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Comparison postharvest quality of conventionally and organically grown 'Washington Navel' oranges

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Summary

This study aimed to compare postharvest quality of conventionally and organically grown 'Washington Navel' oranges. Oranges from the conventional and certified organic citrus orchards were harvested at commercial maturity and kept at 4°C for 5 months. Changes in weight loss, juice percentage, titratable acidity (TA), total soluble solid (TSS), sugars (fructose, glucose and sucrose), organic acids (citric, malic and ascorbic acid) content and incidence of fungal decay and chilling injury were determined at a month interval during storage. Conventionally grown oranges had lower weight loss and higher juice percentage than organically grown oranges during storage. Rind color (L*, C*, h°), TSS, sugar (fructose, glucose and sucrose) and malic acid content were not affected by the production systems at harvest and during storage. In both conventionally and organically grown oranges, rind color become darker (lower L*), more intense (higher C*) and deeper orange color (lower h°) while malic acid content remained constant during 5 months of storage. As storage time extended, a significant increase in TSS and sugar content and a decrease TA and citric acid content occurred in fruits from both production system. Compared to conventionally grown oranges, organically grown oranges had lower TA and citric acid, but better taste scores since they attained higher TSS/TA ratio at harvest and during storage. The taste of conventionally and organically grown oranges was rated as an acceptable throughout the storage period. Although there was no significant difference in ascorbic acid content of fruits between two production systems at harvest, lower ascorbic acid content was found in organically grown oranges, compared to conventionally grown oranges during storage. Incidence of fungal decay was low in conventionally and organically grown oranges after 5 months of storage and the production system did not affect the sensitivity to fungal decay. Chilling injury was not observed any of fruits from both production systems throughout storage period.

Introduction

The global organic food and drink sales reached 54.9 billion US dollars in 2009 with a three-fold increase from 18 billion US dollars in 2000 (Willer and Kilcher, 2011). The consumer demand for organic foods continues to expand rapidly due to the perception that organic products are safe, clean, more nutritious, healthy, better-tasting and environmentally friendlier than conventionally grown foods (Bourn and Prescott, 2002; Lester, 2006). The production of citrus fruits in Turkey has been increasing steadily in the past 20 years, reached about 3.5 million tons in 2009 (Faostat, 2009). Turkey is among the top four citrus producers in the Mediterranean Basin and ranks tenth in the world. Oranges are the main citrus fruit grown in Turkey, accounting for about 48% of total citrus production. The increase in citrus production has resulted in some potential marketing problems, especially for commonly grown citrus cultivars including 'Washington Navel' oranges (Demirkeser et al., 2009). Thus, the citrus industry in Turkey has been tending to organic production expanding due to export market opportunities for organic citrus fruits (Demirkeser et al., 2009). The 68.210 hectares of citrus fruit are grown worldwide (Willer and Kilcher, 2011). Turkey was accounted for 1.2% of the world's area of organic citrus fruits.

The effect of the production system on citrus fruit quality has already studied. Citrus fruits produced in organic farms had greater juice percentage and sugar content (Lester et al., 2007); more soluble solids, a lower maturation index (Duarte et al., 2010), higher malic, citric and ascorbic acid concentration (Duarte et al., 2012), higher contents of minerals and carotenoids and better sensory quality (Beltran-Gonzalez et al., 2008) than those produced by conventional farming systems but the responses depended on citrus species and cultivar (Duarte et al., 2010; 2012) and harvest season (Lester et al., 2007). Some of the authors did not find significant differences in some quality parameters between conventional and organic citrus fruits (Rapisarda et al., 2005; Perez-Lopez et al., 2007; Lester et al., 2007; Beltran-Gonzalez et al., 2008; Esch et al., 2010; Camin et al., 2011). Few studies monitored the postharvest life and quality of organically versus conventionally grown fresh fruits such as kiwi (Amodio et al., 2007), apple (DeEll and Prange, 1992) and grapefruit (Chebrolu et al., 2012a). The aim of this study was compare postharvest quality of conventionally and organically grown 'Washington Navel' oranges.

Materials and methods

Plant material

'Washington Navel' oranges were obtained from the commercial citrus orchards, one organic and one conventional in Seyhan, Adana during 2010 and 2012 growing seasons. The orchards were located close to each other (1 km apart), with trees grafted on the same rootstock and of about the same age to allow a valid comparison of organic versus conventional fruits. Production systems were defined in Tab. 1. Fruits were harvested at commercial maturity from 7 year-old trees which were grafted on sour orange and planted 6 m x 6 m. After harvest, fruits were transported to the postharvest laboratory at the Horticultural Department of Mustafa Kemal University (Antakya-Hatay), where they were sorted for size, color uniformity, and absence of surface defects. Three replicates per treatment were then kept at 4°C and 85-90% relative humidity for 5 months. Each replicates contained 10 fruits.

Evaluation of postharvest quality

Postharvest quality was assessed monthly intervals during storage. Fruits were numbered and individually weighted to determine weight loss. Weight loss was calculated as percentage loss of initial weight. Rind color was determined with a Minolta Chroma Meter CR-300 (Osaka, Japan). Color measurements were recorded using the CIE L*a*b* color space. From these values, hue angle (h°) and Chroma (C*) values were calculated as $h° = \tan-1\ (b^*/a^*)$ and $C^* = (a^{*2}+b^{*2})^{1/2}$, Color values for each fruit were computed as means of two measurements taken from opposite sides at the equatorial region of the

Tab. 1: Fertilizer, weed and insect control inputs of conventionally and organically grown Washington Navel orange orchards

Production system	Input	Description and Rate	Application
Conventional	Fertilizer	N 280 kg ha^{-1} P 100 kg ha^{-1} K 280 kg ha^{-1}	1 1 1
		Attack DF (foliar nutrient spray): Zn 0.168 l ha-^{1}; Fe 0.140 l ha-^{1}; Mn 0.112 l ha-^{1}; Mg 0.084 l ha-^{1}; B 0.042 l ha-^{1}; Cu 0.028 l ha-^{1}; Mo 0.001 l ha-^{1}; S 0.322 l ha-^{1}	1
	Insect control	Applaud 1.82 l ha-^{1} Neoran 1.4 l ha-^{1} Malathion 14 l ha-^{1} Citrus oil 35 l ha^{-1}	1 1 1 1
	Weed control	Cultivation	2
	Irrigation	Flood irrigation	
Organic	Fertilizer	Compost: N115 kg ha^{-1}; P 57.5 kg ha^{-1}; K 115 kg ha^{-1}	1
		Pattrone (foliar nutrient spray) : Free amino acid 630 g ha^{-1}; inorganic N 142 g ha^{-1}; organic N 142 g ha^{-1}; organic acid 578.62 g ha^{-1}	2
	Insect control	Citrus oil 35 l ha^{-1} Flowable sulphur 16.8 l ha^{-1}	1 1
		2-3 predatory insects (*Cryptolaemus montrouzieri*) per tree 10 predatory insects (*Leptemastix dactylopii*) per tree	1 1
	Weed control	Cultivation	2
	Irrigation	Drip irrigation	

fruit. Juice was extracted by using an electric rotary juicer. Juice percentage was calculated by weighing the juice for each sample and dividing by the original fruit weight. Total soluble solids (TSS) content and titratable acidity (TA) were assessed in juice obtained from ten fruits per replicates. TSS content was determined with a refractometer (Atago Model ATC-1E) and TA by titration of 5 ml of fruit juice with 0.1 N NaOH to pH 8.1 and expressed as g citric acid 100 ml^{-1} juice. The incidence of fungal decay was assessed and expressed as percentage of fruit infected by fungal pathogens. Fruits were examined visually for chilling injury (CI) symptoms such as peel pitting or brown staining. Incidence of CI was expressed as the percentage of fruits with CI. A trained panel consisting of 10 people evaluated the sensory quality (taste) of the fruits based on a hedonic scale of 1 (disliked extremely) to 9 (liked extremely) at the beginning of the experiment and monthly throughout the storage period.

Extraction and HPLC analysis of sugar and organic acids

Sugars were extracted from the oranges following a modified method of Lee and Coates (2000). Exactly 5 ml of sample was diluted with deionized distilled water to total volume of 10 ml. After vortexing for a minute, the sample was centrifuged (Rotina 380R Hettich, Tuttlingen, Germany) for 5 min at 9,418 × g (6500 rpm) and 5°C. Twenty microliters of sample was injected directly into the HPLC after filtration through a Millex-HV 0.45 µm filter (Millipore, Bedford, MA). Organic acids (citric and malic) ascorbic acid were extracted according to a modified version of the method described previously (Lee, 1993; Lee and Coates, 1999). A sample of juice (5 ml) was pipetted into a 50 ml centrifuge tube containing 5 ml of 2.5% metaphosphoric acid. After centrifugation at 9,418 × g (6500 rpm) for 5 min at 5°C, the supernatant was recovered. Twenty microliters of sample was filtered using a Millex-HV 0.45 µm filter and injected directly into a Shimadzu HPLC.

HPLC analyses of sugars and organic acids were performed on LC-10A equipment consisting of LC-10AD pumps, an in-line degasser, a CTO-10A column oven, an SCL-10A system controller, an SPD 10Avp, a photo diode array detector, a refractive index detector and operated by LC solution software (Shimadzu, Japan). Sugars were separated using an EC NUCLEOSIL Carbohydrate 250 mm × 4 mm i.d. column (Macherey-Nagel, Düren, Germany) at 25°C. The mobile phase included acetonitrile: deionized distilled water (80:20, v/v) at a flow rate of 2 ml min^{-1}. Organic acids were separated on a TransgenomicTM ICSep ION300 300 mm × 7.8 mm i.d. column (Transgenomic, San Jose, CA, USA) at 65°C. The mobile phase used was 0.0085 N H_2SO_4 at a flow rate of 0.4 ml min^{-1}. Sugars and organic acids were detected using a refractive index and photo diode array detector (210 nm for citric and malic acid and 244 nm for ascorbic acid), respectively. Quantification was performed according to external standard method by the comparison of retention times to those of authentic standards, purchased from Merck KGaA (Darmstadt, Germany) and Chem Service (West Chester, USA).

Statistical analysis

The data were analyzed as a factorial experiment in a completely randomized block design by analysis of variance (ANOVA) using SAS software of SAS Institute, Cary, N.C. (SAS, 1999). Statistical means were across the two growing seasons. Mean separation was performed by Fisher's Least Significance Test at $p<0.05$ level using SAS's Proc GLM procedure.

Results and discussion

Weight loss increased as storage time extended and reached to 10.11% and 11.94% after 5 months of storage in conventionally and organically grown oranges, respectively (Fig. 1A). Conventionally grown oranges had lower weight loss than organically grown oranges during storage. Consistent with our results, conventional grapefruits showed lower water loss than organic grapefruits during 4 weeks of storage at 9°C (Chebrolu et al., 2012a). Fruit size of organically grown oranges (263.31 g to 318.42 g) was higher than that of conventionally grown oranges (223.65 g to 247.40 g) as result of lower number of fruits per tree in organically grown trees (Data not shown). The farming system had a significant influence on the mean fruit weight and equatorial diameter which could be assigned to the lower yield per tree resulting in larger orange fruits due to lower assimilate competition under organic farming (Roussos, 2011). According to Ketsa (1990), the largest tangerines lost 1.66-1.69 times as much weight as did the smallest fruits during shelf life. In agreement with the findings of Ketsa (1990), larger fruit size of organically produced fruits compared to conventionally produced fruits caused higher weight loss.

Juice percentage decreased from 52.91% to 45.24% in conventionally grown oranges and from 49.06% to 41.53% in organically grown oranges during storage (Fig. 1B). These results are in agreement with the findings of Ozdemir and Dundar (2006) who found that juice percentage of orange fruits significantly decreased with the increasing of storage periods. Juice percentage was higher in conventionally grown oranges than organically grown oranges at harvest and during storage. Similar finding was reported for conventional versus organic acid limes (Rangel et al., 2011). In contrast to our results, the previous study showed that grapefruits produced in organic farms had greater juice percentage than those produced by conventional farming systems (Lester et al., 2007). In other studies, no significant differences in juice percentage were found for citrus fruits between two production systems (Rapisarda et al., 2005; Duarte et al., 2010; Nunes et al., 2010; Camin et al., 2011). In our study, compare to conventionally grown oranges, lower juice percentage in organically grown oranges might be as a result of being larger fruit which often have proportionately lower juice content than smaller fruit in oranges (Davies and Zalman, 2004).

Rind color parameters of L* (lightness) and hue angle (h°) values decreased, but Chroma (C*) value increased during storage (Fig. 2).

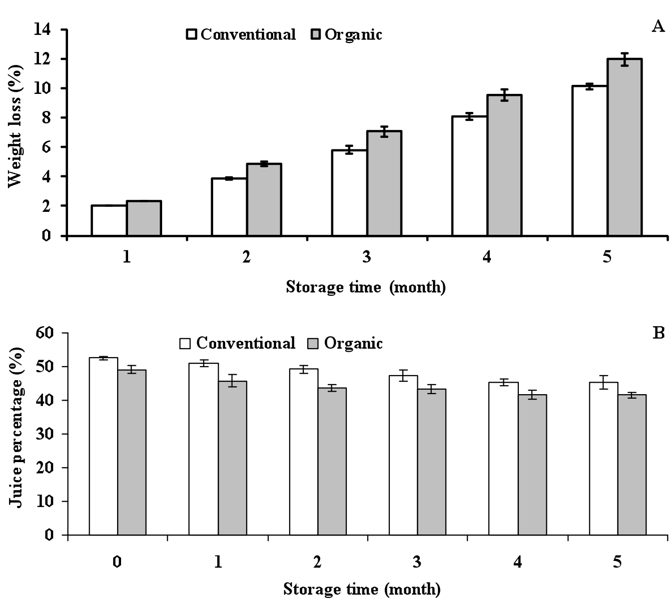

Fig. 1: Changes in weight loss and juice percentage of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

These changes indicate that rind color become darker (lower L* value), more intense (higher C* value), deeper orange color (lower h°). Previous studies demonstrated changes in peel color from green yellow to yellow-orange and a decrease in L* value in 'Washington Navel' oranges with the increasing of storage period (Özdemir et al., 2008). Conventionally and organic grown oranges had similar rind color L*, C* and h° values at harvest and during storage (Fig. 2). Duarte et al. (2010) found higher L* value in organically grown citrus fruits, but more intense color in conventionally grown citrus fruits. Lester et al. (2007) reported that early season conventionally grown citrus fruits had a darker, more intense, reddish-yellow color. As the production season advanced, peel lightness, and color intensity differences from the two systems became non-significant.

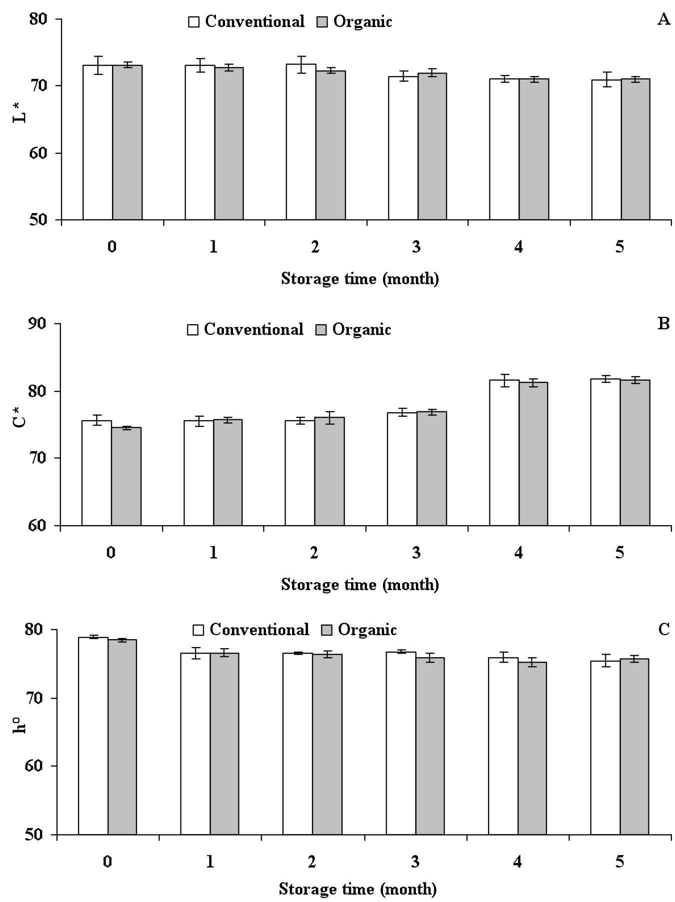

Fig. 2: Changes in rind color L*, C* and h° values of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

Conventionally and organically grown oranges contained about 10% of total soluble solid (TSS) content at harvest (Fig. 3A). An increase in the TSS content of conventionally and organically grown oranges occurred during 5 months of storage. Increases in TSS content have been previously reported in stored 'Pineapple' oranges for 6 weeks at 4°C, 'Valencia' oranges for 12 weeks at 1°C (Davis et al., 1973), 'Hamlin' oranges for 9 weeks at 15°C (Echeverria and Ismail, 1987), 'Valencia' oranges for 24 weeks at 4°C and 6°C (Ozdemir and Dundar, 2006; Özdemir et al., 2008) and navel oranges for 6 weeks at 5°C (Obenland et al., 2008). Our findings were in agreement with previous reports on orange fruits. In our study, there was no significant difference in TSS content between conventionally and organically grown oranges at harvest and during storage. Compared with conventional farming, higher TSS content was reported in organically grown grapefruits (LESTER et al., 2007) and oranges, mandarins and lemons (DUARTE et al., 2010). In agreement with our results, a similar TSS content at harvest under organic and conventional orchard management were reported for 'Navelina' and 'Tarocco' (RAPISARDA et al., 2005; CAMIN et al., 2011), 'Salustiana' (ROUSSOS, 2011) and 'Valencia' oranges (NUNES et al., 2010), 'Clemenules' (PEREZ-LOPEZ et al., 2007) and 'Hernandina' mandarins (BELTRAN-GONZALEZ et al., 2008). CHEBROLU et al. (2012a) found no significant difference in TSS content of grapefruits at harvest and throughout a 5-week storage period at 9C°.

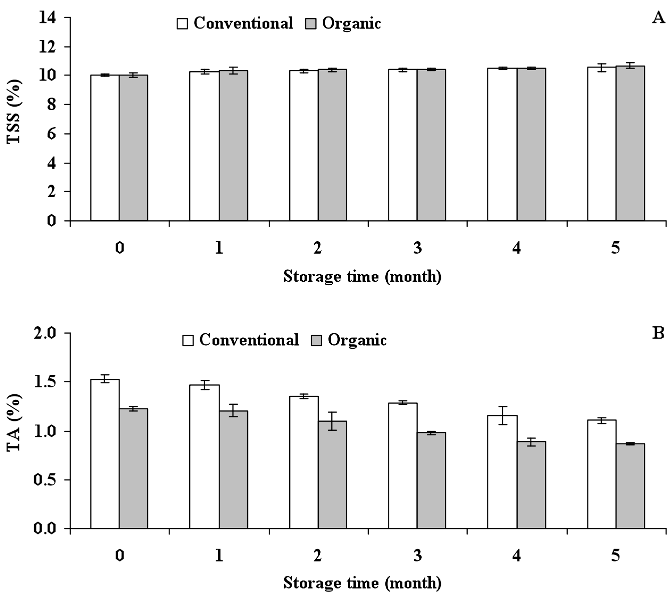

Fig. 3: Changes in total soluble solid (TSS) and titratable acidity (TA) of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

Conventionally and organically grown oranges contained 1.98-2.05 g 100 ml^{-1} of fructose, 1.82-1.83 g 100 ml^{-1} of glucose and 3.27-3.30 g 100 ml^{-1} of sucrose at harvest (Fig. 5). Sugars content of conventionally and organically grown oranges were similar at harvest and during storage. LESTER et al. (2007) found lower total sugars in early and late season 'Rio Red' grapefruits from organic production systems, compare to conventional production systems, but midseason grape fruits from both production systems had similar sugar content. Consistent with our results, sugar content and sugar composition were not affected by the production system in oranges (ROUSSOS, 2011) and kiwifruits (AMODIO et al., 2007) at harvest or during storage. In both conventionally and organic grown oranges, changes in fructose, glucose and sucrose content were not statistically significant for 2 months and then a significant increases in individual sugars occurred in the last 3 months of storage (Fig. 5). In 'Hamlin' oranges, a concurrent increase in sucrose and decrease in fructose were measured during the first 5-6 weeks of storage, and then fructose increased in the last 4 weeks of storage while glucose remaining unchanged during the 10 weeks of storage (ECHEVERRIA and ISMAIL, 1987). AHMAD et al. (1989) reported increases in reducing and non-reducing sugars in 'Blood Red' sweet oranges during 5 weeks of storage at 8-19°C. The increases in individual sugars (Fig. 5) were consistent with increase in TSS content (Fig. 3A) during storage in our study. According to ECHEVERRIA and ISMAIL (1990), the increase in sugar concentration (due mainly to sucrose) accounted for the measured rise in TSS content for 'Hamlin' oranges.

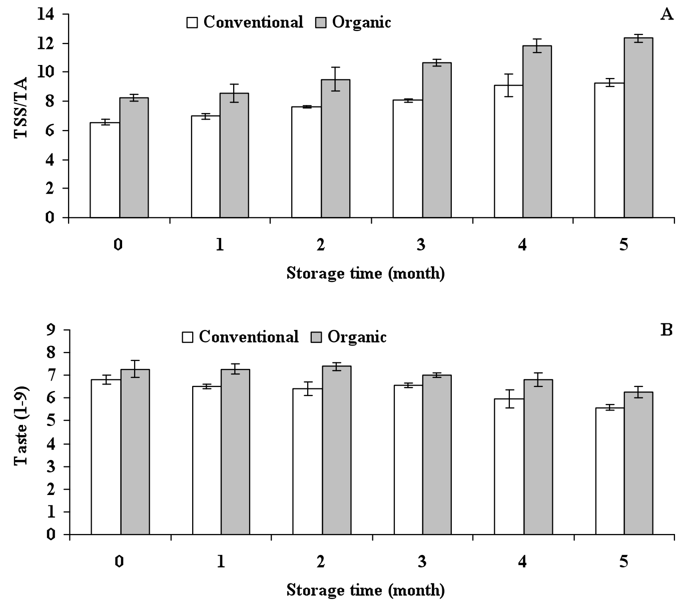

Fig. 4: Changes in sugar/acid ratios (TSS/TA) and taste scores of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

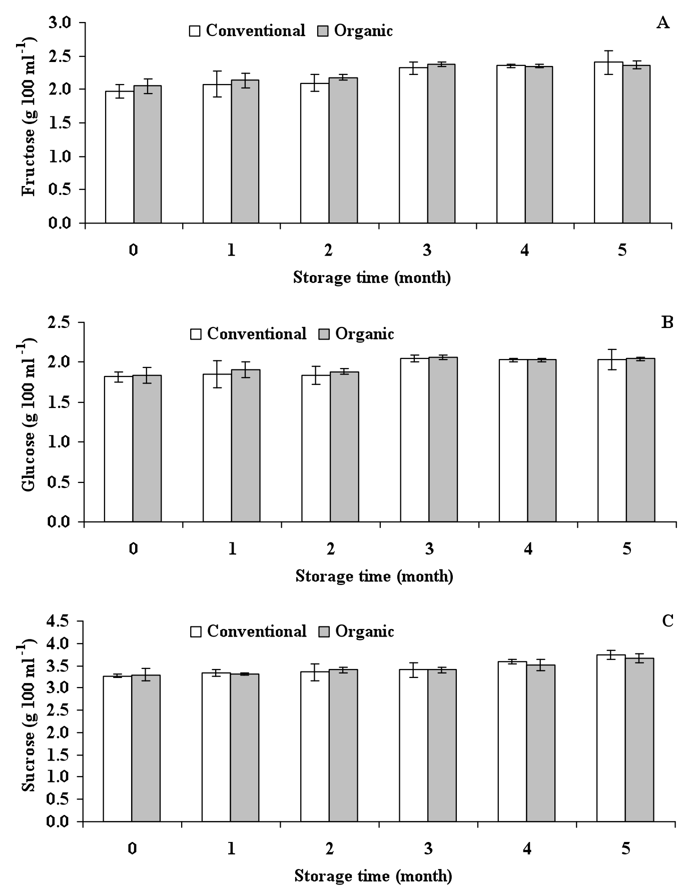

Fig. 5: Changes in sugars content of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

An acid loss was observed in fruits from both production systems during storage (Fig. 3B) as reported previously for citrus fruits (ERKAN and PEKMEZCI, 2000; OZDEMIR and DUNDAR, 2006; OBENLAND et al., 2008). At harvest, conventionally and organically grown oranges had titratable acidity (TA) 1.53% and 1.22% and reached 1.11% and 0.87%, respectively. This is in contrast to what was observed by DUARTE et al. (2010) who found that compared with conventional farming, fruits from organic farming were more acid and had a greater °Brix and lower a lower maturation index (TSS/TA ratio). LESTER et al. (2007) reported that organically grown grapefruits had higher TA than conventionally grown grapefruits during early and midseason, but differences in TA from the two systems became non-significant at late season. No differences were observed for TA between conventional and organic oranges (RAPISARDA et al., 2005; CAMIN et al., 2011), limes (RANGEL et al., 2011), mandarins (BELTRAN-GONZALEZ et al., 2008), grapefruits (CHEBROLU et al., 2012a), kiwifruits (AMODIO et al., 2007) and apples (DEELL and PRANGE, 1992) at harvest or during storage. The minimum acceptable maturity level for navel oranges is a 6.5 to 1 ratio of sugar to acid (OECD, 2010). In conventionally and organically grown oranges, the initial TSS/TA ratio was about 6.6 to 1 and 8.2 to 1 and increased to reached 9 to1 and 12 to 1, respectively, during storage (Fig. 4A). The increase in TSS content and decrease in TA lead to a progressive increase in the TSS/TA ratio as storage time advanced. Likeability (hedonic score) was unchanged for 3 weeks of storage in conventionally grown oranges and for 4 weeks of storage in organically grown oranges and then the scores had declined from 7 (like moderately) to 6 (like slightly) (Fig. 4B). The taste of fruits was still rated as acceptable (≥6) throughout the storage period. OBENLAND et al. (2009) reported that sensory panelists increasingly liked navel oranges as TA declined and SSC/TA rose during navel orange maturation and that the increase in likability did not plateau until SSC/TA values of 18 or more were reached. In our study, it is possible that the loss of acidity had some role in the decline in flavor quality in this cultivar as suggested by OBENLAND et al. (2011). In citrus fruits, a higher SSC/TA ratio is generally desired because the fruit are perceived to be sweeter, although too high of a ratio can cause the fruit to be bland (OBENLAND et al., 2009). Compared to conventionally grown oranges, organically grown oranges had lower TA (Fig. 3B), but better taste scores (Fig. 4B), since they attained higher TSS/TA ratio (Fig. 4A). The difference experienced in our study from previous studies could be the result of different degree of maturity of conventionally and organically grown oranges at harvest. Organic versus conventional production system inputs can change ripening patterns (PERKINS-VEAZIE and LESTER, 2008).

At harvest, conventionally and organically grown oranges had citric and malic acid content ranging from 1.20 g 100 ml^{-1} to 1.42 g 100 ml^{-1} and 0.17 g 100 ml^{-1} to 019 g 100 ml^{-1}, respectively (Fig. 6). Citric acid content decreased during storage period (Fig. 6A). Citric acid has been reported to decrease in stored 'Pineapple' and 'Valencia' (DAVIS et al., 1973) and 'Hamlin' oranges (ECHEVERRIA and ISMAIL, 1987). Malic acid content remained constant in both conventionally and organically grown oranges during storage (Fig. 6B), as reported by DAVIS et al. (1973) in 'Valencia' and by ECHEVERRIA and ISMAIL (1987) in 'Hamlin' oranges. Reduction in TA was mainly to the result of a decrease in citric acid because of steady levels of malic acid during storage. Conventionally grown oranges had higher citric acid content, compared to organically grown oranges. However, malic acid content was similar fruits from both production systems. The farming systems did not result in any significant difference in the individual organic acids of 'Salustiana' oranges (ROUSSOS, 2011) and kiwifruits (AMODIO et al., 2007) at harvest or during storage. DUARTE et al (2012) reported that the concentration of citric acid and malic was generally higher in citrus fruits from

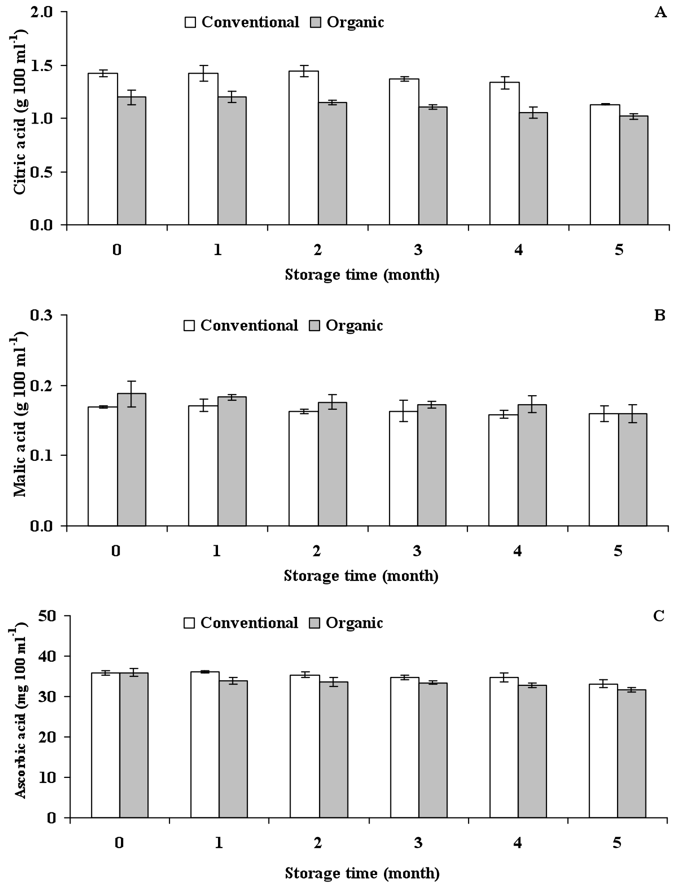

Fig. 6: Changes in organic acids content of conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

organic production, in comparison to conventional production, but similar or higher concentration of citric and malic was found in some of conventionally grown mandarin, lemon and orange cultivars.

Conventionally and organically grown oranges contained 35.77 mg 100 ml^{-1} % and 35.97 mg 100 ml^{-1} of ascorbic acid, respectively at harvest. A range of about 29 to 74 mg of ascorbic acid 100 ml^{-1} of juice was reported for orange varieties (NAGY, 1980; RAPISARDA et al., 2005; DUARTE et al., 2012; ROUSSOS, 2011; CHEBROLU et al., 2012b). Ascorbic acid content of conventionally and organically grown oranges was within range of previous studies. A greater vitamin C content in citrus fruits from organic compared to conventional farming systems was reported for 'Navelina', 'Tarocco' (RAPISARDA et al., 2005), 'Valencia late' and 'Baia' oranges (DUARTE et al., 2010) and 'Rio Red' grapefruits (LESTER et al., 2007; CHEBROLU et al., 2012ab), However, we found that conventionally and organically grown oranges had similar ascorbic acid content at harvest. In agreement with our results, no differences in ascorbic acid content were detected between the fruits from organic or conventional farming in 'Clemenules' mandarins (PEREZ-LOPEZ et al., 2007), 'Dalmau', 'Newhall', 'Lanelate', 'Rohde' (DUARTE et al., 2010; 2012), 'Salustiana' (ROUSSOS, 2011), 'Valencia' and navel oranges (ESCH et al., 2010), acid limes (RANGEL et al., 2011). Based on previous reports, nitrogen fertilizers, especially at high rates, seem to decrease the concentration of vitamin C in citrus and other fruits and vegetables (NAGY, 1980; LEE and KADER, 2000; RAPISARDA et al., 2005). DUARTE et al. (2012) reported that ascorbic acid concentration in the juice was generally higher in citrus fruits produced in the organic orchards, but the response depended on species and cultivar. Of the six types of fruits (lemons, oranges apples green kiwi, and mangoes) analyzed by ESCH et al. (2010), only one, lemon, demonstrated a significantly higher vitamin C concentration for organically grown versus conventionally grown fruit. LESTER et al. (2007) found higher ascorbic acid content early and mid-season 'Rio Red' grapefruits from organic production system to compare conventional production system but differences in ascorbic acid from the two systems became non-significant at late season. CHEBROLU et al., (2012a) compared vitamin C levels of organic and conventional 'Rio Red' grapefruits for two growing season. In the first year, organic grapefruits showed significantly higher levels of vitamin C over conventional grapefruits while no significant difference was found in organic and conventionally grown grapefruits for vitamin C levels in the second year. Previous reports suggested that other factors such as growing season, storage, and shipping conditions, time of harvest, species and cultivars may have also important influence on vitamin C content as well as the growing methods employed by organic and conventional farmers (LEE and KADER, 2000; LESTER et al., 2007; ESCH et al., 2010; DUARTE et al., 2010; 2011; CHEBROLU et al., 2012a). Ascorbic acid content showed a significant decreased during storage and this decrease was higher in organically grown oranges than conventionally grown oranges (Fig. 6c). A loss of vitamin C was reported previously for citrus fruits under refrigerated conditions (NAGY, 1980; LEE and COATES, 1999; ERKAN and PEKMEZCI, 2000; CHEBROLU et al., 2012a). Higher water loss after harvest result in a more rapid loss of vitamin C (LEE and KADER, 2000; NUNES et al., 1998). The decreases in total acids in the juice were also closely correlated with the loss of vitamin C (NAGY, 1980). Comparing to conventionally grown oranges, a lower ascorbic acid level in organically grown oranges could be as a result of a higher weight loss and a lower titratable acidity during storage period, as suggested previously.

Incidence of fungal decay was low at about 7% in conventionally and organically grown oranges after 5 months of storage (Tab. 2). We observed infections mainly caused by *Penicillium digitatum* and *P. italicum* on fruits. Consistent with our result, conventionally and organically grown grapefruits did not show significant difference in the incidence of fungal decay during storage at 9°C (CHEBROLU et al., 2012a). NUNES et al. (2010) concluded that the sensitivity to green or blue mold is determined better by the origin of orange fruits than by the system of production and the reduction or elimination of chemical synthesis compounds in the citrus production does not cause a significant increase in sensitivity of fruits to *Penicillium* spp. Chilling injury was not observed any of fruits from both production systems throughout storage period. Our previous study showed that no or slight incidence of chilling injury occurred in 'Washington Navel' oranges after 5 months at 4°C (ÖZDEMİR et al., 2008).

In conclusion, conventionally grown oranges had higher juice percentage, citric acid, TA and lower weight loss than organically grown oranges at harvest and during storage. Rind color (L*C* h°), TSS, fructose, glucose and sucrose and malic acid content were not affected by the production systems. Compared to conventionally grown oranges, organically grown oranges had lower TA, but better taste scores since they attained higher TSS/TA ratio. There was no significant difference in the ascorbic acid content of fruits between two production systems at harvest, but lower ascorbic acid content was found in organically grown oranges, compared to conventionally grown oranges during storage.

Tab. 2: Incidence of fungal decay in conventionally and organically grown 'Washington Navel' oranges during storage at 4°C.

Storage time (months)	Conventional	Organic
1	0.00±0.00[X]	0.00±0.00 [X]
2	1.67±0.72	1.67±0.72
3	3.33±0.72	5.00±1.25
4	3.33±0.72	5.00±1.25
5	6.67±1.91	6.67±1.44

[X] The values are means of two years ± standard error.

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