International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.2, pp 523-533, 2017

Effect of Post Harvest Treatments with Oxilite on Washington "NavelOrange" Fruits under Cold Storage Conditions

Gehan A.M. EL-Hadidy

Hort. Res. Institute. Fruit Handling Depart..Agric. Res. Center, Giza, Egypt.

Abstract : This study was conducted during two seasons (2014 and 2015), on Washington"Navel Orange"fruits *(Citrus sinensis,* L.) obtained from a private orchard at El-Qalubia Governorate. The aim of the current investigation was to study the effect of post-harvest treatments with Oxilite (O_3)on fruit quality of"NavelOrange"duringcold storage at 8°C and relative humidity (R.H85-90%). Fruits were dipped in Oxilite (**chemical substance for Ozone production**) in two concentrations of Oxilite solution 1:5 or 1:10 (v/v)(10 % Oxilite) for30 or 60 seconds and (20 % Oxilite) for30and 60 seconds beside control treatment. Some Physical and Chemical properties were studied such as fruits weight loss and decay percentage**,** fruit appearance*,* fruit Firmness, fruit color, fruit Juice percentage, Soluble Solids Content, total acidity and ascorbic acid. The data illustrated that fruit dipped in Oxilite solution 1:10(v/v for 60 seconds had less fruit weight loss, decay percentage and good color and appearance till the end of storage period 8 weeks in comparison with other treatments.
Key word : Washington "Navel Orange"–Oxilite-*Weight loss –Decay*- cold storage.

Introduction

Citrus (*Citrus spp*.) is one of the most important fruit crops grown in many tropical and subtropical countries. In Egypt, citrus has great attention due to both its importance for local consumption or as importance for foreign currencies by exportation to the world markets. Therefore, it's playing an important role in the Egyptian economy. During the last few years, harvested area increased rapidly to reach about 530415 feddans in 2014"*. The fruiting acreage of citrus occupies 440706 feddans that produces 4,402,180 Tons. Citrus fruits are subjected to damage by numerous pests and diseases throughout production; packing; storage; transportation and marketing. Some of the fungicides which were developed and used to control fungal diseases during the postharvest handling and storage are no longer registered; others may lose registration in the future.

Gaseous Ozone treatment during storage of table grape has a great potential for degrading contemporary fungicides related to table grape production.**Egea *et al*., [1]** and **Smilanick,*et al*., [2]** evaluated it for this purpose and mentioned that, it can be used in the cold storage atmosphere to prolong grape storage life after harvest .They confirmed that,antioxidant content is an important to increasing fruit and vegetable quality. Doubtless that, low storage temperatures are used to extend fruit post-harvest life.**EL-Hadidy, G. and Nagy [3]** on "Canino" apricot and **El-Saedy,*et al*., [4]** on "mango"observed that, gaseous Ozone treatment during storage is used to reduce fungal diseases effect.

Since ozone (O_3) has excellent ability to reduce microbial populations and does not leave a residue, its postharvest use is increasing.

The ozone antimicrobial effects are a result of the microbial resistance of the plant being maintained by the ozone treatment rather than its direct effect on the plant pathogen.

Its postharvest use is increasing, **Skog and Chu,** [5] on apples, and **Parish *et al.*,** [6] in food science and food safety**.** Recent work indicates that ozone is an effective treatment for increasing shelf-life and decreasing fungal deterioration in the postharvest treatment of fresh fruit, such as grapes**. Whangchai *et al*.,** [7]**, (Ayandiji Adebamiji** [8], on citrus. It was reported that farmers should have more access to micro-credit to reduce losses. **Thaer Yassan , *et al*.,** [9], on apple Indicate that, ozone could be used to increase storage duration of apple varieties to maintain their quality. Generally, application of Ozone has been reported to play an important role in reducing physiological disorders, delaying senescence, and inhibiting postharvest weight loss for the most horticulture crops. Total Soluble Solids (SSC) content of juice slightly increased during storage, while juice percentage, titratable acidity and ascorbic acid contents decreased **Ramanjulu and Reddy,** [10]**.** The same results were concluded by **Echeverria and Ismail** [11] **;Purandare, *et al.,*** [12]**; Rana, *et al*.,** [13] **and Whangechai. *et al*.,** [14] on tangerine. Consequently, the aim of the current investigation was to illustrate the postharvest treatments with Ozone on Washington"NavelOrange" fruits under cold storage conditions. The possibility of using it as a substitute for used fungicides in packing houses was also assessed. According to Annual Report of **Agric. Min. Egypt** [15]**.**

2- Materials And Methods

This study was carried out at the Horticulture Research Institute (HRI), at Fruit Handling Depart. Lab - Giza during two successive seasons of 2014 and 2015. At harvest time (the 1st week of January) fruits were picked from a private orchard at El-Kalubia Governorate.Fruits were selected for uniformity, shape, colour, and size, and any blemished or diseased fruits were discarded anddirectly transported to the laboratory were divided to five groups as follow.

1- T1: Control treatment (dipped in distilled water).
2- T2: Dipped in Oxilite solution: distilled water 1:5 (v/v) for 30 seconds.
3- T3: Dipped in Oxilite solution: distilled water 1:5 (v/v) for 60 seconds.
4- T4: Dipped in Oxilite solution: distilled water 1:10 (v/v) for 30 seconds.
5- T5:Dipped in Oxilite solution: distilled water 1:10 (v/v) for 60 seconds**.**

Then all fruits were air dried againand packed in carton boxes in one layer. Each treatment had 6 boxes each box had 20 fruits, three boxes were used in order to determine weight loss and decay percentage while the other boxes were used in order to determine the other physical and chemical properties.The fruits were stored at 8°C and 85-90 R.H for 60 days. Samples (3 replicates each had 4 fruits) from each group were taken and examined after 2,4,6 and 8 weeks for quality parameters. as well as fruit juice SSC. %, total acidity, SSC.%, total acidity, SSC./Acid ratio was calculated from two values (soluble solids/TA). Vitamin C as mg ascorbic acid were determined and estimated per 100 ml fruit juice (**A.O.A.C.,** [16])

Physical properties:-

***1-Weight loss percentage*:** was calculated as the formula:

Loss in fruit weight % = Initial weight - Weight at time of sampling /Initial weight× 10 0

***2-DecayPercentage*:**The discarded fruits included all the injured or spoiled fruits resulting from fungus or bacteria, shriveling and other various defects, were calculated and expressed as decay percentage.

3- Appearance of fruits:

- Fruit appearance and freshness was rated I = Very good with excellent appearance; 2 = fresh with good appearance; 3 = fairly fresh and acceptable appearance; 4 = not fresh and poor appearance (unmarketable fruits). **(Echeverria and Ismail.** [11] **and Rana, *et al.,*** [13]**.**

***4*-Fruit Firmness:*(g/cm^2)*:**These 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).

5-Fruit color (Hue angle): These values were estimated in six fruits by using hunter Colorimetric model DP 9000. (Hue angel) were determined and the values were calculated according to **McGjuire [17].**

6-Fruit Juice percentage: Juice was extracted and weighed then calculated as percentage of fruit weight.

Chemical properties:-

1:Soluble Solids Content (SSC) %: Was estimated by abbey digital Refractometer.**(A.O.A.C.,[16]).**

2:Total acidity %: Total acidity content was determined according to **A.O.A.C. [17].**

3:SSC. /acid Ratio.

4: Ascorbic Acid (Vitamin C): Ascorbic acid was determined (as mg/100 ml juice) according to **Lucas, [18].**

Statistical analysis: The complete randomized block design was used and data was statistically analyzed according to **Snedecor and Cochran [19].** Averages were compared as significant differences among means according to the Duncan's multiple range test at $P \geq 0.05$ **Duncan, (20).** All data obtained was evaluated by statistical analysis of data using software MSTAT-C.

Table (1): Reactive ions formed in the oxilite and redulite solutions by electrochemical activation.

	REACTIVE MOLECULES	REACTIVE MOLECULES
OXILITE	**Ozone** O_3	**Hydrogen** H^+
	Oxygen O_2	**Hydronium** $H3O^+$
	Hydrogen peroxide H_2O_2	**Hydroxide** OH-
	Chlorine dioxide ClO_2	**Chlorine monoxide** ClO^-
	Hypochlorous acid HClO	
	Chlorine Cl_2 **hydrogen chloride** HCl	

Results and Discussions

A) Physical properties:-

1-- Weight loss %:

Data in **(Table 2)** showed that, weight loss percentage of Washington"NavelOrange"fruits significantly and gradually increased with prolonged storage period 0, 2,4, 6and8 weeks respectively, Oxilite treatments significantly reduced fruit weight loss percentage than control, (5.85 and5.58 %)for both seasons**.** Moreover, Oxilite at 10 %for60swas superior in preserving fruit quality on the average (5.87 and 4.37%) in the two seasons of the study. These, results are in partial agreement with those found **by Palou. *et al.*, [21] and Barboni, *et al.*, [22].** Who mentioned that, a gradual increase in weight loss was shown towards the end of the storage periods**;** **Rocculi *et al.*, [23]** reported that weight loss percentage significantly increased with the progress of storage periods. In additions, **EL-Hadidy, G. and Nagy [3],** indicated that, Ozone treatments on "Canino" apricot was recorded the lowest values while the control treatment was recorded the highest values of weight loss in both seasons.

Moreover, **Di Renzo G.C. *et al.*, [24],** on orange, **Allende, *et al.*, [25],** on strawberries **and Ayandiji Adebamiji [8]** on citrus observed that, gaseous O_3 reduced weight loss of strawberries. Therefore, it reduced fruit weight loss, fruit shelf life for two weeks at room temperature.

Table (2): Effect of post- harvest treatments with Oxilite on weight loss% of Washington "NavelOrange"Under cold storage conditions (8°C & 90%R.H.) during 2014 and 2015 seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	0.00e	3.60c	6.03a	8.70a	10.93a	5.85A	0.00e	3.37a	6.57a	8.87a	10.10a	5.78A
T2	0.00e	4.13ab	4.43d	4.43d	8.50e	4.30C	0.00e	2.80b	5.67b	7.33b	9.83b	5.13B
T3	0.00e	3.30bc	5.13b	8.70a	10.07b	5.14D	0.00e	2.23bc	4.87c	7.17bc	9.50bc	4.75C
T4	0.00e	4.27a	4.80c	7.33b	9.67c	5.21B	0.00e	2.70bc	4.20cd	6.77c	8.27de	4.59D
T5	0.00e	3.57b	4.30e	6.97c	9.17d	4.80E	0.00e	2.73bc	4.20cd	6.40cd	8.50d	4.37E
Means	0.00E	4.57D	4.94C	7.32B	9.67A		0.00E	3.57D	5.10C	6.91B	9.24A	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:15 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

2- Decay percentage:

Data presented in **(Table 3)** clearly illustrated that, decay percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods after These results are in agreement with those obtained by **Barakat, et al. [26],** Moreover, all Oxilite treatments reduced decay percentage of Washington"NavelOrange"fruits than control Oxilite 1:10 for 60s ("T5") had the most significant effect. Regards to the interaction between Oxilite("T5") treatments and the storage periods, data indicated a significant effect. Whereas, 1:10 for 60s was the lowest values in this respect for both seasons, while the control treatment was recorded the highest values of decay was obtained, after 8weeks treatments (1.6 and1.85%) in both seasons (4.6and 4.9%), (1.6o and1.85%) respectively. These results are in line with those obtained by **Skog and Chu [5]** on apple and pear and **Palou *et al.*, [21]**, on peaches and table grapes. **EL-Hadidy G. and Nagy [3],** on "Canino" apricot and **Allende *et al.*, [25]** on strawberries. Also, Ozone treatment has oxidant effect which inhibited mycelia growth and prevented sporulation on citrus Inoculated with Penicilli. **Di Renzo G.C. *et al.*, [24] and Thaer Yassan *et al.*,[9]** on apple,who reported that, Ozone treatment plays a control effect microorganism contaminalation and on increase of Pathogenesis Related Peoteins (PRPs) activity. These results lead to suggest a correlation between the antimicrobial effect of Ozone and plant ability to counteract.

Table (3): Effect of post- harvest treatments with Oxilite on Decay % of Washington "NavelOrange"Under cold storage conditions (8°C & 90%R.H.) during 2014 and 2015 seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	0.00e	0.00e	0.00e	3.20a	4.60a	1.60C	0.00e	0.00e	0.00e	3.46a	4.90a	1.67A
T2	0.00e	0.00e	0.00e	1.82bc	2.10a	0.78B	0.00e	0.00e	0.00e	2.10b	2.40b	0.90B
T3	0.00e	0.00e	0.00e	1.50bc	1.93a	0.69C	0.00e	0.00e	0.00e	1.84cd	2.35bc	0.84C
T4	0.00e	0.00e	0.00e	1.73bc	2.20a	0.79A	0.00e	0.00e	0.00e	1.72cd	2.20bc	0.78D
T5	0.00e	0.00e	0.00e	1.35bc	1.60a	0.59D	0.00e	0.00e	0.00e	1.40ab	1.85a	0.65E
Means	0.00C	0.00C	0.00C	1.92B	2.49A		0.00C	0.00C	0.00C	2.10B	2.74A	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:150 for 60s.
(T4): Dipping fruits inOxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

3- Appearance of fruits:

Nevertheless, data presented in**(Table 4)** cleared that, Oxilite"1:10 for 60s ("T5") significantly reduced the incidence of deterioration of fruits till the end of 8th weeks in the two seasons. After 8 weeks, there were significant differences between the appearances of fruits treated with Oxilite treatments and the control where, Oxilite 1:10 for 60s ("T5") resulted in the highest reduction of deterioration as well as very good appearance. These results disagree with those reported by **Allende *et al.*, [25],** who observed less fruit appearance parallel to Oxilite treatments. Due to the high oxidative capacity of O_3 and its ability to generate toxic molecular species, it

acts as potent phototoxic agent. It elicits plant defense reactions such as the production of phytoalexins **Maharaj, *et al*.,** [27], **González-Barrio *et al.*,** [28] on 'Superior' white table grapes.

Table (4): Effect of post- harvest treatments with Oxilite on appearance% of Washington "NavelOrange"Under cold storage conditions (8°C & 90%R.H.) during 2014 and 2015 seasons.

	Storage period by weeks											
Period Treatment	Zero time	2weeks	4 weeks	6weeks	8weeks	Means (T)	Zero time	2weeks	4 weeks	6week	8weeks	Means (T)
	Season (2014)						season (2015)					
T1 (Cont.)	1.0e	1. 67a	2.67a	3.67a	4.0a	2.60A	1.0e	1.33a	2.67a	3. 33a	4.0a	2.47A
T2	1.0e	1.33b	2.0c	2.65b	3.0b	1.93B	1.0e	1. 33a	1. 67c	2. 33c	3.0 b	1.87C
T3	1.0e	1. 0d	1.67b	2.33c	2.67c	1.80C	1.0e	1.25b	1. 92b	2.50b	3.17c	1.97B
T4	1.0e	1. 0d	2.0d	2.33c	2.67c	1.73D	1.0e	1.0d	1. 67c	2.0d	2.67d	1.67D
T5	1.0e	1.10c	1.33e	1.67d	2.33d	1.47E	1.0e	1.20c	1. 33d	2.0d	2.67d	1.64E
Means	1.0E	1.20D	1.90C	2.50B	2.90A		1.0E	1.20D	1.90C	2.40B	3.01A	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

4- Fruit firmness (g/cm^2) :

(Table 5) showed that, orange fruit firmness was decreased gradually and significantly with the increasing of storage period during the two seasons in this work. Data also cleared that, all Oxilite treatments significantly reduced the effect of storage period on fruit Firmness**.** Oxilite treatments has significantly the highest values while the control treatment was recorded the lowest values of Washington"NavelOrange"fruit Firmness after the 8th week of storage period ,during the two seasons, These results are disagreement with those obtained by, **Barboni*et al.,*** [22]**,** recorded no significant effect of Ozone on kiwi fruits firmness. **Nadas, *et al*.,** [29] on mango, **Skog and Chu,** [5] on apples, **Thaer Yassan *et al*.,** [9] on apple **and El-Saedy,*et al*.,** [4] on mango.

Table (5): Effect of post- harvest treatments with Oxilite on Firmness (g/cm^2) of Washington "NavelOrange" under cold storage conditions (8°C& R.H 90 %) during 2014and 2015 seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	198.0a	172.0cd	166.0ef	142.4i	136.27j	142.3E	202.0a	167.2e	158.8f	138.1h	124.5i	158.1D
T2	198.0a	183. 4b	171.7cd	161.9-f	165.8ef	175.5A	202.0a	187.0c	156.7f	144.6g	121.0i	162.3C
T3	198.0a	185.0b	175.1c	166.2ef	143.9i	173.0B	202.0a	194.0b	168.4e	155.3f	135. 4h	171.0A
T4	198.0a	180.3b	167.6de	154.7gh	156.4 g	170.7C	202.0a	182.4cd	134.3h	158.0f	158.0f	158.5D
T5	198.0a	173.7c	165.6ef	144.0i	151.6h	165.9D	202.0a	178.3d	165.1e	165.7e	121.8h	166.6B
Means	198.0A	178.9B	169.2C	153.8D	150.8E		202..0A	181.8B	156.7C	152.4D	132.1E	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

5- Fruit color (Hue angle):

(Table 6) illustrated that,, peel fruit color,(represented as hue angle value) was changed directly from green yellow to yellow with the increasing of storage periods during the two seasons in this work**.** Also these results showed that, all the Oxilite treatments

significantly increase the change rate of peel color compared with control during the two seasons in this work**.** Reversely, **Skog and Chu,** [5] **and Shalluf *et al*.,** [30] reported that the color change (as" hue angle °) was significantly less pronounced for the ozone-treated fruits where it due to the synthesis of carotenein the fruit mesocarp. However, delay evidence, by the decrease in color change. The results are in agreement with those of **Ornelas-Paz *et al.,*** [31] **and Sancho *et al*.,** [32]**. Whangechai. *et al*.,** [14],who showed that, electrolyzed oxidizing water may be useful for surface sanitation and Ozone has potential to control the recontamination of postharvest diseases in tangerine fruit in storage room.

Table (6): Effect of post- harvest treatments with Oxilite on color of Washington "NavelOrange"fruits during cooling storage conditions (8°C and R.H 90 %) during(2014and 2015)seasons.

	Storage period by weeks											
Period Treatment	Zero time	2weeks	4 weeks	6week	8weeks	Means (T)	Zero time	2weeks	4 weeks	6week	8weeks	Means (T)
	2014 season						2015 season					
T1 (Control)	70.82a	69.63b	67.81c	66.29d	64.87e	67.88A	69. 54a	67.75b	65.81c	64.62d	63.50e	66.24A
T2	70.82a	68.08c	66.65d	64.84e	62.85g	66.65B	69. 54a	66.92c	64.33d	62.55e	60.79j	64.82B
T3	70.82a	66.18d	64.34g	63.44g	62.20h	65.40C	69. 54a	65.28d	63.50e	61.79g	60.58j	64.14B
T4	70.82a	65.29e	63.54f	62.29i	61.38f	64.66D	69. 54a	64.65g	62.24f	60.73j	59.78h	63.38C
T5	70.82a	65.89e	62.28i	61.83f	60.48i	64.26D	69. 54a	63.00h	61.52g	59.87h	58.75i	62.54D
Means	70.82A	67.01B	64.92C	63.74D	62.36C		69. 54A	65.5B	63.48C	61.91D	60.68E	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

6- Fruit Juice percentage:

It is obvious from data presented in **(Table 7)** that, "T5" and "T1" treatments gave highest significant fruit juice % in the1st season and Oxilite 1:10 for 60s ("T5") treatment in the 2ndseason.Moreover, Juice percentage decreased during cold storage. This may be due to reducing of fruit flesh firmness and increasing of Enzymes aging. Concern to the interaction between Oxlite treatment and storage periods data indicated that, there was a significant effect for both seasons. Whereas, "T1"(control) treatment gave the highest fruit juice value and Oxilite 1:5 for 30s ("T2") treatment was the lowest after 4 weeks. It was clear from previously evidence that during postharvest stage, non soluble sugar may be converted into soluble sugar with increasing temperature and storage periods as well as marketing periods. However, are reverse trend was reported **by Rokolhuukeditsu, *et al.,* [33]** on mandarin fruits and **Ladaniya [34]** on lime fruits. These results are not in line with those obtained **by Ramanjulu and Reddy, [10], Echeverria and Ismail,[11], Purandare, *et al.,* [12] and Rana, *et al.,* [13], Erkan, and Pekmezci, M. [35]** who reported that, juice percentage of citrus fruits relatively decreased under cold storage conditions. While **El-Wakil.A. [36],** on "NavelOrange"who found that, juice percentage content of the Navel fruits increased at the beginning and then decreased during the storage periods.

Table (7): Effect of post- harvest treatments with Oxilite on Juice % of Washington "NavelOrange"fruits during cold storage conditions (8°C& R.H 90 %)during (2014and 2015) seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	58.53a	54.96bc	52.98ef	51.78ef	50.82g	53.81A	56.46a	52.36c-h	50.15ch	48.36gh	47.25i	50.92A
T2	58.53a	51.12ef	50.28f	48.38f	46.60g	50.98E	56.46a	49.84b-h	47.35ch	46.14h	44.35i	48.83B
T3	58.53a	52.37de	50.77ef	51.28ef	47.92g	52.17D	56.46a	48.97b-g	48.73bh	47.56f-h	43.30i	49.00B
T4	58.53a	52.77cd	51.47ef	51.66ef	48.53g	52.78C	56.46a	50.44b-d	49.97bg	48.87d-h	45.40i	50.23A
T5	58.53a	53.54b	52.87ef	51.34de	48.72g	53.00B	56.46a	51.17b-f	50.48a	49.65e-h	46.65i	50.88A
Means	58.53A	52.95B	51.47C	50.89D	48.52E		56.46A	50.56B	49.34C	48.12C	45.39D	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits inOxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

B) Chemical properties:-

1- Soluble Solids Content (SSC) %:

Data showed that, total soluble solids of orange fruits were increased gradually and significantly with the increasing of storage periods during the two seasons in this work

(Table8) Data also cleared that**,** Oxilite treatments successfully improved SSC% under cold storage. Obviously, SSC percentage significantly and gradually increased with increasing storage period till 6 weeks

then decreased at 8 weeks in both seasons. As for the interaction effect of Oxilite treatments and storage periods there was insignificant effects, on fruit juice SSC content at the end of storage period for both seasons. These results agree with those found by **Barakat, et al., [26]**, who demonstrated that, total soluble solids contents of orange fruits increased while total acidity and vitamin C contents of orange fruits decreased gradually and significantly with the increasing of storage. These results are in line with those obtained by **El- Wakil.A. [36] and Tzortzakis, *et al*., [37].** On the other hand **Salvador *et al*., [38], Shalluf, *et al*., [30], Barboni*et al.,* [22] and El-Saedy, *et al*.,[4],** on mango. who reported that,O_3 treatments slowed the increase in soluble solid content (SSC) and acid and V.C contents during storage compared to control.

Table (8): Effect of post-harvest treatments with Oxilite on SSC % of Washington"Navel Orange"fruits under cold storage conditions(8°C& R.H 90 %) during (2014and 2015) seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	11.14 d	1370c	14.51ab	14. 80a	13.89abc	13.46A	11.43g	14.37 de	14.47 d	14.93 d	13.67f	13.77C
T2	11.14 d	13. 23b	14.44ab	14.63ab	13.85abc	13.51A	11.43g	13.90 f	14.83 c	15.13ab	13.73f	13.80 BC
T3	11.14 d	13.43abc	14.48ab	14.73ab	13.89abc	13.53A	11.43 g	14.17 e	15.03abc	15.23 a	13. 67f	13.90AB
T4	11.14 d	13.65abc	14.48ab	147.0a	13.95abc	13.58A	11.43 g	13.90 f	14.93bc	15.13ab	13.77f	13.83BC
T5	11.14 d	13.83abc	14.63ab	15.85a	13.99abc	13.63A	11.43g	14.20 e	14.20 e	15.23 a	13.73f	13.94A
Means	11.14 D	13.37C	14.50B	14.74A	13.91C		11.43 E	14.11C	14.27B	15.13 A	13.71D	

Values have the same letter are not significantly different at 5% level using Duncan's Test.

(T1): Control : (water Dipping). (
T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits in Oxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

2- Fruits acidity:

Data presented in **(Table 9)** showed that, Oxilite treatments significantly reduced fruit Juice acidity, and Oxilite 1:5 for 60s ("T2") treatment induced the lowest percentage. Concerning storage period effect, data cleared that, fruit juice acidity reached the highest values after 8th week by (control), in the two seasons. As for interaction effect of Oxilite treatments and storage period, ("T1") treatment (control) gave the highest values while Oxilite1:10 for 60s ("T5") was the lowest after 8th week in the 2 nd seasons. These results agree with those obtained by **El-Oraby and Ekbal-Ali [39]** on Thompson Seedless grapes and Florida Prince peach. Moreover, **Tzortzaki *, et al*., [37] and Whangchai *K.et al.,* [14]** who reported insignificant effect.

Table (10): Effect of post- harvest treatments with Oxilite on acidity% of Washington "NavelOrange"fruits under cooling storage conditions (8°C and R.H 90 %) during (2014) and (2015) seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	1.78a	1.73ab	1.70b	1.66b	1.63d	1. 71A	1.73 a	1.72 a	1.66bcd	1.63bcde	1.57fgi	1.67A
T2	1.78a	1.70abc	1.65abc	1.61egf	1.56 cd	1.66 C	1.73 a	1.62cdef	1.56ghij	1.54hij	1.52ijk	1.60BC
T3	1.78a	1.71d	1.67d	1.64d	1.61c	1.69B	1.73 a	1.68ab	1.65bcde	1.51jkl	1.48klm	1.61B
T4	1.78a	1.74ab	1.71abc	1.66egf	1.64cde	1.70 A	1.73 a	1.67abc	1.61defg	1.47klm	1.44m	1.59 C
T5	1.78a	1. 72e	1.66e	1.63e	1.58e	1.68E	1.73 a	1.66bcd	1.60efgh	1.46 lm	1.437m	1.58C
Means	1.78A	1.74B	1.69 C	1.66D	1.61E		1.73A	1.67B	1.62C	1.52D	1.49E	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping). (T2): Dipping fruits in (Oxilite 1:5 for 30s.
(T3):Dipping fruits inOxilite 1:150 for 60s. (T4): Dipping fruits in Oxilite 1:10 for 30s.
(T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

3- SSC / acid Ratio:

As shown in **(Table 10)**"T5" clearly increased fruit juice TSS/Acid R. when compared to T1 treatment in the two seasons .Moreover, Oxilite treatments improved TSS/Acid R. in navel orange juice during the

storage period .Concern to the effect of storage period on fruit juice TSS/acid R., data cleared that, it's gradually increased with significantly differences till the 6th week and then decreased at the 8th week .

Regard the interaction between Oxilite treatments and storage period there was a significant differentiation in both seasons. Whereas, "T1"treatments gave the lowest values at the 4th week and "T5"treatment was the highest at 8th week for both seasons. These results are in harmony with those obtained by **Chen and Mellenthin, [40], Babalar,*et al.* [41] Nadas, *et al.* [29],and Arnal and Del Rio [42]** who added that, juice total acidity content of citrus fruits decreased during storage due to the destruction of organic acids through oxidation and consumption of these acids as an organic substrate in respiration processes of the fruit tissues and for prolonged storage period raised fruits respiration rate,

Table (10): Effect of postharvest treatments with Oxilite on SSC/acid Ratio of Washington "NavelOrange"fruits under cooling storage conditions (8°C and R.H 90 %) during(2014) and (2015) seasons.

Storage period by weeks												
Period Treatment	Zero time	2weeks	4 weeks	6weeks	8weeks	Means (T)	Zero time	2weeks	4 weeks	6week	8weeks	Means (T)
season (2014)							season (2015)					
T1 (Cont.)	6.18 g	7.43 f	8.51abc	8.82ab	8.53 b c ABC	7.90 A	6.5 J	8.44ghi	8.65 g	8.64g	8.64g	8.28 D
T2	6.18 g	7.53 e f	8.51abc	8.82ab	8.62 a b ABC	7.93 A	6.55J	8.517gh	9.43 d	8.96f	8.96f	8.6 C
T3	6.18 g	7.84cdef	8.64abc	8.98ab	8.64 a b ABC	8.06 A	6.55J	8.37 hi	9.03 e f	9.16ef	9.16ef	8.62 C
T4	6.18g	7.64 de	8.24bcd	8.6abc	8.34abd ABCD	7.80 A	6.55 J	8.26 i	9.20 e	9.48 d	9.48 d	8.74 B
T5	6.18 g	7.84c def	8.72 ab	9.09 a	8.82 a AB	8.13 A	6.55 J	8.50gh	9.44 d	9.52 d	9.52 d	8.87 A
Means	6.18D	7.66 C	8.53 B	8.62abc	8.59 AB		6.55 D	8.42 C	9.15 B	9.159B	9.159 B	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping). (T2): Dipping fruits in (Oxilite 1:5 for 30s.
(T3):Dipping fruits inOxilite 1:150 for 60s. (T4): Dipping fruits in Oxilite 1:10 for 30s.
(T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

4-Ascorbic Acid (Vitamin C.) content:

Generally, Oxilite post-harvest treatments significantly keep fruit juice as corbic acid contents. **(Table11)** "T4" and"T5" treatments significantly gave the highest values when compared to the control fruits in both seasons, there were no significant differences between them. Regard to storage period effect, data revealed that ascorbic acid content gradually and significantly decreased with prolonged storage period in the two studied seasons. Oxilite treatments were more effective and significantly maintained V.C content in the two seasons.

As for the interaction between Oxilite treatments and storage period."T5" treatment was the highest values while control fruit were the lowest in both seasons. Therefore, Ozone gas as a bi- product delayed ascorbic acid deterioration in fruit juice under cold storage. These results are similar with those obtained by **Shalluf *et al*., [30], Ladaniya,M.S. [34], Tzortzakis*et al*., [37] and Barboni *et al.,* [22]**. On the other hand, **Allende *et al.,* [25].** Who foundV.C is able to scavenge oxygen radicals and avoid oxidative stress .**Klopotek *et al*., [43].** Thus, changes in V.C of O_3-treated fruits can be attributed to the activation of an antioxidative system that promotes the biosynthesis of V.C from the carbohydrate pool **Pérez *et al*., [44].**

Table (11): Effect of post- harvest treatments with Oxilite on ascorbic acid (mg/100 ml juice) content of Washington"NavelOrange" fruits under cooling storage conditions(8°C and R.H 90 %) during(2014) and (2015) seasons.

	Storage period by weeks											
Period of Treatment	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)	Zero time	2 weeks	4 weeks	6 weeks	8 weeks	Means (T)
	Season; 2014						Season; 2015					
T1 (Cont.)	47.18a	37.81lm	32.36n	30.47o	28.71p	35.31D	45.27a	35.09f	30.33h	28.42i	25.52j	32.93C
T2	47.18a	44.13c	41.27g	39.32i	37.46m	41.87C	45.27a	42.22c	39.37d	39.80d	33.62g	40.05A
T3	47.18a	44.47c	41.81f	39.68i	37.86l	42.20B	45.27a	42.57bc	39.61d	36.82e	33.77g	39.61B
T4	47.18a	45.23b	42.39e	40.96gh	38.42k	42.83A	45.27a	43.19bc	40.11d	37.28e	34.42fg	40.05A
T5	47.18a	45.53b	42.77d	40.67h	38.85j	43.00A	45.27a	43.41bc	40.37d	37.56e	37.88f	40.30A
Means	47.18A	43.43B	40.12C	38.22D	36.26E		45.27A	41.30B	37.96C	35.98D	32.44E	

Values have the same letter are not significantly different at 5% level using Duncan's Test.
(T1): Control : (water Dipping).
(T2): Dipping fruits in (Oxilite 1:5 for 30s. (T3):Dipping fruits inOxilite 1:150 for 60s.
(T4): Dipping fruits in Oxilite 1:10 for 30s. (T5): Dipping fruits treated with (Oxilite 1:10 for 60s.

V-Conclusion

Oxilite treatments for 1:10 for 30 secondsor60 seconds successfully reduced fruit weight loss, decay percentage ,acidity deterioration for "Navel Orange"fruits under cold storage conditions(8°C& R.H 90%) for 8 weeks., While, it There for, Oxilite could be consider a save component for keeping quality of "Navel Orange" for 8 weeks delaying ripening and senescence stages.

References

1. Egea, M.I.; Martinez-Madrid, M.C.; Sanchez-Bel; P., Muricia, M.A. and Romojaro, F. 2007.The influence of electron-beam ionization on ethylene metabolism and quality parameter in apricot Hort. Science, 27:1254 -1255.
2. Smilanick, J.L., Margosanv, D.M., Mlikota, G. F., Margocan, D. A.andHashim-Buckey,J. 2010.Post-harvestTechnologyResearch &InformationCenter, USDA-ARSL Fresno.(accessed 1004.11). 3- Gehan A.M. EL-Hadidy. and K. Nagy
3. Gehan A.M. EL-Hadidy. and K. Nagy 2015.Effect of Ozone and Perforated Packaging On"Canino"apricotcv.FruitsQuality During Cold Storage. Egypt. Journal ofAgricultural Research Center,93 (3). 2015.
4. El-Saedy,Ragaa M. ;D.O.EL-Ansary;Nermeen EL-Nagar and A.M.Husse in 2011.Postharvest Ozone and hot water treatments increase Storage life of mango fruits. Alex.J.Agric.Res, *Vol. 56, No. 1, pp. 97-108*
5. Skog, JL and Chu, C.L. 2001. Effect of Ozone on qualities of fruits and vegetables in cold storage. Can J Plant Sci 81:773–8.
6. Parish, M.E.; L.R. Beuchat; T.V. Suslow; L.J. Harris; E.H. Garrett; J.N. Farber and F.F. Busta 2003. Methods to reduce/eliminate pathogens from fresh and fresh-cut produce. C.f. Comprehensive reviews in food science and food safety. Chapter 5, Vol.2.
7. Whangchai, K., Saengnil, K., Uthaibutra, J., 2006. Effect of ozcombination with some organic acids on the control of postharvest decay and pericarp browning of longan fruit. Crop Prot. 25: 821–825.
8. AyandijiAdebamiji. 2011.Effects of post harvest losses on income generated in Citrus spp in ifeadp zone of Osun state, Nigeria. African Journal of Food Science and Technology (ISSN: 2141-5455) Vol. 2(3) pp. 052-058.
9. Thaer Yassan, Alessandra RIcellI, BurakTuraN ,PIeTro AlBaNeSe · and Anna Mari D'oNGhIa 2015. Ozone for post-harvest treatment of apple Fruits. Phytopathologia Mediterranea (2015)54:1,94-103 .
10. Ramanjulu, V. and Reddy, M. R. S. (1989): Post-Infection changes in Satgudi sweet orange fruits caused by Gloeosporium Iimetticola. Indian Phytopathology, 42(1): 191-192.
11. Echeverria, E. and Ismail, M. 1990. Sugars unrelated to Brix changes in stored citrus fruits. Hort. science, 25(6): 710.

12. Purandare, N.D.; Khedkar, D.M. and Sontakke, M B. 1992. Physiochemical changes during degreeing in "sweet orange"*(Citrus sinensis,* Osbeck) South Indian Horticulture; 40(3): 128-132. "Sweet orange" fruits caused by GloeosporiumIimetticola. Indian Phytopathology, 42(1): 191-192.
13. Rana, G.S.; Karter-Singh and Singh, K. 1992.Studies on extending post-harvest life of sweet orange" fruits. Crop Research Hissar; 5; Supplement: 154 -157.
14. Whangchai, K.; K. Saengnil; C. Singkamanee and J. Uthaibutra 2010. Effect of electrolyzed oxidizing water and continuous ozone exposure on the control of *Penicillium digitatum* on tangerine cv. 'Sai Nam Pung' during storage. Crop Protection , 29: 386–389.
15. Anonymous 2014. Statistical Year-Book. Ministry of Agriculture and Land Reclamation, Giza, Egypt.
16. A.O.A.C.,1995. Official methods Of Analysis,16thed Association of Official Analytical Chemists. WashingtonDC, USA. Acta Hort. (ISHS) 682:1605-1610.
17. McGuire,R.G. 1992. Reporting of objective color measurements Hort.Science,27:Mediterranea (2015) 54:1, 94−103.
18. Lucas, G. H. (1944). Determining ascorbic acid in large number of plant samples. Ind. Eng. Chem. and Ed.,16:649-652.
19. Snedecor, G. W. and W. G. Cochran, (1980). Statistical methods. Oxford and J. B. H. Bub Com. 6th Edition.
20. Duncan, D. B. (1955) Multiple range and multiple F. test. *Biometrics,* 11, 1- 42.
21. Palou, L; Smilanick, J.L.; Crisosto, C.H.; Mansour, M. and Plaza, P. 2003. Ozone gas penetration and control of the sporulation of Penicillium digitatum and Penicillium talicum with commercial packages of oranges during cold storage. Crop Prot. 22:1131–4.
22. Barboni T.; M. Cannac and N. Chiaramonti 2010. Effect of cold storage and ozone treatment on physicochemical parameters, soluble sugars and organic acids in Actinidiadeliciosa. Food Chemistry, 121: 946–951.
23. Rocculi, P.; Romani, S. and Dalla Rosa, M. 2004.Evaluation of physio-chemical modified atmosphere. Food Res. Int. Vol. 37: 329-335.
24. Di Renzo, G.C., Altieri, G., D'Erchia, L., Lanza, G. and Strano, M.C. 2005. Effects of gaseous Ozone exposure on cold stored orange fruit.Acta Hort. (ISHS) 682:1605-1610.
25. Allende A.; A. Marín; B. Buendía; F. Tomás-Barberán and M. I. Gil 2007. Impact of combined postharvest treatments (UV-C light, gaseous O_3, superatmospheric O_2 and high CO_2) on health promoting compounds and shelf-life of strawberries. Postharvest Biol. and Technol., 46 (3): 201-211.
26. Barakat, M. R.; M. A. A. Mohamed; M. A. Essa and Z.A. Zaki, (2012). Effect of Using Some Biological Post Harvest Treatments on Storability of Washington Navel Orange Fruits Compared with Imazalil Post Harvest Chemical Treatments. Journal of Horticultural Science & Ornamental Plants, 4(1): 50-57.
27. Maharaj, R.; J. Arul and P. Nadeau 1999. Effect of photochemical treatment in the preservation of fresh tomato (*Lycopersicon esculentum* cv. Capello) by delaying senescence. Postharvest Biol. Technol., 15:13–23.
28. González-Barrio, R.; D. Beltrán; E. Cantos; M.I. Gil; J.C. Espín and F. Tomás-Barberán 2006. Comparison of ozone and UV-C treatments on the postharvest stilbenoid monomer, dimer, and trimer induction in var. 'Superior' white table grapes, J. Agric. Food Chem. 54: 4222–4228.
29. Nadas A; Olmo, M., Mart´ınez M.C. and Garcıa J.M. 2000.El-Ozone en la conservaci´on de losc´ıtricos.Levanteagr´ıcola 8:251- 352.
30. Shalluf, M.A.; C. Tizaoui and N. Karodia 2007. Controlled atmosphere storage technique using ozone for delay ripening and extend the shelf life of tomato fruit. IOA Conference and Exhibition Valencia, Spain- October 29-30.
31. Ornelas-Paz, J.J.; M.E. Yahia and A. Gardea 2008. Changes in external and internal color during postharvest ripening of "Manila" and "Ataulfo"mango fruit and relationship with carotenoid content determined by liquid chromatography-APcI+- time-of-flight mass spectrometry. Postharv. Biol. Technol., 50: 145-152.
32. Sancho, L.E.; E.M. Yahia; M. A. Tellez and G. A. G. Aguilar 2010. Effect of maturity stage of papaya maradol on physiological and biochemical parameters. Amer. J. Agric. Biol. Sci., 2: 194-203.
33. Rokolhuukeditsu; Akali-Sema and Maiti, C.S. 2003. Effect of modified packaging and low temperature on post-harvestlife of "Khasi"mandarin.Journal of Food Science and Technology Mysore, 40(6):646-651.

34. Ladaniya,M.S. 2004 : Response of Kagziacid lime to low temperature regimes during storage. Journal of Food Science and Technology Mysore, 41(3):284-288.
35. Erkan, M.andPekmezci, M. 2000.The effect of different storage temperature andpost- harvest treatments onstorage and chilling injuryofWashington Navel oranges. ActaHort, 518:93-100.
36. El-Wakil, Amira F. Abd – El-Aziz 2008.Some physiological studies on some citrustrees. Master of Agric. Sciences. Department of Agriculture .Fac.of Agric. Cairo university plant of physiology.
37. Tzortzakis, N.; A. Borland; I. Singleton and J. Barnes 2007. Impact of atmospheric ozone-enrichment on quality-related attributes of tomato fruit. Postharvest Biol. and Technol., 45: 317–325.
38. Salvador, A.; J., Guquerello and P., Monaverra (2006): New clamante cultivar responses to degreening. Physiological and technological aspects of gaseous thermal treatments of fresh fruit and vegetables. Madrid 98 conference, October Book of abstracts P. 85. Samles. Ind. Eng. Chem. and Ed.,16:649-652.
39. El-Oraby, Samia and Ekbal Z. Ali (2006). Recording and maintaining the National value and other Quality changes of Thompson Seedless grapes and Florida Prince peach fruits during storage and marketing. Egypt. J. of Appl. Sci, 21 (12 B) 2006 pp. 601- 621.
40. Chen, P.M.and W.M. Mellenthin 1981.Effect of harvest date on ripening capacity and Post harvest life of pear. J.12 Amer. Soc.Hort.Sci.106(1):38-42.
41. Babalar, M; A. H. Dolanti; and M.A. Asgari, 1998.The study of Post-harvest changes in quantitative and qualitative traits of "fakhryshahvoodi" and "seedless keshmeshi" grape cultivars. Iranian of Agricultural sciences 29: (8),
42. Arnal, L.and Del R´ıo M.A. 2004. Effect of cold storage and removal astringency on quality of persimmon fruit *(Diospyros kaki* L.) cv. Rojobrillante. Food Sci Tec. Int 10(3): 179–85.
43. Klopotek Y.; K. Otto and V. Böhm 2005. Processing strawberries to different products alters contents of vitamin C, total phenolics, total anthocyanins, and antioxidant capacity. J. Agric. Food Chem., 53: 5640–5646.483 - 490; 17 ref.
44. Pérez, A.G.; C. Sanz; J.J. Ríos; R. Olías and J.M. Olías 1999. Effect of ozone treatment on postharvest strawberry quality, J. Agric. Food Chem., 47: 1652–1656**.**

*****