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Studies on Storage of Valencia Orange Fruits

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Abstract: The present investigation was carried out for two successive seasons 2012 and 2013 on Valencia orange fruit. The effect of postharvest treatments i.e. chitosan at 2%, citric acid 0.5% and malic acid 150 ppm as well as their combinations on some fruit quality parameters during cold storage at 5°C. 90-95% relative humidity, to assess the effect of treatments on weight loss %, decay, fruit firmness (Ib/inch^2), juice TSS %, juice acidity % and respiration rate. It was concluded from the results, that Valencia orange fruits treated with chitosan 2% + citric acid 0.5% + malic acid 150 ppm gave the best results during cold storage at 5°C after 90 days.

Key words: Valencia Orange · Chitosan · Malic acid · Citric acid · Storage · Fruit quality

INTRODUCTION

Orange is the most important fruit crop grown in Egypt. It ranks the first concerning both acreage and production. Valencia orange, a late orange cultivar is the predominant cultivar grown in the newly reclaimed desert land. Late harvest deteriorates the fruit quality due to heat stress. Cold storage is crucial to keep the fruits in shape. Usage of safe substances might be a solution for keeping fruit quality.

Chitosan (poly *B* (1_4) N-acetyl-D-glucosamine), a deacetylated form of chitin, is a natural antimicrobial compound. It can be obtained from crustacean shells (crabs, shrimps and crayfishes) either by chemical or microbiological processes or it can be produced by some fungi (Aspergillusniger, Mucorrouxii, penecilliumnotatum) [1, 2]. Chitosan, an N-acetylated derivative of the polysaccharide chitin, is a natural polymer with a polycationic nature, which has numerous applications in agriculture and agroindustries [3].

Chitosan is an ideal preservative coating for fresh fruit and vegetables because it has a disease-suppressive effect resulting from both physical and biochemical mechanisms. The physical properties of the polymer allow it to produce a film on the surface of treated fruit [3]. Chitosan has been successfully used as food wraps and thus maintains the quality of fruits and vegetables after postharvest [4-6]. Coating Canino apricot fruits with edible chitosan films (1& 2%) under cold storage, increased fruit weight loss (%), decay (%), TSS, total sugars and carotenoids of Canino apricot fruits with prolonging the cold storage duration [7]. Chitosan coating (0.5-2% solution) significantly reduced the respiration rate. Coating markedly reduced the ethylene production of peaches and increased the internal CO_2 and decreased the internal O_2 levels of Shinko pear. Chitosan significantly inhibited the growth of Botrytis cinerea and fungi isolated from decaying Housui pears. Chitosan-coated peaches and Shinko pears were markedly firmer and less mature at the end of storage [8]. The application of chitosan coating reduced respiration rate and weight loss of longan fruits [9]. Chitosan coating can improve the storability of perishable foods by modifying the internal atmosphere as well as decreasing the transpiration losses [10].

The main importance role of citric acid and malic acid is that they inhibit the growth of food spoilage and pathogenic microorganism [11]. Lower weight loss was steadily shown to fresh-cut pineapple treated with 1% citric acid stored at 2°C, whereas a steady increasing trend was exhibited to the other samples throughout the 2 weeks storage period [12].

Postharvest treatment of apple fruits with malic acid (0, 100 and 150 mg^{-1}), results showed significantly decreased in fruit weight loss [13].

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The main objective of the current study is to detect the effect of some safe treatments on keeping quality of Valencia orange fruits during cold storage.

MATERIALS AND METHODS

The present investigation was carried out in the postharvest laboratory of the Faculty of Agriculture Cairo University for two successive seasons (2012 and 2013) on Valencia orange fruits harvested from orchard located at El-Behera governorate, Egypt.

Fruits were harvested (at March) at mature stage according to Kader [14]. Fruits chosen for this study were uniform in size, color and weight. Fruits were immediately transported to the postharvest laboratory. Fruits with any biotic or abiotic disorders were discarded. Fruits were thoroughly washed with distilled water, air-dried, then the treatments were applied and the fruits waxed with paraffin wax. Each 210 fruits were immersed in one of the following treatments for 10 minutes.

The experiment was arranged in randomized complete blocks design with three replications, represented by 5 fruits for each and taken to assess their quality parameters.

The Treatments Were:

- Chitosan 2%.
- Chitosan 2% + Citric acid 0.5%.
- Chitosan 2% + Malic acid 150 ppm.
- Citric acid 0.5%.
- Citric acid 0.5% + Malic acid 150 ppm.
- Malic acid 150 ppm.
- Chitosan 2% + Citric acid 0.5% + Malic acid 150 ppm.
- Control. (untreated)

After treatments application, fruits of each treatment were placed in four carton boxes (one for weight loss studies, one for decay studies and two for samples that will be taken). Cartons were weighed then stored in cold storage at 5°C and 95% RH for 90 days.

Every 15 days, boxes dedicated for weight loss were weighed, boxes dedicated for decay studies were inspected and decayed fruits were counted and discarded. The following parameters were determined during cold storage:

Weight loss %, decay % according to McCarmack and Brown [15], fruit firmness (Ib/inch^2) apparatus using 5/16 Plunger, juice TSS (%) by a hand rafractometer and juice acidity (%) according to A.O.A.C [16]. Respiration rate of fruit was investigated by measuring the oxygen consumption rate [17].

Data were tabulated and statistically analyzed according to Snedecor and Cachran [18]. The mean values were compared by using the least significant differences L.S.D) test at 5% level [19].

RESULTS AND DISCUSSION

Weight Loss Percentage: Significant increases in weight loss took place during a prolonged cold storage. As for chitosan 2% + malic 150 ppm + citric 0.5% and chitosan 2% + malic 150 ppm treatments resulted in significantly the least weight loss % (Table 1). Meanwhile, control and malic 150-ppm treatments gave the highest significant weight loss in both studied seasons. On the average, significantly highest weight loss was recorded after 90 days of cold storage for both seasons.

Interaction data illustrated that chitosan 2% + malic 150 ppm + citric 0.5% gave the lowest significant weight loss % at cold storage after 90 days in both seasons. On the contrary, control treatments gave the highest weight loss % after 90 days of cold storage in both studied seasons.

Decay Percentage: On the average, significantly the lowest decay % was attained by Chitosan 2% + Malic 150 ppm + Citric 0.5% for Valencia orange fruits (Table 2). Meanwhile control treatment gave the highest decay percentage in both studied seasons. On the average significantly highest decay percentage was found after 90 days of cold storage in both studied seasons.

Interaction results showed that, Chitosan 2% + Malic 150 ppm + Citric 0.5% resulted in significantly the lowest decay percentage after 90 days in both seasons. As for control, treatment gave the highest decay percentage during cold storage after 90 days in both studied seasons.

Fruit Firmness: Firmness values were decreased with the prolonging cold storage where the lowest values were recorded after 90 days of storage. On the average, significantly the highest flesh firmness was attained by chitosan 2% + malic 150 ppm + citric 0.5% followed by chitosan 2% + malic 150 ppm treatments during cold storage (Table 3). On the other hand the control treatment gave the lowest significant values in both studied seasons.

Table 1: Weight loss (%) as affected by conducted treatments during cold storage at 5°C (2012 and 2013 seasons).

	2012 season							
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	0.00	3.93	7.20	9.63	11.60	16.40	18.89	9.67 [a]
Malic acid 150 ppm	0.00	3.90	6.50	9.77	12.83	14.37	15.37	8.96 [b]
Chitosan + malic + citric	0.00	3.70	6.97	9.60	12.07	13.03	13.60	8.42 [c]
Citric acid 0.5%	0.00	4.17	7.30	10.57	12.30	13.40	14.03	8.82 [bc]
Chitosan + malic	0.00	3.73	7.07	9.70	11.77	12.90	13.77	8.45 [c]
Chitosan + citric	0.00	4.10	7.33	10.07	12.07	12.90	13.47	8.56 [bc]
Malic + citric	0.00	4.10	7.33	10.07	12.07	12.90	13.47	8.56 [bc]
Chitosan 2%	0.00	3.50	7.27	10.40	12.27	13.33	14.07	8.69 [bc]
Mean (B)	0.00 [g]	3.93 [f]	7.23 [e]	10.11 [d]	12.28 [c]	13.93 [b]	14.89 [a]	
	2013 season							
Control	0.00	11.07	14.50	16.13	18.40	19.31	22.10	14.50[a]
Malic acid 150 ppm	0.00	10.46	13.19	15.37	17.35	18.45	19.07	13.41 [ab]
Chitosan + malic + citric	0.00	6.18	7.70	11.02	14.73	15.93	17.56	10.45 [d]
Citric acid 0.5%	0.00	8.80	12.25	14.99	16.71	19.92	20.12	13.26 [ab]
Chitosan + malic	0.00	6.55	6.80	12.60	15.60	16.80	18.72	11.01 [cd]
Chitosan + citric	0.00	9.10	10.29	15.05	17.03	17.89	18.45	12.55 [bc]
Malic + citric	0.00	7.49	12.24	15.38	17.24	18.30	19.02	12.81 [b]
Chitosan 2%	0.00	8.98	12.27	15.16	17.31	18.96	19.93	13.23 [ab]
Mean (B)	0.00[f]	8.58[e]	11.16[d]	14.46[c]	16.80[b]	18.20[ab]	19.37[a]	
LSD for 2012 season	A= 0.46		B= 0.43		AB= 1.22			
LSD for 2013 season	A= 1.63		B= 1.53		AB= 4.32			

Table 2: Decay (%) as affected by conducted treatments during cold storage at 5°C (2012 and 2013 seasons).

	2012 season							
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	0.00	0.00	0.00	5.53	5.53	9.47	15.50	4.72 [a]
Malic acid 150 ppm	0.00	0.00	0.00	3.46	4.17	6.02	14.50	4.02 [ab]
Chitosan + malic + citric	0.00	0.00	0.00	0.00	0.00	4.17	4.83	1.29 [b]
Citric acid 0.5%	0.00	0.00	0.00	0.00	5.18	8.33	13.20	3.82 [ab]
Chitosan + malic	0.00	0.00	0.00	0.00	3.70	5.53	8.90	2.59 [ab]
Chitosan + citric	0.00	0.00	0.00	0.00	4.17	4.83	5.53	2.08 [ab]
Malic + citric	0.00	0.00	0.00	0.00	4.17	8.80	10.37	3.33 [ab]
Chitosan 2%	0.00	0.00	0.00	4.73	5.53	7.33	8.33	3.71 [ab]
Mean (B)	0.00 [e]	0.00 [e]	0.00 [e]	1.72[d]	4.05[c]	6.81[b]	9.77[a]	
	2013 season							
Control	0.00	0.00	0.00	9.90	11.32	15.04	20.94	8.17 [a]
Malic acid 150 ppm	0.00	0.00	0.00	11.73	12.61	10.20	18.79	7.62 [ab]
Chitosan + malic + citric	0.00	0.00	0.00	0.00	0.00	10.20	11.42	3.09 [e]
Citric acid 0.5%	0.00	0.00	0.00	10.51	12.19	14.11	15.06	7.41 [ab]
Chitosan + malic	0.00	0.00	0.00	0.00	10.60	11.02	11.30	4.70 [d]
Chitosan + citric	0.00	0.00	0.00	0.00	10.29	12.79	15.03	5.44 [cd]
Malic + citric	0.00	0.00	0.00	0.00	11.50	15.43	17.30	6.32 [bc]
Chitosan 2%	0.00	0.00	0.00	0.00	14.21	15.90	19.91	7.15 [ab]
Mean (B)	0.00 [e]	0.00 [e]	0.00 [e]	4.02 [d]	10.34 [c]	13.09 [b]	16.22 [a]	
LSD for 2012 season	A= 3.13		B= 2.92		AB= 8.27			
LSD for 2013 season	A= 1. 33		B= 1.25		AB= 3.5			

Table 3: Fruit firmness (Ib/inch^2) as affected by conducted treatments during cold storage at 5°C (2012 and 2013 seasons

	2012 season							
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	17.20	16.57	15.35	14.95	14.70	14.38	13.83	15.28 ^{e}
Malic acid 150 ppm	17.47	16.47	16.23	16.00	15.70	15.37	15.00	16.03 ^{d}
Chitosan + malic + citric	17.50	17.23	17.17	17.03	17.00	16.83	16.77	17.22 ^{a}
Citric acid 0.5%	17.33	16.47	16.23	16.03	15.80	15.53	15.13	16.07 ^{cd}
Chitosan + malic	17.43	17.23	17.10	16.87	16.47	16.27	16.00	16.77 ^{b}
Chitosan + citric	17.53	16.90	16.73	16.47	16.13	15.90	15.77	16.49 ^{bc}
Malic + citric	16.87	16.73	16.40	16.13	15.87	15.53	15.27	16.11 ^{cd}
Chitosan 2%	17.33	16.47	16.23	16.03	15.80	15.53	15.13	16.07 ^{cd}
Mean (B)	17.28 ^{a}	16.79 ^{b}	16.46 ^{bc}	16.22 ^{cd}	15.97 ^{de}	15.70 ^{ef}	15.43 ^{f}	
	2013 season							
Control	18.20	18.00	17.40	17.20	17.00	16.80	16.00	17.23 ^{d}
Malic acid 150 ppm	18.80	18.10	18.00	17.40	17.30	16.80	16.20	17.51 ^{d}
Chitosan + malic + citric	20.40	20.40	20.20	20.00	20.20	18.20	18.50	19.70^{a}
Citric acid 0.5%	18.30	18.10	18.00	17.60	17.10	17.00	16.80	17.56 ^{d}
Chitosan + malic	20.00	20.20	19.80	19.30	18.70	18.30	17.00	19.16 ^{b}
Chitosan + citric	20.20	20.10	19.40	18.80	18.50	18.30	18.10	19.06 ^{bc}
Malic + citric	20.10	20.00	19.60	19.10	18.27	18.10	17.80	19.00 ^{bc}
Chitosan 2%	20.07	19.00	19.10	18.80	18.50	18.10	17.20	18.68 ^{c}
Mean (B)	19.61^{a}	19.24^{ab}	18.94^{b}	18.53 ^{c}	18.20 ^{c}	17.45 ^{d}	17.20^{de}	
LSD for 2012 season	A= 0.44		B= 0.41		AB= 1.17			
LSD for 2013 season	A= 0.42		B= 0.39		AB= 1.11			

Interaction results showed that, the highest firmness was due to chitosan + malic + citric treatments during cold storage after 90 days in both seasons. On the contrary, control treatment gave the least significant values after 90 days of cold storage in both studied seasons.

Total Soluble Solids: Increase occurred in TSS values with prolonging cold storage. As for the average was significantly the higher TSS content determined Control and Malic acid (Table 4) in both seasons, while the lowest TSS value was determined by Chitosan 2% + Malic 150 ppm + Citric 0.5% in cold storage in both seasons. As for interaction, in general the highest TSS content in the trial was determined in control and malic acid treatments during cold storage after 90 days in both seasons. On the other side, Chitosan 2% + Malic 150 ppm + Citric 0.5% treatment gave the lowest significant TSS after 90 days of cold storage in both studied seasons.

Total Acidity: Juice acidity decreased gradually during the storage. Data in Table (5) showed that, control treatment resulted in significantly the highest acidity followed by malic acid at 150 ppm in both seasons. Significantly, the lowest juice acidity % was attained by (Chitosan 2% + Malic 150 ppm + Citric 0.5%) during cold storage in both seasons respectively. Concerning storage period the lowest acidity was recorded after 90 days of cold storage.

The interaction data revealed that, least acidity was due to Chitosan 2% + Citric 0.5% during cold storage after 90 days in both seasons. On the contrary, control treatment gave the highest acidity after 90 days of cold storage in both studied seasons.

Respiration Rate: Significant increases in respiration rate took place during a prolonged cold storage. On the average, significantly the highest respiration rate was attained by the control during cold storage (Table 6). While the lowest respiration rate values were determined in Chitosan 2% + Malic 150 ppm + Citric 0.5%, treatment in both seasons. On the average, significantly the highest respiration rate was recorded after 90 days of cold storage.

As for interaction, in general the lowest respiration rate was determined by Chitosan 2% + Malic 150 ppm + Citric 0.5% during cold storage after 90 days in both seasons. Control treatment gave the highest respiration rate after 90 days of cold storage in both studied seasons.

In the trials carried out on cold storage of Valencia orange fruits, the weight losses were increased in line with ripening which occurred with the prolonged cold storage. Moreover, changes occurred in overall appearance and increased were observed in decay rates. Weight loss values were quite high in control fruits, the lower weight loss was obtained by Chitosan +Malic +Citric treatment compared with the control [20]. Postharvest chitosan

Table 4: TSS (%) as affected by conducted treatments during cold storage at 5oC (2012 and 2013 seasons).

	2012 season							
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	11.67	12.40	12.71	13.20	14.23	15.23	15.49	13.56[a]
Malic acid 150 ppm	11.70	12.60	12.87	13.40	14.03	14.73	15.13	13.49[a]
Chitosan + malic + citric	11.10	11.97	12.17	12.26	12.50	13.20	13.70	12.53[c]
Citric acid 0.5%	11.50	12.20	12.73	13.30	13.67	14.26	15.30	13.28[a]
Chitosan + malic	11.63	12.60	12.93	12.17	12.89	13.60	14.12	12.85[bc]
Chitosan + citric	11.97	11.50	12.47	12.90	13.33	14.20	15.20	12.94[abc]
Malic + citric	11.90	12.50	12.80	12.93	13.13	13.60	14.17	13.00[abc]
Chitosan 2%	11.90	12.63	12.90	13.23	13.53	13.73	14.12	13.15[abc]
Mean (B)	11.65 [f]	12.30[e]	12.70[de]	12.92[cd]	13.41[bc]	14.1[b]	14.65[a]	
	2013 season							
Control	13.84	14.20	14.94	15.35	16.07	16.20	16.32	15.28[a]
Malic acid 150 ppm	13.72	14.03	14.62	15.07	15.20	15.90	16.10	14.95[ab]
Chitosan + malic + citric	13.06	13.98	14.02	14.09	14.18	14.24	14.32	14.11[c]
Citric acid 0.5%	13.83	14.09	14.25	14.52	14.62	15.07	15.27	14.52[bc]
Chitosan + malic	13.73	13.88	14.04	14.14	14.26	14.38	14.54	14.14[c]
Chitosan + citric	13.63	13.81	14.07	14.18	14.53	15.06	15.12	14.34[c]
Malic + citric	13.90	13.93	14.18	14.30	14.40	14.72	15.05	14.35[c]
Chitosan 2%	13.56	14.41	14.30	14.49	15.01	15.02	15.30	14.44[bc]
Mean (B)	13.65[d]	14.00[cd]	14.30c	14.51[bc]	14.78[b]	15.07[ab]	15.25[a]	
LSD for 2012 season	A= 0.63		B= 0.59		AB= 1.66			
LSD for 2013 season	A= 0.53		B= 0.498		AB= 1.1			

Table 5: Juice acidity (%) as affected by conducted treatments during cold storage at 5°C (2012 and 2013 seasons).

	2012 season							
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	1.48	1.32	1.29	1.28	1.25	1.18	1.17	1.27 [a]
Malic acid 150 ppm	1.40	1.36	1.34	1.32	1.20	1.14	1.08	1.26 [a]
Chitosan + malic + citric	1.36	1.34	1.31	1.13	1.09	1.02	1.01	1.18 [f]
Citric acid 0.5%	1.43	1.33	1.30	1.28	1.22	1.15	1.05	1.25 [b]
Chitosan + malic	1.30	1.26	1.24	1.20	1.19	1.18	1.13	1.21 [e]
Chitosan + citric	1.30	1.28	1.25	1.21	1.20	1.19	1.12	1.22 [de]
Malic + citric	1.30	1.25	1.28	1.26	1.22	1.15	1.12	1.23 [d]
Chitosan 2%	1.36	1.32	1.28	1.25	1.22	1.16	1.12	1.24 [c]
Mean (B)	1.35 [a]	1.31 [b]	1.29 [c]	1.24 [d]	1.20 [e]	1.15 [f]	1.10 [g]	
	2013 season							
Control	1.50	1.39	1.34	1.33	1.30	1.23	1.22	1.32[a]
Malic acid 150 ppm	1.47	1.39	1.33	1.30	1.27	1.21	1.17	1.31[a]
Chitosan + malic + citric	1.38	1.36	1.34	1.18	1.14	1.07	1.06	1.22[c]
Citric acid 0.5%	1.44	1.42	1.39	1.37	1.25	1.19	1.13	1.31[a]
Chitosan + malic	1.31	1.27	1.29	1.25	1.24	1.23	1.18	1.25[b]
Chitosan + citric	1.32	1.30	1.25	1.26	1.24	1.23	1.17	1.25[b]
Malic + citric	1.33	1.32	1.31	1.28	1.27	1.20	1.17	1.27[b]
Chitosan 2%	1.32	1.35	1.33	1.32	1.27	1.20	1.10	1.30[a]
Mean (B)	1.40 [a]	1.35 [b]	1.32 [b]	1.29[c]	1.25[d]	1.20[e]	1.15[f]	
LSD for 2012 season	A = 0.007		B = 0.006		AB = 0.019			
LSD for 2013 season	A = 0.028		B = 0.026		AB = 0.024			

Table 6: Respiration rate (mlco^2 /kg/hμ) as affected by conducted treatments during cold storage at 5°C (2012 and 2013 seasons).

2012 season								
	Storage period (days)							
Treatments	0	15	30	45	60	75	90	Mean (A)
Control	3.39	3.77	3.80	3.85	3.91	3.94	3.98	3.81 ^{a}
Malic acid 150 ppm	3.40	3.72	3.81	3.85	3.90	3.93	3.97	3.80 ^{a}
Chitosan + malic + citric	2.45	2.53	2.56	2.75	2.84	2.93	3.46	2.86 ^{e}
Citric acid 0.5%	3.59	3.67	3.69	3.71	3.77	3.80	3.86	3.73^{d}
Chitosan + malic	3.00	3.20	3.27	3.31	3.36	3.40	3.50	3.29 ^{e}
Chitosan + citric	3.03	3.33	3.37	3.39	3.41	3.50	3.58	3.38^{e}
Malic + citric	3.37	3.40	3.50	3.54	3.60	3.61	3.65	3.53 ^{b}
Chitosan 2%	2.90	3.33	3.51	3.54	3.81	3.91	3.96	3.57 ^{b}
Mean (B)	3.14 ^{e}	3.37 ^{d}	3.44 ^{cd}	3.49 ^{c}	3.58 ^{bc}	3.63 ^{b}	3.81^{a}	
2013 season								
Control	3.93	4.29	4.33	4.34	4.40	4.43	4.47	4.31^{a}
Malic acid 150 ppm	3.74	4.28	4.30	4.34	4.39	4.42	4.46	4.28^{a}
Chitosan + malic + citric	2.88	3.05	3.19	3.24	3.33	3.42	4.00	3.37^{d}
Citric acid 0.5%	4.18	4.20	4.23	4.26	4.29	4.33	4.40	4.27^{a}
Chitosan + malic	3.40	3.68	3.76	3.80	3.85	3.89	3.99	3.77^{c}
Chitosan + citric	3.38	3.62	3.86	3.88	3.90	3.99	4.06	3.81^{c}
Malic + citric	3.65	3.66	3.99	4.03	4.09	4.10	4.14	3.95^{b}
Chitosan 2%	3.44	3.65	4.00	4.03	4.30	4.40	4.45	4.04^{b}
Mean (B)	3.57 ^{f}	3.80 ^{e}	3.95 ^{de}	3.99 ^{cd}	4.06 ^{bc}	4.12^{b}	4.30 ^{a}	
LSD for 2012 season	A= 0.09		B= 0.09		AB= 0.24			
LSD for 2013 season	A= 0.13		B= 0.12		AB= 0.34			

treatments of table grapes, strawberries and sweet cherries reduce their decay in the field and during storage, with the best performance at the highest tested concentration usually 1% [21]. Flesh fruit firmness values of fruits dipping in Chitosan +Malic +Citric were decreased with prolonging cold storage, while TSS value was increased, whereas juice acidity was markedly decreased. These finding are similar to those previously attained by Ghasemnezhad *et al*. [22]; El-Badawy *et al*. [7] and Proud *et al*. [11]. Titratable acidity of coated fruit was decreased slightly at the end of storage period. The delay in the use of organic acids in the enzymatic reactions of respiration can be explained as the result of a slowdown of orange respiration rate. There was no significant difference in titratable acidity among the coated fruits at the end of the storage period [20]. The decrease in fruit acidity during storage period may be due to the metabolic changes in fruits or due to the use of organic acids in respiratory process [23]. Li and Yu [6] found that at the end of the storage period, titratable acidity was increased in the chitosan-treated peaches, while in other crops such as longan and mangoes, acidity was slowly reduced, associating this decrease with loss of eating quality [5,24]. The respiration rate of fruit coated with chitosan reduced the inflow and outflow of gas and water loss. Their higher respiration rate results in a decrease of internal oxygen concentration, whereas that of carbon dioxide increases [20].

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