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# Physical and Chemical Properties of Canino Apricot Fruits During Cold Storage as Influenced by Some Post-harvest Treatments

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**Abstract:** This study was conducted during two successive seasons of 2008 and 2009 to study the effect of some post-harvest treatments i.e. NaOCl (2%), irradiation (0.0, 0.5, 1.0 K.Gy gamma rays) and edible films with chitosan coatings (1& 2%) on some fruit quality parameters of Canino apricot fruits under cold storage. Briefly, fruit weight loss (%), decay (%), T.S.S., total sugars and carotenoids of Canino apricot fruits were increased in most cases with prolonging the storage duration. Meanwhile, fruit firmness, shelf life (days), titratable acidity, ascorbic acid and total phenols were decreased with advancing the storage period. However, the lowest values of weight loss (%) and decay (%) and the best results of shelf life, firmness and total phenols were achieved by using the treatments of chitosan coatings at 1 and 2% treatments. In addition, the highest fruit T.S.S., total sugars and carotenoids content, besides the lowest fruit titratable acidity percentage was scored by 1.0 K.Gy gamma ray treatment. Moreover, the highest fruit ascorbic acid content was produced by chitosan coatings at 1% and NaOCl at 2% treatments.

**Key words:** Canino apricot, Post-harvest, NaOCl, Irradiation, Chitosan, Physical and Chemical properties.

## INTRODUCTION

Apricot (*Prunus armeniaca*, L.) belongs to *Rosaceae* family. It plays an important role in maintenance of human health, because the fruit contains carotene and lycopene pigments that protect the heart and eyes, as well as disease fighter effects of fiber that prevent digestive condition called diverculosis and having antipyretic, antiseptic, emetic, and ophthalmic properties. Apricot fruits enriched different antioxidant compounds such as phenolics, vitamins and carotenoids. Phenolic compounds demonstrated higher antioxidant activity than vitamins and carotenoids (Re *et al.,* 1999). They are able to scavenge reactive oxygen species due to their electron donator properties. The levels of phenolic compounds are different in apricot varieties (Macheix *et al.,* 1990). Antioxidant content is an important parameter with respect to increasingly fruit and vegetable quality. It was found that apricot is a fragile fruit with short storage life (3-5 days) at ambient conditions, 2-4 weeks at cold storage, depending on cultivar. The short storage life of this fruit is due to short period from commercial ripening stage to the degradation process characteristic like senescence (Egea *et al.,* 2007 and Agar and Polate, 1995).

Therefor, there are great interests to evaluate changes in antioxidant status during post-harvest storage of horticultural crops (Fernando *et al.,* 2004). Post-harvest storage can also affect phenolic compounds levels and antioxidant capacity in fruits (Holcroft and Kadr, 1999). Generally, low storage temperatures are used to extend fruit post-harvest life (Manning, 1996). Sodium hypochlorite were reported as efficient substances in enhancing fruit storability through their biological control mechanism (Sugar *et al.,* 1994). In addition, Gamma rays irradiation are used as supplementary treatments to fruit cold storage to reduce weight loss, decay and delay ripening via reduced the respiration rate of pear fruits (Al-Bachir and Sass, 1989). Low dose 1.0 K.Gy on pears and apples irradiation induced softening in the fruit discoloration of middle lamella, wrinkling of cell membranes which generally remained intact and retention of starch by plastids of skin (Kovaces *et al.,* 1988). Higher doses result in fruit tissue injury, increased peroxides and catechol oxides activities and decreased catalase activity (Shi *et al.,* 1993). Chitosan coatings are applied on fresh fruit, to reduce the moisture transfer, the oxidation and the respiration, which in turn help in prolonging the shelf-life of such fruits (Debeaufort *et al.,* 1998).

Consequently, the main target of this trial is to evaluate the effect of sodium hypochlorite, gamma ray irradiation and chitosan coatings on physical and chemical properties of Canino apricot fruits.

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## MATERIAL AND METHODS

This study was carried out during two successive seasons of 2008 and 2009 on Canino apricot fruits to evaluate the effect of some post-harvest treatments on some fruit quality parameters during cold storage. Canino apricot fruits at the commerically mature stage were harvested from an orchard at El-Nubaria, Behira Governorate, Egypt. Fruits were selected for uniformity, shape, color and size and any blemished or diseased fruits were discarded. The initial values of Canino apricot fruit parameters were determined at harvest (initial quality) and the data were presented in Table (1).

**Table 1:** Initial values of Canino apricot fruit parameters at harvest ( 2008 & 2009 seasons).

| Season | Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fruit weight (g) | Firmness ($Ib/inch^2$) | T.S.S (%) | Acidity (mg/100 ml juice) | Total sugars (%) | V.C (mg/100 ml juice) | Carotenoids (mg/100g F.W) | Total phenols (mg/100 g F.W) |
| 2008 | 28.50 | 7.80 | 11.20 | 1.40 | 7.22 | 14.20 | 1.60 | 51.20 |
| 2009 | 26.80 | 7.93 | 10.80 | 1.45 | 7.06 | 13.96 | 1.60 | 49.60 |

The selected fruits were subjected to the following treatments:

***1-Sodium Hypochlorite:***

Apricot fruits were dipped in sodium hypochlorite solution (NaOCl) at 2% for five min., then the treated fruits were air dried.

***2- Gamma Rays Irradiation:***

Three irradiation doses namely 0.0, 0.5 and 1.0 K.Gy gamma rays were used. Irradiation treatments were done by subjecting the fruits, at room temperature to gamma radiation from Co 60 source at the National Center for Radiation Research and Technology, Naser City, Cairo, Egypt. The irradiation facility used was Egypt's mega gamma-1, of the type J.6500 supplied by the atomic Energy of Canada Limited. The doses rate delivered during the experimented duration was 1K.Gy/hr., as monitored by radiochromic film (McLaughlin *et al.*,1985).

***3- Chitosan Coatings:***

Stock solution (2%, w/v) of chitosan, was prepared by dissolving purified chitosan (low molecular weight chitosan was purchased from Sigma Chemical Co.) in 0.5% (v/v) glacial acetic acid (Du *et al.*, 1997), under continuous stirring, and the pH was adjusted to 5.2 using 1 N NaOH. The stock solution was sterilized at 121 °C for 20 min., then made lower concentrations (1%) of chitosan solution were obtained by appropriate dilution with sterile distilled water. After fruit dipping in 1& 2% chitosan solutions for one min., then the treated fruits were allowed to dry.

Generally, all treated fruits in this study were placed carefully in polyethylene bags then placed in open plastic boxes "42×28×12 cm". The aforementioned treated fruits were stored under cold storage at 0±2 ˚C and 90-95 % R.H. Fruit parameters were determined periodically at weekly interval during the storage period at 0±2 ˚C.

The tested post-harvest treatments were arranged in a completely randomized block design and each treatment was replicated three times. Each replicate was represented with five boxes and every one contains four polyethylene bags with 500 g/ bag.

Effect of the tested trearments on Canino apricot fruits were evaluated through the following determinations:

***1. Fruit Physical Properties:***

***1.1. Fruit Weight Loss Percentage:***

The initial weight of Canino apricot fruits was recorded in each treatment and at weekly interval, then fruit weight loss % was calculated by weighing the same fruits at each interval and at the end of cold storage duration using the following formula:

$$\text{Fruit weight loss \%} = \frac{\text{Initial weight} - \text{Weight at specific interval}}{\text{Initial weight}} \times 100$$

### *1.2. Fruit Decay Percentage:*

The decayed fruits of each treatment were discarded and weighed. The weight of such discarded fruits related to the initial weight of fruits per each treatment was estimated and decay percentage was calculated.

### *1.3. Fruit Firmness (Ib/inch$^2$):*

Three fruits of each replicate at weekly interval were taken to determine the changes in fruit firmness using the Effegi firmness tester with an 5/16" plunger (Effegi 48011 Alfonsine, Italy). Fruit firmness was expressed (Ib/inch$^2$).

### *1.4. Shelf Life (Days):*

During cold storage period, samples of the treated fruits were taken at weekly interval and left at room conditions (25±5 ˚C and 65-70% R.H.) and the number of days at which treated fruits still with good appearance were counted and shelf life was determined.

### *2. Fruit Chemical Properties:*

Total soluble solids of fruit juice were measured using a hand refractometer. The total soluble solids were expressed as a percent. Moreover, fruit titratable acidity (grams of malic acid per 100 ml of juice, ascorbic acid (V.C) content (milligrams ascorbic acid per 100 ml fruit juice), Carotenoids content (milligrams per 100 gram fresh weight) and total phenols content (milligrams per 100 gram fresh weight) according to A.O.A.C. (1985). Besides, total sugars were determined using the Nelson arseno molybdate colorimetric method as described by Malik and Singh (1980). The content of total sugars were expressed as percentages of fresh weight.

### *Statistical Analysis:*

All obtained data in both seasons were subjected to analysis of variance according to Snedecor and Cochran (1989). Differences among means for the effect of storage period and tested post-harvest treatments were compared using Duncan multiple range test (Duncan, 1955) at 5% level. The interactions effect between treatments and storage period were differentiated using L.S.D. method at 5% level.

## RESULTS AND DESCUSSION

### *1. Weight Loss %:*

Data in Table (2) show that the lowest fruit weight loss (%) was gained by chitosaon treatments (1 or 2 %) in both seasons, whereas the highest weight loss (%) was recorded by 1.0 K.Gy gamma ray in both seasons and control treatment in the second season. The remained treatments induced less reductive effect on fruit weight loss (%) as compared with control.

**Table 2:** Effect of some post–harvest treatments on weight loss (%) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 1.85 | 4.77 | 8.93 | 14.17 | 20.73 | 10.09 B |
| NaOCl at 2% | 1.65 | 4.25 | 8.90 | 13.99 | 19.70 | 9.70 C |
| Gamma ray at 0.5 K.Gy | 1.83 | 4.54 | 8.14 | 13.30 | 19.33 | 9.43 C |
| Gamma ray at 1.0 K.Gy | 1.85 | 5.09 | 9.85 | 16.10 | 24.43 | 11.46 A |
| Chitosan at 1% | 1.50 | 3.73 | 7.30 | 12.09 | 17.35 | 8.39 D |
| Chitosan at 2% | 1.47 | 3.70 | 7.10 | 13.10 | 18.10 | 8.69 D |
| Means | 1.69 E | 4.35 D | 8.37 C | 13.79 B | 19.94 A | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.80 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 1.73 | 4.60 | 7.97 | 16.43 | 22.53 | 10.65 A |
| NaOCl at 2% | 1.59 | 4.50 | 7.75 | 15.34 | 20.73 | 9.98 B |
| Gamma ray at 0.5 K.Gy | 1.60 | 4.53 | 7.50 | 13.50 | 20.10 | 9.44 C |
| Gamma ray at 1.0 K.Gy | 1.50 | 4.70 | 8.93 | 16.25 | 21.74 | 10.62 A |
| Chitosan at 1% | 1.60 | 3.90 | 6.96 | 11.73 | 17.19 | 8.28 D |
| Chitosan at 2% | 1.43 | 3.76 | 6.84 | 11.70 | 16.50 | 8.05 D |
| Means | 1.58 E | 4.33 D | 7.66 C | 14.16 B | 19.80 A | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.55

Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

As for the effect of storage period, data in Table (2) indicate that apricot fruit weight loss (%) was increased with increasing the storage period, hence seven days storage period under cold storage scored the lowest values in this concern in both seasons.

Concerning the interaction effect between the tested storage period and post-harvest treatments, data in the same Table reveal that the lowest fruit weight loss (%) was obtained by the interactions of seven days storage period, particularly those interacted with chitosan at 2% in both seasons, whereas the highest values in this concern were scored by the interactions of thirty five days storage period, especially those treated with 1.0 K.Gy gamma ray as an average of both seasons.

Weight loss from harvested horticultural crops is mainly due to water loss through transpiration process, while some weight loss is due to loss of carbon in respiration process, but this is only a minor part of the total (Hardenburg *et al.*, 1990). The recorded results of NaOCl go in line with findings of Nnodu and Nwankiti (1986), Mehaisen (1999) and El-Badawy (2007). They recorded that dipping yam tubers in sodium hypochlorite solution (NaOCl) at 10%, "Le Conte" pear and "Costata" persimmon fruits at 1-5% as a post harvest treatments succeeded in decreasing weight loss percentage as compared with the control.
Furthermore, Mahmoud *et al.,* (1988) worked on "Le Conte" pear fruits, Prasad and Badhawan (2004) on Jalore pomegranate fruits and Mahmoud (2008) on Canino apricot fruits. They mentioned similar results to those recorded by irradiation treatment on weight losses of Canino apricot fruits.

Chitosan coatings act as barriers, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration (Ribeiro *et al.,* 2007). Chitosan coating has been reported as an material effective in controlling water loss from other commodities, including longan fruit (Jiang and Li, 2001), banana and mango (Kittur *et al.,* 2001) and strawberries (Ribeiro *et al.,* 2007). High chitosan concentration may increase anaerobic respiration followed by higher fruit weight loss on apricot fruits cv.Darashti (Ghasemnezhad *et al*., 2010).

***2. Fruit Decay %:***

Table (3) indicates that the lowest fruit decay % was recorded by chitosan treatments at 2 or 1 % (12.10&13.56) and (13.11&11.53), whereas the highest values in this concern were obtained by control (21.33&19.49) and 1K.Gy irradiation (20.03&20.70) in the first and second seasons, respectively. The rest treatments showed less fruit decay (%) as compared with control.

Regarding the effect of storage period, Table (3) shows that fruit decay percentage was increased as the storage period prolonged. So, seven days of cold storage period scored the lowest values in this concern. The highest values in this respect was recorded at 35 days storage period in both seasons.

**Table 3:** Effect of some post–harvest treatments on decay (%) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 0.00 | 7.31 | 14.32 | 30.71 | 54.32 | 21.33 A |
| NaOCl at 2% | 0.00 | 0.00 | 11.20 | 26.10 | 46.46 | 16.75 C |
| Gamma ray at 0.5 K.Gy | 0.00 | 5.72 | 12.17 | 25.20 | 42.37 | 17.09 C |
| Gamma ray at 1.0 K.Gy | 0.00 | 5.12 | 13.60 | 28.24 | 53.19 | 20.03 B |
| Chitosan at 1% | 0.00 | 0.00 | 8.09 | 21.19 | 36.28 | 13.11 D |
| Chitosan at 2% | 0.00 | 0.00 | 7.79 | 20.30 | 32.39 | 12.10 D |
| Means | 0.00 E | 3.03 D | 11.19 C | 25.29 B | 44.14 A | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 2.45 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 0.00 | 5.12 | 13.12 | 28.46 | 50.75 | 19.49 B |
| NaOCl at 2% | 0.00 | 0.00 | 12.20 | 25.13 | 46.72 | 16.81 D |
| Gamma ray at 0.5 K.Gy | 0.00 | 5.30 | 12.67 | 23.32 | 47.30 | 17.72 C |
| Gamma ray at 1.0 K.Gy | 0.00 | 0.00 | 16.7 | 31.17 | 55.64 | 20.70 A |
| Chitosan at 1% | 0.00 | 0.00 | 7.65 | 18.30 | 31.70 | 11.53 F |
| Chitosan at 2% | 0.00 | 0.00 | 7.62 | 22.87 | 37.29 | 13.56 E |
| Means | 0.00 E | 1.74 D | 11.66 C | 24.88 B | 44.90 A | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 1.81
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

Referring to the interaction effect between the tested storage period and treatments, data in Table (3) reveal that the lowest fruit decay percentages were registered by the combinations of seven days storage period, whereas the highest values in this concern were recorded by the interactions of thirty five days storage period, specially those combined with 1.0 K.Gy as an average of the two seasons.

The obtained results of NaOCl are coincided with the findings of Nguyen and Souty (1985), Roberts and Reymond (1989), Mehaisen (1999) and El- Badawy (2007). They concluded that sodium hypochlorite as a post harvest treatment was very effective in controlling diseases and rots and decreasing fruit decay percentage of peach, Red Delicious apple, "Le Conte" pear and "Costata" persimmon fruits, respectively.

The results achieved by gamma rays "irradiation" in this respect are in agreement with the findings of Shirzad and Langerak (1984) on grapes, Mahmoud *et al.,* (1988) on pears, Al-Bachir and Sass (1989) on pears, Patterson (1990) on mangoes, Budagovski *et al.,* (1993) on apples, Stevens *et al.,* (1996) on apples and Mahmoud (2008) on apricots.

### *3. Fruit Firmness:*

Table (4) reveals that all tested treatments except 1.0 K.Gy gamma ray and 2% NaOCl in both seasons induced less reductive effect on fruit firmness during storage period as compared with control. The highest values of fruit firmness (Ib/inch$^2$) were recorded by chitosan treatments at 1 or 2% in both seasons. On contrary, the lowest values of this parameter were scored by 1.0 K.Gy irradiated fruits in the first and second seasons.

**Table 4:** Effect of some post–harvest treatments on fruit firmness (Ib/inch$^2$) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 6.67 | 5.13 | 3.57 | 2.27 | 1.50 | 3.83 C |
| NaOCl at 2% | 6.50 | 4.97 | 3.60 | 2.30 | 1.40 | 3.75 C |
| Gamma ray at 0.5 K.Gy | 6.73 | 4.97 | 4.13 | 3.17 | 1.47 | 4.09 B |
| Gamma ray at 1.0 K.Gy | 6.17 | 4.47 | 2.43 | 2.10 | 1.23 | 3.28 D |
| Chitosan at 1% | 7.47 | 6.17 | 4.60 | 4.03 | 1.77 | 4.81 A |
| Chitosan at 2% | 7.33 | 6.07 | 4.63 | 4.17 | 2.57 | 4.95 A |
| Means | 6.81 A | 5.30 B | 3.83 C | 3.01 D | 1.66 E | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.85 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 7.17 | 5.60 | 3.30 | 2.13 | 1.40 | 3.92 C |
| NaOCl at 2% | 7.10 | 5.20 | 3.10 | 2.15 | 1.40 | 3.79 C |
| Gamma ray at 0.5 K.Gy | 7.07 | 5.54 | 3.80 | 3.03 | 1.70 | 4.23 B |
| Gamma ray at 1.0 K.Gy | 6.57 | 4.60 | 2.70 | 2.40 | 1.40 | 3.53 D |
| Chitosan at 1% | 7.47 | 6.67 | 5.10 | 4.33 | 2.10 | 5.13 A |
| Chitosan at 2% | 7.60 | 6.70 | 4.70 | 4.30 | 2.03 | 5.07 A |
| Means | 7.16 A | 5.72 B | 3.78 C | 3.06 D | 1.67 E | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.92

Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

In addition, Canino apricot fruits showed gradual loss in their firmness with the advancement of storage period. Furthermore, data in Table (4) indicate that the combinations of seven days storage period with all treatments induced the highest values in this concern, particularly those combined with chitosan treatments (1 & 2%) in both seasons. On the reverse, the lowest values of this parameter were gained by the interactions of thirty five days cold stored fruits treated with 1.0 K.Gy gamma ray in both seasons.

The decrease in fruit firmness with the progress of storage period is due mainly to decomposition of enzymatic degradation in insoluble protopectins to more simple soluble pectins and solubilization of cell and cell wall contents as a result of the increasing in pectin esterase activity (Deshpande and Salunkhe, 1964). In this respect, Sandhu and Randhawa (1992), Mehaisen (1999) and El- Badawy (2007) emphasized the obtained result of NaOCl.

The obtained results of irradiation in this concept go in line with those of Mahmoud *et al.,* (1988) on pears, Kushad and Myron (1989) on apples, Miller and McDonald (1995) on blueberries and Mahmoud (2008) on apricots. They realized that higher doses of irradiation induced softening of the fruits.

### *4. Shelf Life (Days):*

Table (5) reveals that most tested treatments enhanced shelf life of Canino apricot fruits with the superiority to chitosan at 2% in both seasons as compared with control.

As for the effect of storage period, data in Table (5) show that the shelf life of apricot fruits was decreased as the storage period advanced. Therefore, seven days cold storage period scored the highest values in this concern, whereas the lowest values in this parameter were gained after 35 days storage period in both

seasons. Although, the control fruits showed storability up to 35 days under cold storage (above 50% of decayed fruits), but fruit marketability is considered accepted at 28 days of cold storage period.

**Table 5:** Effect of some post–harvest treatments on shelf life (days) of cold stored Canino apricot fruits during 2008 and 2009 seasons

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 5.33 | 5.00 | 3.00 | 1.67 | 1.00 | 2.67 C |
| NaOCl at 2% | 5.67 | 5.33 | 3.67 | 2.67 | 1.33 | 3.11 B |
| Gamma ray at 0.5 K.Gy | 5.67 | 5.67 | 4.33 | 3.33 | 1.33 | 3.39 B |
| Gamma ray at 1.0 K.Gy | 4.67 | 4.67 | 2.67 | 1.33 | 1.00 | 2.39 C |
| Chitosan at 1% | 7.00 | 6.00 | 5.33 | 4.67 | 2.33 | 4.22 A |
| Chitosan at 2% | 7.00 | 6.33 | 5.33 | 5.00 | 2.33 | 4.33 A |
| Means | 5.89 A | 5.50 B | 4.06 C | 3.11 D | 1.55 E | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.91 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 6.00 | 5.67 | 3.67 | 1.67 | 1.00 | 3.00 D |
| NaOCl at 2% | 6.00 | 6.00 | 3.67 | 3.00 | 1.33 | 3.33 D |
| Gamma ray at 0.5 K.Gy | 6.33 | 6.33 | 4.33 | 4.00 | 2.00 | 3.83 C |
| Gamma ray at 1.0 K.Gy | 6.00 | 6.00 | 3.67 | 2.00 | 1.33 | 3.17 D |
| Chitosan at 1% | 7.00 | 7.00 | 5.67 | 4.67 | 2.33 | 4.45 B |
| Chitosan at 2% | 7.67 | 7.33 | 6.00 | 5.33 | 2.67 | 4.83 A |
| Means | 6.50 A | 6.39 B | 4.50 C | 3.45 D | 1.78 E | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.99
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

Concerning the interaction effect between the tested storage period and some post-harvest treatments, Table (5) demonstrates that the combinations of seven days storage period registered the highest values of shelf life, especially that of 2% chitosan treated fruits. On contrary, the lowest values of this parameter were gained after 35 days storage period, particularly that of control treatment in both seasons.

The gained results of NaOCl in this respect are in harmony with the findings of Mehaisen (1999) on pear fruits and El- Badawy (2007) on persimmon fruits.

The obtained results of irradiation on extending the shelf life of Canino apricot fruits go in line with analogous ones mentioned by Shirzad and Langerak (1984) on grapes, and Mahmoud (2008) on apricots.

### *5. Total Soluble Solid (T.S.S.%):*

Data in Table (6) demonstrate that all tested treatments did not induce a remarkable effect on fruit T.S.S. (%) except NaOCl treatment which reduced T.S.S. (%) in the first season as compared with control. Additionally, twenty eight days storage period scored the highest T.S.S.% in both seasons. On the reverse, the lowest values of this parameter were gained at seven days storage period in both seasons.

**Table 6:** Effect of some post–harvest treatments on total soluble solid (T.S.S.%) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 11.67 | 11.93 | 12.27 | 13.37 | 13.23 | 12.49 AB |
| NaOCl at 2% | 11.20 | 11.43 | 12.30 | 12.70 | 12.60 | 12.05 C |
| Gamma ray at 0.5 K.Gy | 11.70 | 12.03 | 12.16 | 13.60 | 12.90 | 12.48 AB |
| Gamma ray at 1.0 K.Gy | 12.19 | 12.27 | 12.90 | 13.44 | 12.47 | 12.65 A |
| Chitosan at 1% | 11.60 | 11.43 | 12.53 | 12.93 | 13.23 | 12.34 B |
| Chitosan at 2% | 11.63 | 11.76 | 11.93 | 13.30 | 13.10 | 12.34 B |
| Means | 11.66 D | 11.79 D | 12.35 C | 13.22 A | 12.92 B | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.44 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 10.93 | 11.23 | 12.00 | 13.53 | 12.83 | 12.10 A |
| NaOCl at 2% | 11.00 | 11.43 | 11.80 | 12.53 | 13.20 | 11.99 A |
| Gamma ray at 0.5 K.Gy | 11.53 | 11.30 | 12.53 | 13.66 | 12.60 | 12.32 A |
| Gamma ray at 1.0 K.Gy | 11.60 | 11.60 | 13.53 | 12.80 | 11.33 | 12.17 A |
| Chitosan at 1% | 10.93 | 11.07 | 12.10 | 13.10 | 13.37 | 12.11 A |
| Chitosan at 2% | 11.00 | 11.13 | 11.73 | 13.20 | 13.60 | 12.13 A |
| Means | 11.16 C | 11.29 C | 12.28 B | 13.14 A | 12.82 A | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.80
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

Furthermore, Table (6) shows that the combination of twenty eight days storage period with 0.5 K.Gy gamma ray treatment showed to be the most effective ones in inducing the greatest T.S.S.%. This was true in the first and second seasons.

The increase in fruit T.S.S. content during storage may be attributed to the reduction of fruit moisture content degrdation of complex insoluble compounds to simple soluble compounds and accumulation of soluble solids particularly sugars in fruit juice (Morga *et al*., 1979).

The obtained results of NaOCl in this respect are in harmony with the findings of Sandhu and Randhawa (1992) on litchi fruits, Mehaisen (1999) on pear fruits and El- Badawy (2007) on persimmon fruits.

The recorded results concerning the enhancing affect of gamma rays on total soluble solids are in harmony with the findings of Sornsriveai *et al.,* (1990) on Anna apples, Miller and McDonald (1995) on blueberries and Mahmoud (2008) on apricots.

***6. Titratable Acidity (T.A.%):***

Table (7) indicates that the lowest values of titratable acidity % was scored by control and 0.5 &1.0 K.Gy gamma ray treatments in the first season. Meanwhile, 1.0 K.Gy gamma ray and 2% NaOCl treatments recorded the lowest scores in the second season in this concern. On the reserve, the highest values of fruit acidity were registered by chitosan at 2% treatment (average of the two seasons). Besides, fruit titratable acidity content was gradually decreased as the storage period prolonged in both seasons.

Generally, the lowest fruit titratable acidity content was recorded by the combination of twenty eight days storage period with control treatment in the first season. Whereas, the combination of thirty five days storage period with 1.0 K.Gy gamma ray treatment registered the lowest values in this respect in the second season.

**Table 7:** Effect of some post–harvest treatments on titratable acidity (g malic acid/100 ml juice) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 1.35 | 1.20 | 0.95 | 0.76 | 0.80 | 1.01 C |
| NaOCl at 2% | 1.33 | 1.30 | 1.05 | 0.95 | 0.90 | 1.11 B |
| Gamma ray at 0.5 K.Gy | 1.20 | 1.10 | 1.08 | 0.90 | 0.90 | 1.04 C |
| Gamma ray at 1.0 K.Gy | 1.20 | 1.15 | 1.05 | 0.90 | 0.90 | 1.04 C |
| Chitosan at 1% | 1.38 | 1.35 | 1.20 | 1.10 | 0.95 | 1.20 A |
| Chitosan at 2% | 1.38 | 1.30 | 1.15 | 1.10 | 0.95 | 1.18 A |
| Means | 1.31 A | 1.23 B | 1.08 C | 0.95 D | 0.90 E | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.10 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 1.40 | 1.23 | 1.05 | 0.75 | 0.95 | 1.08 D |
| NaOCl at 2% | 1.33 | 1.20 | 0.95 | 0.90 | 0.65 | 1.01 E |
| Gamma ray at 0.5 K.Gy | 1.35 | 1.17 | 1.12 | 1.10 | 0.95 | 1.14 C |
| Gamma ray at 1.0 K.Gy | 1.30 | 1.10 | 0.95 | 0.70 | 0.53 | 0.92 F |
| Chitosan at 1% | 1.40 | 1.30 | 1.25 | 1.10 | 0.85 | 1.18 B |
| Chitosan at 2% | 1.43 | 1.35 | 1.23 | 1.17 | 1.05 | 1.25 A |
| Means | 1.37 A | 1.22 B | 1.09 C | 0.95 D | 0.83 E | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.08

Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

The decrease in fruit acidity during storage period may be due to the metabolic changes in fruits or due to the use of organic acids in respiratory process that is compatible with those of Echeverria and Valich (1989).

The gained results of sodium hypochlorite coincided with the findings of Sandhu and Randhawa (1992), Mehaisen (1999) and El- Badawy (2007).

The obtained results indicate a reductive affect of irradiation as a post harvest treatment on titratable acidity of Canino apricot fruits towards the end of storage period which came in accordance with those outlined by Gurcia *et al.,* (1988) on Washington navel oranges, Mahmoud *et al.,* (1988) on "Le Conte" pears, Sornsriveai *et al.,* (1990) on Anna apples and Miller and McDonald (1995) on blueberries.

***7. Total Sugars (%):***

Data in Table (8) show that the highest fruit total sugars content was gained by 1.0 K.Gy gamma ray treatment in both seasons. Meanwhile, the lowest fruit total sugars content was recorded by 2% NaOCl and

control treatments in the first season, and 0.5 K.Gy gamma ray treated fruits in the second one. In addition, twenty eight storage period showed to be the most effective one for producing the highest fruit total sugar values in both seasons. On the reverse, the lowest fruits total sugar content was registered by seven days storage period in both seasons.

Moreover, Table (8) reveals that the highest fruit total sugars content was recorded by the interactions of twenty eight days storage period, especially with the combinations of irradiation at 0.5 K.Gy gamma ray and chitosan at 2% treatments in the first season and irradiation at 1.0 K.Gy gamma ray in the second one, without significant differences among the aforementioned combinations. The increase in fruit sugars content during the early stage of storage may be attributed to the reduction of fruit moisture content, degrdation of complex insoluble compounds to simple soluble compounds and accumulation of sugars in fruit juice (Morga *et al.*,1979).

**Table 8:** Effect of some post–harvest treatments on total sugars (%) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 7.40 | 8.36 | 8.98 | 9.68 | 9.38 | 8.76 C |
| NaOCl at 2% | 7.33 | 8.37 | 8.85 | 9.71 | 9.44 | 8.74 C |
| Gamma ray at 0.5 K.Gy | 7.50 | 8.53 | 8.94 | 9.73 | 9.48 | 8.84 BC |
| Gamma ray at 1.0 K.Gy | 8.65 | 9.01 | 9.53 | 9.62 | 9.52 | 9.27 A |
| Chitosan at 1% | 7.40 | 8.36 | 9.37 | 9.71 | 9.74 | 8.92 B |
| Chitosan at 2% | 7.39 | 8.35 | 9.41 | 9.73 | 9.72 | 8.92 B |
| Means | 7.61 E | 8.50 D | 9.18C | 9.70 A | 9.55 B | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 2.51 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 7.10 | 8.01 | 8.63 | 9.64 | 9.52 | 8.85 B |
| NaOCl at 2% | 7.12 | 7.98 | 8.63 | 9.58 | 9.63 | 8.59 B |
| Gamma ray at 0.5 K.Gy | 7.24 | 8.06 | 8.71 | 9.60 | 8.71 | 8.46 C |
| Gamma ray at 1.0 K.Gy | 7.26 | 8.10 | 8.83 | 9.73 | 9.63 | 8.71 A |
| Chitosan at 1% | 7.13 | 8.00 | 8.58 | 9.59 | 9.71 | 8.60 B |
| Chitosan at 2% | 7.16 | 7.96 | 8.61 | 9.60 | 9.67 | 8.60 B |
| Means | 7.17 E | 8.02 D | 8.67 C | 9.62 A | 9.48 B | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 1.39
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

The recorded results concerning the effect of NaOCl in this concern go in line with the findings of Sandhu and Randhawa (1992), Mehaisen (1999) and El- Badawy (2007).

The positive and prospective obtained results of irradiation on fruit total sugars content are coincided with those mentioned earlier by Farooqi *et al.,* (1987) on Kinnow mandarins and Mahmoud *et al.,* (1988) on "Le Conte" pears.

***8. Ascorbic Acid Content (mg/ 100 ml Juice):***

Data in Table (9) indicate that 1% chitosan treated fruits showed to be the most effective treatment for inducing the highest fruits ascorbic acid (V.C) content, followed descendingly by chitosan at 2% treatment. This trend was true only in the first season, while in the second one the picture was completely changed, where NaOCl at 2% and chitosan at 1% treatments showed superiority in this concern.

Furthermore, fruit ascorbic acid content was gradually decreased as the storage period advanced in both seasons. In addition, the combinations of seven days storage period with the control fruits in the first season and NaOCl treated fruits in the second season recorded the highest fruit ascorbic acid content. On contrary, the lowest fruit ascorbic acid content was observed by the combinations of thirty five days storage period with control fruits in the first season and 0.5 K.Gy treated fruits in the second one.

The loss in ascorbic acid content during storage could be attributed to the increase in ascorbate oxidase activity (Cardello and Cardello, 1998) on Haden mango fruits. Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate a-tocopherol (Davey *et al.,* 2000). In this concern, Sandhu and Randhawa (1992) and El- Badawy (2007) mentioned similar results to that produced by NaOCl on fruit ascorbic acid content.

The gained results of irradiation regarding its affect on improving fruit quality traits, maintaining eating quality during storage and decreasing the rate of reduction in ascorbic acid are similar to earlier reports of Gurcia *et al.,* (1988), Mahmoud *et al.,* (1988), Singh (1990) and Lacroix *et al.,* (1993).

**Table 9:** Effect of some post–harvest treatments on ascorbic acid (mg/100 ml juice) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 14.10 | 13.46 | 13.20 | 12.13 | 9.63 | 12.50 AB |
| NaOCl at 2% | 13.43 | 12.87 | 12.50 | 12.43 | 11.13 | 12.47 AB |
| Gamma ray at 0.5 K.Gy | 13.75 | 13.53 | 12.90 | 11.53 | 11.58 | 12.66 AB |
| Gamma ray at 1.0 K.Gy | 13.60 | 13.29 | 13.10 | 11.45 | 9.70 | 12.23 B |
| Chitosan at 1% | 13.70 | 13.84 | 13.3 | 12.59 | 11.07 | 12.90 A |
| Chitosan at 2% | 13.86 | 13.60 | 13.25 | 12.73 | 11.00 | 12.89 A |
| Means | 13.74 A | 13.43 AB | 13.04 B | 12.14 C | 10.69 D | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 1.26 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 13.30 | 12.73 | 13.05 | 11.80 | 10.60 | 12.30 AB |
| NaOCl at 2% | 13.53 | 13.10 | 12.53 | 12.60 | 10.97 | 12.55 A |
| Gamma ray at 0.5 K.Gy | 13.46 | 12.60 | 12.60 | 12.63 | 9.78 | 12.21 AB |
| Gamma ray at 1.0 K.Gy | 13.40 | 12.36 | 12.80 | 12.53 | 10.33 | 12.29 AB |
| Chitosan at 1% | 13.30 | 13.15 | 12.93 | 12.10 | 10.20 | 12.34 AB |
| Chitosan at 2% | 12.10 | 13.00 | 12.45 | 11.85 | 10.30 | 11.94 B |
| Means | 13.18 A | 12.82 A | 12.73 AB | 12.25 B | 10.36 C | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 1.19
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

Furthermore,the obtained results concerning the effect of chitosan on ascorbic acid content go in line with the findings of Ghasemnezhad et al.,(2010).They reported that treated Darashti apricot fruits with chitosan showed higher ascorbic acid than the control fruits,but no significant difference was found among treatments.

### *9. Fruit Carotenoids Content (mg/ 100g. F.W):*

Data in Table (10) indicate that the highest values of fruits carotenoids content (mg/ 100g. F.W.) were recorded by 1.0 K.Gy irradiated fruits in both seasons, whereas the lowest values of this parameter were gained by chitosan at 1 or 2% treatments in both seasons.

**Table 10:** Effect of some post–harvest treatments on carotenoids (mg/100g F.W) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 1.67 | 1.73 | 1.78 | 1.85 | 1.93 | 1.79 C |
| NaOCl at 2% | 1.65 | 1.70 | 1.78 | 1.85 | 1.90 | 1.78 C |
| Gamma ray at 0.5 K.Gy | 1.77 | 1.79 | 1.82 | 1.88 | 1.92 | 1.84 B |
| Gamma ray at 1.0 K.Gy | 1.83 | 1.85 | 1.86 | 1.90 | 1.93 | 1.87 A |
| Chitosan at 1% | 1.68 | 1.70 | 1.76 | 1.83 | 1.90 | 1.76 C |
| Chitosan at 2% | 1.67 | 1.73 | 1.76 | 1.80 | 1.87 | 1.77 C |
| Means | 1.71 E | 1.75 D | 1.79 C | 1.85 B | 1.91 A | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 0.07 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 1.64 | 1.75 | 1.80 | 1.87 | 1.92 | 1.80 B |
| NaOCl at 2% | 1.62 | 1.73 | 1.82 | 1.90 | 1.93 | 1.80 B |
| Gamma ray at 0.5 K.Gy | 1.67 | 1.76 | 1.82 | 1.87 | 1.95 | 1.81 AB |
| Gamma ray at 1.0 K.Gy | 1.70 | 1.80 | 1.87 | 1.93 | 1.97 | 1.85 A |
| Chitosan at 1% | 1.60 | 1.72 | 1.79 | 1.83 | 1.90 | 1.77 B |
| Chitosan at 2% | 1.60 | 1.75 | 1.79 | 1.85 | 1.95 | 1.79 B |
| Means | 1.64 E | 1.75 D | 1.81 C | 1.88 B | 1.94 A | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 0.10
Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

As for the effect of storage period, data in Table (10) reveal that extending the storage period resulted in increasing fruit carotenoids content. The longer storage period (35 days), the higher was the fruit carotenoids content in both seasons.

Generally, the greatest fruits carotenoids content was produced by 1.0 K.Gy irradiated fruits under cold storage for thirty five days (average of two seasons). On controry, the lowest values of this parameter was scored by 2% NaOCl and (1&2%) chitosan treated fruits, cold stored for seven days in the first and second seasons, respectively.

El- Badawy (2007) reported that NaOCl at 2% as a post harvest treatment resulted in improving fruit colour of "Costata" persimmon. Furthermore, Singh (1990) and Miller and McDonald (1995) mentioned similar results to that obtained by gamma rays as a post harvest treatment on fruit carotenoids.

***10. Fruit Total Phenols Content (mg/ 100g F.W.):***

Table (11) declares that the highest values of fruits total phenols content were recorded by 2% chitosan treatment in both seasons. Besides, the lowest values of this parameter were scored by 1.0 K.G.y gamma ray treated fruits in the first and second seasons. Also, prolonging the cold storage period for twenty one days gave statistically higher values of fruit total phenols content in comparison with the other tested storage periods. Anyway, extending the storage period up to twenty eight or thirty five days failed to induce an additional increases in fruit total phenols content in both seasons. On the other hand, the combinations of twenty one days storage period, especially 2% NaOCl treated fruits in the first season and control fruits in the second one statistically induced the highest values of this parameter. On contrary, the lowest values of this parameter were produced by the combination of seven days storage period particularly, 1.0 K.Gy irradiated fruit in both seasons.

**Table 11:** Effect of some post–harvest treatments on total phenols (mg/100 g F.W) of Canino apricot fruits stored at 0±2 ˚C during 2008 and 2009 seasons.

| Treatment | 2008 season | | | | | Means |
|---|---|---|---|---|---|---|
| | Storage periods (days) | | | | | |
| | 7 | 14 | 21 | 28 | 35 | |
| Control | 55.60 | 58.20 | 61.73 | 56.70 | 49.77 | 56.40 B |
| NaOCl at 2% | 57.17 | 59.33 | 63.30 | 57.13 | 52.40 | 57.87 A |
| Gamma ray at 0.5 K.Gy | 53.20 | 54.90 | 58.13 | 60.10 | 50.83 | 55.43 B |
| Gamma ray at 1.0 K.Gy | 51.20 | 54.43 | 57.43 | 57.50 | 48.33 | 53.78 C |
| Chitosan at 1% | 56.47 | 57.33 | 60.93 | 62.33 | 55.77 | 58.57 A |
| Chitosan at 2% | 55.57 | 58.17 | 61.47 | 60.90 | 56.37 | 58.49 A |
| Means | 54.87 D | 57.06 C | 60.50 A | 59.11 B | 52.24 E | |
| L.S.D for the interaction effect between treatments and storage periods at 5% = 2.88 | | | | | | |
| Treatment | 2009 season | | | | | Means |
| Control | 52.40 | 60.07 | 65.73 | 63.93 | 54.37 | 59.30 AB |
| NaOCl at 2% | 53.30 | 60.17 | 64.93 | 64.87 | 53.67 | 59.39 AB |
| Gamma ray at 0.5 K.Gy | 50.63 | 58.37 | 61.67 | 62.10 | 55.70 | 57.69 C |
| Gamma ray at 1.0 K.Gy | 49.73 | 54.43 | 58.97 | 59.47 | 54.63 | 55.45 D |
| Chitosan at 1% | 51.53 | 59.87 | 64.90 | 64.73 | 53.77 | 58.96 B |
| Chitosan at 2% | 51.90 | 60.87 | 65.07 | 65.57 | 56.37 | 59.95 A |
| Means | 51.58 D | 58.96 B | 63.54 A | 63.44 A | 54.75 C | |

L.S.D for the interaction effect between treatments and storage periods at 5% = 1.78

Means followed by the same letter (s) within each column or row are not significantly different at 5% level.

Besides, its antifungal activity, chitosan also has a potential of inducing defenserelated enzymes (Bautista-Baños *et al.*, 2006) and phenolic contents in plants (Benhamou, 1996). In the present study, it was found that total phenols in 2% chitosan treated fruits were higher than that of control. Chitosan at 2% was the most effective treatment in increasing total phenols among all different treatments. This result is in compatible with Benhamou and Thériault (1992), and Liu *et al.,* (2007). They reported that the production of phenolic compounds was induced in chitosan treated fruits. The reduction of phenolic compounds at the end of storage might be due to breakdown of cell structure at senescence stage during storage (Macheix *et al.,* 1990).

The recorded results of chitosan coatings go in line with those of Ghasemnezhad *et al.,* (2010). They realized that fruit total phenols content of all coated Darashti apricot fruits was significantly higher than that of control. In all treatments, total phenols were increased at first and thereafter declined up to the end of storage period.

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