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Post-harvest changes in functional and sensory properties of guava (*Psidium guajava* L. cv. Pant Prabhat) fruits as influenced by different edible coating treatments

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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 analyzed for various functional and sensory parameters while the uncoated fruits serve as control. In all treatments, chitosan (1.5%) coating was effective in maintaining superoxide dismutase activity (69.48 units/g fruit weight), total phenolics content (333.35 mg GAE/100 g fresh weight), fruit appearance (8.32), fruit flavour (8.21) and fruit texture (8.28). *Aloe vera* 1:1 gel coating was effective in maintaining total flavonoids content (89.64 mg/100 g fresh weight), total antioxidants capacity (684.27 µmol. TE/100 g fresh weight), fruit colour (8.22), fruit taste (8.19) and overall acceptability (8.18). 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'.

Keywords: Edible coating, Guava, Post-harvest quality, Shelf life

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) [23]. It is rich in vitamin C (260mg /100g) and a fair source of calcium, phosphorus, iron and vitamin A. Zeng *et al*. (2010) [39] reported that the activity of superoxide dismutase in navel orange fruit was induced by chitosan. Slower reduction of total flavonoids in *Aloe vera* and chitosan treated fruits might be attributed to antisenescence properties of *Aloe vera* and chitosan (Wisniewska and Chelcowski, 1999) [38]. Sun *et al*. (2010) [34] in litchi reported that application of chitosan maintained higher phenolics content in fruits during storage by reducing polyphenol oxidase activity. Antioxidant contributing property of phenolic compounds and ascorbic acid has been reported earlier in pomegranate Mirdehghan *et al*. (2007) [24], sweet cherry Serrano *et al*. (2005) [30] and mango Asrey *et al*. (2013) [5]. Mahajan *et al*. (2005) [19] reported that kinnow fruits treated with chitosan maintained uniform colour. Tripathi and Dubey (2004) [35] reported better retention of colour when papaya fruits were treated with *Aloe vera* gel (100%). The maintenance of textural integrity in fruits treated with coatings could be due to their higher antifungal activity, according to previous reports in papaya and sweet cherry coated with chitosan and *Aloe vera* gel (Ali *et al*., 2005 [2]; Martinez- Romero *et al*., 2006) [22]. Marpudi *et al*. (2011) [21] reported that papaya fruits coated with *Aloe vera* gel increased resistance of fruit skin to gas permeability and reduced the respiration rate which was able to maintain a better taste. Due to highly perishable nature, guava fruits undergo rapid postharvest ripening in few days under ambient conditions (Hashem and Alamri, 2009) [12]. The fruit ripening in guava is characterized by loss of green colour, softening, shrinkage, loss of brightness and rot development (Ali and Lazan, 1997) [3]. The postharvest 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) [11]. 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 [8]; Elizabeth *et al*., 1995) [9]. They act as barriers to moisture and oxygen during handling (Olivas *et al*., 2005) [26] 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) [20]. 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 functional and sensory 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 fruits. Selected uniform size fruits were washed in running tap water and dried in shade for few minutes. Coatings of required concentrations of calcium chloride, chitosan, sodium alginate and *Aloe vera* gel (purchased from HiMedia, Mumbai) were prepared for surface treatment of guava fruits. Twenty fruits were dipped in each solution for 10 minutes and then air dried. The trial was carried out in three replicates.

Calcium chloride coating

Calcium chloride 1%, 1.5% and 2% (w/v) solution was prepared by dissolving 1, 1.5 and 2 grams 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) [36]. 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) [29]. 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) [28] 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 100°C 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 85°C for 1 minute. After pasteurization, the gel was quickly cooled to 5°C or below. Finally, the *Aloe vera* gel was filled into pre-sterilized, opaque glass bottles for storage in a chiller at 5°C 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. 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 (27-29°C and 70-75% RH).

Functional attributes

Enzyme activity (Superoxide dismutase activity (Units/g Fruit weight))

SOD activity was determined by measurement of inhibition of photochemical reduction of nitro blue tetrazolium (NBT) at 560 nm (Giannopolitis and Ries, 1977) [10]. The 3 ml reaction mixture contained 50 mmol/L phosphate buffer (pH=7.8), 0.1 mmolg/L Ethylene diaminetetra-acetic-acid (EDTA), 13 mmol/L methionine, 75 µmol/L NBT, 16.7 µmol/L riboflavin and enzyme extract. Riboflavin was added at last and the reaction was initiated by placing the tubes under two 9 watt fluorescent lamps. The reaction was determined after 15 minutes by removal from the light source. An illuminated blank without protein gave the maximum reduction of NBT, therefore, the maximum absorbance was at 560 nm. SOD activity is present as absorbance of sample divided by absorbance for blank, giving the percentage of inhibition.

One unit of SOD activity was defined as the amount of enzyme required for the inhibition of the photochemical reduction of NBT by 50%.

SOD (Units/g) = [(V/v) – 1] × D.F.

Where, v = Absorbance at 5 minutes
V = Absorbance at 15 minutes
D.F. = Dilution factor

Total Flavonoids content (mg Catechin/100 g Fresh weight)

Total flavonoids content was estimated using aluminium chloride method (Zhishen *et al*., 1999) [41]. 1 ml of guava extract in methanol was taken in 4 ml of distilled water, 0.3 ml of 5% sodium nitrite ($NaNO_2$) and 0.3 ml of 10% aluminium chloride ($AlCl_3 \cdot 6H_2O$). The mixture was allowed to stand for 6 minutes at room temperature. Then, after adding 2 ml of 1 N NaOH, the solution was diluted to 10 ml with distilled water. Finally, the absorbance of the solution was recorded at 510 nm in a spectrophotometer against a reagent blank. The results were expressed µg catechin equivalent/ 100g Fresh weight.

$$\text{Total flavonoids content} = \frac{OD_{510} \times \text{Volume made up (with 80\% ethanol)} \times 100}{\text{Aliquot taken} \times \text{weight of sample} \times 1000}$$

Total Phenolics content (mg GAE/100 g Fresh weight)

Total phenolics content in the edible portion of fruit was determined using Folin-Ciocalteu reagent (Singleton *et al*., 1999) [32]. 2.9 ml of distilled water, 0.5 ml of Folin-Ciocalteu reagent and 2.0 ml of 20% Na_2CO_3 solution was added to 100 µl of sample extract (in 80% ethanol). Mixture was allowed to stand for 90 minutes and absorbance was recorded in a spectrophotometer at 760 nm wavelength. The total phenolic content was expressed in microgram of gallic acid equivalent per gram of fresh weight (mg/100 g Fresh weight).

$$\text{Total phenol content} = \frac{OD_{760} \times \text{Volume made up (with 80\% ethanol)} \times 100}{\text{Aliquot taken} \times \text{weight of sample} \times 1000}$$

Total Antioxidants capacity (µmol. trolex eq. /100 g Fresh weight)

Total antioxidants capacity was determined following CUPRAC (Cupric reducing antioxidant capacity) assay (Apak *et al*., 2008) [4]. 0.1 ml of sample extract (in 80% ethanol) was added to 1 ml each of copper (II) chloride solution, neocuproine solution, ammonium acetate buffer solution and distilled water in a test tube. The mixture was then allowed to stand for 30 minutes and the absorbance was recorded at 450 nm in a spectrophotometer. The results were expressed as µmol. trolex equivalent/ 100 g Fresh weight.

$$\text{Total antioxidant capacity} = \frac{OD_{450} \times 4.1 \times \text{Volume made up}}{\text{Weight of sample} \times 1.67 \times 1000 \times 0.1}$$

Organoleptic evaluation

Guava samples were selected randomly and evaluated for their sensory characteristics such as appearance, colour, flavour, texture, taste and overall acceptability, using a semi-trained sensory panel consisting of 10 judges. The evaluation was taken at every 2 days interval. The judges were requested to record their degree of liking and disliking on a sensory score card using 9 point Hedonic scale ranging from 1 to 9 which represents from like extremely to dislike extremely. Data were expressed as the mean of all scores.

Statistical analysis

The data were analyzed according to the procedure for analysis of two factorial completely randomized design as given by Snedecor and Cochran (1987) [33]. 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

Enzyme activity (Superoxide dismutase activity)

Treatments exerted a significant influence on fruit superoxide dismutase activity (Table 1). Maximum superoxide dismutase activity (69.48) was recorded in chitosan 1.5% (T_6) followed by (69.41) in *Aloe vera* 1:1 (T_{10}) and minimum (62.70) was recorded in control (T_{13}) followed by (63.86) in calcium chloride 2.0% (T_3). Storage days affected fruit superoxide dismutase activity significantly which increased gradually upto 3rd day and finally decreased irrespective of the treatment as the storage period progressed. To control the level of reactive oxygen species (ROS) and to protect cells under stress conditions, plant tissues contain several enzymes scavenging reactive oxygen species including superoxide dismutase, catalase, peroxidase *etc*. Superoxide dismutase is an important enzymes in such action and it can protect cells from oxidant stress by dismutating super oxide anion (O_2) to H_2O_2. Previous studies have indicated that chitosan could induce hosts to increase antioxidative activity. Zeng *et al*. (2010) [39] reported that the activity of superoxide dismutase in navel orange fruit was induced by chitosan. In this study, the activity of superoxide dismutase in chitosan treated fruit were induced during storage. Furthermore, the activity of reactive oxygen species-interacting enzyme (superoxide dismutase) in guava fruit was also enhanced by chitosan coating which might scavenge excessive reactive oxygen species and protect the tissues from injury.

Total Flavonoids content

Treatments exerted a significant influence on fruit total flavonoids content (Table 1). Maximum fruit flavonoids content (89.64) was recorded in *Aloe vera* 1:1 (T_{10}) which was statistically *at par with* (87.27) in calcium chloride 2.0% (T_3) and (88.24) in chitosan 1.5% (T_6) and minimum (65.20) was recorded in calcium chloride 1.0% (T_1). Storage day's affected total flavonoids content of guava significantly flavonoids content in fruits was found to decline gradually during storage irrespective of treatments. The loss of total flavonoids content in treated fruits occurred more slowly. Flavonoids the secondary plant phenolic compounds have significant antioxidant and chelating properties. It has numerous beneficial effects on human body such as anti-inflammatory, antimicrobial activities, inhibition of platelet aggregation and inhibition of mast cell histamine release (Koley *et al*., 2011) [17]. Slower reduction of total flavonoids in *Aloe vera* and chitosan treated fruits than control might be attributed to antisenescence properties of *Aloe vera* and chitosan (Wisniewska and Chelcowski, 1999) [38]. Similar results were also reported in litchi and asparagus by Zhang and Quantick (1997) [40] and Wei *et al*. (2011) [37], respectively.

Total Phenolics content

Treatments exerted a significant influence on fruit total phenolics content (Table 2). Maximum fruit total phenolics content (333.35) was recorded in chitosan 1.5% (T_6) followed by (331.64) in sodium alginate 0.5% (T_7) and minimum (265.92) was recorded in calcium chloride 1.0% (T_1) followed by (304.95) in sodium alginate 1.5% (T_9). Storage days affected total phenolic content of guava significantly which decreased gradually irrespective of the treatment as the storage period progressed. Control fruits showed faster decrease in total phenolics than other treatments. This may be ascribed to higher activity of polyphenol oxidase and peroxidase enzymes in control fruits which caused rapid decrease in total phenolics in fruit. On the contrary, higher retention of phenolics in chitosan treated fruits might be due to lower activities of polyphenol oxidase and peroxidase enzymes, there by delaying oxidation of phenolic compounds. Furthermore, due to formation of protective chitosan layer over the fruit surface, there was less moisture loss from the fruit which reduced the loss of compartmentation between polyphenol oxidase and peroxidase enzymes and phenolic compounds present in the vacuole there by decreased its breakdown Awad and De Jager (2000) [6]. This finding is in accordance with the previous findings of Peng and Jiang

(2006) [27] in Chinese water chestnut, Lu *et al*. (2011) [18] in pineapple, Jiang and Li (2001) [16] in longan and Sun *et al*. (2010) [34] in litchi who also reported that application of chitosan maintained higher phenolics content in fruits during storage by reducing polyphenol oxidase activity.

Total Antioxidants capacity

Treatments exerted a significant influence on total antioxidants capacity (Table 2). Maximum fruit antioxidants capacity (684.27) was recorded in *Aloe vera* 1:1 (T_{10}) followed by (679.96) in sodium alginate 1.5% (T_9) and minimum (635.11) was recorded in calcium chloride 1.0% (T_1) followed by (649.42) in calcium chloride 1.5% (T_2). Storage days affected fruit total antioxidants capacity significantly which decreased gradually irrespective of the treatment as the storage period progressed. Antioxidant capacity of fruit is contributed by several bioactive compounds like phenolics, flavonoids, ascorbic acid and so on. In the present study, *Aloe vera* and chitosan treated fruits maintained significantly higher total antioxidant capacity compared to control. This was attributed to higher content of phenolics, flavonoids and ascorbic acid in the treated fruits, owing to delayed senescence. Antioxidant contributing property of phenolic compounds and ascorbic acid has also been reported earlier in pomegranate Mirdehghan *et al*. (2007) [24], sweet cherry Serrano *et al*. (2005) [30] and mango Asrey *et al*. (2013) [5].

Table 1: Effect of different edible coatings and their concentrations on Enzyme activity and Total Flavonoids content of fruit.

Treatments	Superoxide dismutase activity (units/g Fruit weight)						Total flavonoids content (mg/100 g fresh weight)					
	Days after treatments						Days after treatments					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	64.48	68.35	65.22	62.04	60.09	64.04	110.80	66.13	61.47	50.00	37.60	65.20
T_2 Calcium chloride 1.5%	65.32	69.09	65.27	62.20	60.00	64.38	110.80	86.40	76.20	65.40	43.60	76.48
T_3 Calcium chloride 2.0%	65.04	68.83	65.00	61.33	59.09	63.86	110.80	87.60	82.40	80.53	75.00	87.27
T_4 Chitosan 0.5%	64.71	70.05	67.05	65.07	63.09	65.99	110.80	100.60	82.40	58.80	56.00	81.72
T_5 Chitosan 1.0%	65.19	70.33	68.06	67.13	66.09	67.36	110.80	95.40	76.80	72.40	55.60	82.20
T_6 Chitosan 1.5%	65.30	75.01	72.04	68.02	67.02	69.48	110.80	100.00	87.20	72.80	70.40	88.24
T_7 Sodium alginate 0.5%	64.93	70.05	68.32	65.10	64.16	66.51	110.80	97.87	75.20	71.80	53.60	81.85
T_8 Sodium alginate 1.0%	65.08	71.11	69.15	67.11	66.07	67.70	110.80	94.73	88.60	72.67	58.40	85.04
T_9 Sodium alginate 1.5%	64.05	71.18	68.15	66.08	65.10	66.91	110.80	100.00	86.20	76.60	57.60	86.24
T_{10} *Aloe vera* 1:1	65.69	73.89	71.70	69.23	66.55	69.41	110.80	100.00	95.60	75.20	66.60	89.64
T_{11} *Aloe vera* 1:2	64.55	71.06	68.16	65.07	63.07	66.38	110.80	89.40	72.40	51.40	36.80	72.16
T_{12} *Aloe vera* 1:3	64.35	69.07	67.08	66.05	64.07	66.13	110.80	108.00	102.40	64.00	60.40	89.12
T_{13} Control	65.08	67.13	64.18	60.05	57.08	62.70	110.80	104.00	98.40	73.20	45.73	86.43
Factors	CD at 5%		SE(m)				CD at 5%		SE(m)			
Storage Intervals (S)	0.167		0.060				1.924		1.924			
Treatments (T)	0.270		0.096				3.102		3.102			
Interaction (S × T)	0.603		0.215				6.937		6.937			

Table 2: Effect of different edible coatings and their concentrations on Total phenolics content and Total Antioxidants capacity of fruit.

Treatments	Total phenolics content (mg GAE/100 g Fresh weight)						Total Antioxidants capacity (µmol. TE/100 g Fresh weight)					
	Days after treatments						Days after treatments					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	389.40	300.13	238.80	205.60	195.67	265.92	691.90	690.46	689.88	688.41	414.91	635.11
T_2 Calcium chloride 1.5%	389.40	380.20	304.40	294.33	280.67	329.80	691.90	691.35	690.46	685.00	488.40	649.42
T_3 Calcium chloride 2.0%	389.40	354.80	342.80	285.20	245.73	323.59	691.90	685.00	678.00	673.00	671.22	679.82
T_4 Chitosan 0.5%	389.40	384.87	328.00	227.20	206.93	307.28	691.90	682.00	676.33	675.00	651.25	675.30
T_5 Chitosan 1.0%	389.40	344.00	340.40	269.27	255.40	319.69	691.90	688.00	685.00	680.00	637.50	676.48
T_6 Chitosan 1.5%	389.40	363.26	351.20	292.67	270.20	333.35	691.90	691.19	683.00	681.33	641.43	677.77
T_7 Sodium alginate 0.5%	389.40	384.00	353.80	285.00	246.00	331.64	691.90	685.00	682.00	678.00	660.75	679.53
T_8 Sodium alginate 1.0%	389.40	352.52	280.40	278.60	260.33	312.25	691.90	683.67	680.33	675.00	661.89	678.56
T_9 Sodium alginate 1.5%	389.40	316.80	284.40	283.53	250.60	304.95	691.90	684.00	682.00	680.00	661.89	679.96
T_{10} *Aloe vera* 1:1	389.40	347.00	326.00	304.67	244.93	322.40	691.90	690.70	690.26	686.44	662.06	684.27
T_{11} *Aloe vera* 1:2	389.40	382.27	364.27	245.20	234.60	323.15	691.90	690.46	688.24	684.97	640.94	679.30
T_{12} *Aloe vera* 1:3	389.40	354.40	335.00	330.40	217.60	325.36	691.90	683.00	679.67	671.00	664.00	677.91
T_{13} Control	389.40	380.20	330.40	227.67	205.60	306.65	691.90	682.00	671.00	661.00	652.00	671.58
Factors	CD at 5%		SE(m)				CD at 5%		SE(m)			
Storage Intervals (S)	1.924		1.924				6.456		2.305			
Treatments (T)	3.102		3.102				10.411		3.717			
Interaction (S × T)	6.937		6.937				23.279		8.310			

Fruit appearance

Treatments exerted a significant influence on fruit appearance (Table 3). Maximum appearance score (8.32) was recorded in chitosan 1.5% (T_6) followed by (8.15) in *Aloe vera* 1:1 (T_{10}) and minimum (4.90) was recorded in control (T_{13}) followed by (5.53) in calcium chloride 1.0% (T_1). Storage days affected appearance significantly which decreased gradually irrespective of the treatment as the storage period progressed. Maximum appearance acceptability of fruits (8.53, 8.33, 8.30 and 8.10) was retained after 3, 6, 9 and 12 days of storage period, respectively under chitosan 1.5% without any objectionable changes in appearance followed by *Aloe vera* 1:1. Chitosan 1.5% and *Aloe vera* 1:1 was found more acceptable as both maintain the cosmetic appearance of fruits.

Both treatments helped in delaying the ripening and maintained uniform colour in fruits in later storage periods. Mahajan *et al*. (2005) [19] also reported the similar findings in kinnow fruits. These results also confirm the findings of Jagdeesh *et al*. (2001) [15] in guava fruits. Minimum acceptability of appearance was observed under control treatment followed by calcium chloride 1.0% coating application which may be due to development of dark coloured spots on skin and softening of tissues.

Fruit colour

Treatments exerted a significant influence on fruit colour (Table 3). Maximum fruit colour score (8.22) was noted in *Aloe vera* 1:1 (T_{10}) followed by (8.19) in chitosan 1.5% (T_6) and minimum (5.47) was recorded in control (T_{13}) followed by (5.59) in calcium chloride 1.0% (T_1). Storage days affected fruit colour significantly which decreased gradually irrespective of the treatment as the storage period progressed. Treatments did not alter guava colour and the greater acceptance for coated fruit could be due to the glossy appearance imparted by the coating. *Aloe vera* and chitosan coating imparted glossiness in the fruits while there was no glossiness imparted in control fruits. These findings are supported by the findings of Hernandez-Munoz *et al*. (2008) [13] in strawberry. The modified atmosphere created by the both coating material retarded the ethylene production rate. Therefore, delaying ripening, chlorophyll degradation, anthocyanin accumulation and carotenoid synthesis thus ultimately delaying color change of fruits. The above results are supported by the findings of Brishti *et al*. (2013) [7] and Tripathi and Dubey (2004) [35] who found better retention in colour when papaya fruits were treated with *Aloe vera* gel (100%). *Aloe vera* coating imparted an attractive natural-looking sheen to table grapes, papaya which was correlated to lower changes in both skin color and dehydration.

Table 3: Effect of different edible coatings and their concentrations on Fruit appearance and Fruit colour.

Treatments	Fruit appearance					Fruit colour				
	Days after treatments					Days after treatments				
	3	6	9	12	Mean	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	6.51	6.16	5.36	4.10	5.53	6.80	6.19	5.28	4.10	5.59
T_2 Calcium chloride 1.5%	6.96	6.23	5.83	5.00	6.01	6.92	6.65	6.37	5.07	6.25
T_3 Calcium chloride 2.0%	6.86	6.08	5.93	4.30	5.79	7.10	7.00	6.53	4.90	6.38
T_4 Chitosan 0.5%	7.51	7.45	7.07	5.43	6.87	7.63	7.27	7.00	5.53	6.86
T_5 Chitosan 1.0%	8.47	8.01	7.99	7.67	8.04	7.93	7.70	7.68	7.63	7.74
T_6 Chitosan 1.5%	8.53	8.33	8.30	8.10	8.32	8.40	8.21	8.10	8.04	8.19
T_7 Sodium alginate 0.5%	7.40	7.27	7.20	5.20	6.77	7.75	7.72	7.67	5.23	7.09
T_8 Sodium alginate 1.0%	7.77	7.66	7.46	7.23	7.53	8.14	8.00	7.83	7.33	7.83
T_9 Sodium alginate 1.5%	8.00	7.91	7.49	7.46	7.72	8.32	8.11	8.03	7.07	7.88
T_{10} *Aloe vera* 1:1	8.46	8.44	8.20	7.50	8.15	8.47	8.34	8.23	7.83	8.22
T_{11} *Aloe vera* 1:2	7.42	7.35	7.30	5.67	6.93	7.30	6.92	6.52	5.63	6.59
T_{12} *Aloe vera* 1:3	7.21	6.80	6.07	3.50	5.90	6.86	6.83	5.63	3.93	5.81
T_{13} Control	6.07	5.40	5.04	3.10	4.90	6.10	6.04	5.51	4.21	5.47
Factors	CD at 5%		SE(m)			CD at 5%		SE(m)		
Storage Intervals (S)	0.034		0.012			0.026		0.009		
Treatments (T)	0.062		0.022			0.047		0.017		
Interaction (S × T)	0.123		0.044			0.095		0.034		

Fruit flavour

Treatments exerted a significant influence on flavour (Table 4). Maximum organoleptic value for flavour of fruits (8.21) was recorded under chitosan 1.5% (T_6) followed by (8.08) in *Aloe vera* 1:1 (T_{10}) and minimum (5.42) was recorded in control (T_{13}) followed by (5.89) in calcium chloride 2.0% (T_3). Storage days affected flavour significantly which deteriorate gradually irrespective of the treatment as the storage period advance upto 12 days. The best aroma score was recorded under chitosan 1.5% followed by *Aloe vera* 1:1 coating. It seemed that the biochemical changes were slower and conversion of organic compounds into smaller compounds like esters, aldehydes, acids, alcohols and ketones did not take place that contributed significantly to flavor and aroma of the fruits. Whereas in control, flavor and aroma score were lowest than treated guava fruits and started spoiling. It might be due to the production of volatile compounds and due to fluctuations in acids, pH and sugar/acid ratio. Guava fruits without chitosan coating did not develop flavor while chitosan coated fruits showed best results significantly. Desirable flavors may be produced by loss of organic acids during senescence. It might be due to the change in carbohydrates, proteins, amino acids, lipids and phenolic compounds that can influence the flavor of fresh fruits. These results are supported by the findings of Ibrahim *et al*. (2014) [14] in pineapple.

Fruit texture

Treatments exerted a significant influence on fruit texture (Table 4). Maximum fruit texture score (8.28) was recorded in chitosan 1.5% (T_6) followed by (8.17) in *Aloe vera* 1:1 (T_{10}) and minimum (5.24) was recorded in control (T_{13}) followed by (6.04) in calcium chloride 2.0% (T_3). Storage days affected fruit texture significantly which decreased gradually, irrespective of the treatment as the storage period progressed. The retention of fruit texture with chitosan coating is similar with the result of Ali *et al*. (2011) [1] where papayas treated with 2.0% chitosan coating were better in texture than the other treatments during cold storage. In this study, fruit softening was reduced with chitosan and the control fruit lost their textural integrity faster than fruit coated chitosan. Fruit softening is due to deterioration in the cell structure, the cell wall composition and the intracellular materials Seymour *et al*. (1993) [31]. The maintenance of textural integrity in the guavas treated with chitosan coatings could be due to their higher antifungal activity and covering of the cuticle and lenticels, thereby reducing infection, respiration and other ripening processes during storage, according to previous reports in papaya and sweet cherry coated with chitosan and *Aloe vera* gel (Ali *et al*., 2005 [2]; Martinez- Romero *et al*., 2006) [22].

Table 4: Effect of different edible coatings and their concentrations on Fruit flavour and Fruit texture.

Treatments	Fruit flavour					Fruit texture				
	Days after treatments					Days after treatments				
	3	6	9	12	Mean	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	7.37	6.60	6.50	4.50	6.24	7.37	6.60	6.10	4.20	6.07
T_2 Calcium chloride 1.5%	7.37	6.64	6.25	4.47	6.18	7.17	6.77	6.23	4.53	6.18
T_3 Calcium chloride 2.0%	6.87	6.60	6.04	4.03	5.89	7.07	6.63	6.10	4.37	6.04
T_4 Chitosan 0.5%	7.55	7.38	7.29	5.03	6.81	7.51	7.42	7.20	5.00	6.78
T_5 Chitosan 1.0%	7.57	7.53	7.49	6.30	7.22	7.89	7.61	7.41	6.30	7.30
T_6 Chitosan 1.5%	8.33	8.21	8.17	8.13	8.21	8.37	8.30	8.26	8.21	8.28
T_7 Sodium alginate 0.5%	7.83	7.53	7.41	5.10	6.97	7.40	7.35	7.23	4.93	6.73
T_8 Sodium alginate 1.0%	8.05	7.96	7.66	7.43	7.78	7.80	7.60	7.54	7.40	7.59
T_9 Sodium alginate 1.5%	8.13	8.03	7.73	7.13	7.76	8.37	8.00	7.73	7.23	7.83
T_{10} *Aloe vera* 1:1	8.36	8.34	8.10	7.53	8.08	8.46	8.33	8.10	7.80	8.17
T_{11} *Aloe vera* 1:2	8.12	7.53	7.13	4.93	6.93	7.30	7.30	7.23	5.30	6.78
T_{12} *Aloe vera* 1:3	7.90	7.64	5.63	5.17	6.59	7.11	7.10	6.71	5.33	6.56
T_{13} Control	7.79	6.60	5.10	2.20	5.42	6.90	6.11	5.56	2.40	5.24
Factors	CD at 5%		SE(m)			CD at 5%		SE(m)		
Storage Intervals (S)	0.043		0.015			0.038		0.013		
Treatments (T)	0.077		0.027			0.068		0.024		
Interaction (S × T)	0.153		0.055			0.136		0.048		

Fruit taste

Treatments exerted a significant influence on fruit taste (Table 5). Maximum fruit taste score (8.19) was noted in *Aloe vera* 1:1 (T_{10}) followed by (7.99) chitosan 1.5% (T_6) and minimum (5.22) was recorded in control (T_{13}) followed by (6.15) calcium chloride 1.0% (T_1). Storage days affected fruit taste significantly which decreased gradually, irrespective of the treatment as the storage period progressed. The results showed that fruit taste decreased significantly. It might be due to fluctuations in acids, pH and sugar/acid ratio. Chitosan coating maintained taste and retained the quality of fruit during storage. Besides, chitosan retained fruit quality and no off flavor was developed than control sample. These results are supported by the findings of Jiang and Li (2001) [16] who reported that chitosan treated longan fruit had good eating quality even after 30 days of storage at 2°C. These results tally with Munoz *et al*. (2006) [25] who reported the influence of the chitosan on strawberries stored at 20°C for 4 days showing better maintenance of eating quality. Guava fruits treated with *Aloe vera* gel were able to maintain good taste as ethylene production was reduced in coated fruits which was due to reduction in ripening process created by modified atmosphere. Surface coating has been reported to increase resistance of fruit skin to gas permeability and reducing the respiration rate which was able to maintain a better taste. The above results are supported by the findings of Marpudi *et al*. (2011) [21] in *Aloe vera* gel coated papaya fruits.

Overall acceptability

Treatments exerted a significant influence on fruit overall acceptability (Table 5). Maximum fruit overall acceptability score (8.18) was recorded in *Aloe vera* 1:1 (T_{10}) followed by (8.16) in chitosan 1.5% (T_6) and minimum (4.84) was recorded in control (T_{13}) followed by (5.76) in *Aloe vera* 1:3 (T_{12}). Storage days affected fruit overall acceptability significantly which decreased gradually irrespective of the treatment as the storage period advanced. The overall acceptability of *Aloe vera* coated guava fruits was best as compared to control. *Aloe vera* coated guava fruits has greater retention of bright green colour than the uncoated fruits, which means ripening has delayed in coated fruits. *Aloe vera* coated guava fruits were slightly soft at the end of the storage whereas control fruits already damaged. During storage period the judging panel found that flavor was satisfactory in *Aloe vera* coated guava fruits. *Aloe vera* coated guava fruits looked shiny and attractive. The coated fruits did not produce any bad odor or off-flavor. According to the judging panel, guava fruit coated with *Aloe vera* gel had a better appearance than the control fruits. Control guava fruits showed severe symptoms of dehydration during storage periods. None of the judges detected the appearance of off-flavors or aromas in guava coated with *Aloe vera* gel. These results are supported by the findings of Brishti *et al*. (2013) [7], Tripathi and Dubey (2004) [35] and Martinez-Romero *et al*. (2006) [22] in papaya, grapes and cherry fruits, respectively.

Table 5: Effect of different edible coatings and their concentrations on Fruit taste and Overall acceptability.

Treatments	Fruit taste					Overall acceptability				
	Days after treatments					Days after treatments				
	3	6	9	12	Mean	3	6	9	12	Mean
T_1 Calcium chloride 1.0%	7.17	6.63	6.56	4.23	6.15	6.73	6.63	6.32	4.13	5.95
T_2 Calcium chloride 1.5%	7.40	6.72	6.60	4.47	6.30	6.81	6.73	6.60	4.33	6.12
T_3 Calcium chloride 2.0%	7.13	6.82	6.80	4.10	6.21	6.97	6.93	6.83	4.10	6.21
T_4 Chitosan 0.5%	7.53	7.30	7.04	4.93	6.70	7.53	7.13	7.07	6.23	6.99
T_5 Chitosan 1.0%	7.70	7.53	7.24	6.73	7.30	7.73	7.63	7.53	7.23	7.53
T_6 Chitosan 1.5%	8.40	8.11	8.03	7.43	7.99	8.30	8.24	8.13	7.97	8.16
T_7 Sodium alginate 0.5%	7.50	7.10	7.07	5.23	6.73	7.76	7.53	7.41	5.10	6.95
T_8 Sodium alginate 1.0%	7.90	7.71	7.41	6.43	7.36	8.06	8.01	7.97	6.37	7.60
T_9 Sodium alginate 1.5%	8.30	7.83	7.60	6.63	7.59	8.40	7.93	7.83	6.73	7.73
T_{10} *Aloe vera* 1:1	8.40	8.33	8.20	7.83	8.19	8.47	8.23	8.18	7.83	8.18
T_{11} *Aloe vera* 1:2	7.70	7.33	7.05	5.47	6.89	7.57	7.44	7.40	4.33	6.68
T_{12} *Aloe vera* 1:3	7.42	7.21	6.80	5.53	6.74	6.46	6.39	6.07	4.10	5.76
T_{13} Control	7.16	6.24	4.91	2.57	5.22	6.53	6.48	4.21	2.13	4.84

Factors	CD at 5%	SE(m)	CD at 5%	SE(m)
Storage Intervals (S)	0.034	0.012	0.026	0.009
Treatments (T)	0.061	0.022	0.047	0.017
Interaction (S × T)	0.123	0.044	0.094	0.034

Conclusion

It was concluded that the coating of chitosan (1.5%) followed by *Aloe vera* 1:1 gel was effective in maintaining quality of guava fruits. The fruits retained desirable texture and postharvest quality till the end of their storage life in both treatments. However, *Aloe vera* 1:1 gel coating can be integrated into the supply chain management of guava fruits due to its easy availability and low price to extend storage life, marketability and maintaining quality during transport and storage under ambient conditions.

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