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EFFECT OF HARVEST DATE ON YIELD AND STORABILITY OF WASHINGTON NAVEL AND VALENCIA ORANGE FRUITS UNDER ON-TREE AND COLD STORAGE CONDITIONS

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ABSTRACT: This study was conducted during two successive seasons of 2013/2014 and 2014/ 2015 on 15-year-old Washington navel and Valencia orange [*Citrus sinensis* (L.) Osbeck] trees grafted on sour orange rootstock. The experimental trees were grown in clay loam soil of a private citrus orchard located at Menia El-Kamh district, Sharkia Governorate, Egypt. Fruits were harvested at 5 successive monthly intervals on the first of each of Dec., Jan., Feb., Mar. and Apr. for Washington navel orange. Valencia orange fruits were harvested one month later at five periods beginning with first Jan. and ending with first May. On each harvest date fruits of three trees (3 replicates) were harvested, counted and weighed. About 60 healthy undamaged fruits from each replicate were randomly selected for cold storage at 7°C±1 and 85-90% RH. Fruit samples selected at harvest day (15 fruits) and those taken at 30 days intervals from cold stored fruits were subjected to determine the effect of on-tree, cold storage and harvest date on physicochemical fruit characteristics. Washington navel orange gained the highest fruit weight, TSS/acid ratio, fruit weight loss and fruit decay percentages, whereas, Valencia orange produced higher fruit yields with higher vit. C content. Yield/ tree, fruit weight, TSS/ acid ratio and vit. C content were markedly decreased by delaying fruit harvest (on-trees fruits storage) and increasing storage period, but weight loss and decay percentages were increased. All possible interactions between the three tested factors were significant in the two seasons, and confirm the previously recorded trends of each individual factor on the tested physico-chemical fruit characteristics. The obtained results revealed that the storability of Valencia orange fruits was clearly better than that of Washington navel orange fruits, since weight loss and decay percentages of the later orange variety were about 2 and 15 folds than that of Valencia orange fruit, respectively (average of both seasons).

Key words: Harvest date; orange; storability; on-tree; cold storage; fruit decay.

INTRODUCTION

Citrus is one of the most important fruit crops in the world and ranked first among fruit crops in Egypt. The area growing with citrus in Egypt have enormously increased through the last decades reaching about 530415 fad., out of them 440706 fad., are fruitful producing about 4402180 tons with an average of 9.99 tons/fad. Sweet orange [*Citrus sinensis* (L.) Osbeck] is one of the most important citrus species. Total area of orange varieties occupy about 370087 fad., representing 69.77% of total citrus acreage, out of them 300949 fad., are fruitful producing 3135931 tons with an average of 10.42 tons/fad. The acreage of Washington navel orange reached 181,092 fad., representing 53.55% of orange acreage out of them 155,859 fad., are fruitful, producing about 1,663, 284 tons with an average of 10.67 tons/fad. The acreage of Valencia orange reached 145858 fad, representing 39.41% of orange acreage out of them 106862 fad., are fruitful, producing about 1030713 tons with an average of 9.65 tons/fad. (Statistics of the Ministry of Agriculture, 2014).

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Citrus fruits have a considerable postharvest storage potential but varietal differences exist in this case. Porat *et al.* (2004) reported that citrus fruits are relatively non-perishable, and can normally be stored for 6-8 weeks. However, the development of various types of rind disorders limits the post-harvest storage capability, and causes massive commercial losses. Since citrus fruits are non-climacteric and have low respiration rates and thus are quite enable to long-term storage. Citrus fruits are also low in starch reserves and thus undergo very slow changes in internal quality during storage (Batchelor and Bitters, 1954 ; Echeverria and Ismail, 1987).

Grapefruits and Valencia oranges can be stored for three to five months and green lemons even longer. Whereas, many easy peeling, mandarin-like cultivars cannot be store longer than a few weeks. Storage temperature also differ, since grapefruits are sensitive to chilling injury and should be stored at 10 to 16°C; oranges and mandarins are stored at lower temperatures (Grierson and Ben-Yehoshua, 1986). The most suitable storage temperature for Valencia orange fruits is 4°C under 85-90% RH. for about 5 months without significant loss of quality (Dundar and Pekmezci, 1991). Storage at 5°C and 85-90% relative humidity were the most suitable storage conditions for Washington navel orange cv. (Demirkol *et al.*, 2001).

The competitiveness of Egypt citrus sector is a function of quality control in the transformation of fresh fruits. The transformation process commences with the harvest, the timing of which significantly affects fruit quality. In many cases, citrus harvested at the optimum maturity stage have higher quality and higher demand (Caixeta-Filho, 2006).

Delaying citrus harvest influences fruit quality and reduce the subsequent year's yield (Davies and Albrigo, 1994 ; Ioannis *et al.*, 2008).

At present, the charting of on-tree ripening with a view to establish the optimum harvesting date is based purely on the measurement of external color together with occasional destructive measurement of internal quality parameters (Zude *et al.*, 2008).

Citrus growers are increasingly demanding rapid, cost-effective, and non-destructive methods for monitoring changes in physicochemical quality during on-tree ripening, with a view to establish the optimum harvest date. For mandarin producers, the critical decision regarding harvest date is based on perceived fruit ripeness, since the ripeness of harvested fruit has a major impact on its shelf life, quality and market price (Sanchez *et al.*, 2013).

This work was planned to evaluate the impact of harvest date, on-tree and cold fruit storage on: the amount of fruit yield/ tree through the current and subsequent season, the changes in physicochemical fruit characteristics either stored on tree or under standard cold conditions.

MATERIALS AND METHODS

This work was conducted during two successive seasons of 2013/2014 and 2014/2015 on 30 healthy 15-year-old trees of mature well managed orchards of Washington navel and Valencia oranges [*Citrus sinensis* (L.) Osbeck] cvs. grafted on sour orange rootstock. The experimental trees were grown in clay loam soil at 6 m apart (Washington navel orange) or 5 m apart (Valencia orange); orchard located at Menia El-Kamh district, Sharkia Governorate, Egypt. Fruit harvest was performed at five successive monthly intervals on the first of each of December, January, February, March and April for Washington navel orange. Valencia orange fruits were harvested one month later at five periods beginning with first January and ending with first May. On each harvest date, fruits of three trees (3 replicates) were harvested, counted and weighed. Average yield/ tree was then calculated as number of fruits or Kg/ tree. A fruit sample of 15 fruits from each replicate was randomly taken for physical and chemical fruit properties determinations at each harvest date. In addition, 60 healthy undamaged fruits from each replicate were randomly selected for cold storage at 7°C±1 and 85-90 % R.H. after being washed with water and air dried at room temperature.

Fruit samples selected at harvest day and those taken at 30 days intervals from cold storage were weighed. Cold stored fruits were individually weighed at the previous intervals to estimate weight loss and fruit decay percentages. Fruit weight loss percentage (FWL%) was calculated according to the following equation:

$$FWL(\%) = \frac{Wi - Ws}{Wi} \times 100$$

Where:

Wi= fruit weight at initial date, Ws= fruit weight at sampling date.

Decay percentage was estimated according to McCormack and Brown (1973) as follows:

$$Decay(\%) = \frac{Decayed\ fruits}{Initial\ fruits} \times 100$$

Five fruits from each sample were squeezed and the extracted juice was measured and used to estimate the titratable acidity percentage (as citric acid) was done in 5 ml fruit juice by titration against 0.1 N sodium hydroxide solution until reaching pink color using phenolphethalein indicator (AOAC, 2006). Total soluble solids percentage (TSS%) was estimated using a hand-held refractometer. TSS/ acid ratio was then calculated. Vitamin C content as mg ascorbic acid/100 ml juice was estimated by titration against 2, 6-dichlorophenol indophenol dye (AOAC, 2006).

It is worthy to say that tree yield in 2013/2014 season was determined as a basic yield without any previous treatment, thus it was not discussed. As for fruit yield at 2015/2016 season, it was estimated to evaluate the effect of the previously conducted harvest dates on tree yield without taking any samples. Therefore, tree yield in the last two seasons (2014-2015 and 2015/2016) was only discussed.

Statistical Analysis

This experiment was set in a completely randomized block design with 5 harvest dates; at each date fruits were collected from three trees (3 replicates) of both cultivars. The obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1980) using CO-STAT program. Differences between means were compared using Duncan's multiple range test at 0.05 level (Duncan, 1958).

RESULTS AND DISCUSSION

Effect of Harvest Date on Fruit Yield (kg/Tree) and Fruit No./Tree

As shown in Table 1 harvest date significantly affected fruit yield/tree in the two seasons. However, trees harvested on the first date produced the highest yield/tree (81.34 and 73.52 kg/tree ; the highest fruit number 364.33 and 417.50 fruit/tree) in the second and third seasons, respectively. The lowest fruit yield and number/tree (34.93 and 38.53 kg/tree ; 175.67 and 201.67 fruit/ tree) were recorded for trees harvested on the last date of harvest (5^{th} month) in the second and third seasons, respectively. The yield (Kg/tree) of trees harvested on the first date (December) for Washington navel orange and (January) for Valencia were 27.79, 28.32, 26.45 and 52.68% higher than those harvested on Jan., Feb., March and April, respectively (average of the last two seasons). This means that yield/ tree was significantly decreased with delaying fruit harvest (on-tree fruit storage) in the previous season.

There were significant varietal differences between the yields either as fruit number or Kg/ tree of Washington navel and Valencia orange trees in the last two seasons. Valencia orange trees produced higher yields (76.61 and 73.78 kg/ tree ; 443.27 and 489.33 fruit/tree) than those of Washington navel oranges (38.51 and 37.04 kg/ tree ; 161.33 and 171.00 fruit/tree) in the second and third seasons, respectively. Valencia orange trees produced fruit yield (Kg/ tree) 49.37 and 49.80% higher than that of Washington navel orange.

The interaction between harvest date and orange variety was significant in the two studied seasons. Anyhow, the uppermost fruitt yield and number/tree (110.14 and 85.97 kg/tree; 503.00 and 575.00 fruits/tree) was produced by Valencia orange trees harvested on the first date (January) in the second and third seasons, respectively, without significant differences among them and those harvested on February (80.48 kg/tree) in the third season only. Washington navel orange fruits harvested on February and April as well as those harvested on March in the third season recorded the lowest yield/ tree, either as Kg or No. of fruits/ tree.

Table 1. Effect of harvest date on yield (Kg or number of fruits/ tree) of Washington navel and Valencia orange trees during 2013/2014, 2014/2015 and 2015/2016 seasons

Hrvest date	First season (2013/2014)			Second season (2014/2015)			Third season (2015/2016)		
	Navel	Valencia	HD av.	Navel	Valencia	HD av.	Navel	Valencia	HD av.
				Fruit weight/ tree (Kg)					
First date	54.28b	58.45b	56.36b	52.54d	110.14a	81.34a	61.08c	85.97a	73.52a
Second date	30.38ef	40.34cd	35.36d	39.66e	67.81c	53.74c	35.67e	80.48ab	58.07b
Third date	77.34a	55.19b	66.26a	27.22f	85.52b	56.37bc	30.75ef	78.50b	54.62bc
Fourth date	34.73de	44.94c	39.84c	50.72d	72.10c	61.41b	26.38f	78.59b	52.48c
Fifth date	36.71d	28.14f	32.42d	22.40f	47.47de	34.93d	31.33ef	45.37d	38.35d
Dtaes av.	46.69a	45.41a		38.51b	76.61a		37.04b	73.78a	
				Fruit number/ tree					
First date	234.33e	426.00a	330.17a	225.67e	503.00b	364.33a	260d	575.00a	417.50a
Second date	140.33g	272.00d	206.17c	166.33f	454.67c	310.50c	135f	550.00b	342.50c
Third date	315.00c	369.33b	342.17a	115.00g	534.67a	324.83bc	130f	531.67c	330.83d
Fourth date	152.67g	299.00c	225.83b	213.67e	458.67c	336.17b	200e	516.67c	358.33b
Fifth date	158.33g	186.33f	172.33d	86.00h	265.33d	175.67d	130f	273.33d	201.67e
Dtaes av.	200.13b	310.53a		161.33b	443.27a		171.00b	489.33a	

Means in each column which have the same letter(s) are not significantly different.

The other combinations gained inbetween yield/ tree. However, the interaction between the two tested factors confirms the previous trends of each individual factor for yield/ tree. Since, yield of Valencia orange trees was higher than that of Washington navel orange ones throughout the 5th harvest date also, tree yield of both varieties was markedly decreased with delaying harvest date (storing fruits on the tree).

These findings were in agreement with those reported by El-Hammady *et al.* (2000) and Xiong *et al.* (2011), who reported that delaying picking date of Washington navel orange fruits decreased fruit set and total yield in the following season. Betancourt *et al.* (2014) stated that delaying grapefruit harvest caused an average reduction of 30% in fruit yield/ tree. In this respect, Hilgeman *et al.* (1967) reported that mature fruit on trees during blossoming had a more adverse effect on subsequent yield than during the fruit set interval. However, because of the high temperatures during late bloom, this situation may be specific for this particular year.

Effect of Harvest Date and Storage Period on Some Fruit Physico-Chemical Characteristics

Effect on fruit weight

It is quite evident from Table 2 that there were significant varietal differences in average fruit weight of Washington navel and Valencia oranges in the two seasons. Fruit weight of Washington navel orange (230.09 and 240.68g) was significantly higher than Valencia orange ones (165.56 and 161.43g) in the first and second seasons, respectively. Fruit weight of Washington navel orange trees was 28.05 and 32.93% higher than that of Valencia orange ones.

In both varieties, fruits harvested on the third harvest date recorded the highest weight (214.61 and 218.84g) in the two seasons, respectively, followed by those harvested on the second date (213.69 and 212.37g) without significant differences among them on the first season only. The lowest fruit weight (165.34 and

Table 2. Effect of harvest date and storage period on fruit weight (g) of Washington navel and Valencia orange fruits during 2013/2014 and 2014/2015 seasons

*Orange variety	** Harvest date	First season (2013/2014) ***Storage period (month) 0	1	2	3	4	5	Harvest date mean	Second season (2014/2015) Storage period (month) 0	1	2	3	4	5	Harvest date mean
Washington navel	Dec.	238.33^{jkl}	227.53m	250.67i	254.07^{ghi}	270.33^{cd}	242.33c	247.21c	236.00^{lmn}	255.57^{ij}	262.10^{fgh}	272.57^{defg}	285.47^{cd}	295.30^{bc}	267.83b
	Jan.	264.17^{ef}	235.83^{kl}	265.17^{de}	264.50e	288.47^{b}	238.17^{jkl}	259.38b	222.97^{no}	276.60^{de}	241.90^{klm}	253.80^{hijk}	298.60^{abc}	308.90^{a}	267.13b
	Febr.	267.13^{de}	237.93^{jkl}	252.60^{ghi}	256.54^{gh}	294.23^{b}	300.47^{a}	268.15a	231.97^{mno}	265.70^{efgh}	247.00^{jkl}	301.37^{ab}	293.57^{bc}	310.33^{a}	274.99a
	Mar.	233.67^{l}	258.03g	241.37^{jk}	258.30^{fg}	275.13c	0.00^{D}	211.08d	264.37^{efgh}	258.33^{hij}	248.30^{ijkl}	274.33^{def}	295.40^{bc}	0.00^{x}	223.46c
	Apr.	215.93^{n}	253.77^{ghi}	251.13^{hi}	266.77^{de}	0.00^{D}	0.00^{D}	164.60f	239.13^{lm}	261.40^{fghi}	260.57^{ghi}	259.00^{hij}	0.00^{x}	0.00^{x}	170.02d
Variety mean		243.85c	242.62c	252.19b	260.04a	225.63d	156.19gh	230.09A	238.89d	263.52b	251.97c	272.21a	234.61d	182.91f	240.68A
Valencia	Jan.	165.20^{wxy}	167.43^{vwx}	187.50^{op}	158.37^{zAB}	177.47^{rst}	151.53^{C}	167.92e	127.67^{w}	124.17^{w}	124.33^{w}	185.00^{rst}	219.07^{op}	171.17^{u}	158.57f
	Feb.	172.53^{tuv}	173.30^{tu}	181.93^{pqr}	162.00^{xyzA}	162.27^{xyzA}	155.97^{bc}	168.00e	135.70^{w}	128.23^{w}	128.23^{w}	178.23^{stu}	195.27^{qr}	180.03^{stu}	157.62f
	Mar.	127.97^{C}	171.27^{uv}	185.00^{opq}	154.93^{BC}	170.70^{uvw}	156.57^{ABC}	161.07g	152.77^{v}	128.63^{w}	128.63^{w}	186.53^{rst}	205.93^{pq}	173.67^{tu}	162.69ef
	Apr.	165.23^{wxy}	170.93^{uvw}	189.10o	150.87^{C}	160.33^{yzAB}	151.93^{C}	164.73f	171.67^{u}	129.83^{w}	127.83^{w}	174.97^{tu}	190.33^{rs}	176.27^{tu}	161.82ef
	May	162.45^{xyz}	166.93^{vwx}	180.77^{qrs}	150.87^{C}	175.33^{stu}	160.07^{yzAB}	166.07ef	176.50^{tu}	132.43^{w}	132.43^{w}	182.73^{rstu}	203.57^{q}	171.00^{u}	166.44de
Variety mean		158.68g	169.79f	184.86e	155.41h	196.22f	155.21h	165.56B	152.86h	128.66i	128.29i	181.49f	202.83e	174.43g	161.43B

Table 2. Cont. Interaction between storage period and harvest date

First date	201.77kl	197.48m	219.08d	206.22ij	223.90c	196.93m	207.56B	181.83mn	189.87jklmn	193.22ijkl	228.78de	252.27a	233.23cd	213.20B
Second date	218.35de	204.57jk	223.55c	213.25fg	225.37bc	197.07m	213.69A	179.33n	202.42hi	185.07lmn	216.02fg	246.93ab	244.47ab	212.37B
Third date	197.55m	204.60jk	218.80d	205.74jk	232.47a	228.52cd	214.61A	192.37jkl	197.17ij	187.82klmn	243.95ab	249.75ab	242.00bc	218.84A
Fourth date	199.45lm	214.48ef	215.23def	204.58jk	217.73de	75.97p	187.91C	218.02f	194.08ijkl	188.07jklmn	224.65def	242.87b	88.13p	192.64C
Fifth date	189.20n	210.35gh	215.95def	208.82hi	87.67o	80.03p	165.34D	207.82gh	196.92ijk	196.50ijk	220.87ef	101.78o	85.50p	168.23D
Storage per. av.	201.26C	206.37B	218.52A	207.72B	197.43D	155.70E		195.87C	196.09C	190.13D	226.85A	218.72B	178.67E	

*Orange variety= V **Harvest date= H ***Storage period= S

Means in each column which have the same letter(s) are not significantly different.

168.23 g) were recorded for fruits harvested on the fifth date. The other harvest dates resulted in intermediate fruit weight values. This means that fruit weight was gradually increased until the third month (February for Navel and March for Valencia orange), then markedly decreased reaching its minimum value by the fifth month.

Concerning the effect of storage period, the results showed that the fruit weights of Washington navel and Valencia orange trees were significantly affected by storage period in the two seasons. Anyhow, the highest fruit weight (218.52 and 226.85g) was recorded for fruits stored until the second and third periods in the first and second seasons, respectively, compared with those stored until the fifth storage period (155.70 and 178.67g) which gained the lowest fruit weight in the two seasons, respectively. This showed that fruit weight was significantly reduced with increasing storage period.

The interaction among orange variety and harvest date was significant in the two seasons. Fruits of Washington navel orange harvested on February gained the highest fruit weight (268.15 and 274.99 g) in the first and second seasons, respectively. The lowest fruit weights were recorded for fruits of Valencia orange harvested in all times. The other combinations exhibited intermediate fruit weight values.

The interaction between orange variety and storage period was significant in the two seasons. The highest fruit weight (260.04 and 272.21 g) were recorded for Washington navel orange fruits stored until the third period in the two seasons, respectively. The fruit weight of Valencia orange stored until the third and fifth periods (155.41 and 155.21g) and those of Washington navel orange stored until the fifth period (156.19 g) recorded the lowest fruit weights in the first season. While, in the second season Valencia orange fruits stored until the first and second periods gave the lowest fruit weight (128.66 and 128.29g), respectively. The other combinations produced inbetween fruit weight values.

The interaction between harvest date and storage period was significant in the two seasons. Fruits harvested on the fourth and fifth dates and stored until the fifth period gained the lowest fruit weight (75.97 ; 80.03 and 88.13 ; 85.50g) in the first and second seasons, respectively. The highest fruit weight (232.74 g) was recorded for fruits harvested on the third date and stored until the fourth period in the first season. In the second season, the combinations of fruits on the first, second and third dates and stored until the fourth period (252.27, 246.93 and 249.75g), second dates with fifth period (244.47g) and third date with third period (243.95g) recorded the highest fruit weight, without significant differences between them. The other combinations gained intermediate fruit weights.

The interaction among the three tested factors was significant in the two seasons. Higher fruit weight (300.47g) in the first season was recorded for fruits of Washington navel orange harvested on February and stored until the fifth period. Whereas, the combinations of Washington navel orange fruits harvested on February and stored until the fifth and third periods (310.33 and 301.37g) and those harvested on January and stored until the fifth and fourth periods (308.90 and 298.60g), respectively, exhibited the highest fruit weight in the second one without significant differences between them. Navel orange fruits harvested on March (the fourth date) and stored until the fifth period and those harvested on April and stored until the fourth and fifth periods were entirely damaged and discarded. The lowest fruit weight was gained by Valencia orange trees harvested on March at zero time (127.97g) in the first season and those harvested on January and stored until the first period (124.17g) in the second season, without significant differences between them and most of the other combinations. The other combinations produced inbetween fruit weights.

These results were in line with those of Al-Nakib (1979) and Cepeda *et al.* (1993) who reported that the fruit weight of Marsh grapefruit and sweet oranges were increased as the fruits remained on the tree after maturity. In addition, Al-Hassan (2013) observed that late Valencia orange fruit weight was higher in half ripened stage than maturity green one. Beside, Hilgeman *et al.* (1967) declared that the percentage of No. 1 grade fruit was always higher in fruit harvested on February than May.

The deterioration in grade between February and May caused chiefly by the development of coarse, rough, pebbly peel texture and regreening of fruit peel.

Tss/Acid Ratio

It is clear from Table 3 that TSS/acid ratio in fruits of the two varieties was significantly affected in both seasons. TSS/Acid ratio in Washington navel orange fruits was higher (13.21 and 14.01%) than that of Valencia orange (11.44 and 8.13%) in the two seasons, respectively.

TSS/acid ratio in fruit juice was significantly decreased with delaying harvest date in both seasons. The uppermost TSS / acid ratio (13.70 and 11.59%) were detected after the second month of harvest date in both seasons. The least TSS/acid ratio (11.72%) was recorded at the fourth harvest date in the first season and the fifth month in the second one (9.82%). Generally, TSS/ acid ratio in fruit juice was steadily increased until the second harvest date, then gradually decreased reaching its minimum value at the last date of harvest.

Results indicated also that, storage period significantly affected TSS / acid ratio without distinct trend in both seasons.

The interaction between orange variety and harvest date was significant in the two seasons. However, this interaction certains the previously mentioned trend of each individual factor on TSS/ acid ratio. Results revealed that the interaction between orange variety and storage period was significant in both seasons and confirms the trend of each individual factor on TSS/ acid ratio in most cases.

The interactions between harvest date and storage period was significant in both seasons. The lowest values of TSS/acid ratio were recorded for the fruits harvested on the fourth and the fifth dates and stored for three and four months in both seasons. The fruits harvested on the second and third date and stored for four months in the first season and those harvested on the fourth date and stored for two months gained the highest TSS/acid ratio.

The triple interaction among variety, harvest date and storage period was significant in both seasons and support the previously mentioned trend of each individual factor on TSS/ acid ratio.

Similar trends were confirmed by those of Gilfillan *et al.* (1971) on Valencia oranges, Abdel-Latief (1975) and Al-Nakib (1979) on pink March grapefruit and Khalil (1990) on Washington navel orange who reported that advancing the harvest date and cold storage increases the TSS/ acid ratio in fruits juice. Echeverria and Ismail (1987) reported that TSS/ acid ratio was increased for "Hamlin" and "Robinson" oranges and remained unchanged for "Marsh" orange fruits during cold storage.

Iglesias and Echeverria (2009) stated that the increase in TSS/Acid ratio affected fruit taste due to lower acidity and higher sweetness. During storage of orange fruits, organic acids decreased faster than sugars, so that the fruit was predicted to be slightly sweeter. TSS/acid ratio increased by 10% along with a 20-folds increase in ethanol (Samson, 1986 ; Echeverria and Ismail, 1990).

Effect on Vitamin C Content

As shown in Table 4 significant varietal differences were detected in ascorbic acid (vitam. C) content in the fruit juice in both seasons. Fruits of Valencia orange contained higher vitam. C (33.42 and 37.38 mg/100 ml juice) than those of Washington navel orange (23.11 and 27.58 mg/100 ml juice) in the first and second seasons, respectively.

The results showed also that vitam. C content was significantly affected by harvest dates in the two seasons. The highest content of vitam. C was found in fruit juice of fruits harvested on the first two dates (32.75 and 32.98 mg/100ml juice) on the first season and (34.91 and 33.96 mg/100 ml juice) and those harvested on the third date (34.27 mg/100 ml juice) without significant differences among them in the second season, respectively. The lowest vitam. C content was recorded for fruits harvested on the fifth date (22.03 and 28.05 mg/100 ml juice) in the two seasons, respectively. This means that vitam. C content in juice of orange fruits was decreased by on-tree fruit storage (delaying fruit harvest).

Table 3. Effect of harvest date and storage period on fruit TSS/acid ratio of Washington navel and Valencia orange fruits during 2013/2014 and 2014/2015 seasons

*Orange variety	** H.D	First season (2013/2014) ***Storage period (month) 0	1	2	3	4	5	H.D mean	Second season (2014/2015) Storage period (month) 0	1	2	3	4	5	H.D mean
Washington navel	Dec.	11.02^{stuvwxy}	21.44^{ab}	12.09^{opqrstu}	10.18^{uvwxyz}	14.25^{ijklm}	17.78^{cde}	14.46b	12.14^{klm}	13.76^{ijk}	15.77^{efgh}	14.97^{ghi}	15.62^{fgh}	16.56^{defg}	14.80b
	Jan.	22.45^{a}	16.86^{ef}	11.90^{pqrstuv}	11.43^{qrstuvwx}	16.45^{efg}	22.65^{a}	16.96a	14.39^{hij}	15.09^{ghi}	17.44^{cdef}	17.32^{cdef}	19.33^{b}	10.85^{lmnop}	15.74a
	Feb.	16.26^{efgh}	11.53^{qrstuvw}	12.84^{klmnopqrs}	14.44^{hijkl}	15.51^{fghi}	14.36^{hijklm}	14.16b	12.47^{klm}	14.53^{hij}	18.30^{bcd}	18.67^{bc}	21.49^{a}	11.42^{lmno}	16.15a
	Mar.	11.33^{qrstuvwx}	12.76^{lmnopqrs}	14.08^{ijklmn}	14.73^{hijklm}	13.25^{ijklmnopq}	0.00^{F}	10.96d	11.37^{lmno}	15.90^{efgh}	21.67^{a}	17.81^{bcd}	12.10^{klmn}	0.00A	13.14c
	Apr.	13.78^{ijklmnop}	12.89^{jklmnopqrs}	16.33^{efgh}	14.00^{ijklmno}	0.00^{F}	0.00^{F}	9.50e	18.74^{bc}	16.88^{def}	8.26^{rstu}	17.47^{cde}	0.00A	0.00A	10.23d
Variety mean		14.97b	15.09b	13.45c	12.88cd	11.89e	10.96f	13.21A	13.82d	15.23c	16.29b	17.25a	13.71d	7.77fg	14.01A
Valencia	Jan.	10.16^{uvwxyz}	8.30^{zABCDE}	6.20^{E}	7.66^{CDE}	9.98^{vwxyzA}	13.15^{jklmnopqr}	9.24e	6.56^{uvwxy}	6.51^{uvwxy}	6.79^{tuvwx}	9.48^{pqr}	12.55^{klm}	5.81^{xwy}	7.95f
	Feb.	7.61^{CDE}	6.68^{DE}	12.08^{opqrstu}	9.28^{yzABC}	12.20^{nopqrst}	14.83^{ghi}	10.45d	8.42^{rst}	6.39^{vwxy}	6.39^{vwxy}	11.03^{mnop}	3.91^{z}	8.51^{rst}	7.44fg
	Mar.	7.91^{BCDE}	7.92^{BCDE}	9.53^{xyzABC}	10.76^{tuvwxy}	9.69^{wxyzAB}	17.43^{def}	10.54d	6.78^{tuvwx}	6.52^{uvwxy}	7.18^{stuvwx}	4.87^{yz}	7.71^{rstuv}	7.52^{stuvw}	6.76g
	Apr.	8.75^{zABC}	8.05^{ABCDE}	14.50^{ghijkl}	9.69^{wxyzAB}	14.13^{ijklmn}	19.69^{bc}	12.47c	8.83^{qrs}	10.32^{opq}	10.32^{opq}	7.78^{rstuv}	5.53^{xyz}	11.77^{lmno}	9.09e
	May	17.42^{def}	11.20^{rstuvwxy}	12.41^{mnopqrst}	11.97^{pqrstu}	14.74^{ghijk}	19.17^{cd}	14.48b	12.88^{jkl}	10.36^{nopq}	10.37^{nopq}	7.88^{rstuv}	6.50^{uvwxy}	8.44^{rst}	9.41e
Variety mean		10.37fg	8.43h	10.94f	9.87g	12.15de	16.85a	11.44B	8.69e	8.02efg	8.21ef	8.21ef	7.24g	8.41ef	8.13B

Table 3. Cont. Interaction between storage period and harvest date

First date	10.59^{ijkl}	14.87^{bcd}	9.15^{lm}	8.92^{m}	12.12^{gh}	15.46^{bc}	11.85BC	9.35^{no}	10.13^{klmn}	11.28^{hijkl}	12.22^{fgh}	14.09^{bc}	11.19^{hijkl}	11.38AB
Second date	15.^{03bcd}	11.77^{ghi}	11.99^{gh}	10.36^{jkl}	14.33^{cde}	18.74a	13.70A	11.40^{hijk}	10.74^{ikjlm}	11.91^{fghi}	14.18^{cd}	11.62^{ghij}	9.68^{mno}	11.59A
Third date	12.09^{gh}	9.73^{klm}	11.19^{hij}	12.60^{fg}	12.60^{fg}	15.89b	12.35B	9.62^{mno}	10.52^{jklmn}	12.74^{efg}	11.77^{ghij}	14.60^{bc}	9.74^{no}	11.46AB
Fourth date	10.04^{jklm}	10.41^{jklm}	14.29^{cde}	12.03^{gh}	13.69^{def}	9.84^{jklm}	11.72C	10.10^{lmn}	13.11^{def}	15.99^{a}	12.80^{efg}	8.82^{o}	5.88^{p}	11.12B
Fifth date	15.60^{bc}	12.04^{gh}	14.37^{cde}	12.98^{efg}	7.37n	9.58^{klm}	11.99BC	15.81^{ab}	13.62^{cde}	9.31^{no}	12.67^{efg}	3.25^{q}	4.22^{q}	9.82C
Storage per. average	12.67B	11.76CD	12.20BC	11.38D	12.02BCD	13.90A		11.26C	11.63BC	12.25AB	12.73A	10.47D	8.09E	

*Orange variety= V **Harvest date= H ***Storage period= S

Means in each column which have the same letter(s) are not significantly different.

Table 4. Effect of harvest date and storage period on Vitam. C content (mg/100 ml juice) of Washington navel and Valencia orange fruits during 2013/2014 and 2014/2015 seasons

*Orange variety	** H.D	First season (2013/2014) ***Storage period (month) 0	1	2	3	4	5	H.D mean	Second season (2014/2015) Storage period(month) 0	1	2	3	4	5	H.D mean
Washington navel	Dec.	28.27^{klmnopq}	30.72^{ijklmno}	35.20^{fghi}	26.56^{nopqrs}	28.80^{jklmnopq}	26.45^{nopqrs}	29.33c	52.56^{b}	31.21^{opq}	26.15^{rstu}	24.00^{tuvwx}	53.52^{b}	23.05^{tuvwxy}	35.08b
	Jan.	32.53^{hijkl}	32.64^{hijk}	31.36^{ijklmn}	20.99^{tuv}	28.48^{klmnopq}	24.00^{qrstuv}	28.33c	43.52^{defg}	26.24^{qrstu}	26.56^{qrstu}	42.56^{defgh}	20.52^{vwxyz}	24.32^{tuvw}	30.62c
	Feb.	31.87^{hijklm}	23.52^{rstuv}	25.60^{pqrst}	26.25^{opqrs}	15.51^{wx}	19.87^{uvw}	23.77d	33.28^{mnop}	26.88^{qrstu}	42.56^{defgh}	20.75^{vwxyz}	22.56^{uvwxy}	31.04^{opqr}	29.51c
	Mar.	40.97^{cde}	23.03^{rstuv}	24.00^{qrstuv}	12.51^{x}	19.52^{vx}	0.00^{y}	20.00e	24.96^{stuv}	53.44^{b}	19.52^{wxyz}	22.17^{uvwxy}	26.90^{qrstu}	0.00A	24.50d
	Apr.	26.80^{nopqrs}	26.08^{opqrs}	19.52^{vw}	12.37^{x}	0.00^{y}	0.00^{y}	14.13f	41.92^{defghi}	24.01^{tuvwx}	24.32^{tuvw}	19.00^{xyz}	0.00A	0.00A	18.21e
Variety mean		32.09cd	27.20e	27.14e	19.74f	18.46f	14.06g	23.11B	39.25a	32.36bc	27.82d	25.70ef	24.70e	15.68f	27.58B
Valencia	Jan.	32.08^{hijkl}	45.76^{abc}	38.72^{def}	34.88^{fghi}	39.65^{def}	25.92^{opqrst}	36.17a	29.76^{pqrs}	37.44^{ijklmn}	45.76^{cde}	39.80^{fghijk}	18.88^{yz}	36.80^{jklmn}	34.74b
	Feb.	46.73^{ab}	40.64^{de}	33.60^{ghij}	41.92^{bcd}	29.76^{jklmnop}	33.09^{ghijk}	37.62a	29.44^{pqrs}	41.29^{efghij}	62.52^{a}	16.64^{z}	32.90^{nop}	40.97^{efghijk}	37.29a
	Mar.	39.39^{def}	38.08^{defg}	36.80^{efgh}	32.00^{hijkl}	31.36^{ijklmn}	24.00^{qrstuv}	33.60b	36.32^{jklmn}	50.49^{bc}	16.64^{z}	49.60^{bc}	42.28^{defghi}	38.87^{ghijkl}	39.03a
	Apr.	30.51^{jklmnop}	40.96^{cde}	28.32^{klmnopq}	28.80^{jklmnopq}	27.20^{lmnopqr}	22.77^{rstuv}	29.76c	38.11^{hijkln}	27.60^{qrst}	34.24^{lmnop}	49.92^{bc}	37.76^{hijklmn}	39.95^{fghijk}	37.93a
	May	26.88^{mnopqrs}	48.91^{a}	27.36^{lmnopqr}	29.76^{jklmnop}	24.64^{qrstu}	22.08^{stuv}	29.94c	19.24^{xyz}	44.03^{def}	40.96^{efghijk}	46.68^{ed}	36.00^{klmno}	40.44^{fghijk}	37.89a
Variety mean		35.12b	42.87a	32.96bcd	33.47bc	30.52d	25.57e	33.42A	30.57c	40.17a	40.02a	40.53a	33.56b	39.40a	37.38A

Table 4. Cont. Interaction between storage period and harvest date

First date	30.17^{fgh}	38.24^{ab}	36.96^{abc}	30.72^{efg}	34.23^{cde}	26.19ij	32.75A	41.16^{ab}	34.33^{defghi}	35.96^{cdefg}	31.90^{hijk}	36.20^{cde}	29.93^{kl}	34.91A
Second date	39.63a	36.64^{abc}	32.48^{def}	31.45^{efg}	29.12^{fghi}	28.55^{ghi}	32.98A	36.48^{cd}	33.77^{defghij}	44.54^{a}	29.60^{kl}	26.71^{l}	32.64^{fghijk}	33.96A
Third date	35.63^{bcd}	30.80^{efg}	31.20^{efg}	29.13^{fghi}	23.44^{jk}	21.93^{k}	28.69B	34.80^{defghi}	38.69^{bc}	29.60^{kl}	35.18^{cdefgh}	32.42^{ghijk}	34.95^{dfghi}	34.27A
Fourth date	35.74^{bcd}	31.99^{efg}	26.16^{ij}	20.65k	23.36^{jk}	11.39l	24.88C	31.53^{ijk}	40.52^{b}	26.88^{l}	36.04^{cdef}	32.33^{hijk}	19.97^{m}	31.21B
Fifth date	26.84^{efg}	37.49^{abc}	23.44^{jk}	21.07k	12.32l	11.04l	22.03D	30.58^{jk}	34.02^{defghij}	32.64^{fghijk}	32.84^{efghijk}	18.00^{m}	20.22^{m}	28.05C
Storage per. Average	33.60B	35.03A	30.05C	26.60D	24.49E	19.82F		34.91AB	36.26A	33.92BC	33.11C	29.13D	27.54E	

*Orange variety= V **Harvest date= H ***Storage period= S

Means in each column which have the same letter(s) are not significantly different.

Storage period exhibited significant effect on vitam. C content in the two tested seasons. The highest vitam. C content (35.03 and 36.26 mg/100 ml juice) was recorded for fruits stored until the first period, followed by those of zero time (33.60 and 34.91 mg/100 ml juice) in the first and second seasons, respectively. Fruits stored until the fifth (last) period contained the lowest vitam. C content (19.82 and 27.54 mg/ 100 ml juice) in the two seasons, respectively. Fruits stored during the other dates differed in vitam. C contents in both seasons. This show that vitam. C in orange fruits was markedly decreased with increasing storage duration, since, it was reduced by 38.60 and 24.05% at the last storage period compared to the first one.

The interaction between orange variety and harvest date was significant in the two seasons. The highest contents of vitam. C resulted from Valencia orange fruits harvested on Feb. and Jan. (37.62 and 36.17 mg/100 ml juice) in the first season and those harvested on Feb., March, April and May (37.29, 39.03, 37.93 and 37.89 mg/100 ml juice) in the second one, respectively without significant differences among them. The lowest contents of vitam. C (14.13 and 18.21 mg/100 ml juice) were recorded for Washington navel orange fruit harvested on April in the two seasons, respectively. Generally, fruits of Valencia orange harvested on all dates contained higher vitam. C than those of Washington navel orange in the two seasons. Also, in both varieties vitam. C content decreased with delaying harvest date. The other interactions gained intermediate vitam. C contents in the two seasons.

The interaction between orange variety and storage period was significant in the two seasons. However, the highest vitam. C contents were recorded for Valencia orange fruits stored until the first period (42.87 mg/100 ml juice) in the first season and those stored until the third period (40.53 mg/100 ml juice) in the second one, as well as those stored until the first, second, third and fifth periods (40.17, 40.02 and 39.40 mg/100 ml juice), beside Navel orange fruits at zero time (39.25 mg/100 ml juice), without significant differences between them in the second season. Whereas, the lowest vitam. C content (14.06 and 15.68 mg/100 ml juice) was gained by fruits of Washington navel orange stored until the last period in the first and second seasons, respectively. The other interactions produced inbetween vitam. C contents with significant differences between them in most cases.

The interaction between harvest date and storage period was significant in the two seasons. The lowest vitam. C contents were gained by fruits harvested on the fourth date and stored until the last period (11.39 and 19.97 mg/100 ml juice), and those harvested on the fifth date and stored until fourth and fifth periods (12.32 and 11.04 and 18.00 and 20.22 mg/100 ml juice) in the first and second seasons, respectively without significant differences between them. The highest vitam. C content was recorded for fruits harvested on the second date at zero time (39.63 mg/100 ml juice) and those harvested on the first, second and fifth dates and stored until the first period (38.24, 36.64 and 37.49 mg/100 ml juice), respectively without significant differences between them on the first season. In the second season, fruits harvested on the second date and stored until the second period and those harvested and stored on the first date and period gained the highest values (44.54 and 41.16 mg/ 100 ml juice), respectively. The other interactions exhibited intermediate vitam. C contents.

The interaction among the tested three factors (orange variety, harvest date and storage period) was significant in the two seasons. The highest vitam. C contents (48.91 and 46.73 mg/100 ml juice) were recorded for the interactions (Valencia orange × last date × first period) and (Valencia orange × Feb. × zero time) in the first season, respectively, as well as (Valencia orange × Feb. × second period) (62.52 mg/100 ml juice) in the second season. The lowest vitam. C contents were detected in fruits of Washington navel orange harvested on March and April dates during the third period (12.51 and 12.37 mg/100 ml juice) in the first season, respectively and those of Valencia orange harvested on March and stored until the second period (16.64 mg/100 ml juice) in the second one. Fruits of Navel orange harvested on March and stored until the fifth period and those harvested on April and stored until the fourth and fifth periods were damaged and discarded. The other combinations gained intermediate

vitam. C contents, with significant differences between most of them in the two seasons.

The obtained findings are entirely agree with those reported by Harding *et al.* (1940), Sinha *et al.* (1962), Abdel-Latif (1975) and Cepeda *et al.* (1993) who mentioned that ascorbic acid content of citrus fruits decreased with the maturity, especially in late Valencia orange.

Roongruangsri *et al.* (2013) and Hassan *et al.* (2014) reported that the cold stored citrus fruits revealed gradual degradation in vitam. C content under 4-5°C conditions.

The loss of vitamin C by about 10-20% in usual handling and marketing practices of fresh fruit was common (Wills *et al.*, 2007). Various reports had shown that vitamin C decreased under ambient and refrigerated conditions during storage and storage resulted in the higher vitamin C loss of citrus fruit such as blood orange, sweet orange and mandarin (Ting and Attaway, 1971, Raspisarda *et al.*, 2001 and Rajwana *et al.*, 2010). Vitamin C loss was more rapid at higher temperatures storage, since, it was decreased slower at 5°C than at 15°C (Wills *et al.*, 1984 ; Izumi *et al.*, 1990).

Effect on Fruit Weight Loss Percentage

Results in Table 5 reveal that weight loss percentage was significantly differed between the two tested orange varieties in the two seasons. Anyhow, fruits of Valencia orange showed the lowest fruit weight loss percentage (0.66 and 1.47%) as compared with those of Washington navel orange (1.81 and 2.31%), in the first and second seasons, respectively. Weight loss percentage in Washington navel orange fruits was about two folds (2.74 and 1.57%) that of Valencia orange in both seasons, respectively.

Harvest date significantly affected fruit weight loss percentage throughout the studied seasons. However, fruits harvested on the first date showed the lowest weight loss percentage (0.79 and 1.09%) in the first and second seasons, respectively, followed by those harvested on the second date (0.89%) without significant differences between them in the first season only. The highest fruit weight loss percentage was recorded for fruits harvested on the fourth date in the first season (1.75%) and the third, second and fourth dates in the second one (2.27, 2.12 and 2.03%), respectively.

The results show also that fruit weight loss percentage was significantly affected by storage period in the two seasons. The highest weight loss percentage was recorded for fruits stored until the third period (3.17 and 2.82 %) in the first and second seasons, respectively and those stored until the second period (2.68%) without significant differences between them in the second season only. Fruits stored until the fifth period exhibited the lowest weight loss percentage (0.57 and 1.67%) than those stored until each of the second, fourth and fifth periods in the two seasons.

It is worthy to notice that weight loss percentage was low in first two periods of fruit storage, and then increased sharply during the third period to decrease again through the last two periods reaching its minimum value at the fifth (last) period.

The interaction between orange variety and harvest date was significant in the two tested seasons. Anyhow, the lowermost fruit weight loss percentage (0.26 and 1.09 %) was recorded for Valencia orange fruits harvested on Jan. in the two seasons, respectively and those harvested on Feb. (0.41%) in the first season and both Apr. and May (1.48 and 1.28%) without significant differences between them in the second season, respectively. The uppermost percentages (2.49 and 2.44%) were recorded for fruits of Washington navel orange fruits harvested on February and March in the first season, respectively, and those harvested on Jan., Mar. and Apr. (2.42, 2.58 and 2.63 %) in the second one without significant differences between them. The other combinations produced inbetween fruit weight loss percentages.

The interaction between orange variety and storage period was significant in the two seasons and support the previous effect factor of individual factor on the considered parameter. Since, Washington navel orange fruits stored until the third period (5.00%) and the second one (3.58%) gained the highest fruit weight loss percentage in the two seasons, respectively and those stored until the first period (3.30%) without significant difference between them in the second season only. Fruits of the other combinations showed intermediate significantly different fruit weight loss percentages. The lowest weight loss percentages were recorded for both orange varieties at the last (fifth) storage period in the two seasons.

Table 5. Effect of harvest date and storage period on fruit weight loss percentage of Washington navel and Valencia orange fruits during 2013/2014-2014/2015 seasons

* Orange variety	** H.D	First season (2013/2014) ***Storage period (month)						H.D mean	Second season (2014/2015) Storage period (month)						H.D mean
		0	1	2	3	4	5		0	1	2	3	4	5	
Washington navel	Dec.	0.00^{p}	$0.70^{jklmnop}$	0.22^{nop}	1.20^{hijk}	5.53^{cd}	0.24^{nop}	1.31b	0.0^{o}	1.15^{mno}	1.15^{mno}	1.10^{mno}	1.84^{jklmn}	1.34^{lmn}	1.10e
	Jan.	0.00^{p}	$0.89^{hijklmno}$	0.15^{op}	5.34^{d}	$0.57^{jklmnop}$	1.24^{hij}	1.36b	0.0^{o}	2.32^{hijklm}	2.32^{hijklm}	3.49^{fgh}	$2.53^{ghijklm}$	3.88^{def}	2.42a
	Feb.	0.00^{p}	1.07^{hijklm}	0.51^{klmnop}	6.78^{a}	5.64^{cd}	$0.94^{hijklmn}$	2.49a	0.0^{o}	$2.12^{hijklmn}$	3.57efg	4.53^{cd}	2.83^{fghijk}	3.57^{efg}	2.77s
	Mar.	0.00^{p}	1.22^{hij}	1.27^{hi}	5.97^{bc}	6.21^{b}	0.00^{p}	2.44a	0.0^{o}	4.85^{c}	4.11^{cde}	3.07^{fghi}	3.46^{fgh}	0.00^{o}	2.58ab
	Apr.	0.00^{p}	1.12^{hijkl}	1.83^{fg}	5.71^{cd}	0.00^{p}	0.00^{p}	1.44b	0.0^{o}	6.04^{b}	6.76^{a}	2.97^{fghij}	0.00^{o}	0.00^{o}	2.63ab
Variety mean		0.0g	1.00d	0.80e	5.00a	3.59b	0.48f	1.81A	0.0e	3.30ab	3.58a	3.03b	2.13c	1.85d	2.31A
Valencia	Jan.	0.00^{p}	0.22^{nop}	$0.64^{ijklmnop}$	0.26^{nop}	0.22^{nop}	0.24^{nop}	0.26f	0.0^{o}	0.79^{no}	1.03^{mno}	2.32^{hijklm}	1.12^{mno}	1.29^{lmn}	1.09e
	Feb.	0.00^{p}	0.37^{nop}	$0.64^{ijklmnop}$	0.48^{lmnop}	0.53^{klmnop}	0.41^{mnop}	0.41f	0.0^{o}	2.07^{ijklmn}	2.04^{ijklmn}	3.19^{efghi}	2.20^{hijklm}	1.34^{lmn}	1.81c
	Mar.	0.00^{p}	0.32^{nop}	0.49^{lmnop}	1.51^{gh}	0.37^{nop}	1.15^{hijkl}	0.64e	0.0^{o}	1.44^{lmn}	1.25^{lmn}	3.68^{def}	1.60^{klmn}	1.69^{klmn}	1.61cd
	Apr.	0.00^{p}	1.90^{fg}	0.25^{nop}	2.06^{ef}	1.42^{gh}	$0.76^{ijklmnop}$	1.07c	0.0^{o}	1.55^{lmn}	2.69^{ghijkl}	1.87^{jklmn}	0.92^{no}	1.85^{jklmn}	1.48de
	May	0.00^{p}	$0.62^{jklmnop}$	$0.60^{ijklmnop}$	2.35^{e}	1.17^{hijkl}	$0.68^{ijklmnop}$	0.91d	0.0^{o}	1.67^{klmn}	1.85^{jklmn}	1.45^{lmn}	1.42^{lmn}	1.28^{lmn}	1.28de
Variety mean		0.0g	0.68ef	0.53f	1.33c	0.74e	0.65ef	0.66B	0.0e	1.50d	1.77d	2.61c	1.45d	1.49d	1.47B

Table 5. Cont. Interaction between storage period and harvest date

First date	0.00i	0.46fgh	0.43fghi	0.73efg	2.88b	0.24hi	0.79D	0.00k	0.97ij	1.09ij	1.71gh	1.48hi	1.32hij	1.09C
Second date	0.00i	0.63fgh	0.40ghi	2.91b	0.55fgh	0.83ef	0.89D	0.00k	2.20efg	2.18efg	3.34bc	2.37efg	2.61de	2.12A
Third date	0.00i	0.69efg	0.50fgh	4.14a	3.01b	1.05de	1.57B	0.00k	1.78fgh	2.41de	4.11a	2.21efg	2.85cde	2.27A
Fourth date	0.00i	1.56c	0.76efg	4.02a	3.82a	0.38ghi	1.75A	0.00k	3.20cd	3.40bc	2.47def	2.19efg	0.93ij	2.03A
Fifth date	0.00i	0.87ef	1.22d	4.03a	0.59fgh	0.34ghi	1.17C	0.00k	3.86ab	4.31ab	2.21efg	0.71j	0.64j	1.95B
Storage per. average	0.0E	0.84C	0.66D	3.17A	2.17B	0.57D		0.0E	2.40B	2.68A	2.82A	1.79C	1.67D	

*Orange variety= V **Harvest date= H ***Storage period= S

Means in each column which have the same letter(s) are not significantly different.

The interaction between harvest date and storage period was significant in the two seasons. The highest weight loss percentages (4.14 and 4.31%) were recorded for fruits harvested on the third date and stored until the third period and the fifth date during the second period in the first and second seasons, respectively. Fruits harvested on the third and fourth dates and stored until the same periods (4.02 and 3.82%) and the fifth date during the third period (4.03%) in the first season and those harvested on the third date and period (4.11%) and the fifth date during the first period (3.86%) in the second one showed the highest values without significant differences between them. The other combinations gained inbetween fruit weight loss percentages.

The interaction between the three tested factors was also significant in the two seasons. The highest weight loss percentages (6.78 and 6.76%) were induced by the interactions among Washington navel × Feb. × third period and Washington navel x Apr. x second period in the first and second seasons, respectively, followed by those among Washington navel orange × March and April × third period (5.97 and 5.71%) in the first season and those × April and March × first period (6.04 and 4.85%) in the second one, respectively. Fruits of Navel orange which harvested on March and stored until the last period and those harvested on April and stored until fourth and fifth periods were completely damaged and discarded. The other combinations exhibited intermediate significantly different weight loss percentages.

These findings confirm those of Roongruangsri *et al.* (2013), who revealed that weight loss percentage was increased and the peel moisture percentage of Tangerine cultivars fruits decreased at higher temperature and longer hang on the tree. Iba *et al.* (1976) reported that satsuma fruit weight loss was greater in early harvested fruits than late ones.

Several workers reported that weight loss percentage increased with increasing cold storage duration (Khalil, 1990 on Washington navel orange; Fany *et al.*, 2013 on *Citrus tankan* fruits, Kiaeshkevarian *et al.*, 2014 on Thomson navel orange and D'Aquino *et al.*, 2006 on lemon fruits).

In orange and mandarin, even 5-6% water loss could result in some changes in appearance and firmness of the fruit that could be detrimental to its marketability (Ladaniya, 2008).

The losses of fruit weight and moisture content of the peel were mainly caused by fruit transpiration in which water moved out and resulted in wilted rind and a shriveled appearance (Wills *et al.*, 2007).

This phenomenon affected also by storage temperature and duration (Raspisarda *et al.*, 2001) as well as the relative humidity around the stored fruits (Ladaniya, 2008 ; Roongruangsri *et al.*, 2013). The storage temperature had a greater influence than the relative humidity in the control of weight loss and moisture content of the peel.

Fruit Decay Percentage (FDP)

Results in Table 6 clear that, fruits of Washington navel orange recorded higher FDP during cold storage (25.13 and 20.67%) than those of Valencia orange (1.71 and 1.33%) in the first and second season, respectively. Decay percentage in Washington navel orange fruits were (93.20 and 93.60%) higher than that in Valencia orange fruits in both seasons, respectively.

The values of FDP were gradually and significantly increased with storing fruits on the trees (delaying harvest date). So, the lowest percentages of FDP were recorded for fruits harvested on the first two dates in both seasons. While, the uppermost values (29.62 and 23.75%) were found in fruits harvested on the last date.

The FDP were markedly and significantly increased with the advance of storage period to reach its maximum values after the fourth month of cold storage (32.66 and 28.42%) in the two seasons, respectively.

The interaction between orange variety and harvest date (V × H) was significant in both seasons. Washington navel orange fruits harvested on April and Valencia orange ones harvested on May gave the highest percentages of FDP (53.33 and 44.17% and 5.90 and 3.33%) in the two seasons, respectively. While, Washington navel orange fruits harvested on Dec. and Valencia orange ones harvested on Jan. did not show any decay in both seasons.

Table 6. Effect of harvest date and storage period on decay percentage of Washington navel and Valencia orange fruits during 2013/2014-2014/2015 seasons

*Orange variety	** H.D	First season (2013/2014)					H.D mean	Second season (2014/2015)					H.D mean
		***Storage period (month)						Storage period (month)					
		1	2	3	4	5		1	2	3	4	5	
Washington navel	Dec.	0.00j	0.00j	0.00j	0.00j	40.74bcd	8.15d	0.00e	0.00e	0.00e	0.00e	16.67de	3.33d
	Jan.	0.00j	0.00j	0.00j	12.50ghij	20.83efghi	6.67d	0.00e	0.00e	0.00e	0.00e	4.17e	0.83d
	Feb.	0.00j	0.00j	16.67fghij	45.83bc	50.00b	22.50c	0.00e	0.00e	0.00e	45.83c	50.00b	19.17c
	Mar.	0.00j	4.17ij	33.33bcdef	37.50bcde	100.00a	35.00b	0.00e	4.17e	41.67c	33.33cd	100.00a	35.83b
	Apr.	11.11ghij	25.93defgh	29.63cdefg	100.00a	100.00a	53.33a	8.33e	0.00e	12.50e	100.00a	100.00a	44.17a
Variety mean		2.22d	6.02d	15.93c	39.17b	62.31a	25.13A	1.67d	0.83d	10.83c	35.83b	54.17a	20.67A
Valencia	Jan.	0.00j	0.00j	0.00j	0.00j	0.00j	0.00d	0.00e	0.00e	0.00e	0.00e	0.00e	0.00d
	Feb.	0.00j	0.00j	0.00j	0.00j	0.00j	0.00d	0.00e	0.00e	0.00e	3.33e	0.00e	0.67d
	Mar.	0.00j	0.00j	0.00j	0.00j	6.67ij	1.33d	0.00e	0.00e	0.00e	3.33e	0.00e	0.67d
	Apr.	0.00j	0.00j	0.00j	6.67ij	0.00j	1.33d	0.00e	0.00e	3.33e	0.00e	6.67e	2.00d
	May	0.00j	17.00fghij	4.17ij	0.00j	8.33hij	5.90d	3.33e	0.00e	0.00e	6.67e	6.67e	3.33d
Variety mean		0.00d	3.40d	0.83d	1.33d	3.00d	1.71B	0.67d	0.00d	0.67d	2.67cd	2.67cd	1.33B
Table 6. Cont. Interaction between storage period and harvest date													
First date		0.00f	0.00f	0.00f	0.00f	20.37bcd	4.07D	0.00e	0.00e	0.00e	0.00e	8.33de	1.67C
Second date		0.00f	0.00f	0.00f	6.25ef	10.42cdef	3.33D	0.00e	0.00e	0.00e	1.67e	2.08e	0.75C
Third date		0.00f	0.00f	8.33def	22.92b	28.33b	11.92C	0.00e	0.00e	0.00e	24.58c	25.00b	9.92B
Fourth date		0.00f	2.08f	16.67bcde	22.08bc	50.00a	18.17B	0.00e	2.08e	22.50c	16.67cd	53.33a	18.92B
Fifth date		5.56ef	21.46bcd	16.90bcde	50.00a	54.17a	29.62A	5.83de	0.00e	6.25de	53.33a	53.33a	23.75A
Storage per. Average		1.11D	4.71CD	8.38C	20.25B	32.66A		1.17C	0.42C	5.75C	19.25B	28.42A	

*Orange variety= V **Harvest date= H ***Storage period= S

Means in each column which have the same letter(s) are not significantly different.

The interaction between orange variety and storage period was significant and confirm the previous trends. Since, FDP was increased with prolonging storage period. Therefore, the uppermost FDP percentage was observed with interaction of variety (two varieties) stored until the fourth period. Fruits of both orange varieties did not show any decay during zero time and the first storage periods. The differences among values of FDP of Valencia (V_2) × different storage periods (S) were insignificant in the two seasons.

The interaction between harvest dates (H) × storage period (S) was significant in both seasons. The fruits harvested on the third date and stored until the second period maintained without any decay in the two tested varieties in both seasons with only one exception. All combinations treatments of H (first to fifth month) × S (the fifth period) gained the highest values of FDP in both seasons.

The triple interaction among orange variety (V) and harvest date (H) x storage period (S) was significant in both seasons. All fruits of Washington navel orange harvested on March and April and stored until the third and fourth periods were entirely decayed and discarded in both seasons. In addition, the fruits of Valencia orange harvested in the period between Jan. to April and stored for 1 to 5 months maintained without any decay (zero FDP) in both seasons, with only two exceptions, compared with those of Washington navel orange. No significant differences were observed between most triple combinations V × H × S.

These findings are in a harmony with those found by Honda *et al.* (1972) who reported that the loss of fruits was 17.20% of decayed fruits when stored at 3.5°C and 85% RH. and Pailly *et al.* (2004) declared also that the small diameter fruit weight loss of Star Ruby grapefruit was higher than that of large diameter fruits under the cold temperatures (6-10°C for more than 16 weeks). In addition, harvest date had a clear influence on decay percentage reaching 30.7% of decay in BF (before flowering) fruits versus 5.5% in FB (full bloom) fruits.

This may be due to direct effect of temperature on growth of pathogens (Bulger *et al.*, 1987). Since, the pathogens may not be able to develop while the fruits were stored at 5°C, but it resulted in increased disease susceptibility after the fruits were shifted to warmer temperature (Porat, *et al.*, 2004 ; Smilanick *et al.*, 2003). The low temperature (10°C) did not induce any disease susceptibility and hence the pathogens continued to show least disease incidence even when shifted to ambient temperature after storage (Porat *et al.*, 2004; Arpaia and Kader, 2009).

Lindhout *et al.* (2004) who found that chilling-injured navel oranges showed rind breakdown, injury to the integrity of oil glands that may ultimately result in enhancing susceptibility to decay. Likewise, the incidence of *Penecillium italicaum* was higher in fruits stored at 5°C at the start of post-storage incubation which could be attributed to its ability to digest the plant cell wall enzymatically (McCollum, 2004).

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تأثير ميعاد الجمع على المحصول والقدرة التخزينية لثمار صنفي البرتقال بسرة واشنطن والفالنشيا على الأشجار وتحت ظروف التخزين المبرد

فرج المهدي علي جبريل- طلعت علي محمد أبو سيد أحمد- صفاء عبدالغني أحمد نمير- محمد محمود إبراهيم

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أجريت هذه الدراسة خلال موسمين متتاليين ٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥ على أشجار صنفي البرتقال بسرة واشنطن والفالنشيا عمر ١٥ سنة ومطعومة على أصل النارنج ومنزرعة في تربة طينية طميية في أحد حدائق الموالح الخاصة بمركز منيا القمح، محافظة الشرقية، مصر، جمعت ثمار البرتقال بسرة علي خمس فترات شهرية متتالية في أوائل كل من شهر ديسمبر، يناير، فبراير، مارس وأبريل، وجمعت ثمار برتقال الفالنشيا بعد شهر واحد علي خمس فترات بدءاً من أول يناير وحتى الأول من مايو، جمعت ثمار ثلاثة أشجار (٣ مكررات) في كل ميعاد وتم عدها ووزنها، وتم إختيار ٦٠ ثمرة سليمة عشوائياً من كل مكررة للتخزين المبرد علي درجة ٧°م ± ١ ورطوبة نسبية ٨٥ – ٩٠% وخضعت عينات الثمار التي تم اختيارها في يوم الجمع (١٥ ثمرة) وتلك التي أخذت علي فترات كل ٣٠ يوم من الثمار المخزنة بالتبريد لتقدير تأثير التخزين علي الأشجار، التخزين المبرد وميعاد الجمع علي خصائص الثمار الطبيعية والكيماوية، أعطت ثمار البرتقال بسرة واشنطن أعلى القيم لكل من وزن الثمرة، نسبة المواد الصلبة الذائبة/الحموضة، نسبتي الفقد في وزن الثمرة والتلف، بينما أعطت أشجار البرتقال الفالنشيا أعلى محصول ثمار بأعلي محتوى من فيتامين ج، وانخفض محصول الشجرة، متوسط وزن الثمرة، نسبة المواد الصلبة الذائبة/الحموضة ومحتوي الثمرة من فيتامين ج تدريجياً بتأخير ميعاد الجمع (تخزين الثمار على الأشجار) وزيادة مدة التخزين، لكن زادت نسبة كل من الفقد في الوزن والتلف، وكانت كل التفاعلات المحتملة بين عوامل الدراسة الثلاثة معنوية في الموسمين، وتؤكد الإتجاهات التي سجلت سابقاً لكل عامل فردي علي خصائص الثمار الطبيعية والكيماوية، وتشير النتائج المتحصل عليها أن القدرة التخزينية لثمار برتقال الفالنشيا كانت أعلي بشكل واضح عن مثيلتها للبرتقال بسرة، حيث بلغت نسبة كل من الفقد في وزن الثمرة وتلفها في البرتقال بسرة حوالي ٢ و ١٥ ضعف مثيلتها (متوسط الموسمين) في برتقال الفالنشيا، علي التوالي.

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