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Effect of Chitosan, Carboxy Methyl Cellulose and Calcium Chloride Treatments on Quality and Storability of Fresh Cut Cantaloupe

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ABSTRACT

This study was carried out on cantaloupe (*Cucumis melo* L. cv. Gal 152, Galia type) harvested at yellow green color in the winter of 2013 and 2014 seasons from a private farm at EL-Ismailia Governorate, to evaluate the effects of edible coating of chitosan (2000 – 4000 ppm), carboxy methyl cellulose (CMC) at (1500 -3000 ppm), $CaCl_2$ (500- 1000 ppm), and distillate water (control). Also, effect of wrapping with polypropylene and stretch film on maintaining quality and storability of fresh- cut cantaloupe during storage at 2.5° C and 95% RH. for 8 days. Results showed that fresh - cut cantaloupe dipped in chitosan at 2000 ppm, CMC at 1500 ppm and $CaCl_2$ at 500 ppm were the most effective treatments for reduced loss of texture, maintaining general appearance, total sugars content and inhibited discoloration in the cut surface. The higher concentrations of these materials were less effective in this concern. Fresh cut cantaloupe wrapped with polypropylene film maintaining quality (texture and total sugars) also had lower level of microbial load as compared with these wrapped with stretch film, while treated with $CaCl_2$ at 500 ppm or chitosan at 2000 ppm and wrapped with polypropylene film retarded texture loss, reduced the incidence of discoloration, had lowest count of microorganisms and gave good appearance for 8 days of storage. However CMC at 1500 ppm treatment and wrapped with polypropylene film could be stored for 6 days with good appearance.

Key words: Fresh cut cantaloupe, Chitosan, Carboxy methyl cellulose, $CaCl_2$, Wrapping, Microbial load, Total sugars,Texture, Storability

Introduction

Cantaloupe (*cucumis melo* var. cantaloupensis) is a climacteric, favorable fruit to consumers. It is very common to be marked in fresh cut state due to convenience (Amaro *et al*., 2012). However, once the fruits deteriorate to a certain extend, significant texture breakdown and color changes occur which lead to appearance changes followed by the end of shelf life.

Fresh-cut fruits refer to fruits that have undergone process of alteration from its original state. They are increasingly demanded by consumers due to convenience, especially for those having busy lifestyle. However, fresh cut fruits are highly perishable and deteriorate much faster than whole counterpart due to the exposure of inner flesh to environment, thus they have much shorter shelf life (Mantilla *et al*., 2013) and request better procedure to protect their quality.

Currently, one approach for extending the shelf life of fresh cut cantaloupe is applying edible coating on the fruits surface such as, calcium chloride (Luna-Guzman and Barrett, 2000), chitosan (Chong *et al.,* 2015) and methylcellulose (Sangsuwan *et al*., 2008), in conjunction with low temperature. Edible coating potentially prolongs the shelf life of fruits due to the formation of barrier layer blocking the exposure of gas and moisture. The barrier layer can delay the quality deterioration of fruits by reducing the respiration, delaying volatiles loss, decreasing the broke of moisture migration and thus extend the shelf life of fruits (Rojas – Grau *et al*., 2009).

Chitosan has been applied successfully as coating on food surface to extend the shelf life effectively without compromising the natural tastes of product. The chitosan films are used as coating of fresh and fresh cut fruits and vegetable (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 (Zhelyazkov *et al*., 2014; Hussein *et al*., 2015). An additional positive effect of chitosan coating is related to its ability to extend the storage life of fruits and vegetables. Chitosan forms a semipermeable film that regulates the gas exchange and reduces transpiration losses and fruit ripening is slowed down. Also, respiration rate and hence water loss is reduced (Bautista – Banos *et al.,* 2006). This effect has been reported by (EL Ghaouth *et al.,* 1992e) for tomatoes and (chong *et al.,* 2015) for honeydew melon, who found that fresh cut honeydew coated with chitosan at 2% or dipped in solution of $CaCl_2$ at 1% were significantly reduced weight loss, improved firmness, delayed color changes and inhibited microbial growth during storage as compared to untreated.

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Carboxy methyl cellulose (CMC) is one of the polysaccharides used in an edible coating. Carboxy methyl cellulose is flexible and transparent and can act as a barrier to moisture and oxygen. Several studies have suggested the use of carboxy methyl cellulose as a suitable coating material for several products. Maftoonazarad and Ramaswang, (2004) reported that coating avocado with methylcellulose extended the shelf life of the product. Moreover, Ayranci and Tunc, (2004) showed that coating apricot and green pepper with methylcellulose reduced the loss of water and vitamin C. Also, Nadim *et al*., (2015) showed that the methyl cellulose coatings are effective for strawberries shelf life extension and retarded the senescence process compared with control. The addition coatings showed a beneficial effect on reducing decay, weight loss, color change, loss of firmness and delayed the softening of fruit and texture change.

Postharvest application of $CaCl_2$ may delay senescence in commercial and retail storage of cantaloupe fruit with no detrimental effect on consumer acceptance (Lester & Grusak, 2001, 2004). Calcium chloride dips can maintain visual quality by keeping the integrity of the cell wall and retarding flesh softening of fruits resulting in a longer shelf life of fresh cut cantaloupe (Luna- Gazman and Barrett, 2000) and (Shehata *et al*., 2009) of fresh cut pepper. Also, inhibited lipase activity in cantaloupe, maintained fleshness and reduced decay (Lamikanra and Watson, 2007).

The objective of this study was to investigate the potential of some edible coating such as chitosan, carboxy methylcellulose and calcium chloride individually in different concentrations and wrapping materials to extend shelf life and maintain quality of fresh cut cantaloupe during storage at 2.5°C and 95% RH.

Materials and Methodes

Fruits preparation:

Cantaloupe Plants (*Cucumis melo* L. cv. Gal 152, Galia type) were grown under tunnels in private farm at EL-Ismaillia governorate in the winter of 2013 and 2014 seasons. 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, Giza Governorate and were kept overnight at 5° C and 95% relative humidity (RH). The following day fruits were selected with uniformity of size, color and free of visual damage or defects.

All sharp knives, cutting boards and other equipment which come into contact with the fruit were sanitized by immersion in 1000mg/L chlorine solution for 30min before cutting.

Cantaloupe fruits were cut longitudinally into two halves, seed were removed and the fruit were then cut into 8 equal parts and were dipped into 50 ppm sodium hypo chloride (PH7) for 30 seconds. The skin was removed and every part was approximately 2-2.2 cm thickness and weight 70-75 grams, the samples of fresh cut cantaloupe were randomly divided into 7 groups.

Preparation of edible coating solution:

Chitosan is a commercial product, it includes chitosan 90-95%. (2-Amino-2-deoxy-beta-D-glucosamine) EL-Badawy (2014). Chitosan was bought from El-Gomhouria Company, Egypt. Chitosan coating at (2000 or 4000 ppm) was prepared by dissolving 2g or 4 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.

Carboxy methyl cellulose (CMC) was bought from Technogene Company, Egypt. CMC coating at (1500 or 3000ppm) was prepared by dissolving 1.5 g or 3 g of CMC powder in a water ethyl alcohol mixture (2:1) at 75°C under the high speedmixer (900 rpm) for 15 min. then, glycerol (1.5% W/V) were added and the solution was stirred for another 10 min under the same conditions.

Calcium chloride solution coating at (500 or 1000ppm) was prepared by dissolving 0.5 g or 1.0 g $CaCl_2$ powder in 1000 ml of distilled water respectively and homogenized by magnetic stirrer.

Edible coating, wrapping and storage:

The samples were dipped in different coating solutions for 3 min as follow:

1- 2000 ppm coating solution of chitosan (T_1).
2- 4000 ppm coating solution of chitosan (T_2).
3- 1500 ppm coating solution of carboxy methyl cellulose (T_3).
4- 3000 ppm coating solution of carboxy methyl cellulose (T_4).
5- 500 ppm coating solution of calcium chloride (T_5).
6- 1000 ppm coating solution of calcium chloride (T_6).
7- Control (dipping in distilled water) (T_7).

All samples of fresh cut cantaloupe were air dried after dipping directly and placed in polystyrene trays and wrapped with the two types of film, polypropylene and stretch film (control) and each had 250g represented as one replicated. Twelve replicates for each treatment and two wrapping film used were prepared and stored at

2.5°C and 95% RH for 8 days. Samples were taken at random in 3 replicates and the samples were arranged in complete randomized design.

Quality attributes:

Measurements were examined immediately after treatment and every 2 days intervals to determine

1. 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).
2. Texture was recorded by TA-1000 texture analyzer instrument using a penetrating cylinder of 1 mm diameter to a constant distance (3 and 5 mm) inside the pulp of fruits, and by a constant speed 2 mm per sec., and the peak of resistance was recorded in g/cm^2.
3. Discoloration was evaluated as a scale of 1 to 5 where 1= none, 2= slight, 3= moderate, 4= severe and 5= extra severe.
4. Total microbial count: From each replicate, three random melon parts of 10 g were collected using sterile techniques and homogenized with 90 ml of sterile distilled water in for 1 minute. Serial dilutions needed for sample plating were prepared in 9 ml of sterile distilled water. The pour plate method was performed using the following media and culture conditions: Plate Count Agar. The following method was accordingly referred to Luna-Guzmán and Barrett (2000) and Silveira *et al*. (2011). The microbial counts were expressed as log10 (cfu g-1).
5. Total sugar was determined in fresh cut cantaloupe by using Lane and Eynon method according to A.O.A.C (2000).

Statistical Analysis:

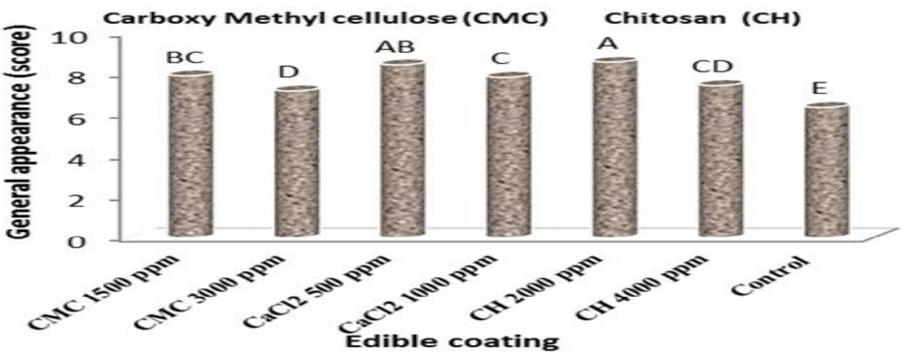
The experiment was factorial with 3 factors in complete randomized design (CRD) with 3 replicates. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance. The statistical analysis was performed according to Sendecor and Cochran, (1982).

Results and Discussion

General appearance

Data in Fig. 1 (A) include the effect of chitosan, CMC and $CaCl_2$ on general appearance quality, which showed that there were significant differences between edible coating treatments in general appearance of fresh cut cantaloupe during storage.

1st season



2 nd season

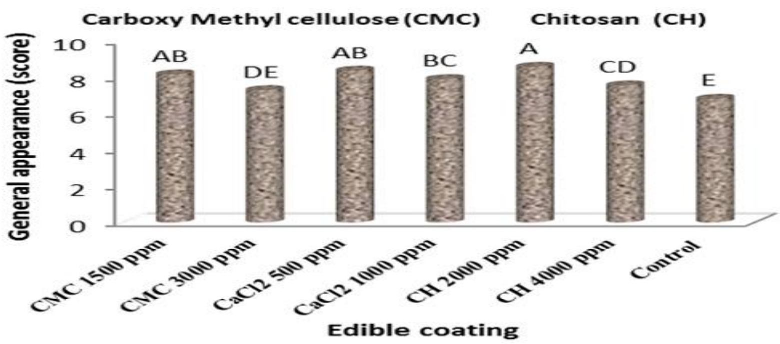
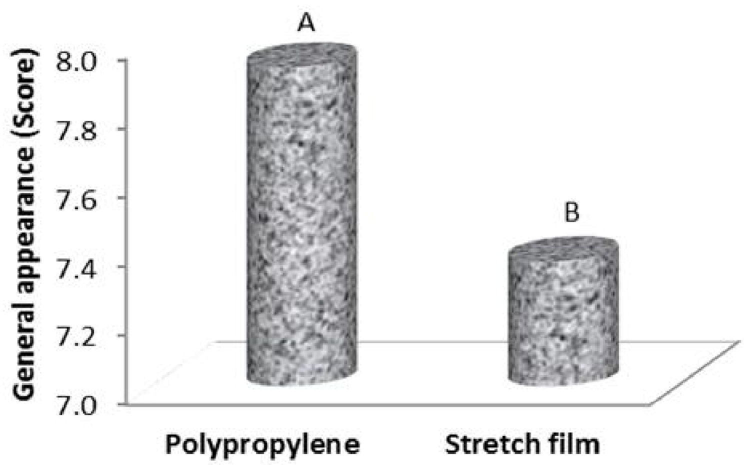


Fig.1 (A). Effect of chitosan(CH), carboxy methyl cellulose(CMC) and $CaCl_2$ treatments on general appearance quality (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

All treatments were better than control, however, fresh cut cantaloupe dipped in solution of chitosan at 2000 ppm, CMC at 1500 ppm and calcium chloride at 500 ppm were the most effective treatments for maintaining general appearance during storage with no significant differences between them in the second season. In another word, these treatments gave the highest score of appearance in both seasons, while untreated (control) obtained the lowest ones in this concern. Fresh cut cantaloupe treated with chitosan at 4000 ppm, CMC at 3000 ppm and $CaCl_2$ at 1000 ppm were less effective in maintaining GA when compared with the other treatments. These results were true in the two seasons and agree with Chong *et al.,* (2015) for $CaCl_2$ and chitosan, Sangsuwan *et al*., (2008) for chitosan and methyl cellulose and Luna-Guzman and Barrett, (2000) for $CaCl_2$. The maintaining of visual quality by using chitosan or carboxy methyl cellulose may be due to the effect of these treatments on the reduction of weight loss, respiratory activity, degradation by enzymes, microbial rot of fruit and ethylene production (Sangsuwan *et al*., 2008). This may be due to that calcium chloride reduced incidence of physiological disorders, decay and delayed senescence of fresh cut cantaloupe (Lamikanra and Watson, 2007).

Concerning effect of wrappers in general appearance data in Fig. 1(B) show that there were significant differences between two wrapping materials on fresh cut cantaloupe during storage. However, fresh cut cantaloupe wrapped with polypropylene film gave highest intensities of freshness, compared wrapped with stretch film in the two seasons and agree with Abou El-Wafa *et al*., (2013).

1st season



2 nd season

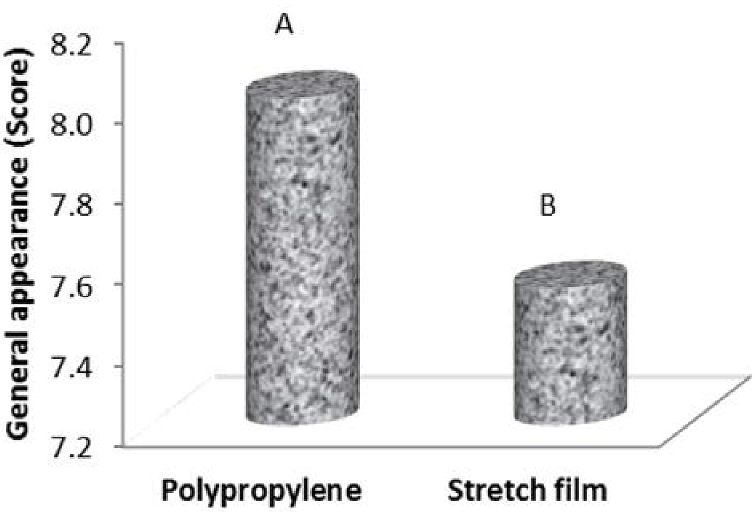
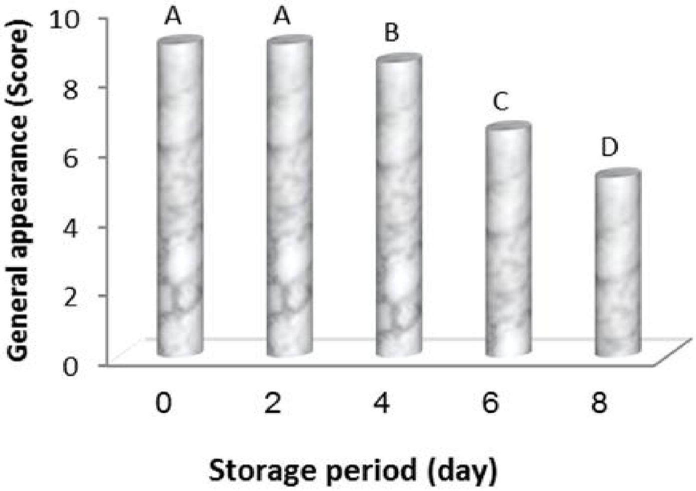


Fig. 1 (B): Effect of wrapping materials on general appearance quality (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Regarding effect of storage period on general appearance data in Fig. 1 (C) showed that general appearance of fresh cut cantaloupe was decreased with the prolongation of storage period. Similar results were reported by (Luna-Guzman and Barrett, 2000 and Attia, 2014) on fresh cut cantaloupe. Quality score was based on fresh appearance, dryness or watery condition, color change and decay.

1st season



2 nd season

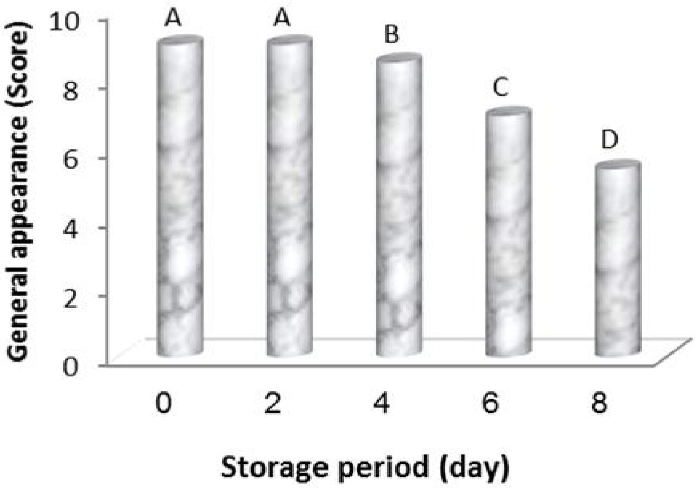


Fig. 1 :(C). Effect of storage period on general appearance (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

General appearance quality scale: 9 = excellent, 7 =good, 5 =fair, 3 = poor, 1=unsalable

Data in Table (1) show that interaction between edible coating treatments, wrapping film and storage period on general appearance, data recorded that fresh cut cantaloupe dipped in chitosan at 2000 ppm or $CaCl_2$ at 500 ppm and wrapped with polypropylene film gave best appearance, it did not exhibit any changes in their appearance till 6th days at 2.5°C and gave good appearance at end of storage period, while, using CMC at 1500ppm or $CaCl_2$ at 1000 ppm and wrapped with polypropylene film, chitosan at 2000 ppm, $CaCl_2$ at 500 ppm and wrapped with stretch film rated good appearance after 6 days of storage and dropped to fair level at end of storage. On the other hand, untreated control wrapped with polypropylene or stretch film had poorest appearance after 8 days of storage.

Table 1: Effect of chitosan(CH), carboxy methyl cellulose (CMC), $CaCl_2$ treatments and wrapping materials on general appearance quality (score) of fresh cut cantaloupe during cold storage (2.5°C and 95% RH) in 2013 and 2014 seasons.

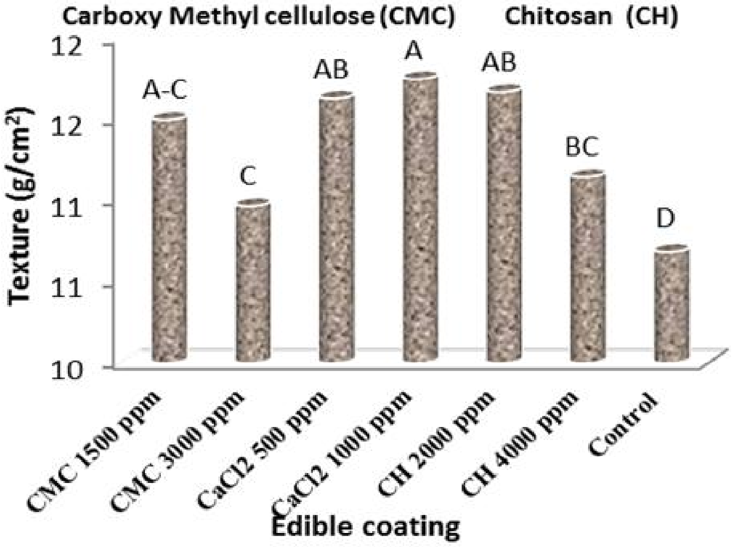
Treatments	Wrapping	Storage period (day)				
		1st season				
		0	2	4	6	8
CH 2000 ppm	P	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab
	St.	9.00 a	9.00 a	9.00 a	7.67 a-c	6.33 b-e
CH 4000 ppm	P	9.00 a	9.00 a	9.00 a	6.33 b-e	5.00 d-g
	St.	9.00 a	9.00 a	8.33 ab	5.00 d-g	4.33 e-g
CMC 1500 ppm	P	9.00 a	9.00 a	9.00 a	7.67 a-c	6.33 b-e
	St.	9.00 a	9.00 a	8.33 ab	6.33 b-e	5.00 d-g
CMC 3000 ppm	P	9.00 a	9.00 a	8.33 ab	6.33 b-e	4.33 e-g
	St.	9.00 a	9.00 a	7.67 a-c	5.67 c-f	3.00 gh
$CaCl_2$ 500 ppm	P	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 a-c
	St.	9.00 a	9.00 a	9.00 a	7.67 a-c	6.33 b-e
$CaCl_2$ 1000 ppm	P	9.00 a	9.00 a	9.00 a	7.00 a-d	6.33 b-e
	St.	9.00 a	9.00 a	8.33 ab	6.33 b-e	5.00 d-g
Control	P	9.00 a	9.00 a	7.67 a-c	4.33 e-g	3.00 gh
	St.	9.00 a	9.00 a	7.00 a-d	3.66 f-h	1.67 h
		2nd season				
CH 2000 ppm	P	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab
	St.	9.00 a	9.00 a	9.00 a	7.67 a-c	6.33 b-e
CH 4000 ppm	P	9.00 a	9.00 a	9.00 a	6.33 b-e	5.00 d-f
	St.	9.00 a	9.00 a	8.33 ab	6.33 b-e	4.33 e-g
CMC 1500 ppm	P	9.00 a	9.00 a	9.00 a	8.33 ab	6.33 b-e
	St.	9.00 a	9.00 a	8.33 ab	7.67 a-c	5.67c -f
CMC 3000 ppm	P	9.00 a	9.00 a	8.33 ab	6.33 b-e	5.67 c-f
	St.	9.00 a	9.00 a	7.00 a-d	5.67 c-f	3.66 fg
$CaCl_2$ 500 ppm	P	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 a-c
	St.	9.00 a	9.00 a	9.00 a	7.67 a-c	5.67 c-f
$CaCl_2$ 1000 ppm	P	9.00 a	9.00 a	9.00 a	7.67 a-c	5.67c-f
	St.	9.00 a	9.00 a	8.33 ab	6.33 b-e	5.67 c-f
Control	P	9.00 a	9.00 a	7.67 a-c	5.67 c-f	4.33 e-g
	St.	9.00 a	9.00 a	7.67 a-c	4.33 e-g	1.67g

Polypropylene (P) *Stretch film (St.)*
General appearance quality scale: 9 = excellent, 7 =good, 5 =fair, 3 = poor, 1=unsalable

Texture

Data in Fig. 2 (A) include the effect of chitosan, CMC and $CaCl_2$ on texture, which showed that edible coating treatments gave significantly greater fruit texture as compared with untreated control. However, fresh cut cantaloupe dipped in $CaCl_2$ at the two concentrations or coating with chitosan at 2000 ppm or carboxy methyl cellulose at 1500 ppm were the most effective treatments in reducing the loss of fruits texture during cold storage with no significant difference between them in the two seasons, however, the other treatments were less effective in this concern. The lowest value of fruit texture was obtained from untreated control. These results were true in the two seasons and agree with Attia, (2014) and Chong *et al*., (2015) for $CaCl_2$ or chitosan and Nadim *et al*., (2015) for methylcellulose. For the effect of chitosan Xing *et al*., (2011) found that chitosan treating on pepper fruit had significantly lower malondialdehyde (MDA) contents and relative leakage rates, as an indicator of membrane integrity was maintained. Also, the maintenance of fruit texture of guava treated with chitosan coating could be due to their higher antifungal activity and covering of the cuticle and lentical, thereby

st season



2 nd season

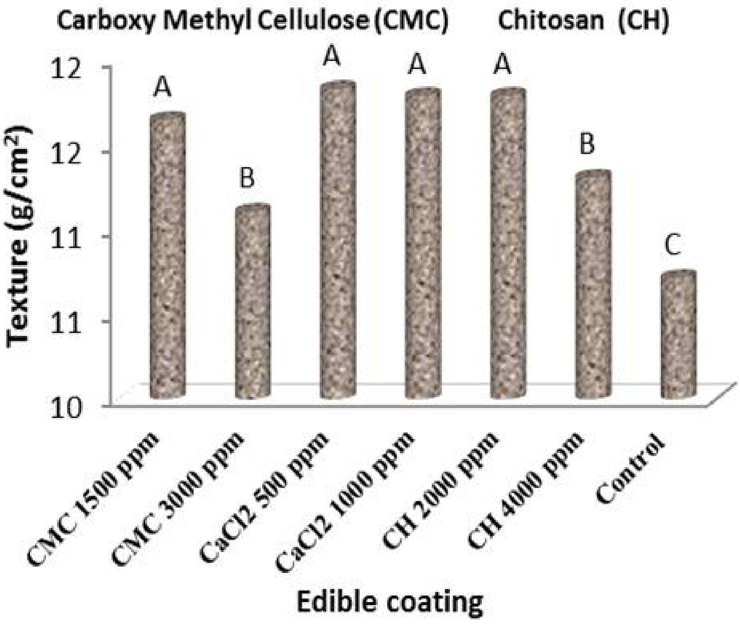


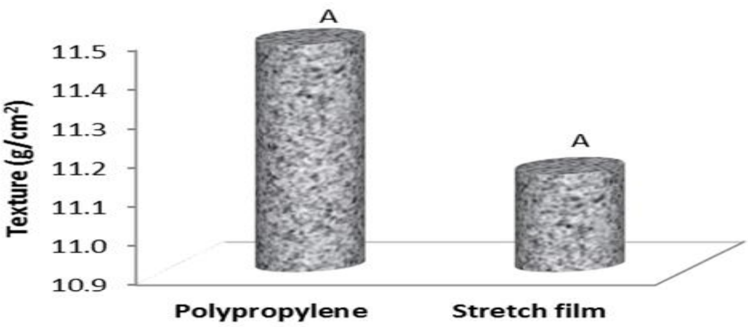
Fig.2 (A): Effect of chitosan(CH), carboxy methyl cellulose(CMC) and $CaCl_2$ treatments on texture (g/cm_2) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

reducing infection, respiration and other ripening processes during storage. For the effect of carboxy methyl cellulose Nadim *et al*., (2015) found that methylcellulose coating of strawberry fruit showed a beneficial effect on firmness during storage. Probably because this coating reduces the metabolism, keeping up the storage life, Maftoonazad and Ramaswamy (2004) stated that the retention of firmness by using CMC could be explained by CMC coating retarded degradation of insoluble proto-pectins to the more soluble pectic acid and pectin. The favorable effect of $CaCl_2$ could be due to that calcium maintain the cell wall structure in fruit by interacting with pectin in the cell wall (Degrave *et al*., 2003); calcium also increases cell wall turgor pressure and stabilizers the cell membrane (Luna-Guzman and Barrett, 2000). Also, the free carboxylic acid liberated by pectin methyl esterase can interact with calcium to form a molecular network which results in an improvement in fruit firmness (Degrave *et al*., 2003).

For the effect of wrapping materials, data in Fig. 2 (B) show that there were significant differences between wrapping materials in the second season. Fresh cut cantaloupe wrapped with polypropylene film retarded texture loss as compared with these wrapped with stretch film. The previous results were true in the two seasons.

Data in Fig. 2 (C) show that texture of fresh cut cantaloupe decreased continuously with extending storage period in different treatments used.

1st season



2 nd season

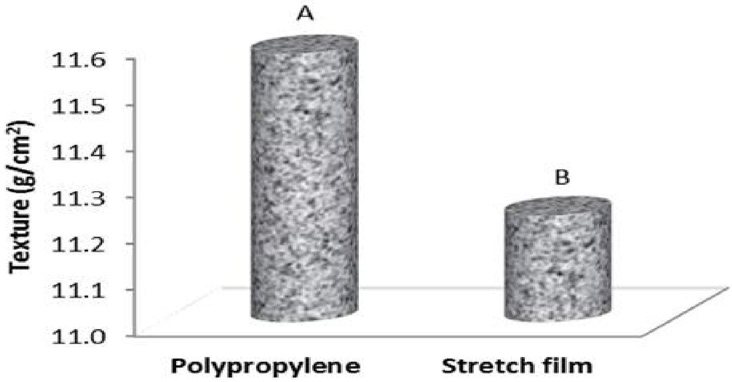
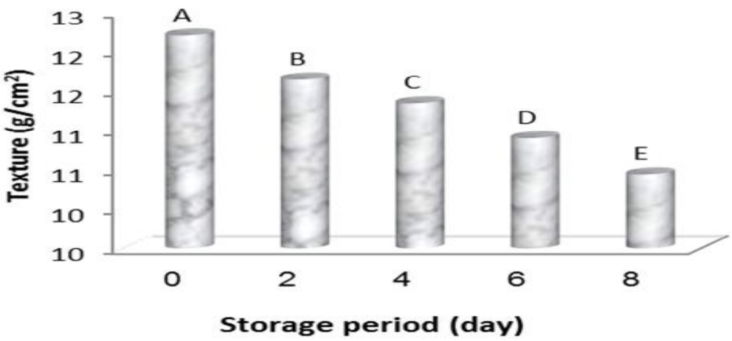


Fig. 2(B): Effect of wrapping materials on texture (g/cm2) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

1st season



2 nd season

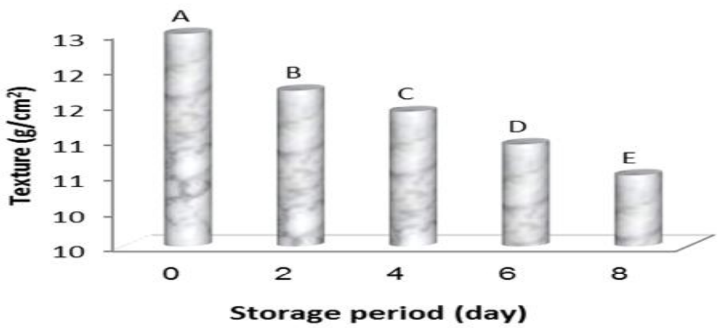


Fig. 2 (C): Effect of storage period on texture (g/cm2) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Table 2: Effect of chitosan(CH), carboxy methyl cellulose (CMC), $CaCl_2$ treatments and wrapping materials on texture (g/cm^2) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Treatments	Wrapping	Storage period (day)				
		1st season				
		0	2	4	6	8
CH 2000 ppm	P	12.20 a	12.10 ab	12.00 a-c	11.60 a-h	11.36 a-l
	St.	12.20 a	11.90 a-d	11.50 a-j	11.00 e-p	10.68 i-q
CH 4000 ppm	P	12.20 a	11.56 a-i	11.23 b-n	10.87 g-q	10.35 n-r
	St.	12.20 a	11.24 b-m	11.00 e-p	10.64 j-q	10.12 o-r
CMC 1500 ppm	P	12.20 a	12.00 a-c	11.84 a-e	11.41 a-k	11.20 c-o
	St.	12.20 a	11.60 a-h	11.20 c-o	10.87 g-q	10.34 o-r
CMC 3000 ppm	P	12.20 a	11.40 a-k	11.00 e-p	10.61k-r	10.12 p-r
	St.	12.20 a	11.10 d-o	10.82 g-q	10.32 o-r	9.74 r-t
$CaCl_2$ 500 ppm	P	12.20 a	12.08 a-c	11.90 a-d	11.53 a-i	11.30 b-m
	St.	12.20 a	11.80 a-e	11.40 a-k	10.93 f-p	10.45 m -r
$CaCl_2$ 1000 ppm	P	12.20 a	12.10 ab	12.00 a-c	11.83 a-e	11.30 b-m
	St.	12.20 a	11.92 a-d	11.62 a-g	11.20 c-o	11.00 e-p
Control	P	12.20 a	11.10 d-o	10.72 h-q	10.00 q-s	9.12 st
	St.	12.20 a	11.10 d-o	10.50 l-r	9.82 r-t	9.00 t
		2nd season				
CH 2000 ppm	P	12.50 a	12.30 ab	12.05 a-e	11.65 a-j	11.45 a-m
	St.	12.50 a	11.95 a-f	11.55 a-l	11.06 c-p	10.75 g-p
CH 4000 ppm	P	12.50 a	11.85 a-h	11.30 b-n	10.95 e-p	10.45 k-r
	St.	12.50 a	11.45 a-m	11.05 c-p	10.70 h-q	10.20 n-s
CMC 1500 ppm	P	12.50 a	12.20 a-c	11.90 a-g	11.50 a-l	11.30 b-n
	St.	12.50 a	11.80 a-h	11.25 b-o	10.95 e-p	10.45 k-r
CMC 3000 ppm	P	12.50 a	11.60 a-k	11.05 c-p	10.70 h-q	10.30 m-r
	St.	12.50 a	11.30 b-n	10.90 e-q	10.40 l-r	9.75 q-s
$CaCl_2$ 500 ppm	P	12.50 a	12.28 ab	11.95 a-f	11.60 a-k	11.40 a-m
	St.	12.50 a	12.00 a-e	11.45 a-m	11.00 d-e	10.50 g-q
$CaCl_2$ 1000 ppm	P	12.50 a	12.30 ab	12.05 a-e	11.40 a-m	11.05 c-p
	St.	12.50 a	12.15 a-d	11.70 a-i	11.25 b-o	10.90 e-q
Control	P	12.50 a	11.30 b-n	10.80 f-q	10.10 o-s	9.30 r-s
	St.	12.50 a	11.30 b-n	10.55 i-q	9.90 p-s	9.1o s

Polypropylene (P) *Stretch film (St.)*

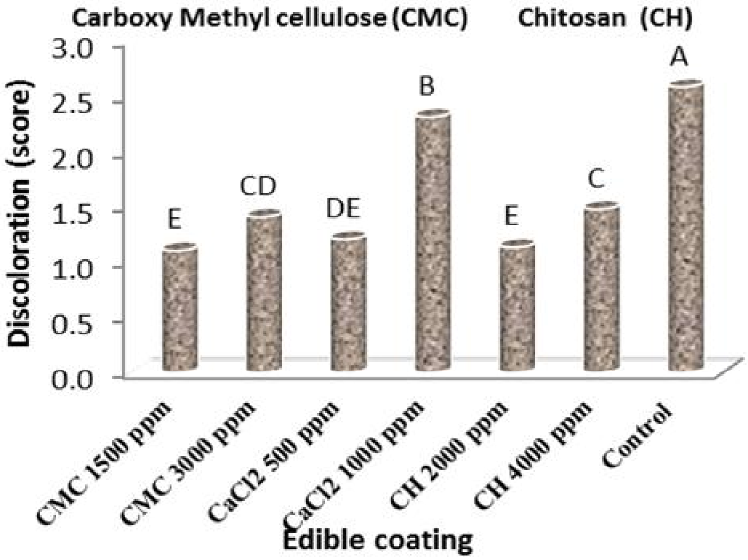
Results were true in the two seasons and agree with Attia, (2014) and Chong *et al*., (2015). The loss of texture caused by the degradation of cell polysaccharides especially pectin component, pectin degradation is not only attributed to modification of pectin contents but also significantly caused by the alteration of pectin nanostructures (Chen *et al*., 2011).

Data in Table (2) indicated the interaction between edible coating treatments and wrapping materials on texture was significant in the two seasons, however, fresh cut cantaloupe treated with $CaCl_2$ at (500 or 1000ppm) or chitosan coating at 2000 ppm or CMC at 1500 ppm and wrapped with polypropylene film was the most obvious in maintaining the fruit texture during storage in the two seasons with no significant between them. The lowest values of fruit texture were obtained from untreated control wrapped with stretch film.

Discoloration

Data in Fig. 3 (A) showed that effect of edible coating treatments, reduced the incidence of discoloration compared to control. However, fresh cut cantaloupe dipped in $CaCl_2$ at 500 ppm, or coating with carboxy methyl cellulose at 1500 ppm or chitosan at 2000 ppm were the most effective treatments in this concern. The higher concentration of $CaCl_2$, carboxy methyl cellulose and chitosan were less effective in reducing the incidence of discoloration, these results were true in the two seasons and agree with Luna-Guzman and Barrett, (2000) for $CaCl_2$ who found that $CaCl_2$ prevented discoloration in cut surface of fresh cut cantaloupe. The reduction in discoloration in cut surface of cantaloupe may be due to that $CaCl_2$ treatments reduced ppo activity and preserved the total phenolic content and reduced color change of cut surface of cantaloupe (Luna-Guzman and Barrett, 2000).

1st season



2 nd season

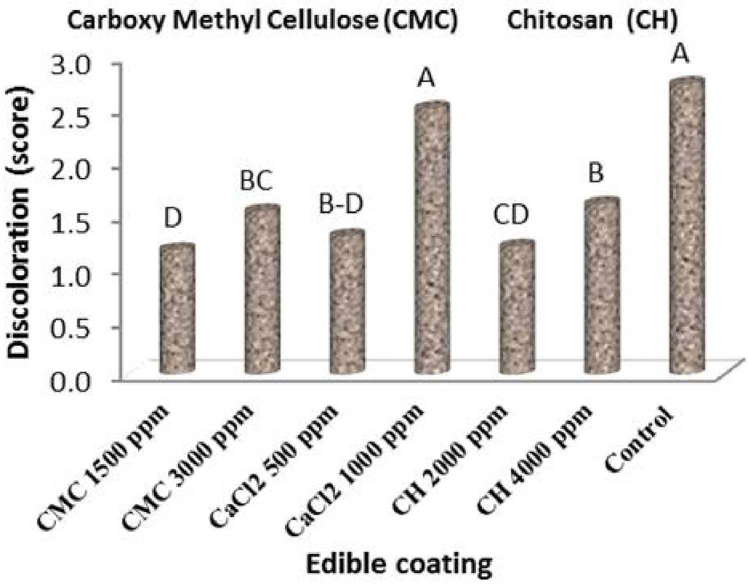


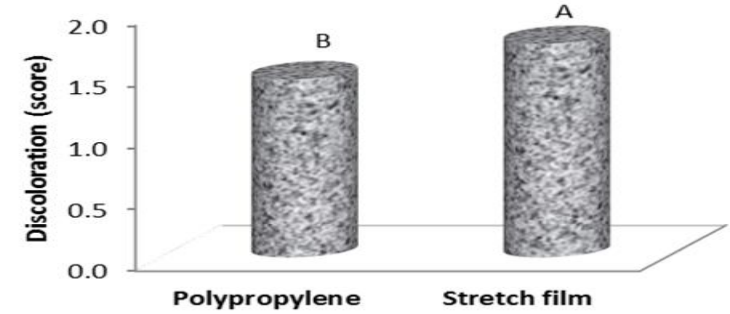
Fig. 3 (A): Effect of chitosan(CH), carboxy methyl cellulose(CMC) and $CaCl_2$ treatments on discoloration (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Concerning the effect of wrapping materials, data in Fig. 3 (B) show that fresh cut cantaloupe wrapped with polypropylene film prevented discoloration in the cut surface which gave the lower score of discoloration than those wrapped with stretch film which gave the highest ones during storage.

Data in Fig. 3 (C) showed that there was increment in discoloration for the cut surface of cantaloupe as the storage period was prolonged, these results were true in the two seasons and agree with Attia (2014).

The change in color development is related primarily to the oxidation of phenolic compounds to o-quinines a reaction, catalyzed by polyphenol oxidase (ppo). Quinines then polymerize to dark brown, black or red polymers (Sapers and Hieks, 1989).

1st season



2 nd season

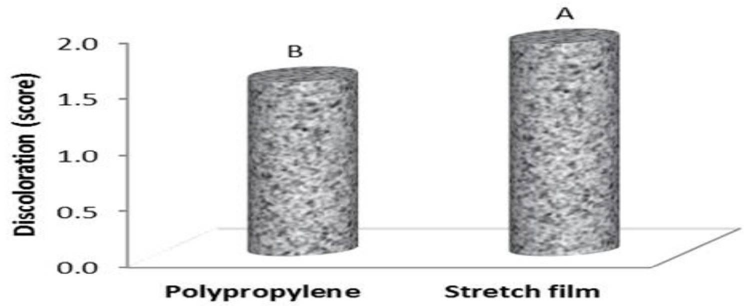
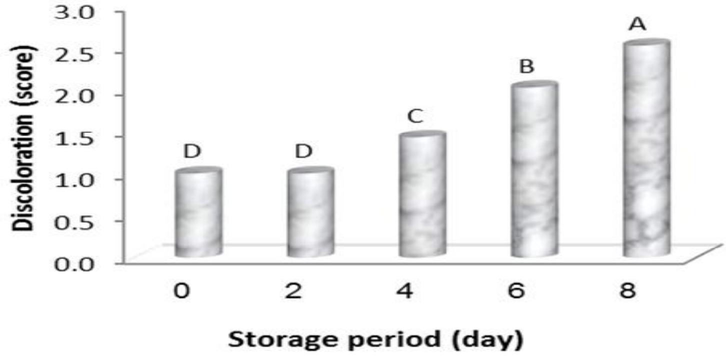


Fig. 3(B): Effect of wrapping materials on discoloration (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

1st season



2 nd season

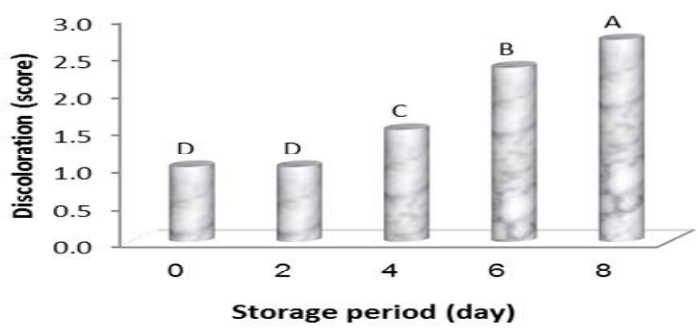


Fig. 3(C): Effect of storage period on discoloration (Score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Regarding the interaction between edible coating treatments, wrapping film and storage period on the discoloration, data in Table (3) revealed that fresh cut cantaloupe treated with CMC at 1500 ppm and chitosan at

2000 ppm and wrapped with polypropylene film did not show any changes in their color till the end of storage (8days). However, CMC at 3000 ppm and chitosan at 4000 ppm treatment and wrapped with polypropylene film gave slight score while $CaCl_2$ at 1000 ppm and wrapped with polypropylene or stretch film gave sever score after the same period. The untreated control and wrapped with stretch film resulted in extra sever discoloration with the highest score, these results were true in the two seasons.

Table 3: Effect of chitosan(CH), carboxy methyl cellulose (CMC), $CaCl_2$ treatments and wrapping materials on discoloration (score) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Treatments	Wrapping	Storage period (day)				
		1st season				
		0	2	4	6	8
CH 2000 ppm	P	1.00 k	1.00 k	1.00 k	1.00 k	1.00 k
	St.	1.00 k	1.00 k	1.00 k	1.66 i-k	1.66 i-k
CH 4000 ppm	P	1.00 k	1.00 k	1.00 k	1.66 i-k	2.33 g-i
	St.	1.00 k	1.00 k	1.00 k	2.00 h-j	2.66 f-h
CMC 1500 ppm	P	1.00 k	1.00 k	1.00 k	1.00 k	1.00 k
	St.	1.00 k	1.00 k	1.00 k	1.33 jk	1.66 i-k
CMC 3000 ppm	P	1.00 k	1.00 k	1.00 k	1.66 i-k	2.00 h-j
	St.	1.00 k	1.00 k	1.00 k	2.00 h-j	2.33 g-i
$CaCl_2$ 500 ppm	P	1.00 k	1.00 k	1.00 k	1.00 k	1.33 jk
	St.	1.00 k	1.00 k	1.00 k	1.66 i-k	2.00 h-j
$CaCl_2$ 1000 ppm	P	1.00 k	1.00 k	2.00 h-j	3.00 e-g	3.66 c-e
	St.	1.00 k	1.00 k	2.66 f-h	3.66 c -e	4.00 b-d
Control	P	1.00 k	1.00 k	2.00 h-j	2.33 g-i	4.66 ab
	St.	1.00 k	1.00 k	3.33 d-f	4.33 a-c	5.00 a
		2nd season				
CH 2000 ppm	P	1.00 h	1.00 h	1.00 h	1.00 h	1.00 h
	St.	1.00 h	1.00 h	1.00 h	2.00 f-h	2.00 f-h
CH 4000 ppm	P	1.00 h	1.00 h	1.00 h	2.00 f-h	2.67 d-g
	St.	1.00 h	1.00 h	1.00 h	2.33 e-h	3.00 c-g
CMC 1500 ppm	P	1.00 h	1.00 h	1.00 h	1.00 h	1.00 h
	St.	1.00 h	1.00 h	1.00 h	1.66 gh	2.00 f-h
CMC 3000 ppm	P	1.00 h	1.00 h	1.00 h	2.00 f-h	2.33 e-h
	St.	1.00 h	1.00 h	1.00 h	2.33 e-h	2.67 d-g
$CaCl_2$ 500 ppm	P	1.00 h	1.00 h	1.00 h	1.00 h	1.66 gh
	St.	1.00 h	1.00 h	1.00 h	2.00 f-h	2.33 e-h
$CaCl_2$ 1000 ppm	P	1.00 h	1.00 h	2.33 e-h	3.33 b-f	4.00 a-d
	St.	1.00 h	1.00 h	3.00 c-g	4.00 a-d	4.33 a-c
Control	P	1.00 h	1.00 h	2.33 e-h	2.67 d-g	5.00 a
	St.	1.00 h	1.00 h	3.66 b-f	4.66 ab	5.00 a

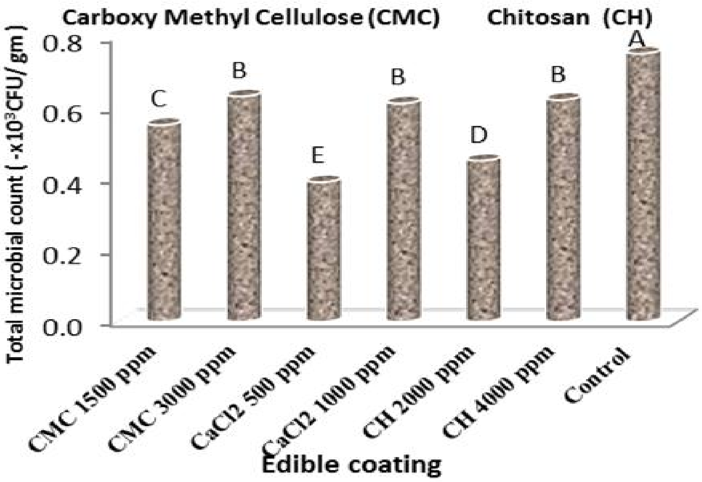
Polypropylene (P) *Stretch film (ST.)*
Discoloration scale: 1= none, 2= slight, 3= moderate, 4= severe and 5= extra severe

Total microbial count

Data in Fig.4 (A) revealed that effect of edible coating treatments, there were significant differences in micro organism growth between edible coating treatments and control. Fresh cut cantaloupe treated with all used treatments had lower levels of microbial load in comparison to control treatment, while, dipped in $CaCl_2$ at 500 ppm or chitosan coating at 2000 ppm provided the lowest count in all types of micro organisms with no significant differences between them in the second season followed by CMC at 1500 ppm in first season and $CaCl_2$ at 1000 ppm in second season, while the other treatment gave less effective in reducing microbial growth.

These results were true in the two seasons and agree with Luna-Guzman and Barrett, (2000); Attia (2014) for $CaCl_2$ and Chong *et al*., (2015) for $CaCl_2$ or chitosan and Nadim *et al*., (2015) for methylcellulose.

1st season



2 nd season

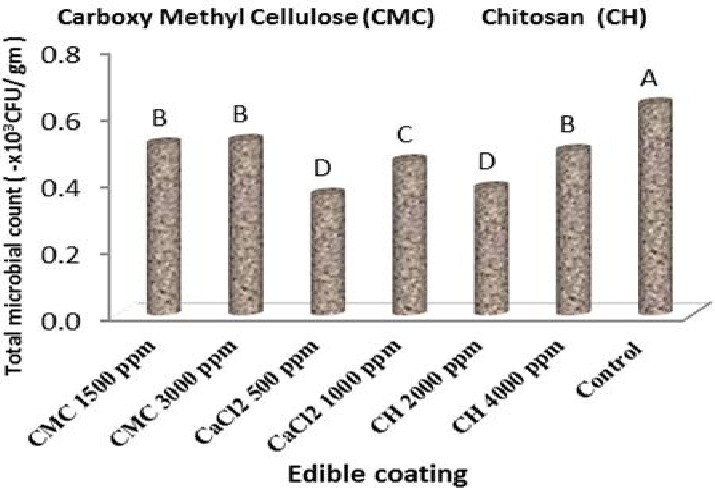
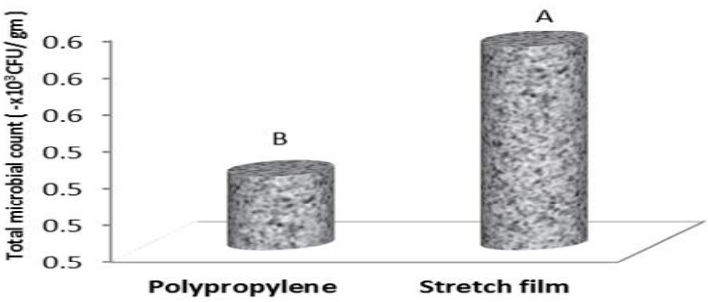


Fig.4 (A): Effect of chitosan(CH), carboxy methyl cellulose(CMC) and $CaCl_2$ treatments on total microbial count-) $x10^3$CFU/ gm) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Rabea *et al*., (2003) revealed that the antimicrobial of chitosan is probably caused by the interaction between chitosan and the microbial cell membranes, which leads to the leakage of proteinaceous and other intracellular constituents. Chitosan can also penetrate to the nuclei of fungi and interferes with RNA and protein synthesis. Also, Krasaekoopt and Mabumrung (2008) found that the fresh cut cantaloupe coated with chitosan at 1% or 2% reduced the psychrotroph counts below the detectable level of lower than 100 $cfug^{-1}$ throughout the storage period, also reduced the number of yeast and mold counts to lower than 200 log $cfug^{-1}$. This was probably due to the fungicidal action of chitosan that caused alteration in the function of the cellular membrane (Fang *et al*., 1994). The favorable effect of $CaCl_2$ Luna-Guzman and Barrett, (2000) found that $CaCl_2$ have provided an inhibitory effect on microbial growth while control treatment allowed for spore spreading and actually increased counts. The reduction of micro organisms in fresh cut cantaloupe treated with $CaCl_2$ may be due to calcium salts can lower intracellular PH or reduce water activity (Shelef, 1994) which provides a protective Antimicrobial barrier against food borne pathogens in product (Weaver and Shelef, 1993). Also, $CaCl_2$ treatment may have provided inhibitory effect on microbial growth (Weaver and Shelef, 1993).

Concerning the effect of wrapping films on micro organism growth data in Fig.4 (B) found significant differences between two wrapping materials during storage, however, fresh cut cantaloupe wrapped with polypropylene film had lower level of microbial load in comparison to these wrapped with stretch film. These results agree with Sangsuwan *et al*., (2008) who found that wrapping film alter the gases surrounding a respiring product in order to slow the normal senescence and delay or prevent the growth of micro organisms on the product's surface, hence, load to an extension of its shelf life.

1st season



2 nd season

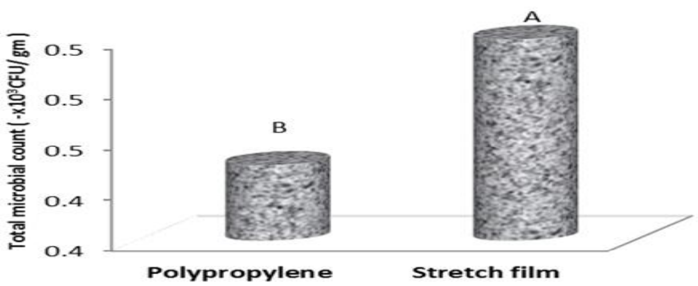
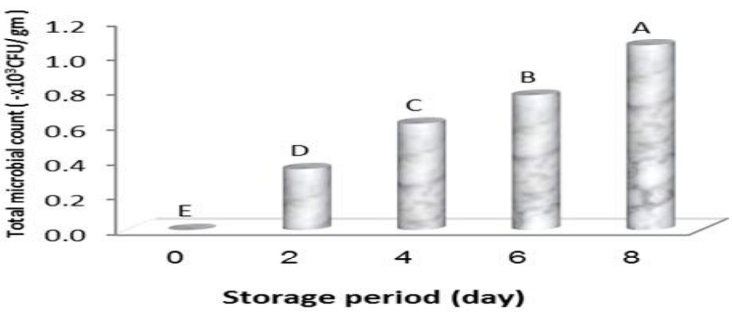


Fig. 4 (B): Effect of wrapping materials on total microbial count (-x10^3CFU/ gm) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Data in Fig.4 (C) showed that microbial growth in fresh cut cantaloupe increased with increasing the storage period particularly in untreated control. These results were true in the two seasons, similar results were reported by Luna-Guzman and Barrett, (2000) and Attia (2014) on fresh cut cantaloupe.

1st season



2 nd season

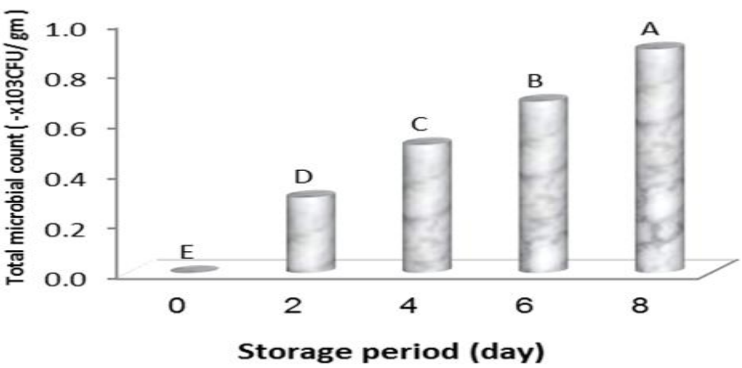


Fig. 4(C): Effect of storage period on total microbial count (-x10^3CFU/ gm) of fresh cut cantaloupe during cold storage) 2.5° C and 95% RH) in 2013 and 2014 seasons.

Data in Table (4) indicated to the interaction between edible coating treatments, wrapping materials and storage period was significant during all storage periods. After 8 days of storage showing that fresh cut cantaloupe treated with $CaCl_2$ at 500 ppm or chitosan at 2000 ppm and wrapped with polypropylene or stretch film were effective in inhibition of bacterial growth.

Table 4: Effect of chitosan(CH), carboxy methyl cellulose (CMC), $CaCl_2$ treatments and wrapping materials on total microbial count (CFU/ gm) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

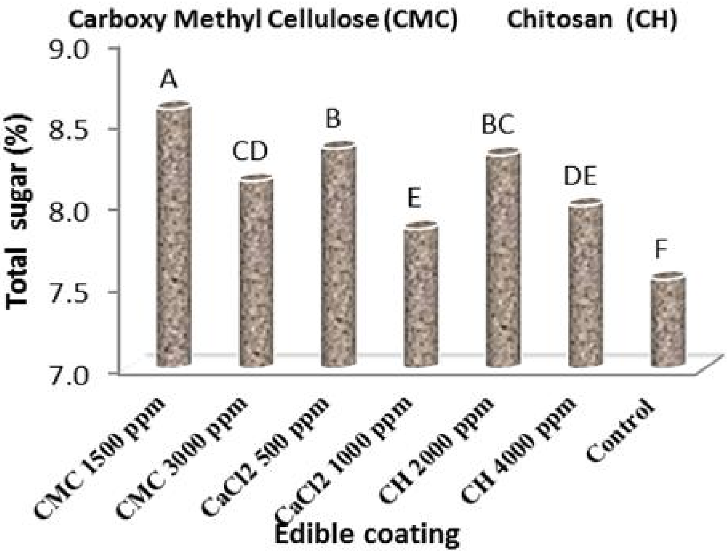
Treatments	Wrapping	Storage period (day)				
		1st season				
		0	2	4	6	8
CH 2000 ppm	P	0.00 n	0.40 k-m	0.50 i-k	0.73 gh	0.73 gh
	St.	0.00 n	0.27 m	0.40 k-m	0.60 h-j	0.83 fg
CH 4000 ppm	P	0.00 n	0.40 k-m	0.67 h	0.87 ef	1.23 bc
	St.	0.00 n	0.30 lm	0.73 gh	0.90 ef	1.10 cd
CMC 1500 ppm	P	0.00 n	0.30 lm	0.50 i-k	0.73 gh	0.90 ef
	St.	0.00 n	0.30 lm	0.70 gh	0.93 ef	1.07 d
CMC 3000 ppm	P	0.00 n	0.27 m	0.47 jk	0.83 fg	1.33 b
	St.	0.00 n	0.33 lm	0.83 fg	1.00 de	1.23 bc
$CaCl_2$ 500 ppm	P	0.00 n	0.30 lm	0.37 k-m	0.50 i-k	0.63 hi
	St.	0.00 n	0.27 m	0.47 jk	0.60 h-j	0.70 gh
$CaCl_2$ 1000 ppm	P	0.00 n	0.40 k-m	0.63 hi	0.73 gh	1.00 de
	St.	0.00 n	0.47 jk	0.83 fg	0.93 ef	1.10 cd
Control	P	0.00 n	0.47 jk	0.60 h-j	1.00 de	1.04 d
	St.	0.00 n	0.53 i-k	0.85 fg	1.02 de	1.95 a
		2nd season				
CH 2000 ppm	P	0.00 w	0.33 s-v	0.43 p-s	0.60 k-n	0.63 j-m
	St.	0.00 w	0.23 v	0.33 s-v	0.50 n-q	0.70 h-k
CH 4000 ppm	P	0.00 w	0.30 t-v	0.53 m-p	0.60 k-n	0.83 e-g
	St.	0.00 w	0.33 s-v	0.70 h-k	0.77 f-i	0.87 d-f
CMC 1500 ppm	P	0.00 w	0.23 v	0.37 r-u	0.67 i-l	1.07 b
	St.	0.00 w	0.27 uv	0.67 i-l	0.80 e-h	1.00 bc
CMC 3000 ppm	P	0.00 w	0.30 t-v	0.53 m-p	0.67 i-l	1.00 bc
	St.	0.00 w	0.23 v	0.60 k-n	0.73 g-j	0.97 b-d
$CaCl_2$ 500 ppm	P	0.00 w	0.00 w	0.23 v	0.60 k-n	0.73 g-j
	St.	0.00 w	0.23 v	0.37 r-u	0.47 o-r	0.57 l-o
$CaCl_2$ 1000 ppm	P	0.00 w	0.27 uv	0.40 q-t	0.63 j-m	0.73 g-j
	St.	0.00 w	0.27 uv	0.57 l-o	0.77 f-i	0.90 c-e
Control	P	0.00 w	0.41 q-t	0.51 m-p	0.81e-h	0.81e-h
	St.	0.00 w	0.47 o-r	0.74 g-j	0.87d-f	1.61a

Polypropylene (P) *Stretch film (St.)*

Total sugars

Data in Fig. 5 (A) showed that effect of edible coating treatments reduced the total sugar loss as compared with control, fresh cut cantaloupe treated with CMC at 1500 ppm or $CaCl_2$ at 500 ppm seems to be the most effective in reducing the total sugar loss with significant differences between them in the two seasons, followed by chitosan at 2000 ppm. The higher concentrations of these materials were less effective in this concern. Similar results were obtained by Bautista-Banos (2006) revealed that mango fruits treated with chitosan coating maintained reducing sugar during storage. Attia, (2014); Lamikrana and Watson, (2007) they found that dipping fresh cut cantaloupe in $CaCl_2$ induce a delay in consumption of sugar during storage with no detrimental effect of consumer acceptance. Also, the effect of $CaCl_2$ on total sugar during storage might be due to calcium delayed the process as shown by increased contents in the cyclohexane. 1.2 diamine tetra-acetate (CDTA), Na_2Co_2 soluble fractions and lower levels in water- soluble fractions (Amal *et al*., 2010).

1st season



2 nd season

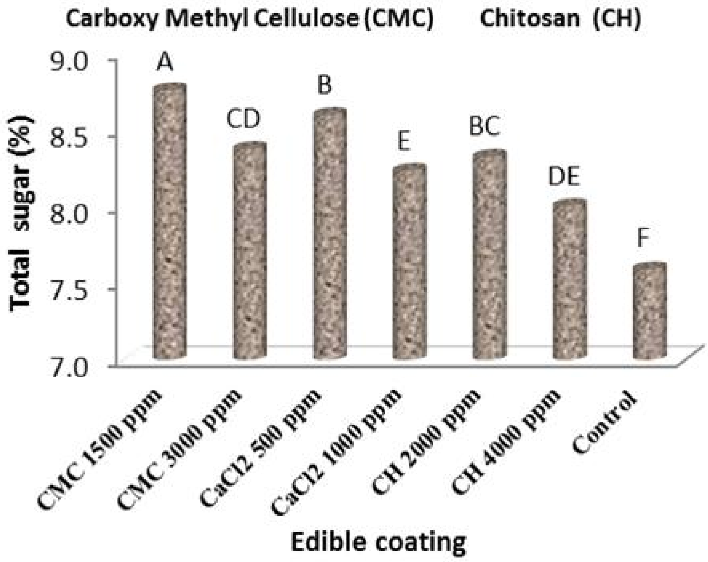
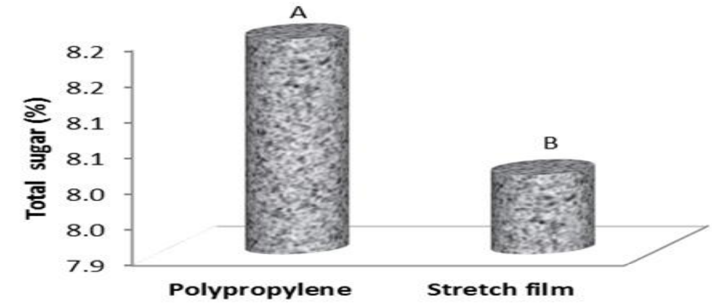


Fig.5 (A): Effect of chitosan(CH), carboxy methyl cellulose(CMC) and $CaCl_2$ treatments on total sugar (%) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Concerning the effect of wrapping materials, data in Fig. 5 (B) show that there were significant differences between wrapping materials, fresh cut cantaloupe wrapped with polypropylene film retarded total sugars loss as compared with those wrapped with stretch film in the two seasons and agree with Abou El-Wafa *et al*., (2013).
Data in Fig. 5 (C) showed that total sugar content of fresh cut cantaloupe was decreased as the storage period was extended. The decrease of total sugar is probably due to the consumption of sugars through respiration (Lamikrana and Watson, 2007). These results were true in the two seasons and agree with Attia, (2014).
Data in Table (5) showed the interaction between edible coating treatments, wrapping materials and storage period on total sugars were significant, however, fresh cut cantaloupe treated with CMC at 1500 ppm and wrapped with polypropylene or stretch film and $CaCl_2$ at 500 ppm or chitosan at 2000 ppm and wrapped with polypropylene film had the highest values of total sugars during storage with no significant differences between them in the two seasons, the lowest value was obtained from untreated control wrapped with stretch film. In general, the interaction between edible coating treatments, wrapping materials and storage period were significant in the two seasons. After 8 days of storage, fresh cut cantaloupe treated with CMC at 1500 ppm, $CaCl_2$ at 500 ppm and chitosan at 2000 ppm and wrapped with polypropylene film gave highest total sugars content, while untreated control wrapped with stretch film gave lowest ones at the same period.

1st season



2 nd season

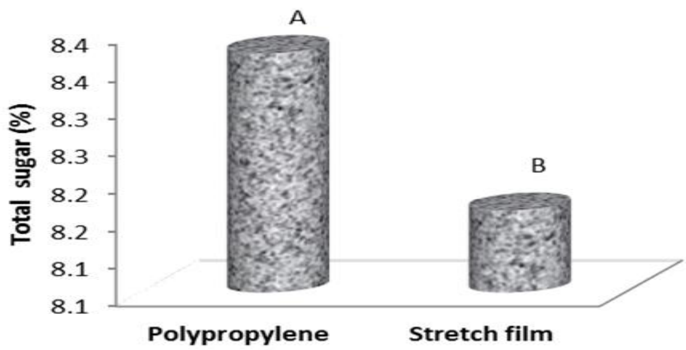
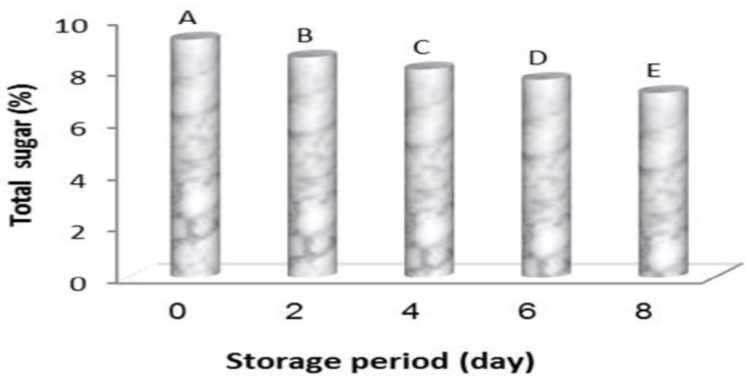


Fig. 5(B): Effect of wrapping materials on total sugar (%) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

1st season



2 nd season

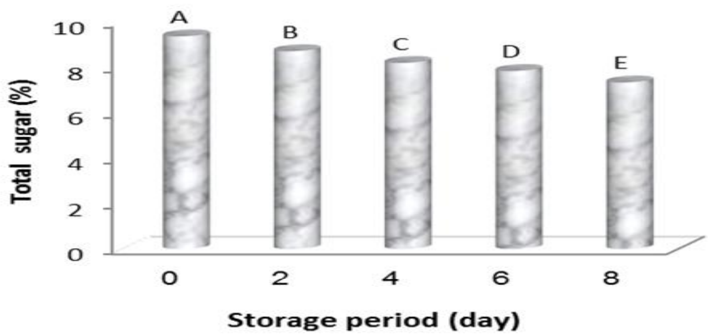


Fig. 5(C): Effect of storage period on total sugar (%) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013and 2014 seasons.

Table 5: Effect of chitosan(CH), carboxy methyl cellulose (CMC), $CaCl_2$ treatments and wrapping materials on total sugars (%) of fresh cut cantaloupe during cold storage (2.5° C and 95% RH) in 2013 and 2014 seasons.

Treatments	Wrapping	Storage period (day)				
		1st season				
		0	2	4	6	8
CH 2000 ppm	P	9.20 a	8.80 a-c	8.33 b-f	8.00 d-j	7.60 f-m
	St.	9.20 a	8.60 a-d	8.10 c-i	7.80 e-l	7.30 j-n
CH 4000 ppm	P	9.20 a	8.50 a-e	8.00 d-j	7.60 f-m	7.14 k-p
	St.	9.20 a	8.30 b-f	7.80 e-l	7.30 j-n	6.80 n-q
CMC 1500 ppm	P	9.20 a	9.00 ab	8.80 a-c	8.33 b-f	7.90 d-k
	St.	9.20 a	8.80 a-c	8.64 a-d	8.23 b-g	7.65 f-m
CMC 3000 ppm	P	9.20 a	8.61 a-d	8.15 c-g	7.80 e-l	7.32 i-n
	St.	9.20 a	8.50 a-e	8.00 d-j	7.60 f-m	7.03 l-p
$CaCl_2$ 500 ppm	P	9.20 a	8.83 a-c	8.45 a-e	8.10 c-i	7.62 f-m
	St.	9.20 a	8.60 a-d	8.11 c-h	7.92 d-k	7.33 h-n
$CaCl_2$ 1000 ppm	P	9.20 a	8.50 a-e	8.00 d-j	7.50 g-n	7.00 m-p
	St.	9.20 a	8.00 d-j	7.62 f-m	7.00 m-p	6.50 o-q
Control	P	9.20 a	8.00 d-j	7.50 g-n	6.80 n-q	6.40 pq
	St.	9.20 a	8.00 d-j	7.20 k-o	6.90 m-q	6.20 q
		2nd season				
CH 2000 ppm	P	9.35 a	8.90 a-f	8.40 b-k	8.10 e-m	7.70 ef
	St.	9.35 a	8.50 a-j	8.00 g-o	7.70 ef	7.20 n-s
CH 4000 ppm	P	9.35 a	8.40 b-k	8.00 g-o	7.60	7.15 o-s
	St.	9.35 a	8.20 c-m	7.90 h-p	7.40 m-r	6.90 q-t
CMC 1500 ppm	P	9.35 a	9.20 ab	8.95 a-e	8.55 a-j	8.05 f-n
	St.	9.35 a	9.05 a-c	8.75 a-h	8.42 b-k	7.80 i-p
CMC 3000 ppm	P	9.35 a	8.80 a-g	8.35 b-l	8.00 g-o	7.50 l-r
	St.	9.35 a	8.65 a-i	8.20 c-m	7.90 h-p	7.53 k-r
$CaCl_2$ 500 ppm	P	9.35 a	9.05 a-c	8.65 a-i	8.40 b-k	7.90 h-p
	St.	9.35 a	8.90 a-f	8.40 b-k	8.10 e-m	7.73 j-q
$CaCl_2$ 1000 ppm	P	9.35 a	9.00 a-d	8.30 c-l	8.00 g-o	7.50 l-r
	St.	9.35 a	8.50 a-j	7.90 h-p	7.50 l-r	6.90 q-t
Control	P	9.35 a	8.15 d-m	7.40 m-r	6.90 q-t	6.50 st
	St.	9.35 a	8.20 c-m	7.10 p-s	6.80 r-t	6.10 t

Polypropylene (p) *Stretch film (St.)*

Conclusion

From the previous results, it could be concluded that fresh cut cantaloupe dipped in chitosan at 2000 ppm and wrapped with polypropylene film were the most effective treatments in reducing total microbial count and maintained quality (texture, total sugar) and gave fruits with good appearance for 8 days at 2.5°C. however $CaCl_2$ at 500 ppm and wrapped with polypropylene film could be stored for 6 days at 2.5°C with good appearance.

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