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Influence of lipid and polysaccharide based edible coatings on quality of guava fruits during storage

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ABSTRACT

Guava fruits were coated with vegetable wax (@ 1:4 v/v) or sodium alginate (@ 2%) and stored at 10°C for 12 days. Post-cold storage, fruits were shifted to ambient conditions (20±2°C) for a 2 day shelf life simulation period. Observations were taken with an interval of 3+2 days (3 days at 10°C followed by 2 days at ambient conditions) up to 12+2 days. The results revealed that fruits coated with vegetable wax significantly lowered the physiological loss in weight, pectin methyl esterase activity and malondialdehyde content followed by sodium alginate coating. Vegetable wax coating proved to be more effective in delaying the fruit skin yellowing on respiration peak attaining of fruits in comparison to sodium alginate coating. The vegetable wax coated fruits retained higher firmness, total phenolic and ascorbic acid contents and total antioxidant activity during storage other treatments, thus maintaining better quality during storage upto 6+2 days.

Key words: *Psidium guajava*, edible coatings, vegetable wax, sodium alginate, firmness.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most important fruit crops of India. Guava fruits are consumed as fresh or in processed forms such as jams, jellies, juices and purees. The fruits are highly nutritious and rich in phenols, carotenoids, ascorbic acid and dietary fiber and are known for their high antioxidant capacity. Being climacteric in nature, guava fruits ripen fast with a resultant storage life of 2 to 3 days at the room temperature. The perishable nature, limited storage life and sensitivity to chilling injury and diseases results in fruit wastage. During the years, researchers have worked on some expensive interventions such as irradiation, controlled/ modified atmospheric storage and application of fungicides to increase the storage life of guava (Antala *et al.*, 1; Singh and Pal, 14; Singh and Pal, 15;). Shifting focus to safe and affordable postharvest practices to address these problems is the need of the hour. This can be dealt with the application of GRAS edible coatings on the fruit surface. The coatings provide an additional protective layer thus creating modified atmospheres and protecting fruit quality. They act as a semi-permeable barrier to gas and water vapour interchange, resulting in reduced weight loss, modification of respiration rate and delay in onset of senescence. Fruits may show varied response to different types of edible coatings based on the hydrophobic/ hydrophilic nature of these coatings. Hence, the influence of a lipid based coating (vegetable wax) and a polysaccharide based coating (sodium alginate) was investigated for the quality retention in guava fruits during storage.

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MATERIALS AND METHODS

Guava fruits (cvs. Allahabad Safeda and Lalit) were harvested at mature green stage from an orchard located in Indian Agricultural Research Institute (IARI), New Delhi. Sound fruits of uniform size and maturity were selected for the experiment. Sodium alginate was procured from Merck while the vegetable wax formulation (GRW-40) was procured from Nipro Technologies Ltd., Panchkula, Haryana. The fruits of each variety were divided into 6 groups, every group having 210 fruits. The fruits were immersed into vegetable wax (1 part of vegetable wax and 4 parts of distilled water) or sodium alginate (2% solution) for 5 min. Prior to sodium alginate treatment, fruits were pretreated in 2% $CaCl_2$ for 5 min for better adhesion of sodium alginate on the fruit surface. Control fruits were dipped in distilled water for 5 min. Fruits were air-dried and stored at 10°C with 80-90% RH. After every 3 days of cold storage, fruits were transferred to ambient conditions (20±2°C) and kept for 2 days for simulation studies and analysed for quality parameters.

Physiological loss in weight (PLW) was measured by subtracting the initial sample weight from the final weight at a particular time interval. Fruit firmness was measured using an Instron-Universal Testing Machine (Stable Microsystems, UK) and expressed as Newton (N). Peel colour was measured by Hunter Colour Lab Scan XE and the CIE L, a, b colour scale. Respiration rate of the fruits was measured by the static headspace technique using an auto gas analyser (Checkmate 9900 O_2/CO_2, PBI Dansensor, Denmark) and expressed as ml CO_2 kg^{-1} fresh weight h^{-1} (Kumar *et al.*, 10). Quantitative determination of ascorbic acid was done by a visual titration method, using 2, 6-dichlorophenol indophenol dye (AOAC, 2) and expressed as mg 100 g^{-1} of fresh weight. Total phenolic content of the fruit extracts was determined by Folin-Ciocalteau reagent method (Singleton *et al.*, 16) and expressed as mg gallic acid equiv/100g, while total antioxidant activity was determined using cupric reducing antioxidant capacity method given by Apak *et al*. (3), and represented in terms of μmol Trolox g^{-1} FW. Pectin methylesterase (PME) activity expressed as μmol $min^{-1}g^{-1}$ FW, and malondialdehyde (MDA) content ($μmol^{-1}$ FW) in the guava fruits were measured according to protocol followed by Hagerman and Austin (6) and Kumar *et al*. (9), respectively.

All observations were taken in triplicate. Data obtained were analysed by two way analysis of variance (ANOVA) using SAS 9.3 and significant effects were noted. Further, a multiple comparison was done by using Tukey's HSD test.

RESULTS AND DISCUSSION

Irrespective of cultivar or coating applied there was a progressive increase in PLW of the guava fruits during storage (Table 1). However, fruits coated with vegetable wax recorded lower PLW in both the varieties. In case of cv. Allahabad Safeda, it was observed vegetable wax coated fruits showed lower PLW (10.07%) followed by sodium alginate coated fruits (10.25%), whereas uncoated fruits showed highest PLW (14.36%) at the termination of the storage period. In case of cv. Lalit also, a similar trend was observed with fruits coated by vegetable wax recorded lower PLW (11.08%) followed by sodium alginate (11.21%) coated fruits while control fruits showed highest PLW (15.09%) at the termination of the storage. Kader (8) has reported that water loss above 5% may result in loss of quality and value of the horticultural produce. We observed no unmarketable symptoms till 6+2 days of storage that was synchronous with a weight loss of 6.43% and 6.52% in wax coated and sodium alginate coated fruits, respectively. Lower PLW in wax coated fruits may be attributed to the hydrophobic nature of this coating that acts as a good moisture barrier. Further, sodium alginate which is a polysaccharide based coating and hydrophilic in nature has comparatively higher permeability to water vapour. Our results are in comparison with those obtained for coated plums by Kumar *et al*. (10).

Firmness of fruits is an important parameter determining the quality and consumer acceptability. In general, firmness of guava fruits of both cultivars was found to reduce gradually with the progress in storage period for all the treatments (Table 1). At the termination of the experiment, vegetable wax coated fruits of cvs. Allahabad Safeda and Lalit exhibited 35.62% and 34.0% retention of firmness, respectively. Sodium alginate coated fruits of both the cultivars however, showed 27.36% and 25.65% retention of fruit firmness, respectively. Polysaccharide coatings such as sodium alginate are hydrophillic. Therefore, in comparison to lipid based formulations, they are less effective in retarding the metabolic processes and the enzyme activities that cause softening of the fruits. Our results are supported by those reported by Machado *et al*. (12) in tangor coated with carnauba wax and Kumar *et al*. (11) in plum coated with three different coatings. Dang *et al*. (4) reported that mango fruits coated with carnauba wax maintained higher firmness compared to fruits coated with polysaccharide (Semperfresh™) based edible coating.

The change of peel colour from green to yellow in guava fruits is an indicative of fruit ripening. Uncoated fruits turned completely yellow after 6+2 days of storage. Vegetable wax coated fruits showed complete transition in colour to yellow after 12+2 days of storage whereas those coated with sodium alginate turned completely yellow earlier i.e., after 9+2 days of storage. Similar results were observed for both the cultivars. This indicates that postharvest application of edible coatings has delayed the ripening process of guava fruits significantly. The slower yellow colour transition in vegetable wax coated fruits indicates the effectiveness of this hydrophobic coating in delaying ripening process compared to sodium alginate. Our results are in accordance with the Tomas *et al*. (17) and Valero *et al*. (18) who investigated the effect of these coatings on guava and plums, respectively.

The respiration rate of the guava fruits showed a gradual increase during storage up to certain period followed by a steady decline in both the cultivars (Fig. 1). In case of control fruits, the rate of respiration was observed to increase rapidly with a typical climacteric peak after 3+2 storage days. The coatings suppressed the respiration rate and also delayed the onset of the respiratory climacteric to 6+2 and 9+2 days of storage in sodium alginate and vegetable wax coated fruits, respectively in both the cultivars. This

Table 1. Influence of edible coatings on different fruit quality attributes in guava cvs. Allahabad Safeda and Lalit stored at 10°C followed by ambient conditions for 2 days.

Treatment	Allahabad Safeda					Lalit				
	0 day	3+2 days	6+2 days	9+2 days	12+2 days	0 day	3+2 days	6+2 days	9+2 days	12+2 days
					Physiological loss in weight (%)					
Vegetable wax	0.00	3.16^{i}	6.43^{g}	8.39^{ef}	10.07^{dc}	0.00	4.13^{h}	7.41^{f}	9.29^{e}	11.08^{c}
Sodium alginate	0.00	4.25^{h}	6.52^{g}	8.43^{ef}	10.25^{c}	0.00	5.62^{g}	7.35^{f}	9.45^{e}	11.21^{c}
Control	0.00	8.29^{f}	9.27^{ed}	11.21^{b}	14.36^{a}	0.00	9.31^{e}	10.26^{d}	12.15^{b}	15.09^{a}
					Colour (hue angle)					
Vegetable wax	116^{a}	105^{b}	100^{cb}	95^{def}	91^{fg}	117^{a}	106^{b}	103^{c}	95^{f}	90^{h}
Sodium alginate	116^{a}	102^{cb}	94^{efg}	91^{fg}	89^{g}	117^{a}	103^{d}	97^{f}	93^{h}	90^{i}
Control	116^{a}	99^{ced}	91^{fg}	90^{fg}	89^{g}	117^{a}	98^{e}	92^{g}	90^{j}	89^{k}
					Firmness (N)					
Vegetable wax	10.16^{a}	8.91^{b}	7.61^{c}	5.82^{e}	3.62^{h}	10.05^{a}	8.75^{b}	7.65^{c}	5.72^{f}	3.42^{h}
Sodium alginate	10.16^{a}	6.71^{d}	5.72^{e}	3.81^{h}	2.78^{i}	10.05^{a}	6.82^{d}	5.69^{f}	3.36^{h}	2.58^{i}
Control	10.16^{a}	5.32^{f}	4.75^{g}	2.08^{j}	1.12^{k}	10.05^{a}	6.16^{e}	4.71^{g}	1.85^{j}	1.21^{k}
					Total phenolic content (mg GAE/100g)					
Vegetable wax	177^{a}	154^{b}	140^{cd}	130^{ed}	117^{g}	163^{a}	139^{b}	133^{cb}	119^{ed}	107^{hfg}
Sodium alginate	177^{a}	149^{bc}	136^{ed}	127^{ef}	111^{gh}	163^{a}	136^{cb}	130^{cb}	116^{ef}	103^{hg}
Control	177^{a}	141^{cd}	128^{ef}	114^{g}	102^{h}	163^{a}	136^{cb}	128^{cd}	112^{efg}	99^{h}
					Total antioxidant activity(μmol Trolox g^{-1} FW)					
Vegetable wax	14.65^{a}	12.81^{b}	11.32^{e}	10.62^{f}	9.45^{i}	13.81^{a}	11.06^{b}	10.36^{c}	9.3^{e}	7.97^{g}
Sodium alginate	14.65^{a}	12.21^{c}	10.49^{f}	9.69^{h}	8.18^{k}	13.81^{a}	11.01^{b}	10.25^{c}	9.19^{e}	7.89^{g}
Control	14.65^{a}	11.86^{d}	9.97^{g}	8.91^{j}	7.92^{l}	13.81^{a}	9.96^{d}	8.75^{f}	7.43^{h}	6.42^{i}
					Malondialdehyde (μmol g^{-1} FW)					
Vegetable wax	23^{i}	29^{ef}	35^{g}	44de	49^{dc}	24^{h}	34^{g}	41^{f}	48^{ed}	52^{cd}
Sodium alginate	23^{i}	37^{gf}	43^{e}	52^{c}	59^{b}	24^{h}	41^{f}	48^{ed}	55^{cb}	64^{a}
Control	23^{i}	42^{cd}	49^{cd}	61^{ab}	65^{a}	24^{h}	46^{ef}	52^{cd}	58^{b}	67^{a}

Each value is the mean of three replicates. $^{a-c}$Means with different alphabet superscripts in the same column differ significantly (P ≤ 0.05).

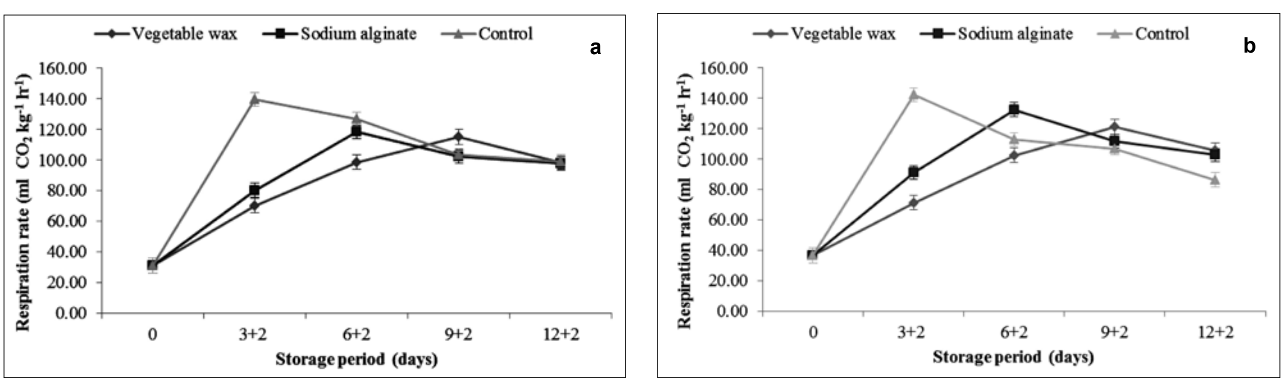

Fig. 1. Effect of edible coatings on respiration rate of guava cvs. a) Allahabad Safeda and b) Lalit during storage at 10°C followed by storage at ambient conditions for 2 days. Bars in lines represent standard error of three replicates for each determination.

effect is owing to the blocking of stomatal openings on the guava fruit surface resulting in limited gas exchange between the fruit and the atmosphere and creation of modified atmosphere around the coated fruits. As has been reported earlier also by Kumar *et al*. (10), lipid based coating such as the commercial vegetable wax coating used in our study perform well in retarding the respiration rate due to better barrier properties. Valero *et al*. (18) have also reported suppression of climacteric peak in plum fruits by application of different coatings.

The high antioxidant potential of guava fruits is attributed to the high ascorbic acid content. Ascorbic acid content increased initially followed by a steady decline with the progress in storage time for all the treatments and cultivars (Fig. 2). In both white fleshed (Allahabad Safeda) and pink fleshed (Lalit) guava fruits, ascorbic acid content in untreated guava fruits increased up to 3+2 days of storage, thereafter it showed a declining trend. On the other hand, coated guava fruits showed an increase in ascorbic acid up to 6+2 days of storage. The increase in ascorbic acid during ripening of guava fruits is due to the conversion of sugars to ascorbic acid in fruit tissues. However, as mentioned before, since coatings delay the metabolic processes, a retarded rate of increase of ascorbic acid was observed in coated fruits. Similar retardation in rate of ascorbic acid loss was observed by Kumar *et al*. (9) in chitosan coated plums. Vegetable wax coated fruits (Allahabad Safeda and Lalit) exhibited higher ascorbic acid content (182 mg $100g^{-1}$ and 134 mg $100g^{-1}$, respectively) than sodium alginate coated ones (171 mg $100g^{-1}$ and 128 mg $100g^{-1}$, respectively). Similar findings have been reported by Qayyum *et al*. (13) in sweet cherries coated with sodium alginate and Jhalegar *et al*. (7) in Kinnow mandarins coated with wax.

With the progression of storage time, total phenolic content showed a declining trend irrespective of coatings or varieties (Table 1). Significantly higher retention of phenolic content was recorded in vegetable wax (66.10% and 65.64%, respectively) coated Allahabad Safeda and Lalit fruits followed by sodium alginate coated fruits (62.71% and 60.73%, respectively). The suppression of enzyme activity due to the coatings is responsible for the phenolic accumulation in fruits. Similar observations were also reported earlier by Kumar *et al*. (11) and Gol *et al*. (5) in wax and sodium alginate coated plum and carambola fruits.

Total antioxidant activity is an important parameter governing the nutritional status of any fruit. Although, the total antioxidant activity reduced during storage across treatments (Table 1), but coatings had a significant influence on the retention of total antioxidant activity. Here also, the commercial vegetable wax formulation was successful in retaining the total AOX for both white fleshed and pink fleshed guava fruits (64.50% and 57.71%, respectively). This might be due to the higher retention of total phenolics and ascorbic acid content that are major contributors in imparting antioxidant activity to fruits, in comparison to the other treatments. Similar findings were reported by Kumar *et al*. (11) and Gol *et al*. (5) in plum and carambola fruits coated with sodium alginate, respectively.

PME enzyme activity is responsible for loss of firmness of respiring commodities. In both the cultivars, irrespective of treatment, control fruits showed the maximum PME activity at 3+2 storage days (Fig. 3), while it reached to its maximum on 6+2 days of storage in fruits coated with sodium alginate. But the peak was delayed till 9+2 days of storage in fruits coated with vegetable wax. The retardation of enzyme activity maybe owing to depletion of oxygen

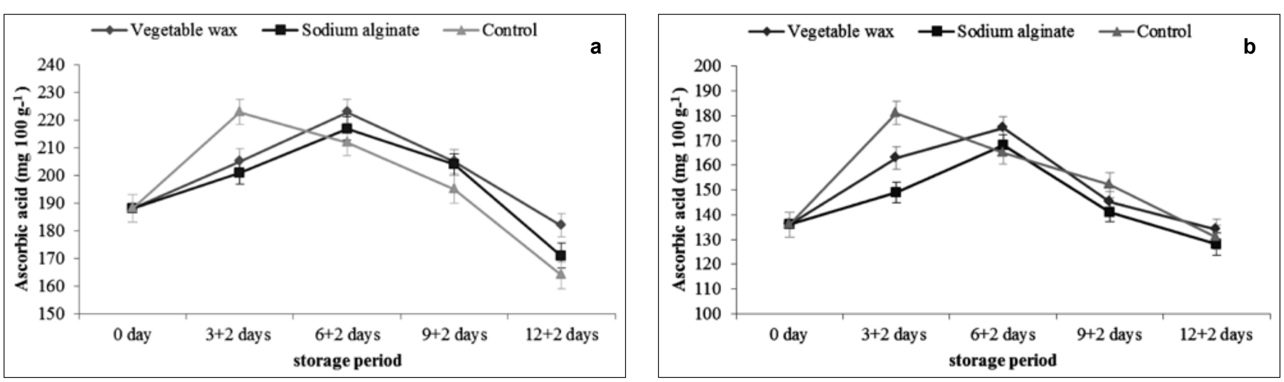

Fig. 2. Influence of edible coatings on ascorbic acid of guava cvs. a) Allahabad Safeda and b) Lalit during storage at 10°C followed by storage at ambient conditions for 2 days. Bars in lines represent standard error of three replicates for each determination.

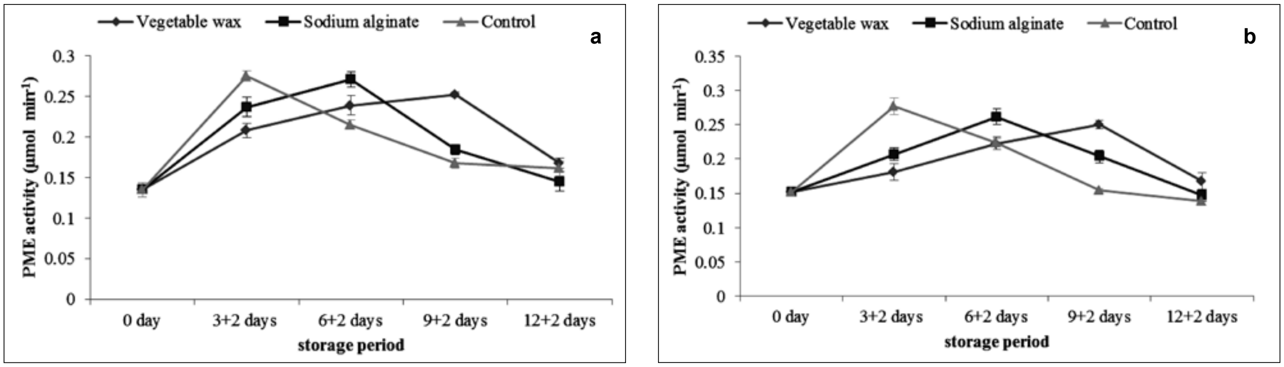

Fig. 3. Effect of edible coatings on pectin methyl esterase activity in guava cvs. a) Allahabad Safeda and b) Lalit during storage at 10°C followed by storage at ambient conditions for 2 days. Bars in lines represent standard error of three replicates for each determination.

in the microclimate surrounding the guava fruits because of the barrier provided by the coatings. These results are in agreement with the work done by Kumar *et al*. (10) who have observed 82-86% reduction in PME activity of plums coated with three different coatings.

MDA is an indicator of oxidative stress of the respiring fruits and vegetables. MDA content increased throughout the storage (Table 1) irrespective of cultivar or coating applied. Lowest MDA content was observed in vegetable wax coated guava fruits with coated fruits of cv. Lalit showing least values (52 µmol g^{-1} FW) at end of storage. Edible coatings with their ability to build modified atmosphere around the fruit surface are able to inhibit the lipid peroxidation and the resultant rise in MDA content. Kumar *et al*. (10) reported that although the malondialdehyde contents continuously increased during the entire storage period, the coatings significantly reduced the malondialdehyde production in coated plums.

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