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Arabic-gum based edible coatings preserving the post-harvest quality of Guava fruits

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ABSTRACT: Guava fruits, being climacteric, tend to be rapidly perishable due to their high respiration rate and consequently ripen faster after harvesting. Therefore, to maintain their physiological and metabolic activities, freshly harvested green mature guava fruits were surface-coated with 10% arabic gum alone, with 2% calcium chloride as a texture enhancer, and with 1% hydrogen peroxide as a biocide. All the treated fruits, including the control, were kept at ambient storage temperature. It was observed that most coating formulations significantly improved various postharvest quality characteristics compared with untreated control fruits over a 15-day storage period. Among treatments, 10% arabic gum incorporated with both 2% calcium chloride and 1% hydrogen peroxide was found to be more effective in reducing the rate of weight loss, decay, and firmness, while also maintaining levels of total soluble solids, ascorbic acid, carotenoids, and organoleptic attributes during storage. As a result, it was revealed that the composite coating formulation of 10% arabic gum incorporated with 2% calcium chloride and 1% hydrogen peroxide performed best as compared to other coated treatments and could be used in delaying the ripening, maintaining the quality, and extending the shelf life of guava fruits by about three times as compared to uncoated control fruits.

Keywords: Calcium chloride, Coatings, Guava, Gum Arabic, Hydrogen peroxide, Postharvest quality

Guava (*Psidium guajava*L.), a tropical plant, belongs to the family *Myrtaceae*. Guava tree possesses wide adaptability to various soils and climates which favor it to adapt from tropical to sub-tropical regions. It originated in the southern part of Mexico and Central America (Kumari *et al*., 2017). Due to inappropriate handling, transportation and processing, 20 – 25% of guava fruits are spoiled before reaching the consumer. It is considered one of the richest sources of vitamin C. Owing to its nutritional composition, it is rich in dietary fibres, vitamin A and C, folic acid, minerals such as potassium, copper, manganese, etc (Prabhudesai *et al*., 2019).

Guava fruit being climacteric remains metabolically active even after harvest and considered as most perishable fruit. The continuous respiration and transpiration led to the decline of essential nutrients. Factors such as ethylene production, chilling injury and microbial spoilage accelerate weight loss, textural degradation, and decay, leading to the loss of vital compounds such as sugars, phenols, amino acids, proteins, flavonoids and ascorbic acid which adversely effects its nutritional and sensory qualities (Feng *et al*., 2021). These physiological changes contribute to guava's short post-harvest shelf life of only 3-4 days at room temperature whereas in cold storage, the shelf life can be extended up to two weeks at 6–8 °C and 90–95% RH. Moreover, refrigeration often worsens chilling injury and accelerates deterioration (Murmu and Mishra, 2017). Various innovations in postharvest technologies of horticultural produce have been made in the last two decades to enhance the shelf life of fruits. Among such methods involve the use of edible substances as surface coating of fruits by replacing the use of chemical surface treatment for extending shelf life of fruits (Salehi, 2020). Nawab *et al*. (2017) revealed that the coatings form a semi-permeable barrier to gas exchange and water vapor, results in alteration of respiration rate, reduction of weight loss, and delay of senescence.

Gum Arabic is one of the most widely used edible film material due to its superior biocompatibility and lack of toxicity. It is a polysaccharide naturally obtained from branches and stems of *Acacia* species and is used extensively in the industrial sector because of its emulsification, film forming and encapsulation properties (Motlagh *et al*., 2006).

Furthermore, some functional ingredients such as texture enhancers, antioxidants and antimicrobials can be incorporated into an edible matrix and applied on the surface of foods, thus enhancing safety or even nutritional and sensory attributes (Mitelut *et al.,* 2021).

Texture enhancers like calcium chloride may be added to the edible coating to minimize softening during the storage of fresh fruits and vegetables. Calcium treatment is a safe treatment that effectively delays fruit ripening and senescence, reduces the incidence of physiological and pathological diseases, regulate enzyme activity and the senescence-related metabolism. Hydrogen peroxide is a firm oxidizing agent and has bacteriostatic and bactericidal effects. Commonly it is recognized to be a safe agent. Moreover, it can be used in food industries for antimicrobial and bleaching purposes (Code of Federal Regulations, 2007). Therefore, study was conducted to assess the efficacy of Arabic gum-based composite coatings in extending the postharvest quality and shelf life of guava fruits.

MATERIALS AND METHODS

Experimental site and materials procurement

Physiologically mature winter season fruits of the guava cultivar 'Pant Prabhat' were harvested from the orchard located at the Horticulture Research Center in Patharchatta, Pantnagar and immediately brought to the postharvest laboratory, Department of Horticulture, G. B. Pant University of Agriculture and Technology in Pantnagar, Uttarakhand for further studies. Fruits were precooled, and then graded for uniformity in size, and any diseased, blemished, or non-uniform fruits were discarded. Acacia gum powder (gum arabic), calcium chloride, and hydrogen peroxide were purchased from Loba Chemie Pvt Ltd, Mumbai, India.

Edible coating preparation

Ten grams of gum Arabic (GA) was dissolved in 100 ml of distilled water to prepare a 10% gum Arabic coating. The mixture was then heated on a hot plate magnetic stirrer at 70°C until a clear, lump-free solution was achieved. After cooling to room temperature, 2% calcium chloride ($CaCl_2$) and 1% hydrogen peroxide (H_2O_2) were added according to the coating formulation to prepare the final coating solution. Four coating treatments were formulated: T_1 (10% GA), T_2 (10% GA + 2% $CaCl_2$), T_3 (10% GA + 1% H_2O_2), and T_4 (10% GA + 2% $CaCl_2$ + 1% H_2O_2). The fifth treatment consisted of untreated fruits that were dipped only in distilled water.

Coating application

Fruits were randomly divided into five groups, with each group having 24 fruits. Each treatment group has three replications having eight fruits each. Four of the groups were treated according to specific coating formulations, while the fifth group was only dipped in distilled water, serving as the control. The fruits were dipped for one minute, then removed and allowed to dry completely with the aid of an air fan. They were subsequently stored on open shelves at ambient room condition ranging from 15 to 21°C and relative humidity levels of 40 to 55%.

Periodic evaluation of traits

The experiment was designed as a two-factor completely randomized design with three replications. The first factor consisted of five treatments, while the second factor included six storage intervals: 0, 3, 6, 9, 12, and 15 days. The analysis of the fruits was conducted at three-day intervals, measuring weight loss, decay, firmness, total soluble solids, acidity, ascorbic acid, total sugars, total carotenoids, and organoleptic quality characteristics.

Determination of physico-chemical and functional quality attributes

Weight loss of both treated and untreated fruits was determined initially on zero day and then at specific intervals for each treatment and the results are expressed as percentage of weight loss at every interval compared to initial fresh weight of zero day of harvest. On the basis of number of fruits spoiled (unfit for human consumption) at every five days interval, the percentage decay was worked out and the spoiled fruits were removed. The firmness of both treated and untreated fruits was determined using a hand-held penetrometer fitted with a 2mm dia conical probe after peeling the surface on at least two sides of each fruit and values are presented as kg/cm^2.

TSS was recorded by using digital hand refractometer at room temperature and expressed in terms of degree brix. Titratable acidity in terms of citric acid was determined by titrating the juice with 0.1 N NaOH using phenolphthalein as an indicator. Ascorbic acid in terms of mg ascorbic acid/100g of juice and total sugars in percentage was determined as per the method described in Ranganna (1986). The total carotenoids content of fruit juice was determined using the AOAC method (1970). The results were expressed as mg of carotenoids per 100 grams of fresh weight (FW).

Organoleptic evaluation

The organoleptic characteristics of guava fruits, including appearance, texture, and taste were evaluated using a nine-point hedonic scale (Ranganna, 1986). Every third day, a fresh organoleptic evaluation was conducted by a panel of seven judges, consisting of faculty members and research scholars, who recorded their preferences. The data were reported as the mean scores from the hedonic scale, which ranged from 1 to 9.

Statistical analysis

The data were analyzed using the procedure for two-factorial completely randomized designs as described by Snedecor and Cochran (1987). The overall significance of difference among the treatments was tested, using critical difference (C.D.) at a 5% level of significance. After conducting the variance analysis, Tukey's multiple-comparison test was employed to identify significant differences between the treatments. The results are presented in tables.

RESULTS AND DISCUSSION

Weight loss (%)

The weight loss of fruits individually coated with Arabic gum and in combined with calcium chloride and hydrogen peroxide was significantly affected during ambient storage. The weight loss continued to increase considerably over the storage period, as shown in Table 1. Based on our results, guava fruits coated with 10% gum arabic, incorporating 2% calcium chloride and 1% hydrogen peroxide (T_4), experienced the lowest weight loss of 9.59% by the 15th day of ambient storage. In contrast, control uncoated fruits lost 13.41% of their weight within six days of storage. Fruits without coating showed almost twice the weight loss (17.08%) at the same ambient temperature during 15 days of storage. Except treatment T_4, fruits became rotten towards the end of the experiment due to significant activities of transpiration, respiration, and mould growth in all the samples. At the end of the 15-day storage period, guava fruits coated with Arabic gum, incorporating 2% calcium chloride as a texture enhancer and 1% hydrogen peroxide (T_4) as a biocide, recorded lower weight loss compared to the control.

Water loss primarily occurs through the fruit's surface and is driven by a combination of factors including temperature, humidity, air movement, and the fruit's internal physiological processes, and leading to dehydration and reduced fruit quality (Gidado *et al.,* 2024). In this study, less weight loss, especially in fruit coated with T_4 (10% GA + 2% $CaCl_2$ + 1% H_2O_2) was due to the synergistic effect of the composite coating where the 10% GA served as a semi permeable barrier against oxygen, carbon dioxide, and moisture, thus reducing respiration, transpiration, and oxidation process, 2% $CaCl_2$ maintainedthe firmness of fruits, while 1% H_2O_2 acted against the microbes and ultimately reduced decay incidence. Samra *et al.* (2014) and Oliveira *et al*. (2018) also observed similarly that a protective layer of edible coating on fruit skin helped in controlling transpiration, respiration, physical and microbial activities and consequently treated fruits had lower physiological loss in weight.

Per cent decay

The study revealed that only 25.20% of fruits were decayed in the treatment T_4 (10% gum Arabic + 2% calcium chloride + 1% hydrogen peroxide), compared to almost three times the decay (65.95%) in untreated control fruits at the end of the 15th day of storage. The decay continued to rise as the storage interval lengthened (Table 1). No fruit decay was observed in gum arabic composite-coated fruits incorporated with 2% calcium chloride and 1% hydrogen peroxide (T_4) until the 6th day of storage, while more than six percent of fruits in the uncoated control group had decayed by the same time. Our results suggest that the low decay rate observed in the T_4 treatment was due to the combined effects of gum arabic, calcium chloride, and hydrogen peroxide. This combination appears to delay physiological processes such as respiration and senescence, and also prevents fungal infection. Huang *et al*. (2021) also reported that the lowest decay rate was observed in the 12% GA-coated group, indicating that GA coating has a preventive effect on fungal infection. Bagheri *et al*. (2019) found that H_2O_2 treated plants have enzymatic activity higher than untreated plants. Chen *et al.* (2015) suggested that H_2O_2 treatment could be a viable alternative to conventional control of postharvest diseases and improvement of storage quality of horticultural products.

Fruit firmness (Kg/cm²)

The values of fruit firmness indicate a decreasing trend, which differs across treatments and storage periods, as depicted in Table 2. Loss of firmness is more noticeable in uncoated fruits than in coated treatments. With increasing storage interval, fruit firmness continued to decline significantly. On the 15th day of storage, gum arabic-based composite coatings treatment T_4 (10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide) retained the highest firmness of 1.78 kg/cm^2, while the lowest mean value of fruit firmness was recorded in the control at the end of storage (Table 2). Coated fruits maintained significantly higher firmness until 9 days of storage, while the rapid decline in firmness was observed in control fruits after 6 days of storage. Since the firmness of treated fruits was higher than that of control fruits, this indicates that the coating slowed the degradation of cell wall compounds through pectin hydrolysis. Gurjar *et al.* (2018) also observed a similar trend and reported that maximum firmness was observed in 10% gum arabic coated fruits followed by 5% gum arabic coated fruits, whereas minimum firmness was estimated in control guava fruits at the end of the storage. Inhibition of loss of firmness by edible coatings has been reported for various fruits,, including 10% GA in mango (Khaliq *et al.,* 2015) and a combined GA and chitosan treatment in banana (Maqbool *et al.,* 2010). So, coating treatment of 10% gum arabic when combined with calcium chloride as a texture enhancer and hydrogen peroxide as a biocide substance favored better retention of firmness than the control fruits due to the creation of a passive modified atmosphere around the fruit surface, and ultimately, degradation activities of the cell wall and pectic substances were reduced by the related enzymes.

Total soluble solids (ºBrix)

Effect of different coating treatments and storage intervals on TSS of guava fruits under ambient storage conditions is depicted in Table 2. Data indicated that Arabic gum coating alone (T_1) and in

Table 1: Effect of Arabic gum-based coatings on weight loss and decay of guava fruits during ambient storage. *Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at P<0.5, Where; GA= Gum Arabic

Quality attributes	Weight loss (%)					Mean	Decay (%)					
Coating treatments	Storage intervals (days)						Storage intervals (days)					Mean
	3	6	9	12	15		3	6	9	12	15	
T_1: 10% GA	4.82^{b}	9.79^{b}	9.79^{b}	14.49^{c}	15.35^{c}	9.60	0.00^{a}	5.95^{a}	22.33^{a}	32.27^{c}	39.95^{c}	16.75
T_2: 10% GA + 2% $CaCl_2$	4.65^{b}	7.66^{d}	7.66^{d}	15.12^{b}	16.58^{b}	9.23	0.00^{a}	6.24^{a}	22.57^{a}	35.71^{b}	58.93^{b}	20.57
T_3: 10% GA + 1% H_2O_2	4.06^{c}	8.11^{c}	8.11^{c}	12.41^{d}	13.56^{d}	8.09	0.00^{a}	4.22^{b}	20.36^{b}	31.41^{c}	38.12^{d}	15.68
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2	2.14^{d}	3.11^{e}	3.11^{e}	7.727^{e}	9.59^{e}	4.72	0.00^{a}	0^{c}	13.9^{c}	21.69^{d}	25.20^{e}	10.13
T_5: Control	5.35^{a}	13.41^{a}	13.41^{a}	15.83^{a}	17.08^{a}	11.04	0.00^{a}	6.32^{a}	23.00^{a}	37.84^{a}	65.95^{a}	22.18
Mean	4.20	8.41	11.06	13.11	14.43		0.00	4.54	20.43	31.78	45.63	

Table 2: Effect of Arabic gum-based coatings on firmness and total soluble solids in guava fruits during ambient storage.
[*] Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at P<0.5, Where; GA= Gum Arabic

Quality attributes	Firmness (Kg/cm^2)						Mean	Total Soluble Solids (ºBrix)						Mean
Coating treatments	Storage intervals (days)							Storage intervals (days)						
	0	3	6	9	12	15		0	3	6	9	12	15	
T_1: 10% GA	3.14[a]	2.92[ab]	2.66[a]	2.22[cd]	1.66[c]	1.24[b]	2.31	13.03[a]	13.36[a]	14.11[b]	14.81[b]	15.21[a]	15.68[a]	14.36
T_2: 10% GA + 2% $CaCl_2$	3.14[a]	2.84[b]	2.6[a]	2.45[b]	1.52[d]	1.18[bc]	2.29	13.03[a]	13.33[a]	14.79[a]	15.76[a]	15.35[a]	14.81[b]	14.51
T_3: 10% GA + 1% H_2O_2	3.14[a]	2.93[ab]	2.66[a]	2.3[c]	1.82[b]	1.2[bc]	2.34	13.03[a]	13.57[a]	13.94[b]	14.26[c]	14.55[b]	15.15[ab]	14.08
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2	3.14[a]	2.96[a]	2.68[a]	2.64[a]	2.09[a]	1.78[a]	2.55	13.03[a]	13.17[a]	13.21[c]	13.44[d]	13.58[c]	14.21[c]	13.44
T_5: Control	3.14[a]	2.85[ab]	2.6[a]	2.14[d]	1.48[d]	1.1[c]	2.22	13.02[a]	13.61[a]	14.72[a]	15.85[a]	15.17[a]	14.64[bc]	14.50
Mean	3.14	2.90	2.6406	2.3488	1.7166	1.3		13.03	13.40	14.15	14.82	14.77	15.68[a]	

Table 3: Effect of Arabic gum-based coatings on titratable acidity and ascorbic acid in guava fruits during ambient storage.
[*] Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at P<0.5, Where; GA= Gum Arabic

Quality attributes	Titratable acidity (%)						Mean	Ascorbic acid (mg/100g)						Mean
Coating treatments	Storage intervals (days)							Storage intervals (days)						
	0	3	6	9	12	15		0	3	6	9	12	15	
T_1: 10% GA	0.42[a]	0.33[a]	0.29[a]	0.23[c]	0.20[d]	0.18	0.28	278.99[a]	240.27[b]	194.21[d]	164.18[c]	144.03[c]	119.47[c]	190.19
T_2: 10% GA + 2% $CaCl_2$	0.42[a]	0.33[a]	0.28[b]	0.23[c]	0.20[d]	0.18[b]	0.27	275.37[a]	220.38[b]	213.70[c]	164.94[c]	104.12[e]	73.75[e]	175.37
T_3: 10% GA + 1% H_2O_2	0.42[a]	0.33[a]	0.28[b]	0.24[c]	0.20[b]	0.18[b]	0.28	278.44[a]	218.28[c]	199.57[cd]	178.54[b]	154.53[b]	137.81[b]	194.53
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2	0.42[a]	0.33[a]	0.30[a]	0.29[a]	0.26[a]	0.24[a]	0.31	280.45[a]	258.04[a]	250.66[a]	223.86[a]	217.34[a]	205.54[a]	239.32
T_5: Control	0.42[a]	0.35[a]	0.29[b]	0.22[c]	0.20[c]	0.17[d]	0.28	276.8[a]	215.35[c]	203[c]	156.54[c]	115.85[d]	90.83[d]	176.39
Mean	0.42	0.33	0.29	0.24	0.21	0.18		278.01	229.13	213.56	177.61	147.17	125.48	

combination with calcium chloride and hydrogen peroxide (T_4) caused a significant and steady increase in TSS compared to the control. TSS in all treatments increased slowly till day 3. In control uncoated fruits (T_5) and arabic gum coated fruits incorporated with calcium chloride (T_2), TSS was first increased rapidly to its maximum value until the 9th days of storage, followed by a decrease toward the end of storage due to the fast degradation process. However, TSS was increased at a steady rate in the best performing coated treatment of T_4, followed by T_3 and T_1. The rate of increase in TSS in coated fruits was much lower than in uncoated fruits, which could be related to the slow conversion of starch into sucrose as a result of low moisture loss. An initial surge in TSS during storage can be attributed to the enzymatic conversion of starch and pectin into simple sugars during ripening and storage (Bidyut *et al*., 2013). The findings of this study are consistent with those of Chauhan *et al.* (2014), who found that *Aloe vera* combined with calcium salt produced superior TSS and physico-chemical characteristics in mango fruits.

Titratable acidity (%)

The titratable acidity of guava fruits was significantly altered by edible coatings and different storage periods in the current experiment as shown in Table 3. With increasing storage time, the titratable acidity of fruits continued to decrease significantly. A significant difference between the treated and control fruits was observed during the 15th day of storage. Results showed that arabic gum coating combined with 2% calcium chloride and 1% hydrogen peroxide slowed the reduction in titratable acidity and maintained it at a higher level compared to the control and other treatments. The titratable acidity decreased from 0.42% to 0.19% on the 15thday. On the 15th day of storage, gum arabic based composite coating of T_4 (10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide) maintained the acidity level to 0.24% as compared

Table 4: Effect of Arabic gum-based coatings on Total sugars content of guava fruits during ambient storage

Quality attributes	Total sugars						Mean
Coating treatments	Storage interval (days)						
	0	3	6	9	12	15	
T_1: 10% GA	8.84[a]	9.05[b]	9.38[b]	9.78[b]	10.32[a]	10.72[a]	11.62
T_2: 10% GA + 2% $CaCl_2$	8.84[a]	9.58[a]	10.75[a]	10.98[a]	10.43[a]	9.23[c]	10.12
T_3: 10% GA + 1% H_2O_2	8.84[a]	8.92[b]	9.48[b]	9.68[b]	10.25[a]	10.34[b]	9.64
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2;	8.84[a]	9.01[b]	9.19[b]	9.28[c]	9.85[b]	10.38[b]	11.31
T_5: Control	8.84[a]	9.66[a]	10.68[a]	10.95[a]	10.29[a]	9.21[c]	10.08
Mean	8.84	9.25	9.89	10.13	10.22	9.97	

*Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at $P<0.5$, Where; GA= Gum Arabic

Table 5: Effect of Arabic gum-based coatings on Total carotenoid content (µg/100g) and organoleptic appearance in guava fruits during ambient storage.* Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at P<0.5, Where; GA= Gum Arabic

Quality attributes	Total carotenoid content (µg/100g)						Mean	Appearance						Mean
Coating treatments	Storage intervals (days)							Storage intervals (days)						
	0	3	6	9	12	15		0	3	6	9	12	15	
T_1: 10% GA	3.82[a]	4.61[bc]	5.32[bc]	6.18[a]	6.21[a]	5.74[a]	5.31	9.00[a]	7.4[c]	7.27[c]	6.75[b]	6.7[b]	4.95[b]	7.01
T_2: 10% GA + 2% $CaCl_2$	3.83[a]	4.73[b]	5.53[b]	6.29[a]	6.14[ab]	5.59[ab]	5.35	9.00[a]	7.57[bc]	6.00[d]	5.53[c]	5.07[c]	2.85[d]	6.00
T_3: 10% GA + 1% H_2O_2	3.82[a]	4.42[c]	5.12[c]	5.34[b]	5.89[bc]	5.56[ab]	5.02	9.00[a]	8.33[a]	7.98[b]	7.85[a]	6.63[b]	4.67[c]	7.41
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2	3.83[a]	3.99[d]	4.48[d]	5.21[b]	5.65[c]	5.71[a]	4.81	9.00[a]	8.41[a]	8.25[a]	8.04[a]	7.75[a]	6.91[a]	8.06
T_5: Control	3.83[a]	5.26[a]	5.90[a]	6.25[a]	6.04[ab]	5.35[b]	5.44	9.00[a]	7.69[b]	6.03[d]	5.5[c]	4.29[d]	2.74[d]	5.87
Mean	3.82	4.60	5.27	5.85	5.98	5.59		9.000	7.88	7.10	6.73	6.08	4.42	

Table 6: Effect of Arabic gum-based coatings on organoleptic texture and taste in guava fruits during ambient storage* Means with same letter in a column showing no significant difference between the treatments according to Tukey's test at P<0.5, Where; GA= Gum Arabic

Quality attributes	Texture						Mean	Taste						Mean
Coating treatments	Storage intervals (days)							Storage intervals (days)						
	0	3	6	9	12	15		0	3	6	9	12	15	
T_1: 10% GA	9.00[a]	7.68[b]	7.21[c]	6.68[b]	6.5[b]	4.96[b]	7.00	9.00[a]	8.30[a]	7.79[b]	7.53[b]	7.16[b]	4.37[b]	7.36
T_2: 10% GA + 2% $CaCl_2$	9.00[a]	7.74[b]	6.13[d]	5.62[c]	5.14[c]	2.73[c]	6.06	9.00[a]	7.81[b]	6.06[c]	5.77[c]	4.96[d]	2.45[c]	6.01
T_3: 10% GA + 1% H_2O_2	9.00[a]	8.39[a]	7.85[b]	7.77[a]	6.58[b]	4.80[b]	7.40	9.00[a]	8.50[a]	8.13[a]	7.97[a]	6.89[c]	4.17[b]	7.44
T_4: 10% GA + 2% $CaCl_2$ + 1% H_2O_2	9.00[a]	8.48[a]	8.29[a]	8.01[a]	7.79[a]	6.94[a]	8.08	9.00[a]	8.48[a]	8.13[a]	8.03[a]	7.92[a]	6.81[a]	8.06
T_5: Control	9.00[a]	7.61[b]	6.09[d]	5.12[d]	4.42[d]	2.49[c]	5.78	9.00[a]	7.20[c]	6.12[c]	5.89[c]	4.32[e]	2.72[c]	5.87
Mean	9.00	7.98	7.11	6.64	6.08	4.38		9.00	8.06	7.24	7.03	6.25	4.10	

to 0.17% of acidity in control (T_5). A specific pattern of lesser acidity during storage might be due to the ongoing ripening process that diminished the organic acid and favored the formation of sugars. These results were also consistent with those reported by Nandaniya *et al.* (2017) and Chulaki *et al.* (2017) for Guava and jackfruit, respectively. Calcium increases acidity retention during storage by reducing organic acid hydrolysis and by accumulating acids that are oxidized more slowly due to the low respiration rate (Gupta *et al.,* 2011).

Total sugars (%)

Due to the quick conversion of starch into sugars as a result of moisture loss, the rate of increase in total sugars content in uncoated fruits was much higher than in coated fruits. With increasing storage interval, total sugars continued to increase. The treated fruits had a significantly slower rate of increase in total sugar than the uncoated fruits, due to reduced respiration rates, delayed ripening, and senescence (Table 4). As of TSS, total sugars also showed a rapid increase to a maximum at the 9thday of storage, followed by a decrease toward the end of storage in control (uncoated) and arabic gum-coated fruits with calcium chloride, due to rapid degradation. These findings agree with those of Kumar *et al*. (2017), who found the lowest total sugars in coated fruits. Because total sugar accounts for a large portion of total soluble solids, the same trend of increase and decrease in their amounts can be observed, and the reason for the change in total sugar amount is similar to that for the change in total soluble solids amount. Findings were also consistent with those of Singh *et al.* (2017a), who found that peaches had lower total sugar content than control or uncoated fruits.

Ascorbic acid (mg/100 g)

Regardless of the treatments, ascorbic acid levels decreased dramatically as the storage interval lengthened (Table 3). A significant difference between the treated and untreated fruits can be observed on the 15th day of storage. The content of ascorbic acid was found to be higher in coated guavas than in the control (T_5), as depicted in Table 3.The rate of decline varies by treatment, with control samples exhibiting the highest rates. The mean ascorbic acid content of 239.32 mg/100 g was found maximum in T_4(10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide) whereas the minimum 175.37 mg/100 g of ascorbic acid could be observed in T_2 (10% gum arabic + 2% calcium chloride) followed by 176.39 mg/100 g in T_5 (control). Storage days had a substantial impact on ascorbic acid content, which declined steadily as the storage duration advanced, regardless of treatment. The initial ascorbic acid content in control samples (276.80 mg/100g) was declined to 90.83 mg/100 g on the 15th day of storage while lowest reduction in ascorbic acid content was found in coated samples of T_4(10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide) wheretheir ascorbic acid reduced only from 280.45 to 205.55 mg/100g at 15th day of storage. The rate of ascorbic acid oxidation decreases in coated fruits because the coatings restrict the permeability of the fruit surface to the external environment, oxygen, and carbon dioxide, as reported by Abd El-Moneim *et al*. (2015). Chulaki *et al*. (2017) also observed that the ascorbic acid level rapidly decreased in fruit as the storage period progressed due to the oxidation of ascorbic acid by enzymes such as ascorbinase, peroxidase, catalase, and polyphenol oxidase.These findings align with those of Mezemir *et al*. (2017), who reported a decline in ascorbic acid concentration after 28 days of storage of orange fruits under ambient conditions.

Total carotenoid content (µg/100g)

Data presented in Table 5 showed a significant difference between the treated and control fruits. The maximum increase in total carotenoid content was observed in uncoated guava fruits, followed by coating with 10% gum Arabic combined with 2% calcium chloride (T_2). Uncoated control fruits from T_5 and gum arabic-coated fruits from T_2 reached their maximum carotenoid content on the 9th day of storage. In contrast, the coated fruits from T_1 and T_3 exhibited their highest carotenoid levels on the 12th day of storage, after which the content declined to a minimum due to over-ripening and decay by the 15th day. The guava fruits coated with gum arabic, combined with calcium chloride and hydrogen peroxide (T_4), showed a continuous increase in carotenoid accumulation until the 15th day of storage, attributed to a slower ripening rate. These results suggest that the composite coating can reduce the carotenoidsynthesis, delaying ripening and senescence, thereby extending the fruit's shelf life.It is evident that coated fruits experience a delay in chlorophyll degradation, which in turn reduces carotenoid synthesis. This observation aligns with the findings of Daisy *et al*. (2019), who reported that a gum Arabic-based coating effectively delays carotenoid synthesis during fruit ripening. Over time, the carotenoid content gradually increased, regardless of the treatment applied. This rise may be attributed to the increased activity of enzymes such as polyphenol oxidase and polygalacturonase.

Organoleptic characteristics

Appearance

Edible coatings significantly affected the appearance of fruits during storage. Treated fruits had a shiny, glossy appearance, whereas the control (uncoated) fruits lacked this appearance. The appearance of fruits decreased moderately with increasing storage days, regardless of treatment. The data on the effect of edible coatings at different storage intervals on the appearance of guava fruits is presented in Table 5. Data on periodic storage revealed that non-treated fruits (T_5) and fruits coated with arabic gum in combination with calcium chloride (T_2) lost their appearance on the 9th day, while fruits coated with arabic gum alone (T_1) and in combination with hydrogen peroxide (T_3) sustained their acceptable appearance till the 12th day. Fruits coated with composite coatings of 10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide only performed best and retained their acceptable appearance until the 15th day of storage.

Pawar and Singh (2020) observed that *Aloe vera* gel-based coatings, when combined with vitamin C as a natural antioxidant, showed a greater possibility to preserve the appearance of ber fruit. Kumar *et al.* (2017) reported that surface coating of fruits decelerates chlorophyll degradation, carotenoid synthesis, and anthocyanin accumulation, and delays color change in the fruits. Similar findings are also supported by the report of Khan *et al.* (2019), who observed a maximum color score (7.08) in apple fruits when coated with 10 percent aloe vera gel and 2 percent calcium chloride, while the control showed the lowest color score (5.76).

Texture

The data in Table 6 show the effect of edible coatings on guava fruit texture across different storage intervals. As storage duration increased, the fruit's texture continued to deteriorate. A significant interaction was observed between the treated and control fruits. The highest mean score for fruit texture, 8.08, was recorded in T_4 (10% gum arabic + 2% calcium chloride + 1% hydrogen peroxide), followed by T_3 (10% gum arabic + 1% hydrogen peroxide) with a score of 7.40. In contrast, the control group (T_5) had the lowest texture score at 5.78. Periodic evaluations indicated that untreated fruits (T_5) and those coated with gum arabic combined with calcium chloride (T_2) softened, and their texture declined by the sixth day. However, fruits coated with gum arabic alone (T_1) and those coated with gum arabic combined with hydrogen peroxide (T_3) maintained their texture until the twelfth day.

Notably, fruits coated with a composite mixture of 10% gum arabic, 2% calcium chloride, and 1% hydrogen peroxide performed best in maintaining textural quality, achieving a higher hedonic value of 6.94 and sustaining their quality until the fifteenth day of storage. Low textural scores during storage across all treatments might be due to the breakdown of insoluble pectic substances into soluble forms through a series of physico-chemical changes caused by the action of enzymes, i.e., pectinesterase and polygalacturonase.

During the investigation, it was discovered that the coatings prevented the fruits from losing firmness. These results are comparable to those reported by Murmu and Mishra (2018), who found that coating guavas with a polymer matrix containing gum arabic, sodium caseinate, and cinnamon essential oil reduced fruit firmness. Moradinezhad *et al.* (2018) also observed that fruits coated with CMC retained texture better after 40 days of cold storage than those coated with 50% Aloe vera. The findings are consistent with Bhavana *et al.* (2019), who reported that *Aloe vera* coatings with a packaging material (propylene) rated best in terms of texture at the end of the fruit's shelf life (21 days).

Taste

The data in Table 6 indicate that as storage duration increases, fruit taste deteriorates. Periodic storage studies revealed that untreated fruits (T_5) and 10% gum arabic + 2% calcium chloride treatment (T_2) lost their acceptable taste by the ninth day. In contrast, fruits in treatments T_1 (10% gum arabic) and T_3(10% gum arabic + 1% hydrogen peroxide) remained acceptable until the twelfth day while fruits coated with a composite mixture of 10% gum arabic, combined with 2% calcium chloride and 1%

hydrogen peroxide, retained an acceptable taste score until the fifteenth day, achieving a hedonic value of 6.81. The control group, however, did not maintain its acceptable taste beyond the sixth day of storage. These findings clearly demonstrate that edible coatings significantly enhance the taste response period of fruits. The observed loss of taste over time may be attributed to changes in biochemical characteristics, such as pH, sugar-to-acid ratio, and total soluble solids (TSS).As the fruit ripens, the acids degrade and the sugar content increases, resulting in a higher sugar: acid ratio and a sweeter taste. Jiang *et al*. (2025) also reported that the sugar-to-acid ratio plays a crucial role in defining the overall taste profile and sensory quality of the fruit.

CONCLUSION

The study revealed that the application of gum arabic, combined with calcium chloride as a texture enhancer and hydrogen peroxide as a biocide, was most efficient in extending the shelf life of guava fruits cv. Pant Prabhat. Among all treatments, the surface coating of 10% gum arabic combined with 2% calcium chloride and 1% hydrogen peroxide was found to be most satisfactory, maintaining fruit quality for up to 15 days of ambient storage by controlling physiological loss in weight, firmness, decay, and biochemical attributes.

As a result, it is possible to conclude that a surface coating of guava fruits with 10% gum arabic incorporated with 2% calcium chloride as a texture enhancer and 1% hydrogen peroxide (T_4) as a biocide should be used as an alternative approach to extend the shelf life and maintain physicochemical quality characteristics of guava fruits during their postharvest handling and storage.

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