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The Effects of Fungicide and Hot Water Treatments on the Internal Quality Parameters of Valencia Oranges*

[1]A.E. Ozdemir and [2]O. Dundar
[1]Department of Horticulture, University of Mustafa Kemal, Hatay, 31034 Turkey
[2]Department of Horticulture, University of Çukurova, Adana, 01330 Turkey

Abstract: We examined the effects of fungicides and hot water treatments on internal quality parameters of Valencia oranges. Fruits were subjected to the following treatments: 3 min water dip at 20°C (Control), Hot Water Dip (HWD) at 53°C for 3 min, fruitgard 70 T (0.5%), foamer (10%) and aliette (2000 ppm). Fruits were then stored at 4°C and 85-90% Relative Humidity (RH) for 6 months. We mainly analysed Total Soluble Solids (TSS), ethanol, juice, vitamin C (L-Ascorbic acid) and acid content for each month during the storage. During the storage, TSS and ethanol content increased, while juice, vitamin C and acid content decreased. HWD and fruitgard 70 T treatments resulted in better internal quality than other treatments.

Key words: Orange, Valencia, hot water dip, fungicide, storage

INTRODUCTION

Valencia oranges could be stored successfully at 4°C and 85-90% Relative Humidity for 5 months[1].

Various preharvest and postharvest factors affect citrus fruit quality. Postharvest factors affecting quality are temperature, relative humidity, ethylene, aromatic volatiles, plant regulators, waxing, fungicides, degreening, precooling, packaging and individual packaging[2].

Postharvest heat treatment as environmental friendly method is used for disinfestation of fruits and vegetables. Heat treatments include hot water, vapor heat and hot air. Hot water dips is used to control insects[3] and prevent fungal rots and chilling injury[4,5]. Hot water treatment of 50-53°C for 2-3 min decreased decay in oranges and mandarins[6]. Chilling injury was reduced by 53°C for 2 min hot water dips before storage of 1°C in Valencia oranges[7].

Today, there has been increasing interest in non-chemical and environmental friendly methods for postharvest decay and insect control. Excessive uses of the synthetic fungicides result in the development of resistance against these fungicides and affect human health and environment. Residue of synthetic fungicides is also problematic in fruit and vegetable export. These chemicals affect also external quality parameters such as fungal and physiological disorders, weight loss and the percent of green button.

The objective of this study was to determine effects of some widely used fungicides in citrus and environmental friendly treatments on internal quality of Valencia oranges.

MATERIALS AND METHODS

Valencia oranges were obtained from an experimental orchard of Department of Horticulture, the Çukurova University, Adana. At both years, fruits were harvested at the first week of April which is the optimum maturity time[8]. After harvest, fruits were immediately transferred to the packinghouse and then received the following treatments: 3 min water dip at 20°C (Control), Hot Water Dip (HWD) at 53°C for 3 min, fruitgard 70 T (0.5%), foamer (10%), aliette (2000 ppm). Fruits were then placed into plastic boxes and stored at 4°C and 85-90% RH for 6 months.

Fruitgard 70 T, including Imazalil 10 and TBZ 14% is used to prevent *Penicillium digitatum, Penicillium italicum, Diplodia natalensis, Phomopsis citri* and *Botrytis cinerea*. Foamer including SOPP 13% is used to prevent same micro organisms. Aliette, an organic phosphate compound and a systemic foliar fungicide includes Phosethyl Al (Aluminium tri-o-ethyl phosphate) 80% WP and is used to prevent powdery mildew, caused by *Penicillium italicum* and especially *Phytophthora, citrophthora*[9].

Each month during storage, three replicates often fruit samples from each treatment were kept at 20°C, 70% of RH for 10 days to evaluate the shelf life.

Corresponding Author: Dr. A.E. Ozdemir, Department of Horticulture, University of Mustafa Kemal, Hatay, 31034 Turkey
Tel.: +90 326 2455849 Fax: +90 326 2455832
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Internal quality parameters (juice, TSS, acid Vitamin C and ethanol content) were determined at the end of each month and after 10-day shelf life.

Vitamin C content (L-ascorbic acid) was determined spectrophotometrically using a Shimadzu UV-1208 Spectrophotometer according to the procedure described by Pearson and Churchill[10].

In order to determine ethanol content, fruit juice samples were immediately frozen in liquid nitrogen and kept in deep freeze until analysis. Ethanol content of juice samples was analysed after thawing using a Shimadzu GC-14A gas chromatography according to procedure described by Gül[11]. Shimadzu GC-14A gas chromatography was equipped with a FID detector (225°C) and a column containing Chromosorb W 60-80 mesh on 30% silicon oil at 200°C.

The experimental design was Completely Randomized Block Design. The data were processed by Analysis of Variance using MSTAT-C software. Mean separation was performed by Tukey's test at p>0.05 level.

RESULTS AND DISCUSSION

Changes in the juice content: As storage tine extends, the juice content decreased during storage in the first year of experiment. Changes in juice content were not statistically different among treatments except for alliette treatment (Table 1). Juice content decreased from 35.24 to 32.39% during storage. The decrease in juice content was the highest in the fruits from aliette treatment. In the second year of the experiment, as storage time extends, juice content slightly increased from 34.88 to 39.46%. The increase in juice content was the lowest in the fruits from HWT while the highest in the fruits from aliette treatments. In the both years, increases in juice content continued during 10 days of shelf life. Foamer treatment resulted in the highest increase in juice content during 10 days at 20°C (Table 2).

The increases in juice content during storage are closely related with the structure of the fruit skin and the water losses. The data obtained are consistent with the previous studies which is previously reported[1,12]. The differences of the juice content between years could be due to climate (warm winter and rainfall before harvest in the second year of experiment).

Changes in the acid content: In the first year of the experiment, acid content decreased during 6 months of storage. The decrease in acid content was the lowest in the hot water and aliette treated fruits. In the second year of the experiment, as storage time extends, acid content decreased. The decreased in acid content was the lowest

Table 1: Juice content of Valencia oranges during the storage in the first year

	Treatments					
Storage time (months)	Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	35.24	35.24	35.24	35.24	35.24	35.24a-c
2	38.78	36.13	39.64	38.84	36.45	37.97a
4	33.80	35.41	31.57	33.49	33.40	33.53b-d
4 (+10 days)	37.48	36.15	34.98	35.03	33.53	35.43ab
5	32.40	30.11	33.60	35.33	31.25	32.54cd
5 (+10 days)	33.97	31.83	34.46	39.16	33.50	34.58b-d
6	33.49	32.64	32.96	32.79	30.06	32.39d
6 (+10 days)	34.23	33.41	34.03	33.08	30.47	33.04b-d
Mean	34.92ab	33.86ab	34.56ab	35.37a	32.99b	

D%5 (Storage time): 2.75, D%5(Treatment): 1.95
Mean values with different letter(s) are significantly different at p>0.05 level

Table 2: Juice content of Valencia oranges during the storage in the second year

	Treatments					
Storage time (months)	Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	34.88	34.88	34.88	34.88	34.88	34.88d
2	38.94	35.74	37.75	37.39	41.67	38.30a-c
4	37.56	38.58	37.92	35.96	41.91	38.39a-c
4 (+10 days)	44.92	38.80	38.72	40.18	42.84	41.09a
5	37.20	35.45	37.95	37.59	39.10	37.46b-d
5 (+10 days)	37.49	35.64	37.96	37.79	31.06	35.99cd
6	39.63	36.59	40.46	40.82	39.78	39.46ab
6 (+10 days)	39.65	37.08	40.54	41.74	40.74	39.95ab
Mean	38.78a	36.60b	38.27ab	38.29ab	39.00a	

D%5 (Storage time): 2.82, D%5(Treatment): 2.00
Mean values with different letter(s) are significantly different at p>0.05 level

in the fruits from aliette treatments. The differences in acid content at harvest between two years could be due to climatic conditions. In the both years, acid content continued to decrease during 10 days of shelf life. Control and foamer treated fruits in the first year and control and aliette treated fruits in the second year showed the highest decrease in acid content when kept at 20°C for 10 days.

Acid loss depends on ecological conditions and maturation. Hot weather above 20°C fastens maturation which increases acid loss rate. Low temperature, low oxygen and high carbon dioxide levels, which slow down metabolism and respiration rate, reduce acid loss. In citrus fruits, acid loss is as a result of abnormal metabolism caused by chilling injury[13].

Acid loss is limiting factor for citrus during storage. The ratio of TSS to titretable acidity affect fruit the quality. Change in this ratio in opposition to acid content decrease the quality[2,8,14-17].

Changes in Total Soluble Solids (TSS) content: TSS content of fruits increased during storage at both years. In the first year, TSS content reached 12.82% at the end of 6 months. The highest increased in TSS content determined in the control, aliette and foamer treated fruits (Table 3). In the second year, TSS content was 12.78% at

Table 3: TSS content of Valencia oranges during the storage in the first year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	10.8	10.8	10.8	10.8	10.8	10.80d
2	12.2	11.8	11.6	11.8	11.8	11.84c
4	12.8	11.9	12.1	12.5	12.9	12.44b
4 (+10 days)	12.9	12.2	11.8	12.2	12.3	12.28b
5	13.1	12.1	12.9	13.0	12.9	12.80a
5 (+10 days)	12.8	12.9	11.6	12.5	12.1	12.38b
6	13.2	12.0	12.2	13.5	13.2	12.82a
6 (+10 days)	12.5	12.7	11.8	12.1	12.6	12.34b
Mean	12.54a	12.05b	11.85b	12.30a	12.33a	

D%5 (Storage time): 0.35, D%5(Application): 0.25
Mean values with different letter(s) are significantly different at p>0.05 level

Table 4: TSS content of Valencia oranges during the storage in the second year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	11.1	11.1	11.1	11.1	11.1	11.10d
2	11.8	12.0	11.8	11.8	11.6	11.84bc
4	12.0	12.6	12.5	11.8	12.1	12.20b
4 (+10 days)	11.8	11.6	11.4	11.8	11.3	11.58cd
5	12.4	12.8	12.1	12.1	12.0	12.28ab
5 (+10 days)	12.5	12.0	11.6	12.1	12.1	12.06bc
6	13.2	12.8	12.8	12.7	12.4	12.78a
6 (+10 days)	12.2	12.1	11.8	11.9	11.8	11.96bc
Mean	12.13a	12.13a	11.89a	11.89a	11.85a	

D%5 (Storage time): 0.50, D%5(Application): ns (non significant).
Mean values with different letter(s) are significantly different at p>0.05 level

Table 5: Vitamin C content of Valencia oranges during the storage in the first year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	63.35	63.35	63.35	63.35	63.35	63.35a
2	60.09	58.10	61.76	55.86	53.74	57.91b
4	51.39	55.21	51.33	50.57	53.89	52.48c
4 (+10 days)	49.64	48.07	46.07	43.01	49.97	47.43d
5	50.71	51.38	53.27	53.15	48.35	51.37c
5 (+10 days)	41.68	44.04	47.44	42.07	41.55	43.36e
6	46.06	43.74	54.00	44.13	42.07	46.00d
6 (+10 days)	40.12	39.13	45.35	37.19	36.85	39.73f
Mean	50.38b	50.38b	52.87a	48.67c	48.72c	

D%5 (Storage time): 1.71, D%5(Application): 1.21
Mean values with different letter(s) are significantly different at p>0.05 level

Table 6: Vitamin C content of Valencia oranges during the storage in the second year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	59.65	59.65	59.65	59.65	59.65	59.65a
2	53.84	57.35	58.82	59.37	53.88	56.65b
4	52.27	53.66	54.40	53.15	54.10	53.50c
4 (+10 days)	42.16	46.12	47.94	42.90	43.40	44.50d
5	48.37	50.74	55.90	53.15	50.86	51.80c
5 (+10 days)	38.36	43.66	43.26	41.83	40.92	41.61e
6	43.87	47.28	78.37	47.89	45.93	46.67d
6 (+10 days)	34.55	41.19	33.61	34.74	38.44	36.51f
Mean	46.63c	49.96ab	50.24a	49.09ab	48.39b	

D%5 (Storage time): 2.27, D%5(Application): 1.61
Mean values with different letter(s) are significantly different at p>0.05 level

Table 7: Ethanol content of Valencia oranges during the storage in the first year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	8.27	8.27	8.27	8.27	8.27	8.27e
2	18.90	16.90	24.17	17.45	20.87	19.66d
4	41.14	39.10	37.96	35.38	41.86	39.09c
4 (+10 days)	45.44	50.78	55.10	47.46	45.61	48.88b
5	39.80	40.58	38.72	45.90	42.04	41.41c
5 (+10 days)	44.21	61.94	49.90	43.24	44.73	48.80b
6	53.02	50.28	56.86	40.86	50.30	50.26b
6 (+10 days)	66.44	65.31	61.58	55.60	62.22	62.23a
Mean	39.65a	41.65a	41.57a	36.77b	39.49a	

D%5 (Storage time): 3.62, D%5(Application): 2.56
Mean values with different letter(s) are significantly different at p>0.05 level

Table 8: Ethanol content of Valencia oranges during the storage in the second year

Storage time (months)	Treatments: Control	Hot water	Fruitgard 70 T	Foamer	Aliette	Mean
0	8.16	8.16	8.16	8.16	8.16	8.16g
2	29.00	16.44	18.18	16.50	16.62	19.35f
4	39.62	38.90	38.72	35.90	38.62	38.35e
4 (+10 days)	56.88	55.60	55.07	51.94	55.02	54.90c
5	41.76	44.23	49.62	48.07	49.54	46.64d
5 (+10 days)	58.63	57.54	56.16	55.80	63.90	58.41b
6	50.38	59.20	53.81	43.64	51.47	51.70c
6 (+10 days)	60.98	69.25	67.24	61.10	71.16	65.95a
Mean	43.18a	43.67a	43.37a	40.14b	44.31a	

D%5(Storage time): 3.75, D%5(Application): 2.39
Mean values with different letter(s) are significantly different at p>0.05 level

the end of storage. Control and hot water treated fruits showed the highest increases in the TSS content (Table 4). TSS content of fruits fluctuated when kept at 20°C for 10 days.

TSS contents of fruits differed between years. This could be due to changes in weather and growth of trees. There was decrease in TSS content of fruits when kept at 4 and 20°C which is previously reported[1,8,11,12,14,18-23].

Changes in the vitamin C content: In the both years, the vitamin C content decreased as the storage time extends. In the first year, vitamin C content of fruits decreased from 63.35 mg ascorbic acid/100 mL fruit juice to 46.00 mg ascorbic acid/100 mL fruit juice. The highest vitamin C loss occurred in the fruits from foamer and aliette treatments. Fruitgard 70 T treated fruits retained their vitamin C content the most at the end of storage (Table 5). In the second year, Vitamin C content of fruits decreased from 59.65 mg ascorbic acid/100 mL fruit juice to 46.67 mg ascorbic acid/100 mL fruit juice. Control fruits showed the highest Vitamin C loss. Hot water, foamer, fruitgard treatments resulted in the least vitamin C loss (Table 6). Fruits from foamer treatment had the lowest vitamin C

content while those from aliette and hot water treatments had the highest vitamin C content at the end of 10 days.

During storage, vitamin C content of fruits decreased which is consistent with studies which is previously reported[1,8,12,19,22,24-26].

Changes in the ethanol content: Ethanol accumulated in fruits during storage. The effects of treatments on the ethanol content of fruits were not significant statistically except for foamer treatment. In both years, foamer treatments resulted in the lowest ethanol accumulation in fruits during storage (Table 7 and 8).

Ethanol continued to accumulate in fruits during 10 days at 20°C. The highest ethanol accumulation was determined in fruits from aliette treatments at 20°C (Table 7 and 8).

Ethanol level in fruit above 150 mg/100 mL fruit juice is undesirable[27]. In this experiment, ethanol content of fruits from all treatments did not reach such level either during storage or shelf life.

Valencia oranges could be stored successfully without internal quality loss for 5 (with foamer and aliette treatments) to 6 months (with fruitgard 70 T and hot water treatments) at 4°C and 85-90% RH. Present data were consisted with previous studies of citrus storage which is previously reported[1,8,12,22].

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