Minia J. of Agric. Res. & Develop.
Vol.(27) No.4 pp 771 -790, 2007

EFFECT OF HOT WATER AND CALCIUM CHLORIDE TREATMENTS ON THE SHELF LIFE AND SOME PHYSIOLOGICAL DISORDERS OF 'WASHINGTON NAVEL' ORANGES DURING STORAGE

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Received 27 July 2007 Accepted 5 Sept. 2007

ABSTRACT

The effect of the interaction between hot water temperatures (20, 40, 50, 60, 70 or 80°C) and dipping time (0.5, 1, 2, 3 or 4 minutes) on peel scalding of 'Washington navel' oranges were studied. At all tested dipping periods, peel scalding was not developed when the fruits were immersed in water at 20°C or 40°C. Water-dip for 0.5 – 2 min at 50°C also considered to be completely safe to the fruits. Extending the dip period more than 2min resulted in slight peel scalding. On the other hand, water temperature at 60°C or above resulted in variable degrees of peel scalding. The severity of this scald was positively related to water temperature and dipping time.

In another experiment, 2min. dip treatment in warm water or in 2% $CaCl_2$ solution, both at 20, 40 and 50°C were evaluated for their effect on shelf life and physiological disorders of 'Washington navel' oranges during cold storage. Both heated liquids at higher temperatures, in particular 50°C, were efficient in decreasing the loss of fruit weight as well as both chilling injury and decay symptoms. Most observed decay was due to green mold (*Penicillium* sp.) and anthracnose (*Colletotrichum* sp.). Heated solution of calcium chloride was also found more efficient than heated water, in this respect. However, in comparable to control fruits (dipped in 20°C water), all treatments had no effect on juice contents of TSS, total acidity and TSS/acid ratio. Vitamin C was negatively affected with raising the temperature of water. Heated calcium chloride solution at 40 or 50°C was effective in alleviating the adverse effects of hot water alone on vitamin C.

Prestorage 2 min dip-treatment of heated calcium chloride solution at 50°C appears to be a promising method of chilling injury and decay control for 'Washington navel' oranges during cold storage without negative effects on fruit quality.

INTRODUCTION

Citrus is considered one of the most important fruit crops all over the world. It ranks the third position between fruit crops and only preceded with grapes and apples. Egypt produces substantial quantities of citrus fruits, in particular oranges. It is the seventh country after US, Brazil, Italy, Spain, Mexico and India in the world's orange production (Kale and Adsule, 1995). Because of the nutrition-conscious consuming public and the natural distinctive flavor of citrus, the demand for fresh citrus fruits and citrus products has increased and is likely to increase further. Furthermore, worldwide marketing and shipment of production have increased the requirement for maintaining fruit quality throughout extended shipping and storage durations. Moreover, citrus fruits, like other fruits, are seasonal, with the result they are available in plenty during certain months of the year and cannot be had in other months. Therefore, using the optimum storage methods of citrus fruits, particularly cold storage, assumes great significance (Kale and Adsule, 1995).

Storing of citrus fruits under low temperature degrees may present environmental conditions of stress for fruit as visible signs of chilling injury (CI). The most common physiological disorder in citrus fruits held below a critical threshold temperature is CI (Grierson, 1986). Who has been described the common symptoms of CI as surface pitting, discoloration of the skin or water-soaked area of the rind. These symptoms become more noticeable when the fruits are transferred from chilling to non-chilling temperatures. Chilling injury is also associated with increased incidence of surface mold and decay (Kader, 2002).

The goal of postharvest storage regimes for fresh fruit distribution is to create a set of conditions conducive to extending shelf life while reducing or eliminating conditions deleterious to consumer appeal. Postharvest physiologists have extensively studied postharvest treatments to identify optimal conditions for the retention of fruit quality, enabling these fruit to be shipped to distant markets.

For years, heat treatment has been tested and used on various fresh horticultural commodities as a non-chemical method of reducing postharvest diseases, insects, and physiological disorders such as chilling injury (Couey, 1989; Barkai-Golan and Phillips, 1991 and Jacobi *et al.*, 2001). In citrus, the increasing demand for fruit with less or no synthetic fungicide residues has led to the development and increased use of hot water (HW) treatments (Wild and Hood, 1989 and Smilanick *et al.*, 1995).

When fruits are exposed to high temperatures, there is potential risk of injury. Symptoms of heat injury (HI) can be external (i.e., peel scalding, pitting, etc.) or internal (i.e., softening, discoloration, tissue disintegration, off-flavors, etc.) (Lurie, 1998). The severity of these HI is related to HW temperature and duration of treatment, implying fruit tolerance of higher temperatures may be possible with short treatment times.

Heated solutions of compounds generally recognized as safe like sulfur dioxide and sodium carbonate have been found to be efficient more than hot water in controlling green mold in citrus (Smilanick *et al.*, 1995). Also, calcium-dip treatment may have a great role in retarding the microbial contamination (Luna-Guzman *et al*, 1999). A combination of heat treatment followed by calcium dip has also been applied for the primary purpose of controlling postharvest pests and/or diseases and has been found to have very good results in maintaining or improving the quality of apples during storage (Lurie and Klein, 1992; Conway *et al.*, 1994).

Accordingly, the intent of this study was to assess the effects of a biotic postharvest stress such as hot water or heated solution of calcium chloride on shelf life of 'Washington navel' oranges during cold storage. Three important questions were kept into conceptions before the start of this experiment:

1- What are the maximum hot water temperature and dip duration that had no heat injury effect on 'Washington navel' oranges.
2- Could the suitable hot water treatment, according to the previous question, be effective in maintaining the shelf life of 'Washington

navel' oranges during cold storage by controlling chilling injury and decay problems?

3- Could heated solution of calcium chloride be effective in giving better results concerning the shelf life of 'Washington navel' oranges than hot water alone?

MATERIALS AND METHODS

Fruits of Washington navel oranges were harvested in mid January in 2004, 2005 and 2006 seasons from a private orchard located at Agaa region, Dakahlia Governorate. The fruits were harvested in the early morning and received their respective treatments following day. Two separate experiments were conducted, first in 2004 and second in 2005 and 2006 seasons.

First experiment:

This experiment was mainly aimed to find the maximum hot water temperature and dipping duration time which had no harmful effects on orange fruits, i.e. representing no peel scalding.

Harvested fruits were dipped in a controlled hot water at 20 (Control), 40, 50, 60, 70 or 80°C for 0.5, 1, 2, 3 or 4 minutes. Water temperature was adjusted by gradual thermometer (0.0-80.0°C). Fruits were air dried, packed in sealed polyethylene bags and stored under room temperature 16- 19°C for 15 days. Each treatment included three replicates of 20 fruits each. At the end of storage period, fruits were evaluated concerning their peel scalding by counting the fruit showing any scald and the percentage of peel scalding was calculated from the total number of fruits in each replicate. Also, the severity of peel scalding on the fruit surface was evaluated on each scalded fruit and expressed on a 1 to 4 scale where 1= Low (about 25% of fruit surface), 2= Moderate (about 50% of fruit surface), 3= High (about 75% of fruit surface) and 4 = Severe (about 100% of fruit surface). The average peel scalding percentage on fruit surface was calculated from the following equation:

$$\text{Peel scalding (\% of fruit surface)} = \frac{(S1)1 + (S2)2 + (S3)3 + (S4)4}{4}$$

$$S1 = \frac{\text{Number of fruits in scale 1}}{\text{Total number of scalded fruits}} \times 100$$

Second experiment:

Some fruit samples were randomly selected before the start of treatments to perform some chemical characters of 'Washington navel' oranges at harvest. The recorded data were represented in Tab.1.

Tab.1: Some chemical constituents of 'Washington navel' orange fruits at picking time, January of 2005 and 2006.

Character	2005	2006
TSS (%)	11.6	12.0
Total acidity (%)	1.280	1.344
TSS /acid ratio	9.1	8.9
Ascorbic acid (mg /100g juice)	58.3	56.2

All safe hot water temperatures on 'Washington navel' oranges those were discovered in the previous experiment were used in this experiment for study their effects with or without calcium chloride on shelf life and physiological disorders on the fruits during storage.

Therefore, the harvested fruits were immersed for 2 minutes in one of the following solutions:

1- Water at 20°C (control)
2- $CaCl_2$ solution (2%) at 20°C
3- Hot water at 40°C
4- Heated solution of $CaCl_2$ (2%) at 40°C
5- Hot water at 50°C
6- Heated solution of $CaCl_2$ (2%) at 50°C

Fruits were air dried, weighed, packed in sealed polyethylene bags and stored at 5°C in the refrigerator for two months. Each treatment included three replicates of 20 fruits each.

At the end of storage period, fruits were transferred to non-chilling conditions under room temperature for 3 days before the following determinations were carried out:

- Fruit weight loss percentage
- Chilling injury index: Chilling injury was identified by signs of surface pitting, discoloration of the skin or water-soaked area of the rind (Grierson, 1986). Chilling injury severity was rated from 0 to 3 (0-none, 1-slight, 2-moderate and 3-severe). The number of fruits in each rating was multiplied by its corresponding rating number and the sum of these products was divided by the total number of fruit in the replicate to give the average CI severity for that replicate according to Pesis et al., (2000).

$$\text{CI index} = \frac{\text{Injury level x Number of fruits at the level}}{\text{Total number of fruits in the replicate}}$$

- Total decay %: The total percentage of fruit with any visible decay was recorded after one month of storage and again at the end of storage period (2 months). Decayed fruits in the first check were removed before placing the fruit back into storage. The type of decay occurring on each fruit was visually identified as green mold (Penicillium sp.) and anthracnose (Colletotrichum sp.) according to the descriptions of Eckert and Brown (1986).
- Total soluble solids and total acidity (as g citric acid /100g juice) percentages. TSS /acid ratio was also calculated.
- Vitamin C (mg ascorbic acid /100g juice) as outlined in A.O.A.C. (1985).

Both experiments were set in a completely randomized design with three replicates. All the obtained data were tabulated, illustrated in figures and statistically analyzed according to the procedure of **Gomez and Gomez (1984)** The Duncan's multiple range test was used to distinguish significant differences between means.

RESULTS AND DISCUSSION

The effect of hot water treatments on peel scalding

As shown in Figs. 1 and 2, fruits of 'Washington navel' orange dipped in 20°C (control) or 40°C water for 0.5, 1, 2, 3 or 4min. did not develop any peel scalding. Using 50°C water as dip-treatment for 0.5, 1 and 2min. was found also to be completely safe on the fruits. However, extending the dip duration period of the previous treatment more than 2min. resulted in little peel scald whether as percent of fruit scalded or percent of fruit surface. Moreover, raising hot water temperature to 60°C, 70°C or 80°C for all tested dip-times caused different degrees of peel scalding. The severity of this injury increased gradually with increasing time of dipping. About 7, 25, 57, 80 or 100% of the fruits dipped in 60°C water for 0.5, 1, 2, 3 or 4min., respectively, developed peel scalding on fruit surface ranged from low (25%) to high (80%), according to the dip duration period. The worst results were obtained when hot water temperature rose up to 70 or 80°C. All tested fruits (100%) represented peel scalding of either moderate – severe level when they dipped in 70°C for 2-4 min. or completely severe with 80°C for 1-4 min.

According to the previous findings, the safe hot water treatment of maximum temperature on 'Washington navel' oranges, which represented no peel scalding, was 50°C for 2min.

In agreement with the present study, the previous studies have shown that peel scalding of citrus fruits was positively related to hot water temperature and time of dipping (Wild and Hood, 1989 on 'Valencia' oranges and Gonzalez-Aguilar *et al.*, 1997 on 'Fortune' mandarins). Ritenour *et al.*, (2003) studied the time and temperature interactions for peel scalding in grapefruit. They found that fruits dipped in water at 56 °C for 120 s, 59 °C for 20-120 s or 62 °C for 10-120 s developed significant peel scalding after 33 days in storage at 10 °C. Hot water dips at 62 °C for 60 or 120 s resulted in 100% peel scalding. Also, heat treatment at 59 °C for 180 s resulted in severe peel scalding of grapefruit (over 77% of the fruit surface). Schirra and D'hallewin (1997) dipped 'Fortune' mandarins in HW at 54, 56 or 58 °C for 3 min and found the scalding incidence was 10%, 70%, or 100%, respectively, after 33 days in storage. Also, dipping 'Tarocco' oranges in 53 °C water for 3 min caused little peel scald (Schirra *et al.*, 1997).

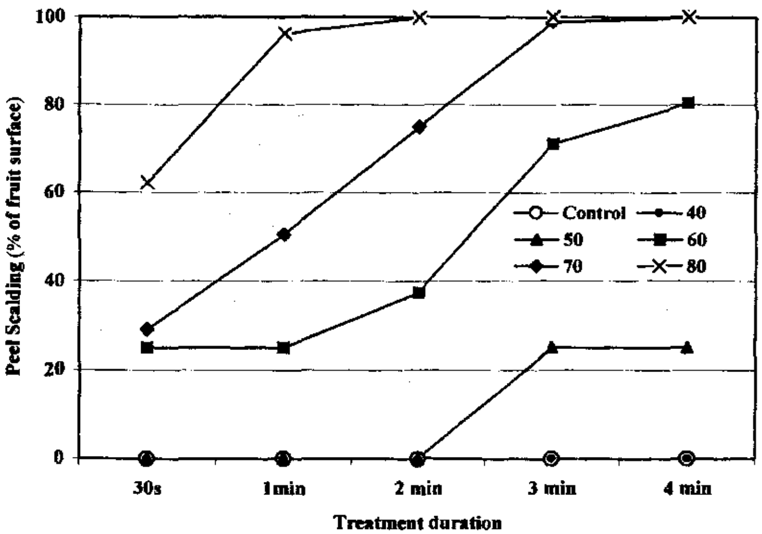

Fig.1: Peel scalding level on fruit surface of 'Washington navel' oranges as influenced by hot water dip temperatures and treatment duration.

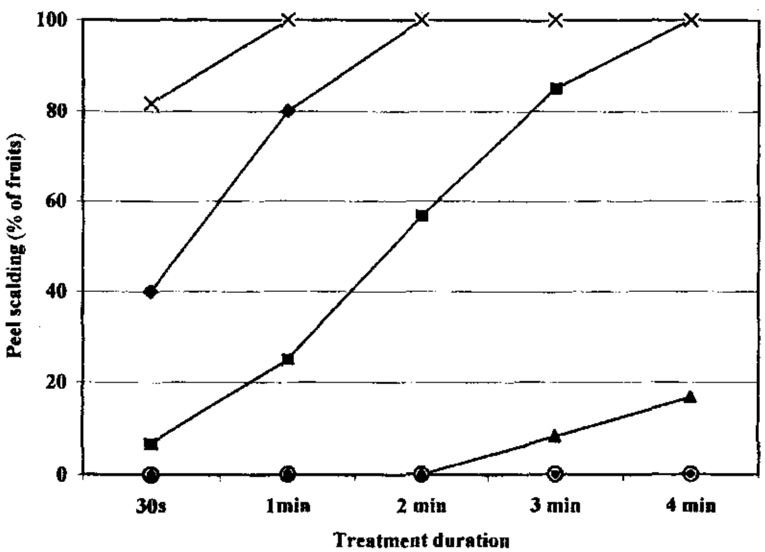

Fig.2: Peel scalding percentage of 'Washington navel' oranges as influenced by hot water dip temperatures and treatment duration.

The effect of hot water and calcium chloride treatments on shelf life of fruits during cold storage

a: The effect on fruit weight loss

Control fruits (dipped in 20°C water for 2 min.) lost greater amount of moisture than all other treatments (Tables 2 and 3). In other words, both hot water and calcium chloride solution (2%) treatments significantly reduced the loss of fruit weight during cold storage as compared with the control. In comparison with hot water treatments (40 or 50°C for 2 min.), heated solution of calcium chloride at similar temperatures and duration period was found to be efficient in this respect. Raising the temperature of water or calcium chloride solution from 40 to 50°C was of great significance in reducing fruit weight loss percentage during storage. The best results in this regard were obtained when fruits were dipped in calcium chloride solution at 50°C for 2min. Similar findings were found in both seasons.

Weight loss is a consequence of fruit dehydration due to changes in surface transfer resistance to water vapour, in respiration rate, and the occurrence of small fissures connecting the internal and external atmospheres (Woods, 1990). Heat treatment causes the redistribution of natural epicuticular wax on the fruit surface and closes many microscopic cuticular cracks (Rodov *et al.*, 1996). This could be the reason for better maintenance of moisture and lower weight loss in heat-treated orange fruits. Also, calcium dip applications have shown to be effective in terms of membrane functionality and integrity maintenance, with lower losses of phospholipids and proteins and reduced ion leakage (Lester and Grusak, 1999), which could be responsible for the lower weight loss found in calcium-treated fruits (Serrano *et al.*, 2004).

b- The effect on fruit characters

Slight increase in TSS and TSS/acid ratio and decrease in acidity and vitamin C of the fruit during storage were observed in all treatments when compared with the values at harvest (Tables 2 and 3). Also, there were no significant differences in total acidity and TSS/acid ratio due to treatments in both seasons. Heated solution of calcium chloride at 40 or 50°C caused a significant decrease in TSS, only in the first experimental season. Other treatments had no effect on TSS, in both seasons. Hot water treatments at 40 or 50°C resulted in a significant loss in fruits content of vitamin C compared with the control treatment. It seemed also that calcium chloride counteracted the negative effect of hot water in this regard. Heated solution of calcium chloride at 40 or 50°C maintained the loss of vitamin C and gave nearly similar values to that of control fruits.

As orange is a non-climacteric fruit with a low respiration rate, loss in acids with ongoing storage period was expected. The observed slight increase in TSS after storage is mainly due to the loss of fruit moisture, which in turn led to concentrating of sugars. Dhalla and Hanson (1988) and Koksal (1989) also reported a gradual decrease in the vitamin C content during prolong storage of climacteric and non-climacteric fruits, respectively.

The obtained results concerning the effect of hot water on chemical quality of the fruits are in agreement with those obtained by Schirra and D'hallewin (1997) on 'Fortune' mandarins. They found that TSS and titratable acidity did not show much difference between the untreated and the heat-treated (50, 54, 56 and 58 °C for 3 min) fruit. Similar trend was also disclosed by Schirra *et al.*, (1997) on 'Tarocco' oranges and Porat *et al.*, (2000) on 'Minneola' tangerines, 'Shamouti' oranges and 'Star Ruby' red grapefruit.

Also, El-Hilali *et al.*, (2004) reported that preharvest spray of calcium on 'Fortune' mandarin trees did not alter both TSS and TSS/acid ratio after prolong cold storage. The combined application of calcium and heat treatment was benefit in terms of prolonging storability and maintaining fruit quality of apples (Conway *et al.*, 1994).

Table 2: Effect of prestorage hot water and calcium chloride dip treatments on some chemical characters of 'Washington navel' oranges after two months of cold storage in 2005 year.

	Weight loss (%)	TSS (%)	TA (%)	TSS / acid ratio	Ascorbic acid (mg /100g juice)
Control (20°C)	5.8 a	12.6 a	1.124 a	11.2 a	52.3 ab
$CaCl_2$ (20°C)	3.8 b	12.4 a	1.105 a	11.2 a	53.4 a
HW (40°C)	3.8 b	12.6 a	1.105 a	11.4 a	48.2 c
H-$CaCl_2$ (40°C)	2.2 d	11.6 b	1.047 a	11.1 a	51.7 ab
HW (50°C)	3.0 c	12.4 a	1.105 a	11.2 a	46.5 c
H-$CaCl_2$ (50°C)	1.4 e	11.4 b	1.047 a	10.9 a	50.4 b

Means of the same letter in each column are not significantly different (p=0.05%).

Table 3: Effect of prestorage hot water and calcium chloride dip treatments on some chemical characters of 'Washington navel' oranges after two months of cold storage in 2006 year.

	Weight loss (%)	TSS (%)	TA (%)	TSS / acid ratio	Ascorbic acid (mg /100g juice)
Control (20°C)	6.7 a	12.8 a	1.152 a	11.1 a	50.6 a
$CaCl_2$ (20°C)	4.8 b	12.6 a	1.152 a	10.9 a	50.4 a
HW (40°C)	5.1 b	12.6 a	1.152 a	10.9 a	45.8 b
H-$CaCl_2$ (40°C)	2.8 d	12.2 a	1.088 a	11.2 a	50.2 a
HW (50°C)	4.0 c	12.4 a	1.109 a	11.2 a	42.2 c
H-$CaCl_2$ (50°C)	1.8 e	12.2 a	1.088 a	11.2 a	48.8 a

Means of the same letter in each column are not significantly different (p=0.05%).

c- The effect on chilling injury and postharvest decays of the fruits

'Washington navel' orange fruits dipped for 2 min. in either hot water at 40 and 50°C or 2% calcium chloride solution at 20, 40 and 50°C developed significantly less chilling injury and decay symptoms than those of control fruits (dipped for 2 min. in water at 20°C) (Figs 3 and 4). Raising the temperature degree of tested solution was associated with reduction in both CI and decay symptoms. Heated solution of calcium chloride was more efficient than heated water, in this respect. The best results were obtained when fruits were dipped for 2 min. in 2% heated solution of $CaCl_2$ at 50°C, in both seasons. Fruits receiving the previous treatment did not show any decays symptoms in the first season of the experiment. Most decay was due to green mold (*Penicillium sp.*) and anthracnose (*Colletotrichum sp.)*. A single fruit may exhibit both types of fungus.

The effect of hot water or calcium chloride treatments either alone or in combination in controlling chilling injury symptoms of 'Washington navel' orange after 2 months of cold storage may be attributed to their positive effect in decreasing fruit weight loss. Purvis (1984) correlated higher weight loss during storage with chilling injury development in citrus fruits. Cohen *et al.*, (1994) used weight loss as an early indicator of chilling injury.

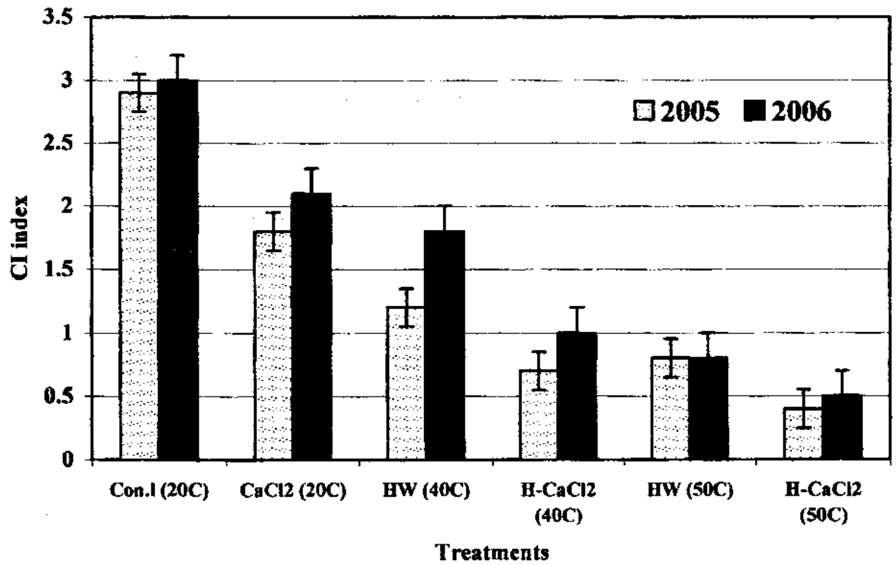

Fig.3: Chilling injury index of 'Washington navel' oranges after two months of cold storage as influenced by prestorage hot water and calcium chloride dip treatments in 2005 and 2006 years.

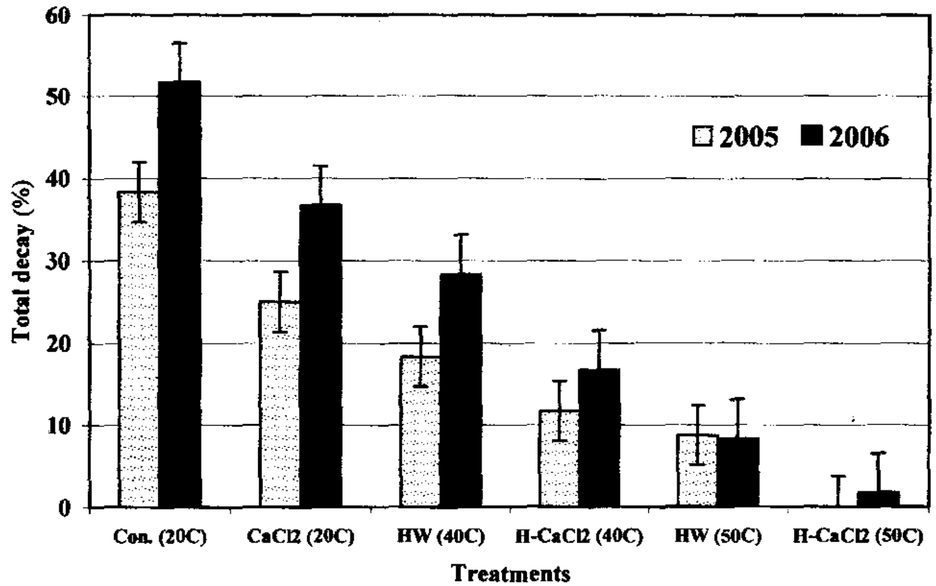

Fig.4: Total decay percentage of 'Washington navel' oranges after two months of cold storage as influenced by prestorage hot water and calcium chloride dip treatments in 2005 and 2006 years.

Serrano *et al.*, (1998) reported also that chilling injury stress was associated with a great increase in conjugated-soluble and cell wall-bound putrescine (Put) and free spermidine (Spd) during storage. However, the increases in these polyamines were significantly lower in fruits that were previously treated with either calcium or heat treatment (Serrano *et al.*, 2004), which could indicate a protective effect of these treatments against this stress.

The obtained results are in agreement with those of Wang (1994) and González-Aguilar *et al.*, (1997). They reported that exogenous application of calcium chloride or hot water dips have been found successful in reducing chilling injury stress of squash or mandarin, respectively.

The main effect of the combined application of calcium and heat treatment was a net increase in fruit firmness (Serrano *et al.*, 2004). Since one of the main effects of both treatments is inducing a greater resistance to pathogen attack. The diffusion of calcium ions into the tissue increases at higher dip temperatures (Luna-Guzman *et al*, 1999). They also suggested that prestorage dip treatment of calcium chloride may effectively retarded the microbial contamination of fruits during storage especially when dip temperatures increased.

Hot water treatment is efficient in preventing growth of surface decay organisms, and cleanses fruit surface during treatment (Shellie and Mangan, 2000). Heat treatments may also have an indirect effect on decay development by inducing anti-fungal substances within the commodity that inhibit fungal development or by promoting the healing of wounds on the commodity (Schirra *et al*., 2000). They also added that heat treatments enhanced wound healing by promoting the synthesis of lignin-like compounds and these compounds act as physical barriers to the penetration of pathogens. Short duration, hot water dip treatments appear to be a promising method to control postharvest decay in citrus (Rodov *et al*., 1995). Also, calcium chloride possess antimicrobial activity and has been demonstrated to control postharvest decays of fruits efficiently (Conway *et al*., 1991). A combination of heat treatment and calcium dip has also been applied for the primary purpose of controlling postharvest diseases of apples (Conway *et al*., 1994).

REFERENCES

Association of Official Agricultural Chemists (1985): Official Methods of Analysis (AOAC) 13Ed., pp. 494-500.

Barkai-Golan, R. and D.J. Phillips. (1991): Postharvest heat treatments of fresh fruits and vegetables for decay control. Plant Dis. 75: 1085-1089.

Cohen, E., B. Shapiro, Y. Shalom and J.D. Klein (1994): Water loss: a nondestructive indicator of enhanced cell membrane permeability of chilling injured citrus fruit. J. Amer. Soc. Hort. Sci. 119: 983-986.

Conway, W.S., C.E. Sams, J.A. Abbott and B.D. Bruton (1991): Postharvest calcium treatment of apple fruit to provide broad-spectrum protection against postharvest pathogens. Plant Disease 75: 620–622.

Conway, W.S., C.E. Sams, C.Y. Wang and J.A. Abbott (1994): Additive effects of postharvest calcium and heat treatments on reducing decay and maintaining quality in apples. J. Amer. Soc. Hort. Sci. 119: 49–53.

Couey, H.M. (1989): Heat treatment for control of postharvest diseases and insect pests of fruits. HortScience 24:198-202.

Dhalla, R. and S.W. Hanson (1988): Effect of permeable coatings on the storage life of fruits. II. Pro-long treatment of mangoes (*Mangifera indica* L. cv. Julie). Int. J. Food Sci. Technol. 23: 107-112.

Eckert, J.W. and G.E. Brown (1986): Postharvest citrus diseases and their control, p. 315-360. In: W.F. Wardowski, S. Nagy, and W. Grierson. (eds.), Fresh Citrus Fruits. AVI Publishing, Westport, CT.

El-Hilali, F., A. Ait-Oubahou, A. Remah and O. Akhayat (2004): Effect of preharvest spray of Ca and K on quality, peel pitting and peroxidases activity of 'Fortune' mandarin fruit in low temperature storage. ISHS Acta Hort. 632: XXVI Inter. Hort. Cong.: Citrus and Other Subtropical and Tropical Fruit Crops: Issues, Advances and Opportunities.

Gomez, K.A. and A.A. Gomez (1984): Statistical Procedures for Agricultural Research. John Wiley and Sons- New York, USA pp. 680.

Gonzalez-Aguilar, G.A., L. Zacarias, M. Mulas and M.T. Lafuente (1997): Temperature and duration of water dips influence chilling injury, decay and polyamine content in 'Fortune' mandarins. Postharvest Biol. and Technol. 12: 61–69.

Grierson, W. (1986): Physiological disorders, p. 361-378. In: W.F. Wardowski, S. Nagy, and W. Grierson. (eds.) Fresh Citrus Fruits. AVI Publishing, Westport, CT.

Jacobi, K.K., E.A. MacRae and S.E. Hetherington (2001): Postharvest heat disinfestation treatments of mango fruit. Scientia Hort. 89: 171-193.

Kader, A. A. (2002): Postharvest Technology of Horticultural Crops. (3^{rd} ed) University of California Agriculture and Natural Recourses Publication 3311: Oakland, California.

Kale, P.N. and P.G. Adsule (1995): Citrus. p.39-65. In: Salunkhe, D.K. and S.S. Kadam: Handbook of Fruit Science and

Technology, Production, Composition, Storage and Processing. Marcel Dekker, Inc. New York. Basel.

Koksal, A.I. (1989): Research on the storage of pomegranate (cv. Gok Bahce) under different conditions. Acta Hort. 258: 295-302.

Lester, G.E. and M.A. Grusak (1999): Postharvest application of calcium and magnesium to honeydew and netted muskmelons: effects on tissue ion concentrations, quality and senescence. J. Amer. Soc. Hort. Sci. 124: 545–552.

Luna-Guzman, I., M. Cantwell and D.M. Barrett (1999): Fresh-cut cantaloupe: effects of $CaCl_2$ dips and heat treatments on firmness and metabolic activity. Postharvest Biol. and Technol. 17: 201–213.

Lurie, S. (1998): Postharvest heat treatments. Postharvest Biol. And Technol. 14: 257-269.

Lurie, S. and J.D. Klein (1992): Calcium and heat treatments to improve storability of 'Anna' apples. HortScience 27: 36–39.

Pesis, E., D. Aharoni, Z. Aharon, R. Ben-Arie, N. Aharoni and Y. Fuchs (2000): Modified atmosphere and modified humidity packaging alleviates chilling injury symptoms in mango fruit. Postharvest Biol. and Technol. 19: 93-101.

Porat, R., A. Daus, B. Weiss, L. Cohen, E. Fallik, and S. Droby (2000): Reduction of postharvest decay in organic citrus fruit by a short hot water brushing treatment. Postharvest Biol. and Technol. 18: 151-157.

Purvis, A.C. (1984): Importance of water loss in the chilling injury of grapefruit stored at low temperature. Sci. Hort. 23: 261-267.

Ritenour, M.A., K.J. John-Karuppiah, R.R. Pelosi, M.S. Burton, T.G. McCollum, J.K. Brecht, and E.A. Baldwin (2003): Response of Florida grapefruit to short-duration heat treatments using vapor heat or hot water dips. Proc. Fla. State Hort. Soc. 116: 405-409.

Rodov, V., S. Ben-Yehoshua, R. Albagli, and D.Q. Fang (1995): Reducing chilling injury and decay of stored citrus fruit by hot water dips. Postharvest Biol. and Technol. 5: 119-127.

Rodov, V., J. Peretz, T. Agar, G. D'hallewin, and S. Ben-Yehoshua (1996): Heat applications as complete or partial substitute of postharvest fungicide treatments of grapefruit and Oroblanco fruits. Proc. VIII Intl. Citrus Congr., 12-17 May Sun City Resort, South Africa. 2: 1187-1191.

Schirra, M. and G. D'hallewin (1997): Storage performance of Fortune mandarins following hot water dips. Postharvest Biol. and Technol. 10: 229-238.

Schirra, M., M. Agabbio, G. D'hallewin, M. Pala, and R. Ruggiu (1997): Response of 'Tarocco' oranges to picking date, postharvest hot water dips, and chilling storage temperature. J. Agr. Food Chem. 45: 3216-3220.

Schirra, M., G. D'hallewin, S. Ben-Yehoshua, and E. Fallik (2000): Host-pathogen interactions modulated by heat treatment. Postharvest Biol. and Technol. 21:71-85.

Serrano, M., M.C. Martinez-Madrid, F. Romojaro and F. Riquelme (1998): CO_2 treatment of zucchini squash reduces chilling-induced physiological changes. J. Agric. Food Chem. 46: 2465–2468.

Serrano, M., D. Martinez-Romero, S. Castillo, F. Guillén and D. Valero (2004): Role of calcium and heat treatments in alleviating physiological changes induced by mechanical damage in plum. Postharvest Biol. and Technol. 34: 155–167.

Shellie, K.C. and R.L. Mangan (2000): Postharvest disinfestations treatments: response of fruit and fruit fly larvae to different heating media. Postharvest Biol. and Technol. 21: 51-60.

Smilanick, J.L., D.A. Margosan, and D.J. Henson (1995): Evaluation of heated solutions of sulfur dioxide, ethanol and hydrogen peroxide to control postharvest green mold of lemons. Plant Dis. 79:742-747.

Wang, C.Y. (1994): Combined treatment of heat shock and low temperature conditioning reduces chilling injury in zucchini squash. Postharvest Biol. and Technol. 4: 65–73.

Wild, B.L. and C.W. Hood (1989): Hot dip treatments reduce chilling injury in long-term storage of 'Valencia' oranges. HortScience 24: 109-110.

Woods, J.L. (1990): Moisture loss from fruits and vegetables. Postharvest News Inform. 1, 195–199.

تأثير معاملات الماء الساخن وكلوريد الكالسيوم على أمد الحياة وبعض التلفيات الفسيولوجية لثمار البرتقال أبو سرة أثناء التخزين

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تم دراسة أثر التفاعل بين درجات حرارة الماء الساخن (20 ، 40 ، 50 ، 60 ، 70 ، 80°م) ومدة نقع ثمار البرتقال أبو سرة (0.5 ، 1 ، 2 ، 3 ، 4 دقائق) على مدى تحمل قشرة الثمرة للأنسلاق. وقد وجد أن جميع فترات الغمس في الماء الساخن على درجة 20 أو 40°م كان آمنا تماما على الثمار حيث لم يلاحظ أي مظاهر للأنسلاق. كما أن معاملات نقع الثمار على درجة 50°م لمدة 0.5 – 2 دقيقة كان له نفس الأثر الآمن على الثمار. في حين أن إطالة مدة النقع لأكثر من 2 دقيقة على نفس درجة الحرارة السابقة كان له الأثر في بداية ظهور القليل من للأنسلاق على سطح الثمرة. على الجانب الآخر، فقد بدا ظهور الأنسلاق على قشور الثمار جليا عند نقعها في الماء الساخن على درجات حرارة أعلى من 50°م . وقد ارتبطت شدة هذا الأنسلاق طرديا مع درجة حرارة الماء ومدة الغمس.

في تجربة أخرى ، تم تقييم أثر نقع الثمار لمدة 2 دقيقة في الماء الساخن أو محلول كلوريد الكالسيوم الساخن (2%)، كلاهما على درجة 20 ، 40 أو 50°م ، على أمد الحياة والتلف الفسيولوجي لثمار البرتقال أبو سرة خلال التخزين البارد. وقد وجد أن كلا السائلين المختبرين ذو أثر فعال في تقليل الفقد في وزن الثمار وكذلك في تقليل

التلف الناجم عن أضرار البرودة والاصابات المرضية خلال التخزين البارد. وقد لوحظ أن التلف الميكروبي للثمار خلال التخزين البارد كان معظمه يعزى للإصابات الفطرية بالعفن الأخضر ، الأنثراكنوز. وقد وجد أن استخدام المحلول الساخن لكلوريد الكالسيوم ذو فعالية أكبر من الماء الساخن، في هذا الشأن. من ناحية أخرى، وفي المقارنة مع ثمار الكنترول (المنقوعة في الماء على درجة 20°م)، فلم يكن للمعاملات المختبرة أي أثر معنوي على محتوى عصير الثمار من المواد الصلبة الذائبة الكلية ، الحموضة الكلية ونسبة المواد الصلبة الذائبة إلى الحموضة. لوحظ أيضا أن محتوى العصير من فيتامين ج قد تأثر سلبيا فقط مع رفع درجة حرارة الماء. ومن التأثيرات الإيجابية الأخرى لكلوريد الكالسيوم المذاب في الماء الساخن على درجة 40 أو 50°م هو تقليل الأثر السلبي للماء فقط والمسخن على نفس درجات الحرارة على محتوى عصير الثمار من فيتامين ج.

يتضح مما سبق أن معاملة ثمار البرتقال أبو سرة قبل تخزينها بالنقع في محلول كلوريد الكالسيوم الساخن على درجة 50°م لمدة 2 دقيقة ذو شأن كبير في تقليل تلف الثمار الناجم عن أضرار البرودة والإصابات الفطرية أثناء التخزين البارد بدون آثار سلبية على جودة الثمار.