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EFFECT OF EDIBLE SURFACE COATINGS ON POSTHARVEST QUALITY AND SHELF LIFE OF GUAVA (*PSIDIUM GUAJAVA* L. CV. PANT PRABHAT) FRUITS

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ABSTRACT
The main aim of the study was to assess the efficacy of different edible coating treatments like calcium chloride (1.0, 1.5, 2.0%), chitosan (0.5, 1.0, 1.5%), sodium alginate (0.5, 1.0, 1.5%) and *Aloe vera* gel (1:1, 1:2, 1:3) at varying concentrations on the post harvest quality attributes of fruits of guava cultivar 'Pant Prabhat'. After treatment, fruits were kept at ambient temperature of 27-29°C till 12 days and analysed for various physico-chemical parameters while the uncoated fruits serve as control. In all treatments, chitosan (1.5%) coating was effective in reducing physiological loss in weight (4.83%), decay (9.38%) and maintaining physical qualities than other treatments while *Aloe vera* 1:1 gel coating was also equally effective. Significant effect on minimum shrinkage in fruit length (7.37%), breadth (6.70%), total soluble solids (10.37%), titratable acidity (0.17%), ascorbic acid (156 mg/100g flesh), total sugars (6.94%), reducing sugars (3.50%) and non-reducing sugar (3.44%) were recorded with chitosan 1.5% coating. Hence, it was concluded that coating treatment of 1.5% chitosan followed by *Aloe vera* 1:1 gel coating can be used for enhancing the shelf life and maintaining postharvest quality in fruits of guava cultivar 'Pant Prabhat'.

INTRODUCTION

Guava (*Psidium guajava* L.) 'The apple of the tropics' is one of the most delicious and nutritious fruit crops grown in India. Guava is considered to be superior to several other fruits by virtue of its commercial and nutritional value (Menzel, 1985). It is rich in vitamin C (260 mg/100g) and a fair source of calcium, phosphorus, iron and vitamin A. Calcium chloride dipping treatment slow down and delayed the changes in ascorbic acid in fig fruit (Irfan *et al*., 2013). Guava fruits treated with calcium chloride @1% and wrapped in newspaper recorded minimum reduction in fruit weight during storage period (Kumar *et al*., 2014). Chitosan @2.5% increased the shelf-life of (Mutiara) guava fruits (Widodo *et al*., 2015). Kumari *et al*. (2015) observed that chitosan alone or in combination were found highly effective in minimizing weight loss of litchi fruit during storage at 4°C. An increase of three days shelf life of mexican guava was observed when fruits were coated with sodium alginate @10% (Gallo *et al*., 2003). Valero *et al*. (2013) reported that alginate treatments significantly decreased weight loss for all plum cultivars. Azarakhsh *et al*. (2014) observed a decrease in softening for fresh-cut pineapple coated with alginate, while firmness of 0.5% was found in control. Dip treatment of sapota fruit in *Aloe vera* gel coating 1:2 for 7 minutes had best retained the physico-chemical characteristics (Padmaja *et al*., 2015). Vieira *et al*. (2016) reported that application of an edible coating containing *Aloe vera* on the blueberry surface after harvesting provides an additional barrier to reduce postharvest contamination by fungi and also by reducing the rate of water loss. Due to highly perishable nature, guava fruits undergo rapid postharvest ripening in few days under ambient conditions (Hashem and Alamri, 2009). The fruit ripening in guava is characterized by loss of green colour, softening, shrinkage, loss of brightness and rot development (Ali and Lazan, 1997). The post harvest losses can be minimized by extension of shelf life through checking the rate of transpiration and respiration, microbial infection. The perishability of fruits requires the development of technologies that reduce their postharvest deterioration and extend their shelf life (Gonzalez Aguilar *et al*., 2009). In a country like India where sufficient refrigeration facilities are not available, the alternative means for increasing shelf life of fruits for a short period are likely to prove more beneficial. Edible coatings can provide an alternative means for extending keeping life of fresh fruits. Several types of edible coatings such as carbohydrate, protein, lipid and combination of these are in practice nowadays to extend the shelf life and quality of fruits. Among these, chitosan, calcium chloride, sodium alginate and *Aloe vera* gel has been known to protect perishable fruits from deterioration by reducing transpiration, respiration and maintaining textural quality. Edible coatings play an important role in the quality, safety, transportation, storage and display of a wide range of fresh and processed foods (Daniel *et al*., 2007; Elizabeth *et al*., 1995). They act as barriers to moisture and oxygen during handling (Olivas *et al*., 2005) and storage. They do not solely retard food deterioration but also enhance its safety due to their natural biocide activity or by incorporating antimicrobial compounds (Maria *et al*., 2008). For maintaining the quality and shelf life of guava fruits,

postharvest application of coatings like *Aloe vera* gel, calcium chloride, chitosan and sodium alginate was done. So, keeping all these in view, an experiment was conducted to assess the suitability of various edible coatings on quality, shelf life and physico-chemical characteristics of guava cv. Pant Prabhat fruits at different storage periods.

MATERIALS AND METHODS

Plant material

Physiologically mature green fresh fruits of guava cv. Pant Prabhat were procured from an orchard of Horticulture Research Centre, Patharchatta of G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) in November, 2015. Fruits were transported to the laboratory in plastic crates where sorting was done to remove immature, misshaped, blemished, diseased and infected fruitsas per method of Hong *et al*. (2012). Selected uniform size fruits were washed in running tap water and dried in shade for few minutes. Coatings of required concentrations of calcium chloride, *Aloe vera* gel, chitosan, sodium alginate (purchased from HiMedia, Mumbai) were prepared for surface treatment of guava fruits. Twenty fruits were dipped in each solution for 1 minutes and then air dried as per method of Hong *et al*. (2012). The trial was carried out in three replicates.

Calcium chloride coating

Calcium chloride 1%, 1.5% and 2% (w/v) solution was prepared according to Khaliq *et al*. (2016) by dissolving 1, 1.5 and 2 g of $CaCl_2$ in 100 mL of distilled water. The solution was agitated constantly using a magnetic stirrer (model SP 18420-26 Barnstead Thermolyne 2555 Kerper Boulevard Dubuque, USA) for 30 minutes and 0.2 mL of Tween 20 (Polyoxyethylene sorbitan monoleate) was added to the solution to improve wettability.

Chitosan coating

Chitosan coating was prepared according to Vargas *et al*. (2006). 5, 10 and 15 grams of chitosan were dispersed separately to make 0.5%, 1% and 1.5% solution in an aqueous solution of glacial acetic acid (1% v/v) at 40°C. Tween 80 at 0.1% was added to improve wettability.

Alginate coating

Alginate coating was prepared according to Rojas-Grau *et al*. (2007). 5, 10 and 15 grams of sodium alginate ($NaC_6H_7O_6$) was dissolved separately to make 0.5%, 1% and 1.5% in sterilized distilled water and heated at 70°C, until the solution became clear. After cooling, glycerol ($C_3H_5(OH)_3$, 85% purity) was added as plasticiser to a final concentration of 1.5 g/100 ml solution. The final volume of solution was made to 1 litre.

Aloe vera gel coating

Aloe vera gel preparation was undertaken according to Ramachandra and Rao (2008) who advised that *Aloe vera* leaves must be processed within 2 hours of harvesting to prevent oxidation of the gel due to their exposure to air. Whole leaves were washed with water and the base and tips of the leaves along with its spikes were removed. Next, the skin was carefully separated from parenchyma to obtain *Aloe vera* flesh. The flesh was then washed and blanched in hot water at 100ºC for 4 minutes. The blanched flesh was then blended and the *Aloe vera* gel obtained was filtered through activated carbon to remove anthraquinones that have a laxative effect. Before pasteurization, the pH of the gel was adjusted to 3.0 by the addition of citric acid to stabilize and prevent browning. The process was then continued with pasteurization at 85ºC for 1 minute. After pasteurization, the gel was quickly cooled to 5ºC or below. Finally, the *Aloe vera* gel was filled into pre-sterilized, opaque glass bottles for storage in a chiller at 5ºC and 75-80% relative humidity. Accordingly, coatings of *Aloe vera* gel was made in 1:1, 1:2 and 1:3 ratio with water.

The treated and non-treated fruits were divided into different lots and were placed in ambient conditions of the postharvest laboratory having 25-28°C and 75% RH. Fruits were dipped in these solutions for 1-2 minutes, drained and surface dried by using procedure according to Hong *et al*. (2012). The observations on various physico-chemical attributes were studied on same day of harvest and after 3, 6, 9 and 12 days of storage at ambient conditions (27-29ºC and 70-75% RH).

Physical attributes

The length and breadth of fruits were measured by digital vernier callipers during the storage period as an index for shrinkage. The physiological loss in weight (PLW) of the fruits was determined by using standard procedures according to AOAC (2000). Decay percentage of coated and uncoated fruit was calculated as the number of decayed fruit divided by initial number of all fruit multiplied by 100 (El-Anany *et al*. 2009) at subsequent intervals.

Chemical attributes

TSS of the fruits was measured with the help of hand held digital refractometer (ERMA, Japan) of 0-32°Brix rangeby using standard procedures according to AOAC (2000). The titrable acidity (expressed as citric acid %) and ascorbic acid expressed in terms of mg ascorbic acid/100g of juice were determined as per method of Ranganna (1986). Lane and Eynon (1923) method as described by Ranganna (1986) was used for determining total sugar, reducing sugar and non-reducing sugar and expressed in percentage.

Statistical analysis

The data were analysed according to the procedure for analysis of two factorial completely randomized design as given by Snedecor and Cochran (1987). The overall significance of differences among the treatments was tested, using critical difference (C.D.) at 5% level of significance. The data were presented through tables and graphs.

RESULTS AND DISCUSSION

Shrinkage in size

Treatments exerted a significant influence on fruit length and breadth of fruits. Minimum shrinkage in fruit length (7.37%) was recorded in chitosan 1.5% (T_6) followed by (8.05%) in chitosan 1.0% (T_5) while maximum shrinkage in fruit length (17.79%) was recorded in control (T_{13}) followed by (17.59%) in calcium chloride 1.5% (T_2) (Table 1). Shrinkage percentage in chitosan 1.5% (T_6) treatment was 7.37% (from 6.32 cm to 5.86 cm) for fruit length and 6.70% (from 6.93 cm to 6.86 cm) for fruit breadth. Minimum shrinkage in fruit breadth (6.70%) was also recorded in chitosan 1.5% (T_6) treatment followed

Table 1: Effect of different edible coatings and their concentrations on length and breadth of fruits

Treatments	Days after treatments Length		Breadth		Shrinkage (%)	
	At harvest	12	At harvest	12	Length	Breadth
T_1: Calcium chloride 1.0%	6.49	5.36	6.95	5.68	17.41	18.35
T_2: Calcium chloride 1.5%	6.40	5.28	6.92	5.67	17.59	18.10
T_3: Calcium chloride 2.0%	6.30	5.66	7.18	6.24	10.11	13.06
T_4: Chitosan 0.5%	6.40	5.72	6.92	6.12	10.63	11.52
T_5: Chitosan 1.0%	6.21	5.71	6.93	6.03	8.05	13.02
T_6: Chitosan 1.5%	6.32	5.86	6.93	6.46	7.37	6.70
T_7: Sodium alginate 0.5%	6.30	5.71	7.12	6.35	9.37	10.85
T_8: Sodium alginate 1.0%	6.41	5.66	7.18	6.12	11.70	14.73
T_9: Sodium alginate 1.5%	6.55	5.84	7.12	6.37	10.89	10.49
T_{10}: *Aloe vera* 1:1	6.41	5.83	6.94	6.44	9.00	7.12
T_{11}: *Aloe vera* 1:2	6.46	5.71	6.92	6.28	11.61	9.25
T_{12}: *Aloe vera* 1:3	6.61	5.64	6.94	5.85	14.67	15.66
T_{13}: Control	6.41	5.27	6.88	5.57	17.79	19.08
Factors	CD at 5%	SE(m)	CD at 5%	SE(m)		
Storage Intervals (S)	0.018	0.006	0.012	0.004		
Treatments (T)	0.029	0.010	0.019	0.007		
Interaction (S × T)	0.066	0.023	0.042	0.015		

Table 2: Effect of different edible coatings and their concentrations on physiological weight loss and decay percentage

Treatments	Physiological loss in weight (%) Days after treatments					Decay (%) Days after treatments				
	3	6	9	12	Mean	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	8.21	12.10	15.75	18.26	10.86	6.50	15.22	20.05	25.03	13.36
T_2Calcium chloride 1.5%	6.03	12.61	15.86	18.62	10.63	6.20	12.21	18.17	22.23	11.76
T_3Calcium chloride 2.0%	4.05	7.68	8.30	12.72	6.55	7.21	15.90	19.07	23.22	13.08
T_4Chitosan 0.5%	2.67	11.65	12.08	15.22	8.32	5.11	11.19	19.48	25.57	12.27
T_5Chitosan 1.0%	1.18	8.91	14.01	17.84	8.39	4.49	11.10	17.50	21.55	10.93
T_6 Chitosan 1.5%	2.14	2.24	8.88	10.91	4.83	0.00	10.29	16.54	20.06	9.38
T_7 Sodium alginate 0.5%	5.19	11.04	17.48	17.42	10.23	6.22	12.03	18.11	25.30	12.33
T_8 Sodium alginate 1.0%	2.58	3.01	11.75	23.41	8.15	5.52	12.56	19.14	26.26	12.70
T_9 Sodium alginate 1.5%	2.28	7.94	12.96	15.12	7.66	4.81	11.50	19.08	25.50	12.18
T_{10}*Aloe vera* 1:1	2.28	5.65	8.24	10.19	5.27	0.00	10.70	15.91	22.59	9.84
T_{11}*Aloe vera* 1:2	4.77	6.67	8.51	11.66	6.32	2.42	14.23	18.14	27.12	12.38
T_{12}*Aloe vera* 1:3	1.64	11.44	16.05	22.67	10.36	5.49	13.47	19.06	27.18	13.04
T_{13} Control	6.16	12.56	17.81	20.77	11.46	9.48	19.23	26.29	35.11	18.02
Factors	CD at 5%		SE(m)			CD at 5%		SE(m)		
Storage Intervals (S)	0.627		0.224			0.064		0.023		
Treatments (T)	1.010		0.361			0.104		0.037		
Interaction (S × T)	2.259		0.807			0.232		0.083		

by (7.12 cm) in *Aloe vera* 1:1 (T_{10}) while the maximum shrinkage in fruit breadth (19.08%) was recorded in control (T_{13}) followed by (18.35%) in calcium chloride 1.0% (T_1). Storage period affected the fruit length and breadth significantly which decreased gradually as the storage period progressed. The decrease in fruit length and breadth with the increase in storage time might be due to increased moisture loss resulting in shrinkage of fruits. The above findings are in agreement with the findings of Tiwary (2011) and Singh *et al*. (2010). Singh *et al*. 2010 also reported that the highest degree of reduction was observed in untreated fruits stored under room temperature in mango. Shrinkage mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration (Vogler and Ernst, 1999). Similarly, It has been reported that coated apple fruit with 1% chitosan reduced shrinkage compared with uncoated fruit (Qi *et al*., 2011). Chitosan coating forms a semi permeable film that regulates gas exchange and reduces the transpiration rate, which is generally determined by the gradient of the water vapour pressure between the fruit and the surrounding air (Bautista-Banos *et al*., 2006). Chitosan coating has been effective in reducing the shrinkage from guava (Hong *et al*., 2012).

Physiological loss in weight

Data depicted in Table 2 showed that all the treatments exerted a significant influence on physiological loss in weight. Minimum physiological loss in weight (4.83%) was recorded in chitosan 1.5% (T_6) followed by (5.27%) in *Aloe vera* 1:1 (T_{10}) and maximum (11.46%) was recorded in control (T_{13}) followed by (10.86%) in calcium chloride 1.0% in (T_1). Loss of weight in fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes (Zhu *et al*., 2008).

Table 3: Effect of different edible coatings and their concentrations on total soluble solids (%) and titratable acidity (%)

Treatments	Total soluble solids (%) Days after treatments						Titratable acidity (%) Days after treatments					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	9.02	9.11	9.21	9.62	10.22	9.44	0.28	0.24	0.24	0.20	0.13	0.22
T_2Calcium chloride 1.5%	9.03	9.13	9.14	9.16	9.17	9.13	0.28	0.24	0.22	0.20	0.16	0.22
T_3Calcium chloride 2.0%	9.01	9.11	9.13	9.50	10.11	9.37	0.28	0.24	0.23	0.21	0.18	0.23
T_4Chitosan 0.5%	9.03	9.05	9.44	10.08	10.54	9.63	0.28	0.24	0.22	0.21	0.16	0.22
T_5Chitosan 1.0%	9.05	9.11	9.13	9.82	10.22	9.47	0.28	0.25	0.22	0.20	0.18	0.23
T_6 Chitosan 1.5%	9.06	9.12	9.22	9.50	10.37	9.45	0.28	0.23	0.21	0.20	0.17	0.22
T_7 Sodium alginate 0.5%	9.05	9.13	9.36	10.02	10.12	9.54	0.28	0.24	0.22	0.20	0.16	0.22
T_8 Sodium alginate 1.0%	9.00	9.06	9.46	10.07	10.36	9.59	0.28	0.24	0.22	0.19	0.15	0.22
T_9 Sodium alginate 1.5%	9.03	9.18	9.38	10.01	10.12	9.55	0.28	0.24	0.20	0.18	0.13	0.21
T_{10}*Aloe vera* 1:1	9.02	9.25	10.41	10.60	11.18	10.09	0.28	0.26	0.24	0.23	0.21	0.24
T_{11}*Aloe vera* 1:2	9.05	9.62	9.87	10.02	10.13	9.74	0.28	0.24	0.22	0.20	0.18	0.22
T_{12}*Aloe vera* 1:3	9.06	9.10	9.14	9.21	9.41	9.19	0.28	0.24	0.22	0.19	0.18	0.22
T_{13} Control	9.01	9.03	9.11	9.15	9.16	9.09	0.28	0.22	0.20	0.16	0.12	0.20
Factors	CD at 5%		SE(m)				CD at 5%		SE(m)			
Storage Intervals (S)	0.034		0.012				0.004		0.001			
Treatments (T)	0.054		0.019				0.006		0.002			
Interaction (S × T)	0.121		0.043				0.014		0.005			

Table 4: Effect of different edible coatings and their concentrations on ascorbic acid (%) and total sugars (%)

Treatments	Ascorbic acid (mg/100g) Days after treatments						Total sugars (%) Days after treatments					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	279.00	273.33	176.67	150.00	125.00	200.80	6.62	6.63	6.92	7.23	7.47	6.97
T_2Calcium chloride 1.5%	275.00	261.00	222.33	173.67	162.00	218.80	6.62	6.65	6.92	7.26	7.50	6.99
T_3Calcium chloride 2.0%	283.00	255.00	232.00	190.00	155.00	223.00	6.62	6.77	7.01	7.19	7.28	6.97
T_4Chitosan 0.5%	284.00	262.00	176.67	175.00	115.00	202.53	6.62	6.81	6.90	7.12	7.25	6.94
T_5Chitosan 1.0%	282.33	261.67	241.00	198.00	152.33	227.07	6.62	6.76	6.92	7.15	7.22	6.93
T_6 Chitosan 1.5%	282.33	261.33	241.00	217.33	156.00	231.60	6.62	6.66	6.73	6.81	6.94	6.75
T_7 Sodium alginate 0.5%	282.67	252.00	241.67	200.00	115.00	218.27	6.62	6.67	7.08	7.21	7.31	6.98
T_8 Sodium alginate 1.0%	283.33	254.00	182.00	155.00	155.00	205.87	6.62	6.65	6.81	7.18	7.38	6.93
T_9 Sodium alginate 1.5%	285.00	210.00	201.67	163.00	152.67	202.47	6.62	6.67	7.12	7.25	7.46	7.03
T_{10}*Aloe vera* 1:1	276.00	251.00	219.33	163.00	156.67	213.20	6.62	6.67	6.73	6.86	7.09	6.79
T_{11}*Aloe vera* 1:2	282.67	226.67	184.33	155.00	151.00	199.93	6.62	6.65	7.13	7.26	7.34	7.00
T_{12}*Aloe vera* 1:3	286.00	258.33	226.67	210.00	105.00	217.20	6.62	6.66	7.05	7.19	7.24	6.95
T_{13} Control	275.00	232.00	205.00	161.00	116.00	197.80	6.62	6.95	7.28	7.34	7.61	7.16
Factors	CD at 5%		SE(m)				CD at 5%		SE(m)			
Storage Intervals (S)	10.179		3.634				0.023		0.008			
Treatments (T)	16.413		5.859				0.037		0.013			
Interaction (S × T)	36.700		13.102				0.082		0.029			

Chitosan coating also forms a layer of semi-transparent to smooth pericarp surface (Dong *et al*., 2004) and can be used as a protective barrier to reduce respiration and transpiration rates through fruit surfaces (Kester and Fennema, 1986). Coating the guava fruit with chitosan was clearly effective in conferring a physical barrier to moisture loss; therefore, a decreased weight loss in the chitosan coated fruit was observed during evaluation in this study. The results are supported by Ali *et al*. (2011) where water loss of papaya fruits can be reduced by coating with chitosan. Brishti *et al*. (2013) also reported similar results that weight loss of uncoated fruit (sample) was significantly greater than that of *Aloe vera* gel coated papaya fruit. At the end of the storage, uncoated papaya showed 22.5% loss in weight, whereas the weight losses of samples coated with *Aloe vera* gel was 7.93%. Reduction of moisture loss may be due to the hygroscopic properties of *Aloe vera* gel that allow the formation of water barrier between the fruit and the surrounding environment, thus preventing its external transferences (Morrilon *et al*., 2002).

Decay

The data on effect of various treatments and storage periods on decay percentage of guava under ambient condition are presented in Table 2. It indicated that all the treatments exerted a significant influence on fruit decay percentage. There was very less sign of decay until 3 days of storage period. Control uncoated fruit had shown maximum decay percentage during the storage period. No symptoms of decay were observed on the fruits coated with chitosan 1.5% (T_6) and *Aloe vera* 1:1 (T_{10}) until 3 days of storage period. Minimum fruit decay percentage (9.38%) was recorded in chitosan 1.5% (T_6) followed by (9.84%) in *Aloe vera*1:1 (T_{10}) and maximum fruit

Table 5: Effect of various treatments on reducing sugars and non-reducing sugars of fruit under ambient storage condition

Treatments	Reducing sugars (%) Days after treatments						Non-reducing sugars (%) Days after treatments					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	3.28	3.29	3.52	3.67	3.83	3.52	3.34	3.34	3.40	3.57	3.64	3.46
T_2Calcium chloride 1.5%	3.28	3.29	3.41	3.62	3.72	3.46	3.34	3.36	3.51	3.64	3.79	3.53
T_3Calcium chloride 2.0%	3.28	3.29	3.45	3.52	3.60	3.43	3.34	3.49	3.55	3.67	3.68	3.55
T_4Chitosan 0.5%	3.28	3.44	3.51	3.66	3.78	3.54	3.34	3.37	3.39	3.46	3.47	3.40
T_5Chitosan 1.0%	3.28	3.37	3.49	3.63	3.68	3.49	3.34	3.39	3.43	3.52	3.54	3.44
T_6 Chitosan 1.5%	3.28	3.30	3.36	3.43	3.50	3.37	3.34	3.36	3.37	3.38	3.44	3.38
T_7 Sodium alginate 0.5%	3.28	3.31	3.42	3.54	3.61	3.43	3.34	3.36	3.66	3.67	3.71	3.55
T_8 Sodium alginate 1.0%	3.28	3.30	3.36	3.67	3.83	3.49	3.34	3.36	3.45	3.51	3.55	3.44
T_9 Sodium alginate 1.5%	3.28	3.32	3.51	3.62	3.76	3.50	3.34	3.35	3.61	3.63	3.71	3.53
T_{10}*Aloe vera* 1:1	3.28	3.31	3.36	3.48	3.56	3.40	3.34	3.36	3.37	3.37	3.54	3.40
T_{11}*Aloe vera* 1:2	3.28	3.30	3.46	3.56	3.63	3.45	3.34	3.35	3.67	3.70	3.71	3.56
T_{12}*Aloe vera* 1:3	3.28	3.30	3.59	3.72	3.76	3.53	3.34	3.36	3.46	3.47	3.48	3.42
T_{13} Control	3.28	3.53	3.68	3.72	3.75	3.59	3.34	3.42	3.60	3.62	3.86	3.57
Factors	CD at 5%			SE(m)			CD at 5%		SE(m)			
Storage Intervals (S)	0.018			0.007			0.029		0.010			
Treatments (T)	0.029			0.011			0.047		0.017			
Interaction (S × T)	0.066			0.024			0.106		0.038			

decay percentage (18.02%) was recorded in control (T_{13}) followed by (13.36%) in calcium chloride 1.0% (T_1). Storage days affected fruit decay percentage significantly which increased gradually irrespective of the treatment as the storage period progressed. The lower decay loss in chitosan 1.5% (T_6) treated fruits might be attributed to induced disease resistance in treated fruits. The chitosan, being polycationic in nature interfered with negatively charged macromolecule residues exposed on the fungal cell surface. This interaction leads to the leakage of intracellular electrolytes and proteinaceous constituents (Leuba and Stossel, 1986; Xu *et al*., 2006). Chitosan reduced the decay of fruit by eliciting host defence response (inducing accumulation of chitinases, â-1,3-glucanases and synthesis of phytoalexins) and providing a structural barrier against fungal penetration (Bautista-Banos *et al*., 2006). Lower decay incidence in *Aloe vera* 1:1 coated fruits was due to the antimicrobial potentiality of the gel (Brishti *et al*., 2013).

TSS

The data presented in Table 3 depicted that 12th days storage shows maximum values of TSS in all the treatments. It is clear from the figure that control fruits had significantly lower TSS values and it was increased progressively till 12th days of storage. Maximum fruit TSS (10.09ºB) was recorded in *Aloe vera* 1:1 (T_{10}) followed by (9.74°B) in *Aloe vera* 1:2 (T_{11}) and minimum (9.09ºB) was recorded in control (T_{13}) followed by (9.13°B) in calcium chloride 1.5% (T_2). Among coating treatments, slow rate of increase in TSS was observed which may be due to slowing down of respiration and metabolic activity results into delaying of ripening process. Martýnez-Romero *et al*. (2006) also found that sweet cherry fruits treated with *Aloe vera* gel had higher levels of TSS. *Aloe vera* coating was more effective because of the lowest gas permeability of *Aloe vera* coating that inhibited the respiratory rates and retarded the overall metabolic activities of raspberry fruits during storage. Sogvar *et al*. (2016) reported that strawberry fruits treated with *Aloe vera* coating had a higher levels of TSS. The solubilisation of the cell wall polyuronides and hemicelluloses in mature strawberry might also contribute to the increase in TSS (Tanada-Palmu and Grosso, 2005). Similar findings has been reported by (Hassanpour, 2015) where *Aloe vera* treated raspberry fruits has higher TSS. Depletion of TSS in the fruit could be explained by a high metabolism of the fruits and senescence processes.

Titratable Acidity

A gradual decrease in titratable acidity was found in both coated and uncoated guava fruits throughout the storage period (Table 3). Maximum fruit titratable acidity (0.24%) was recorded in *Aloe vera* 1:1 (T_{10}) followed by (0.23%) in chitosan 1.0% (T_5) and minimum (0.20%) was recorded in control (T_{13}) followed by (0.21%) in sodium alginate 1.5% (T_9). Slower decline in acidity in treated fruits compared to control might be due to delayed senescence and lower respiration rate in those fruits. Similar observations were also reported by Sayyari *et al*. (2009) in pomegranate and Hernandez-Munoz *et al*. (2007) in strawberry.

A lower acidity loss in chitosan coated fruits during storage was also reported in guava by Hong *et al*. (2012) suggesting that chitosan treatment may play a role in delaying fruit senescence. *Aloe vera* coating was more effective in the retention of titratable acidity because of the lowest gas permeability of *Aloe vera* coating that inhibited the respiratory rates and retarded the overall metabolic activities of guava fruits during storage. Retention of titratable acidity has been reported previously for various fruits treated with edible coatings and films (e.g. Ali *et al*., 2010; Yaman and Bayoindirli, 2002).

Ascorbic Acid

Treatments exerted a significant influence on ascorbic acid (Table 4). Maximum fruit ascorbic acid (231.60) was recorded in chitosan 1.5% (T_6) which was statistically *at par with* T_2 (218.80), T_3 (223.00), T_5 (227.07), T_7 (218.27) and T_{12} (217.20) while minimum (197.80) was recorded in control (T_{13}). Storage

days affected the ascorbic acid content significantly which decreased gradually irrespective of the treatment as the storage period progressed. The results are similar with the findings of Kumar *et al*. (2000), they found that ascorbic acid decreased with increasing period of storage in fruits of kinnow. But the decreased in ascorbic was less in coated fruits as compare to control. Maximum ascorbic acid in control treatment might be due to increased respiration causing loss of ascorbic acid. Ascorbic acid is susceptible to oxidative deterioration as well as mild oxidation of ascorbic acid results in formation of dehydroascorbic acid (Wills *et al*., 1981). Vitamin C in guava fruits gradually decreased during storage and this reduction was effectively inhibited by 1.5% chitosan coating (T_6). The chitosan treatment in fruits might have reduced the oxygen permeability by providing a physical barrier thereby delayed the deteriorative oxidation reaction of ascorbic acid. A similar finding has been reported in litchi by Ayranci and Tunc (2004). It suggests that the modified atmosphere created by chitosan coating suppresses the loss of vitamin C.

Sugars

It is revealed from Table 4 & 5 that there was a significant increase in the total sugar, reducing sugar and non-reducing sugar content of coated as well as uncoated guava fruits during the storage period. However, the rate of increase in total sugar, reducing sugar and non-reducing sugar contents was significantly lower in coated samples as compared with control sample. Maximum total sugars (7.16%) was recorded in control (T_{13}) followed by (7.03%) in sodium alginate 1.5% (T_9) and minimum (6.75%) was recorded in chitosan 1.5% (T_6) followed by (6.79%) in *Aloe vera* 1:1 (T_{10}). Maximum reducing sugars (3.59%) was recorded in control (T_{13}) which was followed by (3.54%) in chitosan 0.5% (T_4) and minimum (3.37%) was recorded in chitosan 1.5% (T_6) followed by (3.40%) in *Aloe vera* 1:1 (T_{10}). Maximum non-reducing sugar (3.57%) was recorded in control (T_{13}) followed by (3.56%) in *Aloe vera* 1:2 (T_{12}) and minimum (3.38%) was recorded in chitosan 1.5% (T_6) followed by (3.40%) in *Aloe vera* 1:1 (T_{10}). The total sugar, reducing sugar and non-reducing sugar contents was found to be higher in uncoated guava fruit which might be due to a decrease in the acidity as a result of physiological changes and rapid conversion of starch to sugars as a result of moisture loss as previously reported by Wills and Rigney (1980). In case of coated samples a significantly slower increase in total sugar, reducing sugar and non-reducing sugar contents were noted with respect to that of control that might be due to their slower ripening rate. This view concurs with the results of Abbasi *et al*. (2009) who studied the effect of chitosan coatings on postharvest quality of mango fruit and observed that the total sugar, reducing sugar and non-reducing sugar contents were less in the coated samples. These results are in agreement with those of Li and Yu (2000) who concluded that reducing sugar and non reducing sugar content was significantly affected by gelatin coatings in mango. Maqbool *et al*. (2011) cited that during ripening the fruit texture is changed due to alteration in the cell wall structure and the degradation of starch and resultantly bound carbohydrate fractions especially pectic substances and hemicelluloses, rapidly depolymerize by hydrolysis. The present results were similar to the results of Hoa and Ducamp (2008) on 'cat Hoa loc' mangoes where they studied the effect of different coatings and observed that the contents of total sugar, reducing sugar and non-reducing sugar were lower in the coated fruit with respect to those of control fruits.

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