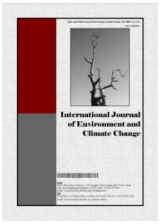

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Effect of the Different Surface Coatings and Packaging Materials for Shelf Life and Quality of Guava (*Psidium guajava* L.) CV. Allahabad Safeda

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SS, VJ and PP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VJ and DV managed the analyses of the study. Authors SS and VJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the potentiality of surface coatings and packaging for achieving extended shelf life with enhance fruit quality attributes in Guava under ambient storage condition.
Study Design: The lab experiment conducted in complete randomized design three replications on Allahabad safeda of Guava.
Place and Duration of Study: The experiment was conducted during November 2019 at College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad.
Methodology: Guava freshly harvested fruits were coated with two different coatings Chitosan (1%), *Aloe vera* gel (25%) and three different packaging materials *viz*., Polypropylene 100 gauge, HDPE 50 microns and LDPE 50 microns comprising of six treatments with four replications in Completely Randomized Design. Periodically effects of surface coatings were observed for

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physiological loss in weight, Shelf Life (days), Firmness (Kg/cm^2), Total Soluble Solids (%), Titrable Acidity (%), Ascorbic Acid (mg/100g), Total Sugars (%), Reducing Sugars (%), Non-Reducing Sugars (%).

Results: With respect to physical parameters, lowest decay percent (13.28%), minimum PLW (14.61%) was recorded in T_2- Chitosan 1% + HDPE 50 microns and highest was recorded in T_6- Aloe vera 25% + LDPE 50 microns (15.49% &18.80%) on 12th day of storage. Highest shelf life (12.91 days) was recorded in T_2- Chitosan 1% + HDPE 50 microns which was at par with T_5- Aloe vera 25%+ HDPE 50 microns (12.89 days) and lowest shelf life (11.25 days) was recorded in T_1 - Chitosan 1% + PP 100 gauge. Highest TSS (10.33^{o}B), From this study it could be concluded that surface coatings, packaging materials found to have influence on the shelf life and quality of guava. Among the packaging materials HDPE 50 microns was superior followed by PP 50 microns and LDPE 100 gauge.

Conclusion: The combined effect of surface coatings and packaging materials revealed that T_2- Chitosan 1% + HDPE 50 microns followed by T_5- Aloe vera 25%+ HDPE 50 microns were found to be superior over other treatments with respect to physical, shelf life and quality parameters.

Keywords: Chitosan; Aloe vera; LDPE; HDPE; PP; packaging; guava.

1. INTRODUCTION

Guava (*Psidium guajava* L.) a Myrtaceae member is one of the important commercial fruit crops in India. It can be grown in tropical and subtropical regions and is called as “Apple of Tropics”. It is the fourth most important fruit crop of India after mango, banana and citrus. It is originated from Tropical America and spread across the globe and was introduced to India in early 17th century. In India, guava is cultivated in an area of 0.26 million-hectare with a production of 3.96 million tonnes and total productivity of 13.7 metric tonnes/ha. Guava is one of the most delicious and nutritious fruit, liked by the consumers for its refreshing taste and pleasant flavour. The fruit is used for the preparation of processed products like jams, jellies, and nectar. Guava fruit has a very short shelf life making it difficult for distant marketing. For long distance transportation, the use of refrigerated transport and also proper packaging with cushioning material is required to enhance the shelf life of fruit. The guava fruit can ripe within two or three days and become over ripe and get spoilt within five days after harvest. *Aloe vera* gel forms a protective layer against the oxygen and moisture of the air and inhibits the action of micro-organisms that causes food borne illnesses through its various antibacterial and antifungal compounds, it also prevents loss of moisture, retains firmness, controls respiratory rate and maturation [1]. Chitosan has a chemical structure close to that of cellulose and has long been known to protect perishable produce from deterioration by reducing transpiration, respiration and maintaining the textural quality. Packaging of fresh fruits and vegetables is one of the most important steps in the long and complicated journey from grower to consumer. A package provides protection, tampers resistance and improves the shelf life and quality of fruits. Generally, guava fruits are packed in LDPE (Low Density Polyethylene) boxes or HDPE (High Density Polyethylene) or in PP (Poly propylene) which reduces moisture loss from fruits during storage [2]. Consumer packages are small in size and designed to hold half dozen to one dozen fruits. Many types of packages in terms of forms and materials are used as consumer packs. The selection criteria for the type of consumer pack depends on marketing characteristics of the product, different types of flexible plastic films like LDPE (Poly ethylene), PVC (Poly Vinyl Chloride), PP (Poly propylene) and cellulose acetate films are used for packaging horticultural produce. These films are mostly used as pouches with holes punched to allow respiration. They are available in a wide range of thicknesses and grades and can be engineered to control the environmental gases inside the pouch. LDPE is the most widely used material, they are very useful because of low cost, high strength, re-usability and require less space. Both plastic films, HDPE and LDPE reduces the weight loss by two-fold when compared to the loss associated with control fruits during the storage period under ambient condition [3]. There is need to find out suitable low-cost packaging techniques to increase the storage life of fruits. Therefore, investigations on low cost technology to increase the shelf life of guava by using edible coatings and appropriate packaging materials will definitely reduce the post-harvest losses in the fast ripening fruits like guava and helps in giving better returns to the farmers.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was conducted at College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad during the year 2019.

2.2 Collection of Guava

Guava fruits Cv. Allahabad Safeda used for research were procured from Fruit research station, SKLTSHU, Sangareddy. Guava fruits were selected for uniformity in size, shape and colour. Diseased, sunburn, bruised and injured fruits were discarded. The remaining fruits were randomized and divided into ten lots of 40 fruits for the following treatments in four replicates (each replicate contained 10 individual fruits).

2.3 Experimental Design and Treatments

The experiment was laid out in completely randomized design (CRD) with four repetitions and consisting of six treatments comprising of surface coatings. T_1: Chitosan 1% + Polypropylene bag 50 microns, T_2: Chitosan 1% + HDPE, T_3: Chitosan 1% + LDPE, T_4: Aloe vera 25% +PP, T_5: Aloe vera 25% + HDPE, T_6: Aloe vera 25% + PP. Stored at Room temperature.

2.4 Collection of Plant Material and Preparation of Surface Coatings

Fresh aloe Vera leaves collected from Medicinal and Aromatic Plants Research Station. The leaves were washed to remove the dust, aloe vera gel matrix was separated from the outer cortex of leaves using knife and then the colorless hydro parenchyma was grinded in a blender and strained through muslin cloth to remove thick particles. Pectin 1 per cent was taken and mixed with water and in turn mixed with *Aloe vera* gel at different concentrations (25%) and heated to the required temperature to prepare the treatment solutions. The liquid obtained, constituted fresh Aloe vera gel (25%) and it was further diluted with distilled water in1:1 ratio (50% Aloe vera extract) and in 3:1 ratio (75% Aloe vera extract). Similarly, 0.5 per cent, 1 per cent and 1.5 per cent chitosan solution was prepared by dissolving 5 g, 10 g and 15 g of chitosan powder in 1000 ml of distilled water. Citric acid 1 per cent, 2 per cent and 3 per cent solution was prepared by dissolving 5 g, 10 g and 15 g of citric acid in 1000ml of distilled water. Fruits were coated as per the treatments by dipping in treatment wise solution for 5-10 min. Coated fruits then allows for air drying at ambient conditions.

2.5 Data Collection

Physiological loss in weight during storage was calculated by subtracting the final fresh weight (10^{th} day of storage) from the initial fresh weight (0 days of storage) of the fruits. Cumulative weight losses were expressed as a percentage loss of original weight. Shelf life of the fruits was determined by recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 per cent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days [4]. Penetrometer was used to record the firmness of fruits and direct readings were obtained in terms of kg/cm^2. The sample fruits were subjected to penetrometer by pressing near the center of the fruit and direct reading on the scale was recorded at two days intervals. The total soluble solids of the fruits were determined with the help of Erma hand refractometer, Japan and expressed as ^{0}Brix [5]. Titratable Acidity (%) was observed Ten grams of sample was taken, ground well and transferred to volumetric flask and volume was made up to 100 ml with distilled water. The contents were filtered through Whatmann No.1 filter paper. An aliquot of 10 ml was taken into conical flask to which 2-3 drops of phenolphthalein indicator was added and titrated against 0.1 N NaOH till a pink color was obtained which persists at least for 15 seconds, as an end point [5]. The reducing sugars was determined by the method of Lane and Eyon. Non reducing sugars were calculated from the calculated values of total and reducing sugars. Ascorbic acid was estimated by method outlined by Ranganna, [5].

2.6 Data Analysis

The design adopted was (CRD) completely randomized design with and the data was processed at the Computer centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad using the established statistical analysis as per the procedure (windowstat version 9.1) outlined by Murali Khetan [6]. Significance was tested by 'F' value at 5 percent level of significance.

3. RESULTS AND DISCUSSION

3.1 Physiological Loss in Weight (%)

The effect of surface coatings and packaging materials on physiological loss in weight of guava stored at room temperature is presented in the Table 1. The percent PLW values showed an increasing trend from 2nd day to 12th day at room conditions. There was a significant difference observed among all the treatments with respect to PLW. On 2nd day T_2- Chitosan 1% + HDPE 50 microns recorded least PLW (5.82) which was on par with T_5- Aloe vera 25%+ HDPE 50 microns (5.93) while highest PLW was recorded T_4- Aloe vera 25% + PP 50 microns (6.30). On 4th day T_2- Chitosan 1% + HDPE 50 microns packing recorded least PLW (5.96) followed by T_5- Aloe vera 25%+ HDPE 50 microns (6.02) and highest PLW was recorded in T_1 - Chitosan 1% + PP 50 microns (6.89). On 6th day T_2- Chitosan 1% + HDPE 50 microns recorded least PLW (6.88) and highest PLW was recorded in T_4- Aloe vera 25% + PP 50 microns (7.83). On 8th day T_2- Chitosan 1% + HDPE 50 microns recorded least PLW (8.86) and highest PLW was recorded in T_6- Aloe vera 25% + LDPE 50 microns (10.16). Similar result was observed on 10th day of storage with respect to PLW. On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and among the treatments, T_2- Chitosan 1% + HDPE 50 microns recorded least PLW (14.61) and highest PLW was recorded in T_6- Aloe vera 25% + LDPE 50 microns(18.80). Among all the treatments, fruits treated with chitosan (1%) and packed in 50 microns HDPE showed minimum loss of physiological weight in fruits during storage compared to other treatments, as chitosan coating and HDPE packing reduced the water loss and respiration rate of fruits during storage by acting as a protective layer between fruit surface and atmosphere. Singh et al. [7] also found that physiological loss in weight was maximum in control ber fruits during storage while lowest recorded in fruits packed in polybags.

3.2 Decay (%)

Decay percent of guava fruits treated with surface coatings and packaging materials stored at room temperature is presented in the Table 2. Decay percent increased throughout the storage period, on 2nd day significantly lowest decay percent was recorded in T_2- Chitosan 1% + HDPE 50 microns (3.60) followed by T_5- Aloe vera 25%+ HDPE 50 microns (3.98) while highest decay was recorded in T_4- Aloe vera 25% + PP 50 microns (4.14). Similar trend was observed on 4th, 6th and 8th day with respect to decay percentage. On 10th day, lowest decay was observed in T_2- Chitosan 1% + HDPE 50 microns (11.79) while highest decay was recorded in T_6- Aloe vera 25% + LDPE 50 microns (13.95). On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns

Table 1. Effect of the different surface coatings and packaging materials on physiological loss in weight (%) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Physiological loss in weight (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	6.29	6.89	7.64	10.10	14.21	*
T_2	5.82	5.96	6.88	8.86	10.45	14.61
T_3	6.18	6.86	7.83	10.04	13.92	*
T_4	6.30	6.80	7.75	9.97	14.29	*
T_5	5.93	6.02	7.00	9.12	11.04	17.15
T_6	6.14	6.88	7.73	10.16	14.31	18.80
SEm±	0.02	0.03	0.04	0.03	0.08	
CD @5%	0.04	0.09	0.14	0.10	0.24	

**- End of the shelf life of fruits*
T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

Table 2. Effect of the different surface coatings and packaging materials on Decay (%) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Decay (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	4.09	7.06	10.14	12.27	13.90	*
T_2	3.60	6.60	9.11	9.90	11.79	13.28
T_3	4.12	7.13	10.11	12.73	13.73	*
T_4	4.14	7.12	10.10	12.57	13.72	*
T_5	3.98	6.77	9.09	9.80	12.16	13.43
T_6	4.13	7.10	10.09	12.25	13.95	15.49
SEm±	0.05	0.04	0.02	0.15	0.10	
CD @5%	0.17	0.13	0.06	0.44	0.31	

**- End of the shelf life of fruits*
T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

Table 3. Effect of the different surface coatings and packaging materials on shelf life (days) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Shelf life (days)
T_1	11.25
T_2	12.91
T_3	11.44
T_4	11.80
T_5	12.89
T_6	12.05
SEm±	0.17
CD @5%	0.52

T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and among the treatments, lowest decay was observed in T_2- Chitosan 1% + HDPE 50 microns (13.28) while highest decay was recorded in T_6- Aloe vera 25% + LDPE 50 microns (15.49). Among all the treatments, fruits treated with T_2- Chitosan 1% + HDPE 50 microns showed least decay percentage in fruits during storage compared to other treatments. Chitosan has broad spectrum anti-microbial activity thereby it could control post-harvest decay of the fruits. These findings are in the accordance with the results of Barka et al. (2004).

3.3 Shelf Life (days)

Shelf life days of guava treated with surface coatings and packaging materials is presented in the Table 3. Highest shelf life was (12.91) recorded in T_2- Chitosan 1% + HDPE 50 microns which was at par with T_5- Aloe vera 25%+ HDPE 50 microns (12.89) and lowest shelf life (11.25) was recorded in T_1 - Chitosan 1% + PP 100 gauge. From the results, Chitosan (1%) coating with packing in HDPE recorded highest shelf life, this may be due to the fact that Chitosan coating reduces fresh weight by reducing loss of moisture and thereby retains freshness of fruits. HDPE packing helps in reducing transpiration there by reduces respiration losses [8].

3.4 Firmness (kg/cm^2)

Results on firmness of guava fruit as influenced by surface coatings and packaging materials

stored at room temperature is presented in the Table 4. On 2nd day T_2- Chitosan 1% + HDPE 50 microns recorded significantly highest firmness (4.43) followed by T_5- Aloe vera 25%+ HDPE 50 microns (4.34) while lowest firmness was recorded in T_4- Aloe vera 25% + PP 50 microns (3.84). Similar trend was observed in firmness among the treatments on 4th ,6th and 8th day respectively. On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and among the treatments highest firmness was recorded in T_2- Chitosan 1% + HDPE 50 microns(3.12) and lowest firmness was recorded in T_6- Aloe vera 25% + LDPE 50 microns(2.64). Chitosan (1%) coating with packaging in HDPE recorded highest firmness as chitosan reduces shrinkage by reducing loss of moisture and thereby retaining freshness of fruits. HDPE helps in reducing transpiration there by reduces respiration losses [8]. Sandeep and Bal [9] also reported that ber fruits can be stored economically for 6 days in ambient conditions when packed in polyethylene bags.

3.5 Total Soluble Solids (TSS) (ºB)

The synergistic effect of surface coatings and packaging materials of guava fruits on total soluble solids is presented in the Table 5. Total soluble solids increased with the storage period at room temperature from first day to twelfth day. On 2nd day, highest TSS was recorded in T_2- Chitosan 1% + HDPE 50 microns (9.33) which was on par with T_5- Aloe vera 25%+ HDPE 50 microns (9.30) and lowest TSS was recorded in T_6- Aloe vera 25% + LDPE 50 microns (9.18). On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and among the treatments, highest TSS was recorded in T_2- Chitosan 1% + HDPE 50 microns(10.33) and lowest TSS was recorded T_6- Aloe vera 25% + LDPE 50 microns(10.23). From the above results, it can be concluded that the fruits treated with Chitosan (1%) showed superior over other treatments, this may be due to the fact that chitosan forms a semi permeable film and modifies the internal atmosphere, decreases transpiration losses and regulates the quality of the fruits as reported by Olivas et al. [10]; Sabir and Sabir [11]. The increment in soluble solids is attributed towards rapid conversion of complex starch molecules in to simple sugars as reported by Gallo et al. [12]. Excess loss of water from the fruiting tissues may also be a valid reason behind this increment [13]. The results are in accordance with Baviskar et al. [14]; Padmaja and Bosco [15]; Samra [16].

3.6 Titrable Acidity (%)

Results on titrable acidity of guava fruit as affected by surface coatings and packaging materials stored at room temperature is presented in the Table 6. Acidity of fruits decreased with the progress in the storage period. On 2nd day, T_2- Chitosan 1% + HDPE 50 microns recorded lowest titrable acidity (0.40) followed by T_5- Aloe vera 25%+ HDPE 50 microns (0.47) while highest acidity was noticed

Table 4. Effect of the different surface coatings and packaging materials on firmness (kg/cm^2) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Firmness (kg/cm^2)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	4.05	3.82	3.47	3.28	3.03	*
T_2	4.43	4.10	3.81	3.62	3.33	3.11
T_3	4.22	3.79	3.37	3.30	3.12	*
T_4	3.84	3.75	3.28	3.38	2.96	*
T_5	4.34	4.03	3.60	3.55	3.25	3.10
T_6	4.22	3.84	3.36	3.31	3.11	2.66
SEm±	0.07	0.03	0.03	0.04	0.03	
CD @5%	0.21	0.10	0.11	0.12	0.10	

**- End of the shelf life of fruits*
T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%)+ High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%)+ Low Density Polyethylene (LDPE) 50 microns

Table 5. Effect of the different surface coatings and packaging materials on TSS content (^{0}Brix) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	TSS content (^{0}Brix)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	9.19	9.60	9.83	9.96	10.12	*
T_2	9.33	9.84	10.03	10.15	10.28	10.30
T_3	9.19	9.51	9.80	10.00	10.17	*
T_4	9.19	9.73	9.82	9.98	10.14	*
T_5	9.30	9.73	9.90	10.06	10.24	10.28
T_6	9.18	9.65	9.87	9.97	10.07	10.23
SEm±	0.02	0.04	0.02	0.03	0.01	
CD @5%	0.07	0.12	0.07	0.09	0.03	

**- End of the shelf life of fruits*
T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

in T_4- Aloe vera 25% + PP 50 microns (0.56). Similar trend was noticed on 4th 6th and 8th day among the treatments with respect to titrable acidity. On 10th day, T_2- Chitosan 1% + HDPE 50 microns recorded lowest titrable acidity (0.26) and was on par with T_5- Aloe vera 25%+ HDPE 100 (0.27) and T_3- Chitosan 1% + LDPE 50 microns (0.28) while highest acidity was noticed in T_4- Aloe vera 25% + PP 50 microns (0.35). On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and among the treatments, T_2- Chitosan 1% + HDPE 50 microns recorded lowest titrable acidity (0.23) while highest acidity was noticed in T_6- Aloe vera 25% + LDPE 50 microns(0.29). Titrable acidity of fruits decreases due to increase of soluble sugars during course of ripening. This decrease was observed less in fruits coated with surface coating compared to control. Similar findings were reported by Baviskar et al. [14] in ber fruits where acidity decreased continuously towards the end of storage period regardless of post-harvest treatments and storage conditions. The packaging films helped in better retention of acidity as compared to control. In wrapped fruits, the lowering of acidity was delayed, which might be due to the effect of packaging films in delaying the respiratory and ripening process as reported by Mahajan et al. [17].

3.7 Ascorbic Acid Content (mg/100 g)

The effect of surface coatings and packaging materials on Ascorbic acid content of guava is presented in the Table 7. On 2nd day there was significant difference observed among the treatments with respect to ascorbic acid content with highest content recorded in T_2- Chitosan 1% + HDPE 50 microns(183.82) and was on par with T_5- Aloe vera 25%+ HDPE 50 microns (182.25) and lowest was noticed in T_3- Chitosan 1% + LDPE 50 microns(178.80). On 4th day of storage, highest ascorbic acid content was recorded in T_2- Chitosan 1% + HDPE 50 microns (180.49) followed by T_5- Aloe vera 25%+ HDPE 50 microns (179.76) and lowest was observed in T_4- Aloe vera 25% + PP 50 microns (175.90). On 6th day, there was significant difference observed among the treatments in ascorbic acid content with highest noticed in T_2- Chitosan 1% + HDPE 50 microns (177.31) and lowest was observed in T_1 - Chitosan 1% + PP 50 microns (171.53). On 8th day of storage, highest ascorbic acid content was recorded in T_2- Chitosan 1% + HDPE 50 microns (174.36) and lowest was observed in T_3- Chitosan 1% + LDPE 50 microns (168.70). On 10th day of storage, T_2- Chitosan 1% + HDPE 50 microns recorded highest ascorbic acid content (170.78) and lowest was observed in T_1 - Chitosan 1% + PP 50 microns (161.27). On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and there was significant difference observed among the treatments with highest ascorbic acid content recorded in T_2- Chitosan 1% + HDPE 50 microns(167.83) and lowest was noticed in T_6- Aloe vera 25% + LDPE 50 microns(158.40). Fruits coated with Chitosan (1%) + HDPE50 microns recorded highest ascorbic acid. The decrease trend of ascorbic acid is less in surface coated and packed fruits

compared to control where there is a rapid decrease of ascorbic acid. This may be due to increase in total soluble sugars increases in the fruits. The results obtained were close to findings of Jagtar Singh et al. [18].

3.8 Total Sugars (%)

The effect of surface coatings and packaging materials on total sugars of guava fruits stored at ambient temperature is presented in the Table 8. On 2nd day, T_2- Chitosan 1% + HDPE 50 microns recorded highest total sugar content (7.36) which was on par with T_5- Aloe vera 25%+ HDPE 50 microns (7.40) while lowest was noticed in T_3- Chitosan 1% + LDPE 50 microns (6.81). On 4th day, highest total sugar content (7.92) was noticed in T_2- Chitosan 1% + HDPE 50 microns which was on par with T_5- Aloe vera 25%+ HDPE 50 microns (7.85) and lowest was noticed in T_6- Aloe vera 25% + LDPE 50 microns (7.09). On 6th day, T_5- Aloe vera 25%+ HDPE 50 microns recorded highest total sugar content (7.97) followed by T_2- Chitosan 1% + HDPE 50 microns(7.96) and T_3- Chitosan 1% + LDPE 50 microns(7.930 and were on par to each other while lowest total sugar content was noticed in T_1 - Chitosan 1% + PP 50 microns(7.62). On 8th day, T_2- Chitosan 1% + HDPE 50 microns recorded highest total sugar content (8.25) which was on par with T_5- Aloe vera 25%+ HDPE 50 microns (8.24) while lowest was noticed in T_3- Chitosan 1% + LDPE 50 microns (7.88). Similar trend was observed among the treatments on 10th day of storage. On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and there was significant difference observed among the treatments, T_2- Chitosan 1% + HDPE 50 microns recorded highest total sugar content (8.67) while lowest was noticed in T_6- Aloe vera 25% + LDPE 50 microns(7.09). The coated a reason for the raise in reducing and total sugars was due to the conversion starch in to sugars. Similar trends of total and reducing sugars content was reported by Ramachandra and Ashok [19] and Jayachandran et al. [20].

3.9 Reducing Sugars (%)

The effect of surface coatings and packaging materials on reducing sugars of guava fruit is presented in the Table 9. On 2nd day, T_2- Chitosan 1% + HDPE 50 microns recorded highest reducing sugars (4.61) followed by T_5- Aloe vera 25%+ HDPE 50 microns (4.26) and T_4- Aloe vera 25% + PP 50 microns recorded lowest reducing sugars (3.94). On 8th day, reducing sugar content was maximum in T_2- Chitosan 1% + HDPE 50 microns (5.28) and lowest reducing sugars was recorded in T_6- Aloe vera 25% + LDPE 50 microns (4.90). Similar result was notice among the treatments on 10th day of storage. On 12th day, treatments *viz*., T_1- Chitosan 1% + PP 100 gauge, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and there was significant difference observed among the treatments, highest reducing sugars was recorded in T_2- Chitosan 1% + HDPE 50 microns(5.63) and lowest reducing sugars was recorded in T_6- Aloe vera 25% + LDPE 50 microns(5.20).

Table 6. Effect of the different surface coatings and packaging materials on titrable acidity (%) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Titrable acidity (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	0.50	0.47	0.38	0.35	0.29	*
T_2	0.40	0.40	0.35	0.33	0.26	0.23
T_3	0.53	0.50	0.43	0.34	0.28	*
T_4	0.56	0.53	0.36	0.36	0.35	*
T_5	0.47	0.42	0.35	0.34	0.27	0.27
T_6	0.50	0.48	0.47	0.41	0.32	0.29
SEm±	0.01	0.02	0.02	0.01	0.01	
CD @5%	0.03	0.05	0.06	0.03	0.04	

**- End of the shelf life of fruits*

T_1- Chitosan (1%) + Polypropylene (PP) 50 microns

T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns

T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns

T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns

T_5- Aloe vera (25%)+ High Density Polyethylene (HDPE) 50 microns

T_6- Aloe vera (25%)+ Low Density Polyethylene (LDPE) 50 microns

Table 7. Effect of the different surface coatings and packaging materials on ascorbic acid content (mg/100 g) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Ascorbic acid (mg/100 g)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T1	178.88	177.36	171.53	169.24	161.27	*
T2	183.82	180.49	177.31	174.36	170.78	167.82
T3	178.80	177.65	172.14	168.70	162.77	*
T4	178.86	175.90	171.75	169.02	163.38	*
T5	182.25	179.76	175.55	172.04	169.97	165.33
T6	180.35	176.96	172.71	168.83	165.08	158.40
SEm±	0.50	0.51	0.50	0.42	0.70	
CD @5%	1.60	1.55	1.50	1.28	2.11	

**- End of the shelf life of fruits*

T_1- Chitosan (1%) + Polypropylene (PP) 50 microns; T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns; T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns; T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns; T_5- Aloe vera (25%)+ High Density Polyethylene (HDPE) 50 microns; T_6- Aloe vera (25%)+ Low Density Polyethylene (LDPE) 50 microns

Table 8. Effect of the different surface coatings and packaging materials on total sugar content (%) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Total sugar content (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	6.86	7.15	7.62	8.00	8.12	*
T_2	7.36	7.92	7.96	8.25	8.46	8.67
T_3	6.81	7.15	7.93	7.88	8.12	*
T_4	6.85	7.13	7.77	7.99	8.15	*
T_5	7.40	7.85	7.97	8.24	8.33	7.84
T_6	6.86	7.09	7.81	8.00	8.16	7.09
SEm±	0.03	0.02	0.04	0.05	0.01	
CD @5%	0.10	0.07	0.13	0.15	0.04	

**- End of the shelf life of fruits*

T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

Table 9. Effect of the different surface coatings and packaging materials on Reducing sugar content (%) of **guava Cv. Allahabad Safeda under ambient conditions**

Treatments	Reducing sugar content (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	3.96	4.06	4.65	4.96	5.05	*
T_2	4.61	4.87	5.12	5.28	5.48	5.63
T_3	4.00	4.06	4.58	4.96	5.07	*
T_4	3.94	4.09	4.77	4.94	5.04	*
T_5	4.26	4.81	4.97	5.08	5.38	5.44
T_6	4.05	4.14	4.70	4.90	5.04	5.20
SEm±	0.02	0.01	0.05	0.02	0.02	
CD @5%	0.06	0.05	0.16	0.07	0.06	

**- End of the shelf life of fruits*

T_1- Chitosan (1%) + Polypropylene (PP) 50 microns; T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns; T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns; T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns; T_5- Aloe vera (25%)+ High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

Table 10. Effect of the different surface coatings and packaging materials on Non-Reducing sugar content (%) of guava Cv. Allahabad Safeda under ambient conditions

Treatments	Non-Reducing sugar content (%)					
	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	2.88	2.90	3.00	3.00	3.11	*
T_2	2.75	2.88	2.82	2.90	2.95	3.03
T_3	2.91	3.04	3.11	3.07	3.05	*
T_4	2.80	2.96	2.99	2.94	3.07	*
T_5	2.80	2.87	2.96	2.93	2.98	3.13
T_6	3.14	3.06	3.35	3.15	3.11	3.15
SEm±	0.01	0.02	0.02	0.03	0.02	
CD @5%	0.03	0.04	0.05	0.09	0.06	

**- End of the shelf life of fruits*
T_1- Chitosan (1%) + Polypropylene (PP) 50 microns
T_2 - Chitosan (1%) + High Density Polyethylene (HDPE) 50 microns
T_3- Chitosan (1%) + Low Density Polyethylene (LDPE) 50 microns
T_4- Aloe vera (25%) + Polypropylene (PP) 50 microns
T_5- Aloe vera (25%) + High Density Polyethylene (HDPE) 50 microns
T_6- Aloe vera (25%) + Low Density Polyethylene (LDPE) 50 microns

3.10 Non-Reducing Sugars (%)

The data pertaining to non-reducing sugars as influenced by the effect of surface coatings and packaging materials on guava is presented in the Table 10. On 2nd day lowest non-reducing content was recorded in T_2- Chitosan 1% + HDPE 50 microns (2.75) followed by T_5- Aloe vera 25%+ HDPE 50 microns (2.80) and highest non reducing sugars was recorded in T_6- Aloe vera 25% + LDPE 50 microns (3.14). Similar trend was noticed among the treatments with respect to non-reducing sugar content on 4th, 6th, 8th and 10th day respectively. On 12th day, treatments *viz.*, T_1- Chitosan 1% + PP 50 microns, T_3- Chitosan 1% + LDPE 50 microns& T_4- Aloe vera 25% + PP 50 microns showed the end of shelf life and there was significant difference observed among the treatments, lowest non reducing sugar content was recorded in T_2- Chitosan 1% + HDPE 50 microns(3.03) while highest non reducing sugar content was recorded in T_6- Aloe vera 25% + LDPE 50 microns(3.15). The non-reducing sugar content was found to increase up to ripening there after showed a decline at the end of shelf life in all treatments. The initial raise in sugars may be due to conversion of starch into sugars, while later the decrease was due to consumption of sugars for respiration during storage. Similar observation was reported by Ramachandra and Ashok [19].

4. CONCLUSION

Among the packaging materials, HDPE (High Density Polyethylene) 50 microns was significantly superior in recording highest shelf life, firmness and quality parameters which was followed by Poly propylene 50 microns and LDPE (Low Density Polyethylene) 50 microns. With respect to the combined effect of surface coatings and packaging materials, T_2- Chitosan 1% + HDPE 50 microns followed by T_5- Aloe vera 25%+ HDPE 50 microns were found to be superior over other treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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