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EFFECT OF COLD STORAGE ON THE QUALITY ATTRIBUTES OF CANTALOUPE FRESH CUTS

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ABSTRACT

Cantaloupe is one of the most popular vegetables and some interesting functional products could be developed. Cantaloupe is a horticultural product with a high nutritional value that can be consumed fresh but also minimally processed. Cold storage affected on quality of stored fresh cuts at 5°C. An increase for colour values was recorded. The results indicated that fresh-cuts stored at 5°C had better colour and quality. In fresh-cuts control sample, colour values of lightness (L) and yellow blue colour (b) were 25.64 and 12.20. After seven days of storage at 5°C, these values increased to 25.79 and 12.71, respectively. Also, red to green colour (a) values increased during storage period for 14 days. In control sample, the pH value was 6.05, and then increased to 6.44 after 14 days of storage. On contrary, soluble solids content were in the same range of 6.20 %, and then decreased to 5.77 % at the end of storage for 14 days. During seven days of storage, total sugars, vitamin C and total carotenoids were nearly stable at 5°C. The values were 2.392 % for total sugars, 40 mg/ 100 ml juice for ascorbic acid and 7.5 µg/ ml juice for total carotenoids. In fresh sample, titratable acidity was 0.0657 %, and then the value decreased to 0.05928 % and 0.0516 % after 7 and 14 days of storage at 5°C, respectively. For pectin substances and phenol compounds of fresh-cuts, the values were 1.62 and 0.87 %, then decreased to 1.26 and 0.55 % at the end of storage period, respectively. Concerning flavour compounds, the typical strong flavour and delicate aroma of cantaloupe fresh-cuts attributes were related to its high content of ester compounds, of which 27 were identified. Flavour compounds losses of aldehydes and alcohols were observed and some relevant compounds of cantaloupe aroma profile were developed. Also, most of esters increased during storage period. After fourteen days of storage at 5°C, many of flavour compounds were not detected. Total bacterial count increased from 2.3×10^3 CFU/g sample in fresh control sample to 6.3×10^3 CFU/g sample. Results of sensory evaluation showed that flavour and appearance were maintained at 5°C and significant differences in flavour were found at stored sample for 14 days.

Key words: Cantaloupe, chemical, microbiological, sensory evaluation.

INTRODUCTION

Cantaloupes are one of the most consumed vegetables worldwide because of its flavour and health benefits (Ismail *et al.,* 2010). Cantaloupes are a nutritive vegetables containing high levels of biologically active components. Many medicinal properties have been attributed to that vegetable. It helps protecting from eye problems, cancer and heart disease. Cantaloupes represent one of the most valued agriculture commodities with significant volumes exported every year (Brazilian Fruit Year Book, 2011). Among subtropical vegetables, "Cantaloupe" is the fourth largest produced 31.053.716 tones behind orange, banana and grape (USDA, 2009). Also, cantaloupe is used in industry than other vegetables such as banana (Lamikanra and Lee Bulevara, 2002). Cantaloupe (*Cucumis melo*) is the important genus of the *Cucurbitaceae* family. In United States of America, the word "Cantaloupe" is used; especially to describe the netted fruit or muskmelon *(Cucumis melo*, var. reticulates). In Egypt, cantaloupe was cultivated

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as early as 2400 B.C., and then speared in the Middle East. The cultivated area was 33.380 hectare produced 239.82 kg/ha (Arab Organization for Agriculture Development, 2011).

Cantaloupe is a round or slightly oblong and ranges from four to eight inches in diameter. The rind is tough and creamy. The melon is the edible fruit from the pericarp that is bright orange or yellow. The center of the melon is hollow and holds hundred of tiny seeds (Parnell *et al.,* 2003). Cantaloupe melons have high amounts of functional substances such as carotenoids, minerals and certain amino acids (USDA, 2011). One hundred grams of cantaloupe provide 36.7 mg of vitamin C and 3382 I.U. vitamin A, corresponding to 61.17% of the daily value for vitamin C and 67.64% of the daily value for vitamin A. In addition, cantaloupes are a good source of potassium and vitamin B_6 (USDA, 2010). According to the dietary reference intakes (DRI), the recommended daily amount (RDA) for healthy adults are: 900 µg for men and 700 µg for women as to vitamin A and 90 mg for men and 75 mg for women as to vitamin C. Consuming half of cantaloupe melon would meet the recommended daily amount RDA of vitamins A and C (USDA-ARS, 2009).

Cantaloupe can be reasonably high in sugar content, with wide variation in soluble solids being reported for different cultivars. A range of 10.6 to 12.9 °Brix for the variety of Aurora was reported by Norton *et al.* (1985) and a range of 5.7 to 10.7 °Brix for variety of Saticoy as reported by Dull *et al.* (1989). A value of 13.1 °Brix was reported by Evensen (1983) for the variety of Superstar. Esebua and Abdurazakova (1971) reported that titratable acidity (TA) is low. In raw cantaloupe juice, a range of 0.14 to 0.19 percent as citric acid was reported. Sweeny *et al.* (1970) reported a range of 0.06 to 0.08 percent. Cantaloupes are regarded as a good source of ascorbic acid with a value of 42.2 mg/ 100 ml juice (Gebhardt *et al.,* 1982). Eitenmiller *et al.* (1985) reported a mean of 21.1 mg ascorbic acid /100 ml juice. Norton *et al.* (1985) found a range of 39 to 91 mg / 100 ml juice for different maturity stages.

In food industry, introduction of new technologies might reduce the processing time and improve the industrial operating conditions, resulting in high quality products (Cárcel *et al.,* 2011). Physical damage caused by slicing, peeling and other mechanical injuries in minimally processed vegetables, results in increasing rates of respiration and ethylene production within minutes. So that, packaging and coating have been used to protect fresh-cuts cantaloupe from surface dehydration. The coating acts as a gas barrier around each piece and creates a modified atmosphere inside each coated piece (Martin-Belloso *et al.,* 2007). The increase occur in biochemical reactions are related to changes in colour, flavour, texture, nutritional quality and susceptibility to dehydration. These responses occur in disrupted tissues where cellular decompartmention leads to intermixing of enzymes and substrates as well as release of acids and hydrolyzing enzymes (Watada and Yamaguchi 1990). Few studies have been demonstrated the effectiveness of this technique when applied to fresh-cuts commodities. However, treatment and storage conditions are still being largely explored to better keep their fresh-like quality attributes (Ma Alejandra *et al.,* 2008). These characteristics suggest that cantaloupes have the potential for being converted to products. There are few reports regarding to the effect of storage conditions such as temperature and storage time on the nutritional components (López *et al.,* 2005).

For processing cantaloupe, many variables must be taken into account such as cultural practices, weather conditions and maturity at harvest. Unfortunately, full-slip melons have short shelf-life, over ripening and flavour loss may occur before completion of marketing process.

The aim of the present study is utilizing of cantaloupe melons to produce minimally processed fresh-cuts. The chemical, microbiological and sensory attributes were evaluated during storage at 5°C for 14 days of cantaloupe fresh-cuts.

MATERIALS AND METHODS

Green-fleshed ripe cantaloupe *(Cucumis melo,* var. reticulates*)* (Brimo Hybrid F1) was selected at 3/4 maturity from Grow Technology for Agriculture Development Company, Zagazig, Egypt, on June, 2011. All melons were grown in open fields, hand harvested and selected in a commercial packing house according to size, discarding damaged and immature fruits. Maturity of cantaloupe melons was determined based on their case of separation from vine with a slight twist leaving clean cavity (Laur and Tian, 2011). All melons were of similar shape, size and were without skin blemishes or bruising. Soluble solids content (SSC) were measured with manual refractometer. Fresh melons were analyzed immediately after harvesting.

Methods of Processing

Processing of cantaloupe fresh-cuts

Each melon was approximately 1500 gram. Ten melons were dipped in water containing 200 ppm chlorine for 10 seconds, washed in water bath, air-dried, hand peeled and seed removed (Nguyen and Carlin, 1994). The edible portion (mid-section of mesocarp) was sliced into cuts. Cuts were split longitudinally into six fractions of approximately equal size about 4 cm x 10 cm of pulp (Silva *et al.*, 2006). Melon of cantaloupe gave a yield being 76.5 and 21.28% wastes. Cuts placed in foam rubber traies approximately 250±25 g of processed cantaloupe melon followed by covering and closing by two layer of polyethylene transparent film containers under 100 % air atmosphere and they stored at 5°C for 1 , 7 and 14 days.

Methods of Analyses

Physical analyses

Weight was observed by a digital scale with graduation 5 gram. Size (cm^3) was measured by water displacement method. Water temperature during measurements was kept at 25°C (Ngouajio *et al.*, 2003). Specific gravity was calculated as weight (gram) /size (cm^3) (Silva *et al.*, 2006). Firmness was determined by hand held penetrometer (McCormick, FT 327 and Alphonsine, Italy). The maximum penetration force was measured at 8 mm-probe on three cubes from each replicate (Amaro *et al.*, 2012). External firmness was approximately measured and conducted by three measurements. After carefully removing thin section of the peel, firmness was measured at the first indication of tissues collapse. This indicates the external consistency of the melon. Internal firmness was evaluated by cutting the peel and rind of the melon one inch below the equator and taking three measurements. Firmness was measured when the penetrometer was introduced 1 cm into the pulp, as indicated by the tip of penetrometer. This indicates the consistency of the pulp (Fonseca, 2005). The firmness was expressed as force in Newton (N) as a mean of three samples.

Soluble solid contents (SSC) were determined using a refractometer at 20°C (Atago, Japan) according to the method described in AOAC (2000). The pH of cantaloupe juice was determined using a digital pH meter (Model 41150 S/ N 790aa 411 Icm 163 S.W) at 25°C (AOAC, 2000). The sugar/ acid ratio was calculated as described by Fuleki *et al.* (1995). Colour was measured using spectrophotometer (Tristimulus Colour Machine) with the CIE lab colour scale (Hunter, Lab Scan XE-Reston VA, USA) whereas; L = white (100) to black (-80), a = red (100) to green (-80) and b = yellow (70) to blue (-80). Three values of (L), (a) and (b) were taken. Results were expressed as lightness (L), Chroma (C) = $[(a)^2 + (b)^2]^{½}$, hue angle (hab=tan^{-1} [(b) (a)$^{-1}$], where 0° = red purple; 90°=yellow; 180°=bullish green; 270° = blue. Euclidean distance between two colours points (ΔE) was calculated as the mean square of differences in individual (L), (a) and (b) values [ΔE.=(ΔL^2+Δa^2+ Δb^2=)] ½ (Sapers and Douglas, 1987).

Chemical analyses

Moisture content was determined at 105°C according to AOAC (2000). Total acidity was determined by titration with 0.1 NaOH using phenol phthalein as an indicator and was expressed as anhydrous citric acid/ 100 ml juice of sample (AOAC, 2000). Total nitrogen content was determined by kjeldahl method and crude protein content of the fresh cantaloupe was estimated by multiplying the nitrogen value by 6.25 (Femenia *et al.*, 2008).

Ash content was gravimetrically determined by over night heating at 550°C according to AOAC (2000). Total content of lipids were determined gravimetrically by extraction with diethyl ether using a Soxhlet apparatus (AOAC, 2000). Reducing, non-reducing and total sugars were determined according to the methods of Bernfled (1955) using 3, 5 dinitro salicylic acid as an indicator at wave length of 550 nm. The difference between the concentration of the total and reducing sugars was taken as concentration of non-reducing sugars. Free amino acids were determined using formol titration method (AOAC, 2000).

Carotenoids were determined according to AOAC (2000). Two grams of sample were mixed with 30 ml of acetone 85 % as a solvent in dark bottle and left to stand for 15 hours at room temperature. The mixture filtered through glass wool into 100 ml volumetric flask and made up to volume with acetone 85%. The crude pigment is assayed using spectrophotometer (Genway 6405 UV/ VIS) at wave length 440, 644, 662 and 642 nm. The following equations were used to calculate carotenoids:

Chlorophyll a = (9.784 x E642) _ (0.99 x E644) = mg/liter

Chlorophyll b = (21.426 x E644) _ (4.65x E662) = mg/liter

Carotenoids = (4.495 x E440) _0.268 (Chl .a +Chl .b) = mg/liter. Whearse: E is the absorbance at the dictated wave length. Total phenolic substances were measured calorimetrically (as tannic acid) at 640 nm. Samples were extracted in alcohol 95%, centrifuged and foline-ciocalteu reagent were used as indicator (Dóka and Bicanic, 2002). Ascorbic acid was determined using 2, 6 dichlorophenol indophenol (AOAC, 2000). Pectin substances were determined by method of Gee *et al.* (1959). One gram of dried sample was added to 50 ml distilled water. Sample was heated to 97°C/ 30 min. Citric acid can be added until pH=2.5, washed by ethyl alcohol 95 % and filtered throughout Whatman paper No 9.0. Floating pectin substances have been be collected, dried and weighted.

Crude fibers were determined according to AOAC (2000). Five grams of cantaloupe fresh-cuts samples were boiled with 200 ml H_2SO_4 and filtered to analyze protein. Two hundred ml of boiled NaOH (0.1 N) were added for saponification, washed by alcohol 95%, dried and weighted. After samples drying, it burned in oven at 600°C for 20 mins. Redish colour of sample was taken as indicator for full burn. Samples have been weighted again and the weight of crude fibers was obtained from this equation:

(%) Crude fiber = the difference between two weighted samples / weight of sample ×100.

Browning was determined according to the method of Klim and Nagy (1989). Cantaloupe juice was centrifuged at 2000 rpm to remove the pulp. The resultant serum was diluted with equal volume of ethanol 95% as a solvent, recentrifuged and filtered throughout filter paper Whatman No.4. The absorbance of the colour was measured at 420 nm with a spectrophotometer (Genway 6405 UV/VIS) using 60% aqueous ethanol as blank.

Identification of volatile compounds

Cantaloupe cubes were juiced into a slurry with mixter (Moulinex Type.241, France.) and the stir bar sorptive extraction (SBSE, Gerstel, Muelheim ander Ruhr, Germany) technique was used to extract volatiles stir bars (Poly dimethyl siloxane) with 10 mm length, were conditioned at 300°C for one hour and reconditioned between samplings on an agilent gas chromatograph inlet at 280°C, with a constant 50 ml/min helium flow, for 8 mins. Stir bars were placed in 10 ml vials containing 1 ml juice for each replicate sample. Extraction was performed for 1 hour at 37.5°C and 85 rpm on a variomag multipoint HP15 (Oberschleissheim, Germany) stir plate (Baltussen *et al.,* 1999). After extraction, volatile compounds were fractionated by using Gas Chromatography (GC). The GC device was inserted into injection port of GC type (Perkin Elmer Auto system XL); equipped with flame ionization detector (FID). The content of the GC fiber were desorbed in a split/splitless injection port, held in splitless mode at 230°C into a retention gap. The retention gap was attached to CP-wax fused silica capillary column (60m×0.32 mm×0.32μm film thickness). The stainless steel needle was placed throughout the hole and penetrated the liner after equilibration. The retention gap contained small loops in a coil which were cooled in solid carbon dioxide and contained within a beaker sample volume (1μl). During desorption, the oven was maintained initially at 40°C, held at 40°C for 5 mins and programmed from 40 to 250°C at rate of 3°C min^{-1}. Helium gas was used as a carrier gas, resulting in a flow of 1ml/ min. Compounds of C5 to C25 were analyzed under conditions to obtain retention time (RT) for the components. Approximate quantities of the volatile estimated by comparison of their peak areas obtain from all chromatograms.

Microbial analyses

Cantaloupe fresh-cuts were prepared for plating immediately after processing. The microbial population on cantaloupe fresh-cuts was determined according to method of D'Amato *et al.* (2010). Five grams of minimally processed cantaloupe fresh-cuts were diluted with 180 ml sterile saline solution (0.9 percent NaCl) for 1 min in a blender (Type 309, Poland). The media and the conditions used were as follows:

For total bacterial count, plate count method was adopted using nutrient agar medium which contains: 3 grams beef extract, 5 grams peptone, 1 gram glucose and 20 grams agar in one liter distilled water. One ml of dilution was plated in the above medium replicates and incubated at 32°C for 2 days. Psychrophilic bacteria were performed using nutrient agar medium. One ml of dilution was plated in the above medium and incubated at 7°C for 10 days. Yeast and mould colonies were accounted as described by Harrigan and Margaret (1976). One ml of dilution was transferred to petri dishes and malt agar was poured. The plates were incubated at 32°C for 5 days. Nutrient agar medium was used to grow spore forming bacteria in petri dishes and incubated at 30°C for 4 days. Results were expressed as colony forming unit per gram sample (CFU/g). For each batch, the analysis was repeated three times.

Sensory analyses

Sensory analysis was carried out as defined by Kilcast and Subramanian (2000). Sensory attributes as visual appearance, aroma, texture, sweetness and colour were evaluated using ten point hedonic scale (where: 9-10= excellent, 7-8=very good, 5-6=good, 4=poor and 2-3= unacceptable). Samples were presented at random to twelve panelists for sensory evaluation (gender: 5 men, 7 women; age group; 25-40). Panelists have been selected from faculty staffs who usually consume fruit products.

The samples stored at 5°C for 14 days have been served in poly propylene transparent plats. Control samples of cantaloupe fresh-cuts were evaluated according to Galeb *et al.* (2002)

RESULTS AND DISCUSSION

The average weight and size of cantaloupe melon were 1.5 kg and 698 cm^3, respectively. So, average of specific gravity was 2.16 g / cm^3.

Weight loss is principally due to storage temperature, relative humidity, skin removal and cutting that expose interior tissues to a dramatically increase in water evaporation rate (Brecht, 1995). Some of weight loss 10 to 20% could be due to loss of carbon by respiration as reported in fresh-cuts carrot (Izumi and Watada, 1995).

Firmness is highly correlated with overall quality index. The external and internal firmness measurements taken to cantaloupe fresh-cuts were 22.29 and 4.54 Newten. Firmness of stored fresh-cuts cantaloupe at 5°C changed quickly during 14 days of storage (Fig. 1). The external and internal firmness measurements taken after 7 days were 16.72 and 3.40, and then decreased close to 11.14 and 2.27, respectively at the end of storage. These results are in accordance with those obtained by Amaro *et al.* (2012). He showed that firmness decreased during the first 4 to 7 days and remained relatively unchanged for the remaining storage. During storage, the firmness of fresh-cuts cantaloupe decreased between 20 to 50%. The firmness of papaya cubes decreased to 57% after 16 days of storage at 5°C (López, *et al.*, 2005), respectively. The soluble solids in fruits are mainly sugars, organic acids, minerals and some vitamins. Fresh-cuts stored at 5°C showed no changes in soluble solids content during seven days of storage. On the other hand, soluble solids content (SSC) decreased quickly to 5.77°Brix at 14 days of storage (Fig. 2) The decrease may be due to high metabolic activity occurs when fruit are stored (Ayala-Zavala *et al.*, 2004).

Cantaloupe fresh-cuts have pH value of 6.05. In fact, the initial value of pH ranged from 6.05 for control to 6.44 for fresh-cuts cantaloupe samples stored for 14 days (Fig. 3). These values were higher than citrus fresh juices (pH 2.3 for lime, pH 2.4 for lemon juice) (USDA, 2006) and pH 3.6 for orange juice (Carvalho *et al.*, 2006).

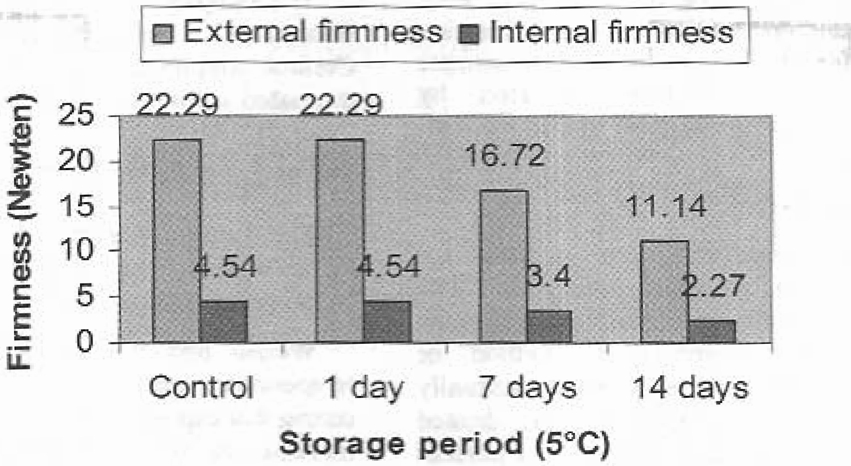

Fig. 1. Firmness measurements of cantaloupe fresh-cuts during cold storage

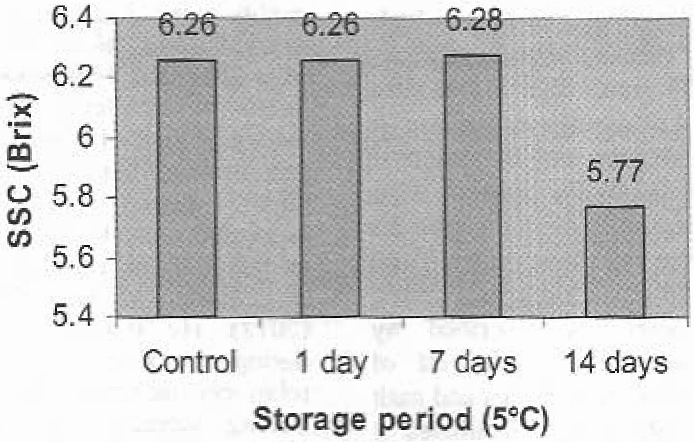

Fig. 2. Soluble solids content (SSC) of cantaloupe fresh-cuts during cold storage

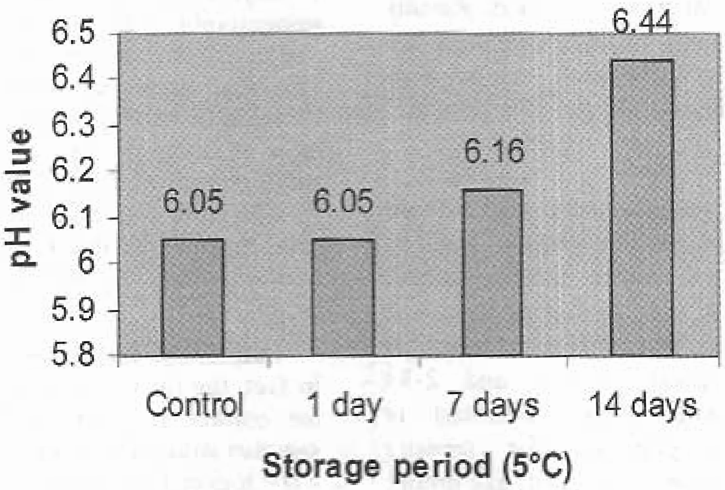

Fig. 3. pH values of cantaloupe fresh-cuts during cold storage

Total titratable acidity showed that fresh cantaloupe juice contains 0.0657% (Fig. 4). During storage at 5°C, no changes have been shown regarding this value. Only samples stored for 14 days decreased to 0.0516%. These results are in accordance with those obtained by Silveira *et al.* (2013).

Sugar/acid ratio was slightly increased (Fig.5). The ratio was 95.28 for control sample and increased to 99.84, 106.08 and 111.82 for samples stored for 1, 7 and 14 days, respectively.

In fresh-cuts cantaloupe, lightness (L) value was 25.64. The value increased to 25.70 and 25.79 after 1, 7 days of storage at 5°C, respectively. After 14 days of storage, lightness (L) decreased to 18.33 (Fig. 6). Changes in lightness (L) were attributed to browning on the surface and loss of water indicating that tissues became darker with storage period at 5°C (Rattanaponone *et al.*, 2001).

In fresh cantaloupe, the value of (a) parameter which reflect losses of red and green colours recorded -3.57. This value increased to -3.26, -2.41 and -2.92 in fresh-cuts stored at 5°C for 1, 7 and 14 days, respectively (Fig. 7).

Also, there were changes in (b) parameter which reflect losses of yellow and blue colours (Fig. 8). These values were 12.20 for control sample and increased to 12.54, 12.71 for fresh-cuts stored at 5°C for 1, 7 days, respectively and decreased to 8.28 for cantaloupe fresh-cuts samples stored for 14 days.

For Chroma (C) values of, the control sample recorded 12.71 (Fig. 9). After 1 and 7 days of storage at 5°C, the value increased to 12.95, 12.93, respectively. On contrary, samples stored for 14 days had a lower chroma value being 8.77.

Changes in colour expressed as hue angle (°Hue) are shown in (Fig.10). There were an effect on colour during storage of cantaloupe slices due to changing in hue angle values from 73.65° for control sample to 75.42°, 79.26° and 70.57° in fresh-cuts stored samples for 1, 7 and 14 days, respectively. The hue angle may improve the understanding of colour variations found in cantaloupe melon (Fonteles *et al.*, 2012).

Total colour difference (ΔE) values were 28.16 for control samples, and then decreased to 27.7, 26.89 for samples stored at 5°C for 1, 7 days, respectively (Fig. 11). After 14 days, the value was 19.85.

Concerning to moisture content of fresh-cuts cantaloupe stored at 5°C, there were no pronounced differences between samples stored for 1, 7 and 14 days. Moisture content decreased from 89.64% in control samples to 88.34% at the end of storage period (Table 1).

Despite cantaloupe melon is poor in protein and fats content being 0.88 % and 0.20 %, respectively. However, protein was higher than lemon 0.38 % (USDA, 2006). The content of free amino acids can be measured by formol number of being 0.0052 meq /100 ml juice in fresh-cuts samples (Table 1) and there were no changes in the free amino acids occurred during storage at 5°C. Cantaloupe fresh-cuts are rich in minerals. In cantaloupe fresh-cuts, total ash were 2.94% of fresh weight and there were no differences in total ash between samples stored at 5°C.

Reducing sugars were nearly in the same range being 1.586% in samples stored for 1, 7 days, and then decreased to 1.336% at the end of storage. On the other hand, non-reducing sugars were 0.806 %. This value was almost stable through period of storage for 7 days at 5°C.

Table 1 represents the total sugars in fresh-cuts cantaloupe. It could be noticed that fresh-cuts product contained 2.392 % total sugars of fresh weight which is always the same as reported by González-Aguilar *et al.* (2000). After 1, 7 and 14 days of storage at 5°C, there were no pronounced effects of cooling on total sugars content of cantaloupe fresh-cuts. These results are similar to those obtained for mango fresh-cuts by D'Amato *et al.* (2010).

Cantaloupe fresh-cuts stored at 5°C did not present any change in carotenoids during 14 days of storage (Table 1). Carotenoids were about 7.5 μg/ ml of fresh weight.

Polyphenols were 8.74 mg/100 ml juice. A decrease for phenolic compounds was recorded during storage of cantaloupe fresh-cuts at 5°C for 14 days. The decrease of phenol compounds was about 36.05% and 17.63% after 1 and 14 days of storage at 5°C, respectively. This may be resulted from action of polyphenol oxidase (PPO). At seven days of storage at 5°C, the percent of decrease was 6.63% (Table 1).

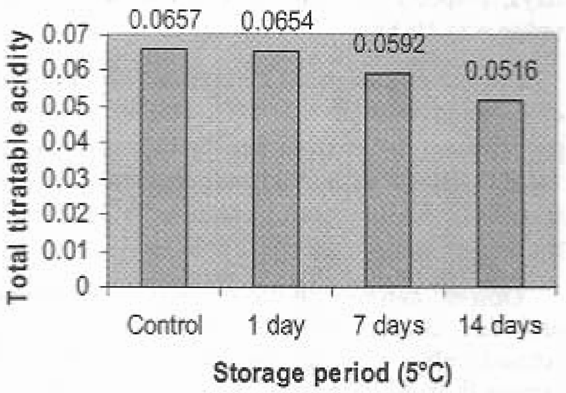

Fig.4. Total titratable acidity of cantaloupe fresh-cuts during cold storage

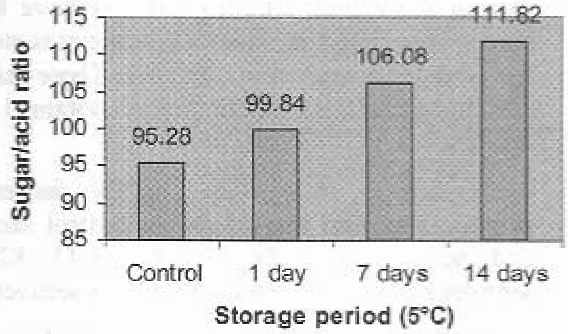

Fig.5. Sugar/acid ratio of cantaloupe fresh-cuts during cold storage

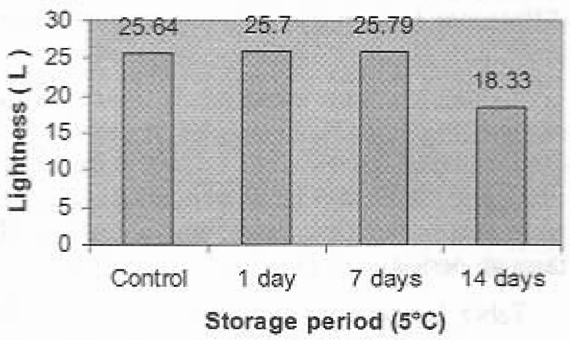

Fig. 6. Lightness (L) parameter of cantaloupe fresh-cuts during cold storage

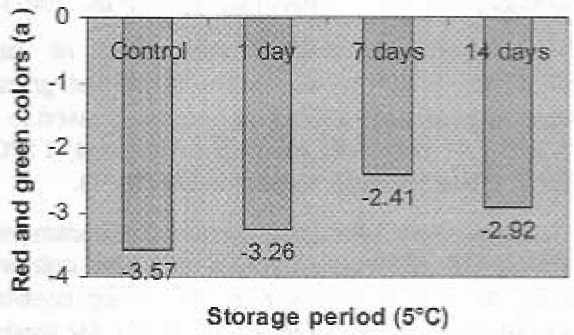

Fig. 7. Red and green colours (a) parameter of cantaloupe fresh-cuts during cold storage

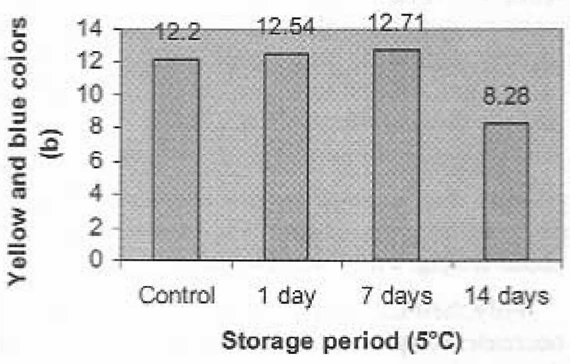

Fig. 8. Yellow and blue colours (b) parameter of cantaloupe fresh cuts during cold storage

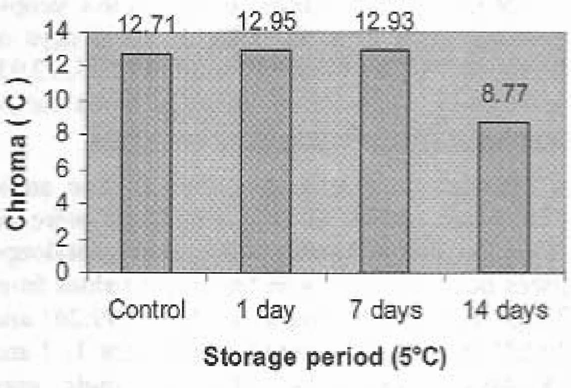

Fig. 9. Chroma (C) values of cantaloupe fresh cuts during cold storage

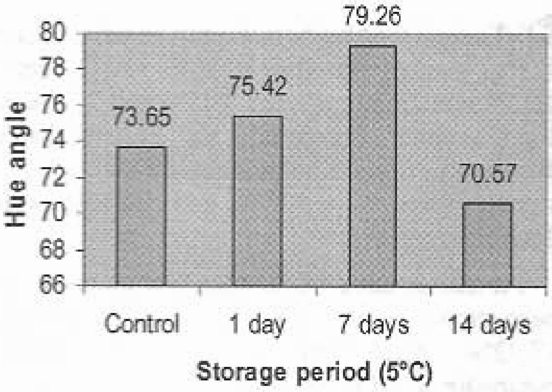

Fig.10. Hue angle of cantaloupe fresh- cuts during cold storage

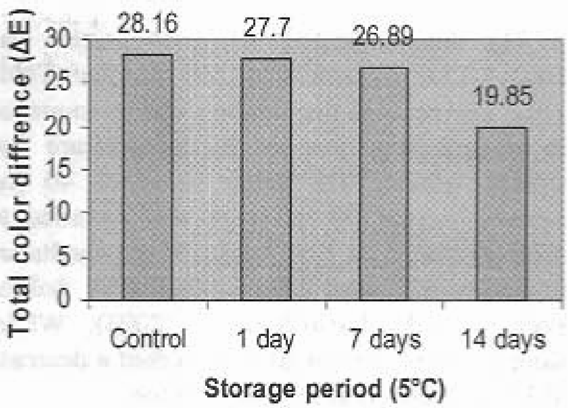

Fig. 11. Total colour difference (ΔE) of cantaloupe fresh-cuts during cold storage

Table 1. Chemical properties of cantaloupe fresh-cuts stored at 5°C

Property	Values*			
	Control	Fresh-cuts stored at 5°C		
		1 day	7 days	14 days
Moisture (%)	89.64	89.64	88.39	88.34
Crude protein (N×6.25) (%)	0.88	0.88	0.87	0.87
Total fats	0.2	0.2	0.2	0.2
Formol number (meq/100 ml)	0.0052	0.0052	0.0059	0.0054
Total ash (%)	2.94	2.94	2.94	2.94
Total sugars (%)	2.392	2.392	2.392	2.116
Reducing sugars (%)	1.586	1.586	1.586	1.336
Non reducing sugars	0.806	0.806	0.806	0.780
Carotenoids (μg /ml juice)	7.5	7.5	7.5	7.5
Polyphenols(as tannic acid mg/100 ml juice)	8.74	7.20	8.16	5.59
Ascorbic acid (mg/100 ml juice)	40	40	40	35
Colour index (as O.D.** at 420 nm)	0.01	0.194	0.227	0.230
Pectin substances (%)	1.62	1.62	1.53	1.26
Crude fibers (%)	0.98	0.98	0.98	0.98

* Values are means of three determinations and based on 100 gm fresh-weight of edible portion

** O.D., optical density

The data indicated that pulp portion has about 40 mg ascorbic acid /100 ml juice (Table 1). Ascorbic acid degradation was pronounced in air and was changed by temperature and storage period. The same value of 40 mg ascorbic acid /100 ml juice was recorded to samples stored for 1 or 7 days. These results are in accordance with those obtained by Soliva-Fortuny and Martin-Belloso, (2003). While, samples stored for 14 days presented a decrease at 35 mg ascorbic acid /100 ml juice.

In fresh-cuts vegetables, browning is a major problem that affects its quality and appearance with a consequent loss of sensorial and nutritional properties (Oms-Oliu *et al.*, 2008). The colour index of cantaloupe fresh-cuts stored at 5°C increased during 14 days of storage (Table 1). After one day of storage at 5°C, colour index of browning increased to 0.194 (O.D at 420 nm). At 7 and 14 days, colour index values increased from 0.227 (O.D at 420 nm) to 0.230 (O.D at 420 nm), respectively.

For pectin contents, large amounts of pectic polymers in the cell wall are solubilized. These are mainly from the less branched parts of the rhamnogalaturonan backbone of the pectic substances. The softening and deterioration in fresh-cuts cantaloupe have been shown after 7 days of storage at 5°C which attribute to hydrolytic enzymes. The amounts of pectin substances decreased from 1.62% for control sample to 1.26 % after 14 days of storage at 5°C (Table 1).

In fresh-cuts cantaloupe, crude fibers were about 0.98 g /100g of fresh weight. Storage at 5°C for 14 days did not affect the percentage of crude fibers (Table 1).

Exposure of cantaloupe melon slices to cooling for 1 day caused increase in concentrations of aliphatic esters such as methyl-2-methyl propanoate 1.34%, methyl butanoate 0.34%, iso propyl butbanoate 3.35%, (E)-3-hexen-yl acetate 4.64%, 1-octen-3-hepten-1-yl acetate 0.17 % and (Z)-5-octen-1-yl acetate 19.34% (Table 2.). On the other hand, compounds of methyl propanoate 7.63%, ethyl propanoate 9.78%, propyl propanoate 0.69%, (Z)-3- hepten-1-yl acetate 0.04%, 3, 5-octadienone 0.62%, 2-(methyl thio) ethyl acetate 0.09%, methyl geranate 20.20%, nonyl acetate 0.22% and 2,6 nonadienal 0.25% and 2, 3 nona-1-yl acetate decreased to 26.10% were decreased. Alcohol compounds such as 1, 3 cineole increased to 4.83%, and ethanol has not detected.

At seven days of storage, an increase has been shown for esters such as methyl propanoate 17.32%, ethyl propanoate 12.55%, methyl butanoate 1.12%, ethyl butanoate 1.53% and (Z)-5-octen-1-yl acetate 64.15%. On contrary, compounds of methyl- 2- methyl propanoate 0.69%, propyle propanaote 1.45 %, iso propyle butanoate 0.09% have been decreased. The other compounds were not detected.

After 14 days of storage, most compounds are not detected. Only compounds of methyl butanoate 25.67%, propyl Propanoate 35.97%, iso butyl-2- methyl butanoate 0.95 %, 1-octen-3-hepten-1-yl acetate 1.51% and (Z)-3-hepten-1-yl acetate 0.92% were increased. Also, alcohols such as ethanol and 1, 3 Cineole increased to 24.06% and 2.95%. Storage time had effect on all acetate esters. This accepted with results obtained by Amaro *et al.* (2012) which showed that storage of cantaloupe cubes for 14 days under modified atmosphere packaging increased acetate esters. Four of the ten acetate esters quantified (2-methyl propyl acetate, 2-methyl butyl acetate, hexyl acetate and benzyl acetate) accounted for 87-93 % of the integrated total.

Effect of Cold Storage at 5°C on Microbial Count

Microbial population (as total count) in control sample was 23×10^2 CFU/g sample (Table 3). Total microbial count (TC) of fresh-cuts cantaloupe increased notably after 7 and 14 days of storage .The rates of increase were 50×10^2 and 63×10^2 CFU/g sample, respectively. Fresh-cuts fruits have their natural microbial flora about 10^4-10^5 CFU /g sample and typically, products become spoiled since these levels increased to $10^7\times10^8$ CFU /g sample (Martinez-Ferrer *et al.*, 2002).

In control sample, the count of 13×10^2 CFU/g sample for aerobic psychrophilic bacteria was observed. After one day, the count doubled to 26×10^2 CFU/g sample. By 7 days, the count

Table 2. Volatile compounds of cantaloupe fresh-cuts stored at 5°C

Peak No.	RT (min)	Compound	Area* (%) Control	Fresh cantaloupe cuts stored at 5°C 1day	7days	14days	Identification®	Aroma	Reference©
1	7.760	Methyl propanoate	12.68	7.63	17.32	ND	GC,RT	Musky	[1]
2	7.914	Methyl 2- methyl propanoate	1.10	1.34	0.69	ND	GC,RT	Acidity	[1]
3	7.988	Ethanol	1.16	ND	ND	24.06	GC,RT	Musky	[2]
4	8.341	Ethyl propanoate	10.12	9.78	12.55	3.42	GC,RT	Fruity	[1]
5	8.914	Methyl butanoate	.025	0.34	1.12	25.67	GC,RT	Grape-like	[1]
6	9.649	Ethyl butanoate	0.14	0.15	1.53	ND	GC,RT	Medicinal, sweet	[1]
7	9.986	Propyl propanoate	3.74	0.69	1.45	35.97	GC,RT	Fruity	[1]
8	12.645	Iso propyle butanoate	2.16	3.35	0.09	ND	GC,RT	Fruity, ethereal	[1]
9	13.398	Iso butyle-2-methyl butanoate	0.09	ND	ND	0.95	GC,RT	Fruity, floral	First time
10	14.284	1,3-Cineole	3.26	4.83	ND	2.59	GC,RT	Green, cherry	[1]
11	16.862	(E)-3-hexen-yl-acetate	1.90	4.64	ND	3.30	GC,RT	Leafy, wine-like	[3]
12	19.326	1-octen-3-hepten-1-yl acetate	0.06	0.17	ND	1.51	GC,RT	Woody, oily	[1]
13	20.148	(Z)-3-hepten-1-yl acetate	0.19	0.04	ND	0.92	GC,RT	Fruity	First time
14	20.869	3,5 Octadienone	1.74	0.62	1.09	1.61	GC,RT	Fruity, floral	[2]
15	22.025	Octyl acetate	0.14	ND	ND	ND	GC,RT	Cucumber-like	[1]
16	22.875	2-(methyl thio) ethyl acetate	0.46	0.09	ND	ND	GC,RT	Unknown	[1]
17	23.657	(Z)-5-octen-1-yl acetate	7.35	19.34	64.15	ND	GC,RT	Fresh, rosy	[1]
18	24.694	Methyl geranate	21.30	20.20	ND	ND	GC,RT	Fruity	First time
19	24.987	Nonyl acetate	0.54	0.22	ND	ND	GC,RT	Oily, fruity	First time
20	25.323	Methyl decanoate	0.41	0.14	ND	ND	GC,RT	Musky	[1]
21	25.465	(E,Z)2,6-Nonadienal	0.41	0.25	ND	ND	GC,RT	Green/vegetative	[4]
22	25.840	2,3-Nona-1-yl acetate	29.80	26.10	ND	ND	GC,RT	Unknown	NR[a]
23	30.722	Unknown	0.11	ND	ND	ND	GC,RT	Unknown	NR
24	40.312	Unknown	0.11	ND	ND	ND	GC,RT	Unknown	NR
25	42.983	Unknown	0.13	ND	ND	ND	GC,RT	Unknown	NR
26	45.036	Unknown	0.11	ND	ND	ND	GC,RT	Unknown	NR
27	56.835	Unknown	0.53	ND	ND	ND	GC,RT	Unknown	NR

*Area (%) is determined from total chromatogram, and therefore should be considered as approximate.
® GC, RT; Gas chromatography and retention time agree with authentic compound.
© Refers to report of compound in melon *(Cucumis melo).*
[1] Kourkoutas *et al.* (2006) [2] Martinez-Ferrer *et al.* (2002)
[3]Beaulieu and Grimm (2001) [4] Amaro *et al.* (2012). NR [a]: No reference ND: Not detected

Table 3. Effect of cold storage of cantaloupe fresh-cuts at 5°C on microbial count

Microbial types	CFU/g sample Control	Fresh-cuts stored at 5°C 1day	7days	14days
Total bacterial count (x10^2)	23	3	50	63
Psychrophilic bacteria (x10^2)	13	26	60	76
Yeasts & Moulds (x10)	16	20	33	43
Spore forming bacteria	ND	ND	ND	ND

ND: Not detected

increased to 60×10^2 CFU/g sample and 76×10^2 CFU/g sample at the end of storage for 14 days, respectively.

For yeasts moulds and, an average of 16CFU/g sample was observed for control sample. After 14 days of storage, it was increased to 43×10 CFU/g sample. These results are in accordance with Europe standards for production of fresh-cuts cantaloupe (RD 3484/2000, 2001).

Effect of Cold Storage at 5°C on Sensory Evaluation

During storage for 14 days, total scores of sensory evaluation showed that the scores were from 42.97 for control sample to 37.08 for processed cantaloupe fresh-cuts at 5°C for 14 days. Table 4 shows that appearance values of fresh-cuts cantaloupe were differences. In control samples, the value of appearance was 9.27, at 7 and 14 days of storage, the values decreased to 7.90 and 8.00, respectively. Changes in appearance can be explained by relative higher activity of physiological metabolism and polyphenol oxidase (PPO) activity (Wenzhong *et al.,* 2007).

Concerning texture, changes in values noticed from the first day with score of 8.54 for control sample. After 1, 7 and 14 days of storage, scores decreased to 7.90, 7.45 and 7.00, respectively. This may be due to the action of pectin enzymes.

For sweetness values, there were no changes during storage at 5°C. Scores were 7.81 for control sample and 8.18, 7.09 and 7.18 for 1, 7 and 14 days stored samples, respectively.

Colour quality, expressing by visual colour was studied too. The visual colour values showed a decrease in scores from 8.81 for control sample to 8.72, 8.09, and 7.63 for 1, 7 and 14 days stored samples, respectively.

Studying physical, chemical and sensory properties showed that cold storage at 5°C prolonged shelf-life of minimally processed cantaloupe up to 14 days.

Table 4. Sensory evaluation of cantaloupe fresh-cuts stored at 5°C

Treatments*/ Attributes	Control	1day	7days	14days
Appearance (10)	9.27	8.54	7.90	8.00
Texture (10)	8.54	7.90	7.45	7.00
Sweetness (10)	7.81	8.18	7.09	7.18
Flavour (10)	8.54	8.36	7.54	7.27
Colour (10)	8.81	8.72	8.09	7.63
Total (50)	42.97	41.70	38.07	37.08

* Values are means of the panelist's scores(n=3).9-10=excellent; 7-8=very good; 5-6=good; 4=poor; 2-3= unacceptable.

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تأثير التخزين البارد على خواص الجودة في قطع الكانتلوب الطازجة

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الكانتلوب واحداً من الخضروات الشائعة ذو القيمة الغذائية العالية، وهى تستهلك إما طازجة أو في صورة منتجات مصنعة جزئياً، هذه المنتجات تكون حساسة تجاه بعض المعاملات مثل التبريد والتخزين على درجات الحرارة المنخفضة. تشير النتائج المتحصل عليها إلى ارتفاع في قيم اللون حيث ارتفعت قيم اللون مثل قيم اللمعان، وقيم اللون الأزرق إلى الأصفر من ٢٥,٦٤ ، ١٢,٢٠ في العينة الطازجة غير المعاملة إلى ٢٥,٧٩ ، ١٢.٧١ بعد ٧ أيام من التخزين على ٥م° على التوالي بينما ازدادت قيم اللون الأحمر إلى الأخضر طوال مدة التخزين حتى ١٤ يوم ، ومن ناحية أخرى فان قيم رقم الحموضة ازدادت من ٦,٠٥ في العينة الطازجة إلى ٦,٤٤ بعد ١٤ يوم من التخزين على ٥م° ، وعلى العكس فان المواد الصلبة الكلية ، ومع حلول اليوم السابع من التخزين كانت في نفس المعدلات للقطع الطازجة ، وبمتوسط ٦,٢ في المائة ثم انخفضت في نهاية مدة التخزين إلى ٥,٧٧ في المائة، كانت السكريات الكلية،حمض الاسكوربك ، والكاروتينات ثابتة تقريبا خلال الأيام السبعة الأولى من التخزين على ٥م°. حيث كانت ٢,٣٩٢ في المائة للسكريات الكلية و ٤٠ مللي جرام/١٠٠ مللي عصير حمض الاسكوربك ، ٧,٥ ميكروجرام/ مللي للكاروتينات على التوالي. كما شهدت قيم الحموضة انخفاضا على الرغم من تسجيلها قيمة منخفضة نسبيا في العينة الطازجة وصلت إلى ٠,٠٦٥٧ في المائة ، ثم انخفضت إلى ٠,٠٥٩٢ و٠,٠٦١٦ في المائة بعد ٧ و١٤ يوم من التخزين على ٥ م° على التوالي.وتعتبر القطع الطازجة لثمار الكانتلوب مصدرا جيدا للمواد البكتينية والمركبات الفينولية حيث تصل النسبة إلى ما يقارب ١,٦٢ ، ٠,٨٧ في المائة على التوالي ، وقد شهدت انخفاضا وصل إلى ١,٢٦ ، ٠,٥٥ في المائة ، وذلك في نهاية مدة التخزين. إن النكهة المميزة للكانتلوب ومنتجاته هي في الأصل مرتبطة بالمحتوى العالي من الاسترات ، والتي يصل عدد مركباتها إلى ٢٧ مركب تم التعرف عليهم. وارتفعت الغالبية العظمى من مركبات النكهة ، والمتمثلة في الاسترات بصورة ملحوظة ، وعلى النقيض كان هناك انخفاضا في الالدهيدات والكحولات في نهاية مدة التخزين. هذا الفقد في الكثير من مركبات النكهة مع نهاية مدة التخزين تسببت في زيادة أعداد الميكروبات الكلية من ٢٣× ١٠^{٢} في العينة الطازجة حتى وصلت إلى ٦٣×١٠^{٢}خلية / جرام، أما ما يخص التقييم الحسي، فان قيم المظهر والنكهة تأثرت بالتخزين على ٥م° وحتى ١٤ يوم.

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