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EFFECT OF GIBBERELLIN AND SOME ANTIOXIDANTS PRE-HARVEST FOLIAR APPLICATION ON YIELD, FRUIT QUALITY AND SHELF LIFE OF WASHINGTON NAVEL ORANGE

Halah M.I. El-Khayat*

Hort. Res. Inst., Agric. Res. Cent., Egypt

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ABSTRACT: The present study was conducted during 2015and 2016 seasons on ten years old Washington navel orange trees grown in clay soil. Trees were sprayed three times in July, September and November with gibberellic acid at 30 ppm as well as ascorbic acid, citric acid and salicylic acid each at 400ppm (for the three doses) in order to investigate their effect on tree yield and fruit quality characteristics at harvest and during shelf life (7-14 days). Trees were harvested on the end of February (late season). All sprayed substances delayed fruit peel ageing, fruit color break and decreased pre-harvest fruit drop. Also, results indicated that gibberellic acid treatment increased canopy volume index, shoot length, fruit peel thickness, leaf calcium and fruit peel resistance. Moreover ascorbic acid sprays led to an access in fruit length, fruit diameter, leaf nitrogen, potassium and calcium, Vitam. C, TSS, TSS/acid ratio, leaf area and chlorophyll a and b contents. Ascorbic and citric acid treatments gave higher trunk across, total and reducing sugars. Salicylic acid application enhanced, yield, fruit peel thickness, acidity and fruit peel resistance. Applying previous antioxidants then storaging at room temperature for a week and two weeks revealed that ascorbic acid application increased, Vitam. C, TSS, TSS/acid ratio and total sugars of fruits during shelf life after 1-2 weeks. Also, ascorbic and citric acid treatments increased reduced and unreduced sugars. Citric acid spraying led to an increase of weight loss than all other treatments. Gibberellic and salicylic acid application enhanced fruit peel resistance. All antioxidants treatments reduced decay during shelf life as compared with control. The TSS, TSS/acid ratio, total and non reducing sugars, fruit weight loss percentage and decay of citrus fruits were increased, whereas acidity, reduced sugar and fruit peel resistance were gradually and significantly decreased by increasing storage periods.

Key words: Gibberellin, antioxidants, pre-harvest, fruit quality, yield, whshington navel orange.

INTRODUCTION

Washington navel orange is the leading citrus variety in Egypt. The cultivated area reached 156514 fad., with total production estimated to be1697222 tons of orange fruits according to the statistics of **Ministry of Agriculture (2015)**. Generally, citrus face several quality fruit disorders such as creasing, splitting, puffing and peel pitting which would all affect its marketing and keeping quality such as Navel orange. In Egypt Washington navel orange is mainly fresh consumed either in the local market or for exportation. Therefore, producing Navel orange fruit with the best external and internal quality characteristics at harvest and during marketing is a main objective of growers. Thus, pre-harvest foliar application with some agrochemicals that may play an important role in improving fruit quality would be investigated. Several studies to overcome fruit quality deterioration at and after harvest by using different types of agrochemicals were reported (**Marzouk and Kassem, 2011**). The plant growth regulators such as gibbrellic acid may be a tool for enabling a good quality produce (**Ismail, 1997**). Gibberellic acid is known to slow down fruit ripening and to delay fruit

* **Corresponding author: Tel. :** +20
E-mail address: elkhayat_h_m66@yahoo.com

senescence. It is proven to be effective in retarding citrus fruit maturation and quality disorders such as rind softening, creasing, peel pitting and puffing (**Agusti *et al.,* 2002**). Similarly, salicylic acid is reported to retard quality disorders and decrease disease infection especially fungal diseases in many fruit species (**Rizk-Alla *et al.,* 2006**). It is a phenolic compound that regulates number of processes in plants such as inhibiting ethylene biosynthesis (**Leslie and Romani, 1988**), regulating expression of pathogenesis related protein genes, and provides resistance against pathogen attack (**Srivastava and Dwivedi, 2000**). In the mean time, exogenous application of salicylic acid is reported to reduce decay, delay ripening and extend storage life of various fruits such as banana and Kiwi (**Zhang *et al.,* 2003**). Moreover, ascorbic acid is an abundant component of plants which occurs in all cell compartments, including the cell wall. It is considered as an antioxidant and in association with other components of the antioxidant system. It protects plants against oxidative damage resulting from aerobic metabolism, photosynthesis and a range of pollutants (**Smirnoff, 1996**). Further, citric acid plays an essential role in signal activating transporter enzymes, metabolism and translocation of carbohydrates, transduction system, membrane stability and functions (**Bhaskaren *et al.,* 1985; Smirnoff, 1996**). Salicylic participates in the regulation of physiological processes in plants such as growth, development, transpiration as well as uptake and transport of nutrients, ethylene production and photosynthesis, nitrate metabolism (**Van-Huijsduijnen *et al*., 1986; Hayat and Ahmed, 2007**). In addition, it provides protection against biotic and abiotic stresses (**Kaya *et al*., 2002**). Also, salicylic acid may also have a role in enhancing the antioxidant defense system against the free radical damages of plant cells, which would slow fruit tissues deterioration and senescence.

In accordance to the above discussed objectives, the present study was conducted to investigate the effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid pre-harvest foliar sprays on Navel orange fruit quality at harvest and after keeping for 7 and 14 days at room temperature.

MATERIALS AND METHODS

Plant Materials and Statistical Design

The present study was carried out during the two successive seasons of 2015 and 2016 on ten years old Washington navel orange (*Citrus sinensis*, L. Osbeck) budded on sour orange rootstock (*Citrus. aurantium,* L.) grown in clay soil in a private citrus orchard, in Kafr Dawar, Behera Governorate, Egypt. The trees were spaced at 5 x 5 m and received similar cultural practices adopted in the orchard. Sixty trees were selected as uniform as possible in growth, productivity and appearance. Trees were sprayed three times on July, September and November with gibberellic acid (GA_3) at 30ppm and salicylic acid (SA), ascorbic acid (AA) and citric acid (CA) each at 400 ppm (for the three sprays) and water as control. The Triton B emulsifier at a rate of 0.2% was used with each spray solution as wetting agent to have best solution penetration. Trees were sprayed until runoff. Five treatments were arranged in a randomized complete block design (RCBD) with 4 replicates per treatment and three trees per each replicate .In the spring of each season, 20 non-fruiting shoots of spring cycle were tagged at constant height and at all directions of each tree. In September, the average length of the tagged shoots was measured.

- The canopy height and diameter at 1 m were measured at the end of both growing seasons (October).
- The trunk cross sectional area (TCSA) at 20 cm was calculated at the end of both growing seasons.
- Leaf area was measured -Chlorophyll a and b contents were determined according to **Wintermans and Mats (1965)**.
- Leaves were oven dried at 70°C to constant weight and then were finleg ground. To determine the leaf mineral contents, the ground material of each sample was digested with H_2SO_4 and H_2O_2 according to **Wolf (1982)**.
- In the digested solution, total nitrogen and phosphorus were determined colorimetrically according to **Evenhuis and Dewaard (1976)** and **Murphy and Riley (1962)**, respectively.

- Potassium was determined by flame photometer as described by **Cheng and Bray (1951)**.
- Calcium was determined by atomic absorption according to **Carter (1993)**.

Fruit Sampling

After commercial harvest date on the end of February, a sample of 15 fruits was randomly collected from each replicate in order to determine the effect of different treatments on fruit quality characteristics at harvest date. Another sample of 30 fruits per replicate was taken and left at room temperature (22±2°C) for 7 and 14 days in order to investigate the effect of the different treatments on fruit shelf life and keeping quality after harvest.

Quality Assessments

At harvest

Average fruit weight (g) was recorded then the total yield/tree (kg) was calculated and average peel thickness (mm) was measured. Fruit peel resistance values were determined using Lfra Texture Analyser in 5 mm depth and 0.2 mm/second speed, for measuring firmness of orange, these values were determined by taking the firmness value of six fruits by two sides and the average of the fruit firmness was calculated as (g/sq. cm) **Harold (1985)**.

In fruit juice, vitamin C (mg ascorbic acid /100 ml juice) was determined according to **AOAC (1995)** the percentage of fruit total soluble solids (TSS) was measured using a hand refractometer. Acidity (%) as citric acid and the TSS: acid ratio was calculated.

In addition, total and reducing sugars percentages (%) were determined according to **Malik and Singh (1980)**. The non-reducing sugars were then calculated.

After 7 and 14 days at (22±2°C) shelf life

Fruit weight loss (WL) was recorded by weighing (g) the fruits before and after shelf life and the percentage of weight loss was calculated as follows:

Weight loss (%)=final weight/initial weight ×100

Fruit peel resistance, ascorbic acid (VC) content, fruit TSS, acidity, TSS: acid ratios and sugars percentages were measured as mentioned above.

Fruit decay percentage was detected as fruits defected with any pathological or physiological disorders and the percentage of fruit decay was calculated according to the total number of the fruits.

Statistical Analysis

The obtained data of both seasons were subjected to analysis of variance according to **Clarke and Kempson (1997)**. Least significant difference (LSD) at 0.05 level of probability (**Steel and Torrie, 1984**) was used to compare the main effect of the different treatments on fruit quality characteristics at harvest and after keeping at room temperature for 7 and 14 days. The obtained data were analyzed using the SAS program, 2000.

RESULTS AND DISCUSSION

Results in Table 1, indicate that gibberellic acid significantly increased canopy volume index in both seasons as compared with all other treatments. Also, ascorbic and salicylic acids gave similar results in the second season. More over, gibberellic acid treatment gave significantly longer shoots in the first season as compared with trees sprayed with other treatments. Besides, in both season, ascorbic acid gave significantly longer shoots as compared with citric acid and salicylic acid. Furthermore, plants sprayed with citric acid and ascorbic acid indicated significant increase in trunk cross sectional area when compared with all other treatments. (**Smirnoff, 1996; Lee and Kader, 2000; Pignoochi and Foyer, 2003**) indicated that increasing vegetative growth parameters as a result of ascorbic and citric acids application may be due to their auxinic action and its role in many metabolic and physiological processes. Also, **Moustafa and Saleh (2006)** on "Anna" apple trees, **Kassem *et al.* (2010) and Fathi *et al.* (2011)** on "Costata" persimmon trees revealed that shoot length was increased by GA application.

The application of ascorbic acid in both seasons gave significant increase in leaf area, while gibberellic acid was the lowest (Table1). **Abd El Raheem *et al.* (2013)** on navel orange found that, there were significant differences among growth regulators treatment on leaf area whereas, all treatments increased leaf area compared to control treatment.

Table 1. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on canopy volume index, shoot length, trunk cross sectional area, leaf area, chlorophyll a and b contents and leaf nitrogen percent (seasons of 2015/2016 and 2016/2017)

Treatment	Canopy volume index (m^3)		Shoot length (cm)		Trunk cross sectional area (cm^2)		Leaf area (cm)		Chlorophyll a (mg/l)		Chlorophyll b (mg/l)		Leaf nitrogen (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	8.8 b	9.8 c	11.5 d	12.9c	49 b	d55.1c	17.2 b	18.9 c	2.00 c	2.02 c	1.42 b	b1.35	2.63 c	2.57 c
Gibberellic acid (GA3)	11.3 a	11.8 a	13.2 a	13.4b	49.7 b	57.1 b	18.2 b	24.5 b	2.23 b	2.27 b	a1.49	1.37 b	2.71 cb	2.55 c
Ascorbic acid (AA)	9.5 b	11.7 a	12.7 b	13.9a	54.4 a	61.2 a	23.9 a	28.8 a	1.98 c	1.98 c	c1.39	1.24 d	3.91 a	3.01 a
Citric acid (CA)	8.9 b	11.4 b	11.8 c	13.3b	53.3 a	60.8 a	b20.3a	19.13c	1.98 c	1.94 c	bc1.41	1.3 c	2.97 b	2.72 b
Salicylic acid (SA)	9.5 b	11.7 a	11.7 c	13. 5b	49.7 b	55.2 c	22.67 a	24.7 b	2.35 a	2.43 a	a1.48	1.47 a	2.66 c	2.57 c
LSD 0.05	1.3085	0.2855	0.1575	0.3420	1.4002	1.3798	4.2117	1.2284	0.0924	0.1353	0.0266	0.0206	0.3017	0.0555

Moreover, results in Table 1 indicate that, spraying salicylic acid increased significantly chlorophyll a and b content than other applications. In addition gibberellic acid treatment gave significantly higher leaf chlorophyll a and b content than citric acid treatments. **Abd El Raheem *et al.* (2013)** on navel orange reported that the high concentrations of CPPU [N(2-chloro-4-pyridinyl)-N-phenyl urea] (Sitofex compound) at 7.5 or 10 ppm caused the demolition of chlorophyll, decreased the concentrations of leaf chlorophyll (a and b) contents.

Regarding mineral composition in Tables 1 and 2, leaf nitrogen percent in both seasons tended to be significantly higher with ascorbic acid treatment as compared with other treatments. These results are in line with those obtained by **Ahmed and Seleem (2008)** who found that spraying "Thompson seedless" grapevines with ascorbic acid and citric acid antioxidants increased leaf N content. Also, **Fayed (2010a)** on "Manfalouty" pomegranate trees, **Fayed (2010b)** on "Thompson seedless" grapevine indicated that foliar application of ascorbic acid increased leaf N content. While, **Hassan *et al.* (2010)** on" Hollywood" plum trees and **Shahin *et al.* (2010)** on "Anna" apple trees revealed that spraying gibberellic acid increased leaf N percentage.

As for leaf phosphorus percent, the results indicated that, leaf phosphorus was significantly increased with salicylic acid treatment as compared with other treatments in the 1st season while in the second season no clear differences were found between all treatments. These results are partially similar with those obtained by **Hassan *et al.* (2010)** who found that spraying "Hollywood" plum trees with GA3 decreased leaf P content, whereas citric acid enhanced leaf P content. On the other hand, **Ahmed and Seleem (2008)** and **Fayed (2010a)** on "Manfalouty" pomegranate trees and **Fayed (2010b)** on "Thompson seedless" grapevines reported that spraying grapevines with antioxidants *i.e.* ascorbic acid and citric acid increased leaf P. Also, **Shahin *et al.* (2010)** on "Anna" Apple trees found that spraying gibberellic acid increased leaf P contents as compared with control.

With regard to leaf potassium percent, no clear differences were found between different treatments. These results are in line with those obtained by **Ahmed and Seleem (2008)** and **Fayed (2010a)** on "Manfalouty" pomegranate trees and **Fayed (2010b)** on "Thompson seedless" grapevines who found that spraying "Thompson seedless" grapevines with antioxidants *i.e.* ascorbic acid and citric acid increased leaf K content. On the other hand, **Hassan *et al.* (2010)** on" Hollywood" plum trees, **Shahin *et al.* (2010)** on "Anna" Apple trees reported that spraying gibberellic acid increased leaf K content as compared with control.

Table 2. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on leaf phosphorus, potassium and calcium percent, peel thickness, fruit diameter and fruit length (seasons of 2015/ 2016 and 2016/2017)

Treatment	Leaf phosphorus (%)		Leaf potassium (%)		Leaf calcium (%)		Yield (Kg/ tree)		Peel thickness (mm)		Fruit diameter (cm)		Fruit length (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	0.153bc	.145 a	1.1 a	1.33 b	2.5 c	2.73 c	98.6 c	94.1c	5.05 e	5.16 d	7.5 a	11.5 c	10.66 d	8.9 a
Gibberellic acid (GA3)	0.151dc	0.147 a	1.15 a	1.27 b	3.01 a	2.93 b	102 a	102 a	5.81b	6.33 a	7.78 a	10.66 d	11.5 c	9.3 a
Ascorbic acid (AA)	0.156ab	0.152 a	1.25 a	1.44 a	2.79 b	3.10 a	99.5 bc	104.6 a	c5.56	5.74 b	7.9 a	12.59 a	12.59 a	9.2 a
Citric acid (CA)	0.148d	0.152 a	1.12 a	1.36 ab	2.8 b	2.95 b	b100.8a	105.9 a	5.3d	5.46 c	7.56 a	11.89 c	11.89 c	9.0 a
Salicylic acid (SA)	0.158a	0.151 a	1.11 a	1.35 ab	2.56 c	2.93 b	101.6 a	100.8 a	6.27 a	6.39 a	7.82 a	10.33 e	10.33 e	9.2 a
LSD 0.05	0.0041	0.0075	0.3263	0.1078	0.2025	0.1275	1.5454	7.7049	0.0579	0.646	0.923	0.2611	0.2611	0.7944

Results of leaf calcium content revealed that gibberellic acid treatment in 2015 and ascorbic acid treatment in 2016 gave significantly the highest leaf calcium percentages. These results are similar to those reported by **El-Shazly *et al.* (2013)** who indicated that "Swelling" peach trees received salicylic acid had significantly less leaf calcium content than those treated with gibberellic acid, ascorbic and citric acids in both seasons.

Tree Yield

Regarding to the results in Table 2, yield was significantly increased with salicylic acid and gibberellic acid application as copmared with those treated with ascorbic acid and control in 2015.

All treatments significantly increased yield as compared with control in the 2nd season (Table 2). These results are similar to those found by **Kabeel (1999) and Kassem *et al.* (2010)**, on "Costata" persimmon trees, **El-Seginy *et al.* (2003)** on "Anna" apple trees, **Yehia and Hassan (2005)** on "Le-Conte" pear trees, **Hassan *et al.* (2010)** on "Hollywood" plum trees, **Shahin *et al.* (2010)** on "Anna" apple trees, and **Stino *et al.* (2011)** on "Le-Conte" pear trees, **Marzouk and Kassem (2011)** on Navel orange reported that, gibberelic acid increased total yield as compared with other different agro- chemical.

Fruit Quality at Harvest

Fruit physical characters

Results in Table 2 indicate that trees sprayed with gibberellic acid and salicylic acid showed significantly higher peel thickness than those sprayed with other treatments. Also, peel thickness of control fruits was significantly thinner than all other treatments. Moreover, ascorbic acid treatment gave significantly thicker peel thickness than citric acid treatment in both seasons. As for fruit diameter, the results in Table 2 show that ascorbic acid treatment significantly recorded the highest fruit diameter and fruit length in both seasons. It was also noticed that, all treatments significantly increased fruit length as compared with control in 2015 season. These findings are in harmony with those obtained by **Ahmed *et al.* (2007)** on "Sewy" date fruits, **Maksoud *et al.* (2009)** on olive trees and **Fayed (2010b)** on "Thompson seedless" grapevines revealed that spraying ascorbic acid improved fruit length. Also, **Burak and Buyukyilmaz (1998)** on "Starking Delicious" apple, **El-Shaikh *et al.* (1999)** on "Costata" persimmon, **Qayum *et al.* (2002)** on "Red Delicious" apples, **Usenik and Kastelec (2004)** on sweet cherry cultivars "Van and Sunburst", **Yehia and Hassan (2005)** on "Le-Conte" pear trees and **Ismail (2006)** on "Desert Red" peach fruits. They all indicated that GA3 application increased fruit diameter and length (fruit dimentions).

As for fruit peel resistance (Table 3), gibberellic acid and salicylic acid treatments gained significant increase in fruit peel resistance as compared with all other treatments. Besides, ascorbic acid caused a significant increase in fruit peel resistance compared with spraying citric acid in both seasons. Furthermore, fruits peel resistance in fruits of all treatments was

Table 3. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on fruit peel resistance, Vitam. C, TSS, acid ratio, TSS/acid ratio, total, reduced and non reduced sugars percentages (seasons of 2015/2016 and 2016/2017)

Treatment	Fruit peel resistance (g/sq.cm).		VC mg ascorbic acid/ 100 ml juice		TSS (%)		Acidity (%)		Tss/acid ratio		Total sugars (%)		Reduced sugars (%)		Non reduced sugars (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	287.3d	285.2e	57c	55 c	11.5c	12 b	1.3 b	1.4 d	8.84 b	8.57b	6.40b	5.74abc	2.73 b	2.48 c	3.68 a	3.25 a
Gibberellic acid (GA3)	360.47a	342.05a	69b	67 b	10.66d	10.78c	1.52 a	1.6 b	7.01 c	6.74c	5.47c	5.48bc	2.56 b	2.3 c	3.37 a	3.18 a
Ascorbic acid (AA)	319.1 bb	316.86c	81a	82 a	12.59a	12.99a	1.21 b	1.35 d	10.40a	9.62a	7.19a	6.29ab	3.54 a	2.92 b	3.66 a	3.37 a
Citric acid (CA)	304.28c	299.66d	72b	71 b	11.89c	12.32b	1.3 b	1.5 c	9.15 b	8.21b	7.103a	6.55 a	3.45 A	3.52 a	3.65 a	3.03 a
Salicylic acid (SA)	359.57a	327.76b	68b	66 b	10.33e	10.52c	1.52 a	1.75 a	6.80 c	6.01d	5.99cb	5.41 c	2.57B	2.32 c	3.42 a	3.09a
LSD 0.05 T	3.7276	4.9847	4.5345	5.0522	0.2611	0.5582	0.1444	0.0835	0.9063	0.6722	0.4403	0.8294	0.3594	0.3926	0.4145	0.5911

significantly higher compared with control. These results are similar to those indicated by **Kappel and Mac-Donald (2002)** on sweet cherries, **El-Seginy *et al.* (2003)** on "Anna" apple trees, on sweet cherry fruits, **Yehia and Hassan (2005)** and **Hegazi (2011)** on "Le-Conte" pear trees, **Cline and Trought (2007)** on "Bing and Sam" sweet cherries, **Hassan *et al.* (2010)** on "Hollywood" plum trees. They all reported that gibberellic acid (GA_3) applications increased fruit firmness. Moreover, **Kazemi *et al.* (2011a)** on "Jonagold" apple fruits, **Kazemi *et al.* (2011b)** on "Hayward" Kiwi fruit and **Shaaban *et al.* (2011)** on "Anna" apple fruits. They found that spraying of salicylic acid increased fruit firmness.

Fruit chemical characters

Results in Table 3, clear that Vitam. C content, TSS and TSS/acid ratio in fruits of the trees sprayed with ascorbic acid significantly increased Vitam. C, TSS and TSS/acid ratio compared to fruits of trees sprayed with all other treatments in both seasons. Whereas, trees sprayed with salicylic acid recorded higher acidity percentage compared with those with all other treatments. These findings are confirmed with those obtained by **Ahmed *et al.* (2007)** on "Sewy" dates fruits, **Fayed (2010a)** on "Manfalouty" pomegranate trees, **Fayed (2010b)** on "Thompson seedless" grapevines, **Hafez *et al.* (2010)** on "Le-Conte" pear fruits and **Mansour *et al.* (2010)** on mango fruits. They reported that spraying ascorbic and citric acids improved fruit TSS. Moreover, **Barakat *et al.* (2012)** demonstrated that, total soluble solids percentage of orange fruits was increased by some biological treatments.

With regard to total sugars percentage, results in Table 3 show that using citric and ascorbic acid gave significantly higher total sugars in comparison with all treatments in 2015 season, otherwise, citric acid increased total sugars significantly as compared with salicylic acid and control in 2016 season. Also, citric acid treatment gained significant increase in reduced sugars percentage compared with salicylic acid and gibberellic acid and control in both seasons. Whereas, insignificant differences were found for non reducing sugars percentage. The obtained results are in line with those of **Ahmed *et al.* (2007)** on "Sewy" date fruits, **Ahmed and Seleem (2008)** on "Thompson seedless" grapevines, **Fayed (2010a)** on "Manfalouty" pomegranate trees, **Hafez *et al.* (2010)** on "Le–Conte" pear fruits and **Mansour *et al.* (2010)** on mango fruits. They reported that spraying

ascorbic acid and citric acid increased fruit total sugars percentages. On the other hand, **El-Seginy *et al.* (2003)** and **Shahin *et al.* (2010)** on "Anna" apple trees found that GA3 improved fruit total sugar percentage.

Fruit Quality During Shelf Life

Fruit weight loss

Weight loss of fruits of trees sprayed with citric acid gained significantly higher fruit weight loss as compared with fruits from trees sprayed with other treatments (Table 4). Furthermore, fruit weight loss percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods. These results are in line with those obtained by **Hussein *et al.* (2001a)** on "Anna" and "Dorset Golden" apple cultivars, **Samara *et al.* (2007)** on apricot fruits, who reported that spraying trees with GA3 reduced weight loss of fruits during storage. Also, **Kazemi *et al.* (2011a)** on "Jonagold" apple fruits, **Kazemi *et al.* (2011b)** on "Hayward" Kiwi fruit, and **Tareen *et al.* (2012)** on "Flordaking" peach fruits, found that, fruits treated with salicylic acid exhibited less weight loss after storage. Moreover, **Chien *et al.* (2007)** and **Barakat *et al.* (2012)**, illustrated that, weight loss percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods.

Results in Table 4 reveal also that fruit peel resistance was significantly higher with gibberelic acid and salicylic acid treatments compared with all other treatments. Also, trees sprayed with ascorbic acid recorded significantly higher fruit peel resistance compared with those sprayed with citric acid. Moreover, all treatments significantly increased fruit peel resistance compared with the control. Furthermore, fruit peel resistance of citrus fruits were decreased gradually and significantly with the increasing storage periods. These results are in harmoney with those reported by **Barakat *et al.* (2012)** who found that, orange fruits firmness was gradually and significantly decreased with the prolongation of storage periods. Also, **Yan *et al.* (1998)** and **Li and Han (1999)** on peach fruits, **Srivastava and Dwivedi (2000)** on banana fruits, **Wang *et al.* (2007)** on mango fruits, **Solaimani *et al.* (2009)**, on kiwifruit fruits, **Kazemi *et al.* (2011a)** on apple fruits and **Tareen *et al.* (2012)** on peach fruits, demonstrated that postharvest treatments with salicylic acid significantly exhibited higher flesh firmness of fruits during storage.

Chemical constituents

Results in Tables 5 and 6 clear that, ascorbic acid treatment gained significantly higher vitamin C, TSS and TSS/acid ratios compared with all other treatments in both seasons. Also, the results revealed that TSS and TSS/acid percentages of citrus fruits were increased, while vitam. C content decreased gradually and significantly with increasing of storage periods. The obtained results are in harmony with **Stino *et al.* (1986)** on peach fruits and **Facteau *et al.* (1992)** on sweet cherry. They reported that GA3 delayed TSS accumulation in fruits. Also, these findings are confirmed with those obtained by **Ahmed *et al.* (2007)** on "Sewy" dates fruits, **Fayed (2010a)** on "Manfalouty" pomegranate trees, **Fayed (2010b)** on "Thompson seedless" grapevines, **Hafez *et al.* (2010)** on "Le-Conte" pear fruits and **Mansour *et al.* (2010)** on mango fruits. They all reported that spraying citric acid improved fruit TSS. Moreover, **Barakat *et al.* (2012)** demonstrated that, total soluble solids contents of orange fruits were increased with increasing storage periods. On the other side, **Yehia and Hassan (2005)** on "Le-Conte" pear trees, **Ghafir *et al.* (2008)** on "Stanly "plum fruits and **Shahin *et al.* (2010)** on "Anna" apple trees found that, total soluble solids content was increased with GA3 sprays. **Wassel *et al.* (2007)** on "White banaty seedless" grapevines, **Fayed (2010a)** on "Manfalouty" pomegranate fruits and **Fayed (2010b)** on "Thompson Seedless" grapevines, found that spraying ascorbic and citric acids increased TSS: acid ratio. Moreover, **Hussein *et al.* (2001a)** on "Anna and Dorset Golden" apples and **Wassel *et al.* (2007)** on "White banaty seedless" grapevines and **Shahin *et al.* (2010)** on "Anna" Apple trees, reported that spraying gibberellic acid reduced the ratio between total soluble solids and acidity.

The results in Table 6 show that, gibberellic acid and salicylic acid caused significant increase in total acidity as compared with all other treatments and control. Also, total acidity percentage of orange fruits was significantly decreased gradually with increasing storage periods.

Table 4. Effect of gibberellic acid, ascorbic acid , citric acid and salicylic acid on weight loss percentage and fruit peel resistance (seasons of 2015/2016 and 2016/2017)

Treatment	Weight loss (%)								Fruit peel resistance (g/sq. cm)							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean
Control	0	5.01	8.4	4.47 b	0	4.51	8.72	4.41 c	287.3	261	232	260.41d	285.2	256.68	228.16	256.68e
Gibberellic acid (GA3)	0	4.31	7.95	4.09 e	0	4.27	7.5	3.92 e	360,47	320.82	291.98	324.42a	342.05	309.56	280.48	310.7a
Ascorbic acid (AA)	0	4.86	8.06	4.31 d	0	4.33	8.46	4.26 d	319.1	290.38	258.47	289.32b	316.86	285.81	259.83	287.5c
Citric acid (CA)	0	5.38	8.43	4.60 a	0	4.53	9.36	4.63 a	304.28	293.46	249.51	276.79c	299.49	272.54	248.58	273.59d
Salicylic acid (SA)	0	5.43	7.67	4.37 c	0	4.12	9.44	4.52 b	359.57	323.61	291.25	324.42a	327.76	297.28	265.49	296.84b
Mean P	0c	b4.99	8.10 a		0	4.35 b	a8.7		326.33 a	294.48 b	264.64c	1.43	314.31a	284.37b	256.51c	3.46
LSD 0.05	Between T 0.0534	Between P 0.2648	Between T×P 0.1077		Between T 0.0438	Between P 0.1451	Between T×P 0.08831		Between T 1.85	Between P 1.43	Between T×P 3.755		Between T 4.47	Between P 3.46	Between T×P 9.075	

Table 5. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on Viam. C content and TSS percentage (seasons of 2015/2016 and 2016/2017)

Treatment	Vitam. C content (mg ascorbic acid /100ml juice)								TSS (%)							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean
Control	57	53	51	53.00 d	55	55	53	55.00 d	11.50	12.76	13.92	12.73 c	12.00	13.68	14.76	13.48c
Gibberellic acid (GA3)	69	64	62	64.33 c	67	66	64	66.33c	10.66	12.37	12.69	11.91 e	10.78	12.50	13.69	12.32d
Ascorbic acid (AA)	81	79	76	79.00 a	82	78	79	78.00 a	12.59	14.10	13.97	13.55 a	12.99	14.93	15.74	14.55a
Citric acid (CA)	72	68	66	68.33 b	71	69	68	69.33b	11.89	13.56	13.79	13.09 b	12.32	14.17	15.15	13.88b
Salicylic acid (SA)	68	63	61	63.33 c	66	65	63	65.33c	10.33	11.88	13.93	12.06 d	10.52	11.89	13.15	11.84e
Mean P	68.2 a	65.4 a	63.2 b		69.4 a	66.6 a	64.4 a		11.40c	12.94b	13.92a		11.72 c	13.4 b	14.76 a	LSD0.05
LSD 0.05	Between T 1.69	Between P 2.66	Between T×P 3.395		Between T 1.465	Between P 5.1095	Between T×P 2.951		Between T 0.0962	Between P 0.4065	Between T×P 0.1938		Between T 0.2036	Between P 0.2906	Between T×P 0.4101	

Table 6. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on acidty and TSS/acid ratio ((seasons of 2015/2016 and 2016/ 2017)

Treatment	Acid (%)								TSS/acid ratio							
	2015/2016				2016/2017				2015/2016				2016/2017			
	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean
Control	1.30	1.21	0.99	1.17 b	1.40	1.30	1.15	1.27 c	8.84	11.50	12.89	11.08 c	6.57	11.35	11.9	10.67 b
Gibberellic acid (GA3)	1.52	1.30	1.03	1.28 a	1.60	1.50	1.34	1.48 a	7.01	9.76	12.01	9.43 d	6.74	8.73	9.33	8.27 c
Ascorbic acid (AA)	1.21	1.07	0.93	1.07 c	1.35	1.25	1.21	1.28 c	10.40	13.06	15.16	12.89 a	9.62	12.59	12.34	11.52 a
Citric acid (CA)	1.30	1.16	0.98	1.15 b	1.50	1.35	1.20	1.35 b	9.15	11.89	13.84	11.64 b	8.21	12.12	11.81	10.72 b
Salicylic acid (SA)	1.52	1.30	1.12	1.30 a	1.75	1.55	1.12	1.47 a	6.80	10.72	10.61	9.60 d	6.01	8.48	10.62	8.37 c
Mean	1.36 a	1.2 b	1.01 c		1.51 a	1.39 b	1.20 c		8.5 c	11.39 b	12.90 a		7.87 c	10.65 b	11.21 a	
LSD 0.05	Between T	Between P	Between T×P		Between T	Between P	Between T×P		Between T	Between P	Between T×P		Between T	Between P	Between T×P	
	0.0456	0.0255	0.09377		0.0316	0.0091	0.0637		0.2775	0.1047	0.5591		0.2256	0.2974	0.4544	

These results agreed with those found by **Al-Obeed (2010)** on "Barhee" date palms, **Bal and Celik (2010)** on "Hayward" kiwifruit, **Shaaban *et al.* (2011)** on "Anna" apple fruits and **Tareen *et al.* (2012)** on "Flordaking" peach fruits. They reported that spraying trees with salicylic acid increased fruit total acidity contents. Also**, Ahmed *et al.* (2007)** on "Sewy" date fruits, **Wassel *et al.* (2007)** on "White banaty seedless" grapevines, **Fayed (2010b)** on "Thompson seedless" grapevines and **Mansour *et al.* (2010)** on mango fruits reported that spraying ascorbic and citric acids reduced total acidity percentage. Moreover, the previous results are in harmony with those demonstrated by **Barakat *et al.* (2012)** who reported that total acidity percentage of orange fruits was decreased gradually and significantly with increasing storage periods.

Results in Tables 7 and 8 indicate that ascorbic and citric acids spraying gave significantly higher total and reduced sugars percentage when compared with all other treatments. Also, ascorbic and citric acids treatments significantly increased non reduced sugars percentage compared with salicylic and gibberellic acid. The results also revealed that total and non reduced sugars percentages of the fruits were increased and reduced sugars decreased gradually and significantly with increasing storage periods. Trend of the obtained results are in line with those of **Awad *et al.* (2004)** on "Anna" apple fruits, On the other hand, **El-Seginy *et al.* (2003)** and **Shahin *et al.* (2010)** on "Anna" apple trees found that GA3 improved fruit total sugars, percentage. Also, **Nawaz *et al.* (2008)** on "Kinnow" mandarin and **Kassem *et al.* (2011)** on "Pu-yun" jujube trees, found that application of GA3 significantly increased fruit reducing sugars. Moreover, **Shaaban *et al.* (2011)** on "Anna" apple trees reported that application of salicylic acid increased non reducing sugars percentages.

Fruit decay percentage

Results in Table 8 indicate that control treatment showed significantly higher decay percentage compared with other treatments. Also, decay percentage of citrus fruits were increased gradually and significantly with increasing of storage periods. These results are in agreement with those obtained by **Chien *et al.* (2007)** and **Barakat *et al.* (2012)**, who illustrated that decay percentage of citrus fruits was increased gradually and significantly with the increasing of storage periods. Also, **Yao and Tian (2005)** on sweet cherry fruits, **Wang *et al.* (2007)** on peach fruits, **Kazemi *et al.* (2011a)** on apple fruits and **Tareen *et al.* (2012)** on peach fruits. They demonstrated that, post harvest application with salicylic acid significantly reduced decay incidence of fruits during storage compared with that of the untreated fruits. Also, **Mohamed *et al.* (2012)** on Naval orange reported that decay percentage was increased gradually and significantly with increasing storage periods.

Conclusion

Gibberellic acid treatment increased canopy volume index, shoot length, fruit peel thickness, leaf calcium and fruit peel resistance. Moreover, ascorbic acid sprays increased fruit length, fruit diameter, leaf nitrogen, potassium and calcium, Vitam. C content, TSS, TSS/ acid ratios. Citric acid increased leaf area. Ascorbic acid and citric acid treatments gave higher trunk across area, total and reducing sugars. Salicylic acid application enhanced, yield, fruit peel thickness, acidity percentage and fruit peel resistance. Applying previous antioxidants then storing at room temperature for a week and two weeks revealed that ascorbic acid application increased Vitam. C content, TSS, TSS/acid ratio and total sugars percentage. Also, ascorbic and citric acids treatments increased reduced and unreduced sugars percentages. Citric acid spraying led to increase weight loss percentage than all other treatments. Gibberellic acid and salicylic acid application enhanced fruit peel resistance. All antioxidants treatments reduced decay percentage compared with control. The TSS, TSS/acid, total and non reducing sugars percentages, fruit weight loss and decay percentage of citrus fruits were increased whereas, acidity, reduced sugars and fruit peel resistance were decreased gradually and significantly with increasing storage periods.

Table 7. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on total and reduced sugars percentages (seasons of 2015/2016 and 2016/2017)

Treatment	Total sugars (%)								Reduced sugars (%)							
	2015/2016				2016/2017				2015/2016				2016/2017			
	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean
Control	5.4	6.19	6.74	6.11b	6.41	6.49	7.15	6.68 b	2.48	2.27	2.05	2.27 b	2.73	2.46	2.35	2.51 b
Gibberellic acid (GA3)	6.57	5.81	5.48	6.57	5.79	6.27	6.91	6.32 c	2.3	2.11	2.00	2.13 cb	2.57	2.19	2.05	2.27 c
Ascorbic acid (AA)	7.18	7.13	6.63	6.96 a	7.19	7.53	7.68	7.47 a	3.26	3.07	2.54	2.96 a	3.53	3.31	2.62	3.18 a
Citric acid (CA)	6.99	6.89	6.79	6.89 a	7.11	7.44	7.56	7.36 a	3.42	2.99	2.35	2.92 a	3.45	3.26	2.54	3.08 a
Salicylic acid (SA)	6.92	5.16	5.41	5.83 c	5.99	6.41	6.74	6.49 c	2.32	1.98	1.74	2.01 c	2.57	2.35	2.05	2.32 c
Means P	5.94 c	6.24 b	6.89 a		6.5 c	6.83 b	7.27 a		2.76 a	2.48 ab	2.12 b		2.97 a	2.73 b	2.32 c	
LSD 0.05	Between T	Between P	Between T×P		Between T	Between P	Between T×P		Between T	Between P	Between T×P		Between T	Between P	Between T×P	
	0.0927	0.0.0718	o.1882		0.1526	0.1182	0.3097		0.188	0.2964	0.3645		0.116	0.0759	0.2334	

Table 8. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on non reduced sugars and decay (%) (seasons of 2015/2016 and 2016/2017)

Treatment	Non reduced sugars (%)								Decay (%)							
	2015/2016				2016/2017				2015/2016				2016/2017			
	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean	At harvest	After a week	After two weeks	Mean
Control	2.92	3.92	4.69	3.84 b	3.68	4.03	5.16	4.02 a	0	4.56	6.94	3.83 a	0	4.05	7.29	3.78 a
Gibberellic acid (GA3)	3.18	3.70	4.52	3.8 b	3.22	4.08	4.86	4.52 b	0	3.27	4.97	2.75 d	0	3.36	6.05	313 c
Ascorbic acid (AA)	3.37	4.06	4.64	4.02 a	3.66	4.22	5.06	4.31 a	0	3.64	5.54	3.06 b	0	3.79	6.83	3.50 b
Citric acid (CA)	3.37	3.90	4.64	3.97 a	3.66	4.18	5.02	4.29 a	0	3.74	5.69	3.14 b	0	3.98	7.17	3.72 a
Salicylic acid (SA)	3.09	3.42	4.94	3.82 b	3.42	4.06	4.69	4.56 b	0	3.60	5.20	2.93 c	0	3.37	6.06	3.14 c
Means P	3.0c	3.80 b	4.69 a		3.53 c	4.11 b	4.96 a		0	b3.76	a5.67		0c	3.71 b	6.65 a	
LSD0.05	Between T	Between P	Between T×P		Between	Between P	Between T×P		Between T	Between P	Between T×P		Between T	Between P	Between T×P	
	0.181	0.0605	0.1588		T0.0946	0.0732	0.6070		0.118	0.161	0.2380		0.0809	0.0732	0.1629	

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محصول وجودة ثمار وفترة التسويق لثمار البرتقال بسرة واشنجطون وتأثرها بالإضافة الورقية قبل الحصاد بأحماض الجبريليك والستريك والأسكوربيك والسالسيلك

هاله محمد إبراهيم الخياط

مركز بحوث البساتين – مركز البحوث الزراعية - مصر

أجريت هذه الدراسة خلال موسمي ٢٠١٥/٢٠١٦، ٢٠١٦/٢٠١٧ على أشجار البرتقال أبو سرة عمر ١٠ سنوات ومنزرعة بمزرعة خاصة بمركز كفر الدوار محافظة البحيرة لدراسة تاثير الاضافة الورقية لحمض الجبريليك٣٠جزء فى المليون والاسكوربك والستريك والسالسليك بتركيز ٤٠٠ جزء فى المليون وذلك فى بداية شهر يوليو وسبتمبر ونوفمبر (لدفعات الرش الثلاثة) لدراسة تأثيرها على المحصول وإطالة عمر الثمار بغرض الإحتفاظ بصفات جودة الثمار لزيادة قدرتها التسويقية بدون فقد اقتصادى، جمعت ثمار البرتقال بسرة فى ميعاد متأخر (نهاية فبراير)، وقد أظهرت النتائج أن جميع المواد المستخدمة أدت إلى تأخير حدوث ليونة الثمار وانكسار اللون الأخضر مع انخفاض نسبة تدهور القشرة، أدت بعض المعاملات أيضًا إلى زيادة محتوى الثمار من المواد الصلبة الذائبة الكلية والسكريات وفيتامين ج، وقد أظهرت النتائج أن إضافة حامض الجبريليك أدت إلى زيادة محيط الشجرة وطول الأفرع وسمك القشرة والكالسيوم فى الورقة ومقاومة قشرة الثمار، بينما أدى الرش بحمص الاسكوربك إلى زيادة طول وقطر الثمار ومحتوى الأوراق من النتروجين والبوتاسيوم والكالسيوم وإلى زيادة محتوى الثمار من المواد الصلبة الذائبة الكلية وفيتامين ج ونسبة المواد الصلبة الذائبة الكلية/الحموضة. وأدت المعاملة بحمض الستريك لزيادة مساحة الورقة، كما أدت إضافة كل من حمض الاسكوربك والستريك لزيادة محيط الجذع وكذلك السكريات الكلية والمختزلة فى حين أدت إضافة حمض السالسيليك لزيادة محتوى الأوراق كلوروفيل a&b والمحصول وسمك القشرة وحموضة الثمار ومقاومة قشرة الثمار، أظهرت النتائج أيضاً أن الإضافة الورقية لحمض الجبريليك بتركيز ٣٠ جزء فى المليون وأحماض الاسكوربك والستريك والسالسليك بتركيز ٤٠٠ جزء فى المليون غلى الأشجار ثم التخزين على درجة حرارة الغرفة لمدة أسبوع وأسبوعين أن المعاملة بحامض الاسكوربك أدت إلى زيادة المواد الصلبة الذائبة الكلية و فيتامين ج ونسبة المواد الصلبة الذائبة الكلية /الحموضة والسكريات الكلية وأدت المعاملة بحمض الستريك لزيادة الفقد فى وزن الثمار أثناء فترة التخزين بينما أدت إضافة حامض الجبريليك إلى زيادة سمك القشرة أثناء فترة التخزين، كان لجميع المعاملات تأثيرًا إيجابيًا على تقليل تلف الثمار أثناء فترة التخزين مقارنة بالكنترول، أيضًا أظهرت النتائج لذلك زيادة معنوية فى نسبة المواد الصلبة الذائبة الكلية ونسبة المواد الصلبة الذائبة الكلية/الحموضة والسكريات الكلية والغير المختزلة وكذلك فقد وزن الثمار وتلفها بينما أظهرت نقص السكريات المختزلة ومقاومة القشرة تدريجيا بزيادة فترة التخزين.

المحكمون :

١- أ.د. صفـــاء عبدالغنـــي أحمد نميـر أستاذ الفاكهة المتفرغ – كلية الزراعة – جامعة الزقازيق.

٢- أ.د. طلعت علي محمد أبو سيد أحمد أستاذ الفاكهة المتفرغ – كلية الزراعة – جامعة الزقازيق.