Current Journal of Applied Science and Technology

40(19): 36-47, 2021; Article no.CJAST.72343
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Impact of Chitosan and Alginate Based Edible Coating on Shelf Life and Postharvest Quality of Kinnow Mandarin

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i1931454
Editor(s):
(1) Prof. Qing-Wen Wang, Shanghai University, China.
Reviewers:
(1) Purabi Banerjee, Bidhan Chandra Krishi Viswavidyalaya, India.
(2) Kumari Sita, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72343

Original Research Article

Received 05 June 2021
Accepted 10 August 2021
Published 16 August 2021

ABSTRACT

The Kinnow mandarin (*Citrus nobilis x Citrus deliciosa*) was highly perishable citrus fruit, after harvest the quality of Kinnow fruits undergoes rapid changes due to the sharpen rate of ripening, respiration and transpiration. Edible coating formulation of chitosan (0.5%, 1%, and 1.5%), alginate (0.5%, 1%, and 1.5%), composite formulation of chitosan and alginate (0.5% chitosan+0.5% alginate & 1% chitosan+0.5% alginate) were evaluated in relation to enhancing and improving shelf life and postharvest quality of Kinnow respectively. Kinnow fruit shelf life efficiency was evaluated on the basis of postharvest quality parameters like weight loss percent, firmness, pH, total soluble solids, total acidity and ascorbic acid from 6^{th} to 24^{th} day during incubation at ambient room temperature (20-25°C). The results signifies that the Kinnow fruit coated with alginate 1% have higher shelf life efficiency up to 24 days; however chitosan 1% coated fruits shown to have higher ascorbic acid retention as compared to untreated Kinnow fruits. The principal component analysis of different quality parameters for studied treatment shows 65.7 % variation in component 1 and 16.6% variation in component 2. PCA plot elucidate that coated fruit samples were high positive values and completely different from untreated samples.

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Keywords: Kinnow; Edible coating; chitosan; alginate; principle component analysis (PCA).

1. INTRODUCTION

Kinnow a hybrid between King (*citrus nobilis*) and Willowleaf (*Citrus deliciosa*) mandarins and majorly cultivated in Punjab with respect to area and production [1]. Mandarins, loose skinned citrus fruits, constitute a commercially important group of fruit trees and have high economic value in India. Punjab state produces about 9, 88,633 MT of Kinnow from an area of 45,851 ha having productivity of 21.6 MT/ha. The area for Kinnow cultivation has been intensified in recent years due to wider adaptability and high economic values. The significant loss extent of postharvest loss [2-3] was up to 35-40% and major factor responsible for such losses are inadequate postharvest management practices. Ample supply chains of Kinnow market are generally affected by improper postharvest practices and storages which adversely impact the Kinnow market economy.

Several postharvest technologies have been introduced to reduce the deterioration of citrus fruits to minimize the losses [4-5]. However the most common and economic technologies implemented are coating application [6-7]. It has been evidenced that at room temperature storage, fruit coating aids to increase shelf life and reduce weight loss in oranges by the principle of controlling moisture and exchanging gas. Mandarin tends to deteriorate and deformed during prolonged room temperature storage and prevalence of fungal rot during such conditions are high. One such instance reported by Singh et al. [8] that about 20-30% Kinnow mandarin harvested fruits are lost before consumption due to improper handling. Dehydration and proliferation of microbial contaminants can be prevented by edible or biodegradable coating by polysaccharides, proteins, lipids, or their mixtures [9]. Moreover the major advantages of edible films are they are consumable along with fruit and it improves quality and shelf life of fruit by amending antioxidant and antimicrobial properties. The present study optimizes composite edible coating of chitosan and alginate on Kinnow fruits at room temperature to extending shelf life and improves postharvest quality.

2. MATERIALS AND METHODS

2.1 Plant Material and Postharvest Handling

The Kinnow fruits were collected from Horticulture Research Centre, Punjab Agricultural University orchard for experiment. The fresh Kinnow fruits of uniform size, disease and bruise free were picked randomly from all the four directions of the plants with the help of secateurs, at physiological mature stage. The fruits were collected in plastic crates and shifted to postharvest laboratory; the fruits were sorted and graded, washed with chlorine solution (100 ppm).

2.2 Chitosan and Alginate Coating Preparation

Chitosan 75-85% deacetylated of viscosity 200-800cP was purchased from Sigma–Aldrich (Jalandhar). Different chitosan proportion along with 0.7% (v/v) of acetic acid was mixed with sterile water to form 0.5%, 1.0% and 1.5% (w/v) solutions. Similarly 0.5, 1, 1.5 g of sodium alginate were mixed with 100 ml sterile water to form 0.5, 1, 1.5% (w/v) alginate coating by mechanical shaking with magnetic stirrer for two hour.

Table 1. Effect of different coating based treatments on physiological loss in weight percent (%) of Kinnow fruits. The mean followed by different letters are significantly different at p<0.05, according to DMRT (Duncan's multiple range test) for separation of means

Treatments		Day 6	Day 12	Day 18	Day 24	Mean
T0	Control	5.13	6.62	7.19	11.30	7.56
T1	Alginate (0.5%)	3.33	4.99	7.64	10.77	6.68
T2	Alginate (1%)	1.97	2.76	3.14	5.68	3.38
T3	Alginate (1.5%)	2.35	7.16	7.40	10.25	6.79
T4	Chitosan (0.5%)	5.09	3.81	3.44	8.58	5.23
T5	Chitosan (1%)	4.34	6.72	7.69	9.37	7.03
T6	Chitosan (1.5%)	4.09	4.18	4.84	10.12	5.80
T7	Chitosan + Alginate (0.5+0.5%)	1.90	6.69	9.49	10.19	7.06
T8	Chitosan + Alginate (1+0.5%)	2.11	6.11	7.04	8.04	5.82

2.3 Experimental Design

Methods of Chien et al. [10] were adopted for edible coating. Formulation of chitosan (0.5%, 1%, and 1.5%), alginate (0.5%, 1%, and 1.5%), composite formulation of chitosan and alginate (0.5% chitosan+0.5% alginate & 1% chitosan+0.5% alginate) were coated. The fruits were dipped in the coating solution for 2 min and then they were transferred to a container in order to drain off the excess coating from the fruits surface. The fruits were air dried for 2-3 hrs at room temperature and stored at room temperature along with the untreated control fruits. The experiment was planned with 9 treatments i) T1= Control with no coating, ii) T2= Alginate (0.5%) coating, iii) T3= Alginate (1%) coating, iv) T4= Alginate (1.5%), v) T5= Chitosan (0.5%) coating, vi) T6= Chitosan (1%) coating, vii) T7= Chitosan (1.5%) coating, viii) T8= Chitosan + Alginate (0.5+0.5%) coating, ix) T9= Chitosan + Alginate (1+0.5%) coating. With 9 treatments and 3 replications factorial Complete Randomized Design (CRD) was applied to record weight loss, firmness, pH, total soluble salts, total acidity and ascorbic acid content change from 0-24 days of edible film coated fruits stored at ambient temperature (18-25^{o}C).

2.4 Statistical Analysis

The overall postharvest quality parameters (pH, firmness, weight loss percent, total soluble solids, total acidity and ascorbic acid concentration) of different edible coating treatments were subjected to principal component analysis to determine the variation in treatments with the fruit quality. PCA plot were graphed by PAST software [11] version 2.14. Loading scores of different treatments were used to assess the relative distance between the treatments. Difference between mean values of postharvest quality parameters were evaluated by one way analysis of variance and component of variation with Fisher's LSD test as post-hoc tests using SPSS 16.0 (SPSS Inc., Chicago, U.S) for test of significance. Unless otherwise stated, the level of significance referred to the results was $P < 0.05$.

3. RESULTS AND DISCUSSIONS

3.1 Weight Loss

The statistical analysis indicated that treatments, storage and their interaction had no significant effect on weight loss of Kinnow fruits. The weight loss of all the treatments ranged varies from 1.90 to 11.30% (Table 1). At the storage room temperatures, the weight loss of the control was found to be more pronounced as compared to the other coated Kinnow fruits. The weight loss of the samples after 6 days was 5.13% for the control whereas the weight losses for the chitosan + alginate (0.5+0.5%) samples were 1.90 %. The weight loss then progressively increased to 6.62%, 2.76% and 3.81% for control, alginate (1%) and chitosan (0.5%) samples respectively by the 12th day.The weight loss of the samples after 18 days was 7.19% for the control whereas for the alginate (1%) and chitosan (0.5%) samples were 3.14% and 3.44% respectively. The weight loss then increased to 11.30%, 5.68% and 8.58% for control, alginate (1%) and chitosan (0.5%), samples respectively on 24th day. Treatment of chitosan + alginate (0.5+0.5%) composite coated fruits shown significantly less weight loss (1.90%) as compared to other treatments after 6 days. Treatments of alginate (1%) show least weight loss (5.68%) after 24 days followed by 8.04% in T8 [Chitosan (1%) + Alginate (0.5%)].

These results confirm that weight loss of the alginate (1%) coated samples was less when compared to the chitosan samples and control. Dong et al. [12] reported that the use of chitosan on litchi retards moisture loss which maintains the fruits weight for longer period. Nussinovitch and Hershko showed that the application of alginate coatings served as a barrier to moisture loss in garlic [13]. Similar study by NurulHanani et al. [14] suggested that chitosan edible coating were efficient postharvest methodology for improving quality and shelf life during room temperature storage by reducing weight loss. Overall chitosan was the best coating formulation as it showed good moisture barrier and gas barrier properties. This result was also supported by the previous finding that different edible coating combination with storage reduced fruits weight loss. Perez-Gago et al. [15] found that coated mandarin had lower weight loss than uncoated mandarin; indicate the effectiveness of coating as a moisture barrier.

3.2 Firmness

The result indicates that storage and interaction of storage and treatment have significant impact on firmness of Kinnow fruits. The firmness of all the treatments ranged from 0.22 to 0.51 kg/cm^2 (Fig. 1). Firmness values of the Kinnow fruits decreased, demonstrating texture softening, as the length of storage progressed for both coated and control fruits at room temperature. However, coating of fruits showed a significant beneficial effect on firmness retention, with alginate (1%) demonstrating a better effect than control at storage room temperatures. While control have lowest value after 24 days in terms of firmness (0.3 kg/cm^2) and proved inefficient (Fig. 1). The effect of Chitosan coating on fruit firmness was non-significant, but small variation might be due to uniform and even coating of alginate, which might reduce the respiration and transpiration. The firmness of the alginate (1%) coated ones reduced from 0.47 kg/cm^2 on day 6 to 0.42 kg/cm^2 on day 24 showing no sign of spoilage, similarly the firmness of the Chitosan (1%) coated sample reduced from 0.4 kg/cm^2 on day 6 to 0.32 kg/cm^2 on day 24 . The firmness of the control reduced from 0.44 kg/cm^2 on day 6 to 0.30 kg/cm^2 on day 24. Munoz [16] also reported that Chitosan based coatings delayed changes in firmness compared to untreated strawberries.

3.3 pH

The statistical analysis indicated that treatments, storage and their interaction had a less significant effect on pH of Kinnow fruits. The pH of the treated Kinnow juice was found to be gradually increased during the course of storage as shown in (Fig. 2). The pH of all the treatments ranged from 3.05 to 4.15. The final value of pH for uncoated Kinnow fruits was 4.15, while that coating of alginate (1%) was shown 3.72 less increased compared to the control after 24 days. It was found that coated Kinnows had higher value at the end of storage period; this was due to the semi-permeability created by alginate and chitosan coatings on the surface of the Kinnow fruit, which might have modified the internal atmosphere i.e. endogenous O_2 and CO_2 concentrations in the fruit, thus retarding ripening [17]. The pH of the alginate and chitosan coated samples was lesser than the control Kinnow fruits at the room temperatures. The edible composite coatings had protective effect of reducing the ripening rate of the fruit there by maintaining the acidity of the fruit than the control. The pH of the alginate (1%) coated samples increased gradually from 3.05 on day 6 to 3.72 on day 24, which shown the best results. The pH of the alginate (1.5%) samples increased from 3.15 – 3.78 on day 24 ; which also shown the best results as compared to control, whereas the pH of the control increased steadily from 3.6 on day 6 to 4.15 on day 24. Similar results were noticed at room temperature for coated and uncoated samples but the rate of pH increased was more than the refrigerated storage temperatures of 4°C and 12°C. Titratable acidity and pH remained unchanged until day 9 when minimally processed mangoes were coated with chitosan (0.25% w/v) and stored at 6°C for a period of 9 days [18].

3.4 Total Soluble Solids

TSS-Total soluble solid measured in °Brix was most imperative ripeness index of vast range of fruits. It has been observed that edible coatings lower the TSS or in other words, lowering ripening rates. The TSS increased during storage time for coated and non-coated samples at room temperatures. The TSS of the control increased steadily from 10.87°Brix to 11.86°Brix on day 12, and maintained 13.86°Brix till day 24 for control at room temperature, whereas the TSS for the alginate (1%) samples increased from 10.33°Brix to 12.0°Brix slowly and maintained till day 24. The TSS for the chitosan (1%) samples increased from 12.02°Brix to 12.28°Brix slowly and maintained till day 24 (Table 2). The mean value for TSS of coated Kinnow ranged from 10.77 to 12.78°Brix, while that of uncoated Kinnow was 12.53°Brix. Higher soluble solids in non-coated Kinnow fruits were due to dehydration and subsequent water loss, however higher TSS also represent the conversion of carbohydrates in water soluble sugars which are the major cause of fruit softening. Mitra and Ramaswamyreported that edible coatings delayed ripening has been indicated by TSS change during the experiment [19]. In an similar experiment Chien et al. [10] report that chitosan based coating improve postharvest quality however variation in chitosan content does not mediate any significant change in total soluble solid content.Interesting study by Maftoonazad and Ramaswamy reported that there fruit coated with methylcellulose and the sodium alginate has similar impact on soluble solids of peaches during storage [20].

3.5 Total Acidity

The samples coated with alginate and chitosan showed significantly lesser decrease in titratable acidity and it was greatest in the uncoated samples (Table 3). The titratable acidity of the coated samples at room temperature was more in comparison with the control. The coatings reduced ethylene production in Kinnow fruits thereby maintaining acidity in comparison with the control. But acidity of all the samples including alginate and chitosan reduced with increase in number of days of storing at room temperatures. The titratable acidity of the alginate (0.5%) coated Kinnow reduced from 1.19% to 0.80% on day 24. Similarly, the acidity of the alginate (1%) samples reduced from 1.33% to 0.96% on day 24, and acidity of the alginate (1.5%) samples reduced from 0.96% to 0.68% whereas the control samples acidity reduced rapidly from 1.44% on day 6 to 0.21% on day 24 (Table 3).

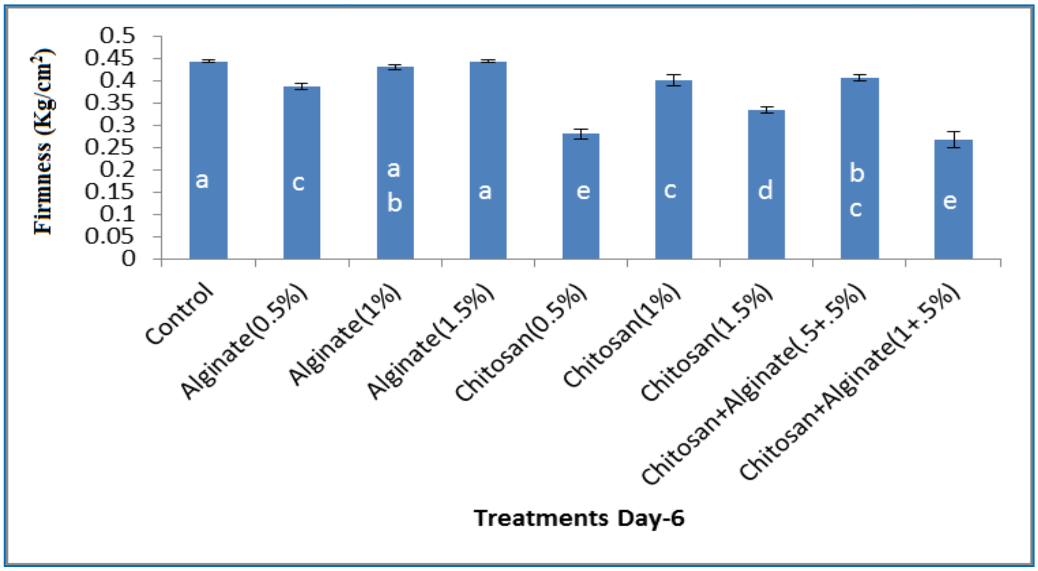

Fig. 1a. Firmness (vs) time for control, alginate and chitosan coated samples at Day 6 treatments having same alphabets are not significantly different

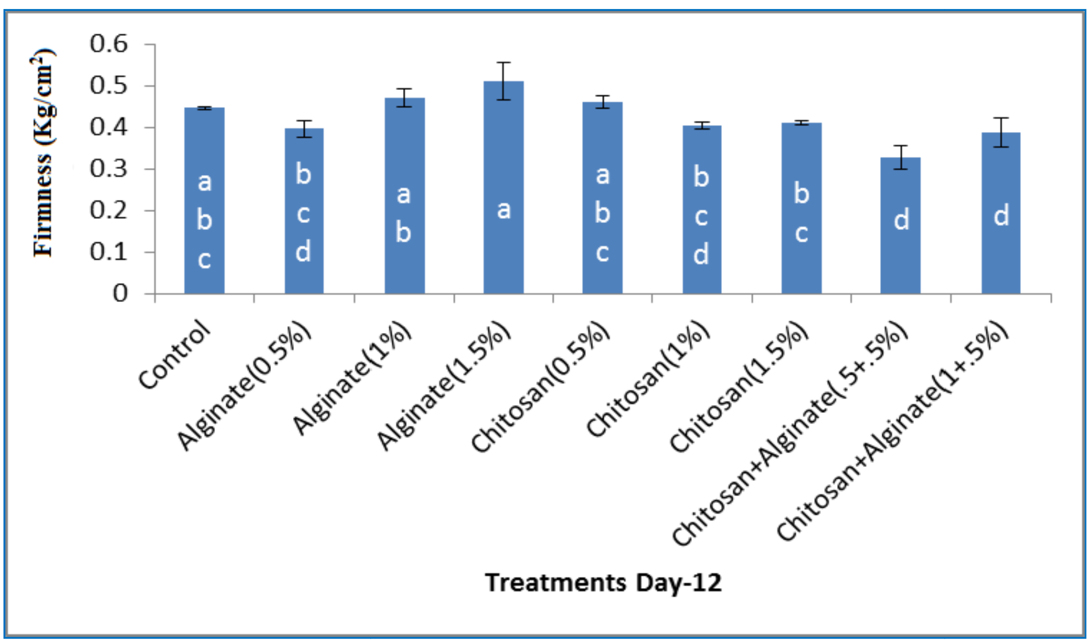

Fig. 1b. Firmness (vs) time for control, alginate and chitosan coated samples at Day 12 treatments having same alphabets are not significantly different

The titratable acidity of the chitosan (0.5%) coated Kinnow reduced from 0.97% to 0.83% on day 24. Similarly, the acidity of the chitosan (1%) samples reduced from 0.90% to 0.47% on day 24, and acidity of the chitosan (1.5%) samples reduced from 1.14% to 0.47% whereas the control samples acidity reduced from 1.44% on day 6 to 0.21% on day 24 (Table 3). The statistical analysis indicated that treatments of composite coating of chitosan and alginate and their interaction had a no significant effect on titratable acidity of Kinnow fruits. The titratable acidity of the chitosan and alginate composite (0.5+0.5%) coated Kinnow reduced from 1.19% on day 6 to 0.84% on day 24. Similarly, the acidity of the chitosan and alginate composite (1+0.5%) coated samples reduced from 1.38% on day 6 to 0.7% on day 24 . Dong et al. [12] report that coated litchi exhibits decrease in acidity and similar study by El Gaouth et al. [21] also reports decline in acidity and consequently delay in ripening.

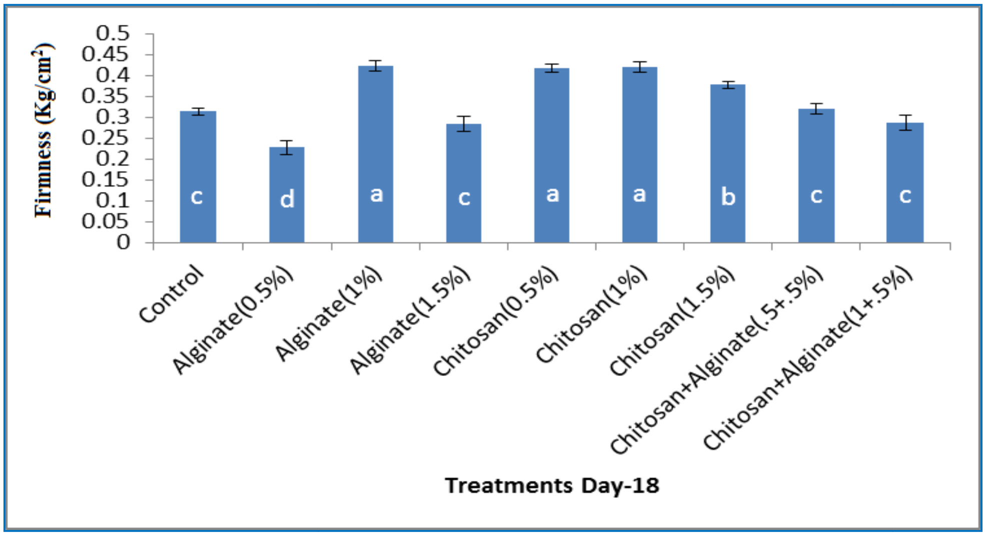

Fig. 1c. Firmness (vs) time for control, alginate and chitosan coated samples at Day 18 treatments having same alphabets are not significantly different

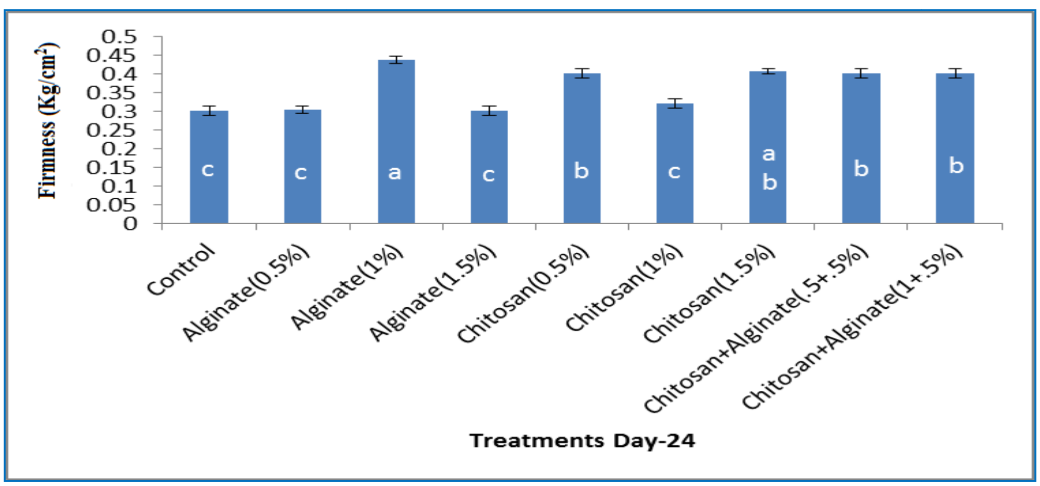

Fig. 1d. Firmness (vs) time for control, alginate and chitosan coated samples at Day 24 treatments having same alphabets are not significantly different [17]

Fig. 1. Firmness (vs) time for control, alginate and chitosan coated samples at 6, 12, 18 and 24 days of treatment.Mean values having same alphabets are not significantly different

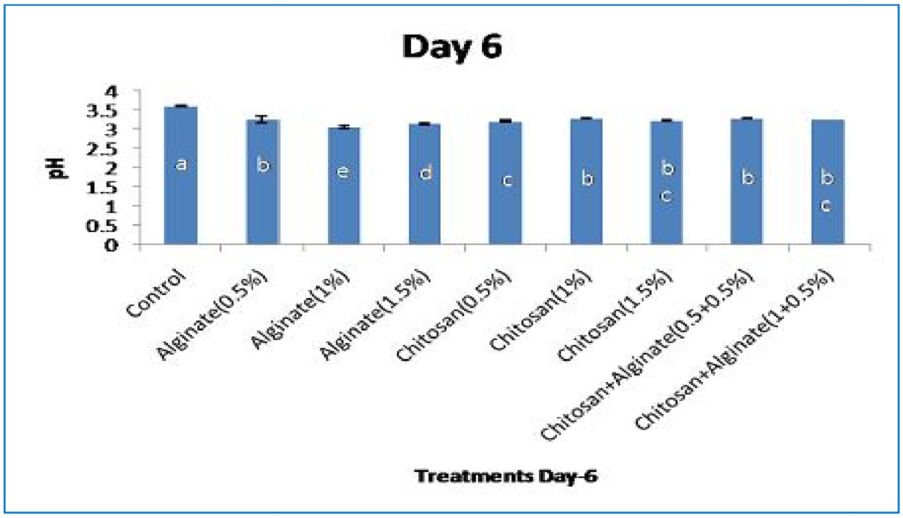

Fig. 2a. pH (vs) time for control, alginate and chitosan coated samples at Day 6 treatments having same alphabets are not significantly different

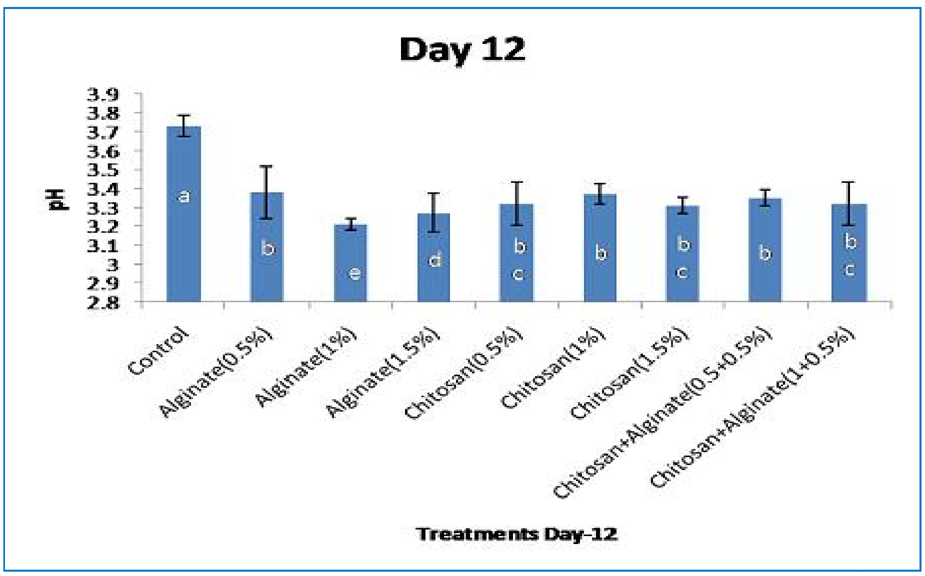

Fig. 2b. pH (vs) time for control, alginate and chitosan coated samples at Day 12 treatments having same alphabets are not significantly different

3.6 Ascorbic Acid

The statistical results for ascorbic acid content of coated Kinnow fruits presented in Table 4 indicated that ascorbic acid was significantly affected by the storage days, different treatments at storage room temperatures. The Kinnow fruits when stored without application of any coating treatment (control) exhibited the lowest ascorbic acid content (8.33mg/100 ml) as compared to the Kinnows coated with alginate (1%) and chitosan (1%) based coating which showed maximum ascorbic acid content i.e., 16.33 mg/100 ml and 19.33 mg/100 ml, respectively during storage on day 24. The Kinnow fruits treated with either alginate based coating or chitosan based coating showed no significant variation in ascorbic acid content (Table 4).The Ascorbic Acid of the alginate (0.5%) coated Kinnow reduced from 25.33 mg/100 ml to 16 mg/100 ml on day 24. Similarly, the ascorbic acid of the alginate (1%) samples reduced from 26 mg/100 ml to 16.33

mg/100 ml on day 24, and ascorbic acid of the alginate (1.5%) samples reduced from 21 mg/100 ml to 14 mg/100 ml whereas the control samples ascorbic acid reduced from 16.66 mg/100 ml on day 6 to 8.33 mg/100 ml on day 24 (Table 4). The statistical analysis indicated that treatments of composite coating of chitosan and alginate and their interaction had a no significant effect on ascorbic acid of Kinnow fruits. The ascorbic acid of the chitosan and alginate composite (0.5+0.5%) coated Kinnow reduced from 23 mg/100 ml on day 6 to 17.33 mg/100 ml on day 24, Similarly the ascorbic acid of the chitosan and alginate composite (1+0.5%) coated samples reduced from 22.66 mg/100 ml on day 6 to 16 mg/100 ml on day 24.

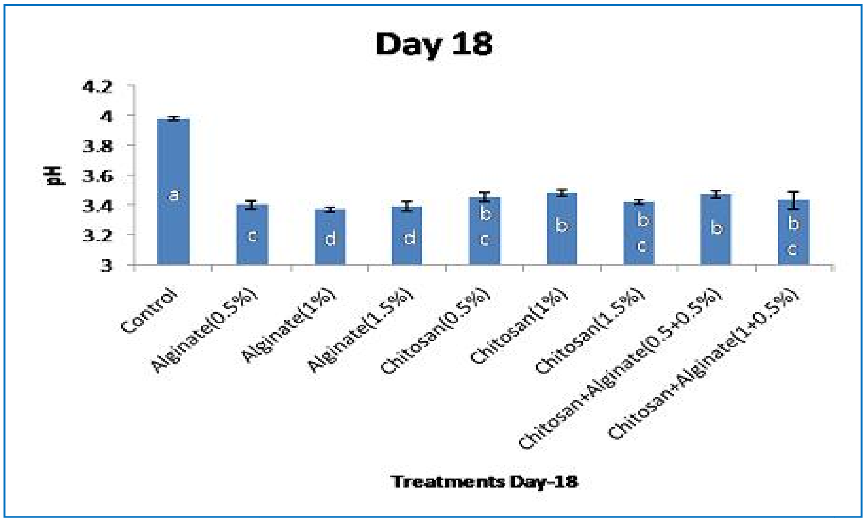

Fig. 2c. pH (vs) time for control, alginate and chitosan coated samples at Day 18 treatments having same alphabets are not significantly different

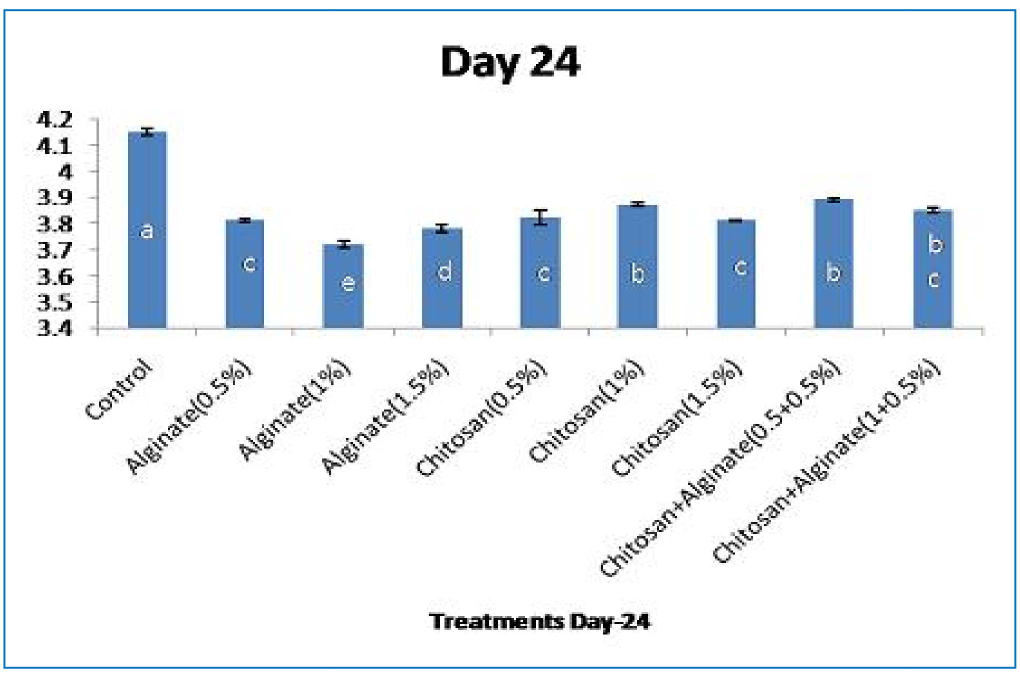

Fig. 2d. pH (vs) time for control, alginate and chitosan coated samples at Day 24 treatments having same alphabets are not significantly different

Table 2. Effect of different coating based treatments on Total soluble solid (°Brix) of Kinnow fruits. The mean followed by different letters are significantly different at p<0.05, according to DMRT (Duncan's multiple range test) for separation of means

Treatments	Day 6	Day 12	Day 18	Day 24	Mean
T0	10.87^{d}±0.2	11.86^{c}±0.11	13.53^{a}±0.37	13.86^{a}±0.11	12.53
T1	9.66^{e}±0.24	11.8^{c}±0.11	12.56^{b}±0.23	12.86^{b}±0.17	12.23
T2	10.33^{d}±0.06	11.5^{c}±0.17	11.66^{cd}±0.17	12^{cd}±0.11	11.37
T3	12.7^{b}±0.20	12.8^{b}±0.11	12.82^{b}±0.11	12.83^{b}±0.08	12.78
T4	12.2^{b}±0.11	10.06^{d}±0.06	$11.86b^{c}$±0.17	12.73^{bc}±0.17	11.71
T5	12.02^{b}±0.11	9.73^{e}±0.17	11.46^{d}±0.17	12.28^{c}±0.2	11.4
T6	11.5^{c}±0.28	9.8^{e}±0.11	11.2^{d}±0.11	10.6^{e}±0.23	10.77
T7	11.63^{c}±0.20	13^{a}±0.11	12.2^{bc}±0.11	11.66^{d}±0.24	12.12
T8	14.26^{a}±0.29	11.4^{c}±0.30	10.4^{e}±0.3	10.8^{e}±0.11	11.71

Note- T0=Control (uncoated), T1=Alginate (0.5%), T2=Alginate (1%), T3=Alginate (1.5%), T4= Chitosan (0.5%), T5=Chitosan (1%), T6= Chitosan (1.5%), T7= Chitosan + Alginate (0.5+0.5%), T8= Chitosan + Alginate (1+0.5%).

Table 3. Effect of different coating based treatments on Total Acidity (%) of Kinnow fruits. The mean followed by different letters are significantly different at p<0.05, according to DMRT (Duncan's multiple range test) for separation of means

Treatments	Day 6	Day 12	Day 18	Day 24	Mean
T0	1.44^{a}±0.01	0.996^{bc}±0.008	0.816^{d}±0.012	0.21^{f}±0.005	0.86
T1	1.19^{b}±0.005	1.17^{a}±0.014	1.12^{a}±0.005	0.803^{c}±0.014	1.07
T2	1.33^{ab}±0.05	1.10^{b}±0.008	1.01^{b}±0.047	0.963^{a}±0.006	1.1
T3	0.963^{c}±0.008	0.94^{c}±0.005	0.683^{e}±0.012	0.683^{d}±0.008	0.81
T4	0.97^{c}±0.005	0.91^{d}±0.005	0.843^{d}±0.020	0.83^{b}±0.01	0.88
T5	0.903^{d}±0.008	0.83^{e}±0.005	0.776^{de}±0.017	0.473^{e}±0.008	0.74
T6	1.14^{b}±0.005	0.84^{e}±0.005	0.68^{e}±0.011	0.473^{e}±0.008	0.78
T7	1.19^{b}±0.005	1.11^{b}±0.008	0.963^{c}±0.008	0.843^{b}±0.008	1.02
T8	1.38^{a}±0.008	1.18^{a}±0.008	0.976^{c}±0.014	0.7^{c}±0.011	1.06

Table 4. Effect of different coating based treatments on Ascorbic Acid (mg/100 ml) of Kinnow fruits. The mean followed by different letters are significantly different at p<0.05, according to DMRT (Duncan's multiple range test) for separation of means

Treatments	Day 6	Day 12	Day 18	Day 24	Mean
T0	16.66^{d}±0.33	14^{d}±0.33	11.33^{e}±0.5	8.33^{e}±0.58	12.58
T1	25.33^{a}±0.33	20.33^{bc}±0.88	18.33^{bc}±0.57	16^{c}±0.78	19.99
T2	26^{a}±0.54	22.33a±0.5	19.66^{ab}±0.88	16.33^{bc}±0.66	21.08
T3	21^{c}±0.55	18.66^{c}±0.574	16^{d}±0.23	14^{d}±0.57	17.41
T4	23^{b}±0.54	19^{c}±0.88	17.33^{c}±0.57	16^{c}±0.27	18.83
T5	23^{b}±0.881	22^{a}±1.15	20.2^{a}±0.47	19.33^{a}±0.17	21.13
T6	22.66^{bc}±0.53	22.33^{a}±0.57	19^{b}±0.88	17.6^{b}±0.88	20.4
T7	23^{b}±0.33	21^{b}±0.57	19^{b}±0.27	17.33^{b}±0.57	20.08
T8	22.66^{bc}±0.52	21^{b}±0.57	19^{b}±0.17	16^{c}±0.66	19.66

Note- T0=Control (uncoated), T1=Alginate (0.5%), T2=Alginate (1%), T3=Alginate (1.5%), T4= Chitosan (0.5%), T5=Chitosan (1%), T6= Chitosan (1.5%), T7= Chitosan + Alginate (0.5+0.5%), T8= Chitosan + Alginate (1+0.5%).

3.7 Principal Component Analysis (PCA)

The principal component analysis shows significant variation in coated fruits as compared to uncoated fruits. The positive scores has been observed in coated treatment and maximum positive score has recorded in T2 (Alginate 1% coated fruits). Individual studied parameter also signifies that alginate (1%) coating in Kinnow fruit increase the postharvest quality and shelf life. Principal component analysis shows 65.7 variations of data on axis 1 and 16.6% variation in axis 2 (Fig. 3). Treatment T1 (Alginate 0.5% coating) and T8 (Chitosan 1 % and alginate 0.5%) have similar impact on Kinnow fruit postharvest quality and shelf life. Similar to present study Marcillaet al. [22] also used PCA based on titratable acidity, soluble solid content, maturity index, to correlate different treatments.

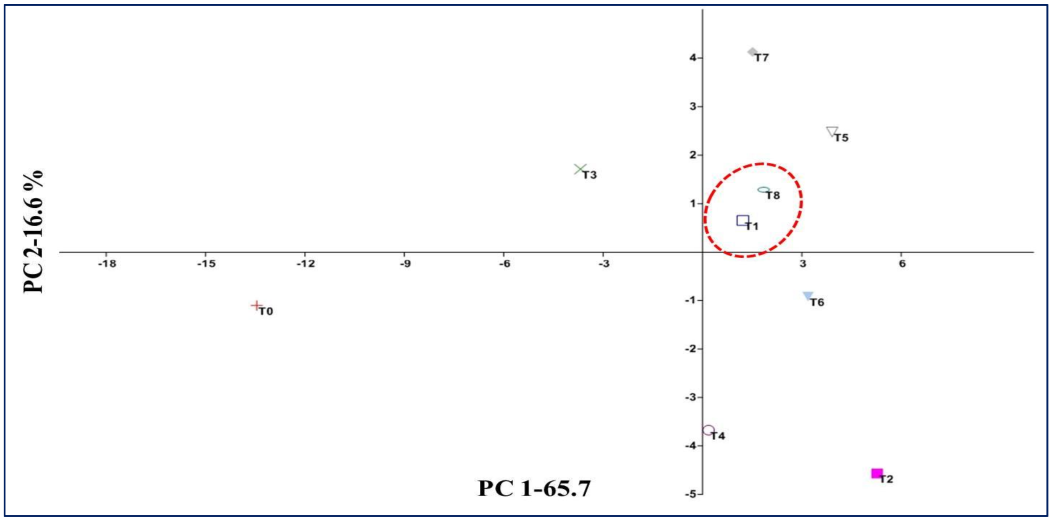

Fig. 3. PCA ordination of different postharvest quality parameters (weight loss percent, firmness, pH, total soluble solids, total acidity and ascorbic acid) for 9 different treatments. Principal component 1 represents 65.7% variation while principal component 2 represents 16.6% data variation. Shorter distances between treatments in the PCA ordination indicate high degree of similarity between them in relation to post harvest quality parameters

Note- T0=Control (uncoated), T1=Alginate (0.5%), T2=Alginate (1%), T3=Alginate (1.5%), T4= Chitosan (0.5%), T5=Chitosan (1%), T6= Chitosan (1.5%), T7= Chitosan + Alginate (0.5+0.5%), T8= Chitosan + Alginate (1+0.5%).

Fig. 4. Impact of edible coating as compared to control (uncoated) on 28th day of experiment

4. CONCLUSION

Application of alginate and chitosan coating to Kinnow fruits was shown to be beneficial in retarding the ripening process. The observations from present study suggest that coating acted as a physical barrier for the gas exchange between the fruits and the environment. While comparing all treatments, alginate (1%) showed the more significant effect on physiological weight loss percentage of Kinnow fruits while the untreated (control) & alginate (0.5%) treatments during storage showed exhibited highest weight loss (Fig. 4). Result suggest that application of alginate and chitosan coating slower the respiration rate which further reduce the softening of tissue and increased the shelf life of Kinnow fruits. The application of alginate (1%) and chitosan (1.5%) showed significant positive impact on firmness of Kinnow fruits, interestingly untreated and alginate (1.5%) treatments showed very less firmness protection on 24^{th}day from coating. Different concentration of alginate coated (1 and 1.5%) fruit samples demoed significantly lesser increase in pH; however samples treated with lesser concentration of alginate (0.5%) and higher concentration of chitosan (1.5%) have similar impact on pH. Alginate 1% coated samples are shown delay in ripening indicated by change in pH as compared to untreated Kinnow fruits. In addition the coating of alginate (1%) and chitosan (1%) on Kinnow fruits prevent the increase of total soluble solids; however in control samples soluble solids increased rapidly with respect to time. The samples coated from alginate (1%) and composite coating of chitosan + alginate (0.5+0.5%) showed the higher percent of total acidity after 24 days, as compared to control which showed steadily decreased in total acidity percent after 24^{th} day. Ascorbic acid retention in Kinnow coated with chitosan (1%), chitosan (1.5%) and alginate (1%) was very high as compared to uncoated Kinnow fruits. PCA scores signifies the best impact of T2 (Alginate 1%) on Kinnow fruit post-harvest quality and shelf life. This study recommends the alginate (1%) coating to Kinnow; however further intensive studies are required to explore the role of edible coating on postharvest quality parameters on molecular level. Our experimental results shows that coating of Kinnow with alginate 1% and chitosan 1.5% increase shelf life of the fruit and such recommendation will prevent fruit loss via microbes.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors

ACKNOWLEDGEMENT

This work was supported by Lovely Professional University, Phagwara-144411. Authors are thankful to two anonymous reviewers from Indian Agricultural Research Institute for critical reading and suggestions. Authors are also grateful to J. Jayanthi for her valuable assistance in statistical analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/72343