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APPLICATION OF EDIBLE SURFACE COATINGS TO PROLONG THE STORAGE LIFE OF BARAMASI LEMON (*Citrus limon* L. Burm) FRUITS

Jaskirat Singh*, S.K. Jawandha and Harminder Singh

Department of Fruit Science, College of Agriculture, Punjab Agricultural University, Ludhiana – 141 004, Punjab (India)
*e- mail: *jaskiratdhanoa@gmail.com*

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ABSTRACT

Mature light green, uniform and healthy fruits of Baramasi lemon (*Citrus limon* L. Burm) *cv.* PAU Baramasi lemon-1 were coated with different concentrations (0.25, 0.50 and 0.75%) of chitosan, carboxymethyl cellulose and *Aloe vera*gel to analyze their effects on storage life and fruit quality. Fruits were analyzed after 15, 30, 45 and 60 days for various physicochemical parameters. Physiological loss in weight increased with increase in storage period, whereas peel thickness and vitamin-C content declined with the extension of storage period. Other parameters like juice percentage and titratable acidity showed an increasing trend during initial stages of storage, but at the end of storage a decline was observed. Chitosan @ 0.75% was found most effective to enhance the storage life of Baramasi lemon fruits up-to 45 days at low temperature storage by reducing physiological loss in weight, maintaining high peel thickness, juice content, acidity and vitamin- C content.

Key words: *Aloe vera* gel, Baramasi lemon, carboxymethyl cellulose, chitosan, storage life

INTRODUCTION

Citrus fruits belong to family Rutaceae and are widely cultivated in tropical and sub-tropical parts of the world. In India, citri-culture is the 3rd largest component of fruit industry after mango and banana (Sidana *et al.*, 2013). In Punjab, citrus fruits occupy 52,836 ha area with annual production of 1.05 lakh tonnes (Anonymous, 2017). Plentiful of health profiting nutrients are packed within lime and lemons, especially with respect to vitamin-C and minerals like iron, copper, potassium and calcium. Exceptional quality pickles, soft drinks, lemonades, lime cordials and commercial citric acid are prepared from lime and lemons.

Agro-climatic conditions of Punjab are advantageously fit for the cultivation of Baramasi lemon (*Citrus limon* L. Burm). Baramasi lemon trees yield fruits twice a year (July-August and December-January) with meager flowering and fruiting all over the year. But, the cold period of year coincides with the harvest period of winter crop of Baramasi lemon resulting in the low consumption of lemon fruits and economic losses to the farmers. Baramasi lemon being a non-climacteric fruit has reasonably a good shelf life, yet the improvement in its storage life may prove valuable for its use during off-season when the prices are very high. During storage, postharvest losses are mainly of physical, pathological and physiological nature. But, by monitoring the rate of respiration and transpiration, microbial infection and membrane disorganization one can minimize the post-harvest losses (Bisen and Pandey, 2008). The quality and storage life of fruits can be improved, to some extent, by storing the fruits at low temperature and through use of growth regulators, wax emulsions,

fungicides, chemicals, oil coatings, irradiation, packing materials and edible coatings (Bisen *et al.*, 2008). The continuous post-harvest application of synthetic waxes, chemicals, fungicides and oils may cause accumulation of chemical residues or proliferation of pathogenic strains, so a concern for health and environment (Palou *et al.*, 2015). Therefore, it is necessary to find some eco-friendly and economical alternatives for enhancing the shelf-life of fruits.

Edible coating is one of the novel natural methods for retaining the quality and extending the shelf-life of fresh fruits due to its biodegradable nature, edibleness, interpenetration, physical and mechanical protective covering (Palou *et al.*, 2015). These coatings are free from noxious, hypersensitive and indigestible components, and are also environmentally safe, economically viable and easy to apply (Janjarasskul and Krochta, 2010). Edible films and coatings, used mainly in fruits, are polysaccharide-based coatings and films (cellulose, alginates, starch based, chitin and chitosan), protein-based coatings and films (gelatin, whey protein, wheat gluten, soy protein, zein protein), lipid-based coatings and films (carnauba, shellac wax, bee wax), composite films (blend of polysaccharides or lipids and proteins) and others (*Aloe vera*, cactus-mucilage, gellan, pullulan, etc.) (Nayik *et al.*, 2015). Keeping the above facts in view, the present research was undertaken to study the effect of surface coatings on storage life and quality of Baramasi lemon fruits under low temperature storage conditions.

MATERIALS AND METHODS

For present study, fresh, light green colour, mature, uniform and healthy fruits of Baramasi lemon *cv.* 'PAU Baramasi lemon-1' were harvested in the month of January from Fruit Research Farm, Department of Fruit Science, PAU, Ludhiana (India). The storage studies were conducted in Post-Harvest Laboratory, Department of Fruit Science, PAU, Ludhiana in the year 2017. The selected fruits were washed with chlorinated water and dried under shade. Three types of coating materials *viz.*, chitosan (Sisco Research Laboratories), carboxymethyl cellulose (CMC) (Fisher Scientific) and *Aloe vera* gel {*Aloe vera* gel freeze dried powder (200:1)} were used, each tested at three concentrations 0.25, 0.50 and 0.75% alongwith a control (uncoated). Coated fruits were air-dried under shade and fruits from each replication of each treatment were packed in ventilated (5% perforation) corrugated fiber board (CFB) boxes with paper lining before storage at 11±1°C and 90-95% relative humidity for 60 days. Fruit samples were analyzed for various physicochemical properties after 15, 30, 45 and 60 days of storage. The experiment was conducted in a completely randomized design and comprised of ten treatments with three replications in each treatment. Each treatment contained 3 kg fruit (one kg fruit per replication) for analysis on each storage interval. A total of 120 kg fruits was used for the study.

The percent physiological loss in weight after each storage interval was calculated by subtracting the final weight from initial weight of fruits and then converted into percentage value. The colour of fruits was measured with Colour flex® meter (Hunter Lab) and expressed as 'b*' hunter values (Hunter, 1975). The peel thickness was recorded with help of a Vernier caliper and measured in (mm). Fruit juice was extracted with the help of citrus juicer and weighed. The juice percentage was calculated on fresh fruit weight basis. For determining the acid content, 2 mL fresh juice was titrated against 0.1N sodium hydroxide solution using phenolphthalein as indicator. The acid content was expressed as percentage of citric acid in juice (AOAC, 1990). Ascorbic acid content (mg 100 mL^{-1} juice) was determined by using 2,6 dichlorophenol indophenol (DCPIP) dye visual titration method (Ranganna, 1994). The total sugars content was analyzed by following AOAC (1990) method and expressed in percentages. The data was analyzed by using CPCS1 software as a statistical analysis tool (Cheema and Singh, 1990).

RESULTS AND DISCUSSION

The physiological loss in weight (PLW) of fruits during storage determines the storage quality of fruits. Results revealed that PLW increased linearly in all the treatments with the advancement of storage period (Table 1). The mean minimum PLW (3.26%) was observed after 15 days of storage and mean maximum (10.58%) after 60 days of storage. Among the treatments, after 15 days of storage the fruits coated with chitosan @ 0.75% showed minimum PLW (2.54%), followed by the fruits coated with *Aloe vera* gel @ 0.75%, but maximum PLW (4.45%) was noticed in control fruits. Similar trend was recorded in all treatments after 30, 45 and 60 days of storage. This might be due to the reduction in respiration and transpiration rates of fruit by surface coatings. The results are in accordance with Arowora *et al*. (2013) who reported a reduction in PLW of 'Valencia' oranges coated with *Aloe vera* gel under low temperature storage conditions. Sogvar *et al.* (2016) also reported lower weight loss (12.6%) in fruits treated with a combination of *Aloe vera* gel and ascorbic acid than in fruits treated with *Aloe vera* gel alone (21.3%).

There was delay in the loss of green colour of lemon peel with the use of different surface coatings under cold storage (Table 1). Fruits coated with chitosan @ 0.75% showed minimum b* value of 52.24, 60.36, 65.17 and 68.75 after 15, 30, 45 and 60 days of storage, respectively, and maximum b* values on above intervals were recorded in control fruits. The loss of green colour from fruit peel might be due to the degradation of chlorophyll pigments and increased synthesis of carotenoids. Krishna and Rao (2014) also observed a low b* value in chitosan (1 and 2%) coated fruits as compared to acetic acid treated and control fruits.

A reduction in peel thickness was observed with the advancement of storage period, irrespective of the treatments. The mean maximum peel thickness (4.36 mm) was observed after 15 days and mean minimum thickness (3.18 mm) after 60 days of storage (Fig. 1). Mean maximum peel thickness (4.11 mm) was observed in the fruits coated with chitosan @ 0.75%, followed by the fruits coated with *Aloe vera* gel @ 0.75% having 4.01 mm peel thickness while mean minimum peel thickness of 3.29 mm was found in control fruits. The peel thickness was significantly less in uncoated fruits because of continuous moisture loss from the peel of fruits through evapotranspiration that leads to drying of cell cytoplasm.

An increase in mean juice percentage was observed upto 30 days of storage and thereafter a decline was noticed. After 15 days of storage, the minimum juice percentage (42.34%) was found in the fruits coated with chitosan @ 0.75% and maximum juice content (45.14%) in control treatment (Fig. 2). After 30 days of storage, an increase in juice content was noticed in all the treatments, except

Table 1: Effect of surface coatings on physiological loss in weight (PLW) and 'b*' value of fruit colour of Baramasi lemon fruits (winter crop) during cold storage

Treatments	Physiological loss in weight (%)					Fruit colour 'b*' value				
	Days after storage (DAS)									
	15	30	45	60	Mean	15	30	45	60	Mean
Chitosan @ 0.25%	2.87	4.35	7.84	9.58	6.16	53.74	62.17	67.05	69.75	63.18
Chitosan @ 0.50%	2.86	4.06	7.42	9.16	5.88	53.15	61.70	66.25	69.34	62.61
Chitosan @ 0.75%	2.54	3.49	5.24	6.53	4.45	52.24	60.36	65.17	68.75	61.63
CMC @ 0.25%	4.03	7.48	11.62	13.75	9.22	55.60	65.12	69.25	70.64	65.15
CMC @ 0.50%	3.71	6.69	10.43	13.15	8.50	55.49	64.52	69.19	70.55	64.94
CMC @ 0.75%	3.14	4.52	7.93	9.83	6.36	53.91	63.01	67.64	70.23	63.70
Aloe vera gel @ 0.25%	3.16	5.15	8.55	10.66	6.88	54.84	63.74	69.15	70.53	64.57
Aloe vera gel @ 0.50%	3.15	4.66	8.32	10.24	6.59	54.13	63.15	69.05	70.25	64.15
Aloe vera gel @ 0.75%	2.73	4.05	5.85	7.80	5.11	52.64	61.35	65.31	69.15	62.11
Control	4.45	8.05	11.85	15.05	9.85	57.15	68.19	70.62	71.45	66.85
Mean	3.26	5.25	8.51	10.58	-	54.29	63.33	67.87	70.06	
$CD_{0.05}$	Treatment (T) = 0.03, Storage (S) = 0.02 S × T = 0.07					T = 0.04, S = 0.03, S × T = 0.09				

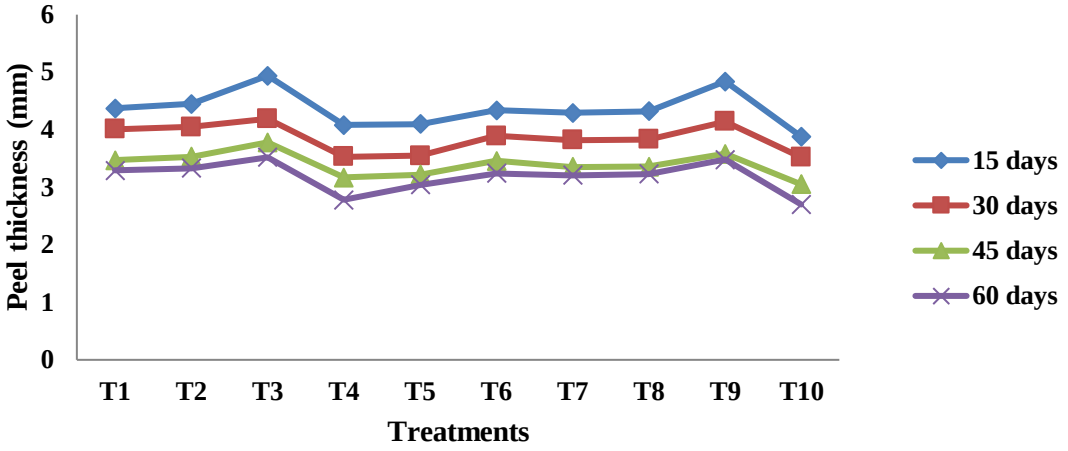

Fig. 1: Effect of surface coatings on peel thickness of Baramasi lemon fruits during cold storage; T1- Chitosan 0.25%, T2 - Chitosan 0.50%, T3 - Chitosan 0.75%, T4 - Carboxymethyl cellulose 0.25%, T5 - Carboxymethyl cellulose 0.50%, T6 - Carboxymethyl cellulose 0.75%, T7 - *Aloe vera* gel 0.25%, T8 - *Aloe vera* gel 0.50%, T9 - *Aloe vera* gel 0.75%, T10 - Control

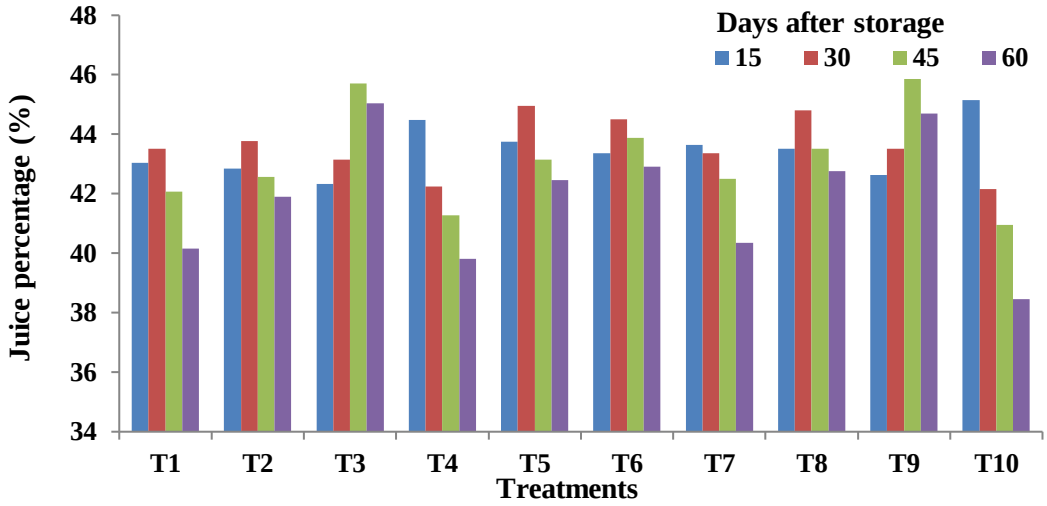

Fig. 2: Effect of surface coatings on juice content of Baramasi lemon fruits during cold storage; T1- Chitosan 0.25%, T2 - Chitosan 0.50%, T3 - Chitosan 0.75%, T4 - Carboxymethyl cellulose 0.25%, T5 - Carboxymethyl cellulose 0.50%, T6 - Carboxymethyl cellulose 0.75%, T7 - *Aloe vera* gel 0.25%, T8 - *Aloe vera* gel 0.50%, T9 - *Aloe vera* gel 0.75%, T10 - Control

in the fruits coated with CMC @ 0.25%, *Aloe vera* gel @ 0.25% and control where a decline in juice content was recorded. After 45 days of storage, all the treatments showed a decline in juice content as compared to the previous storage intervals, except chitosan @ 0.75% and *Aloe vera* gel @ 0.75% treatments where an increase in juice content was recorded.

At the end of storage, a decline in juice content was recorded in all the treatments. Chitosan @ 0.75% and *Aloe vera* gel @ 0.75% treatments showed high juice recovery at the end of storage period. The results are in conformity with Molina *et al*. (2004) who studied the effect of edible coatings on juice percentage of 'Mexican lime' and reported higher juice percentage in coated fruits as compared to the control (uncoated) fruits. Ghosh *et al*. (2015) reported that 'Assam lemon' fruits treated with different concentrations of corn starch coatings showed higher juice percentage as compared to the control fruits.

The acidity of fruits showed an increase upto 30 days of storage and thereafter a decline in all

Table 2: Effect of surface coatings on titratable acidity, vitamin-C and total sugar contentof Baramasi lemon fruits during cold storage

Treatments	Titratable acidity (%)					Vitamin-C (mg100 mL^{-1} juice)					Total sugars (%)				
	Days after storage (DAS)														
	15	30	45	60	Mean	15	30	45	60	Mean	15	30	45	60	Mean
Chitosan @ 0.25%	5.04	5.08	5.00	4.96	5.02	50.5	48.1	45.1	39.9	45.9	2.15	2.17	2.20	2.24	2.19
Chitosan @ 0.50%	5.02	5.04	5.02	4.99	5.02	50.7	48.5	45.5	41.6	46.6	2.13	2.15	2.19	2.22	2.17
Chitosan @ 0.75%	4.95	5.02	5.10	5.07	5.04	51.3	49.6	45.7	42.9	47.4	2.02	2.04	2.07	2.09	2.06
CMC @ 0.25%	5.08	5.09	4.98	4.94	5.02	47.8	45.1	42.2	38.2	43.3	2.19	2.21	2.26	2.29	2.24
CMC @ 0.50%	5.07	5.14	5.00	4.97	5.05	48.2	46.7	43.8	40.1	44.7	2.17	2.18	2.25	2.28	2.22
CMC @ 0.75%	5.05	5.09	5.06	5.03	5.06	49.8	47.3	44.5	41.1	45.7	2.15	2.16	2.20	2.25	2.19
Aloe vera gel @ 0.25%	5.09	5.10	5.00	4.95	5.04	48.4	46.7	43.9	38.8	44.4	2.15	2.19	2.23	2.26	2.21
Aloe vera gel @ 0.50%	5.06	5.09	5.02	4.97	5.04	48.5	46.1	43.2	40.2	44.5	2.12	2.15	2.19	2.22	2.17
Aloe vera gel @ 0.75%	5.01	5.06	5.10	5.05	5.06	51.2	49.2	45.1	42.1	46.9	2.03	2.06	2.09	2.11	2.07
Control	5.11	5.10	4.98	4.93	5.03	47.2	44.9	41.8	37.4	42.8	2.20	2.23	2.28	2.31	2.26
Mean	5.05	5.08	5.03	4.99		49.3	47.2	44.1	40.2		2.13	2.15	2.20	2.23	
$CD_{0.05}$	Treatment (T) = ns Storage (S) = 0.02 S × T = 0.07					T = 0.05 S = 0.03 S × T = 0.10					T = 0.03 S = 0.02 S × T = ns				

other treatments, except chitosan @ 0.75% and *Aloe vera* gel @ 0.75% treatments, where increase was noticed up to 45 days of storage (Table 2). After 45 days of storage, maximum acidity (5.10%) was found in fruits coated with chitosan @ 0.75% and minimum in *Aloe vera* gel @ 0.75%. A decrease in acid content during storage was due to the breakdown of acids into sugars during respiration. During storage, fruits itself utilized acids, so acid content in fruits decreased with storage (Bhattarai and Gautam, 2006). The results are in concordance with Arowora *et al.* (2013) who reported higher acid content in *Aloe vera* coated oranges as compared to the uncoated fruits during storage. Din *et al*. (2015) reported higher acidity in kinnow fruits coated with edible coatings during storage.

The vitamin-C content of fruits decreased with extension in storage period (Table 2). Fruits coated with chitosan @ 0.75% retained maximum ascorbic acid (47.15 mg 100 mL^{-1} juice) after 45 days of storage which was significantly higher than control and all other treatments. Reduction in ascorbic content during storage might be due to the oxidation of ascorbic acid into dehydro-ascorbic acid. Rokaya *et al.* (2016) reported higher retention of vitamin-C in mandarins coated with different concentrations of waxes and fungicides as compared to control during 4 weeks of storage.

A significant effect of surface coatings and storage period was observed on total sugars of lemon fruits. An increase in total sugars content was observed upto 45 days of storage in all the treatments. Mean minimum total sugars were found in chitosan @ 0.75% coated fruits, whereas mean maximum was found in control fruits (Table 2). Increase in total sugars might be due to the enzymatic breakdown of complex carbohydrates into simpler sugars during storage (Kittur *et al.,* 2001). Similarly, Shah *et al.* (2015) reported a slow increase in total sugars content of kinnow fruit coated with CMC and guar gum-based silver nanoparticle coatings during storage. It can be summarized from the results that chitosan @ 0.75% coated fruits of Baramasi lemon can be stored upto 45 days at low temperature.

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