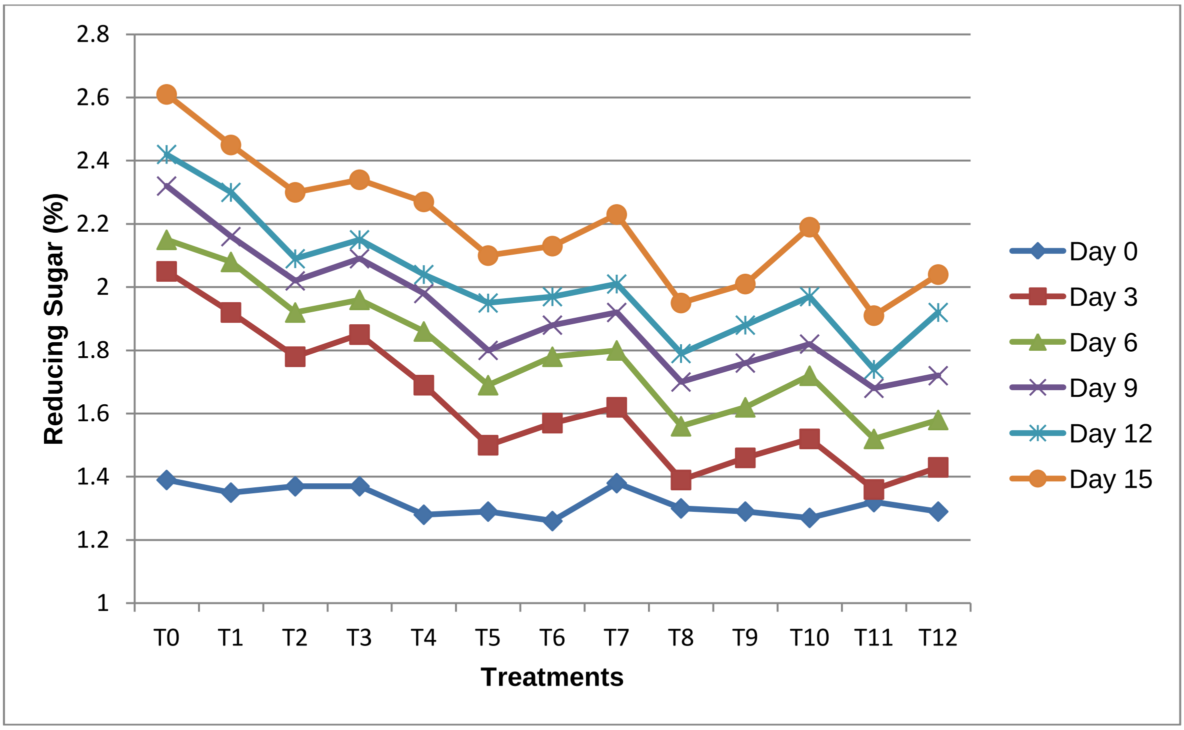

Fig. 5. Effect of different packaging materials and chemicals on reducing sugar (%) of aonla

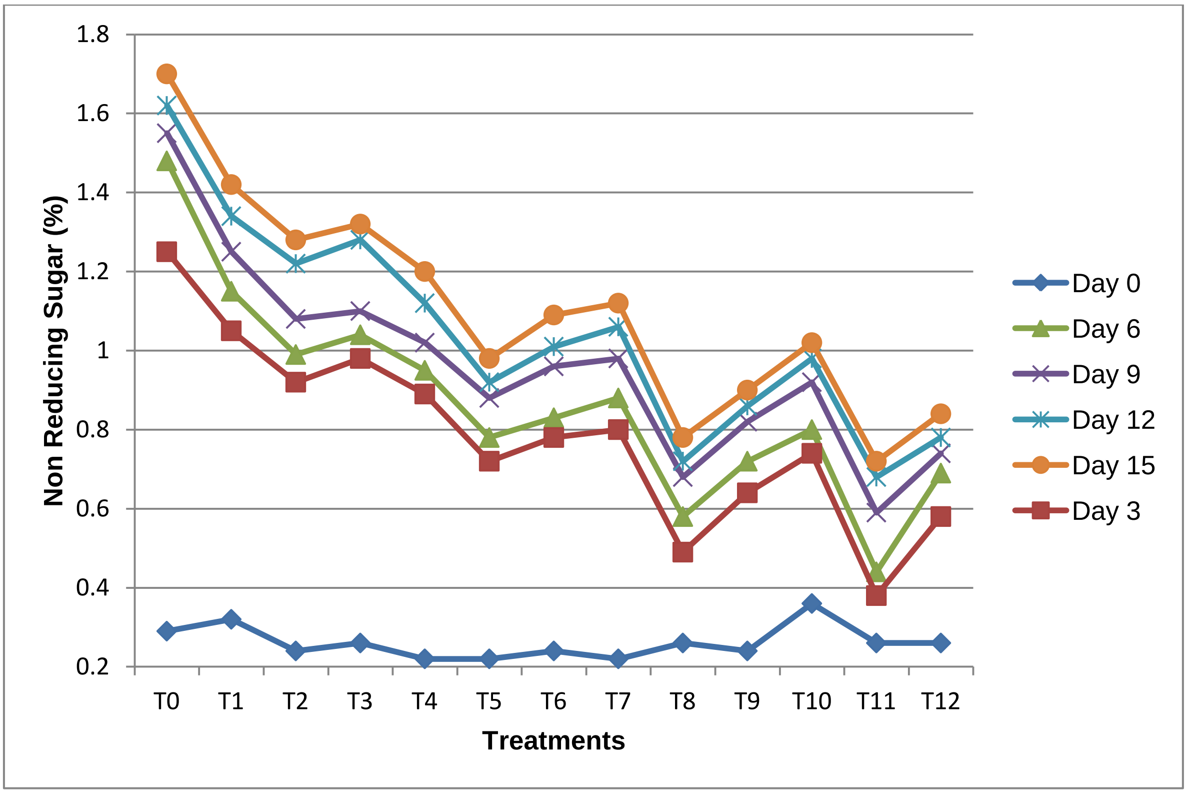

Fig. 6. Effect of different packaging materials and chemicals on non-reducing sugar (%) of aonla

Table 3. Effect of different packaging materials and chemicals on organoleptic score

Treatment	Hedonic score for colour			Fruit shrivelling score		
	9 Days	12 Days	15 Days	9 Days	12 Days	15 Days
T_0	6.50	5.80	4.50	2.00	2.55	3.55
T_1	7.50	7.10	6.90	1.55	2.10	3.15
T_2	7.75	7.55	7.30	1.40	1.95	2.85
T_3	7.60	7.50	7.20	1.40	2.01	3.05
T_4	7.30	6.90	6.85	1.20	1.50	2.10
T_5	7.70	7.50	7.30	0.60	1.25	1.90
T_6	7.60	7.30	7.20	0.65	1.30	2.05
T_7	7.50	7.20	7.05	0.80	1.20	2.05
T_8	7.95	7.80	7.60	0.40	0.90	1.50
T_9	7.90	7.60	7.40	0.45	0.95	1.55
T_{10}	7.20	6.80	6.70	1.30	1.85	3.00
T_{11}	7.60	7.30	7.10	0.90	1.50	2.65
T_{12}	7.55	7.10	7.00	1.05	1.65	2.75
F-Test	**S**	**S**	**S**	**S**	**S**	**S**
C.V.	**1.544**	**1.270**	**1.569**	**5.772**	**4.439**	**2.765**
S.E.(m)	**0.067**	**0.053**	**0.063**	**0.035**	**0.041**	**0.039**
C.D. (5%)	**0.195**	**0.153**	**0.183**	**0.102**	**0.119**	**0.115**

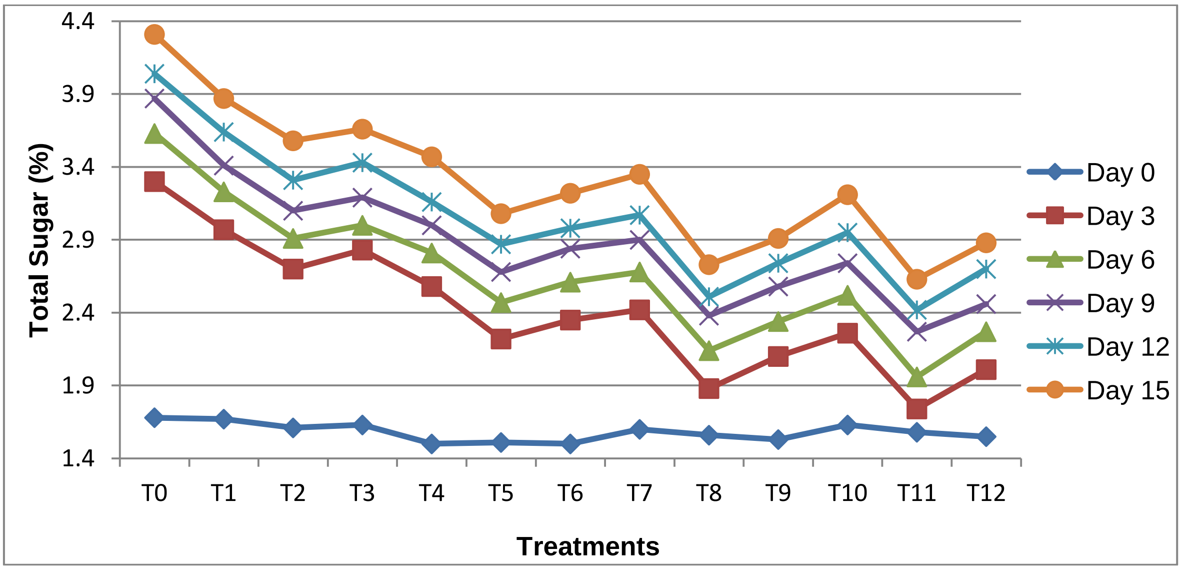

Fig. 7. Effect of different packaging materials and chemicals on total sugar (%) of aonla

4. CONCLUSION

From the present investigation, it is concluded that treatment T_8 (5% Wax + 400 ppm Cycocel + PE Bags) performed best by extending the shelf life of aonla upto 15 days. It was also found best in terms of Physiological attributes (Minimum Physiological Loss in Weight (%) and minimum per cent rotting) and bio-chemical attributes (TSS, Titrable Acidity (%) and Ascorbic Acid). Fruits treated with Treatment T_8 (5% Wax + 400 ppm Cycocel) and packed in perforated polyethylene bags scored best for organoleptic score.

So from results gathered from investigation, it is concluded that Cycocel applied with chitosan coating and packed in Perforated polyethylene bags helped in extending the shelf life of aonla and could be useful in short term storage and to regulate marketing of fruit to distant places with minimum loss.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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