



Natural/synthetic edible coatings in Guava

K Susmitha Reddy¹, Jatinder Singh^{2*}, Vandna Chabra³

School of Agriculture, Department of Horticulture (Agronomy), Lovely Professional University, Phagwara, Punjab, India

Abstract

This research work was carried out to evaluate the impact of some herbal/chemical materials (like leaves of neem, ber along with some edible chemical substances (Putrescine, Hydroxypropyl Methyl Cellulose {HPMC} and their combination) on storage of guava fruits concerning retainment of physio-chemical properties and enhancement of shelf life. Fresh fruit of guava were collected from Lovely Professional University, Research Farm, Phagwara, sorted into different lots and different coating material was applied by dipping technique and kept under ambient conditions. These fruits were analyzed at intervals of 3rd, 6th, 9th and 12nd days of storage. From present research experimentation, it can be concluded that ber leaf extraction has retained/improved the physico-chemical parameters like (fruit length, firmness, palatability rating, TSS, vitamin C, total sugars along with palatability rating and also minimized physiological loss in weight under ambient conditions. While in another treatment combination of ber and neem leaf has exhibited encouraging results concerning fruit diameter and least level of acidity. The outcome of present study can greatly accommodate in increasing the revenue of fruit growers and making assured guava availability throughout the year.

Keywords: guava, ambient storage, edible coatings, physio-biochemical properties and shelf life

Introduction

Guava (*Psidium guajava*) is one of India's common commercial fruit, family Myrtaceae and after mango, banana and citrus; fourth most popular crop. Being native to tropical America and can be found all over the tropics of India. It is a rich source of calcium, phosphorus vitamin C and pectin content. Because of perishable nature, guavas are sold as soon as they are harvested. Only 0.05 per cent of the harvest crop is exported to other countries because of its shorter shelf life and lack of cold refrigeration chain including infrastructure. Application of several kinds of postharvest treatments quality retention has got promising results Prasad *et al.*, (2016)^[10], but most of them are chemical in nature and thus may have health and eco issues. Use of such chemical's is discouraged by scientific communities' time to time. Moreover, in this concern monitoring laws and strict regulations are implemented by the various quality control organizations' APEDA, (2014)^[2]. When 'proven' edible coatings are applied over the surface of the fruit like commodities not only extend their marketability but also shelf life sOchoa-Reyes *et al.*, (2021)^[9]. Such edible coatings are biodegradable, improve the appearance of surface and have no worse impact towards health but on the other hand, use of chemical substances may increase the cost comparatively and may leave a residue Kumar and Kapur, (2016)^[7]. Generally speaking, nature wise these coatings may be lipid, protein, polysaccharide or resin based used in combination or alone. Several benefits of edible coatings can be listed *viz.* reducing packaging cost and wastage, extending the shelf life of fresh and minimally processed products, and protecting them from adverse environmental effects by maintaining the transfer of oxygen, CO₂, moisture in food etc. Many functional ingredients such as antioxidants, nutrients, and flavour can be added to edible coatings to improve food stability, quality, functionality, and safety and

can be applied to fruits and vegetables by dipping, spraying or brushing to create a semi-permeable membrane that suppresses respiration, controls moisture loss, and performs other functions Susmitha and Singh, (2020)^[15].

Materials and Methods

Present research work was carried out in the Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara during the year 2020-2021. Medium sized fully matured but green colour guava fruits of winter season were collected (freshly harvested) during last week of January, sorted and washed with water after cleaning fruits were treated with different prescribed chemical/and herbal substances. There were 16 treatments *viz.* T₁ (ber leaf extract 30%), T₂ (ber leaf extraction 40%), T₃ (neem leaf extraction 30%), T₄ (neem leaf extraction 40%), T₅ (ber + neem leaf extract 20% +20% each), T₆ (ber + neem leaf extract 10% + 30%, respectively), T₇ (ber + neem leaf extract 30%+ 10%, respectively), T₈ (Putrescine 1 mM), T₉ (Putrescine 2mM), T₁₀ (Hydroxypropyl Methyl Cellulose 1%), T₁₁ (Hydroxypropyl Methyl Cellulose 4%), T₁₂ (Putrescine + HPMC, 1mM and 1%, respectively), T₁₃ (Putrescine + HPMC, 1mM and 4%, respectively), T₁₄ (Putrescine HPMC, 2mM and 1%, respectively), T₁₅ (Putrescine +HPMC, 2mM and 4%, respectively), T₁₆ (control, distilled water). Treated fruits were kept under ambient conditions and observations were recorded.

Preparation of plant extracts:

Fresh leaves of neem and ber (about 250g each) were collected and blended with 500 ml of distilled water. Then 30% and 40% neem leaf extract solutions were prepared according to Sarmin *et al.*, (2018)^[11] and for combination treatments 10%, 20% and 30% each leaf extracts are prepared separately by mixing 25ml, 45ml and 75 ml of leaf extracts in 225ml, 205ml, and 175 ml of distilled water and

made final volume 500ml was made with the help of distilled water. For preparation of putrescine solution @ 1 mM and 2 mM was prepared by dissolving 0.088 gms, 0.018 gms, respectively in 500 ml distilled water. Hydroxypropyl methylcellulose (HPMC) was prepared as described by Valencia-Chamorro *et al.* (2008) [16]. An aqueous solution of HPMC 1% w/v and 4% w/v was prepared by dissolving the HPMC in distilled water at 90°C for two hours. For combination treatments, PUT (putrescine) at 1 mM and 2 mM of 250ml was added into an aqueous solution of HPMC, after the preparation of HPMC 1% w/v and 4% w/v 250ml each and made up to 500ml. Fruit length and diameter were measured from stem end to calyx end in with the help of vernier caliper and expressed in centimeters. Firmness was recorded in three guava fruits per replication at two equatorial sites to determine the penetration force by using a hand-held fruit firmness tester (FT – 327, Italy) equipped with an 8mm cylindrical stainless plunger tip Watkins and Harman, (1981) [17] and expressed as kg/cm² while TSS, acidity, vitamin C and total sugars (reducing sugars and non-sugars) were calculated using the AOAC standard procedures (2005) [1]. Physiological loss in weight was worked out by subtracting the final fruit weight from initial weight, dividing by initial weight and multiplied it with 100. Palatability rating of the fruit was recorded by removing the slices of guava fruit and tasted by a panel of five judges. Three main parameters were taken into consideration *viz.* taste (10 marks), flavor (10 marks) and general appearance (10 marks). If a certain fruit obtains a score of 25-30, it is designated as “Excellent”, similarly “Good” (20-24), “Fair” (15-19) and “Poor”, if score is below 15. Marketability of the fruits was calculated based on the visual observations along with fruit firmness, then the percentage of the marketability was estimated by dividing by the total number of fruits kept for treatment, multiplied with 100.

Statistical Method of analysis

Data (collected observations) were analyzed statistically according to completely randomized block design (CRBD) with factorial arrangement help of OP Stat software. All the parameters were assessed at $p < 0.05$ significance level.

Results and Discussion

Physical Characters

Effect of different coating treatments on fruit length, diameter along with guava firmness have been described in Table1 under ambient storage.

Fruit Length: Various treatments have shown variable effects on (fruit length) has been as presented in Table 1. Maximum fruit length was recorded in T₂ (ber leaf extraction 40%) to the tune of 68.06 cm, followed by T₁₁ (66.82cm), whereas minimum fruit length (65.81cm) in control (T₁₆). It was interesting to note that maximum values concerning fruit length were recorded during commencement of storage. As the storage progressed guava fruit length declined and least values were observed at the end of the storage period.

Fruit diameter: Table 1 exhibited the impact of different treatments (herbal/chemical substances) on fruit diameter. Maximum fruit diameter was observed in ber + neem leaf extract 30%+ 10%, respectively (T₇) whereas minimum

diameter was observed under controlled fruits (59.94 cm). Retainment in size of guava fruits was better where coatings were done and it was due to less evaporation and improved inner physiology during growth and development which stimulated efficient utilization of several resources like nutrients, dynamic compounds etc. Moreover, Malik *et al.*, (2015) also got maximum fruit size with combination of neem 20% and newspaper while working with guava Jammu.

Fruit Firmness: Effect of various treatments on the fruit firmness is represented in Table 1. Maximum fruit firmness was retained in ber leaf extraction 40% (T₂, 6.4kg/cm²) followed by T₁₂ (5.8 kg/cm²), T₉ (5.7 kg/cm²), whereas minimum was observed in T₁₆ (4.1 kg/cm²). Fruits were recorded with higher values of firmness in the starting of storage and gradually declined till the end of storage period. In climacteric fruits, during ripening fruit firmness is normally attributed loss of turgor pressure in the cells due to water and degradation of the cell wall. Hosea *et al.*, (2017) [5] revealed that fruit firmness ranged 4.00 – 2.00 for various varieties of tomato when treated with neem leaf powder.

Marketable fruits: Maximum marketable fruit percentage observed in ber leaf extraction 40% (T₂, 87.31%) followed by T₅ (86.28%) and T₃ (82.92%), whereas minimum was observed in T₈ (70.24% fig 2). Hosea *et al.*, (2017) [5] submitted similar results while working with various cultivars of tomato fruits, treated with neem leaf powder and concluded that marketability fluctuated from 10.00- 0.00 for different cvs. of tomato and shelf life of 22.0±0.00 days and sustained quality of the fruits throughout storage.

Quality traits

Palatability Rating: Taste, flavor and general appearance (palatability rating) of guava fruits was recorded highest in T₂ treatment (ber + neem leaf extract 20% +20% each) with value of 21.58, followed by T₁ to the tune of 21.50. It was noted that palatability rating was maximum (28.00/30.00) during the 3rd day of storage while decreased to 23.33, 18.83 (6th day and 9th day, respectively) and finally it was observed as 15.00 with an average value of 22.83. Generally, we can conclude that as the storage progressed, palatability rating showed a decreasing trend. Chauhan *et al.*, (2014) [13] concluded that apples coated with neem oil (3.0%), marigold extract 30% and aloe vera gel 10.0% showed highest visual scaling, aroma or flavor and overall acceptability over uncoated fruits.

Total soluble solids: Maximum average total soluble solids (10.71⁰ brix) were observed in T₂ treatment (ber leaf extraction 40%) and content was 12.00 at 0 day of storage but it showed a declining trend with progression of storage (11.67, 0.83, 10.33 and 10.00, respectively on 3rd, 6th, 9th and 12th day). This treatment was followed by T₉ (10.33⁰ brix), whereas the least values of TSS were noted in control and T₇ (9.33⁰ brix). The inclination in total soluble solids during the preliminary phases of storage may be ascribed to the conversion of starchy substances and various polysaccharides into soluble forms of sugary materials. The consequent reduction in TSS at progressive phase was owing to the improved rate of respiration in later periods of storage consequential in its quicker consumption in the oxidation procedure through krebs cycle. Deshmukh *et al.*,

(2020) [3] concluded that fruits of Nagpur mandarin coated with 20% neem leaf extract maintained the maximum total soluble solids (14.08 o Brix) over uncoated fruits.

Physiological loss in weight: As the storage period increased the loss in weight increases in all the treatments. During the storage period the lowest physiological loss in weight was observed in ber leaf extraction 40% (7.45%), T₁ (8.51%) and T₃ (8.65%), while PLW was highest in control treatment (13.58). Two main vital plant processes are linked with PLW activity, are moisture evaporation and respiration activity which takes place through the surface. PLW has different values at different locations and the same happens with the respiration process as it depends from species to species. Above all, Sarmin *et al.*, (2018) [11] concluded similar outcomes that the mangoes treated with neem leaf extract alone and in combination with banana pulp extract, showed less PLW compared to the control.

Biochemical traits

Acidity: Table 2 revealed acidity of guava fruits that decreases with increase in storage period regardless treatment. Minimum acidity (1.07%) was recorded in T₇, where the acidity was 1.47%, 1.22%, 0.96% and 0.64%, respectively on the 3rd, 6th, 9th and 12th day during storage. This treatment was followed by ber leaf extraction 40% (T₂) with an average value of (1.10%). This might be due to the utilization of organic acids for respiration and utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Jhalegar *et al.*, 2015) [6]. Deshmukh *et al.*, (2020) [3] also recorded improved retention in titratable acidity content in neem leaf extract followed by tulsi leaf extract in Nagpur mandarin.

Vitamin C: Generally, vitamin C content decreased under all the treatments with the advancement of storage period (table 2). The maximum vitamin C was found in ber leaf extraction 40% (T₂, 237.10 mg/10g pulp) followed by T₈, (233.28 mg/ 10g pulp) and T₃ (232.80 mg/ 10g pulp), whereas minimum in controlled fruits. Highest vitamin C value (247.07) was observed on the 3rd day of storage and the lowest value (208.90) on the 12th day. During experimentation, it was found that ascorbic acid (vitamin C) content declined at a slower rate in treated fruits in comparison to untreated one. Reason behind this phenomenon was ineffective penetration of oxygen within the fruit that failed to cause oxidative breakdown of organic acids *viz.* ascorbic acid. Shrestha *et al.*, (2018) [12] observed that the mangoes treated with 50% concentration of neem leaf extract, retained the maximum vitamin C content coatings.

Total sugar: Table 3 revealed that total sugars in guava were fairly low at harvest stage and increased during storage and reached maximum value and followed by further decline. Maximum total sugar content was found in ber leaf extraction 40% (T₂, 7.27) followed by T₉ and T₁, whereas, it was minimum in control (6.93). During studies highest total sugar (7.44) was observed on 6th day and lowest (6.61) on 12th day. During storage, enzymatic degradation of complex carbohydrates in the cell wall structure into simpler sugars resulted in an increase in total sugars and reducing sugars Deshmukh *et al.*, (2020) [3].

Reducing sugar: Maximum reducing sugar was found in ber leaf extraction 40% to the tune of 3.42 followed by T₉ and T₁. While it was minimum in control (3.16). Table 3 explained that reducing sugar of guava increased with increase in storage days up to 6th day and then declined. Highest reducing sugar (3.57) was observed on 6th day and lowest (2.94) on 12th day. According to the results, up to the sixth day, there is a significant increase in reducing sugars. This may be due to the accumulation of starch into sugars, which then began to degrade as a result of the degradative process. It was observed that when bananas were treated with hot water at 45°C for 2 minute +20% neem leaf extract, retained highest reducing sugars over controlled fruits Siddiqua *et al.*, (2018) [14].

Conclusion

Best results were obtained in ber leaf extraction 40% (T₂) treatment. In this treatment, fruits were well retained as improved physical properties like fruit length (67.34 cm), firmness (6.4kg/cm²) and bio chemical properties like TSS (10.71 brix), vitamin C (237.10 mg/10 g of pulp), total sugars (7.27) along with non-reducing sugars (2.42) were retained up to their best. Above all, this treatment proved to be best for minimization of physiological loss of weight which was a prime concern of this research. It was interesting to note that treatment T₇ (combination of ber and neem leaf extract 30%+10 %) showed minimum level of acidity in stored fruits and also retained the highest fruit diameter (63.02 cm).

Future guidelines

Extraction of ber leaf @ 40% has exhibited promising results. In literature no reference about use of ber leaf extract coating is available. For improved and advanced studies, characterization should be done and concentration of above said extract, should be varied and its combination with different plant growth regulators especially salicylic acid, should be tried under varied storage conditions.

Table 1: Effect of edible coatings on length, diameter and fruit firmness of guava fruit

Treatments	Length (cm)					Mean	Diameter (cm)					Mean	Fruit firmness (kg/ cm-2)				Mean
	0 Day	3 Day	6 Day	9Day	12Day		0 Day	3 Day	6 Day	9Day	12Day		3 Day	6 Day	9Day	12Day	
T ₁	67.25 b	66.43 b	64.10 c	62.56c	62.43 b	64.55	62.84 c	62.31 c	60.50 c	59.14 b	56.88 c	60.33	7.60	6.10 c	3.70	1.50 b	4.70
T ₂	70.06 a	69.64 a	68.20 a	66.70 a	65.70 a	68.06	64.26 b	63.86a	64.67 a	61.00 a	60.00 a	62.76	10.20 a	7.90 a	5.30 a	2.20a	6.40
T ₃	67.94 b	67.04 b	64.89 b	63.50 b	62.10 b	65.09	63.38 b	62.88 b	61.65 c	59.63 b	58.43 b	61.19	7.80	6.60 c	4.90 a	2.00 a	5.30
T ₄	68.68 b	68.00 b	66.38 a	63.95 b	61.42 c	65.69	64.72 a	64.20 a	62.81 b	60.61 a	58.86 a	62.24	8.70 c	7.00 c	4.00	2.10 a	5.40
T ₅	68.62 b	67.68 b	66.54a	64.66 a	62.92 b	66.08	63.89 b	63.09 b	62.20 b	60.18 b	57.89 b	61.45	6.40	5.90	4.90 a	2.00 a	4.80
T ₆	67.20 b	69.49 a	67.71a	64.81 a	63.25 b	66.49	64.88 a	64.20 a	63.07 b	61.47 a	59.53 a	62.63	7.60	6.50c	4.90 a	2.00 a	5.30
T ₇	69.22 a	68.96 a	67.79 a	64.84 a	61.61 c	66.49	65.73 a	65.19 a	63.82 a	61.45 a	58.90 a	63.02	7.60	6.10 c	4.90 b	2.10 a	5.20
T ₈	70.73a	69.98 a	67.79 a	64.12 b	60.39 c	66.6	65.89 a	65.14 a	63.96 a	60.99 a	57.65 b	62.72	9.60 b	7.30 b	3.50	1.80 a	5.60

T ₉	69.12 a	68.41 a	67.32 a	65.24 a	58.98	65.81	65.08 a	64.30 a	63.28 b	61.35 a	58.06 b	62.41	9.90 a	7.50 b	3.40	2.10 a	5.70
T ₁₀	68.91 a	68.21 a	66.12 b	65.01 a	61.70 c	65.99	65.02 a	64.40 a	62.54 b	60.91 a	57.05 c	61.98	9.20 c	6.90 c	2.50	1.40 c	5.00
T ₁₁	70.00 a	69.26 a	68.13 a	64.09 b	62.64 b	66.82	65.35 a	64.52 a	62.56 b	61.84 a	58.00 b	62.45	8.50 c	6.20 c	3.20	1.90 a	4.90
T ₁₂	68.78 b	68.05 b	66.41 a	64.37 b	60.91 c	65.7	64.48 b	63.77 b	62.35 b	62.02 a	57.79 b	62.08	9.70 b	7.50 a	4.10 c	2.00 a	5.80
T ₁₃	67.22 b	66.36 b	64.88 b	60.31 a	60.95 c	63.94	63.84 b	62.97 b	61.52 c	59.68 b	57.59 b	61.12	8.80 c	6.50 c	2.40	1.10 c	4.70
T ₁₄	68.22 b	67.45 b	65.91 b	63.74 b	64.20 a	65.91	63.97 b	63.29 b	61.23 c	60.44 b	57.87 b	61.36	8.70 c	6.70 c	3.40	1.70 b	5.10
T ₁₅	70.57 a	69.89 a	67.74 a	63.27 b	60.31 c	66.36	63.90 b	63.17 b	61.37 c	59.39 b	57.70 b	61.11	8.20	6.40 c	3.30	1.60 b	4.90
T ₁₆	66.03 c	65.22 c	64.51 b	63.89 b	56.87	63.3	63.02 c	62.08 c	61.31 c	59.76 b	53.52	59.94	8.10	5.90	1.50	0.80	4.10
Mean	68.66	68.13	66.53	64.07	61.65	65.81	64.39	63.71	62.43	60.62	57.86	61.80	8.50	6.70	3.70	1.80	5.20
0 day																	10.8

C.D. (p ≥ 0.05) Treatment 1.826, Storage days NS Treatment 1.388, Storage days NS Treatment 0.41, Storage days 0.20

Table 2: Effect of edible coatings on total soluble solids (TSS), acidity and vitamin C content of guava fruit

Treatments	TSS (° Brix)				Mean	Acidity (%)				Mean	Vitamin C (mg/100g pulp)				Mean		
	3 Day	6 Day	9Day	12Day		3 Day	6 Day	9Day	12Day		3 Day	6 Day	9Day	12 Day			
T ₁	11.67 a	10.00 c	9.83 b	9.50 b	10.25	1.54 a	1.34 a	1.02 b	0.77 a	1.17	245.90 b	239.37 b	230.20	215.57	232.76		
T ₂	11.67 a	10.83 a	10.33 a	10.00 a	10.71	1.60 a	1.34 a	0.90 c	0.58	1.10	247.07 a	241.70 a	235.17 a	224.47 a	237.10		
T ₃	11.17 b	10.33 b	10.00 a	9.50 b	10.25	1.54 a	1.28 b	1.02 b	0.77 a	1.15	245.53 b	238.73 c	229.43	217.50	232.80		
T ₄	10.50 b	10.00 c	9.67 b	9.00 c	9.79	1.47 b	1.28 b	1.02 b	0.70 b	1.12	244.90 b	236.27	225.33	213.57	230.02		
T ₅	10.00 c	9.67 c	9.00	8.50	9.29	1.60 a	1.41 a	1.15 a	0.77 a	1.23	243.50	235.57	224.43	214.20	229.43		
T ₆	10.50 b	10.00 c	9.50 c	9.00 c	9.75	1.47 b	1.34 a	1.09 a	0.83 a	1.18	244.83 c	236.63	227.60	219.03	232.03		
T ₇	9.83 c	9.50	9.33 c	8.67	9.33	1.47 b	1.22 c	0.96 c	0.64 c	1.07	247.23 a	241.53 a	232.60 c	217.53	234.72		
T ₈	11.17 b	10.83 a	9.67 b	8.83 c	10.13	1.54 a	1.34 a	1.09 a	0.77 a	1.18	245.70 b	237.33	229.33	220.73	233.28		
T ₉	11.17 b	10.67 a	10.17 a	9.33 b	10.33	1.54 a	1.28 b	1.00 b	0.64 c	1.11	244.40 c	236.87	229.00	217.77	232.01		
T ₁₀	10.67 b	10.50 a	9.83 b	9.00 c	10.00	1.60 a	1.41 a	1.02 b	0.77 a	1.20	242.57	234.37	223.63	211.07	227.91		
T ₁₁	10.83 b	10.33 b	9.83 b	9.00 c	10.00	1.47 b	1.28 b	1.02 b	0.70 b	1.12	243.70 c	236.20	226.83	212.90	229.91		
T ₁₂	10.33	10.00 c	9.33 c	8.83 c	9.63	1.60 a	1.41 a	1.15 a	0.83 a	1.25	245.37 b	237.70	227.87	215.27	231.55		
T ₁₃	11.00 b	10.50 a	9.50 c	8.83 c	9.96	1.54 a	1.28 b	1.02 b	0.77 a	1.15	245.43 b	236.93	225.23	214.57	230.54		
T ₁₄	10.83 b	10.50 a	10.17 a	9.33 b	10.21	1.54 a	1.22 c	0.96 c	0.77 a	1.12	243.27	234.73	224.17	215.33	229.38		
T ₁₅	10.83 b	10.33 b	9.83 b	9.00 c	10.00	1.54 a	1.34 a	1.02 b	0.70 b	1.15	244.83 c	236.47	224.73	213.60	229.91		
T ₁₆	9.83 c	9.50	9.33 c	8.67	9.33	1.60 a	1.34 a	1.02 b	0.70 b	1.17	241.93	234.70	221.23	208.90	226.69		
Mean	10.75	10.22	9.71	9.06	9.93	1.54	1.32	1.03	0.73	1.16	244.76	237.19	227.30	215.75	231.25		
0 day			12					1.73					249.5				

C.D. (p ≥ 0.05) Treatment 0.41, storage days 0.20 Treatment 0.075, storage days 0.037 Treatment 1.183, storage days 0.591

Table 3: Effect of edible coatings on reducing sugars and total sugars of guava fruit

Treatments	Reducing sugars (%)					Total sugars (%)				
	3 Day	6 Day	9Day	12Day	Mean	3 Day	6 Day	9Day	12Day	Mean
T ₁	3.33 a	3.47 b	3.38 a	3.25 a	3.36	7.14 a	7.44 a	7.27 b	6.98 b	7.21
T ₂	3.38 a	3.57 a	3.42 a	3.29 a	3.42	7.18 a	7.49 a	7.35 a	7.06 a	7.27
T ₃	3.33 a	3.42 c	3.33 b	3.25 a	3.33	7.10 b	7.30 c	7.23 b	6.98 b	7.15
T ₄	3.29 b	3.42 c	3.29 c	3.09	3.27	7.06 b	7.23	7.18 c	6.79	7.07
T ₅	3.25 c	3.38	3.29 c	3.25 a	3.29	7.02 c	7.30 c	7.18 c	6.94 b	7.11
T ₆	3.29 b	3.52 a	3.33 b	3.13 c	3.32	7.06 b	7.27 c	7.14 c	6.87 c	7.08
T ₇	3.33 a	3.47 b	3.38 a	3.21 b	3.35	7.06 b	7.35 b	7.27 b	6.94 b	7.16
T ₈	3.25 c	3.42 c	3.38 a	3.16 c	3.30	7.02 c	7.40 b	7.23 b	6.91 c	7.14
T ₉	3.33 a	3.52 a	3.38 a	3.25 a	3.37	7.14 a	7.44 a	7.30 a	6.98 b	7.22
T ₁₀	3.25 c	3.43 c	3.25 c	3.25 a	3.29	7.10 b	7.27 c	7.14 c	6.76	7.07
T ₁₁	3.25 c	3.38	3.33 b	3.16 c	3.28	7.06 b	7.30 c	7.23 b	6.91 c	7.12
T ₁₂	3.21	3.38	3.25 c	3.09	3.23	7.10 b	7.27 c	7.10	6.83	7.08
T ₁₃	3.21	3.33	3.25 c	3.05	3.21	7.06 b	7.23	7.14 c	6.79	7.06
T ₁₄	3.25 c	3.42 c	3.29 c	3.01	3.24	7.02 c	7.23	7.02	6.72	7.00
T ₁₅	3.25 c	3.38	3.21	3.01	3.21	7.06 b	7.30 c	7.06	6.76	7.05
T ₁₆	3.29 b	3.25	3.16	2.94	3.16	6.98 c	7.18	6.96	6.61	6.93
Mean	3.28	3.42	3.31	3.15	3.29	7.07	7.31	7.17	6.86	7.11
0 day			3.13					6.83		

C.D. (p ≥ 0.05) Treatment 0.05, Storage days 0.02 Treatment 0.07, Storage days 0.03

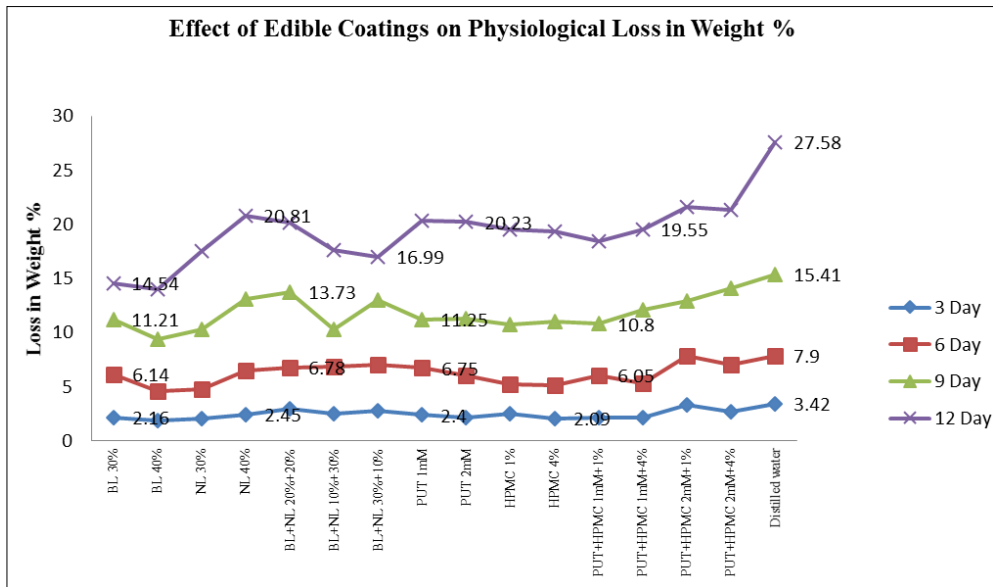


Fig 1

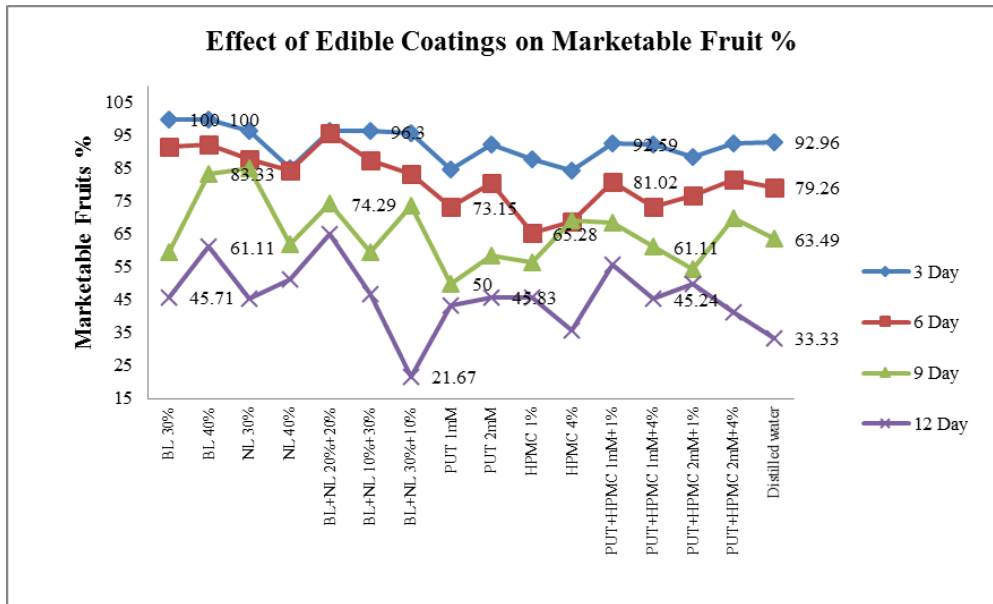


Fig 2

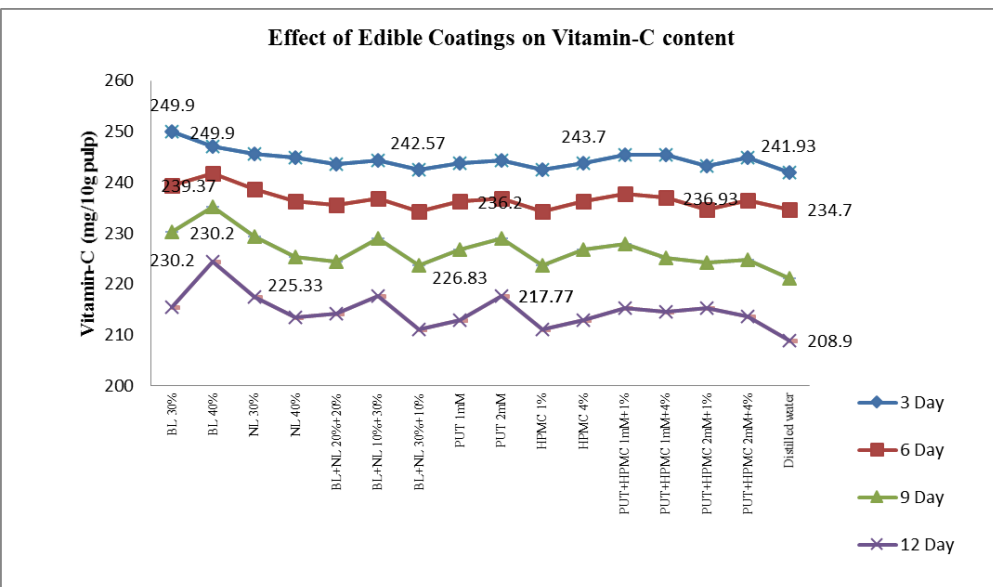


Fig 3

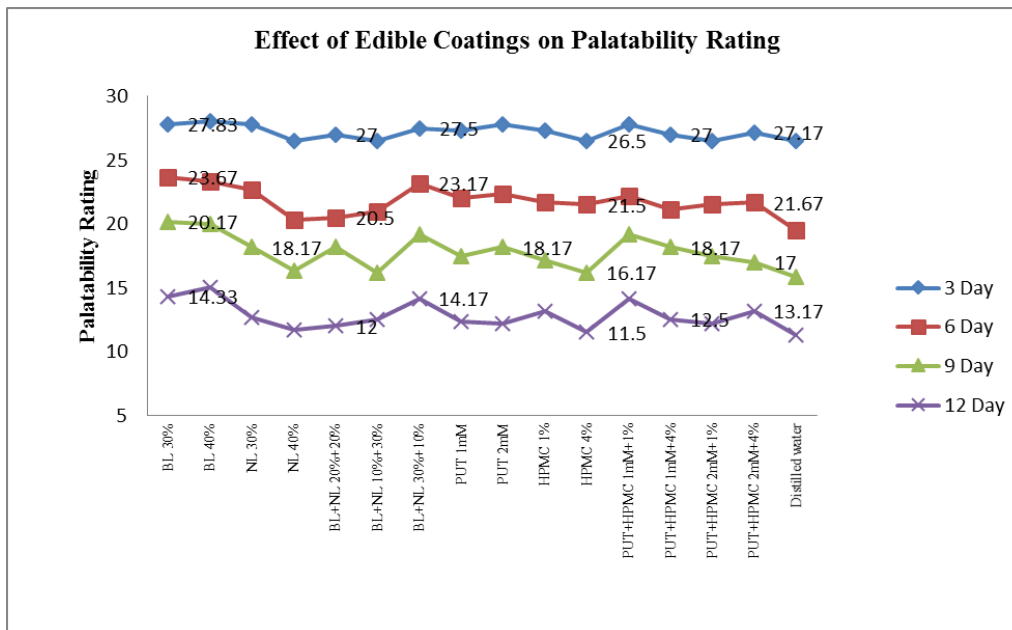


Fig 4

Abbreviations used---BL-- Ber Leaf, NL--Neem Leaf, PUT--Putrescine, HPMC-- Hydroxypropyl Methyl Cellulose

References

1. AOAC. Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists; Arlington, VA, USA, 2005.
2. APEDA RN. Agricultural and processed food products export development authority, 2014.
3. Deshmukh SD, Patil SR., & Rajvaidya RR. Storage behavior of Nagpur mandarin fruits as affected by postharvest application of plant leaf extracts under cold storage condition. *International Journal of Chemical Studies*, 2020;8(2):877-880.
4. Freitas RVDS, Souza PAD, Ferreira Senhor R., Moura CFH, & Costa FBD. Post-harvest storage of papaya fruits coated with extracts of leaves and fruits of neem. *Revista Caatinga*, 2018;31(2):290-296.
5. Hosea ZY, Liamgee K, Owoicha Terna AL, Agatsa D. Effect of Neem leaf powder on postharvest shelf life and quality of tomato fruits in storage. *International Journal of Development and Sustainability*, 2017;6(10):1334-1349.
6. Jhalegar MD, Jameel RR, Sharma, Singh SK. Effect of surface coatings on post-harvest quality of Kinnow mandarin. *Indian Journal of Horticulture*, 2015;72(2):267-272.
7. Kumar R, Kapur S. Morpholine: A glazing agent for fruits and vegetables coating/waxing. *International Journal of Science Technology & Engineering*, 2016;2(11):694-697.
8. Malik AA, Bhat A, Ahmed N, & Kaul R. Effect of postharvest application of plant extracts on physical parameters and shelf life of guava. *Asian Agri-History*, 2015;19(3):185-193.
9. Ochoa-Reyes E, Martínez-Vazquez G, Saucedo-Pompa S, Montañez J, Rojas-Molina R, Leon-Zapata MAD *et al.* Improvement of shelf-life quality of green bell peppers using edible coating formulations. *Journal of Microbiology, Biotechnology and Food Sciences*, 2021:2448-2451.
10. Prasad K, Sharma RR, Srivastav M. Postharvest treatment of antioxidants reduces lenticel browning and improves cosmetic appeal of mango (*Mangifera indica L.*) fruits without impairing quality. *Journal of Food Science and Technology*, 2016;53(7):2995-3001.
11. Sarmin RA, Khan SAKU, Fatema K and Sultana S. Effect of neem leaf and banana pulp extracts on shelf life and quality of mango (*Mangifera indica L.*). *Journal of Bangladesh Agricultural University*, 2018;16(3):343-350.
12. Shrestha S, Pandey B, Mishra BP. Effects of different plant leaf extracts on postharvest life and quality of mango (*Mangifera indica L.*), *International Journal of Environment, Agriculture and Biotechnology*, 2018;3:2.
13. Chauhan S, Gupta KC and Agrawal M. Efficacy of natural extracts on the storage quality of Apple. *International Journal of Current Microbiology and Applied Sciences*, 2014;3(3):10-11.
14. Siddiqua M, Khan SAKU, Tabassum P and Sultana S. Effects of neem leaf extract and hot water treatments on shelf life and quality of banana. *Journal of Bangladesh Agricultural University*, 2018;16(3):351-356.
15. Susmitha Reddy K and Jatinder Singh. Edible Coatings in Fruits - A Review. *International Journal of Current Microbiology and Applied Sciences*, 2020;9(11):2953-2969.
16. Valencia-Chamorro SA, Palou L, del Río MA and Pérez-Gago MB. Inhibition of *Penicillium digitatum* and *Penicillium italicum* by hydroxypropyl methylcellulose-lipid edible composite films containing food additives with antifungal properties. *Journal of Agricultural and Food Chemistry*, 2008;56(23):11270-11278.
17. Watkins C, Harman J. Use of penetrometer to measure flesh firmness of fruit. *Orchardist of New Zealand*, 1981;54(1):14-16.