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# IMPACT OF HOT SALINE WATER ON IMPROVING PERSIMMONS QUALITY DURING COLD STORAGE

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## ABSTRACT

Persimmons (*Diospyros kaki* L.) cv. "Costata" were treated with hot water at 20 ºC for 60 min (control) or 47 ºC for 120 min or 50 ºC for 60 min in the presence of sodium chloride or calcium chloride at 200 mM for each. Treated fruits were stored at 0 ºC & 90-95 %RH for 8 weeks plus 5 days at 20 ºC & 70-75 % RH as shelf life period. In general, marketable persimmon fruits percentage were decreased after storage. Combined treatment of hot water at 47 ºC for 120 min and NaCl at 200 mM showed higher fruit dry matter content. A gradual decrease in fruit firmness was significantly observed after storage, whereas NaCl and $CaCl_2$ treatments maintained clearly fruit firmness. SSC: acid ratio was significantly increased after storage, and the highest value was obtained by hot water at 47 ºC for 120 min accompanied with $CaCl_2$ treatments. Fruit skin color was significantly increased by 14.47 and 16.88 % after storage and the highest fruit skin color was obtained by hot water at 47 ºC for 120 min. Fruit skin color might depended upon Chlorophyll *a* content and carotene content. Tannins content was significantly decreased after storage. Fruit treated with 47 ºC for 120 min and $CaCl_2$ resulted in low tannins content. Total chlorophyll content was significantly decreased, on the other hand, carotene content increased after period of cold storage. Treated fruit by hot water at 47 ºC for 120 min showed the highest total chlorophyll.

**Keywords**: Persimmon fruit; cold storage; hot water; NaCl; $CaCl_2$; fruit quality; deastringency; firmness; tannins content.

## INTRODUCTION

The persimmon (*Diospyros kaki* L.) is native to East Asia, most likely China (Collins and Tisdell, 1995). In the last few years, the interest for persimmon cultivation has increased, both for the favorable trends of the market and for easy to be adaptable to the climate of Mediterranean area. Moreover, the compounds having nutraceutical effects have obviously increased the interest of consumers towards this fruit. The main nutraceutical compounds are carotenoids, tannins and fibers, where appear to be active in the prevention of such chronic-degenerative diseases, and they have antiradical and antibacterial activity (Testoni, 2002). Since, it considers to be seasonal fruits, storage is necessary to extend its availability on local market and for transport to distant market.

Persimmons are host to a number of pest species which classified as quarantine pest in many importing countries. Methyl bromide is often used for mandatory fumigation of live quarantine pests intercepted on imported products. However, it is an environmentally hazardous toxic gas, a major contributor to ozone depletion (WMO, 1994) and phytotoxic to persimmons. Environmentally sustainable alternatives for disinfestations are therefore required to supply markets with the presence of quarantine restrictions.

Alternative disinfestations methods for ensuring that products are free of live insects include treatments such as cold storage (Jessup *et al.*, 1993), controlled atmosphere (Whiting *et al.*, 1995) and hot air or water treatments (Lay-Yee *et al.*, 1999 & Hoa *et al.*, 2006).

Heat treatments have a potential effect on controlling a number of pest diseases on various horticultural crops (Lester *et al.*, 1997; Plaza *et al.*, 2004 and Hoa *et al.*, 2006). Several postharvest heat treatments have been reported to induce fruit tolerance to cold stress and to reduce the development of chilling injury symptoms during both cold storage and cold quarantine treatments (Dentener at al., 1997)

Like other subtropical fruits, persimmons are affected by chilling injury when subjected to low or nonfreezing temperature to extend their postharvest life (Wang, 1990). Therefore, they develop specific disorders when stored below critical temperatures. Symptoms of chilling injury in persimmons depend largely on the cultivar. Gelling of flesh, firmness loss, and changes in soluble solids have been reported as chilling injury manifestations (Burmeister *et al.*, 1997; Woolf *et al.*, 1997 and Salvador *et al.*, 2004).

Treatment at a 47 $^{o}$C up to 3 h period, followed by immediate cold storage, has a beneficial effect of delaying the onset of chilling injury in persimmons, while causing only slight internal and external damage to the fruit (Woolf *et al.*, 1997).

Sodium chloride may be useful in reducing the incidence of damage from hot water immersion treatments used for surface disinfestations (Obenland and Aung, 1997). The benefit of adding NaCl to hot-water treatment solution is likely not due to any specific property of each compound, but more to the resulting decrease in osmotic potential of the water. Such a decrease would have to the effect of lessening the entry of potentially injurious hot water into the fruit.

Chilling injury was minimal in the flesh near the shell of stored pineapples, where calcium concentrations were significantly higher (Hewajulige *et al.*, 2003). It is therefore possible that calcium chloride may reduce the damage from hot water treatments in addition to its benefit effect on reducing chilling injury.

The high level of soluble tannins in persimmons is a critical problem for persimmon industry. In the astringent persimmon "Triumph", postharvest treatments for 2-5 h at 40-60 $^{o}$C , resulted in significant decreases in astringency level (Ben-Arie and Sonego, 1993). It is therefore possible that postharvest heat treatments may reduce residual soluble tannin levels of "Costata" persimmons.

In this work, the author aimed to investigated the effect of hot water treatments with the present of both sodium chloride or calcium chloride on "Costata" persimmons quality, to decrease the tannin levels and try to maintain fruit firmness after cold storage period at 0 $^{o}$C and 90-95 % RH for 8 weeks plus 5 days at 20 $^{o}$C as a shelf life.

## MATERIAL AND METHODS

This work was carried out during two successive seasons (2005 & 2006). Persimmons (*Diospyros kaki* L.) cv. "costata: were obtained from commercial orchard in El-Korashia-Gharbia Governorate, on the last week of October (167 days from full bloom), where the fruits were at commercial mature stage, hard and orange yellow colored. The fruits were free from any external blemishes and damage. Fruits were held at ambient temperature (20 ± 2 ° C & 70-75 % RH) for 2 days prior to the following treatments; where the treated fruits were immersed in the following solutions:

Water at 20 ° C for 60 min.
NaCl solution 200 mM at 20 °C for 60 min.
$CaCl_2$ solution 200 mM at 20 °C for 60 min.
Water at 47 ° C for 120 min.
NaCl solution 200 mM at 47 °C for 120 min.
$CaCl_2$ solution 200 mM at 47 °C for 120 min.
Water at 50 ° C for 60 min.
NaCl solution 200 mM at 50 °C for 60 min.
$CaCl_2$ solution 200 mM at 50 °C for 60 min.

Every treatment was replicated three times with eight persimmon fruits for each. The treated fruits were then stored at 0 °C and 90-95 % RH. Fruits stored out after 8 weeks followed by 5 days at 20 °C and 70-75 % RH to assess the quality parameters of fruits.

Marketable fruits percentage were recorded and expressed as the percentage of sound fruits weight, without any decayed, related to the initial fresh weight before storage. Flesh dry matter was calculated by weighted 100 g fruit fresh weight and oven dried for 2 days at 70 °C, then reweighted and calculated as percentage. Skin color was visually evaluated according to color chart. These color categories were given a score 1, 2, 3 and 4 which corresponds to greenish yellow, yellow, orange yellow and orange, respectively. Fruit softening or flesh firmness was determined by using push-pull dynamometer (pressure tester - 8 mm, diameter accessory plunger) and expressed as Newton units. Four measurements around the fruit equatorial were made directly through the skin, average values were calculated Tannins content was assessed using tannin prints on $FeCl_3$ discs (Lay-Yee *et al.*, 1997). Prints were produced by placing the freshly cut surface of the fruit onto a dry filter paper disc previously impregnated with 5 % $FeCl_3$ solution. The resultant was then graded from 1 to 5 according to its intensity of blacking with a grade of 5 indicating the highest tannin level and the greatest astringency. Juiciness was rated as the amount of juice which could be squeezed from the fruit fresh by hand (0= very juicy, 1=juicy, 2=some juice, 3=little juice, 4=very little juice and generally viscous, and 5=no juice) (Lay-Yee *et al.*, 1997).

Three fruits for every treatment in each replication were blended and juiced to determine: soluble solid content (SSC), by hand refractometer (ATAGOON-1-E), titratable acidity (TA) as malice acid percentage, by titration the fruit juice against 0.1 N NaOH. SSC:acid was calculated.

Ascorbic acid was determined by using 2, 6 diclorophenolindophenol dye (A.O.A.C, 1965)

Chlorophyll a (Chl *a)*, chlorophyll b (Chl *b*), total chlorophyll (T chl) and carotene contents were determined in fruit flesh and expressed as mg/g fresh weight according to Sadasivam and Manickam (1992).

The experimental design was completely randomized design with factorial arrangement of treatments (Byrkit. 1987). Three replicates of 8 fruits per each treatment were used. Data in percentages were transformed to arcsine of the square root. Mean comparisons were calculated and the significance among treatment compared by Duncan's multiple range test (DMRT) at 0.05%.

## RESULTS AND DISCUSSION

Data in Table (1) shows that marketable persimmon fruits were decreased by 1.45 and 4.44 % after 8 weeks storage at 0 $^{o}$C plus 5 days at 20 $^{o}$C in the two seasons, respectively, whereas it showed non significant differences as affected by hot saline water treatments. It was observed that fruit fresh weight loss significantly increased by 1.10 and 3.64 % after storage and it showed non significant differences as affected by the other treatments.

**Table (1):Effect of hot water, NaCl or $CaCl_2$ followed by cold storage at 0 $^{o}$C and RH 91-95 % for 8 weeks plus 5 days at 20 $^{o}$C and RH 70-75 % treatments on some physical quality parameters of "Costata: persimmons**

| Parameter / Treatments | Marketable fruit (%) | | Fresh weight loss (%) | | Dry matter content (%) | |
|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2005** | **2006** | **2005** | **2006** |
| Period treatments | | | | | | |
| 5 days 20 $^{o}$C | 96.69 | 97.81 | 3.02 | 2.21 | 26.00 | 26.63 |
| 8 week 0$^{o}$C + 5 days 20$^{o}$C | 95.24 | 93.37 | 4.12 | 5.85 | 28.21 | 30.92 |
| *F test* | NS | ** | ** | ** | ** | ** |
| Heat treatments | | | | | | |
| 20 $^{o}$C / 60 min | 95.71 a | 95.21 a | 3.76 a | 4.79 a | 25..86 c | 27.13 a |
| 47 $^{o}$C / 120 min | 96.34 a | 95.38 a | 3.66 a | 3.78 a | 28.37 a | 28.13 a |
| 50 $^{o}$C / 60 min | 65.85 a | 96.19 a | 3.28 a | 3.91 a | 27.09 b | 27.99 a |
| Salts treatments | | | | | | |
| Control (water) | 96.32 a | 95.30 a | 3.15 a | 3.82 a | 27.32 a | 29.63 a |
| NaCl 200 mM | 95.94 a | 96.12 a | 3.25 a | 3.48 a | 27.64 a | 28.88 ab |
| $CaCl_2$ 200 mM | 95.62 a | 95.37 a | 4.33 a | 4.63 a | 26.34 b | 27.75 b |
| Interaction significant | | | | | | |
| S * H | NS | NS | NS | NS | NS | NS |
| S * P | NS | NS | NS | NS | NS | NS |
| H * P | NS | NS | NS | NS | ** | NS |
| S * H * P | NS | NS | NS | * | NS | NS |

**In the same cell of the treatment, means followed by the same letter are not significantly different at the level of 5% according to DMRT.**

Dry matter (DM) was significantly increased by 8.50 & 16.11 % after storage. Fruits treated by hot water at 47 $^{o}$C for 120 min had higher DM in the two seasons comparing with the other treatments. $CaCl_2$ treatment significantly reduced fruit DM, however, NaCl maintained DM comparing with the control. These results might be depend on the elevated transpiration rate and potential loss in water content (Maha Abd El-Aziez, 2001) and the respiration activity in which some fruit constituent are consumed (Bhowmik and Sebic, 1988) during cold storage and shelf life period.

It appears from Table (2), that soluble solid content (SSC) was increased after storage. This increase might be due to the loss of water content via transpiration during storage. Fruits treated with hot water at 50 $^{o}$C for 60 min showed lower SSC value than the other heat treatments. Also, $CaCl_2$ reduced SSC value than the other treatments in this respect in both seasons. This reduction in SSC might be due to decrease of soluble tannins, which are responsible for fruit astringency (r = -0.296 P= 0.002), since they are included in SSC measurement and the reduction in astringency occurred (Arnal and Del Rio, 2003).

**Table (2): Effect of hot water, NaCl or $CaCl_2$ followed by cold storage at 0 $^{o}$C and RH 91-95 % for 8 weeks plus 5 days at 20 $^{o}$C and RH 70-75 % treatments on soluble solids content, titrartable acidity, SSC:acid ratio and ascorbic acid content of "Costata: persimmons**

| Parameter / Treatments | Soluble solids content (%) | | Titatable acidity ( malic acid % ) | | SSC: acid ratio | | Ascorbic acid (mg/100 ml juice) | |
|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| **Period treatments** | | | | | | | | |
| 5 days 20 $^{o}$C | 22.06 | 18.96 | 0.51 | 0.43 | 46.57 | 45.71 | 5.94 | 8.62 |
| 8 week 0$^{o}$C + 5 days 20$^{o}$C | 22.26 | 21.81 | 0.33 | 0.26 | 70.97 | 85.44 | 4.82 | 3.92 |
| *F test* | NS | ** | ** | ** | ** | ** | ** | ** |
| **Heat treatments** | | | | | | | | |
| 20 $^{o}$C / 60 min | 22.42 a | 20.60 a | 0.39 a | 0.34 a | 59.73 ab | 64.14 ab | 5.88 a | 5.90 b |
| 47 $^{o}$C / 120 min | 21.83 b | 20.75 a | 043 a | 0.32 a | 61.24 a | 71.09 a | 5.16 b | 6.03 b |
| 50 $^{o}$C / 60 min | 22.22 ab | 19.81 b | 0.45 a | 0.38 a | 55.34 a | 61.49 b | 5.19 b | 6.88 a |
| **Salts treatments** | | | | | | | | |
| Control (water) | 22.79 a | 19.49 b | 0.43 a | 0.38 a | 56.77 b | 60.59 b | 5.27 a | 6.15 a |
| NaCl 200 mM | 22.16 b | 19.82 ab | 0.43 a | 0.36 a | 57.35 ab | 61.84 b | 5.28 a | 6.13 a |
| $CaCl_2$ 200 mM | 21.52 c | 20.09 a | 0.39 a | 0.30 a | 62.19 a | 74.30 a | 5.60 a | 6.54 a |
| **Interaction significant** | | | | | | | | |
| S * H | NS | * | NS | NS | ** | NS | ** | NS |
| S * P | NS | * | NS | NS | NS | * | ** | NS |
| H * P | ** | ** | ** | ** | ** | ** | ** | ** |
| S * H * P | NS | NS | ** | * | ** | * | ** | NS |

**In the same cell of the treatment, means followed by the same letter are not significantly different at the level of 5% according to DMRT.**

Titratable acidity (TA) was significantly decreased to be 64.71 and 60.00 % of the initial values before storage. This reduction in TA might be due to the organic acid catabolism and ripening process which leads to utilizing the organic acid in respiration. Similar trends were obtained by El-Azabe *et al.*, 1994 and Maha Abd El-Aziez, 2001). Titratable acidity showed non significant differences as affected by both heat and salts treatments.

As showed in Table (2), SSC:acid ratio was significantly increased to be 152.39 and 186.92 % after storage comparing with their values before storage in the two seasons, respectively. This increase might due to the reduction of titratable acidity (r= -0.913 P=0.000) than the increase of SSC (r= 0.388 P=0.000). Fruit treated with hot water at 47 $^{o}$C for 120 min had the highest SSC:acid ratio value in the both seasons. In this respect, $CaCl_2$ treatment showed higher SSC:acid ratio than either NaCl or control treatment.

Ascorbic acid content was significantly decreased by 18.69 and 54.36 % after storage in the two seasons, respectively. These results are in line of Turk, (1993); El-Azabe *et al.*, (1994) and Maha Abd El-Aziez, (2001). However, it showed different affect by heat treatments. In this respect, salt treatments did not show significant effect on ascorbic acid contents.

Fruit skin color (Table, 3) was significantly increased by 14.47 and 16.88 % after storage. Fruits treated with hot water at 47 $^{o}$C for 120 min showed higher skin color value than other treatments. However, salt treatments had no significant effect on skin color. The present data, showed highly significant negative correlation between fruit skin color and both Chl *a* (r = - 0.471 P =0.000) and Chl *b* (r = - 0.434 P=0.000) and highly significant positive correlation with carotene content (r =0.436 P =0.000). The stepwise regression indicated that fruit skin color might depends on Chl *a* (St Coeff = -0.345 P 0.000) and carotene content (St Coeff = 0.282 P =0.003) only.

Tannins values were significantly reduced to 34.64 and 84.34 % after storage period as compared to the initial values. Fruits treated with hot water at 47 $^{o}$C for 120 min had lower tannins value, especially in the first season, compared with other treatments. Also, $CaCl_2$ treatment showed lower tannins value, especially in the second season. These results related to the reduction in soluble tannins content induced by the increase in acetaldehyde production and appearance of insoluble material inside the vacuoles of some tannic cell, and related to the precipitation of tannins to insoluble forms (Oz *et al.*, 2005 and Salvador *et al.*, 2007).

A progressive decline in fruit firmness was observed after storage (Table, 3), where it declined by 34.86 and 23.19 % comparing with its initial values before storage in the two seasons, respectively. This result might be due to increase in the activities of pctinmethylestrase and polygalacturonase (Luo-Zisheng, 2006) and a progressive increase in water-soluble pectin substraces and a progressive decrease in chelator-soluble pectic substances and alkali-soluble pectic substances (Luo-Zisheng, 2006, 2007). Fruits treated with hot water at 50 $^{o}$C for 60 min showed the highest fruit firmness values (40.41 & 41.67 %), however the non heated fruits showed the lowest firmness values (37.33 & 37.87 N) in the two seasons, respectively. Fruits treated with salts, either NaCl or $CaCl_2$, showed significant higher firmness

values comparing with control fruits. Data revealed non significant differences between NaCl and $CaCl_2$ in this respect. The effect of $CaCl_2$ may be due to that calcium, serve as an intermolecular binding agent that stabilizes pectin-protein complex of middle lamella (Dey and Brinson, 1984) and make the cell wall less accessible to such enzymes included in the fruit that cause softening (Sames *et al.*, 1993).

**Table (3): Effect of hot water, NaCl or $CaCl_2$ followed by cold storage at 0 ºC and RH 91-95 % for 8 weeks plus 5 days at 20 ºC and RH 70-75 % treatments on skin color, tannin content and fruit juiciness of "Costata: persimmons**

| Parameter / Treatments | Skin Color [S] (1-4) | | Tannins content [T] (1-5) | | Firmness (Newton) | | Fruit Juiciness [J] (1-5) | |
|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| **Period treatments** | | | | | | | | |
| 5 days 20 ºC | 3.11 | 3.20 | 3.06 | 3.13 | 57.68 | 62.06 | 2.44 | 1.99 |
| 8 week 0ºC + 5 days 20ºC | 3.56 | 3.74 | 1.06 | 2.64 | 20.11 | 14.39 | 0.86 | 1.26 |
| *F test* | ** | ** | ** | ** | ** | ** | ** | ** |
| **Heat treatments** | | | | | | | | |
| 20 ºC / 60 min | 3.27 a | 3.47 ab | 2.80 a | 2.87 a | 37.33 b | 37.78 b | 1.90 a | 1.78 a |
| 47 ºC / 120 min | 3.39 a | 3.56 a | 2.10 b | 2.85 a | 38.95 ab | 35.23 c | 1.46 b | 1.52 a |
| 50 ºC / 60 min | 3.36 a | 3.38 b | 2.62 a | 2.93 a | 40.41 a | 41.67 a | 1.60 ab | 1.58 a |
| **Salts treatments** | | | | | | | | |
| Control (water) | 3.27 a | 3.50 a | 2.56 a | 3.06 a | 35.73 b | 38.32 b | 1.75 a | 1.77 a |
| NaCl 200 mM | 3.39 a | 3.46 a | 2.50 a | 3.06 a | 39.62 a | 40.36 a | 1.13 b | 1.50 b |
| $CaCl_2$ 200 mM | 3.36 a | 3.45 a | 2.46 a | 2.53 b | 41.33 a | 36.00 a | 1.96 a | 1.61 ab |
| **Interaction significant** | | | | | | | | |
| S * H | NS | NS | NS | NS | ** | ** | * | NS |
| S * P | NS | NS | NS | ** | ** | NS | NS | NS |
| H * P | NS | ** | NS | ** | ** | ** | ** | ** |
| S * H * P | NS | NS | NS | NS | ** | ** | NS | NS |

**In the same cell of the treatment, means followed by the same letter are not significantly different at the level of 5% according to DMRT.**

**[S] (score 1, 2, 3 and 4 which corresponds to greenish yellow, yellow, orange yellow and orange, respectively); [T](score 1 to 5 according to its intensity of blacking with a grade of 5 indicating the highest tannin level and the greatest astringency); [J](0= very juicy, 1=juicy, 2=some juice, 3=little juice, 4=very little juice and generally viscous, and 5=no juice).**

Fruit juiciness was significantly decreased to 35.25 & 63.33% after storage. The lowest fruit juiciness was obtained by hot water at 47 ºC for 120 min treatment (1.46 & 1.52) and NaCl treatment (1.13 & 1.50).

Chlorophyll a content (Chl *a*) as shown in Table (4), was significantly decreased to 60.78 & 56.67 % after storage in the two seasons, respectively. Heated fruits showed higher Chl *a* content comparing with controlled fruit. On the other hand, the lowest Chl *a* content was obtained by NaCl treatment (0.37 & 0.44 mg/g FW) in the two seasons respectively.

Chlorophyll b (Chl *b*) content was significantly decreased to 52.44 & 51.92 % after storage in the two seasons, respectively. However, heat treatment by hot water at 47 °C for 120 min led to maintain Chl *b* content (1.06 & 1.02 mg/g FW) in the two seasons, respectively. Salts treatments significantly reduced Chl *b* content compared to controlled fruit. The lowest Chl *b* content was obtained by $CaCl_2$ treatment (0.64 & 0.66 mg/g FW) in the two seasons, respectively.

**Table (4): Effect of hot water, NaCl or $CaCl_2$ followed by cold storage at 0 °C and RH 91-95 % for 8 weeks plus 5 days at 20 °C and RH 70-75 % treatments on Chlorophyll a, chlorophyll b. total chlorophyll and carotene contents of "Costata" persimmons**

| Parameter / Treatments | Chlorophyll a (mg/g FW) | | Chlorophyll b (mg/g FW) | | Total Chlorophyll (mg/g FW) | | Carotene (mg/g FW) | |
|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| **Period treatments** | | | | | | | | |
| 5 days/ 20 °C | 0.51 | 0.60 | 1.03 | 1.04 | 1.54 | 1.64 | 0.97 | 0.98 |
| 8 week 0°C + 5 days 20°C | 0.31 | 0.34 | 0.54 | 1.54 | 0.85 | 0.88 | 1.64 | 1.70 |
| *F test* | ** | ** | ** | ** | ** | ** | ** | ** |
| **Heat treatments** | | | | | | | | |
| 20 °C / 60 min | 0.39 b | 0.45 b | 0.67 b | 0.64 c | 1.05 b | 1.10 c | 1.27 b | 1.47 a |
| 47 °C / 120 min | 0.43 a | 0.48 a | 1.06 a | 1.02 a | 1.49 a | 1.50 a | 1.38 a | 1.11 b |
| 50 °C / 60 min | 0.42 ab | 0.48 a | 0.06 c | 0.70 b | 1.04 b | 1.18 b | 1.26 b | 1.44 a |
| **Salts treatments** | | | | | | | | |
| Control (water) | 0.44 a | 0.49 a | 0.94 a | 0.91 a | 1.37 a | 1.41 a | 1.40 a | 1.43 a |
| NaCl -200 mM | 0.34 b | 0.44 b | 0.77 b | 0.79 b | 1.14 b | 1.23 b | 1.24 b | 1.27 b |
| $CaCl_2$ -200 mM | 0.43 a | 0.47 a | 0.64 c | 0.66 c | 1.07 b | 1.14 c | 1.27 b | 1.32 b |
| **Interaction significant** | | | | | | | | |
| S * H | * | ** | ** | ** | ** | ** | ** | ** |
| S * P | NS | * | ** | ** | ** | ** | NS | * |
| H * P | ** | ** | ** | ** | * | ** | ** | ** |
| S * H * P | ** | ** | ** | ** | ** | ** | ** | ** |

**In the same cell of the treatment, means followed by the same letter are not significantly different at the level of 5% according to DMRT.**

Total chlorophyll content (T chl) showed the same trend of both Chl *a* and Chl *b* and significantly decreased to 55.19 & 53.66 % after storage in the two seasons, respectively. Treated fruits by hot water at 47 °C for 120 min showed the highest T ch content (1.49 & 1.50 mg/g FW) in the two seasons, respectively. Salts treatment significantly reduced total chlorophyll content in the both seasons. The present data revealed that total chlorophyll content might be correlated to Chl *b* content (r=0.975 P=0.000) than Chl *a* content (r=0.782 P=0.000).

Carotene content was significantly increased to be 169.07 and 173.47% after storage. However, heat treatment showed different effect on carotene content in the two seasons. The obtained data revealed that salt

treatment significantly reduced carotene content. The present data showed that there are highly significant correlation between carotene content and both Chl *a* (r= - 0.440 P=0.000) and Chl *b* (r= - 0.393 P=0.000).

The present data revealed that, the stepwise regression for the different studied parameters indicated that marketable fruit might depend on hardness (St Coeff= 0.581 P=0.000) only. Tannins content might depend on firmness (St Coeff=0.365 P=0.001). However firmness might depend on ascorbic acid content (St Coeff=0.335 P=0.000), acidity (St Coeff= 0.459 P=0.005), carotene content (St Coeff= -0.204 P=0.001), skin Color (St Coeff= -0.159 P=0.002), fresh weight loss (St Coeff – 1.39 P =0.014) and Ch a content (St Coeff=0.150 P=0.020).

In conclusion, cold storage decreased persimmons marketable fruit percentage, fruit firmness, tannins value, total chlorophyll and ascorbic acid contents, however increased SSC:acid ratio, skin color and carotene content. Hot water treatment maintained fruit dry matter, fruit firmness, skin color and reduced tannins value, lowered fruit juiciness and maintained total chlorophyll content. NaCl and $CaCl_2$ treatment maintained fruit firmness and $CaCl_2$ treatment showed higher SSC:acid ratio and lower tannin value.

In this work one can recommend the use of a combination between $CaCl_2$ at 200 mM and hot water at 47 $^oC$ for 120 min treatment to overcome cold storage injury of persimmons cv. "Costata" rather than improving fruit quality. Further studies are being needed for overcome lower fruit juiciness and to increase fruit firmness during cold storage.

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## تأثير الماء الملحي الدافئ على تحسين جودة ثمار الكاكي اثناء التخزين المبرد

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اجريت هذه الدراسة خلال موسمي ٢٠٠٥ & ٢٠٠٦ على ثمار الكاكي صنف "كوستاتا" حيث عوملت الثمار بالغمس في الماء الدافئ على درجة حرارة ٢٠ ° م لمدة ٦٠ دقيقة (معاملة الكنترول) أو ٤٧ ° م لمدة ١٢٠ دقيقة أو ٥٠ ° م لمدة ٦٠ دقيقة وذلك في وجود كلوريد الصوديوم أو كلوريد الكالسيوم بتركيز ٢٠٠ ملي مول لكل منهما. ثم تخزين الثمار المعاملة تحت ظروف التخزين المبرد على درجة حرارة الصفر المئوي ورطوبة نسبية ٩٠-٩٥ % وذلك لمدة ثماني اسابيع ثم وضعت الثمار بعد ذلك على درجة حرارة ٢٠ درجة مئوية ورطوبة نسبية ٧٠-٧٥ % لمدة خمسة ايا م.
إنخفضت النسبة المئوية للثمار القابلة للتسويق بعد التخزين المبرد في حين أن معاملة الثمار بالماء الدافئ على درجة ٤٧ ° م لمدة ١٢٠ قيقة وكذلك معاملة كلوريد الصوديوم أظهرت أعلى محتوى من المادة الجافة. هذا وقد انخفضت صلابة الثمار بعد التخزين في حين أدت المعاملة بكل من كلوريد الصوديوم وكلوريد الكالسيوم الى المحافظة على صلابة الثمار. هذا و لقدإرتفعت النسبة بين المحتوى الكلي للمواد الصلبة الذائبة : الحموضة بعد التخزين وأن أعلى نسبة قد ظهرت نتيجة معاملة الثمار بالماء االدافئ على درجة ٤٧ ° م لمدة ١٢٠ دقيقة وكذلك المعاملة بكلوريد الكالسيوم. هذا وقد ارتفعت درجة تلون الثمار وذلك بنسبة ١٤,٤٧ & ١٦,٨٨ % بعد التخزين وأن أعلى نسبة تلوين تم الحصول عليها بمعاملة الماء الدافئ على درجة ٤٧ ° م لمدة ١٢٠ دقيقة وأن تلون الثمار قد يعتمد على محتوى الثمار من كل من الكلوروفيل أ و الكاروتين .
هذا وقد انخفضت قيم التانينات الذائبة بعد التخزين كذلك فان معاملة الثمار بالماء الدافئ على درجة ٤٧ ° م لمدة ١٢٠ دقيقة وكذلك المعاملة بكلوريد الكالسيوم أدت الى إنخفاض قيم محتوى التانينات الذائبة. كما أدت عملية التخزين إلى إنخفاض محتوى الثمار من الكلوروفيل الكلي والى زيادة المحتوى من الكاروتين في حين أدت المعاملة بالماء الدافئ على درجة ٤٧ ° م لمدة ١٢٠ دقيقة الى المحافظة على محتوى الثمار من الكلوروفيل الكلي.
ويمكن التوصية باستخدلم معاملة النفع في محلول كلوريد الكالسيوم الدافئ بتركيز ٢٠٠ ملليموز على درجة حرارة ٤٧ ٥ م لمدة ١٢٠ دقيقة وذلك للتغلب على اضرار التخزين المبرد بالإضافة الى تحسين جودة ثمار الكاكي صنف " كوستاتا" اثناء التخزين المبرد.

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