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EFFECT OF USING LOW CONCENTRATIONS OF HOT IMAZALIL IN COMPARISON WITH COLD IMAZALIL ON VALENCIA ORANGE FRUIT PROPERTIES

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ABSTRACT

This investigation was carried out during two successive seasons (2012 and 2013) to verify the efficiency of hot imazalil (IMZ) dip treatment on commercially mature Valencia orange fruits [*Citrus sinensis* (L.) Osbek] quality during cold storage and shelf life. The fruits were submitted to the following treatments: Submerged in 1000 mg/l IMZ at 20°C for five min., and packed in net (control). Submerged in 1000 mg/l IMZ at 20°C for five min., and packed in 0.05% PPE. Submerged in 100 mg/l IMZ at 52°C for two min., and packed in 0.05% PPE. Hot IMZ treatment maintained fruit pulp firmness, juice volume and vitamin C as compared with control. Moreover, Hot IMZ treatment decreased fresh weight losses, fruit peel firmness, TSS and pH compared to control. No significant differences were observed in total acidity between Hot IMZ treatment and control. The advance in storage period during six months caused progressive increments in fresh weight losses, TSS and pH. On the contrary, the advance in cold storage period depressed fruit pulp and peel firmness, juice volume, total acidity and vitamin C. Hot IMZ treatment improved fruit properties more than control.

Key words: Heat treatment, imazalil, cold storage, Valencia orange, storage life.

INTRODUCTION

Citrus ranks first among fruit crops in Egypt. The area grown with Orange in Egypt have enormously increased through the last few decades, reaching about 282579 faddans, (FAO, 2012). Valencia orange is one of the most important orange cvs. for exportation to Europe and China because of its late harvesting date.

It has been shown that the effectiveness of postharvest hot water dip treatments at 50°C for 180 second in alleviating chilling injury (CI) in citrus fruit, notably improve when applied in combination with the fungicide thiabendazole (TBZ) (Schirra *et al.*, 1998, 2000a). Hot water treatments should be raised to produce the heat-induced beneficial effects in terms of physical changes of epicuticular wax (ECW), host defensive responses and inhibition of pathogen development (Schirra *et al.*, 2000b and 2011).

All pesticides sold or distributed in the United States must be registered by the Environmental Protection Agency (EPA), based on scientific studies showing that they can be used without posing unreasonable risk to people or the environment (United States Environmental Protection Agency, 2005). Imazalil is a systemic imidazole fungicide used to control a wide range of fungi on fruit, vegetables and ornamentals. Imazalil is also used for postharvest treatment of citrus, banana and other fruits to control storage decay. Under natural conditions, it is less likely that resistant strains of fungi will develop with imazalil than with some of the other fungicides (Food and Agriculture Organization of the United Nations, 1977). Approximately, 6000 lbs. of imazalil is used annually in the USA (United States Environmental Protection Agency, 2005). Imazalil is classified as "Likely to be carcinogenic in humans," according to EPA's July 1999 Draft

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Guidelines for Carcinogenic Assessment, on the other hand, (Food and Agriculture Organization of the United Nations, 1977) suggested that imazalil is non-carcenogenic

However, no data are available in the literature on the influence of short hot water treatments used in commercial installations and its combination with Imazalil on ultrastructure changes of fruit surface, Imazalil residues, decay incidence, external and internal fruit quality attributes of Valencia orange exposed to a quarantine treatment.

Increasing heat temperature enhanced absorption of IMZ and this save the used quantity. Previous studies on lemon (Schirra *et al.*, 1996) showed that dipping fruits for three min., in IMZ 250 ppm at 50°C was as effective as 1500 ppm at 20°C during 13 weeks of storage. 'Tarocco' orange treated with TBZ at 50°C experienced a greater persistence of TBZ with respect to fruit treated at room temperature and this occurrence was related to the better encapsulation as coverage with epicuticular wax (ECW), thus providing better protection to the fungicide (Schirra *et al.*, 1998).

The present investigation aimed to compare the effect of using low concentration of imazalil in hot water with high concentration of imazalil in normal water on physical and chemical properties and decay control of Valencia orange.

MATERIALS AND METHODS

Fruits were picked from a private orchard located in Wadi El-Molak, Ismailia Governorate using small clippers and packed in plastic boxes then taken directly to post-harvest laboratory in Horticulture Department, Faculty of Agriculture, Zagazig University. Fruits were kept for one day at room temperature. All fruits were washed with water, soap and then rinsed with water to remove the residue of soap. Then, fruits were emerged in 0.5 solution of sodium ortho phenyl phenol (SOPP) at pH 11.8-12.1 at 32°C for two min. Fruits free of defects were selected and used in treatments.

Each treatment included three replicates. Uniform fruits were chosen at random for each replicate of Valencia orange and received one of the following treatments:

1. Dipping in 1000 mg/l (IMZ) at 20°C for five min., and then packed in net.
2. Dipping in 1000 mg/l (IMZ) at 20°C for five min., and then packed in 0.05% perforated plastic bags.
3. Dipping in 100 mg/l (IMZ) at 52°C for two min., and then packed in 0.05% perforated plastic bags.

Fruits of all treatments were stored at 8±1°C and 90-95% relative humidity (RH) during two seasons (2012 and 2013). Samples of each treatment were randomly taken at monthly intervals to evaluate treatments effect during cold storage and shelf life (after six days). Evaluation of treatments and shelf life effects were carried out through the following parameters. The number of used fruits in this experiment was 1620 fruits represented 3 IMZ treatments × 3 replicates × 6 periods × 30 fruits/ bag.

Fruit weight losses percentage (FWL%)

Fruits were weighed just before and after cold storage treatments and six days shelf life, and then FWL% was calculated.

Peel and Pulp firmness

Five fruits for each replicate were used to determine pulp firmness as g/cm^2 and peel firmness as kg/cm^2. Pull Dynamometer (Model FD 101) was used in this concern.

Juice percentage

The extracted juice of random fruits samples of each replicate was weighted and juice content was expressed as percent of fruit weight (w/w).

Juice total soluble solids percentage (TSS%)

It was determined using a hand refractometer.

Juice total acidity (%)

It was calculated by titration against 0.1 N sodium hydroxide in presence of phenolphthalein dye according to the method described by AOAC (1980).

Juice activated acidity (pH value)

It was determined using a digital pH meter (style Hanna 8514).

Ascorbic acid (Vitam. C) content

It was determined as milligrams ascorbic acid/ 100 ml fruit juice using the procedures which described by Lucass (1944).

Statistical Analysis

Collected data were subjected to statistical analysis according to Snedecor and Cochran (1980). The complete randomized block design with three replicates and the factorial arrangement was followed throughout the whole work. The individual comparisons between the obtained means were carried out by New LSD at 5% level.

RESULTS

Fresh Weight Losses (FWL) Percentage

During cold storage

Data in Table 1 show that fruit FWL was markedly increased as cold storage period increased. The highest values were recorded from treatments after six months. As for the tested treatments, the highest FWL was induced by the control, whereas, hot IMZ induced the lowest FWL. The interaction between heat treatments and cold storage period was significant in both seasons.

During shelf life

Data in Table 1 also indicate that FWL after six days shelf life decreased gradually after the two first cold periods and then increased gradually from the third to the sixth months of cold storage during the two tested seasons. The tested treatments significantly reduced FWL compared with control after six days of shelf life in both seasons. Moreover, the interaction between treatments and shelf life after cold storage periods on FWL was significant in both seasons. The hot IMZ treatment × the first three months recorded the least FWL values in the two seasons.

Fruit Pulp Firmness (FPF) g/cm^2

During cold storage

Data in Table 2 clarify that FPF was significantly decreased with the advance in cold storage period. The least values resulted from treatments after six months of cold storage, while, the highest values resulted from treatments after one month cold storage. Moreover, hot and cold IMZ treatments maintained significantly higher FPF compared with the control in both seasons. However, there were no significant differences between them. The interaction between cold storage period and IMZ treatments was significant in both seasons.

During shelf life

The data in Table 2 also reveal that FPF during shelf life was significantly decreased as cold storage period was advanced in both seasons. In addition, IMZ treatments and packaging in PPE maintained higher FPF compared to control without significant differences between them in both seasons.

Fruit Peel Firmness (PF) kg/cm^2

During cold storage

Data in Table 3 clarify that PF was significantly increased with the advance in cold storage period in the two seasons. No significant differences between the 1st and 2nd months in both seasons and between 3rd and 4th months in the second season only whereas, IMZ treatments and packaging PPE decreased significantly PF values compared with control in both seasons without significant differences between them in the second season only. In addition, the interaction between cold storage period and IMZ treatments was significant in the two seasons.

During shelf life

After six days of shelf life, the data also reveal that PF values were significantly increased as cold storage period advanced in both seasons. In addition, IMZ with packaging PPE treatments decreased significantly PF values compared with control in both seasons.

Juice Volume from one Kilogram Fruits (JV)

During cold storage

Data in Table 4 show a gradual decrease in JV with the advance in cold storage period in both seasons. The IMZ treatment with PPE retained significantly higher JV compared with control in both seasons. On the other hand, the hot IMZ treatment retained significantly higher JV compared with cold IMZ in the first season only.

During shelf life

The same trend was observed during cold storage between treatments and storage periods, except, no significant differences were observed between the IMZ treatments with packaging in PPE in the two seasons.

Table 1. Effect of hot and cold IMZ treatments on fresh weight losses (%) of Valencia orange fruits during cold storage, shelf life periods and their interaction in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
							First season (2012)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	8.2	12.1	15.4	16.5	18.9	20.2	15.2b	2.6	2.0	1.9	3.1	3.8	4.2	2.9a
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	0.8	1.6	1.9	2.0	2.1	2.8	1.9a	2.2	1.7	1.7	1.7	2.0	3.5	2.1b
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	0.8	0.9	1.2	1.2	1.8	2.6	1.4a	2.2	1.4	1.4	1.4	1.5	3.0	1.8c
Mean	3.3a	4.9b	6.2c	6.6c	7.6d	8.5e		2.3b	1.7c	1.7c	2.1b	2.4b	3.6a	
New LSD		T=0.51	P=0.88		T×P= 0.12				T=0.17	P=0.33		T×P=0.41		
							Second season (2013)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	4.3	8.4	12.0	15.3	16.8	17.3	12.4a	5.0	3.4	6.6	7.1	8.1	8.9	6.5a
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	1.3	2.0	2.4	2.5	2.8	3.4	2.4b	4.8	2.3	2.2	2.3	4.5	6.2	3.7b
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	1.0	1.6	1.6	1.7	1.8	2.3	1.7c	4.3	2.2	2.1	2.3	4.3	5.9	3.5b
Mean	2.2f	4.0e	5.3d	6.5c	7.1b	7.7a		4.7ab	2.6bc	3.6b	3.9b	5.6ab	7.0a	
New LSD		T=0.53	P=0.44		T×P=1.29				T=1.50	P=2.42		T×P=3.68		

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 2. Effect of hot and cold IMZ treatments on fruit pulp firmness (g/cm^2) of Valencia orange fruits during cold storage and shelf life periods and their interaction in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
							First season (2012)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	222.5	193.8	141.0	131.5	103.8	66.7	143.2b	204.3	172.8	130.0	100.0	66.7	60.0	122.3b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	238.0	206.2	196.0	166.3	158.3	116.9	180.3a	230.0	196.3	183.0	156.3	143.3	100.0	168.1a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	239.9	196.4	180.8	176.8	169.0	159.6	187.1a	208.0	180.8	167.3	164.5	150.8	119.5	165.1a
Mean	233.5a	198.8b	172.6c	158.2d	143.7e	114.4f		214.1a	183.3b	160.1c	140.3d	120.2e	93.2f	
New L.S.D			T=9.0	P=9.8	T×P=22.0					T=4.7	P=8.4	T×P=11.4		
							Second season (2013)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	211.3	201.5	178.0	140.0	134.5	129.8	165.8b	200.0	192.5	140.5	122.5	112.6	106.1	145.7b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	240.7	226.3	193.8	178.8	160.0	147.5	191.2a	226.3	212.3	183.8	152.5	145.0	128.8	174.8a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	237.0	218.8	202.5	170.8	159.5	148.3	189.5a	229.5	215.0	191.0	155.0	148.8	130.0	178.2a
Mean	229.7a	215.5b	191.4c	163.2d	151.3de	141.9de		218.6a	206.6b	171.8c	143.3d	135.4e	121.6f	
New LSD			T=7.7	P=13	T×P=18.9					T=5.9	P=8.8	T×P=14.4		

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 3. Effect of hot and cold IMZ treatments on peel firmness (Kg/cm²) of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
First season (2012)														
1000 mg/l IMZ at 20°C for 5 min., packed in net (Control)	2.78	2.93	3.49	4.11	5.89	6.28	4.24a	3.78	4.02	4.30	4.48	6.17	6.84	4.93a
1000 mg/l IMZ at 20°C for 5 min., packed in 0.05% PPE	1.33	1.73	1.97	2.00	3.20	3.31	2.25b	2.26	2.42	2.53	2.62	3.38	3.52	2.79b
100 mg/l IMZ at 52°C for 2 min., packed 0.05% PPE	1.94	2.15	2.24	2.45	3.00	3.46	2.54c	2.10	2.21	2.49	2.64	3.44	3.74	2.77b
Mean	2.01e	2.26e	2.56d	2.85c	4.03b	4.35a		2.7d	2.9d	3.1cd	3.2c	4.3b	4.7a	
New LSD	T=0.2131 P=0.2761 T×P=0.5221							T=0.1677 P=0.3160 T×P=0.4107						
Second season (2013)														
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	2.76	2.85	3.01	3.16	4.05	5.72	3.59a	3.89	4.39	4.45	4.89	5.11	6.23	4.83a
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	1.70	1.96	2.01	2.10	2.22	2.28	2.04b	2.43	2.48	3.06	3.32	3.44	3.85	3.10b
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	1.84	1.92	2.05	2.17	2.28	2.35	2.10b	2.48	2.54	2.69	2.78	3.53	3.89	2.98b
Mean	2.1d	2.2d	2.4c	2.5c	2.9b	3.5a		2.9e	3.1e	3.4d	3.7c	4.0b	4.6a	
New LSD	T=0.1039 P=0.1562T×P=0.2545							T=0.1720P=0.2969T×P=0.4212						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 4. Effect of hot and cold IMZ treatments on juice volume (cm³) of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
First season (2012)														
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	346.7	333.7	320.0	252.1	235.7	227.8	286.0c	344	298	255	248	226.3	217.7	264.8b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	369.5	333.8	305.3	295.8	286.3	280.0	311.8b	353	326	301	292	281.1	260.1	302.2a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	395.3	386.3	347.5	317.3	308.8	289.7	340.8a	352	339	314	304	265.2	255.9	304.8a
Mean	370.5a	351.3a	324.3b	288.4c	276.9d	265.8c		349.7a	321.0b	290.0c	281.3c	257.5d	244.6d	
New LSD	T=10.749 P=22.459 T×P=26.329							T=8.2983 P=15.849 T×P=20.326						
Second season (2013)														
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	338.7	310.0	283.7	256.0	228.0	225.0	273.6b	320	303	278	248	214.2	203.1	261.0b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	364.8	349.8	310.1	306.3	283.8	270.2	314.2a	327	320	283	266	261.3	238.1	282.4a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	361.8	341.8	316.3	310.8	292.0	291.3	319.0a	314	299	293	274	266.3	233.5	280.0a
Mean	355.1a	333.9a	303.4b	291.0b	267.9c	262.1c		320.3a	307.3a	284.7b	262.7c	247.3d	224.9e	
New LSD	T=15.559 P=24.322 T×P=38.111							T=9.3716 P=15.620 T×P=22.956						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Total Soluble Solids (TSS Brix°)

During cold storage

From Table 5, it is clear that TSS was increased with the advance of cold storage period in both seasons. Moreover, TSS was significantly affected by the tested treatments. The hot IMZ treatment recorded the least values in both seasons compared with other treatments. The interaction between treatments and cold storage period was insignificant in the two seasons.

During shelf life

TSS was increased during shelf life as the cold storage period was advanced. Moreover, TSS was significantly affected by the tested treatments. The hot IMZ treatment recorded the least values in the first season compared with the control. While the hot IMZ treatment recorded the highest values in the second season compared with the control.

Total Acidity (g citric acid/100 ml Juice)

During cold storage

From Table 6, it is clear that acidity was gradually and significantly decreased with the advance in storage period in the two seasons. The least values were recorded after six months in the two seasons. Moreover, IMZ treatments retained significantly higher acidity compared with control in the two seasons. The hot IMZ treatment retained significantly higher acidity in the second season only. Moreover, the interaction between cold storage and heat treatments was significant in the two seasons.

During shelf life

The data also show that total acidity was decreased during shelf life with the advance in cold storage period. In the two seasons the least values during shelf life were after six months. In addition, IMZ treatments retained significantly higher acidity compared with control in the two seasons. But, there were no significant differences observed between IMZ treatments. Moreover, the interaction between treatments and periods was significant in both seasons. The least values during shelf life always came from all treatments × six months cold storage.

Activated Acidity (pH)

During cold storage

Table 7 clarifies that pH was gradually and significantly increased with the advance in storage period in the two seasons. The highest values were recorded after six months in the two seasons. Furthermore, pH significantly affected by the tested treatments. The hot IMZ treatment recorded the highest values in both seasons as compared with other treatments. In addition, the interaction between cold storage and treatments was significant in both seasons.

During shelf life

The data also show that pH was increased during shelf life with the advance in cold storage period. In the two seasons the highest values during shelf life were after six months. Moreover, no significant differences were obtained between hot IMZ treatment and control. In addition, the interaction was significant in both seasons. The least values during shelf life always came from all treatments × one month cold storage.

Ascorbic Acid (Vitamin C) Content (mg/100ml Juice)

During cold storage

Data in Table 8 show that vitamin C content was significantly affected by cold storage period. The least values came from six months cold storage period. The data also show that the control treatment recorded significantly lowest vitamin C content compared to other tested treatments in both seasons. Moreover, the interaction between cold storage period and packaging treatments was significant in the two seasons.

During shelf life

In both seasons, obtained results showed continuous reduction in vitamin C content during shelf life with the advance in storage period. Moreover, the data indicate also that there were significant differences between the tested treatments in vitamin C content in the second season only, while, there were significant differences between IMZ treatments and the control in the first season. On the other hand, tested heat treatments recorded significant increments in vitamin C content during shelf life compared to the control in both seasons. The interaction between storage periods and treatments was significant between most values in this regard in the two seasons.

Table 5. Effect of hot and cold IMZ treatments on total soluble solids (TSS) (Brix°) of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	3	3	4	5	6	Mean	1	2	3	4	5	6	Mean
								First season (2012)						
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	7.4	7.9	8.3	8.8	9.5	9.8	8.6a	7.9	8.5	8.6	9.1	9.7	10.0	8.9a
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	7.6	7.9	8.3	8.5	8.6	8.8	8.2b	8.0	8.3	8.6	8.6	9.0	9.3	8.6b
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	7.6	7.8	8.1	8.1	8.4	8.8	8.1b	7.9	8.1	8.3	8.4	8.5	9.0	8.4b
Mean	7.5d	7.9c	8.2c	8.4bc	8.7b	9.1a		7.9e	8.3d	8.5cd	8.7bc	9.0b	9.4a	
New LSD	T=0.1674 P=0.3325 T×P=0.4101							T=0.2039 P=0.3460 T×P=0.4996						
								Second season (2013)						
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	8.8	9.1	9.5	9.8	10.1	10.5	9.6a	9.0	9.4	10.0	10.0	10.7	11.2	10.0ab
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	8.9	9.0	9.5	9.8	10.2	10.5	9.6a	9.1	9.3	9.5	10.0	10.4	11.0	9.9b
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	8.5	9.0	9.3	9.6	9.8	10.0	9.3b	9.3	9.8	10.0	10.3	10.6	11.0	10.1a
Mean	8.7e	9.0de	9.4cd	9.7bc	10.0ab	10.3a		9.1e	9.5d	9.8c	10.1c	10.6b	11.0a	
New LSD	T=0.1695 P=0.4574 T×P=0.4151							T=0.1538 P=0.2260 T×P=0.3768						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 6. Effect of hot and cold IMZ treatments on total acidity of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
								First seasons (2012)						
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	0.011	0.010	0.008	0.008	0.006	0.005	0.0080b	0.010	0.007	0.006	0.006	0.005	0.004	0.0063b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	0.012	0.010	0.009	0.008	0.007	0.006	0.0087a	0.010	0.009	0.008	0.007	0.006	0.006	0.0077a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	0.012	0.010	0.009	0.008	0.008	0.006	0.0088a	0.010	0.009	0.007	0.007	0.006	0.005	0.0073a
Mean	0.0116a	0.0100b	0.0086c	0.0080c	0.0070d	0.0050e		0.0100a	0.0083b	0.0070c	0.0067c	0.0056d	0.0050d	
New LSD	T=0.0005 P=0.0007 T×P=0.001							T=0.0005 P=0.0007 T×P= 0.001						
								Second season (2013)						
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	0.012	0.011	0.011	0.010	0.009	0.007	0.0100c	0.011	0.009	0.008	0.007	0.006	0.005	0.0076b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	0.014	0.012	0.011	0.010	0.009	0.008	0.0106b	0.012	0.011	0.010	0.008	0.007	0.006	0.0090a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	0.014	0.013	0.012	0.012	0.010	0.007	0.0113a	0.011	0.011	0.009	0.008	0.008	0.007	0.0090a
Mean	0.0133a	0.0120b	0.0113c	0.0106d	0.0093e	0.0073f		0.0113a	0.0103b	0.0090c	0.0077d	0.0070e	0.0060f	
New LSD	T=0.0005 P=0.0007 T×P=0.001							T=ns P=0.0007 T×P=0.001						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 7. Effect of hot and cold IMZ treatments on activated acidity (pH) of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
							First season (2012)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	3.98	4.30	4.85	5.16	5.49	5.68	4.91c	4.50	4.56	5.24	5.39	5.68	5.82	5.19b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	4.11	4.28	4.94	5.00	5.70	5.74	4.96b	4.58	4.92	5.48	5.56	5.81	5.97	5.39a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	4.24	4.34	4.98	5.30	5.58	5.75	5.03a	4.45	4.45	5.27	5.38	5.78	5.81	5.19b
Mean	4.1f	4.3e	4.9d	5.2c	5.6b	5.7a		4.5f	4.6e	5.3d	5.4c	5.7b	5.8a	
New LSD	T=0.0339 P=0.0594 T×P=0.0830							T=0.0266 P=0.0411 T×P=0.0651						
							Second season (2013)							
1000 mg/l IMZ at 20 °C for 5 min., packed in net (Control)	4.50	4.70	4.75	5.03	5.25	5.38	4.93c	4.85	4.85	5.05	5.40	5.49	5.71	5.22b
1000 mg/l IMZ at 20 °C for 5 min., packed in 0.05% PPE	4.58	4.80	4.98	5.18	5.18	5.28	5.00b	4.95	5.08	5.44	5.53	5.70	5.80	5.41a
100 mg/l IMZ at 52 °C for 2 min., packed 0.05% PPE	4.68	4.78	5.05	5.20	5.38	5.46	5.09a	4.68	5.18	5.26	5.35	5.54	5.60	5.25b
Mean	4.6f	4.8e	4.9d	5.1c	5.3b	5.4a		4.8f	5.0e	5.3d	5.4c	5.6b	5.7a	
New LSD	T=0.0632 P=0.1019 T×P=0.1548							T=0.0570 P= 0.0498T×P=0.1396						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

Table 8. Effect of hot and cold IMZ treatments on vitamin C mg/100 ml juice of Valencia orange fruits during cold storage and shelf life period in 2012 and 2013 seasons

Treatments	Cold storage period (months)							6 days shelf life						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
							First season (2012)							
1000 mg/l IMZ at 20°C for 5 min., packed in net (Control)	52.9	51.1	50.4	49.3	35.7	32.5	45.3c	52.2	50.4	43.8	39.2	33.2	29.8	41.4b
1000 mg/l IMZ at 20°C for 5 min., packed in 0.05% PPE	56.5	53.6	51.2	48.0	42.4	38.0	48.3b	53.8	52.8	46.0	43.8	42.0	35.1	45.6a
100 mg/l IMZ at 52°C for 2 min., packed 0.05% PPE	59.5	56.8	52.4	46.8	45.6	41.0	50.3a	57.3	56.3	51.6	38.0	38.1	36.7	46.3a
Mean	56.3a	53.8b	51.3c	48d	41.2e	37.2f		54.4a	53.1a	47.1b	40.3c	37.7c	33.8d	
New LSD	T=1.3679 P=1.2941 T×P=3.3505							T=1.8016 P=2.7676 T×P=4.4130						
							Second season (2013)							
1000 mg/l IMZ at 20°C for 5 min., packed in net (Control)	53.8	51.5	50.0	49.8	43.8	39.7	48.1c	51.3	50.0	48.1	47.5	42.1	38.3	46.2c
1000 mg/l IMZ at 20°C for 5 min., packed in 0.05% PPE	54.0	52.9	51.2	50.3	49.0	46.9	50.7b	51.8	51.0	49.8	48.5	47.8	44.5	48.9b
100 mg/l IMZ at 52°C for 2 min., packed 0.05% PPE	64.0	55.5	53.8	52.8	52.5	49.5	54.7a	54.0	52.5	52.3	51.5	50.8	48.0	51.5a
Mean	57.3a	53.3b	51.7bc	51.0c	48.4d	45.4e		52.4a	51.2ab	50.1bc	49.2c	46.9d	43.6e	
New LSD	T=1.2114 P=1.7799 T×P=2.9673							T=1.0232 P=1.4904 T×P=2.5062						

T= Treatment P= period T×P= interaction between treatments and period IMZ= imazalil

DISCUSSION

The present work revealed that FWL was increased as cold storage period was advanced; the control treatment revealed higher FWL values compared with hot water treatments. Water loss can be one of the main causes of fruit deterioration, since it is not only quantative losses, but also causes losses in appearance due to wilting and shriveling as well as in nutritional quality (Kader, 1986). Hot water treatment melted the fruit epicuticular waxes and thus covered and sealed the stomata and cracks on the fruit surface and this may reduce the transpiration and also serve as potential pathogen invasion sites (Porat *et al.*, 2000).

Data clarified that all heat treatments maintained significantly FPF compared with control in both seasons, while FPF was decreased with the advance in cold storage period. In this regard, many investigators pointed out that heat treatments maintained FPF during storage Gad, (2013) and Hussein *et al.* (1998) who indicated that the rate of degradation of insoluble protopectins to simple soluble pectins was increased with the progress of storage time. Pectinesterase activity also is expected to increase progressively during storage and this led to a decrease in hardiness of peel and pulp of pear fruits during storage (Ponomarev, 1968). If the fruit transpire too much water, they lose turgidity, and hence firmness, and may even appear slightly shriveled (Hong *et al.*, 2007). While, the data recorded that PF increased with the advance in cold storage period and the control was harder than heat treatments. This is may be due to the peel water transpiration and shriveling that make it more hard and sweating.

The data, also, showed a gradual decrease in JV with the advance in cold storage period and the heat treatment retained significantly higher JV compared with control. This is may be due to the water transpiration from the fruit.

Results also clear that TSS increased with the advance in cold storage and shelf life periods. The gradual increase in the percentage of TSS with the increase of storage period could be due to the degradation of complex insoluble compounds, like starch, to simple soluble compounds, like sugars, which are the major components, which degrade to soluble forms, as pectin and, so, leading to accumulation of TSS in the fruits, or to water loss by transpiration through storage period (Hussein *et al.*, 1998 ; Gad, 2013).

In addition, results also clear that TA was decreased with the advance in cold storage and shelf life periods. The decrease of acid percent during storage period could be due to the destruction of organic acids through oxidation and consumption of these acids, as an organic substrate in the respiration processes of the fruit tissues. The progress of storage time raised the respiration rate of the fresh fruits (Hussein *et al.*, 1998 ; Gad, 2013).

Results also clear that vitamin C was decreased with the advance in cold storage and shelf life periods. The loss in ascorbic acid content during storage might be attributed to the rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (Hussien *et al.* 1998; Gad, 2008).

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تأثير استخدام تركيزات منخفضة من الايمازليل الساخن بالمقارنة بالايمازليل البارد على صفات البرتقال الصيفى

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أجرىَ هذا البحث خلال موسمى ٢٠١٢ و ٢٠١٣ لمعرفة كفاءة النقع فى المطهر الفطرى إيمازليل الساخن على جودة ثمار البرتقال الفالنشيا أثناء التخزين المبرد والعرض على الرف حيث تعرضت الثمار للمعاملات التالية: النقع فى إيمازليل بتركيز ١٠٠٠ مللجرام/لتر على درجة ٢٠°م لمدة خمس دقائق ثم التغليف فى شباك (مقارنة)، النقع فى إيمازليل بتركيز ١٠٠٠ مللجرام/لتر على درجة ٢٠°م لمدة خمس دقائق ثم التغليف فى بلاستيك مثقب بنسبة ٠,٠٥%، النقع فى إيمازليل بتركيز ١٠٠ مللجرام/لتر على درجة ٥٢°م لمدة دقيقتين ثم التغليف فى بلاستيك مثقب بنسبة ٠,٠٥%، حافظت المعاملة بالإيمازليل الساخن على صلابة الثمار، حجم العصير وفيتامين ج بالمقارنة بالكنترول، بالإضافة لذلك فإن المعاملة بالإيمازليل الساخن أدت إلى تقليل الفقد فى الوزن الطازج، صلابة القشرة، المواد الصلبة الذائبة الكلية ورقم الحموضة بالمقارنة بالكنترول، لم تلاحظ فروق معنوية فى الحموضة الكلية بين المعاملة بالإيمازليل الساخن والكنترول، أدى التقدم فى فترة التخزين المبرد خلال ٦ أشهر إلى زيادة مضطردة فى الفقد فى الوزن الطازج، المواد الصلبة الذائبة الكلية ورقم الحموضة، على العكس فإن التقدم فى فترة التخزين المبرد أدى إلى تقليل صلابة الثمار، صلابة القشرة، حجم العصير، الحموضة الكلية و فيتامين ج أدت المعاملة بالإيمازليل الساخن إلى تحسين صفات الثمار أكثر من الكنترول.

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