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Postharvest Application of Hot Water, Fungicide and Waxing on the Shelf Life of Valencia and Local Oranges of Siavarz

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Abstract: For postharvest losses reduction, this experiment conducted on two orange cultivars, with name of Valencia and local oranges of Siavarz (*Citrus sinensis* L. Osbeck), grown under subtropical climatic conditions in Khuzestan, Iran. Each orange cultivar was harvested in optimal time and then divided into 2 groups for different postharvest treatments. Treatments included heat treatment (hot water dip 52°C for 3 min and water 25°C for 3 min), Thiabendazol (TBZ) fungicide (2 g L^{-1}), without fungicide, wax and combination of these treatments. Consequently, all fruit samples were stored at 6±1°C and 85-90% humidity (RH) for 3 months. The results showed that, using hot water, wax and TBZ fungicide treatments minimized the postharvest decay especially penicillium molds. Using of these treatments on Siavars cultivar caused to a decay reduction to 2% as compared to control treatment with 26.7% decay. Application of wax significantly ceased to inhibition of fruit weight, ascorbic acid and fruit tissue firmness reduction. Hot water treatment significantly ceased to inhibition of fruit weight and tissue firmness, but a decrease in ascorbic acid content. During cold storage period titratable acidity (TA%) as well as ascorbic acid content significantly decreased. Conversely, Total Soluble Solids (TSS) content and rations of TSS/TA rate significantly increased.

Key words: Orange, valencia, local orange of Siavars, hot water, fungicide (TBZ), wax

INTRODUCTION

Sweet orange is one of the important horticultural fruits in Khuzestan province of Iran. The orange production in Iran has reached more than 3703 thousands tones during in 2000 (Shahbig, 2000). Postharvest losses of sweet orange in the country may reach more than 30% of total production; which is approximately, 350 million dollars per year (Anonymous, 2001). Main problems of citrus postharvest are fruit decay, effect of pathogenic agents especially fungus, fresh fruit weight loss and fruit appearance quality (Kinary *et al*., 2005).

Many techniques are used to maintaining the quality of citrus pre and after harvest (Ferguson *et al*., 1982; Eckert *et al*., 1990; Kinay *et al*., 2005). The decay losses in stored orange fruit were mostly brought about by fungus attacks (Porat *et al*., 2000; Plaza *et al*., 2003). Diseases due to fungus agents can be control with suitable fungicides and fruit stores in low temperatures. But numerous material poisons, after many years used, fungous and insects resistant to them and then researchers have introduced new material (Holmes and Eckert, 1999; Smilanick *et al*., 2006). But numerous material poisons, after many years used, fungous and insects resistant to fungicides and insecticides and then researchers have introduced new material (Holmes and Eckert, 1999; Smilanick *et al*., 2006). Recently, chemical poison consumptions more than administration such as fungicides and insecticides, have caused to pollution of environment and exposed human health to serious threat (Rodov *et al*., 2000). To solve this problem and to help the horticultural crops productions with good quality, researchers have studied several methods of hot water treatments (Abdelaziz and Ahmed, 2000; Ben-Yehoshua, 2001; Abad and Martinez, 2002). Fungus spores and other microorganisms mostly act on skin and superficial layer of fruit and pathogens mostly perform by penetration and ovulation in inter skin of fruit (Rodov *et al*., 1995; Baker *et al*., 1929) indicated that hot water can eliminate eggs and larvas of Mediterranean citrus fruit fly (Rodov *et al*., 2000). Effect of hot water on alternaria black decay prevalence in mango indicated, that treated mango fruits quality with hot water was better than control fruits (Schirra and Mulas, 1995). Also, using of surface coating material such as wax can more maintained the quality, taste and increase the storage capacity in mandarin (Porat *et al*., 2005).

Maximum citrus fruits productions in Khuzestan are specialized to sweet orange in period January to March. After February, region air is onset to warm, so that day

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temperature is over than 40°C in May. These conditions prepare filed and store for fungus actions, reduce quality after postharvesting (Stange and Eckert, 1994).

The aim of this research was to evaluate the effects of hot water, fungicide, wax coating and various combinations of above treatments which are more effective on shelf life and quality of Iranian popular sweet orange cultivars during cold storage.

MATERIALS AND METHODS

The research was conducted on Valencia (Va) and Local oranges of Siavarz (Si) (*Citrus sinensis* L. Osbeck), grown in Khuzestan province of Iran. The fruits were harvested at optimal time harvest in mid-January and mid-March 2004, respectively Si and Va cultivars (Ansari, 1996) and immediately carried to physiology lab of horticulture department. At first, they were selected for their healthy and uniformity and then detected total soluble solid (TSS), titratable acidity (TA), ascorbic acid content, juice volume and fruit firmness. Remaining fruits were divided into two groups. The first group was treated with hot water at 52°C for 3 min (HW); but, the second was with cold water at 25°C for 3 min the control one. Then each group was dived into two groups, the first groups was treated with Thiabendazol (TBZ) fungicide (2 grams per litter) and second was without TBZ. And then each group was divided in two groups, wax was applied the first group but the second group was contacted without wax. After doing of water and fungicide treatments, fruits were completely dried in free air and then fruits surfaces uniformly were covered with thin layer of wax. Every five treated fruits were placed in one polyethylene bag.

All the fruits were stored in cold storage room of the Department of Horticulture, Ahwaz University of Khuzestan at 6±1°C and relative humidity (RH) 75%.

During storage each treatment was examined at certain intervals for weight loss, pitting development on the peel surface and decay development on all fruits and then 5 fruits of each treatment were cut and squeezed in order to examine them for juice percentage, TSS, TA and ascorbic acid content (vitamin C). For the measuring of fruit firmness, in the first, fruit diameter had measured and then had pressured then with 5 kg weight in the line of fruit height, after some seconds, the range of the fruit diameter changes had calculated. Minimums fruits diameter changed indicate high tissue firmness of them. A factorial experiment was undertaken a randomized complete design with four replications, the results were tested for significant differences by Duncan's Multiple Range Test, a probability of 5%. Data were analyzed statistically with statistica version 5.1.

RESULTS AND DISCUSSION

Decay percent of fruit: Study of decay percent average indicated that with increasing of maintenance period, decay percent increased in all treatments. Minimum losses amount was observed in fruits that used fungicide combinations. Statistical analysis indicated that losses of local oranges Ls were lower than Va cultivar. In first and second months, using Hw significantly caused to 5% decrease of fruit decay percent in two cultivars compared to control and wax treatments. Application of wax in first two months didn't affect fruit decay amount, but in 3rd month it decreased 5% compared to control. Group minimum losses were recorded for fruits treated with combined treatment of Hw, wax and TBZ (Table 1).

Decrease percent of fruit weight: Results show that with increasing of maintenance period, fruits weight reduced in all treatments. Minimum decrease percent of fruit weight was observed in treatments. Where wax was used in them. Also, statistical analysis of results indicated that cultivar dose not significant affect decrease percent of fruit weight. Using hot water and TBZ, in two cultivars significantly caused to inhibition of fruit weight decrease; and wax cover exactly inhibited to a fruit water decrease from skin surface. Maximum weight decrease was found in control treatments. Decrease percent of fruit weight, after using of hot water was significantly lower than control treatment (Table 2). Also, study of interaction effects of hot water and wax on decrease percent of fruit weight, in length of time, indicated that decrease percent of fruit weight in treated fruits with hot water and wax, compared to control and wax treatments significantly reduced to 5%.

Vitamin C: Acquired results indicated that with increasing of maintenance period, Vit. C content reduced in two cultivars. Also, Vit. C in two cultivars was different. Mean of Vit. C Ls cultivar had 45 mg per 100 cm^2 after 3 months and in wax, TBZ and Hw treatments had 36 mg Vit. C per 100 cm^2. With increasing of fruit maintenance period, Vit C content decreased, in all treatments (Table 3). Minimum decrease of Vit. C content was observed in wax treatment. Using hot water significantly caused to Vit. C decrease in two cultivars. Thus, minimum Vit. C content was found in treated fruits with Hw.

Total soluble solid percent: Results of experiment indicated that TSS increased in maintenance period, in two cultivars. Changes of TSS content in first month, was

Table 1: Comparative effect of hot water, waxing, fungicide and combination treatments on decay fruits percentage in Ls and Va oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	12.0a	8a	21.0a	23.6a	27.6a	29.2a
Waxing (W)	11.0a	6.9a	17.6a	19.6a	21.0b	25.3b
Fungicide (F)	0.0	0.0	1.6c	1.0c	2.7d	3.0d
Hot water (Hw)	1.0	0.0	1.5c	1.5c	4.5d	2.7d
W+F	0.0	0.6b	5.1b	4.2b	11.7c	10.6c
Hw+W	1.1b	0.0	4.3b	2.6c	9.6c	9.8c
Hw+F	0.0	0.0	1.2c	1.2c	2.2d	2.5d
Hw+F+W	0.0	0.0	0.9c	2.0c	2.0d	3.1d

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range test, p = 0.05

Table 2: Comparative effect of hot water, waxing, fungicide and combination treatments on fruit weight loss percentage in Ls and Va oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	2.3a*	2.03a	5.10a	4.20a	8.30a	7.56a
Waxing (W)	0.41c	0.69c	2.20b	1.80d	4.60c	4.20c
Fungicide (F)	2.50a	1.23b	3.30b	2.60c	6.20b	5.60b
Hot water (Hw)	2.03b	1.50a	3.90b	3.20b	7.00b	5.20b
W+F	0.23c	0.94c	1.50cc	2.10c	2.60d	4.40c
Hw+W	0.20c	0.80c	1.41c	2.11c	3.00d	4.30c
Hw+F	1.26b	2.03a	3.70b	3.14b	6.90b	4.90b
Hw+F+W	0.92c	0.55c	1.04c	2.06c	2.90d	3.80c

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range test, p = 0.05

Table 3: Comparative effect of hot water, waxing, fungicide and combination treatments on vitamin C (mg in 100 CC juice) in Local Sivaras and Valencia oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	40.83b*	30.50b	36.40b	26.70c	32.30b	22.90c
Waxing (W)	46.83a	32.60b	38.32a	28.60c	37.00a	24.06c
Fungicide (F)	41.00b	31.00b	38.20a	27.00c	34.00b	23.00c
Hot water (Hw)	42.00b	30.20b	35.00b	25.60c	32.00b	20.00c
W+F	45.10a	34.50b	39.35a	28.00c	37.41a	20.25c
Hw+W	45.70a	33.70b	37.42b	27.80c	36.00a	24.00c
Hw+F	44.80a	32.00b	36.80b	26.00c	32.70b	20.20c
Hw+F+W	45.00a	33.20b	37.80a	28.00c	36.00a	24.00c

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range test, p = 0.05

very minimal, so that in Ls cultivar didn't show any significant differences between various treatments. But since second month, TSS changes significantly increased. Minimum changes of TSS content were observed in wax treatments; and the maximum changes were found in control treatment. Using hot water alone or with wax and fungicide caused to decrease of TSS percent, compared to control treatment (Table 4).

Titratable acidity: With increasing of fruit maintenance period in store, TA reduced. TA content decrease in Ls cultivar was more than Va cultivar. In two cultivars, using

Table 4: Comparative effect of hot water, waxing, fungicide and combination treatments on TSS in Local Sivaras and Valencia oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	10.2a*	10.3a	10.8a	11.2a	11.5a	11.7a
Waxing (W)	9.9a	9.6b	10.2b	10.4b	10.9b	11.0b
Fungicide(F)	10.3a	10.2a	10.5a	11.3a	11.0b	11.4a
Hot water(Hw)	10.0a	10.2a	10.3b	10.98a	11.0b	11.3a
W+F	10.2a	9.8b	10.3b	10.3b	10.9b	10.4c
Hw+W	10.1a	10.1a	10.2b	10.5b	10.3c	10.6c
Hw+F	10.1a	10.0a	10.3b	10.7b	11.1a	11.2b
Hw+F+W	9.9a	10.0a	10.2a	10.4b	10.5c	10.7c

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range Test, p = 0.05

Table 5: Comparative effect of hot water, waxing, fungicide and combination treatments on titratable acidity in Local Sivaras and Valencia oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	0.97a*	1.01a	0.86c	0.94a	0.79e	0.82c
Waxing (W)	1.00a	1.03a	0.99a	1.01a	0.90b	0.94a
Fungicide (F)	0.95a	1.00a	0.88c	0.97a	0.82c	0.90b
Hot water (Hw)	0.97a	1.02a	0.92b	1.00a	0.88c	0.95a
W+F	1.00a	1.01a	0.97a	1.00a	0.91b	0.98a
Hw+W	1.00a	1.03a	1.00a	0.99a	0.92a	0.90b
Hw+F	0.98a	1.01a	0.96a	0.98a	0.83c	0.89b
Hw+F+W	1.00a	1.02a	0.99a	1.00a	0.95a	0.97a

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range Test, p = 0.05

Table 6: Comparative effect of hot water, waxing, fungicide and combination treatments on in Local Sivaras and Valencia oranges

	Storage period					
	30 days		60 days		90 days	
	Cultivar		Cultivar		Cultivar	
Treatments	La	Va	La	Va	La	Va
Control	1.01a*	1.04a	1.80a	1.47a	2.24a	1.50a
Waxing (W)	0.38b	0.24b	0.50d	0.35c	0.64d	0.41d
Fungicide (F)	1.00a	0.95a	1.30b	1.2b	1.70b	1.37b
Hot water (Hw)	0.98a	0.90a	1.17c	1.09b	1.32c	1.17c
W+F	0.39b	0.20c	0.52d	0.39c	0.60d	0.45
Hw+W	0.46b	0.39b	0.40e	0.50c	0.64d	0.59d
Hw+F	1.00a	1.00a	1.11c	1.05b	1.42c	1.12c
Hw+F+W	0.30b	0.35b	0.46e	0.40c	0.54e	0.50d

*Within each column a different letter above indicates a significant difference by the Duncan's Multiple Range Test, p = 0.05

of wax caused to inhibition of TA changes. Also, application of hot water and fungicide caused to inhibition of TA decrease, compared to control treatment (Table 5).

Tissue firmness: With increasing of fruit maintenance period in store, tissue firmness reduced. Maximum decreases percent of fruit tissue firmness was observed in 3rd month. These results show that Va cultivar can maintain tissue firmness better than Ls cultivar. Treatments used wax, had better tissue firmness. Compared control, Hw and TBZ treatments was significantly higher than tissue firmness (Table 6).

Juice content: The juice content of the oranges was found to be 57 and 40.5% in Ls, Va, respectively during the harvest time. The juice content of the fruits decreased during the storage period (Fig. 1). The effects of the

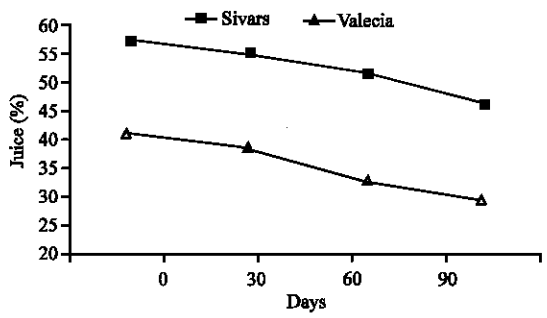

Fig. 1: Changes of juice percent orange content cultivars in cold storage.

postharvest treatments and cultivars on oranges juice content were found to be statistically significant ($p<0.05$). At the end of the 90 days storage period, the juice content of the Wax+BZ+HW treated fruits in Va was almost equal to their harvest time level which was 40.41%.

DISCUSSION

In this experiment, it was shown that Hw with and or without wax and TBZ has a great effect on storage decay of sweet orange fruit. In this correlation, many researchers confirm this object (Palo *et al*., 2001; Obagwu and Korsten, 2002). Hw has many roles in improvement of wounds and micro cleaves on skin surface, production of ligninand free phenols compounds in tissues (Rodov *et al*., 2000; Schirra and Mulas, 1995). Decreases of fruit weight, fruit skin luminosity and tissue firmness and destruction of Vit C, are some of the citrus fruits problems in store. Generally, every factor which decreased the transpiration from fruit surface can affect fruit quality and its marketability. Also, wax has important role on the above characterizes (Safizadeh, 2001; Davis *et al*., 1994). If fruit luminosity reckon among appearance quality, treatments that use wax, in them in addition to inhibition of decrease of fruit weight, Vit C, tissue firmness, caused to higher fruits luminosity.

Sweet orange fruit taste mostly detected by TSS, TA and TSS/TA ratio has changes in store. Many of researchers confirmed that in sweet orange fruits TSS, TSS/TA ratio increase and Ta decreases in store (Lee and Kader, 2000; Lurie, 1998). This experiment confirms the previous results and treatments. Especially was used Hw, waxand TBZ caused to improvement of sweet orange taste. Because in addition to inhibition of TSS increase, inhibit Ta decrease.

CONCLUSIONS

Using Hw treatment affected control of decay after sweet orange harvest and if it is used with wax, will acquire better results.

Results acquired after using it wax, indicated that a fruit weight decrease in treatment fruit, was low and wax affected control of tissue firmness and inhibition of vit C decrease.

TBZ had better effect on control of decay caused by green and blue mold, as compared to Hw and wax treatments.

Compared to Va cultivar, Ls cultivar had more vit C. Also, Ls cultivar, approximately had better shelf life rather than Va cultivar.

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