EFFECT OF CHITOSAN AND POTASSIUM PERMANGANATE TREATMENTS ON QUALITY AND STORABILITY OF CANTALOUPE FRUITS

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(Manuscript received 22 October 2018)

Abstract

This study was carried out on cantaloupe fruits (*Cucumis melo* L. cv. Gal 152, Galia type) harvested at yellow green color stage in the winter of 2013 and 2014 seasons from a private farm at EL-Ismailia Governorate, to evaluate the effects of chitosan at 1000 and 2000 ppm, potassium permanganate sachets contained 2.5 and 5g per box and distillate water (control) on maintaining quality and storability of cantaloupe fruits during storage at 5 °C and 95% relative humidity for 28 days in addition to 2 days at 10 °C (shelf life conditions). Results showed that all postharvest treatments reduced weight loss %, the loss of TSS%, L. ascorbic acid and total sugars, had the higher values of firmness and general appearance as compared with untreated control during storage and shelf life condition. Cantaloupe fruits soaked in chitosan at 2000 ppm or packed with 5g potassium permanganate were the most effective treatments in this concern and gave fruits with good appearance after 21 days at 5° C plus 2 days at 10°C. The lower concentrations of these materials were less effective treatments in this concern.

Keywords: Cantaloupe fruits; chitosan; potassium permanganate; total sugars; firmness; L. ascorbic acid; quality; storability.

INTRODUCTION

Cantaloupe (*Cucumis melo var. Reticulatus*) is a climacteric fruit and favorable to consumers. Its ripening is highly coordinated by ethylene (Seymour *et al*., 1993). Galia are premium melons consumption with excellent flavor and intense aroma, however, the storage life of the fruit harvested pre ripe is 2 to 3 weeks even at low temperatures at 5 to 6°C (Fallik *et al*., 2001).

Climacteric fruits such as cantaloupe could reduce the postharvest life by accelerating ripening if they exposure to ethylene (Reid, 1985). To maintaining fruit quality and improve storability and extend the shelf life of cantaloupe fruit, chitosan and potassium permanganate were used as postharvest treatments in conjunction with low temperature.

Chitosan one of successfully edible coating material on food surface without compromising the tasting, so chitosan used by effectively to extend the shelf life of product. The chitosan films are used as coating of fresh fruits and vegetables (apples, oranges, tomato, pepper, cantaloupe …etc.) because they are flexible, offer valuable

properties such as elasticity, selective permeability and act as antimicrobial barrier against pathogens (Hussein *et al*., 2015). Also chitosan has positive effect of coating that it could to extend the storage life of fruits and vegetables. Chitosan has a semi permeable film that regulates the gas exchange and reduces transpiration and slow down ripening of fruits. Also, respiration rate and hence water loss are reduced (Bautista - Banos *et al.* 2006). This effect has been reported by Chong *et al.* 2015 in honeydew melon.

Potassium permanganate reduces or removes the ethylene of the storage environment, by oxidizing the ethylene produced by the fruit during ripening, extending the pre climacteric period and the postharvest life. Easy appliance and low price are the benefits of using potassium permanganate (Klein and lurie, 1992).

The objective of this work was to investigate the potential of some postharvest treatments on quality and storability of cantaloupe fruits (chitosan and potassium permanganate) individually in different concentrations to extend shelf life and maintain quality of cantaloupe fruits during storage and shelf life conditions.

MATERIALS AND METHODES

Cantaloupe plants (*Cucumis melo* L. cv. Gal 152, Galia type) were grown under plastic tunnels condition in a private farm at EL-Ismaillia governorate in the winter season of 2013 and 2014. Fruits were harvested at yellow green color stage (color stage 3) according to Fallik *et al*. (2001) on May 3 and 7 in 2013 and 2014 seasons, respectively. Then transported to laboratory of Handling of Vegetable Crops, Department, Horticulture Research Institute, Giza Governorate and were selected with uniformity of size, color and free of visual damage or defects. The fruits were washed and surface-sterilized in 200 ppm sodium hypochlorite solution for 5 min, rinsed and air dried in a well-ventilated room. The fruits were treated with the following five treatments:

1- Soaking in chitosan at 1000 ppm for 3 minutes.
2- Soaking in chitosan at 2000 ppm for 3 minutes.
3- Potassium permanganate sachets contained 2.5 g per box.
4- Potassium permanganate sachets contained 5g per box.
5- Control (soaking in distilled water for 3 minutes).

All samples of cantaloupe fruits were air dried, placed in carton box (33cm x23cm x12.5cm) contained three fruits and wrapped with polypropylene film for all treatments, each box represented as one experimental unit. Twelve experimental units were made for each treatment and stored at 5 °C and 95 % relative humidity for 28 days. A complete randomized design was adopted. Three replicates from each treatment were taken at random and examined immediately after treatment and every

7 days at 5 °C in addition to 2 days at 10 °C (shelf life conditions) for the following properties: weight loss percentage, general appearance, fruit firmness, total soluble solids, total sugar and L. ascorbic acid content.

Preparation of edible coating solution:

Chitosan is a commercial product, it includes chitosan at 90-95%. (2-Amino-2-deoxy-beta-D-glucosamine). Chitosan was bought from El-Gomhouria chemical Company, Egypt. Chitosan coating at (1000 or 2000 ppm) was prepared by dissolving 1g or 2 g chitosan powder in 1000 ml of distilled water, respectively and homogenized by magnetic stirrer. Glycerol (1.5% W/V) was added into the mixture as a plasticizer.

Quality attributes:

1- Weight loss percentage:

It was estimated according to the equation:

$$\text{Weight loss percentage} = \frac{\text{Initial weight of fruits} - \text{weight at fruits at sampling date}}{\text{Initial weight}} \times 100$$

2- **General appearance (GA)**: was evaluated using scale from 9-1, where 9 = excellent, 7 =good, 5 =fair, 3 = poor, 1=unsalable as described by Kader *et al*. (1973).

3- **Firmness:** Fruit firmness was determined at the two positions on each fruit using a firmness tester, (Pressure Tester) with an 8 mm plunger.

4- **Total soluble solids:** Total soluble solids were determined from the fresh materials by using PR- 101 digital refractometer.

5- **Total sugar:** Total sugar was determined in fresh cut cantaloupe by using Lane and Eynon method according to AOAC (2000).

6- **L. Ascorbic acid:** Ascorbic acid was determined by titration method using 2.6 dichloro-phenol indo-phenols as described in AOAC (1990).

Statistical Analysis:

The experiment was factorial with 2 factors (tested treatments and storage periods) distributed in complete randomized design (CRD) with 3 replicates. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance. The statistical analysis was performed according to Sendecor and Cochran (1982).

RESULTS AND DISCUSSION

1- Weight loss percentage

Data in Tables (1&2) demonstrate that weight loss percentage of cantaloupe fruits increased considerably and consistently with the prolongation of storage period.

These results were true in the two seasons. Similar results were reported by Atress and Attia (2011) on cantaloupe fruits. The weight loss is natural consequence of the catabolism of horticulture products, the weight loss may be related to respiration and metabolic processes during storage as reported by Watada and Qi (1999).

Table 1. Effect of chitosan and potassium permanganate treatments on weight loss (%) of cantaloupe fruits during cold storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)					
	0	7	14	21	28	Mean
			First season (2013)			
Chitosan (1000 ppm)	0.00 n	1.35 k	2.28 l	3.44 ef	5.80 a	**2.57 C**
Chitosan (2000 ppm)	0.00 n	0.88 lm	1.14 kl	2.62 h	4.62 c	**1.85 E**
$KMnO_4$ (2.5 g)	0.00 n	0.85 m	3.30 f	4.47 cd	5.16 b	**2.76 B**
$KMnO_4$ (5 g)	0.00 n	1.30 k	1.71 j	2.95 g	4.30 d	**2.05 D**
Control	0.00 n	1.94 j	3.64 e	4.68 c	6.05 a	**3.26 A**
Mean	**0.00 E**	**1.26 D**	**2.41 C**	**3.63 B**	**5.19 A**	
			Second season (2014)			
Chitosan (1000 ppm)	0.00 n	1.91 j	2.61 i	3.01 h	5.26 bc	**2.56 B**
Chitosan (2000 ppm)	0.00 n	0.77 l	1.26 k	3.64 fg	5.02 c	**1.14 D**
$KMnO_4$ (2.5 g)	0.00 n	0.35 m	2.15 j	4.31 d	5.12 bc	**2.38 C**
$KMnO_4$ (5 g)	0.00 n	1.07 k	2.10 j	3.90 ef	4.07 de	**2.23 C**
Control	0.00 n	2.06 j	3.47 g	5.40 b	7.67 a	**3.72 A**
Mean	**0.00 E**	**1.23 D**	**2.32 C**	**4.05 B**	**5.43 A**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Table 2. Effect of chitosan and potassium permanganate treatments on weight loss (%) of cantaloupe fruits during storage at 5°C plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)					
	0	7+2days	14+2days	21+2days	28+2days	Mean
			First season (2013)			
Chitosan (1000 ppm)	0.00 l	2.14 j	3.55 h	4.58 f	6.11 cd	**3.28 C**
Chitosan (2000 ppm)	0.00 l	1.64 k	2.58 i	3.80 h	5.50 e	**2.70 E**
$KMnO_4$ (2.5 g)	0.00 l	2.82 i	4.17 g	5.84 d	7.62 b	**4.09 B**
$KMnO_4$ (5 g)	0.00 l	1.95 j	2.80 i	4.26 g	6.32 c	**3.07 D**
Control	0.00 l	3.68 h	5.24 e	7.34 b	9.78 a	**5.21 A**
Mean	**0.00 E**	**2.45 D**	**3.67 C**	**5.16 B**	**7.07 A**	
			Second season (2014)			
Chitosan (1000 ppm)	0.00 k	2.75 hi	3.50 g	4.80 e	6.31 c	**3.47 C**
Chitosan (2000 ppm)	0.00 k	1.75 j	2.80 h	4.20 f	4.80 e	**2.71 E**
$KMnO_4$ (2.5 g)	0.00 k	2.88 h	3.83 g	5.39 d	7.45 b	**3.91 B**
$KMnO_4$ (5 g)	0.00 k	2.03 j	2.42 i	4.45 ef	6.41 c	**3.06 D**
Control	0.00 k	3.75 g	5.18 d	7.18 b	8.99 a	**5.02 A**
Mean	**0.00 E**	**2.63 D**	**3.55 C**	**5.20 B**	**6.79 A**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Data revealed that the tested postharvest treatments had significantly effective on loss of weight during storage or shelf life. They reduced the loss in weight as compared with control. However, cantaloupe fruits soaked in chitosan at 2000 ppm or packed with 5 grams (g) potassium permanganate were the most effective treatment in reducing the weight loss with significant differences between them in the two seasons during storage and shelf life, the control gave the highest values of weight loss. Similar results were obtained by Fard *et al*. (2010) for chitosan and Akbari and Rahemi (2004) for potassium permanganate.

The lowest weight loss from chitosan treatment is due to the semi permeable film on the fruit surface which formed by the chitosan, consequently modifying the internal atmosphere of the fruits with limited gas exchange due to the coating barrier, enzymatic activity and metabolism in evolving respiration can be thus affected, thereby resulting in lower weight loss (Raymond *et al*., 2012).

Minimizing weight loss of cantaloupe fruits during storage with potassium permanganate treatment may be due to that potassium permanganate removes ethylene from produce's atmosphere surrounding as potassium permanganate oxidizing it to ethylene glycol, which later turns to water and carbon dioxide (Sardabi *et al*., 2013)., which decreases respiration rate (Hao and Hao., 1993) and consequently reduces fresh weight loss. Also, Sammi and Masud (2007) found that potassium permanganate significantly delayed the onset of climacteric ethylene production and respiration rate in tomato fruits during storage, which diminished the weight loss in fruit during storage.

In general, the interaction show that cantaloupe fruits soaked in chitosan at 2000 ppm or packed with 5 g potassium permanganate decreased weight loss percentage of fruits during all storage periods. On other hand, cantaloupe fruits soaked in chitosan at 1000 or 2000 ppm or packed with 5 g potassium permanganate decreased weight loss during shelf life as compared to the other tested treatments.

2- General appearance (GA)

Data in Figs (1&2) show that general appearance of cantaloupe fruits decreased significantly with prolonging of the storage period and this was true in two seasons. Such decrease in general appearance of fruits, mostly may be due to a slight dryness of the fruit surface, instead of translucency or macroscopic decay, as reported by Atress and Attia (2011).

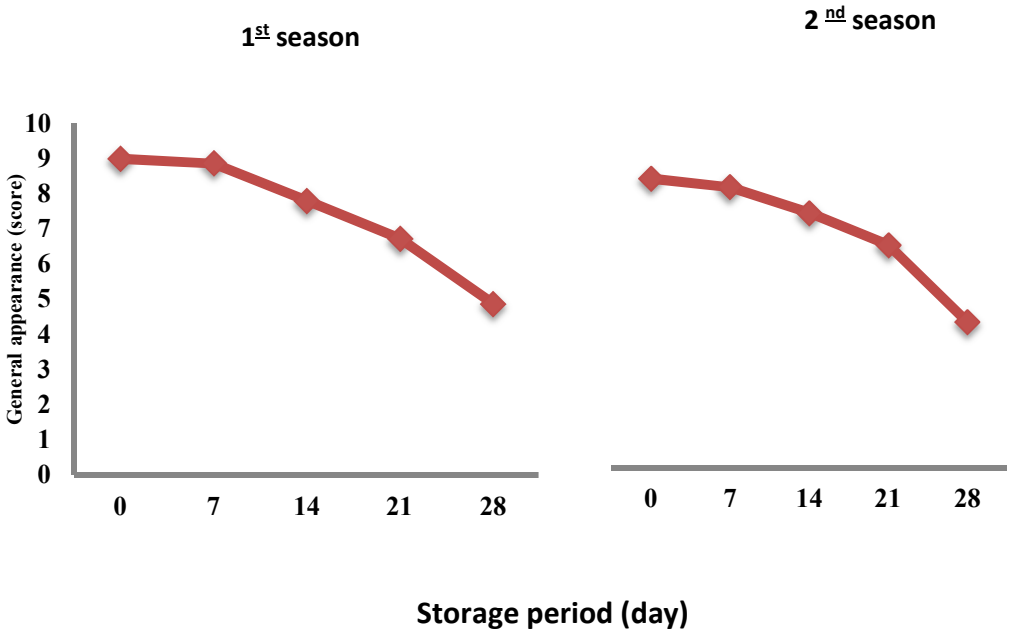

Fig. 1. Effect of storage period on general appearance (score) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

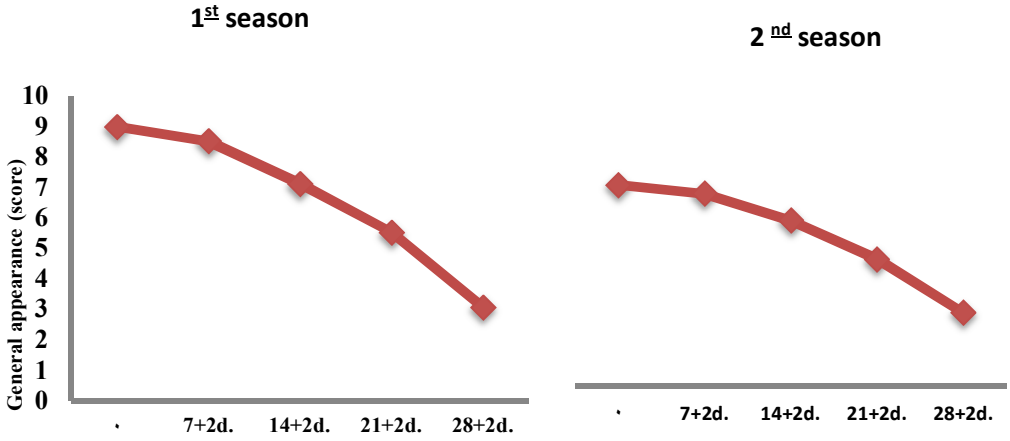

Fig. 2. Effect of storage period on general appearance (score) of cantaloupe fruits during storage at 5°C and 95% RH plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Concerning the effect of postharvest treatments, data in Figs (3&4) show that there were significant differences between postharvest treatments and control. Cantaloupe

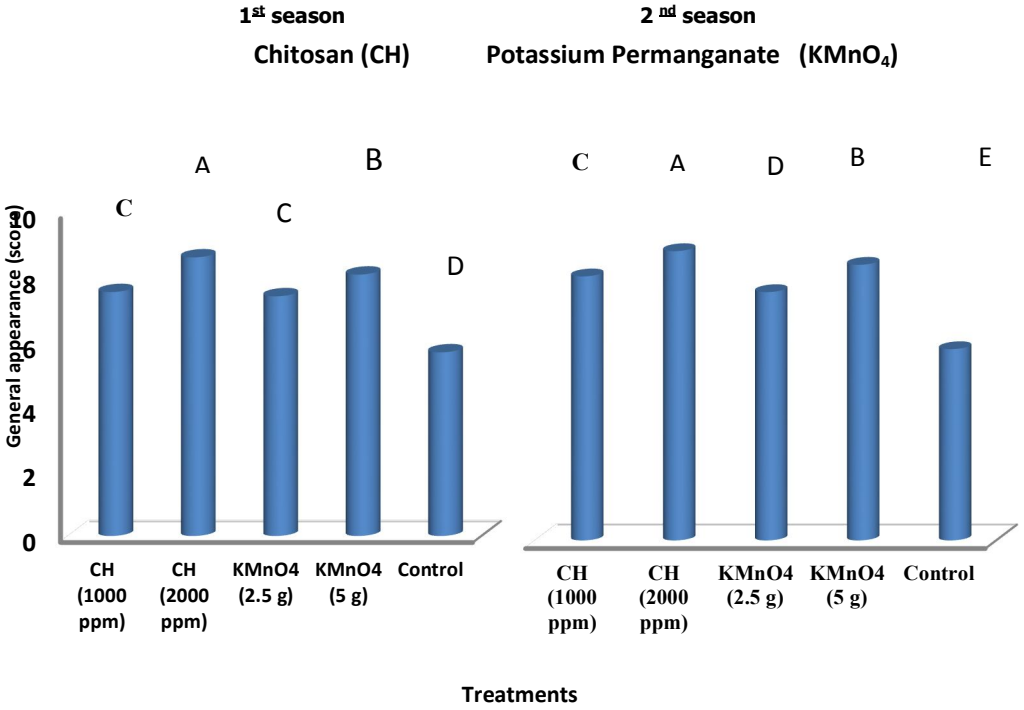

Fig. 3. Effect of chitosan and potassium permanganate treatments on general appearance (score) of cantaloupe fruits at 5°C and 95% RH in 2013 and 2014 seasons.

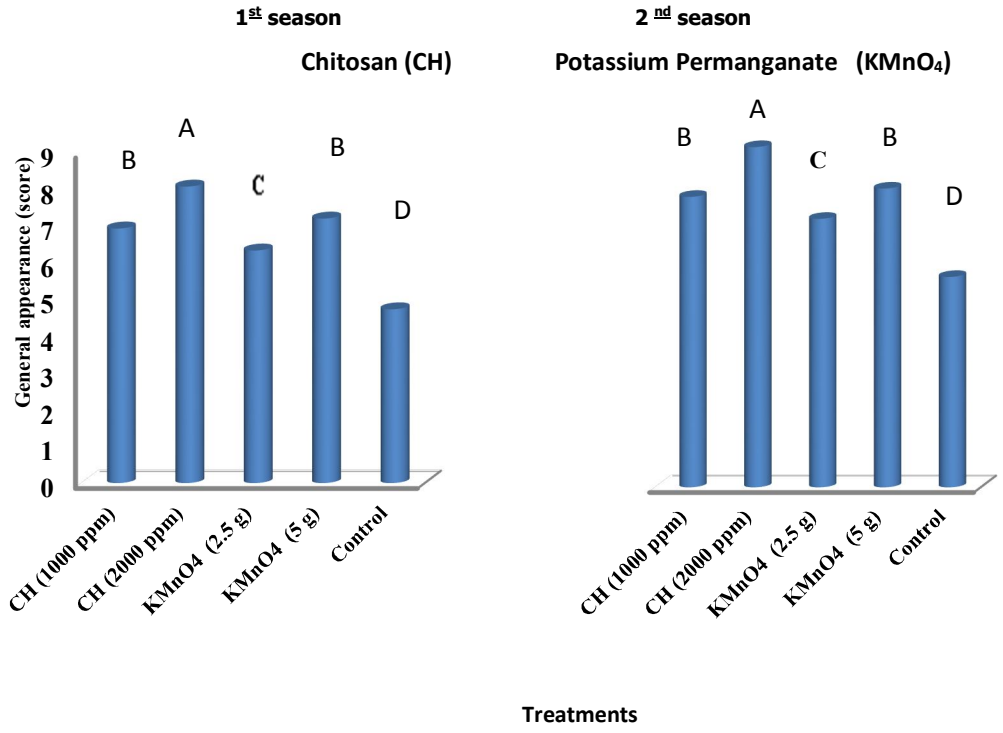

Fig. 4. Effect of chitosan and potassium permanganate treatments on general appearance (score) of cantaloupe fruits during storage at 5°C plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

fruits treated with all treatments were better than control during storage or shelf life. During the storage at 5°C fruits soaked in chitosan at 2000 ppm or packed with 5g potassium permanganate were the most effective treatments for maintaining general appearance with significant difference between them during the storage in the two seasons. In another words, these treatments gave the highest scores of appearance, while control obtained the lowest ones in this concern.

Table 3. Effect of interaction between chitosan, potassium permanganate treatments and storage period on general appearance (score) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)				
	0	7	14	21	28
	First season (2013)				
Chitosan (1000 ppm)	9.00 a	9.00 a	8.33 ab	6.33 d	5.00 e
Chitosan (2000 ppm)	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 bc
$KMnO_4$ (2.5 g)	9.00 a	9.00 a	7.67 bc	7.00 cd	4.33 ef
$KMnO_4$ (5 g)	9.00 a	9.00 a	9.00 a	8.33 ab	5.00 e
Control	9.00 a	8.33 ab	5.00 e	3.67 f	2.33 g
	Second season (2014)				
Chitosan (1000 ppm)	9.00 a	9.00 a	8.33 ab	7.67 bc	4.67 de
Chitosan (2000 ppm)	9.00 a	9.00 a	9.00 a	8.33 ab	7.00 c
$KMnO_4$ (2.5 g)	9.00 a	9.00 a	7.67 bc	7.00 c	3.67 ef
$KMnO_4$ (5 g)	9.00 a	9.00 a	9.00 a	8.33 ab	5.00 d
Control	9.00 a	7.67 bc	5.67 d	3.33 fg	2.33 g

Values with the same letters are not significantly different at P≤ 0.05 level; Tukey's multiple range test.

Cantaloupe fruits soaked in chitosan at 1000 ppm or packed with 2.5 g potassium permanganate were less effective in maintaining general appearance when compared with the other treatments. During shelf life conditions, fruits soaked in chitosan at 2000 ppm followed by chitosan at 1000 ppm or packed with 5g $KMnO_4$ gave the highest scores of appearance. However, coating cantaloupe fruits with chitosan at 2000 ppm was the most effective treatment for maintaining general appearance during shelf life in the two seasons. These results were in agreement with those reported by Hernandez-Munoz *et al*. (2008) for chitosan and Sardabi *et al*. (2013) for potassium permanganate.

Table 4. Effect of interaction between the tested postharvest treatments and storage period on general appearance (score) of cantaloupe fruits during storage at 5°C plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)				
	0	7+2day	14+2day	21+2day	28+2day
	Frist season (2013)				
Chitosan (1000 ppm)	9.00 a	9.00 a	7.67 bc	5.33 d	3.67 e
Chitosan (2000 ppm)	9.00 a	9.00 a	9.00 a	7.67 bc	5.67 d
$KMnO_4$ (2.5 g)	9.00 a	8.33 ab	7.00 c	5.00 d	2.33 f
$KMnO_4$ (5 g)	9.00 a	9.00 a	8.33 ab	7.00 c	2.67 ef
Control	9.00 a	7.33 bc	3.67 e	2.67 ef	1.00 g
	Second season (2014)				
Chitosan (1000 ppm)	9.00 a	9.00 a	7.67 a-c	5.67 de	3.67 fg
Chitosan (2000 ppm)	9.00 a	9.00 a	9.00 a	7.67 a-c	6.33 c-e
$KMnO_4$ (2.5 g)	9.00 a	9.00 a	7.00 b-d	5.00 ef	2.33 gh
$KMnO_4$ (5 g)	9.00 a	9.00 a	8.33 ab	7.00 b-d	2.67 gh
Control	9.00 a	7.00 b-d	5.00 ef	3.00 g	1.33 h

Values with the same letters are not significantly different at P≤ 0.05 level; Tukey's multiple range test.

As for the interaction between the tested postharvest treatments and storage period, data in Tables (3&4) showed that there were significant differences during storage period and shelf life condition. Cantaloupe fruits soaked in chitosan at 2000 ppm and packed with 5g potassium permanganate did not exhibit any changes in their appearance till 14 days at 5°C plus 2 days at 10°C and showed good appearance after 21 days at 5°C plus 2 days at 10°C, mean while fruits soaked in chitosan at 1000 ppm and packed with 2.5g potassium permanganate showed good appearance after 14 days at 5°C plus 2 days at 10°C and dropped to poor level at the end of the shelf life.

3- Fruit firmness

Data in Figs (5&6) show that significant reduction in fruit firmness had occurred by prolongation of the storage period. These results were true in the two seasons and in agreement with those of Atress and Attia (2011) on cantaloupe. The decrease in fruit firmness may be due to gradual breakdown of protopectin to lower molecular weight fractions which are more soluble in water and this is directly correlated with the rate of softening of the fruits (Wills *et al.*, 1981). Deterioration in the cell structures and the composition of cell wall causes the fruit softening (Seymour *et al.*, 1993).

Concerning effect of used postharvest treatments, data in Figs (7&8) revealed that all treatments had significant effect on fruit firmness during storage and shelf life. Cantaloupe fruits soaked in chitosan at 2000 ppm followed by chitosan at 1000 ppm

or packed with 5g potassium permanganate gave the highest value of fruit firmness during storage and shelf life. Fruits soaked in chitosan at 2000 ppm were the best treatment in reducing fruit firmness loss during storage and shelf life in the two seasons. However, the other treatments were less effective in this concern. The lowest value of fruit firmness was obtained from control. These results were in agreement with those of Hong *et al*. (2012) for chitosan and with Hao and Hao (1993) for potassium permanganate.

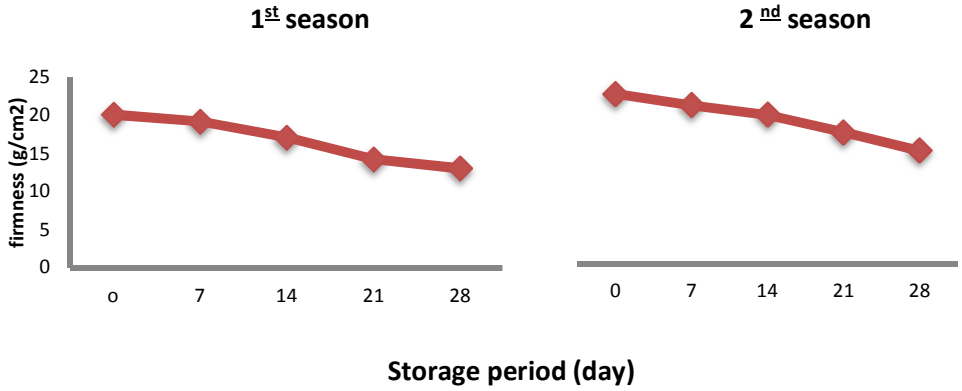

Fig. 5. Effect of storage period on firmness (g/cm^2) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

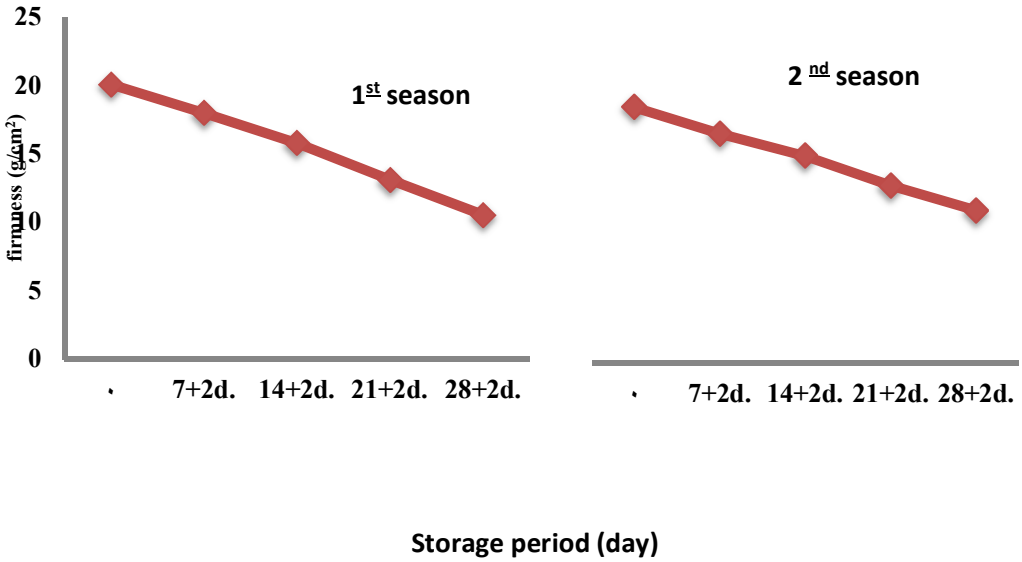

Fig. 6. Effect of storage period on firmness (g/cm^2) of cantaloupe fruits during storage at 5°C and 95% RH plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

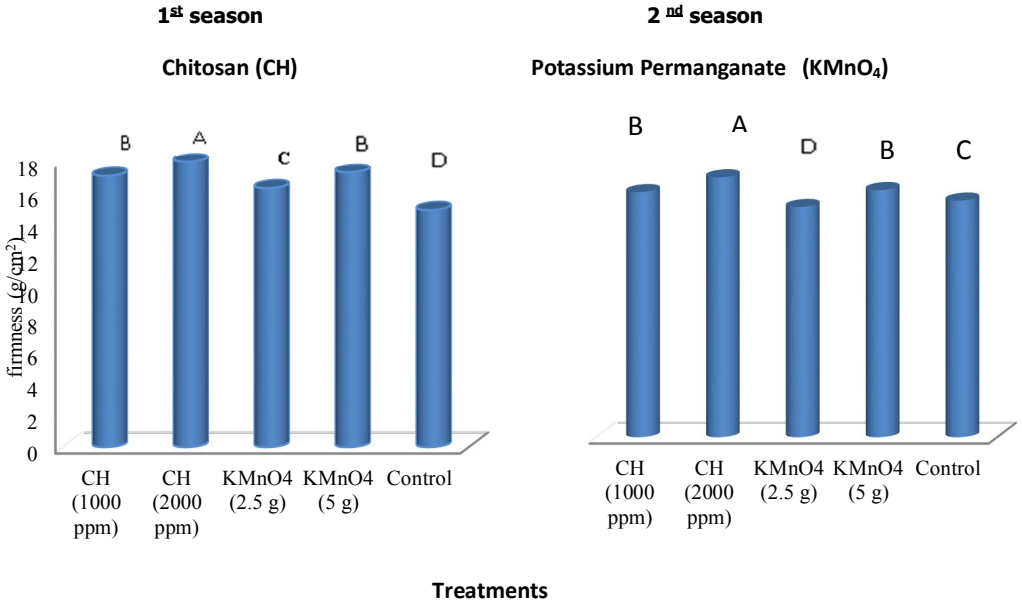

Fig.7. Effect of chitosan and potassium permanganate treatments on firmness (g/cm^2) of cantaloupe fruits at 5°C and 95% RH in 2013 and 2014 seasons.

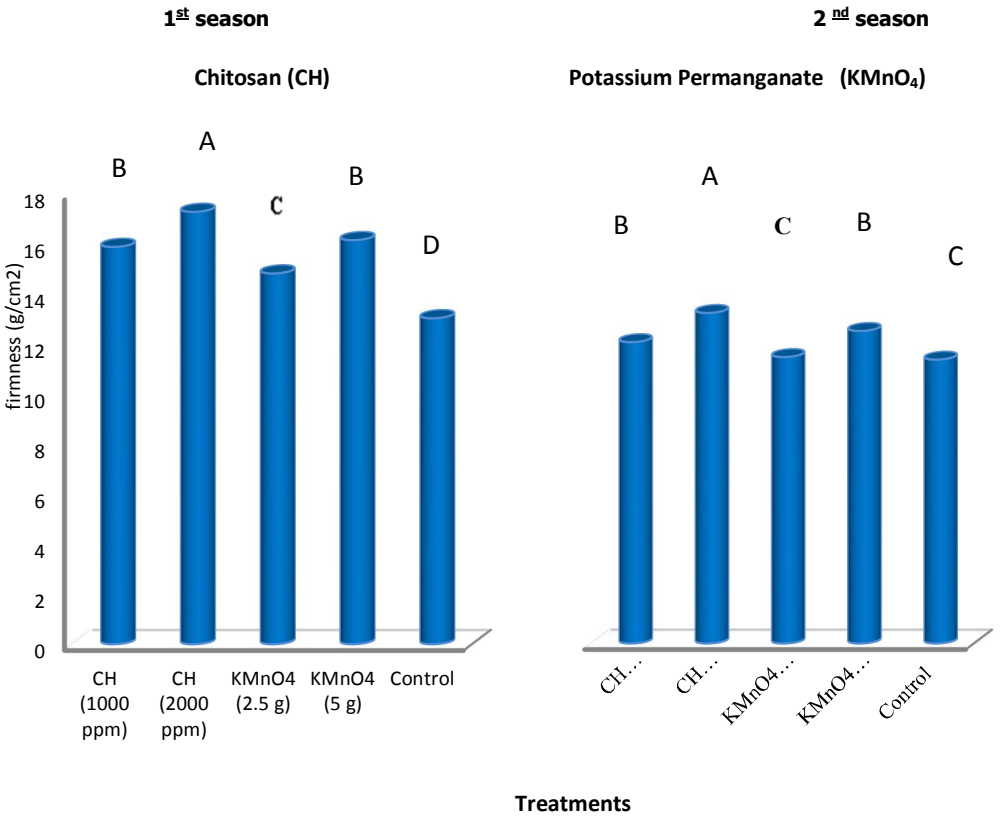

Fig. 8. Effect of chitosan and $KMnO_4$ treatments on firmness (g/cm^2) of cantaloupe fruits during storage at 5°C plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

The favorable effect of chitosan on the maintenance of fruit firmness may be due to the height of antifungal activity and the cover of cuticle and lentical, thereby the infection reduce, respiration and ripening processes during storage as reported by Hong *et al*. (2012).

In general, the interaction between postharvest treatments (chitosan, potassium permanganate) and storage periods, showed that there were significant differences during

Table 5. Effect of interaction between chitosan, potassium permanganate treatments and storage period on firmness (g/cm^2) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)				
	0	7	14	21	28
	First season (2013)				
Chitosan (1000 ppm)	20.08 a	19.46 ab	17.68 cd	14.21 f-h	13.86 f-h
Chitosan (2000 ppm)	20.08 a	19.83 a	18.98 a-c	16.23 de	14.65 fg
$KMnO_4$ (2.5 g)	20.08 a	18.90 a-c	16.21 de	13.35 g-i	12.87 hi
$KMnO_4$ (5 g)	20.08 a	19.50 ab	17.99 bc	15.19 ef	13.71 f-h
Control	20.08 a	18.00 bc	14.42 fg	12.00 i	10.00 j
	Second season (2014)				
Chitosan (1000 ppm)	20.65 a	19.50 ab	18.86 b-d	16.03 h-j	13.22 lm
Chitosan (2000 ppm)	20.65 a	19.73 ab	19.20 bc	17.43 e-h	16.60 g-i
$KMnO_4$ (2.5 g)	20.65 a	18.59 b-e	16.69 f-i	14.23 kl	12.76 mn
$KMnO_4$ (5 g)	20.65 a	19.60 ab	17.78 d-g	16.26 hi	14.71 jk
Control	20.65 a	18.00 b-d	15.06 i	13.99 m	10.48 o

Values with the same letters are not significantly different at P≤ 0.05 level; Tukey's multiple range test.

Table 6. Effect of interaction between chitosan, potassium permanganate treatments and storage period on firmness (g/cm^2) of cantaloupe fruits during storage at 5°C plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)				
	0	7+2day	14+2day	21+2day	28+2days
	First season (2013)				
Chitosan (1000 ppm)	20.08 a	18.60 b	16.50 de	12.07 h	10.08 ij
Chitosan (2000 ppm)	20.08 a	19.00 ab	18.00 bc	15.26 ef	14.00 fg
$KMnO_4$ (2.5 g)	20.08 a	18.31 b	15.30 e	11.25 hi	9.11 jk
$KMnO_4$ (5 g)	20.08 a	18.50 b	16.80 cd	13.72 g	11.58 h
Control	20.08 a	15.56 de	12.40 h	9.21 j	7.86 k
	Second season (2014)				
Chitosan (1000 ppm)	20.65 a	18.80 ab	17.00 b-d	13.83 e-h	11.70 h
Chitosan (2000 ppm)	20.65 a	19.12 ab	18.60 ab	16.00 c-e	15.60 c-e
$KMnO_4$ (2.5 g)	20.65 a	17.50 bc	15.00 d-g	13.00 gh	11.80 h
$KMnO_4$ (5 g)	20.65 a	18.60 ab	17.00 b-d	15.50 c-f	13.26 f-h
Control	20.65 a	16.46 cd	13.90 gh	11.23 h	9.02 i

Values with the same letters are not significantly different at P≤ 0.05 level; Tukey's multiple range test.

storage and shelf life in the two seasons. However, cantaloupe fruits soaked in chitosan at 2000 ppm were the most obvious in maintaining fruit firmness at the end of storage period or shelf life.

4- Total soluble solids (TSS)

Data in Tables (7&8) indicate that there was a significant reduction in TSS by prolonging of storage period in both seasons. These results agree with those of Atress and Attia (2011) on cantaloupe. The reduction in TSS percent during storage may be due to the higher rate of sugar loss through respiration than the water loss through transpiration (Wills *et al.*, 1981). Regarding the effect of postharvest treatments, data revealed that cantaloupe fruits soaked in chitosan at 2000 ppm retained more TSS percentage with significant differences with the other treatments followed by fruits soaked in chitosan at 1000 ppm or packed with 5 g potassium permanganate with no significant differences between them in the first season during storage and shelf life in the two seasons.

Table 7. Effect of chitosan and potassium permanganate treatments on TSS (%) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)					
	0	7	14	21	28	Mean
			First season (2013)			
Chitosan (1000 ppm)	11.50 a	11.20 ab	10.67 a-e	10.00 d-g	9.74 fg	**10.62 BC**
Chitosan (2000 ppm)	11.50 a	11.33 a	11.20 ab	10.67 a-e	10.33 b-f	**11.01 A**
$KMnO_4$ (2.5 g)	11.50 a	11.00 a-c	10.33 b-f	9.80 e-g	9.20 g-i	**10.37 C**
$KMnO_4$ (5 g)	11.50 a	11.00 a-c	10.70 a-d	10.30 c-f	9.80 e-g	**10.66 B**
Control	11.50 a	10.30 c-f	9.30 gh	8.70 hi	8.33 i	**9.63 D**
Mean	**11.50 -**	**10.97 B**	**10.44 C**	**9.89 D**	**9.48 E**	
			Second season (2014)			
Chitosan (1000 ppm)	11.00 a	10.50 ab	10.20 a-e	10.00 b-e	9.52 c-g	**10.24 A**
Chitosan (2000 ppm)	11.00 a	10.67 ab	10.40 a-c	10.33 a-d	10.00 b-e	**10.48 A**
$KMnO_4$ (2.5 g)	11.00 a	10.67 ab	9.80 b-f	9.40 d-g	8.70 gh	**9.91 B**
$KMnO_4$ (5 g)	11.00 a	10.33 a-d	10.20 a-e	10.00 b-e	9.50 c-g	**10.21 AB**
Control	11.00 a	10.33 a-d	9.33 e-g	9.00 f-h	8.33 h	**9.60 C**
Mean	**11.00 -**	**10.50 B**	**9.99 C**	**9.75 C**	**9.21 D**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Table 8. Effect of chitosan and potassium permanganate treatments on TSS (%) of cantaloupe fruits during storage at 5°C and 95% RH plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)					
	0	7+2days	14+2days	21+2days	28+2days	Mean
			First season (2013)			
Chitosan (1000 ppm)	11.50 a	10.82 a-d	10.20 c-e	9.74 e-h	9.20 g-j	**10.29 B**
Chitosan (2000 ppm)	11.50 a	11.30 ab	11.00 a-c	10.60 b-e	10.10 d-f	**10.86 A**
$KMnO_4$ (2.5 g)	11.50 a	10.00 d-g	9.80 e-h	9.00 h-j	8.40 jk	**9.74 C**
$KMnO_4$ (5 g)	11.50 a	10.80 a-d	10.60 b-e	10.10 d-f	9.30 f-i	**10.46 B**
Control	11.50 a	10.10 d-f	9.25 f-j	8.74 i-k	7.00 L	**9.54 D**
Mean	**11.50 A**	**10.61 B**	**10.17 C**	**9.64 D**	**9.02 E**	
			Second season (2014)			
Chitosan (1000 ppm)	11.00 a	10.11 a-c	9.80 b-d	9.32 c-f	8.47 f-h	**9.74 B**
Chitosan (2000 ppm)	11.00 a	10.50 ab	10.33 ab	10.00 bc	9.67 b-e	**10.30 A**
$KMnO_4$ (2.5 g)	11.00 a	10.33 ab	9.00 d-g	8.21 gh	7.70 h	**9.25 C**
$KMnO_4$ (5 g)	11.00 a	10.20 a-c	9.82 b-d	9.21 c-f	8.70 e-g	**9.79 B**
Control	11.00 a	10.00 bc	9.00 d-g	8.33 f-h	7.06 h	**9.20 D**
Mean	**11.00 A**	**10.23 B**	**9.60 C**	**9.01 D**	**8.44 E**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Control fruits gave the lowest value of TSS percent. These results agree with those of Shiri *et al.* (2013) for chitosan and Hao and Hao (1993) for potassium permanganate.

Effect of chitosan or potassium permanganate on maintaining TSS of fruits during storage might be due to that these materials reduce respiration rate and physiological changes of fruit during storage.

In general, the interaction between postharvest treatments and storage period was significant, however after 28 days at 5°C plus 2 days at 10°C of storage, cantaloupe fruits soaked in chitosan at 2000 ppm or packed with 5g potassium permanganate resulted in higher TSS content with no significant differences between them, while control fruits gave the lowest ones at the same period.

5- Total sugars

Data in Tables (9&10) show that there was a significant reduction in total sugars

Table 9. Effect of chitosan and potassium permanganate treatments on total sugars (%) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)					
	0	7	14	21	28	Mean
			First season (2013)			
Chitosan (1000 ppm)	9.46 a	9.28 a	9.00 ab	8.50 a-d	7.60 cd	**8.77 AB**
Chitosan (2000 ppm)	9.46 a	9.30 a	9.10 ab	8.75 a-c	8.00 b-d	**8.92 A**
$KMnO_4$ (2.5 g)	9.46 a	9.00 ab	8.47 a-d	8.00 b-d	7.50 d	**8.49 B**
$KMnO_4$ (5 g)	9.46 a	9.26 a	8.85 ab	8.65 a-d	7.60 cd	**8.76 AB**
Control	9.46 a	8.85 ab	8.00 b-d	7.50 d	6.00 e	**7.96 C**
Mean	**9.46 A**	**9.13 A**	**8.68 B**	**8.28 C**	**7.34 D**	
			Second season (2014)			
Chitosan (1000 ppm)	9.80 a	9.35bc	9.12 c-e	8.55 gh	7.76 j	**8.92 B**
Chitosan (2000 ppm)	9.80 a	9.50 ab	9.20 b-d	8.87 d-g	7.80 j	**9.03 A**
$KMnO_4$ (2.5 g)	9.80 a	9.20 b-d	8.74 fg	8.24 hi	7.65 j	**8.73 C**
$KMnO_4$ (5 g)	9.80 a	9.32 bc	8.90 d-f	8.80 e-g	7.85 j	**8.93 AB**
Control	9.80 a	8.90 d-f	8.20 i	7.56 j	6.63 k	**8.22 D**
Mean	**9.80 A**	**9.25 B**	**8.83 C**	**8.40 D**	**7.54 E**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

by the prolongation of storage period in both seasons. These results are in agreement with those of Atress and Attia (2011) on cantaloupe. The decrease of total sugars percent is probably due to the consumption of sugars through respiration (Wills *et al.*, 1981).

Concerning the effect of postharvest treatments, data revealed that all treatments reduced the loss of total sugars as compared with control.

Table 10. Effect of chitosan and potassium permanganate treatments on total sugars (%) of cantaloupe fruits during storage at 5°C and 95% RH plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)					
	0	7+2days	14+2days	21+2days	28+2days	Mean
			First season (2013)			
Chitosan (1000 ppm)	9.46 a	8.82 a-c	8.41 b-e	8.00 c-g	7.13 g-i	**8.36 AB**
Chitosan (2000 ppm)	9.46 a	9.10 ab	8.75 a-c	8.32 b-f	7.45 e-h	**8.62 A**
$KMnO_4$ (2.5 g)	9.46 a	8.74 a-c	8.25 b-f	7.40 f-h	7.10 g-i	**8.19 B**
$KMnO_4$ (5 g)	9.46 a	9.00 ab	8.60 a-c	8.44 b-d	7.25 gh	**8.55 A**
Control	9.46 a	8.50 a-d	7.60 d-h	7.00 hi	6.27 i	**7.77 C**
Mean	**9.46 A**	**8.83 B**	**8.32 C**	**7.83 D**	**7.04 E**	
			Second season (2014)			
Chitosan (1000 ppm)	9.80 a	9.00 bc	8.72 b-e	8.15 d-g	7.31 hi	**8.60 AB**
Chitosan (2000 ppm)	9.80 a	9.25 ab	8.87 b-d	8.46 b-f	7.54 g-i	**8.78 A**
$KMnO_4$ (2.5 g)	9.80 a	8.97 bc	8.39 c-f	8.00 e-h	7.23 hi	**8.48 B**
$KMnO_4$ (5 g)	9.80 a	9.10 a-c	8.76 b-e	8.67 b-e	7.35 hi	**8.74 AB**
Control	9.80 a	8.67 b-e	7.75 f-i	7.10 ij	6.36 j	**7.94 C**
Mean	**9.80 A**	**9.00 B**	**8.50 C**	**8.08 D**	**7.16 E**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Cantaloupe fruits soaked in chitosan at the two concentrations (1000 and 2000 ppm) or packed with 5g potassium permanganate seems to the most effective in reducing the total sugar losses with no significant differences between them in the first season during storage and in the two seasons during shelf life. These results are in agreement with those of Bautista-Banos *et al*. (2006) for chitosan and Sammi and Masud (2007) for potassium permanganate.

In general, the interaction between postharvest treatments was significant after 28 days at 5°C plus 2 days at 10°C of storage. Cantaloupe fruits treated with various treatments had the highest values of total sugars as compared with those of control with no significant differences between them in the second season during storage and in the two seasons during shelf life, while control treatment gave the lowest ones at the same period.

6- Ascorbic acid

Data in Tables (11&12) indicate that ascorbic acid content in cantaloupe fruits decreased gradually with the prolongation of storage period and shelf life. These results were true in the two seasons and are in an agreement with those of Atress and Attia (2011) on cantaloupe fruits.

Concerning the effect of postharvest treatments, data show that all treatments were effective in preventing ascorbic acid degradation during storage and shelf life conditions as compared with control. Moreover, cantaloupe fruits soaked in 2000 ppm were the most effective treatment in this concern with significant differences with the other treatments in the second season during storage and in the two seasons during shelf life conditions. The lowest values were noticed in control fruits in both seasons. These results are in agreement with those reported by Hong *et al*. (2012) for chitosan and Sammi and Masud (2007) for potassium permanganate.

In general, the interaction between postharvest treatments and storage period was significant during all storage periods. All postharvest treatments retained more ascorbic acid content compared to control treatments during all storage periods at 5°C or shelf life condition.

Table 11. Effect of chitosan and potassium permanganate treatments on ascorbic acid (mg/100g F.W) of cantaloupe fruits during storage at 5°C and 95% RH in 2013 and 2014 seasons.

Treatments	Storage period (day)					
	0	7	14	21	28	Mean
			First season (2013)			
Chitosan (1000 ppm)	32.97 a	31.00 b	28.00 cd	26.33 ef	21.90 h	**28.04 B**
Chitosan (2000 ppm)	32.97 a	31.50 b	29.10 c	27.00 de	22.00 h	**28.51 A**
$KMnO_4$ (2.5 g)	32.97 a	29.00 c	27.17 de	26.00 ef	21.00 h	**27.23 C**
$KMnO_4$ (5 g)	32.97 a	31.50 b	28.60 c	26.77 de	22.17 h	**28.40 AB**
Control	32.97 a	25.21 f	23.60 g	18.00 i	15.55 j	**23.07 D**
Mean	**32.97 A**	**29.64 B**	**27.29 C**	**24.82 D**	**20.52 E**	
			Second season (2014)			
Chitosan (1000 ppm)	28.15 a	26.30 bc	24.25 de	22.75 fg	18.00 i	**23.89 C**
Chitosan (2000 ppm)	28.15 a	27.10 ab	25.10 cd	23.00 ef	22.50 fg	**25.17 A**
$KMnO_4$ (2.5 g)	28.15 a	26.05 bc	24.25 de	21.50 g	18.00 i	**23.59 C**
$KMnO_4$ (5 g)	28.15 a	27.00 ab	25.00 cd	22.37 fg	19.50 h	**24.40 B**
Control	28.15 a	25.00 cd	22.60 fg	19.00 hi	15.00 j	**21.95 D**
Mean	**28.15 A**	**26.29 B**	**24.24 C**	**21.72 D**	**18.60 E**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

Table 12. Effect of chitosan and potassium permanganate treatments on ascorbic acid (mg/100g F.W) of cantaloupe fruits during storage at 5°C and 95% RH plus 2 days shelf life at 10°C in 2013 and 2014 seasons.

Treatments	Storage period and shelf life (day)					
	0	7+2days	14+2days	21+2days	28+2days	Mean
			First season (2013)			
Chitosan (1000 ppm)	32.97 a	26.80 c	23.53 f	18.13 jk	14.90 lm	**23.26 B**
Chitosan (2000 ppm)	32.97 a	29.30 b	25.30 de	19.33 hi	15.00 lm	**24.38 A**
$KMnO_4$ (2.5 g)	32.97 a	25.13 e	22.18 g	19.00 h-j	14.00 mn	**22.66 C**
$KMnO_4$ (5 g)	32.97 a	26.30 cd	24.80 e	18.25 i-k	15.50 l	**23.56 B**
Control	32.97 a	23.21 fg	20.00 h	17.75 k	13.00 n	**21.39 D**
Mean	**32.97 A**	**26.14 B**	**23.16 C**	**18.49 D**	**14.48 E**	
			Second season (2014)			
Chitosan (1000 ppm)	28.15 a	27.75 a	24.30 bc	19.75 e	14.90 hi	**22.97 B**
Chitosan (2000 ppm)	28.15 a	27.90 a	23.72 c	21.00 d	18.49 f	**23.86 A**
$KMnO_4$ (2.5 g)	28.15 a	25.39 b	23.18 c	20.57 de	14.50 i	**22.36 C**
$KMnO_4$ (5 g)	28.15 a	26.93 a	23.25 c	19.52 ef	14.30 g	**22.83B**
Control	28.15 a	24.00 c	19.70 ef	16.00 gh	10.80 j	**19.66 D**
Mean	**28.15 A**	**26.39 B**	**22.83 C**	**19.37 D**	**14.93 E**	

Means with the same capital letters in the same column or row are not significantly different at P≤ 0.05 level; Tukey's multiple range test and the small letters for interaction.

CONCLUSION

From the previous results, it could be concluded that cantaloupe fruits soaked for three minutes in chitosan at 2000 ppm or packed with 5g potassium permanganate were the most effective treatments in reducing weight loss, color changes and maintained quality (firmness, total sugars, flavor) and gave fruits with good appearance after 21 days at 5° C plus 2 days at 10°C.

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تأثير المعاملة بالشيتوزان وبرمنجنات البوتاسيوم على الجودة والقدرة التخزينية لثمار الكنتالوب

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أجريت هذه الدراسة على ثمار الكنتالوب صنف جال 152 من طراز جاليا والمحصود فى مرحلة اللون الاصفر المخضر فى الموسم الشتوي 2013 /2014 من مزرعة خاصة بمحافظة الاسماعيلية لتقييم تاثير الشيتوزان بتركيز 1000 و2000 جزء فى المليون و اكياس برمنجنات البوتاسيوم 2.5 و5جم لكل صندوق على المحافظة على الجودة والقدرة التخزينية لثمار الكنتالوب خلال التخزين على 5° م ورطوبة نسبية 95 % لمدة 28 يوما مضاف اليها يومين على درجة 10°م لمحاكاة ظروف العرض فى السوبر ماركت .

اظهرت النتائج ان ثمار الكنتالوب المغموسة فى الشيتوزان تركيز 2000 جزء فى المليون او المعبئة مع اكياس برمنجات البوتاسيوم 5جم كانت اكثر المعاملات تاثيراً فى تقليل الفقد فى الوزن، فقد الصلابة، الفقد فى المواد الصلبة الكلية والمحافظة على المحتوى من الجودة الكيميائية (السكريات الكلية، الاسكوربيك اسيد) واظهرت الثمار جودة مظهرية حتى 21 يوم على درجة 5° م مضاف اليها يومين على درجة 10 ° م اما التركيزات الاقل من تلك المواد كانت اقل تاثيراً .