EFFECT OF ETHYLENE INHIBITORS ON REGULATE RIPENING OF AVOCADO FRUITS "FUERTE"

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ABSTRACT: *This study was carried out during 2013 and 2014 seasons on "Fuerte" avocados trees grown in clay loam soil under surface irrigation at avocado orchard belonging to Horticulture Research Station at El-Kanater El-Khayira, Kalyubeia Governorate, Egypt. Twenty one trees were selected to study the effect of foliar application of calcium chloride at 1 and 2%, silver nitrate at100 and 200µM and cobalt sulphate at 100µM and 200µM and all materials were sprayed at 15 days before harvest on ripening behavior of fruits, marketable life and physical-chemical properties of "Fuerte" avocado. The results revealed that 2 % $CaCl_2$ significantly increased the number of days taken for ripening of fruits, led to a reduction of weight loss, percentage of discarded fruits, respiration rate, electrolyte leakage %, total phenols and marketable life of fruits compared to control. This treatment was effective in minimizing respiration rate gradually during cold storage which acquire the fruits the chilling injury tolerance. While, the untreated fruits and the treatment of $AgNO_3$ with the two concentrations caused the highest values of weight loss and discarded fruits due to increasing of respiration rate, electrolyte leakage % and total phenols.*

Key words: *Avocado, Ethylene inhibitors, Storage, Ripening, Physical and chemical properties.*

INTRODUCTION

The avocado (*Persea americana* Mill.) is a tropical and subtropical fruits damaged by the cold. It grows and matures on the tree, but only ripens after it is picked (Lu *et al*., 2009) with an optimal cold storage temperature of approx 5-7ºC depending on cultivar and the stage of fruit maturity (Woolf *et al*., 2005). The "Fuerte" is one of the most common avocado varieties in the international market. Because of its economic importance, Mexico, Brazil and other countries are interested in finding ways to improve its storage and consumption (Forero *et al*., 2007and Daiuto *et al*., 2010). The "Fuerte" avocado pulp is noted for its relatively large size, lower moisture content and larger amount of unsaturated fats. The chemical composition of avocados depends on the cultivar and stage of ripening (Vekiari *et al*., 2004).

Due to their considerable nutritional value, avocado fruits have potential health benefits. They can protect against liver injury (Kawagishi *et al*., 2001). They contain vitamins, minerals, proteins, pectin, dietary fiber and a relatively high amount of unsaturated fats that are beneficial in preventing cardiovascular disease. Avocados also contain carotenoids and vitamin E (Lu *et al*., 2009), sterols (Plaza *et al*.,2009), phenolic (Rodríguez *et al*., 2011), and serotonin (Feldman and Lee 1985), and have antioxidant activity (Tremecoldi *et al*., 2012).

The plant hormone ethylene has become the focus of plant biology over the last 100 years. It is a gaseous plant hormone that is responsible for fruit ripening, growth inhibition, leaf abscission and aging. Most studies on fruit ripening and ethylene biosynthesis have been confined to climacteric fruits such as avocado. Ethylene is also at the centre of postharvest technology acting as a key in the extension of marketable life and fruit quality during storage (Golden *et al*. 2014).

Calcium chloride treatments increase the marketable life of fruits, mainly by making cell wall less accessible to pathogens and softening enzymes and reducing physiological disorders and postharvest diseases (Sharples and Johnson, 1977 and Abeywickrama, 2009). Increasing of Ca^{+2} levels reduce respiration and rate of ethylene production in variety of fruits. $CaCl_2$ application in fruits can be done in three ways as dipping, vacuum and pressure infiltration (Senevirathna and Daundasekara, 2010).

The main target of this study was to regulate Fuerte avocado fruit ripening and decrease the post-harvest loss of avocados and to maintain their quality for a longer time. The $CaCl_2$, $AgNO_3$ and $CoSO_4$ as ethylene inhibitors on regular ripening of Fuerte avocado fruits were examined.

MATERIALS AND METHODS

The present study was conducted during two successive experimental seasons (2013 and 2014) on Fuerte avocado (*Persea americana* Mill.) at avocado orchard belonging to Horticulture Research Station at El-Kanater El-Khayira, Kalyubeia Governorate, Egypt.

The trees were about 9-years old when this study started, planted according to square system at 7 meters apart, the soil orchard was clay loam. The trees received the regular cultural treatments by the Ministry of Agriculture and irrigated through farrow (surface) irrigation system.

Twenty one trees uniform in their vigor, size, shape and disease free, were selected for the investigation. The trees selected for the experiment were kept under the normal cultural practices, except for the treatments of this investigation.

This experiment was carried out in order to study the effect of spray with some ethylene inhibitors on behavior ripening of Fuerte avocado fruit through spraying different concentrations of $CaCl_2$ at 1% and 2%, $AgNO_3$ at 100µM and 200µM and $CoSO_4$ at 100µM and 200M on fruit ripening, marketable life and physical-chemical properties of “Fuerte” avocado fruits.

The Randomized Complete Block Design with three replicates was used, each replicate involved seven treatments and each treatment was represented by one tree.

Investigated Ethylene inhibitors treatments and their application:

In this respect two different concentrations of $CaCl_2$ (1% and 2%), Ag NO_3 (100µM and 200µM) and Co SO_4 (100µM and 200µM) each applied solely, besides the spraying with fresh water as control were investigated.

Thus, the ethylene inhibitors treatments included in such experiment were as follows:

1. $CaCl_2$ 1%.
2. $CaCl_2$ 2%.
3. $AgNO_3$ 100 µm.
4. $AgNO_3$ 200 µm.
5. $CoSO_4$ 100 µm.
6. $CoSO_4$ 200 µm.
7. Control spraying with fresh water.

Each ethylene inhibitors spray of calcium chloride, silver nitrate and cobalt sulphate were sprayed at 15 days before harvest.

Post harvest storability:

Fruits selected from the pre harvest treatments were used for post harvest study. Fruits were sorted and size graded using carton boxes of 5kg (40 x 30 x 10 cm^3) for packaging and lined with plastic film 60 microns, after harvest and transferred to Horticulture Department, Faculty of Agriculture, Ain shams University. All treatments were stored at cold storage (7 ± 1°C and 90% RH) for 28 days followed by 5 days at market conditions (20 ± 2°C with 85% RH).

Each treatment had 3 replicates, each of them involved 2 cartons, one for physical quality analysis and the other for chemical quality analysis, each carton package contained 10 fruits. Samples were taken every one week intervals and continued for 4 weeks to study physical and chemical characteristics. A sample of randomly selected fruits at the beginning of cold storage duration (0 day) and weekly (7 days) intervals was collected from each replication for all treatments during the storage period. The treatments in cold storage were arranged in randomized complete block design.

Measurements:

1- Fruit physical properties

1.1. Fruit firmness (Kg/f):

Fruit firmness was measured on the equatorial zone of the both cheeks after removing fruit skin using Tester (GY-1, China) equipped with a 2-mm plunger tip a digital basic force gauge .Values were expressed in kilo gram force(Kg/f) .

1.2. Weight loss %:

Weight loss percentage was determined for the fruits in all treatments according to the following equation:

Weight loss (%) =

$$\frac{\text{Initial weight – weight at sampling date}}{\text{Initial weight}} \times 100$$

1.3. Discarded fruits %:

On each sampling date, any fruit that began to suffer from any physiological disorder or pathological symptoms that affected is appearance and loss on its marketability was discarded. Discarded fruits % were calculated using the following formula.

Discarded fruits (%) =

$$\frac{\text{Weight of discarded fruits at each sampling date}}{\text{Total weight of fruits}}$$

2- Fruit chemical properties

2.1. Total soluble solids %:

Fruits were taken from each replicate and each sampling date than TSS were measured by using hand a Carl-Zeiss refractometer according to the A.O.A.C. (1985).

2.2. Titratable acidity:

Titratable acidity was expressed as percentage of tartaric acid (g tartaric acid / 100 ml of juice) according to A.O.A.C. (1995).

2.3. T.S.S/acid ratio:

In fruits juice, this ratio was calculated by divided TSS on acidity.

2.4. Respiration rate (mg CO_2/kg fruit/hr):

Carbon dioxide produced by avocado fruits was determined after 10 hrs finished from treatments and then every 7 days during storage until experiment termination. The air-flow was passed through concentrated Na OH, to insure that air-flow is CO_2 free, before passing into 1-liter jar fruit container (fruit ambient) one fruit/jar was considered as one replicate. The out-coming air-flow was then passed into 100 ml Na OH of 0.1 N for 1 h. Such solution was then titrated against 0.1 N HCl and CO_2 levels produced by the fruits were then calculated as mg CO2/kg fruits/h according to A.O.A.C. (1990).

2.5. Electrolyte leakage (EC leakage %)

Ten grams disks of the fruits tissues were placed in a 100-ml glass beaker containing 30 ml of deionized water and magnetic stirred for 15 min. Electrical conductivity (EC) of the stirrered solution was measured using electrical conductivity meter. Stirrered solution of each beaker was then replaced by equal volume (30 ml) of deionized water for homogenizing the disks in a blender, and the aliquot was then used for measuring EC level as previously described. Percentage of solute leakage was then calculated as EC leakage using the following formula by Mirdehghan *et al.*, (2007).

$$\text{EC leaking \%} = \frac{\text{EC of stirrered solution}}{\text{EC of stirrered solution} + \text{EC of homogenized disks}} \times 100$$

2.6. Total Chlorophyll (mg/100g fresh weight):

Total chlorophyll in avocado fruits was determined by using the protocol devised Nagata and Yamashta (1992). One gram of avocado fruits were ground in 10 mL of 80% acetone and filtered through Whitman's filter paper No. 1. The filtered extract was transferred in a cuvette and absorbance was noted at 663 and 645, nm using a UV-spectrophotometer (UV-4000, O.R.I. Germany). Chlorophyll a and b and total chlorophyll were calculated according to following formulae:

Chlorophyll a (mg g-1) = [(12.7 × A663) - (2.6 × A645)] × ml acetone / mg leaf tissue

Chlorophyll b (mg g-1) = [(22.9 × A645) - (4.68 × A663)] × ml acetone/mg leaf tissue

Total chlorophyll= Chlorophyll (a) + Chlorophyll (b).

2.7. Total phenols (mg/100g fresh weight):

Total phenols were determined by using Folin Denis colorimetric method (A.O.A.C.1990) at 730 nm wave length, the concentration was calculated from a standard curve of pyrogallol as mg /100 g fresh weight.

3- Statistical analysis:

Data recorded in two seasons were subjected to analysis of variance by MSTAT-C statistical package (MSTAT-C, 1990). Duncan's multiple rang test at the level of 5 % was used according to Duncan (1955).

RESULTS AND DISCUSSION

Fruit physical analysis:

Data presented in Table (1) show the change in fruit firmness, weight loss and discarded fruits of "Fuerte" avocado fruits as affected by some ethylene inhibitors treatments.

Fruit firmness (Kg/f):

Results indicated that calcium chloride at 2% significantly increased fruit firmness as compared with all other treatments in both seasons. In addition, calcium chloride play an important role in reducing evaporation then may regulate respiration and perhaps other metabolic processes in the mature fruits.

At cold storage (0 day to 28 days) and room temperature (marketable life) calcium chloride ($CaCl_2$) treatment at concentration 2 %, achieved the highest fruit firmness values which recorded (19.89, 5.90 and 3.89 Kg/ force) and (20.35, 5.20 and 3.74 Kg/force) at 2013 and 2014 seasons, respectively. However, $CoSO_4$ treatment at 200µm was similar to $CaCl_2$ treatment at 2 % in affecting of "Fuerte" avocado fruit firmness without significant different between them, meanwhile, the opposite trend was observed with the control treatment which resulted in the least statistical value in this concern.

Moreover, fruit firmness decreased as the rate of degradation of insoluble proto-pectins to more simple pectins increased with the advanced of storage periods. Ca was capable of altering fruit firmness loss by protecting cell membrane (Nasr, Samah 2004).

Table (1): Effect of ethylene inhibitors substances on firmness, weight loss and discarded fruits of "Fuerte" avocado, through storage (at 7 ± 1ºC) and subsequent days at storage (at 20 ± 2ºC) during 2013 and 2014 seasons.

Treatment \ Periods	Firmness			Weight loss (%)			Discarded fruits (%)		
	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life
First season; 2013									
Control	11.10c	1.77c	1.12de	7.11a	19.12a	23.63a	6.67a	60.00a	66.67a
$CaCl_2$ 1%	11.99bc	3.60b	2.10bc	5.39d	12.84e	16.41c	0.00b	33.33d	53.33c
$CaCl_2$ 2%	19.89a	5.90a	3.89a	3.82e	7.70f	10.33e	0.00b	13.33e	26.67d
Ag NO_3 100µm	14.16b	1.90c	0.85e	6.62ab	17.89b	20.00b	0.00b	53.33b	66.67a
Ag NO_3 200µm	12.55bc	1.87c	1.66cd	6.23bc	15.44c	20.13b	0.00b	46.67c	60.00b
Co SO_4 100µm	11.53c	3.43b	2.70b	5.69cd	14.02d	16.44c	0.00b	46.67c	53.33c
Co SO_4 200µm	19.29a	5.27a	3.80a	3.92e	7.55f	12.52d	0.00b	13.33e	20.00e
Second season; 2014									
Control	11.73c	1.07c	0.97c	7.46a	19.85a	26.72a	6.67a	53.33a	73.33a
$CaCl_2$ 1%	12.62c	2.90b	2.00b	6.02b	14.10c	15.25e	0.00b	46.67b	46.67d
$CaCl_2$ 2%	20.35a	5.20a	3.74a	4.00c	8.11d	11.41f	0.00b	20.00c	26.00e
Ag NO_3 100µm	15.18b	1.20c	1.00c	6.64ab	18.66a	19.43c	6.67a	53.33a	53.33e
Ag NO_3 200µm	13.64bc	1.50c	1.12c	6.70ab	16.67b	21.74b	0.00b	53.33a	60.00b
Co SO_4 100µm	11.79c	2.73b	2.60b	6.69ab	15.07c	17.32d	0.00b	46.67b	53.33c
Co SO_4 200µm	19.58a	4.57a	3.66a	4.48c	8.58d	12.54f	0.00b	13.33d	26.67e

Means followed by a similar letter, within column, do not significantly differ at 0.05 level, Duncan's multiple rang test.

Weight loss (%):

Data in Table (1) observed an increase in weight loss % with increasing time of storage with all treatments was noticed. Calcium chloride at concentration of 2 % and cobalt sulphate at concentration of 200 µM led to a reduction of weight loss percentage under all different storage periods temperature at (7 ±1° C) and room temperature at (20 ±2°C). Losses in fruit fresh weight was significantly higher in control and the highest concentration of $AgNO_3$ (100 and 200 µm) than other all treatments. It is clear from data in Table (3) which discussed letter evident an increase the respiration rate of these treatments. The treatment of calcium chloride 2% and cobalt sulphate (200 µM) under temperatures (7 ±1°C) and room temperature at (20 ±2°C) maintaining the lowest weight loss %. When chilling injury occurs, the associated abnormal metabolism may be reflected in an increase in respiration rate in Table (3) of the damaged tissues causing microscopic cracks in the peel and pits. Such cracks enable a greater water loss from the fruit (Nasr, Samah *et al*., 2013).

Discarded fruits (%):

Data in Table (1) show an evident increase in discarded fruits % with prolonging the days in all the two storage conditions and regardless of the used treatments. The control and $AgNO_3$ at 100 μM treatments recorded the highest percentage of discarded fruits. At the end of storage, the highest percentage of discarded fruits was obtained with untreated fruit (control) where it reached to about (6.67, 60.00 and 66.67 %) and (6.67, 53.33 and 73.33 %) during 0, 28 day at 7 ±1°C and at 20 ±2°C during 2013 and 2014 seasons, respectively. Such increase was true for all treatments including the control and this increase was significant at the values of discarded fruits percentage at the different consecutive storage periods when compared to each other for both cold storage and at room temperature condition in two seasons of study.

In this respect, results regarding the response of fruit firmness, weight loss and discarded fruits to studied treatments under different storage periods were supported by the findings of Cohen *et al*., (1983) on lemon, Hisaw (1991); Siddiqui and Bangerth (1995) and Baneh *et al*., (2003) on apples, Youn (2000) and Moon (2002) on pear, Aly and Ismail (2000), Mehaisen (2005) on guava, Samara *et al.* (2008) on peach, Nasr, Samah (2004) on mango, Ahmed, Dorria, *et al*., (2010) on avocado, and Nasr-Samah *et al*., (2013) on plum.

Fruit chemical analysis:

Data presented in Table (2) show the change in total soluble solids (TSS) %, Total acidity (%) and TSS/acid ratio of “Fuerte” avocado fruit as affected by some ethylene inhibitors treatments.

Total soluble solids (%):

Data in Table (2) show the change in TSS % under different storage periods and treatments. The results show that the highest values of fruit TSS % in 0 day (8.32 & 8.31) were obtained with treated fruits by control and $AgNO_3$ at 100 µM, respectively in first season and (8.11 & 8.06 & 7.11) with untreated and treated fruits by , $AgNO_3$ at 100 and 200 µM , respectively in second season. Meanwhile, the least values of fruit TSS %) were obtained with treated fruits by $CaCl_2$ at 1 & 2 % and $CoSO_4$ at 100 and 200 µM in 0 day in both seasons. The results show that the highest values of fruit TSS % in 28 days and marketable life (8.27 , 8.42 & 7.82 , 7.93)were obtained with treated fruits by $CaCl_2$ at 2 % and $CoSO_4$ at 200 µM, respectively in first season and (8.00 , 8.14 & 8.20 , 8.23 & 8.22 , 8.30) by $CaCl_2$ at 1 & 2 % and $CoSO_4$ at 200 µM, respectively in second season. Meanwhile, the least values of fruit TSS % (6.29, 5.90 & 4.20, 4.13) were obtained with treated fruits by control in both seasons.

Total acidity (%):

Data tabulated in Table (2) show that, the change in total acidity under different storage periods and treatments. The highest values of total acidity percentage during the first storage period (0 day) were obtained with treatments $CaCl_2$ at 1, 2 % and $CoSO_4$ at 100, 200 μM, and the lower values of total acidity percentage were obtained with treatments $AgNO_3$ at 100 and 200 μM and control in both seasons. Meanwhile, the highest values of total acidity percentage during storage period (28 day) and marketable life were obtained with control treatment, and the least values were obtained with treatments $CaCl_2$ at 1, 2 %

and $CoSO_4$ at 100, 200 μM, in both seasons. It is suggest, therefore that acidity increment is an accurate inductor far fruit chilling injury (Nasr-Samah *et al*., 2013) on plum.

Table (2): Effect of ethylene inhibitors substances on TSS, Total acidity and TSS/acid ratio of " Fuerte" avocado, through storage (at 7 ± 1ºC) and subsequent days at storage (at 20 ± 2ºC) during 2013 and 2014 seasons.

Periods / Treatments	TSS (%)			Total acidity (%)			TSS/acid ratio		
	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life
First season; 2013									
Control	8.32a	6.29de	5.90c	0.313b	0.805a	1.054a	26.58a	7.81e	5.60c
$CaCl_2$ 1%	4.05c	6.53cd	7.30b	0.767a	0.299de	0.258d	5.28c	21.84b	28.29a
$CaCl_2$ 2%	4.08c	8.27a	8.42a	0.780a	0.228e	0.294d	5.23c	36.27a	28.64a
Ag NO_3 100µm	8.31a	6.22e	5.93c	0.417b	0.620b	0.624b	19.93b	10.03e	9.50b
Ag NO_3 200µm	7.23b	6.70c	6.21c	0.363b	0.465c	0.545c	19.92b	14.41d	11.39b
Co SO_4 100µm	3.72c	5.26f	6.42c	0.733a	0.283de	0.264d	5.08c	18.59c	24.32a
Co SO_4 200µm	3.82c	7.82b	7.93a	0.717a	0.330d	0.303d	5.33c	23.70b	26.17a
Second season; 2014									
Control	8.11a	4.20e	4.13c	0.263c	0.706a	1.062a	30.84a	5.95e	3.89d
$CaCl_2$ 1%	3.94b	8.00a	8.14a	0.717a	0.365d	0.297e	5.50d	21.92c	27.41b
$CaCl_2$ 2%	3.97b	8.20a	8.23a	0.730a	0.266f	0.353d	5.52d	30.64a	23.31b
Ag NO_3 100µm	8.06a	6.17d	6.11b	0.467b	0.643b	0.733b	17.26c	9.60de	8.34c
Ag NO_3 200µm	7.11a	6.60c	6.10b	0.313c	0.514c	0.581c	22.72b	12.84d	10.50c
Co SO_4 100µm	3.56b	7.26b	7.75a	0.683a	0.281f	0.272f	5.21d	25.84bc	28.49a
Co SO_4 200µm	3.69b	8.22a	8.30a	0.673a	0.305e	0.295e	5.48d	26.95b	28.14a

Means followed by a similar letter, within column, do not significantly differ at 0.05 level, Duncan's multiple rang test.

TSS/acid ratio:

Data in Table (2) show the change in fruit TSS /acid ratio under different storage periods and treatments. The results show that the highest values of fruit TSS / acid ratio in 0 day (26.58 & 30.84) were obtained with treated fruits by control. Meanwhile, the least values of fruit TSS /acid ratio were obtained with treated fruits by CaCl2 at 1 & 2 % and $CoSO_4$ at 100 and 200 µM in both seasons. The results show that the highest values of fruit TSS / acid ratio in 28 days (36.27 & 30.64) were obtained with treated by $CaCl_2$ at 2 % in both seasons, respectively. Meanwhile, the least values of fruit TSS / acid ratio (7.81, 5.95 & 10.03, 9.60) were obtained with treated fruits by control and $AgNO_3$ at 100 μM, respectively in both seasons. The results show that the highest values of fruit TSS/ acid ratio in marketable life were obtained with treated fruits by $CaCl_2$ at 1 & 2 % in first season and $CoSO_4$ at 100 and 200 μM in both seasons. Meanwhile, the least values of fruit TSS / acid ratio (5.60 & 3.89) were obtained with treated fruits by control in both seasons.

The present results with respect to the response of the three studied chemical fruit characters to all investigated treatments under study are in harmony with those previously mentioned by Abd El-Naby (1995) on peaches; Youn (2000) on pear fruits; Aly and Ismail (2000), Hassan (1993) and Beneh *et al*., (2003) on apples and Ahmed, Dorria, *et al*., (2010) on avocado.

Electrolyte leakage % (EC):

Data in Table (3) it is observed that an increase in solute leakage with advanced in cold storage with all treated or untreated fruits.

The results show that the highest values of EC % in 0 day (9.93 & 10.29) were obtained with untreated fruits in 2013 and 2014 seasons. Meanwhile, the least values of EC % were obtained with treated fruits by $CaCl_2$ at 2 % (7.72 & 7.99) and $CoSO_4$ at 200 µM (7.55 &8.00) in both seasons. The results show that the highest values of EC % in 28 days were obtained with untreated fruits (32.35 & 32.12) and $CoSO_4$ at 100 μM (31.93 & 32.10) in both seasons. Meanwhile, the least values of EC % were obtained with treated fruits by $CaCl_2$ at 1% (22.34 & 21.91), $CaCl_2$ at 2% (22.15 & 21.80) and $CoSO_4$ at 200 μM (21.95 & 21.86) in both seasons. The results show that the highest values of EC % in marketable life were obtained with treated by control (41.61 & 45.12) in 2013 and 2014 seasons, Meanwhile, the least values of fruit EC % were obtained with treated by $CaCl_2$ at 2% (26.54 & 26.70) and $CoSO_4$ at 200 μM (27.31 & 27.62) in both seasons. Respectively, Regardless of the used treatment the increase in solute leakage with increasing fruit life could be considered a reason far increased respiration rate and weight loss where caused the collapse of cells. On contrary, the control treatment exhibited the chilling of sensitive fruit has increased membrane permeability (Lester *et al*., 1998 and Nasr, Samah, 2013).

Respiration rate (mg CO_2/kg fruit/hr):

Results in Table (3) showed that at the beginning of the cold storage duration it is clear the respiration rate was decreased with all used treatments.

The results show that the highest values of respiration rate in 0 day (16.17 & 17.20) were obtained with treated fruits by control in 2013 and 2014 seasons. Meanwhile, the least values of respiration rate were obtained with treated by $CaCL_2$ at 1 % (14.20 & 14.37) and $CaCl_2$ at 2 % (14.13 & 14.13) in both seasons. The results show that the highest values of respiration rate in 28 days were obtained with treated fruits by control (130.0 & 130.7) in both seasons. Meanwhile, the least values of respiration rate were obtained with treated fruits by $CaCl_2$ at 1% (53.0 & 55.33), $CaCl_2$ at 2% (51.0 & 55.33) and $CoSO_4$ at 200 μM (52.33 & 55.0) in both seasons. The results show that the highest values of respiration rate in marketable life were obtained with treated fruits by control (153.6 & 151.2) in 2013 and 2014 seasons, Meanwhile, the least values of fruit respiration rate were obtained with treated fruits by $CaCl_2$ at 1 & 2% (87.40 & 84.60) in first season and $CaCL_2$ at 2% (84.30) in second season. It is evident that, $CaCl_2$ both concentrations caused a decrease in respiration rate in cold storage and in marketable life at 20 ± 2ºC. This finding explained the importance of these treatments in increasing chilling injury tolerance of treated fruits. Ca, reducing fruit respiration before and during cold storage may arrest the accumulation of such respiratory metabolites (Nasr, Samah 2004). Untreated fruits exhibited a sharp increase after removal from cold storage and during holding at room temperate 20 ± 2ºC. The rate of oxidation relative to glycolysis which may lead to accumulation of an intermediate respiratory substances to toxic. Leaves of fermentation casing chilling injury development (Nasr-Samah *et al.*, 2013).

Table (3): Effect of ethylene inhibitors substances on electrolyte leakage and respiration rate of " Fuerte" avocado, through storage (at 7 ± 1ºC) and subsequent days at storage (at 20 ± 2ºC) during 2013 and 2014 seasons.

Periods / Treatments	Electrolyte leakage % (EC)			Respiration rate (%)		
	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life
First season; 2013						
Control	9.93a	32.35a	41.61a	16.17a	130.0a	153.6a
$CaCl_2$ 1%	7.95bc	22.34c	29.52d	14.20c	53.00e	87.40e
$CaCl_2$ 2%	7.72c	22.15c	26.54e	14.13c	51.33e	84.60e
Ag NO_3 100µm	8.47b	29.08b	28.12de	15.30b	121.70b	130.60b
Ag NO_3 200µm	8.10bc	28.11b	39.64b	15.37ab	105.00c	133.7b
Co SO_4 100µm	8.50b	31.93a	36.53c	15.10b	95.33d	107.6c
Co SO_4 200µm	7.55c	21.95c	27.31e	14.77bc	52.33e	94.70d
Second season; 2014						
Control	10.29a	32.12a	45.12a	17.20a	130.7a	151.2a
$CaCl_2$ 1%	8.11bc	21.91c	28.41de	14.37c	55.33e	91.70e
$CaCl_2$ 2%	7.99c	21.80c	26.70e	14.13c	55.33e	84.30f
Ag NO_3 100µm	8.83b	29.00b	37.70c	16.00b	126.7b	144.7c
Ag NO_3 200µm	8.08bc	27.88b	40.53b	16.20b	110.7c	147.7b
Co SO_4 100µm	8.17bc	32.10a	29.74d	15.67b	98.00d	113.4d
Co SO_4 200µm	8.00c	21.86c	27.62e	16.33b	55.00e	93.80e

Means followed by a similar letter, within column, do not significantly differ at 0.05 level, Duncan's multiple rang test.

Total chlorophyll content (mg/100g):

Results in Table (4) it is obvious that, the total chlorophyll (mg/100g) in fruits decreased with increased by prolonging period's storage days in both seasons.

The results show that the highest values of total chlorophyll in 0 were recorded with treated fruits by $CaCl_2$ at 1 % and 2 % day (1.99 , 2.02 & 2.03 , 2.13) and show that in 28 days and marketable life were recorded with treated fruits by $CaCl_2$ at 2 % (1.31, 1.20 & 0.93, 0.96) in 2013 and 2014 seasons. Meanwhile, the least values of total chlorophyll in 0 and 28 day (1.66, 1.65 & 0.81, 0.80) were obtained with treated fruit by control in both seasons, and $CoSO_4$ at 100 μM (1.69 & 0.81) in first season. The least values in marketable life (0.56 & 0.53) were obtained with treated fruit by control in both seasons.

Table (4): Effect of ethylene inhibitors substances on total chlorophyll and total phenols of "Fuerte" avocado, through storage (at 7 ± 1ºC) and subsequent days at storage (at 20 ± 2ºC) during 2013 and 2014 seasons.

Treatments \ Periods	Total chlorophyll			Total phenols		
	0 Day	28 Day	Marketable life	0 Day	28 Day	Marketable life
First season; 2013						
Control	1.66c	0.81c	0.56c	0.103a	0.660a	0.776a
$CaCl_2$ 1%	1.99a	1.21ab	0.92a	0.068cd	0.565b	0.593e
$CaCl_2$ 2%	2.03a	1.31a	0.93a	0.073b-d	0.574b	0.590e
Ag NO_3 100µm	1.77bc	0.91c	0.66b	0.090ab	0.579b	0.632c
Ag NO_3 200µm	1.74bc	1.13b	0.90a	0.091ab	0.652a	0.664b
Co SO_4 100µm	1.69c	0.81c	0.70b	0.081bc	0.582b	0.611c
Co SO_4 200µm	1.89ab	1.20ab	0.87a	0.060d	0.574b	0.598e
Second season; 2014						
Control	1.65c	0.80e	0.53c	0.125a	0.643a	0.817a
$CaCl_2$ 1%	2.02a	1.07b	0.84ab	0.077d	0.576b	0.601cd
$CaCl_2$ 2%	2.13a	1.20a	0.96a	0.082cd	0.571b	0.584d
Ag NO_3 100µm	1.76bc	0.89cd	0.63c	0.099bc	0.581b	0.657b
Ag NO_3 200µm	1.73bc	0.92c	0.81b	0.113ab	0.638a	0.674b
Co SO_4 100µm	1.92ab	0.84de	0.65c	0.090cd	0.585b	0.612c
Co SO_4 200µm	2.06a	1.05b	0.87ab	0.082cd	0.576b	0.603cd

Means followed by a similar letter, within column, do not significantly differ at 0.05 level, Duncan's multiple rang test.

Total phenols content (mg/100g):

It was noticed that, Table (4) the total phenols (mg/100g) in fruits increased with increased by prolonging periods storage days in both seasons. These compound increased with untreated fruit and no significant different were reported among ($CaCl_2$ 1 & 2 % and $CoSO_4$ at 100 & 200 μM) treatments which give less significantly values. The results show that the highest values of total phenols in 0 day, 28 day periods and marketable life at 20 ± 2ºC (0.103, 0.660, 0.776 & 0.125, 0.643, 0.817) were obtained with treated fruits by control in 2013 and 2014 seasons

Increase of phenolic compounds in tissues during chilling treatments may be partially due to chilling adaptation as defense mechanisms and also to mediate these stresses (Christie *et al*., 1994). It is assumed that freezing temperatures with distribution of cell membranes may trigger the release of oxidative and hydrolylic enzymes that would destroy the antioxidants probably, deactivating these enzymes avoid the loss of phenolics and therefore lead to the increase of total phenolics content (Nasr, Samah, *et al*., 2013) on plums.

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تأثير مثبطات الإثيلين على تنظيم نضج ثمار الأفوكادو " فيورت "

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الملخص العربى

أجريت هذه الدراسة على أشجار أفوكادو صنف فيورت نامية فى مزرعة محطة بحوث البساتين بالقناطر الخيرية – محافظة القليوبية – مصر، خلال موسمين ٢٠١٣، ٢٠١٤ وقد تم اختيار واحد وعشرين من الأشجار لدراسة تأثير رش الثمار بكلوريد الكالسيوم تركيز(١ و ٢٪) , نترات الفضة تركيز (١٠٠و٢٠٠ ميكرو مول) وسلفات الكوبالت تركيز (١٠٠و٢٠٠ ميكرو مول) على نضج الثمار والقدرة التسويقية و الخصائص الفيزيائية والكيميائية لثمار الأفوكادو "فيورت". وتم رش جميع المواد قبل ١٥ يوم من الحصاد . بحيث استخدمت هذه المعاملات منفردا ، إضافة إلى معاملة المقارنة (رش الثمار بماء الصنبور).

ومن أهم النتائج المتحصل عليها كانت كالأتى:-

١- **القياسات الفيزيائية:** سجلت معاملتى كلوريد الكالسيوم بتركيز ٢% و سلفات الكوبلت بتركيز ٢٠٠ ميكرو مول أعلى القيم فى صلابة الثمار وأقل القيم فى نسبة الفقد فى الوزن ونسبة الثمار المستبعدة فى كلا موسمى الدراسة.

٢- **القياسات الكيميائية :** حققت معاملة كلوريد الكالسيوم بتركيز ٢% لتحقق أعلى القيم لكل من المواد الصلبة الذائبة الكلية والكلوروفيلات الكلية ولم تكن هناك فروق معنوية بينها وبين معاملات كلوريد الكالسيوم بتركيز ١% و سلفات الكوبلت بتركيز(١٠٠و٢٠٠ ميكرو مول) فى قيم المواد الصلبة الذائبة الكلية الى الحموضة الكلية فى كلا موسمى الدراسة .

بينما حققت معاملة كلوريد الكالسيوم بتركيز ٢% أقل القيم فى الحموضة الكلية , نسبة التسرب الالكتروليتى , معدل التنفس والفينولات الكلية ولم تكن هناك فروق معنوية بينها وبين معاملات كلوريد الكالسيوم بتركيز ١% و سلفات الكوبلت بتركيز(١٠٠و٢٠٠ ميكرو مول) فى كلا الموسمين .

وعليه يمكن أن نوصى باستخدام كلوريد الكالسيوم بتركيز ٢% لرش ثمار الافوكادو تحت الظروف المشابهة لنفس التجربة.

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