**J. Agric. & Env. Sci. (Damanhour University)** **2022, 20 (2): 45-71**
**Print: ISSN 1687-1464** **Online: 2735-5098**

# FIELD APPLICATIONS TO ENHANCE COLORATION AND RIPENING OF CANINO APRICOTS IN THE PRESENCE AND ABSENCE OF AN ANTI-ETHYLENE COMPOUND

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## ABSTRACT

**The present study was conducted during the two successive seasons 2019 and 2020 to determine the effects of pre harvest applications of ProTon, Ethrel, Lisophos individually or plus Aminoethoxyvinylglycine (AVG) (ProTon + AVG, Ethrel + AVG, and Lisophos + AVG) compared with control on the coloration and ripening of six years old Canino apricot (*Prunus armeniaca* L.) trees in a private orchard at El-Bostan region, El-Behiara governorate, Egypt. The obtained results indicated that, the lowest number of leaves drop was recorded with LPE treatment whether alone or when was combined with AVG in consistent manner in both seasons. In similar manner AVG treatment did not cause any leaves drop in the tagged and treated branches in the two seasons. Applied Ethrel alone caused greater fruit abscission than ProTon. However, the combination of ProTon plus AVG resulted in more fruit abscission than that obtained with Ethrel plus AVG in the two seasons of the study. The highest increase in fresh fruit weight, stone weight and flesh weight were obtained by the application of LPE combined with AVG. The results indicated that, fruit size was increased significantly under the three treatments ProTon plus AVG or Ethrel plus AVG and LPE plus AVG and the individual treatment of lisophos. Ethrel alone or combined with AVG led to increase in TSS and reduce the electrolyte leakage percentage compared with the control. Even AVG alone reduced TSS in both seasons. ProTon treatment increased juice acidity and ascorbic acid. Only lisophos alone or in presence of AVG resulted in**

**increasing TSS/acid ratio in consistent manner in both seasons as compared with the control. The data revealed that all treatments resulted in significant reduction of chlorophyll a, b and carotene as compared with the control. The highest increase in total carbohydrates, reducing sugar, non-reducing sugar, total sugar and crude fiber were obtained in fruits that treated with Ethrel in both seasons followed by ProTon. In conclusion, it could be recommended to apply lisophos plus AVG to improve "Canino" apricot coloration and carotene content while avoiding electrolyte leakage.**

## INTRODUCTION

Apricot (*Prunus armeniaca* L.) is one of the most important and favorable fruit over the world where it had highly nutritional value, antioxidant and aroma (**Solis-Solis *et al.* 2007)**. Apricot is one of the most favorable fruits to the Egyptian consumers. In Egypt, apricot occupied about 70165 feddans, with fruit production reached 340217 tons **(Anonymous, 2014)**. Apricot is a climacteric fruit that produces large amounts of ethylene at maturity **(Mita *et al.* 1999)**. The loss of apricot fruit physical and chemical qualities starts directly after harvest and rapidly during the storage period **(Ezzat *et al.* 2012)**.

Ethylene profoundly affects quality of harvested climacteric fruits. Ethylene regulates the expression of downstream genes which produce the typical ripening events including color changes, altered sugar metabolism, fruit softening and alterations in texture, increased susceptibility to pathogen infection and volatile compounds synthesis **(El-Sharkawy *et al.* 2005)**. Ethylene is a growth regulator that would pose negative impact on important physical properties of apricot fruits such as size, weight and firmness. Furthermore, since it releases ethylene, it can drift and get absorbed by the leaves, causing yellowing and defoliation. This would adversely affect tree productivity in the current season and sprouting in the following season **(Roberto *et al.*2012)**.

To reduce the adverse effect of ethylene in growth, fruit yield and fruit chemical and physical properties after harvest treatments must start before harvest. Several chemicals' compounds can inhibit biosynthetic enzymes or block the ethylene receptor. These compounds could be applied pre- or post-harvest.

Lysophosphatidylethanolamine (LPE) is applied to attached and detached leaves of dicotyledonous species. The reported effects include delay of natural senescence, mitigation of ethylene-induced senescence. LPE (100 $mgL^{-1}$) containing 1-2% ethanol showed delayed senescence, as assessed by the lower rates of ethylene and CO2 production, higher fresh weight and chlorophyll content, and lower electrolyte leakage (**Farag and Palta, 1991b)**. LPE can accelerate ripening of cranberry fruits while prolong shelf-life at the same time. Furthermore, LPE treatment has also been found to reduce senescence of leaves, fruits and cut-flowers **(Cowan, 2009)**. LPE retards polygalacturonase-mediated fruit softening **(Hong *et al.* 2008)**. The decrease of fruit weight loss in fruit by LPE application before harvest, could be attributed to its effect on the maintaining the plasma membrane which led to retarding the process of fruit senescence (**Farag *et al.* 2011)**.

Moreover, Ethrel as a growth regulator can enhance ethylene production, stimulate progressive loss of chlorophyll and gain of more carotenoids. In a previous study of Kelany ***et al.* (2011)** spraying berry clusters by Ethrel at 500 ppm decreased texture and acidity and increased TSS, TSS/acid ratio and anthocyanin percentage more than control. In addition, Ethrel application increased significantly berry weight loss % and exhibited the highest values of berries decay percentages as compared with untreated fruits after four weeks of cold storage of Flame seedless grapes.

Aminoethoxyvinylglycine (AVG) is growth regulator could be used individually or combined with other treatments as a pre-harvest application to control drop of fruits. However, AVG might indirectly affect the fruit size by delaying ripening **(Greene, 2006)**. Application of AVG or AVG plus lisophos reduced pre-harvest fruits drop and

increased yield, fruit firmness, acidity, starch and chlorophyll (a, b) contents as compared with control and other treatments in both seasons. On the other hand, fruit weight, size, length and diameter were increased by NAA or NAA plus lisophos relative to the control and other treatments in a consistent manner **(Kotb, 2019)**.

Meanwhile, Methylcyclopropene (1-MCP) (C4H6) is an inhibitor of ethylene action that blocks ethylene receptors **(Sisler, 2006)**. It is a cyclic olefin that inhibition ripening process by occupying irreversibly ethylene binding sites, so that ethylene is unable to bind and elicit subsequent signal transduction and translation. **Farag et al. (2012)** worked on "Canino" apricot cultivar and they reported that ethephon treatment caused a significant reduction in fruit weight as compared with the control in both seasons. Finally, the use of anti-Ethylene production must start in the field to reduce fruit and leaves drop and increase fruit physical and chemical properties. Therefore, the objectives of this study were to determine the useful role of the pre-harvest foliar spraying of some growth regulator individually or combined with AVG on increasing apricot fruit yield and quality as well extended fruit shelf life during the storage.

## MATERIALS AND METHODS

The present study was conducted during the two successive seasons 2019 and 2020 to determine the effects of pre harvest applications of ProTon, Ethrel, Lisophos individually or plus Aminoethoxyvinylglycine (AVG) (ProTon + AVG, Ethrel + AVG, and Lisophos + AVG) compared with control on the fruits coloration and ripening of six years old Canino apricot (*Prunus armeniaca* L.) trees. Trees were budded on local apricot rootstock and spaced at 4x5 m apart and grown under drip irrigation system in a private orchard at El-Bostan region, El-Behiara governorate, Egypt. Seventy-two uniform trees, free from various, physiological and pathological disorders were selected and divided into three replicates each replicate contained of three trees.

All trees received the standard agricultural practices. Soil and irrigation water chemical and physical properties are presented in (Table 1 and 2). The trees were sprayed with all treatments two times using a hand sprayer. The first application time at the beginning of fruiting with one week between the two spraying, during the two seasons. The used treatments (individually or combined) were used as the following rate: ProTon (at 200ppm), Ethrel (at 250ppm), Lisophos (at 200ppm) and plus AVG (at 50ppm). In the combined treatments plus AVG was sprayed one week after spraying ProTon, Ethrel and Lisophos.

**Data recorded:**

**1- Pre-harvest measurements:**

To determine the effect of used treatments on the percentage of leaves and fruit shedding. Four branches of last season located at the southern side of Canino apricot trees were tagged and these labeled branches were monitored to survey the leaves and fruits were counted in each treatment three times i.e., pre-spraying, one week post spraying and at harvest and the total number of shedding leaves and fruits were estimates to determined shedding percentages.

**2- Quality parameter of harvested fruits:**

After each harvest, 100 fruits were washed with tap water, surface sterilized with NaCl for 3 mins., washed again by quick rinsing then left for air drying then used to determine the following records.

**2-1-Physical properties: -**

10 fruits randomly selected to determine fruit weight (g), stone weight (g), flesh weight (g) and fruit size.

**2-1- chemical constituents:**

1. **Chlorophyll content**: was estimated as the method described by **Goodwine (1965)**.
2. **Total carotenoids: Estimation of total Carotenoids (Sumanta *et al.* 2014)**.
3. **Total carbohydrates**: To determine total carbohydrates 0.1 g of air-dried samples was submerged overnight in 10 ml of 80 % (v/v) ethanol at 25 °C with periodic shaking. The ethanolic mixture was

filtered and the ethanolic filtrate was made up to known volume. Carbohydrates and first hydrolyzed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone a green-colored product with an absorbtion maximum at 630 nm. standard curve was prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of glucose. Amounts of carbohydrate present in 100 g of the sample = mg of glucose / volume of test sample x 100 **(Hedge and Hofreiter 1962)**.

4. **Crude fiber contents**: To determine crude fiber contents two g of the defatted powder of each sample were boiled with 200 ml of 1.25% sulphuric acid under reflux for 30 minutes and filtered. The residue was washed with distilled water, then transferred back to the flask with 200 ml of 1.25% NaOH Solution. Boiling for 30 minutes under reflux, rapidly filtered and washed with distilled water. The residue was dried at $100^{O}C$ to a constant weight. The difference between the weight of residue after drying at $110^{O}C$ and the of powder represents the weight of crude fiber **(A.O.A.C., 1984)**.
5. **Total soluble solids content (TSS):** Fruit juice total soluble solids content (TSS) was measured using a hand refractometer, 0-32 scale (ATAGO N-$1_E$, Japan) and expressed in °Brix after making the temperature correction at 20°C.
6. **Total soluble sugar:** It was determined according to the method described by **Sadasivam and Manickam, (1996**).
7. **Reducing sugar:** Estimated by Nelson-Somogy method as described by **Naguib (1964).** The reducing sugar was heated with alkaline copper tartrate to reduce the copper from the cupric to cuprus state and thus cuprous oxide is formed. When cuprous oxide is treated with arsenomolybdic acid; the reduction of molybdic acid to molybdenum blue took place. The intensity of blue colour was measured by spectrophotometer at wavelength 620 nm. The amount of reducing sugar in the samples was calculated through the calibration standard curve using of pure D-glucose.

8. **Non-reducing sugar:** Was calculated according to the following equation:

   **Non-reducing sugar** = Total soluble sugar - Reducing sugar

9. **Total acidity (%):** The acidity was colormetrically measured based on estimated malic acid using five milliliters of the fruit juice of each fruit sample and titrated with sodium hydroxide solution of a known normality using phenolphthalein as an indicator **(A.O.A.C. 1984)**. The results of these titrations were converted to percent of titratable acidity using the following equation: percent of titratable

$$Acidity = \frac{[mls\ NaOH\ used]x\ [0.1N\ NaOH]x\ 0.067\ x[100]}{Juice\ used\ (ml)}$$

Where:

**0.067=** mill equivalent factor of malic acid

10. **TSS/acid ratio:** Was calculated as a ratio between TSS (%) and acidity (%).
11. **Ascorbic acid:** For ascorbic acid analysis, an oxalic acid solution was added to each fruit sample and then samples were titrated with a 2,6-dichlorophenol-indophenol dye solution. Results were calculated as milligrams of ascorbic acid and represented as milligrams per 100 ml of juice.
12. **Electrolyte leakage:** Membrane permeability was determined based on electrolyte leakage as described by **Montoya et al. (1994)**. Ten disks (2–3 mm thickness; 10 mm diameter) were excised from the fruit pulp using a cork borer. They were then washed with distilled water to remove the sap from ruptured cells and placed in a beaker with 100 ml of 0.4 M mannitol. After incubation at 25ºC for 4 h, the conductivity of the suspending solution was measured with a conductivity meter (CM-30ET). The beakers were then covered in aluminum foil and autoclaved at 121℃ for 30 min to liberate all electrolytes before total leakage was determined. Measurements were performed in triplicate, and the average was calculated. Electrolyte leakage was determined using the following formula:

Ion leakage (%) = [Initial leakage/Final (total) leakage] × 100

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Print: ISSN 1687-1464 Online: 2735-5098

**Statistical analysis**

Data was analyzed as a randomized complete block design with three replicates. Comparisons among means were made via the least significant differences multiple ranges (LSD) according to **Gomez and Gomez (1984)**. The data were analyzed using SAS (2000).

## RESULTS

### 1. Leaves shedding:

The effect of pre-harvest application of some growth regulators such as ProTon, Ethrel and LPE alone or when combined with AVG on leaves abscission or shedding percentage at harvest were reported in **Table 1** and **Fig.1**. The data revealed that the greatest leaves abscission was found with Ethrel application at 250 ppm. However, when Ethrel was combined with AVG, a significant reduction in leaves abscission occurred in both seasons as compared with Ethrel alone. No leaves drop was recorded with LPE treatment whether alone or when was combined with AVG in consistent manner in both seasons. In similar manner AVG treatment did not cause any leaves drop in the tagged and treated branches in the two seasons.

**Table 1. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on leaf shedding from labeled branches of Canino apricot at different stage during 2019 and 2020 seasons.**

| Treatments | Leaf number/tagged branch | | | | shedding % | |
|---|---|---|---|---|---|---|
| | At application time | | At harvest | | | |
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 98.06 $^{c}$ | 101.56 $^{bc}$ | 49.31 $^{g}$ | 60.44 $^{e}$ | 49.25 $^{b}$ | 40.06 $^{b}$ |
| **Ethrel** | 84.13 $^{e}$ | 88.38 $^{e}$ | 27.31 $^{h}$ | 33.44 $^{f}$ | 67.38 $^{a}$ | 61.73 $^{a}$ |
| **AVG** | 114.38 $^{a}$ | 111.88 $^{a}$ | 114.38 $^{a}$ | 111.88 $^{a}$ | 0.00 $^{e}$ | 0.00 $^{e}$ |
| **Ethrel +AVG** | 90.19 $^{d}$ | 93.75 $^{d}$ | 66.13 $^{f}$ | 69.00 $^{d}$ | 26.54 $^{c}$ | 26.26 $^{d}$ |
| **ProTon + AVG** | 88.88 $^{d}$ | 97.63 $^{cd}$ | 75.38 $^{e}$ | 67.25 $^{d}$ | 15.25 $^{d}$ | 31.34 $^{c}$ |
| **Lisophos +AVG** | 109.00 $^{b}$ | 104.38 $^{b}$ | 109.00 $^{b}$ | 104.38 $^{bc}$ | 0.00 $^{e}$ | 0.00 $^{e}$ |
| **Lisophos** | 99.56 $^{c}$ | 101.50 $^{bc}$ | 99.56 $^{d}$ | 101.50 $^{c}$ | 0.00 $^{e}$ | 0.00 $^{e}$ |
| **Control** | 105.19 $^{b}$ | 105.63 $^{b}$ | 105.19 $^{c}$ | 105.63 $^{b}$ | 0.00 $^{e}$ | 0.00 $^{e}$ |

Values in each column accompanied with the same letters were not significantly different according to mean comparison by least significant differences (LSD) at 5%.

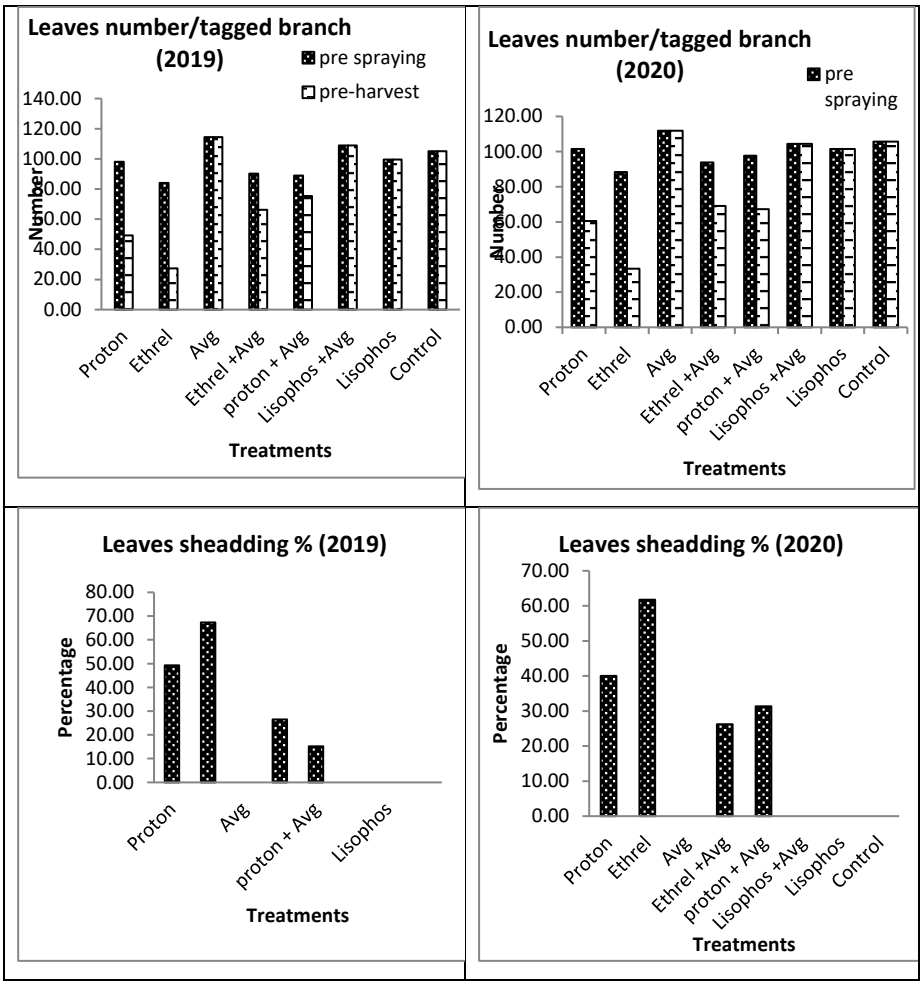



**Fig. 1. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on leaf shedding of Canino apricot at different stage during 2019 and 2020 seasons.**

On the other hand, ProTon plus AVG resulted in a noticeable reduction in leaves abscission in both seasons as compared with ProTon alone or when compared with the individual application of ProTon. In treated apricot tree, the most effective treatment regarding to leaves abscission in response to various applied treatments was found with LPE whether alone or when combined with AVG followed by ProTon plus

in both seasons. It was evident that the application of AVG alone or combined with Ethrel or ProTon able to mitigate the adverse effect of either Ethrel or ProTon with consistently in both seasons.

## 2. Fruits abscission:

With regard to the influence of various treatments on "Canino" apricot fruits during the two seasons 2019 and 2020 (**Table 2**) the data clearly showed that the individually treatments of Ethrel or ProTon resulted in a significant increase in fruits abscission while no fruit abscission occurred with LPE application in both seasons. Applied Ethrel alone caused greater fruit abscission than ProTon.

**Table 2. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on fruits shedding of Canino apricot at different stage during 2019 and 2020 seasons.**

| Treatments | Fruits number/tagged branch | | | | Shedding % | |
|---|---|---|---|---|---|---|
| | At application time | | At harvest | | | |
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 13.00 b | 12.44 c | 7.31 cd | 7.50 cd | 45.44 | 39.82 |
| **Ethrel** | 11.56 c | 12.06 c | 5.38 d | 5.63 d | 54.23 a | 53.29 |
| **AVG** | 13.19 b | 12.38 c | 13.19 | 12.38 b | 0.00 e | 0.00 e |
| **Ethrel +AVG** | 11.13 c | 11.25 d | 8.88 c | 8.69 c | 20.11 d | 22.50 |
| **ProTon + AVG** | 9.69 d | 11.94 c | 7.31 cd | 8.50 c | 24.30 c | 28.88 |
| **Lisophos** | 13.31 b | 15.00 a | 13.41 | 15.00 a | 0.00 e | 0.00 e |
| **Lisophos** | 14.69 a | 13.56 b | 14.61 a | 13.56 | 0.00 e | 0.00 e |
| **Control** | 11.75 c | 12.13 c | 11.65 b | 12.13 b | 0.00 e | 0.00 e |

Values in each column accompanied with the same letters were not significantly different according to mean comparison by least significant differences (LSD) at 5%.

However, the combination of ProTon plus AVG resulted in more fruit abscission than that obtained with Ethrel plus AVG in the two seasons of the study. Tree under the control did not show any fruits abscission during the two seasons which emphasized that the application

of Ethrel or ProTon that caused fruits drop in the two seasons while the reduction in magnitude of fruit abscission could be ascribed to the presence of AVG along with ProTon or Ethrel. The above explanation about the role of AVG was again emphasized by the AVG alone that resulted in no fruits abscission.

## 3. Fruit physical characteristics:

### 3.1. Fresh fruit weight.

The response of "Canino" apricot fruit physical properties to various treatments are shown in **Table 3**. Fresh weight of ten apricots fruits clearly showed that fresh fruit weight significantly increased by either ProTon or Ethrel treatments as compared with the control especially in the second season. On the other hand, LPE caused a significant increase in fresh fruit weight relative to the control or the sole used of Ethrel or ProTon especially in the second season. However, the highest increase in fresh fruit weight was obtained by the application of LPE combined with AVG. Furthermore, the combined effects of Ethrel + AVG as well as the combination of ProTon plus AVG did not cause significant effect in fruit fresh weight compared with the individual application of Ethrel or ProTon.

### 3.2. Stone weight.

Stone weight response to pre-harvest treatments was shown in **Table 3.** The results revealed that, treated apricots with Ethrel had similar stone weight compared to the control in the first season only while in the second season Ethrel resulted in increased stone weight. Moreover, LPE led to insignificant increase in stone weight as compared with the control. In the same way, LPE combined with AVG resulted in larger increase in stone weight than control in both seasons while ProTon plus AVG resulted in heavier stone weight than these in control in the first season only. Meanwhile, stone weight under Ethrel plus AVG treatment did not differ significant with those in the control in both seasons.

### 3.3. Flesh weight.

With regard to flesh weight of fruits as affected by the pre-harvest treatments used in this study the results in **Table 3** confirmed that, lisophos application was effective on increasing flesh weight compared with control in both seasons. Also, the individual application of ProTon or Ethrel resulted in significant increase on flesh weight compared to control in both seasons. Meanwhile, the combined treatment of LPE + AVG led to significant increase in flesh weight compared with the control in both seasons. In contrary, flesh weight did not differ significant in the other combination treatments when compared with the control in both seasons. The application of AVG alone resulted in heavier flesh weight than this in the control.

### 3.4. Fruit size.

Changes in fruit size in response to the various pre-harvest treatments were reported in **Table 3**. Fruit size was recorded as the average size of ten fruits. The results indicated that, fruit size was increased significantly under the three treatments ProTon plus AVG or Ethrel and the individual treatment of lisophos. The three treatments were effective on increasing fruit size in both seasons. Even the sole application of these materials led to significant reduction in fruit size compared with the control in both seasons.

## 4. Fruit chemical characteristics:

### 4.1. Total soluble solids (TSS):

The effect of pre-harvest treatments of "Canino" apricot fruits content of TSS was shown in **Table 4** and Fig. 3. The data revealed that the fruits treated with Ethrel had the highest TSS value in the first season when compared with all other used treatments without any significant difference with the control. In similar trend, the combination of Ethrel with AVG led to similar increase in TSS in both seasons compared with this obtained in the control. Even AVG alone reduced TSS in both seasons.

**J. Agric. & Env. Sci. (Damanhour University) 2022, 20 (2): 45-71**
**Print: ISSN 1687-1464 Online: 2735-5098**

**Table 3. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on some fruit physical properties of Canino apricot during 2019 and 2020 seasons.**

| Treatments | Fresh weight (g) | | Stone (g) | | Flesh weight | | Fruits Size (cm) | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 359.33 cd | 452.25 b | 24.06 c | 24.75 d | 335.27 cd | 427.50 b | 370.00 c | 445.00 cd |
| **Ethrel** | 375.75 bc | 462.25 b | 23.66 c | 26.63 bc | 352.10 bc | 435.63 b | 382.50 bc | 485.00 b |
| **AVG** | 399.71 ab | 412.50 c | 26.34 a | 25.00 d | 373.38 ab | 387.50 c | 385.00 bc | 477.50 bc |
| **Ethrel +AVG** | 380.10 bc | 462.88 b | 24.36 bc | 25.38 cd | 355.74 bc | 437.50 b | 385.00 bc | 525.00 a |
| **ProTon + AVG** | 381.39 bc | 450.75 b | 26.43 a | 25.50 cd | 354.96 bc | 425.25 b | 380.00 bc | 450.00 bcd |
| **Lisophos +AVG** | 413.98 a | 521.75 a | 27.14 a | 28.38 a | 386.84 a | 493.38 a | 407.50 b | 537.50 a |
| **Lisophos** | 370.47 c | 523.50 a | 25.67 ab | 27.50 ab | 344.80 c | 496.00 a | 436.25 a | 527.50 a |
| **Control** | 339.20 d | 392.63 c | 23.09 c | 23.00 e | 316.11 d | 369.63 c | 338.75 d | 415.00 d |

Values in each column accompanied with the same letters were not significantly different according to mean comparison by least significant differences (LSD) at 5% level of probability.

Moreover, the individual application of ProTon or combined with AVG also reduce or did not affect TSS at harvest. Also, lisophos alone or combined with AVG had no significant effect on TSS in both seasons when compared with the control. Thus, in general, there was consistent influence of treatments on TSS as compared with the control.

### 4.2. Juice acidity:

The influence of various treatments on juice acidity of "Canino" apricot fruits was presented in **Table 4**. The data indicated that the apricot fruits that treated with the individual treatments of ProTon had lower juice acidity than ProTon plus AVG also, the individual treatments of Ethrel had lower juice acidity than the combined treatment of Ethrel plus AVG in both seasons. Similarly, fruits that treated with lisophos had lower juice acidity than lisophos plus AVG especially in the first season. Moreover, the individual treatments did not result in a consistent trend when compared with the control since Ethrel or lisophos alone had similar juice acidity to this obtained in the control in the first season while the same treatments caused reduction on juice acidity in the second season compared with the control. On the other hand, ProTon treatment increased juice acidity relative to the control in the first season only.

**Table 4. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on fruit contents of TSS, titratable acidity and TSS/ titratable acidity of Canino apricot during 2019 and 2020 seasons.**

| Treatments | TSS % | | Acidity % | | TSS/Acidity | |
|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 14.35 abc | 14.00 d | 1.15 | 0.95 | 12.48 c | 14.74 c |
| **Ethrel** | 14.90 a | 14.15 cd | 1.09 | 0.79 | 13.67 b | 17.91 a |
| **AVG** | 13.73 d | 13.95 d | 1.51 | 0.93 | 9.09 e | 15.00 c |
| **Ethrel +AVG** | 13.90 bcd | 14.55 bcd | 1.34 | 0.87 c | 10.37 d | 16.72 b |
| **ProTon + AVG** | 13.65 d | 14.75 bc | 1.35 | 1.03 a | 10.11 de | 14.32 c |
| **Lisophos +AVG** | 13.90 bcd | 15.50 a | 1.46 | 0.91 | 9.52 de | 17.03 ab |
| **Lisophos** | 13.83 cd | 15.00 ab | 1.09 | 0.89 c | 12.69 bc | 16.85 b |
| **Control** | 14.45 ab | 14.80 bc | 0.98 | 1.00 | 14.74 a | 14.80 c |

Values in each column accompanied with the same letters were not significantly different according to mean comparison by least significant differences (LSD) at 5%.

### 4.3. TSS/acidity ratio:

The response of the ratio of TSS/acidity of "Canino" apricot to various used treatments was reported in Table 4 and Fig. 3. Fruits that treated with any of the used treatments had lower TSS/acidity ratios than that occurred in the control treatment except Ethrel where it showed equal ratio to the control in both seasons. Meanwhile, only lisophos alone or in presence of AVG resulted in increasing TSS/acidity ratio in consistent manner in both seasons as compared with the control while all other used treatments caused reduction in the maturity index as compared with the control in both seasons.

### 4.4. Ascorbic acid content:

The effect of different treatments in "Canino" apricot fruits content of ascorbic acid was presented in **Table 5**. The obtained data revealed that all used treatments: ProTon, Ethrel, AVG and lisophos that applied individually or combined resulted in significantly increase of fruit content of ascorbic acid on apricot fruits in both seasons. Fruits that treated with ProTon alone recorded the highest ascorbic acid content compared with all others individual or combined treatments in both seasons. Also, the combined treatment of ProTon plus AVG had higher ascorbic acid content than all others treatment as well as the control in both seasons except Ethrel and AVG in the second season. The individual treatment of AVG significant exceeded the combined treatments of Ethrel plus AVG and lisophos + AVG in increase fruit content of ascorbic acid in both seasons. Fruits that treated with lisophos plus AVG had higher fruit content of ascorbic acid than lisophos alone in both seasons.

### 4.5. EC% of the flesh:

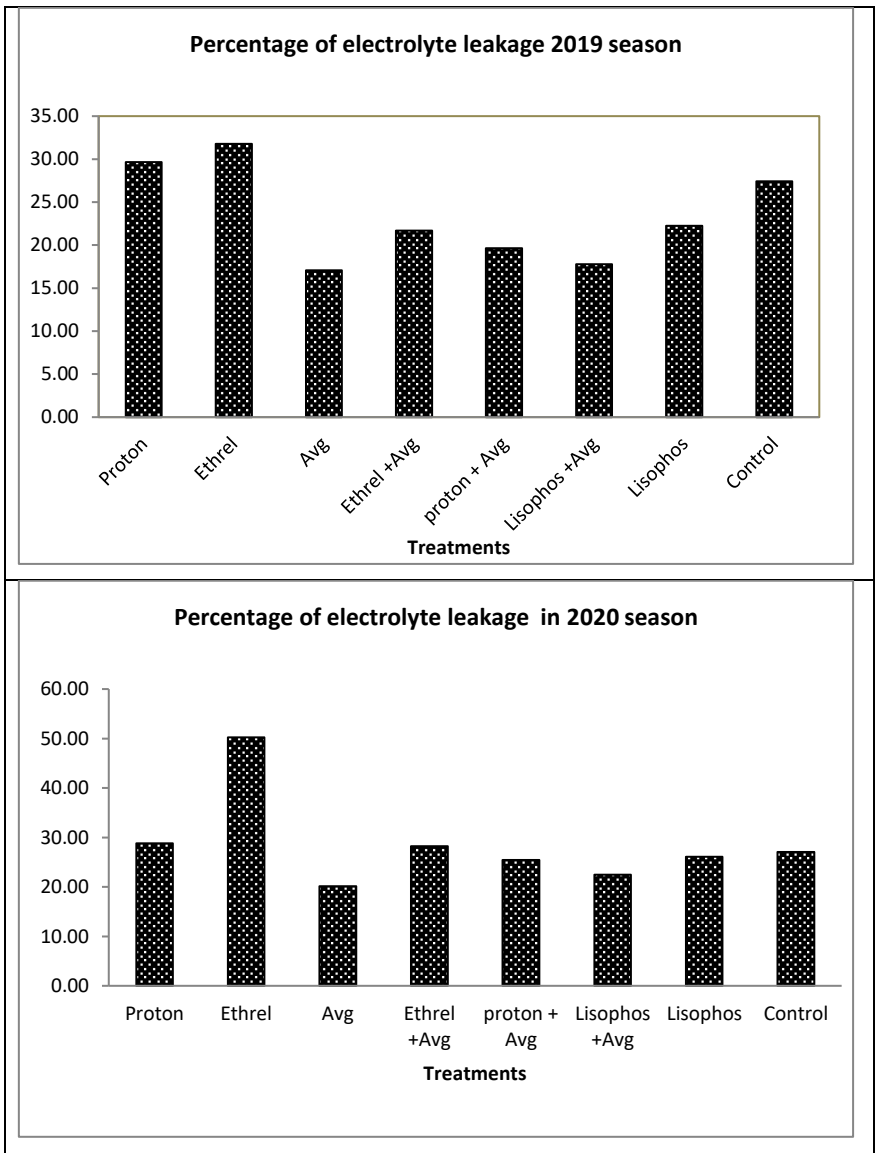
The effect of different application treatments on electrical conductivity of "Canino" flesh was reported in **Table 5 and Fig 2**. The

data showed that the pre-harvest application of Ethrel resulted increased significant the electrolyte leakage in consistent manner in both seasons as compared with the control. However, Ethrel plus AVG reduced the electrolyte leakage percentage in the first season only. ProTon alone did not cause any significant change in the leakage of electrolyte relative to the control. Lower percentage of electrolyte leakage were obtained with the application of lisophos plus AVG than AVG and ProTon plus AVG. finally, more the EC percentage more the tissue damage.

**Table 5. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on fruit contents of Ascorbic acid and EC of Canino apricot during 2019 and 2020 seasons.**

| Treatments | Ascorbic acid (mg/100 g fw.) | | EC % | |
|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 0.25 bc | 0.33 a | 29.67 ab | 28.84 b |
| **Ethrel** | 0.20 c | 0.30 ab | 31.79 a | 50.21 a |
| **AVG** | 0.25 bc | 0.28 abc | 17.08 d | 20.13 d |
| **Ethrel +AVG** | 0.25 bc | 0.25 bc | 21.69 c | 28.20 bc |
| **ProTon + AVG** | 0.20 c | 0.28 abc | 19.66 cd | 25.47 c |
| **Lisophos +AVG** | 1.15 a | 0.25 bc | 17.78 d | 22.47 d |
| **Lisophos** | 0.20 c | 0.23 c | 22.26 c | 26.07 bc |
| **Control** | 0.30 b | 0.25 bc | 27.41 b | 27.03 bc |

Values in each column accompanied with the same letters were not significantly differ according to mean comparison by least significant differences (LSD) at 5%.




### 4.6. Chlorophyll a content:

The effect of various pre-harvest treatments on "Canino" apricot fruit content of chlorophyll a were reported in **Table 6**. The data revealed that all treatments resulted in significant reduction of chlorophyll a as compared with the control. The magnitude of such reduction varied among the other used treatments. The data also

indicated that the chlorophyll a content in the fruit were relatively lower with Ethrel than ProTon application. However, chlorophyll a content under the combination of Ethrel plus AVG or ProTon were lower than these in the control or the combined treatment of lisophos plus AVG. apricot fruit that treated with lisophos had lower chlorophyll a content than the control but these values still larger than chlorphyll values under Ethrel or ProTon treatments.

### 4.7. Chlorophyll b:

The influence of the used treatments on content in "Canino" apricot fruits at harvest are presented in **Table 6**. The data provided evidences that there is a reduction in chlorophyll obtained by all treatments as compared with the control in both seasons. However, the magnitude of that reduction varied between treatments.

**Table 6. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on fruit pigments of Canino apricot during 2019 and 2020 seasons.**

| Treatments | Chlorophyll a | | Chlorophyll b | | Total | | Carotene | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 0.18 f | 0.16 | 0.12 | 0.10 | 0.29 g | 0.26 g | 7.74 | 7.39 |
| **Ethrel** | 0.15 | 0.13 | 0.10 | 0.09 | 0.26 h | 0.22 h | 7.99 | 7.63 |
| **AVG** | 0.29 | 0.26 | 0.19 | 0.19 | 0.48 b | 0.45 b | 6.28 | 6.01 |
| **Ethrel +AVG** | 0.20 | 0.18 f | 0.13 f | 0.12 f | 0.33 f | 0.30 f | 7.50 | 7.11 |
| **ProTon + AVG** | 0.25 | 0.22 | 0.16 | 0.16 | 0.41 d | 0.37 d | 6.86 | 6.77 |
| **Lisophos** | 0.22 | 0.20 | 0.14 | 0.13 | 0.36 e | 0.33 e | 7.23 | 6.84 |
| **Lisophos** | 0.26 | 0.24 | 0.17 | 0.17 | 0.44 c | 0.41 c | 6.64 f | 6.27 |
| **Control** | 0.31 | 0.29 | 0.20 | 0.20 | 0.51 a | 0.49 a | 5.94 | 5.74 f |

Values in each column accompanied with the same letters were not significantly differ according to mean comparison by least significant differences (LSD) at 5%.

For example, fruits under Ethrel treatment had lower chlorophyll b content than that found under the individual application of ProTon, lisophos or AVG. moreover, the application of Ethrel plus AVG, ProTon plus AVG and lisophos plus AVG significantly varied in their effect on chlorophyll b content in both seasons with higher magnitude

of Ethrel plus AVG than the other two combinations. The largest differences were found between the application of lisophos alone or when was combined with AVG in the two seasons.

### 4.8. Carotene content:

Changes in carotene content of "Canino" apricot flesh as affected by all used treatments is presented in **Table 6**. The data revealed that fruits under the control treatments had the lowest content of carotene while the fruit that treated with Ethrel recorded the highest carotene content in both seasons. Application of Ethrel plus AVG resulted in higher carotene content than the control. ProTon alone was more effective on increasing carotene content than control in both seasons. Meanwhile, increasing carotene under ProTon alone was significantly greater than that obtained by ProTon plus AVG. Even the antiethylene compound AVG was able to slightly increase carotene in fruit. Again, all used treatments were able to increase carotene in different magnitude to such others, but all higher than the control.

### 4.9. Total carbohydrates:

With regard to the effect of different treatments on "Canino" apricot content of total carbohydrates the data in **Table 7** confirmed that all used treatments caused a significant increase in total carbohydrates when compared with the control in both seasons. Meanwhile, the highest increase in total carbohydrates was obtained in fruits that treated with Ethrel in both seasons followed by ProTon. Apricot fruits that treated with lisophos had higher total carbohydrates content than the control but the increase of total carbohydrates under lisophos was lower than these obtained under Ethrel or ProTon in both seasons. The application of AVG as an ethylene biosynthesis inhibitory led to increase total carbohydrate as compared with the control. Moreover, the inhibitions of AVG plus either Ethrel or ProTon and lisophos resulted in an increase in total carbohydrate as compared with the control and relative to AVG treatment in a consistent manner in both seasons.

**4.10. Reducing sugar %:**

Results in **Table 7** showed that the percentage of reducing sugars in "Canino" apricot fruits significantly affected by application ProTon, Ethrel, AVG and lisophos in both seasons. All used treatments alone or combined caused significant increase in the percentage of reducing sugars compared with the control in both seasons. The highest percentages of reducing sugars were recorded when apricot fruits treated with Ethrel, ProTon and Ethrel + AVG, respectively compared with the control. In the contrast of this, the lowest percentages of reducing sugars were showed under the control followed by AVG then lisophos in the two seasons of this study.

**4.11. Non-reducing sugars %:**

The effect of different treatment in apricot fruits content on non-reducing sugar was showed in **Table 7**. The obtained data showed that the percentage of non-reducing sugars significantly increased under all tested treatments compared with the control in both seasons. The individual application of ProTon or Ethrel recorded higher increase in non-reducing sugar percentages than all other used treatments as well as the control in both seasons. Also, fruit that treated with the combined treatment of Ethrel+AVG or ProTon plus AVG had higher non-reducing sugars percentages than this in the control treatment. The lowest non-reducing sugars percentages were recorded in the control treatment followed by lisophos alone in both seasons.

**4.12. Total sugars %.**

The influence of different treatment in apricot fruits content on total sugar was presented in **Table 7**. The results that the percentage of total sugars significantly increased under all tested treatments compared with the control in both seasons. The individual application of ProTon or Ethrel recorded higher increase in total sugar percentages than all other used treatments as well as the control in both seasons. Also, fruit that treated with the combined treatment of Ethrel+AVG or ProTon plus AVG had higher total sugars percentages than this in the control

treatment. The lowest total sugars percentages were recorded in the control treatment followed by AVG alone in both seasons.

### 4.13. Crud fibers %:

Crud fibers as affected by different pre-harvest treatments are presented in **Table 7**. The obtained data confirmed that the percentage of crud fibers significantly increased under all tested treatments compared with the control in both seasons. The individual application of ProTon or Ethrel recorded higher increase in crud fibers percentages than all other used treatments as well as the control in both seasons. Also, fruit that treated with the combined treatment of Ethrel+AVG or ProTon plus AVG or lisophos plus AVG had higher fibers percentages than this in the control treatment. The lowest crud fibers percentages were recorded in the control treatment followed by AVG alone in both seasons.

**Table 7. Effect of pre-harvest treatments of some growth regulators alone or combined with AVG on fruit chemical properties of Canino apricot during 2019 and 2020 seasons.**

| Treatments | Total carbohydrates% | | Reducing sugars % | | Non-reducing sugars % | | Total sugars % | | C. fiber % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **ProTon** | 13.3 | 12.9 | 5.8 | 5.6 | 3.88 | 3.84 | 9.7 | 9.51 | 3.2 | 3.4 |
| **Ethrel** | 13.6 | 13.2 | 5.9 | 5.8 | 4.01 | 3.89 a | 9.9 | 9.72 | 3.4 | 3.7 |
| **AVG** | 12.1 | 11.8 | 5.2 | 5.1 | 3.49 | 3.53 | 8.7 | 8.65 | 2.3 | 2.6 |
| **Ethrel** | 13.1 | 12.7 | 5.7 | 5.5 | 3.79 | 3.73 | 9.5 | 9.31 | 3.0 | 3.3 |
| **ProTon +** | 12.6 | 12.2 | 5.5 | 5.3 | 3.65 | 3.61 | 9.1 | 9.20 | 2.7 | 2.9 |
| **Lisophos** | 12.9 | 12.5 | 5.6 | 5.4 | 3.71 | 3.69 c | 9.3 | 9.16 | 2.8 | 3.1 |
| **Lisophos** | 12.4 | 12.0 | 5.4 | 5.2 | 3.56 | 3.51 | 8.9 | 8.76 | 2.5 | 2.8 |
| **Control** | 11.9 | 11.5 | 5.1 | 5.0 | 3.44 | 3.35 e | 8.6 | 8.37 | 2.1 | 2.5 |

Values in each column accompanied with the same letters were not significantly differ according to mean comparison by least significant differences (LSD) at 5%.

## DISCUSSION

There have been increasing demands on the cultivation and consumption of apricot fruits all around the world and in Egypt. However, the climacteric nature of the fruit is main barrier to the expansion of production in addition to the increase in fruit losses either before or after harvest. The increase in ethylene production and respiration rates at maturity due to the climacteric nature also, lead to more internal production of endogenous ethylene or what is known as autocatalysis. Thus, the utilization of an anti-ethylene compound, namly aminoethoxyvinylglycine (AVG) is scientifically logic. This compound has been established to be able to block or inhibit ethylene production by inhibiting the conversion of S-adenosyle methionine (SAM) to amino cyclopropane (ACC) which causes more biosynthesis of polyamines such putrescine and sperimine.

Moreover, AVG is a safe compound and has been utilized before harvest on plums **Byers (1997)** or even after harvest with many economic fruits **Yildiz, *et al.* (2012) and Kotb (2019)**. Thus, the utilization of AVG enabled the fruit to avoid a catabolic event to gothrough an anabalic event (namely, the biosynthesis of polyamines). In addition, it was reported that AVG has been used heavily to decrease pre-harvest fruit drop, improve the quality of fruit, delay fruit maturity and protect the fruit firmness by inhibiting ethylene which causes the acceleration of ripening and senescence **(Yuan and Carbaugh, 2007)**. Furthermore, the use of AVG has been manipulating the control of vegetative growth and regulating flowering, size, shape, color development and postharvest qualities **(Green, 2006)**.

No wonder that the application of AVG alone or even when combined with Ethrel, ProTon or lisophos resulted in significantly lower electrolyte leakage (Table 5) than the control. The combination of lisophos plus AVG even resulted in lower electrolyte leakage than lisophos alone in a consistent manner in both seasons. Meanwhile, lisophos alone resulted in a significant reduction of electrolyte leakage as compared with ProTon alone or with Ethrel alone due to the ability of lisophos (lysophophtilyethanolamine) to delay tissue senescence and

delay the loss of tissue firmness **(Farag 1990, Farag and Palta, 1991b, Cowan, (2009) Hong *et al.* (2008) and Farag *et al.* (2011))** that finding has been very important worldwide and novel which deserved granting many patents to the innovdor by the USA patent office **(Abeles *et al.* 1992)**. Moreover, the utilization of AVG applications under field condition was reported to affect many fruit charcteristics related to enhancing its marketing for example, **Ebubekir *et al.* (2020)** reported that AVG applications two weeks before harvest affected some characters of pulms (cv. Presiblent) that are related to postharvest hurdling, processing and packaging of plums to reduce the damage caused by mechanical and the amount of needed force applied to processed fruits such as fruit length and diameter surface area of fruits and thickness (size dimensions) as also reported by **Ozturk *et al.* (2013)**. The fruit size data, in this study of AVG treated apricots was greater than that of the control in both seasons. In addition, the application of AVG alone resulted in the lowest fruit color index. However, such index was improved with the combination of AVG plus Ethrel or ProTon or lisophos.

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**J. Agric. & Env. Sci. (Damanhour University)** **2022, 20 (2): 45-71**
**Print: ISSN 1687-1464** **Online: 2735-5098**

## الملخص العربي

### المعاملات الحقلية لتحسين تلوين ونضج ثمار مشمش الكانينو في وجود وغياب أحد مضادات الإيثلين

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أجريت هذه الدراسة خلال موسمي 2019-2020 لتقدير تأثير معاملات قبل الجمع باستخدام البروتون، الايثريل والليزوفوس سواء فردياً أو من خلال خلط كل منهما مع مركب أمينو إيثوزوكسي فينيل جليسين (AVG) ومقارنته بالكنترول وذلك على تلوين ونضج المشمش صنف كانينو النامية علي أشجار عمرها ست سنوات بمزرعة خاصة بمنطقة البستان بمحافظة البحيرة بمصر، وقد أشارت النتائج المتحصل عليها أن أقل تساقط للأوراق خلال الموسمين قد حدثت مع معاملة الليزوفوس سواء بمفرده أو في وجود مضاد الايثلين (AVG) في كلا الموسمين، كذلك لم تتسبب معاملة AVG أي تساقط للأوراق في الأفرع المعاملة خلال الموسمين. وأدت المعاملة بالايثريل بمفرده إلي زيادة تساقط الثمار مقارنة بالبروتون ومع ذلك فإن معاملة البروتون مع AVG نتج عنها زيادة في تساقط الثمار بالمقارنة مع معاملة الايثريل مع AVG خلال موسمي الدراسة. تم الحصول على أعلي زيادة في الوزن الطازج للثمار وفي وزن النواة ووزن اللحم مع معاملة الخلط بين الليزوفوس وAVG وقد أشارت النتائج إلى أنه قد حدثت زيادة في حجم الثمرة بطريقة معنوية مع المعاملات الثلاثة سواءً البروتون مع AVG أو الايثريل مع AVG أو الليزوفوس مع AVG بينما المعاملة الفردية بالليزوفوس بمفرده أو الايثريل بمفرده أو مخلوطاً مع AVG قد أحدثت زيادة في نسبة TSS وانخفاض في التسرب الالكتروليتي بالمقارنة مع الكنترول وحتى مع معاملة AVG بمفردها حيث أدت إلى تقليل نسبة TSS في كلا الموسمين. وأدت معاملة البروتون بمفرده إلي زيادة حموضة العصير وزيادة حمض الاسكوربيك، بينما نجد أن معاملة الليزوفوس بمفردها أو في وجود AVG قد نتج عنه زيادة نسبه TSS على الحموضة بشكل ثابت في كلا الموسمين وذلك بالمقارنة مع الكنترول، وكشفت النتائج أن كل المعاملات أدت إلى انخفاض معنوي في محتوى كلوروفيل A,B والكاروتين مقارنة مع الكنترول وكانت أعلي زيادة في الكربوهيدرات الكلية والسكريات المختزلة والغير مختزلة والألياف قد حصل عليها في الثمار المعاملة بالايثريل في كلا الموسمين وتبعهم معاملة البروتون. يمكن التوصية بإضافة الليزوفوس مع AVG لتحسين تلوين ثمار المشمش كانينو ومحتوى الكاروتين مع تجنب زيادة التسرب الالكتروليتي.