Effect of Spraying Some Natural Compounds on Quality and Marketing of "Anna" Apple Fruits

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ABSTRACT: This investigation was carried out during two successive seasons 2017 and 2018 to study the effect of some natural compounds on quality and extend the storage period of seven years old "Anna" apple trees (*Malus domestica* L.) budded on Malus rootstock grown in sandy soil, under drip irrigation system and grown in a private orchard at El-Nubaria region, El-Behira governorate, Egypt. Trees were sprayed in two application times at (15[th] and 22[th] May) during 2017 and 2018, respectively, with a hand sprayer to the run off. Treatments included lysophosphatidylethanolamine (LPE) at (125 and 250) mg/L, phenylalanine at (100 and 200) mg/L and Ethrel at (250 and 500) mg/L and water as a control. Results showed that, at harvest, LPE and phenylalanine treatments were more effective in increasing physical characteristics such as (fruit weight, size, fruit length and diameter) in both seasons compared with other treatments. Meanwhile, both concentration of Ethrel did not affected on these characteristics in both seasons. Furthermore, in two seasons of study, LPE led to a marked increase in fruit firmness as compared with other treatments. On the contrary, both phenylalanine and Ethrel treatments decrease fruit firmness but the differences were big enough to be significant compared to the control, except for phenylalanine at 200 mg/L in both seasons. All substances increased red skin color compared to control, also, different treatments caused a reduction of chlorophyll (a, b) contents and acidity compared to control in both seasons. Using Ethrel at (250 and 500) mg/L caused a significant increase in TSS in both season as compared with other treatments except Ethrel at 250 mg/L in the second one. In addition, LPE at 250 mg/L increased ascorbic acid content in both season as compared with other treatments. Phenylalanine and Ethrel treatments caused a higher effect in increasing total sugars content than other treatments. Concerning cold storage period, spraying Ethrel at (250 and 500) mg/L caused a reduction in chlorophyll (a, b) contents and acidity as compared with other treatments in both seasons. Fruit weight loss% and fruit disorders percentage were decreased with LPE applications in both seasons. There is positive correlation between Ethrel and fruit weight loss in both seasons. Pre-harvest spraying Ethrel recorded the highest values of TSS and total sugars while, vitamin C followed somewhat similar pattern to that of the result at harvest. It could be concluded that, pre-harvest spraying of LPE and Phenylalanine before harvest could increases physical characteristics, improves color, decreases fruit disorders and extend the storage period of "Anna" apple fruit.

Key words: Anna apple, LPE, Phenylalanine, Ethrel, Fruit coloration, Fruit quality

INTRODUCTION

Apple (*Malus domestica* Borkh.) is a deciduous plant of the *Rosaceae* family that produces pomaceous fruits, suitable and liked for consumption by humans. Anna is the common and commercially important apple cultivars grown in Egypt. The area cultivated with apple in Egypt is 83519 Feddan which produces about 36388 tons according to (Ministry of Agriculture Statistics, Egypt in 2015).

In Egypt, "Anna" apple fruits suffer from poor and erratic development of red blush on the surface causes serious economic losses to the growers, where trees have been exposed to heat stress and slight difference between day and night temperatures. Apple color is a blend of chlorophyll, carotenoids, and flavonoids. Anthocyanins are a compound of flavonoids, are responsible for the red skin color of apples (Lancaster & Dougall, 1992). Anthocyanin biosynthesis in apple has also been reported to be influenced by the concentrations of endogenous ethylene (Whale and Singh, 2007). Ethylene is thought to be the naturally-occurring hormone that triggers fruit ripening (Blanpied, 1972).Ethylene is the main plant growth regulator used to enhance fruit red color (Steffens *et al*., 2006). So, Apple growers try to increase color intensity and uniformity and accelerate maturity in order to harvest and market early which increases their profits (Farag, 2006) by spraying the fruits with ethylene-releasing compounds such as Ethrel.

Since apple fruits are autocatalytic they are very sensitive to ethylene whether the internal or the atmospheric ethylene which reflect on the rapid loss of tissue firmness and reduce their keeping quality.

Ethrel (2- chloroethylphosphonic acid) or also called ethephon has been known as a plant growth regulator that releases ethylene in plant tissue and enhances ripening of many fruits (Farag, 2006). Ethephon applied as a foliar spray will enter the plant where it is subjected to a higher pH converting it to ethylene. It is ethylene that causes the plant's physiological responses to occur. In this conversion the plant releases chlorides and phosphonates. The known physiological and biochemical effects of ethephon (C_2H_4) on harvested horticultural crops include increase respiratory rate and enzymes activity (Kader, 1985). It is application advances fruit maturity, allows early harvest, and also increases the red color of fruit skin when used just before optimal harvest time (Ban *et al*., 2007). Meanwhile, it does significantly accelerated loss of flesh firmness, shorten shelf life, fruit storage time and can cause excessive fruit drop if fruits are not harvested within 10 days after application (Omafra, 2007; Singh and Shafiq, 2008). Also, application of Ethephon significantly improved percent red blush, concentrations of total anthocyanin and cyanidin 3-galactoside in the fruit skin (Brackmann *et al*., 2014, 2015; Shafiq *et al*., 2014).

Recently, new studies have been carried out with the objective of finding chemical products that stimulate the accumulation of anthocyanins in fruit skin without the inconveniences of maturity acceleration, ethylene production and reduction of storage potential (Bizjak *et al*., 2013). To reach this goal can be used some safe compound, like lysophosphatidylethanolamine (LPE) and phenylalanine.

LPE is a natural product of membrane phospholipid metabolism and is formed from phosphatidylethanolamine (PE) by action of phospholipase A2 and remains in the lipid phase. Studies have provided evidence that LPE can accelerate ripening of tomato and cranberry fruits while prolong shelf-life at the same time (Farag and Palta, 1993; Ozgen *et al*., 2004). LPE treatment has also been found to reduce senescence of leaves, fruits and cut-flowers (Hong *et al*., 2009a; Kaur and Palta, 1997).

Phenolic compounds "phenylalanine" is the primary compound in the biosynthesis of such pigment. Moreover, phenolic compounds play a major role in strengthening the structure of the plant cell wall by increasing the deposition of Legnins. Phenolic compounds in fruit contribute to their sensory qualities such as colour, aroma, bitterness and astringency (Ozawa *et al*. 1987; Macheix *et al.*, 1990). In most plant species, anthocyanins are synthesized from L–phenylalanine via the phenylpropanoid pathway catalyzed by phenylalanine ammonia lyase (PAL), chalcone synthase (CHS), chalcone-flavanone isomerase (CHI), flavanone-3-hydroxylase (F3H), dihydroflavonol 4-reductase (DFR), anthocyanidin synthase (ANS), and UDP-glycose:flavonoid 3-O-glycosyltransferase (UFGT), among other enzymes (Winkel-Shirley, 1999; Jaakola, 2013)

Storing fruits at low temperature is the major method of controlling respiration rate and extending the storage life of fruits, although it is limited in most tropical fruits by their chilling sensitivity (El-Oraby *et al*. 2004). Prolonged storage is difficult since temperatures low enough to delay ripening injury these fruits. Moreover, an appropriate temperature management after harvest is the most important factor in maintaining fruit quality, delaying ripening of climacteric fruit like apples and extending and improving storage- and shelf-life (Lee and Kader, 2000; Lurie, 2002).

Therefore, the objectives of this study reported here were to study the effectiveness of pre-harvest spraying of lysophosphatidylethanolamine, phenylalanine and Ethrel treatments on fruit coloration, fruit quality and extend the storage period of “Anna” apple fruits.

MATERIALS AND METHODS

The present study was conducted during the two successive seasons 2017 and 2018 on 7-year old “Anna” apple trees (*Malus domestica* Borkh.) budded on Malus rootstock, grown in sandy soil, spaced at 4×4m, under drip irrigation system and grown in a private orchard at El-Nubaria region, El-Behira governorate, Egypt. Twenty one uniform trees, free from various physiological and pathological disorders receiving common horticultural practices were selected for investigation. Treatments included water as the control, lysophosphatidylethanolamine (LPE) at (125 and 250) mg/L, phenylalanine at (100 and 200) mg/L and Ethrel at (250 and 500) mg/L. Trees were sprayed in two application times at (15^{th} and 22^{th} May) during 2017 and 2018, respectively. The non-ionic surfactant Tween 20 at 0.05% (v/v) was added to all treatments to reduce the surface tension and increase the contact angle of sprayed droplets. Trees were sprayed to the run off using a hand sprayer.

The treatments were sprayed at the time corresponding to specific fruit growth stages established by monitoring the progress of the sigmoid curve, and before the onset of climacteric ethylene. The study treatments were arranged in a randomized complete block design. Three replications were used per each treatment. Thus twenty one trees were used in this study. Random samples were collected from each tree two week after the application, and then divided into two groups, the first to monitor physical and chemical characteristics at harvest. Meanwhile, the second group fruits were placed into fiberboard boxes with vented plastic liners and stored for 30 days at 2^{o} C in air (85-95% relative humidity).

Fruit quality parameters:

(A) Physical properties:

The following fruit parameters were measured directly after the harvest at 5th and 12th June during 2017 and 2018, respectively.

1- Fruit weight (g):

The average weight of ten fruits of each replication was determined.

2- Fruit size (cm^3):

The average fruit size was measured using a graduated cylinder of 1000 ml containing tap water.

3- Fruit dimensions:

Fruit length (cm) and fruit diameter (cm) were measured using a Vernier caliper.

4- Fruit firmness (Newton):

Apple firmness was determined on red and green cheeks as (Ib/inch^2) using Effigi Pressure Tester (mod. Ft327) the results of these measurements were converted to (Newton) using the following equation:

Newton= Ib/ Inch²* *4.448*

5- Fruit weight loss (%):

It equals the amount of water loss through evaporation and transpiration plus the amount of dry matter lost by respiration. It was determined by weighting the fruits. The fruits were weight at the end of cold storage period and their weight loss was calculated as follows:

$$\text{Weight loss \%} = \frac{\text{Average loss in fruit weight}}{\text{Average fruit weight at the beginning of storage}} \times 100$$

6- Fruit disorders (%):

Fruits affected with either pathological or physiological disorders were counted by visual and calculated as a percentage to the initial number of fruits per each sample (replicate) and treatment too.

(B) Chemical constituents:

1-Total soluble solids (%):

TSS% was determined in apple fruit juice using a hand refractometer.

2- Acidity (%):

Fruit juice acidity was determined according to (A.O.A.C., 1985) by titration with 0.1 N sodium hydroxide using phenolphthalein as an indicator and expressed as malic acid percentage.

3- Vitamin C (Ascorbic Acid):

Vitamin C content was determined in fruit juice using 2, 6-dichlorophenol-indo-phenol blue dye as mg ascorbic acid per 100 ml Juice. (A.O.A.C., 1985).

4-Total sugars:

Total sugars were determined by using the phenol sulfuric acid method (Smith, 1956), and the concentration was calculated from a standard curve of glucose (mg. per g. fresh weight of fruit tissue).

5- Chlorophyll a and b:

Chlorophylls a and b were determined on red and green cheeks according to (Wintermans and Mat, 1965) as follows:

Half gram of fresh peel was extracted by about 15 ml of 85% acetone and 0.5 g calcium carbonate, the mixture was filtered through a piece of cotton by using a glass funnel and the residue was washed with a small volume of acetone and brought up to 25 ml. The optical density of a constant volume of filtrate was measured at a wave length of 663 nm, for chlorophyll A and 644 nm, for chlorophyll B using spectrophotometer.

The following equations were used:-

Chlorophyll concentration (mg/100g)

Chl. A = $\{12.7(D_{663}) - 2.69(D_{645})\} \times V/1000W$.

Chl. B = $\{22.9(D_{645}) - 4.68(D_{663})\} \times V/1000W$.

Where,

D = Value of absorbance optical density at 645 and 663 nm.

V = Volume of pigment solution (ml).

W = Fresh weight of sample(g).

6- Anthocyanin:

Anthocyanin was determined on red and green cheeks of the fruit according to the method of Fuleki and Francis (1968) as follow: 10 grams of fresh peel, was extracted by using 20 ml of the extraction solution (85% (V/V) ethyl alcohol 95% + 15% (V/V) HCl 1.5N), the mixture was left for the extraction of anthocyanin for 2 weeks, 2 ml of the filtrate was used to determine the optical density at 535 nm, after adding 5 ml of the extraction solution. The blank was just the used extraction solution, using spectrophotometer.

Assessment the fruits during cold storage:

At harvest, a random sample of ten fruits from each replication was taken to the laboratory, washed with tap water, surface sterilized for 3 min in 0.05% sodium hypochlorite, rinsed quickly in distilled water to remove the residues of such sterilizer, then left for air drying and the initial fruit weight was determined. All fruits were then placed into fiberboard boxes with vented plastic liners and stored for 30 days at 2^{o} C in air (85-95% relative humidity), at the end of cold storage period, the following measurements were taken:

The fruit weight (g) which was then used to determine the weight loss percentage.

Furthermore, some physical and chemical parameters were detected such as fruit firmness by the Pressure Tester (Effigi Tester), TSS, acidity, vitamin C, total sugars, chlorophylls a, b and anthocyanin contents by using the same mentioned methods and procedures.

Statistical analysis:

Data of the present study were subjected to the analysis of variance test (ANOVA) as complete randomized block design (RCBD). The least significant differences (LSD) at the 5% level of probability were calculated using a computer program Costat according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Physical characteristics at harvest:

1.1. Fruit weight:

The response of fruit weight to spraying with LPE, phenylalanine and Ethrel at harvest was reported in Table (1). The data revealed that, in both seasons, there were highly significant differences in fruit weight. Furthermore, LPE at (125 and 250) mg/L was more effective in increasing fruit weight compared with other treatments. Similar trend was obtained with the applications of phenylalanine at both concentrations in the first and second season. On the other hand, Ethrel treated fruits did not consistently differ from that of the control in both seasons. These results are in contrary with those obtained by El-Salhy (1996) who found that Ethephon sprays on Dorsett Golden apple trees exhibited similar fruit weight. Furthermore, 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. While, McArtney *et al*. (2008) reported that applied ethephon on apple cv. ('Delicious' and 'Golden Delicious') did not have a consistent effect on fruit weight in the year of treatment. Moreover, Derhab (2015) worked on "Anna" apple fruit and they reported that the application of ethephon alone did not result in any significant change at harvest in "Anna" apples in a consistent manner in both seasons.

1.2. Fruit size:

Data concerning the influence of foliar application of LPE, phenylalanine and Ethrel at harvest on "Anna" apple fruit size are shown in Table (1). The data indicated that some treatments tended to cause an increase in fruit size such as LPE and phenylalanine compared to control in both seasons. In addition, no significant differences were noticed between LPE and phenylalanine in both seasons. On the other side, application of Ethrel at (250 and 500) mg/L resulted in lowest fruit size as compared with LPE and Phenylalanine.

Although the mechanism of action by LPE was not exactly understood, earlier application of LPE may responsible for cell enlargement of sweet cherries. Earlier studies demonstrated that LPE acts as a signaling molecule and impacts either directly or indirectly membrane transport processes, ionic balance, homeostasis, and cell/organ turgor (Cowan, 2006). Furthermore, LPE increased leaf activity which could reflect on enhancing the partitioning of more carbohydrates from the leaves to the apple. The above trend of fruit weight and fruit size agreed with those reported by (Ozgen *et al*., 2015) who reported that preharvest applications of LPE treatment led to increase in sweet cherry fruit weight at harvest as compared with control. In addition, Farag and Attia (2016) they found that there was a trend of a larger fruit size when treated with LPE.

On the other hand, the increase of ethylene production by Ethrel application or through the autocatalysis cause a cessation of growth and a reduction of fruit weight and size (Abeles *et al*., 1992). The no significant change in fruit weight at harvest could be explained on the time of Ethrel applications by the end of the sigmoid curve (where the curve levels off (Farag, 2006). Our results were consistent with previous results where ethylene as a growth retardant would pose negative impact on important physical properties of the berries such as size and weight (Roberto *et al*., 2012).

1.3. Fruit dimensions:

The effect of various treatments on "Anna" apple fruits dimension was shown in Table (1). The data indicated that, all spraying treatments significantly increased fruit length and fruit diameter compared with control in both seasons of study, except for Ethrel at (250 and 500) mg/L where the differences were not big enough to be significant. In addition, in two seasons of this study, the statistical analysis showed that, LPE at 250 mg/L and phenylalanine at 200 mg/L treatments were more effective in increasing fruit length and fruit diameter compared with other treatments.

The obtained results could be due to that phenylalanine influence cell expansion in the longitudinal direction or at any other directions. These results are in line with those reported by El-Abd (2011) on "Florida Prince" peach. Furthermore, the greatest fruit length and diameter was observed with LPE application meanwhile, the lowest value with Ethrel (Farag and Attia, 2016).

1.4. Fruit firmness:

Data of the present investigation in Table (2) showed the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on flesh firmness at red and green cheeks of "Anna" apple fruits in 2017 and 2018 seasons. Results showed that, LPE at (125 and 250) mg/L caused a significant increase in fruit firmness at red and green cheeks compared with the control. Moreover, in two seasons of study, LPE at 250 mg/L caused a higher effect in increasing fruit firmness at red and green cheeks than those of other treatments. On the contrary, phenylalanine and Ethrel treatments decrease fruit firmness at red and green cheeks and the differences were big enough to be significant compared with the control, except for phenylalanine at 200 mg/L in 2017 and 2018 seasons.

The increase in fruit firmness as a result of LPE treatments may be due to maintain the plasma membrane integrity and mitigated the effect of ethylene on the cell wall or membranes lipid degradation (Farag and Palta, 1993). Moreover, LPE retarded polygalacturonase-mediated fruit softening (Hong *et al*., 2008), reduced activity of phospholipase D (PLD; EC 3.1.4.4), membrane leakiness (Ryu *et al*., 1997; Hong *et al*., 2009b) and delayed tissue senescence. The obtained results are in agreement with the findings of (Farag and Attia, 2016). While, the decrease in firmness with increase in Ethrel concentration could be due to enhance activity of polygalactouronase and pectin lyase enzymes result into breakdown of insoluble protopectin into soluble pectin or by cellular disintegration leading to membrane permeability (Brinston *et al*. 1988; Ali *et al*., 1995; Yashoda *et al*., 2006). The loss of pectin substances in the middle lamella of the cell wall is perhaps the key steps in the ripening process that leads to the loss of cell wall integrity thus cause loss of firmness and softening (Solmos and Laties, 1973). The present results are in harmony with those previously reported by Drake *et al*. (2006) treated 'Scarletspur Delicious' and 'Gale Gala' apple trees preharvest with Ethrel. They found that Ethrel reduced firmness. Also, Mohamed and Abu-Goukh (2003) in mango, Kulkarni *et al*. (2011) in banana. Smith and Whiting, (2010) Firmness of ‘Chelan’ sweet cherry cultivar was reduced by Ethephon applications. On the other hand, Özgen *et al*. (2015) stated that, LPE treatment had no significant effect on fruit firmness at harvest. Moreover, El-Abd (2011) found that "Florida Prince" peach at color initiation with phenylalanine at 100 or 200 ppm tended to increase fruit firmness at harvest as compared with the control.

2. Chemical characteristics at harvest:

2.1. Anthocyanin:

The response of anthocyanin content on "Anna" apple fruits at red and green cheeks to pre-harvest spraying of LPE, phenylalanine and Ethrel at harvest was reported in Table (2). Data showed that, in both seasons, all treatments caused a significant increase in anthocyanin at red and green cheeks compared with control. In addition, the statistical analysis showed that, phenylalanine at 200 mg/L, Ethrel at 250 mg/L and Ethrel at 500 mg/L caused a higher effect in increasing anthocyanin at red and green cheeks than that other treatments and the differences were big enough to be significant.

The increased amount of anthocyanin by phenylalanine could be attributed to their influence on anthocyanin biosynthesis since phenylalanine is the primer compound in the biosynthesis pathway of anthocyanin. The availability of phenylalanine, might lead to more activity to the enzyme phenylalanine ammonium lyase (Kanellis and Roubelakis-Angelakis, 1993). Besides, a correlation was found between PAL activity in the skin of colored grapes and the accumulation of anthocyanin (Pandey, 1974; Kataoka *et al*., 1982; Hrazdlna *et al*., 1984). These results were found to be in harmony with those obtained by (Ezz, 1994) who found that anthocyanin pigment was increased with increasing the concentration of phenylalanine application in “Red roomy” cultivar. Moreover, Ezz and El-Kobbia (2000) found that phenylalanine treated Pairi mango fruits showed higher amount of carotene and anthocyanin than the control. Furthermore, (El-Abd, 2011) found that, phenylalanine was effective in increasing anthocyanin content when compared with the control.

To explain the role of Ethrel on anthocyanin, Ethrel increased phenylalanine-ammonia-lyase (PAL) activity in table grapes which was accompanied by increased color development (Steenkamp *et al.* 1977). It is also likely that, ethylene released from ethephon stimulated the activity of phenylalanine ammonia-lyase (PAL), a key enzyme in the anthocyanin biosynthetic pathway (Faragher and Brohier, 1984; Lister *et al*., 1996). Ethrel treatments have also been shown to enhance gene expression for enzymes involved in anthocyanin biosynthesis such as UDP glucose-flavonoid 3-o-glucosyl transferase (UFGT) with concomitant increases in anthocyanin accumulation in *Vitis vinifera cv*. Cabernet Sauvignon (El-Kereamy *et al*., 2002 and 2003). Higher anthocyanin levels at harvest in ethylene-treated Cabernet Sauvignon grapes were due to increased synthesis of anthocyanins, namely malvidin-3-glucoside (Mv-gluc) (El-Kereamy *et al*., 2002 and 2003). Also, Ethrel has been previously reported to increase the activity of PAL in the skin of 'Starking Delicious' (Larrigaudiere *et al*., 1996) and 'Fuji' apples (Li *et al*., 2002). The results are harmony with those reported by Larrigaudiere *et al*. (1996) on 'Starking Delicious', Awad and Jager (2002) on 'Jonagold' apple and Li *et al*. (2002) on 'Fuji' apples they reported that Ethrel application before commercial harvest increased the activity of PAL, accelerated the anthocyanin accumulation in the skin. Ban *et al*. (2007) also, found that, ethephon application accelerated the anthocyanin accumulation and greatly increased its final concentration compared to the control in rabbiteye blueberry (*V. ashei*).

With respect to the effect of LPE on fruit color, preharvest application of LPE can accelerate ripening of Sweet Cherry c.v. '0900 Ziraat' fruits, increase anthocyanin accumulation while prolong shelf-life at the same time (Hong *et al*., 2008; Ozgen *et al*., 2015).

2.2. Chlorophyll a and b:

Data concerning the influence of pre-harvest spraying of LPE, phenylalanine and Ethrel on chlorophyll a and b at red and green cheeks of "Anna" apple fruit are reported in Table (3). Data showed that, in both seasons, all treatments caused a significant decrease in chlorophyll a and b at red and green cheeks compared with the control. In addition, statistical analysis of the present data indicated that, phenylalanine and Ethrel treatments caused a higher effect in decreasing chlorophyll a and b at red and green cheeks than those other treatments and the differences were big enough to be significant.

The above findings could be explained on the basis that phenylalanine might be involved in the activation of chlorophyllase that break down chlorophylls (El-Abd, 2011). The same tendencies were observed, the degradation of chlorophyll pigments in fruit peel by Ethrel application could be due to Ethrel increased activities of chlorophyllase and chlorophyll degrading peroxidase enzymes resulting in the accumulation of chlorophyllide a, and reduction in chlorophyll a concentration. Terai *et al.* (1973) also, reported that, Ethrel accelerated rate of diffusion of exogenous ethylene into peel of Ethrel treated fruits which triggered the degradation of chlorophyll pigments. The results within hand are in agreement with those obtained by (El-Abd, 2011) who stated that phenylalanine applications at 100 or 200 ppm tended to reduce chlorophyll a and b content in "Florida Prince" peach. In the same trend, Mohamed and Abu-Goukh, (2003) in mango, Kulkarni *et al*. (2011) in Banana, Singh *et al.* (2012) papaya. Gupta *et al*. (2015) in mango fruit. They stated that Ethrel was reported to accelerate chlorophyll destruction .Similarly, Reyes and Paull (1995); Mahajan *et al*. (2008) reported that Ethephon are known to accelerate the chlorophyll degradation or synthesis of carotenoids by stimulating the synthesis of chlorophyllase enzyme in calamondin tissue which is responsible for chlorophyll degradation and expression of β-carotene pigments.

2.3. Acidity:

Results of the present investigation, presented in Table (4) showed the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on acidity content of "Anna" apple fruit, in 2017 and 2018 seasons. Data showed that, all treatments significantly decreased fruit acidity compared with the control in two seasons of this study. In addition, statistical analysis of the present data indicated that, phenylalanine and Ethrel treatments caused a higher effect in decreasing fruit acidity contents than those other treatments and the differences were big enough to be significant.

Reduction in acidity as a result of Ethrel application might be due to the fact that Ethrel enhance the conversion of organic acids to sugars which increases the sugar content and decreases the acidity (Singh *et al.*, 2012). In addition, it may be attributed to the utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Rhodes *et al*., 1968; Ulrich, 1974). In addition, Ethrel increased membrane permeability allows the acids, stored in cell vacuoles to be respired at faster rate. Kamal and Rabeh (1989) reported that Ethephon treatment increased the loss of fruit acidity through its activation affect on respiration rate. These findings are in the line with the reports of Yashoda *et al.* (2006) in Alphonso mango, Makarem *et al.* (1995) on "Anna" apple and Kulkarni *et al*. (2011) in banana.

2.4. Total Soluble Solids:

Data of studying the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on total soluble solids of "Anna" apple fruit, in 2017 and 2018 seasons are reported in Table (4). In the two seasons of study, results showed that all treatments caused a significantly increase in fruit total soluble solids content compared with the control. Moreover, data indicated that, phenylalanine at 200 mg/L, Ethrel at 250 mg/L and Ethrel at 500 mg/L were more effective in increasing fruit total soluble solids content than those other treatments and the differences were big enough to be significant.

Increase TSS with Ethrel application may be due to that Ethrel accelerate fruit ripening which reflect on the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from the leaves to the developing fruits (Tripathi and Shukla, 2007). Furthermore, could be due to the rapid induction of preclimacteric and climacteric phases and onset of climacteric peak in respiratory metabolic pathways in starch hydrolysis (Marriot, 1980). The results of these findings were also confirmed by Ahmad and Zargar (2005) found that Ethephon treatment (500 ppm) increased TSS and accumulation of sugars in cv. Perlette. Moreover, Elsabagh (2010) revealed that Ethephon increased SSC especially at 500 ppm. In the same trend, Ezz and El-Kobbia (2000) treated Pairi mango fruits with phenylalanine that contained higher amount TSS%. In addition, Crimson Seedless, phenylalanine application led to increase TSS % as compared with the control (El-Sayed, 2013).

2.5. Vitamin C:

With respect to the effect of various applied treatments on ascorbic acid content of "Anna" apple fruits, in both experimental seasons, the data demonstrated in Table (4) declared that as an average for all used treatments, the initial of ascorbic acid significantly increased in both seasons compared with control. Moreover, the statistically analysis showed that**,** phenylalanine and Ethrel treatments caused a higher effect in increasing fruit ascorbic acid contents than those other treatments and the differences were big enough to be significant.

In spite of the increase in the ascorbic acid content by Ethrel application may be attributed to the higher synthesis of some metabolic intermediary substances which promoted the greater synthesis of the precursor of ascorbic acid (CenturianYan *et al*., 1998). Gonzalez (1998) and Novelo (1998) also found an increase in the ascorbic acid content of tomato with application of Ethephon.

2.6. Total sugars:

Data concerning the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on total sugars content of "Anna" apple fruit, in 2017 and 2018 seasons are reported in Table (4). Results, generally, showed that all treatments significantly increased total sugar contents compared with the control. In addition, Statistical analysis of the present data indicated that, phenylalanine and Ethrel treatments caused a higher effect in increasing total sugars content than those other treatments and the differences were big enough to be significant.

The increase in total sugars by Ethrel could be due to that Ethrel increased promoted hydrolysis of starch into sugars (Kacha *et al*., 2014). The present results are in conformity with the findings of (Singh *et al*., 2011) and (Meitei *et al*., 2013). The improvement of fruit total sugars content due to ethephon treatment was discussed by Kamal and Rabeh (1989) and Park *et al*. (1998). They concluded that the most stricking chemical changes (fruit sweetness which occur due to Ethephon treatment and during post-harvest ripening of fruits seem to be due to the hydrolysis if starch and accumulation of sugars. Also, may be due to the increase of glucose and fructose content of non astringent Ethephon treated fruits (Srinivasan *et al*., 1973).The positive results of Ethephon treatment on fruit sugar parameters are coincided with those mentioned earlier by Srinivasan *et al*. (1974), Abd El-Wahab *et al*. (1983), Kamal and Rabeh (1989) and Park *et al*. (1998) on persimmon fruits. The result within hand are in agreement with those obtained by Ezz (1994) who observed that total sugars of “Red roomy” grape were increased with increasing the concentration of phenylalanine application.

Table (1). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on fruit weight, fruit size, fruit length and fruit diameter of "Anna" apple trees at harvest in 2017 and 2018 seasons

Treatments	Fruit Weight (g)		Fruit Size (cm^3)		Fruit Length (cm)		Fruit Diameter (cm)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	91.20	90.27	88.00	87.05	4.71	4.82	4.33	4.52
LPE at 125 mg/L	115.53	116.03	111.42	111.05	5.50	5.58	5.54	5.47
LPE at 250 mg/L	117.30	117.63	112.65	112.30	5.72	5.80	5.83	5.78
Ethrel at 250 mg/L	91.35	91.11	88.40	87.42	4.81	4.88	4.42	4.58
Ethrel at 500 mg/L	91.52	91.64	89.12	87.53	4.88	4.89	4.52	4.65
Phenylalanine at 100 mg/L	114.53	114.23	110.57	110.64	5.48	5.60	5.47	5.40
Phenylalanine at 200 mg/L	115.40	115.00	111.58	111.75	5.73	5.82	5.65	5.60
LSD at $_{0.05}$	**2.14**	**2.79**	**1.41**	**1.49**	**0.18**	**0.07**	**0.29**	**0.14**

Table (2). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on anthocyanin (at red and green cheeks) and firmness (at red and green cheeks) of "Anna" apple fruit at harvest in 2017 and 2018 seasons

Treatments	Anthocyanin at Red Cheek (mg/100g)		Anthocyanin at Green Cheek (mg/100g)		Firmness of Red Cheek (Newton)		Firmness of Green Cheek (Newton)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	16.82	17.56	2.17	2.63	52.78	53.93	55.70	56.59
LPE at 125 mg/L	19.18	19.83	2.73	2.89	56.45	56.93	58.18	59.25
LPE at 250 mg/L	19.75	20.05	2.98	3.12	57.22	58.18	59.48	60.23
Ethrel at 250 mg/L	21.65	21.85	3.37	3.42	45.87	46.65	46.18	46.82
Ethrel at 500 mg/L	22.15	22.35	3.47	3.57	46.52	47.28	47.08	48.02
Phenylalanine at 100mg/L	20.22	20.63	3.17	3.35	51.22	52.12	54.04	54.97
Phenylalanine at 200mg/L	20.95	20.98	3.28	3.50	52.20	52.80	55.28	55.47
LSD at $_{0.05}$	**0.65**	**0.41**	**0.23**	**0.17**	**1.05**	**0.83**	**0.99**	**0.83**

Table (3). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on chlorophyll a (at red and green cheeks) and chlorophyll b (at red and green cheeks) of "Anna" apple fruits at harvest in 2017 and 2018 seasons.

Treatments	Chlorophyll a at Red Cheek (mg/100g)		Chlorophyll a at Green Cheek (mg/100g)		Chlorophyll b at Red Cheek (mg/100g)		Chlorophyll b at Green Cheek (mg/100g)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	1.048	1.069	1.075	1.085	0.403	0.477	0.452	0.458
LPE at 125 mg/L	0.769	0.785	0.814	0.832	0.338	0.354	0.375	0.374
LPE at 250 mg/L	0.708	0.714	0.716	0.724	0.309	0.336	0.327	0.345
Ethrel at 250 mg/L	0.597	0.607	0.611	0.624	0.261	0.282	0.282	0.295
Ethrel at 500 mg/L	0.581	0.591	0.589	0.614	0.259	0.263	0.258	0.269
Phenylalanine at 100 mg/L	0.638	0.652	0.648	0.661	0.286	0.298	0.318	0.314
Phenylalanine at 200 mg/L	0.606	0.622	0.616	0.629	0.268	0.283	0.278	0.294
LSD at $_{0.05}$	**0.072**	**0.051**	**0.601**	**0.061**	**0.051**	**0.062**	**0.052**	**0.048**

Table (4). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on acidity, total soluble solids, vitamin C and total sugars of “Anna” apple fruits at harvest in 2017 and 2018 seasons

Treatments	Acidity (%)		TSS (%)		Vitamin. C (mg/100 ml)		Total Sugars (%)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	0.61	0.65	10.68	11.02	4.95	5.08	7.95	8.10
LPE at 125 mg/L	0.55	0.56	11.98	12.11	5.35	5.40	8.75	8.80
LPE at 250 mg/L	0.53	0.52	12.17	12.34	5.52	5.56	9.02	9.08
Ethrel at 250 mg/L	0.39	0.41	12.47	12.57	5.22	5.28	9.45	9.48
Ethrel at 500 mg/L	0.34	0.36	12.65	12.69	5.31	5.35	9.50	9.52
Phenylalanine at 100 mg/L	0.46	0.47	12.23	12.29	5.27	5.31	9.30	9.41
Phenylalanine at 200 mg/L	0.43	0.42	12.38	12.43	5.34	5.43	9.38	9.43
LSD at $_{0.05}$	**0.03**	**0.02**	**0.15**	**0.16**	**0.09**	**0.13**	**0.10**	**0.13**

3. Physical characteristics after cold storage:

3.1. Fruit weight loss:

Weight loss data of "Anna" apple fruits as influenced by pre-harvest spraying of LPE, phenylalanine and Ethrel after 30 days of cold storage was reported in Table (5). The results revealed that, in both seasons, LPE and phenylalanine treatments caused a significant decrease in fruit weight loss compared with control. Moreover, LPE at (125 and 250) mg/L were more effective on decreasing fruit weight loss than those of phenylalanine treatments and the differences were not big enough to be significant. In contrast, in 2017 and 2018 seasons of the same study, data revealed that Ethrel at 250 mg/L and Ethrel at 500 mg/L were increased fruit weight loss compared with the control and the differences were big enough to be significant, except for Ethrel at 500 mg/L in 2017 season. According to Woods (1990), weight loss in fruit during storage could be due to the water exchange between the internal and external atmosphere, the transpiration rate being accelerated by cellular breakdown.

In spite of the decrease of fruit weight loss in Anna apple fruit by LPE application before harvest, could be attributed to their effect on the maintaining the plasma membrane which led to retard the process senescence of apple fruits (Farag *et al*., 2011). Also, LPE can retards polygalacturonase mediated fruit softening (Hong *et al*., 2008), reduces activity of phospholipase D (PLD; EC 3.1.4.4) and membrane leakiness (Ryu *et al*., 1997; Hong *et al*., 2009). The above trend of fruit weight loss agreed with those reported by (Farag and Attia, 2016). In the same trend Ezz and El-Kobbia (2000) found that preharvest phenylalanine foliar spray decreased weight loss for Pairi mango.

With respect to the effect of Ethrel in increasing weight loss of fruits may be due to the effect of Ethrel on increasing respiration rate and accelerating fruit ripening. It is well known that ripe fruits lose their moisture content more quickly than unripe ones (Kamal and Rabeh, 1989). Also, the increase in physiological loss in weight during ripening of fruits with Ethephon and ethylene gas application may be due to upsurge in respiration rate of the fruits (Kretchman and Short, 1972; Mutton, 1978). In the same trend.

These results are in line with Ibrahim (1994) on “Anna” apple, he noticed that fruits treated with ethephon at 200ppm show the highest percentage of weight loss compared to control. Pal (1998) and Gala *et al*. (2001) also, realized that, Ethephon treatment at 250-1250 ppm increased weight loss percentage of mango fruits cv. Rataul and banana fruits varieties Hindi, Maghrabi and Williams, respectively. Moreover, fruit weight loss percentage increased as the storage period advanced. Furthermore, applied Ethylene accelerates the chemical changes associated with ripening and caused a shift in the time axis of the onset of the climacteric rise. In climacteric fruits, exogenous C_2H_4 caused the peel and flesh to ripen out of phase, with the flesh ripening faster than the peel (Hussien, 2014).

3.2. Fruit disorders:

Data of studying the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on disorders percentage of "Anna" apple fruit, in 2017 and 2018 seasons are reported in Table (5). In the two seasons of study, results showed that all treatments caused a significantly decrease in fruit disorders compared with control, except for Ethrel at 500 mg/L. Moreover, data indicated that, LPE at 250 mg/L and phenylalanine at 200 mg/L were more effective on decreasing fruit disorders than those other treatments but the differences were not big enough to be significant.

The results within hand are in agreement with those obtained by (Abd-El-Wahab, *et al*., 1983) they found that the fruits treated with Ethrel were more senescence due to loss of fruit firmness and the increase in respiration rate. Such fruits became weakened easy to be attack by decay pathogens. Furtheremore, Abd El-Wahab *et al*. (1983) and Kamal and Rabeh (1989) on Costata persimmon fruits. They mentioned that Ethephon treatments (100-2000 ppm) induced a gradual increase in decay percentage with the extension of storage period. Ibrahim (1994) and Makarem *et al.* (1995) also, found that, ethylene treatment increased decay percentage of "Anna" apple. Furthermore, Hussein (2014) noticed that ethylene has an “evil” effect makes such fruits more perishable and shortens the shelf life of these crops.

3.3. Fruit firmness:

The effect of various applied preharvest treatments on flesh firmness at red and green cheeks of "Anna" apple fruits in 2017 and 2018 seasons after 30 days of cold storage was reported in Table (6). Results showed that, LPE at 125 mg/L and LPE at 250 mg/L caused a significant increase in fruit firmness at red and green cheeks compared with the control. Moreover, in two seasons of study, LPE at 250 mg/L caused a higher effect in increasing fruit firmness at red cheek than those other treatments.

On the contrary, phenylalanine and Ethrel treatments decreased fruit firmness at red and green cheeks and the differences were big enough to be significant compared with the control, except for phenylalanine at (100 and 200) mg/L in 2017 and 2018 seasons.

The decrease in fruit firmness with storage period is mainly due to decomposition of enzymatic degradation in insoluble protopectin to more simple soluble pectins and solubilization of cell and cell wall contents as a result of the increase in pectin estrase activity (Deshpande and Salunkhe, 1964). The role of Ethephon in decreasing fruit firmness may be attributed to its activation to such decomposition and solubilization (Kamal and Rabeh, 1989).

The recorded results dealing with Ethrel (Ethephon) affects on firmness are in harmony with earlier studies of Mann *et al*. (1990) on pear fruits, Ibrahim (1994) and Makarem *et al.* (1995) on “Anna” apple fruit, Zora *et al*. (2001) on mango fruits cv. Kensington, Imagawa *et al*. (2003) on persimmon fruits, and Kulkarni *et al*. (2004) on mango fruits cv. Neelum, They found that treated fruit with ethylene from different sources as Ethephon or ethylene generator the efficacy on accelerating fruit softness and senescence and decrease fruit firmness during storage period.

4. Chemical characteristics after cold storage:

4.1. Anthocyanin:

Data of studying the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on anthocyanin contents at red and green cheeks of "Anna" apple fruit after 30 days of cold storage, in 2017 and 2018 seasons are reported in Table (6). In both seasons, results revealed that, all treatments significantly increased fruit anthocyanin content at red and green cheeks compared with control. Moreover, phenylalanine at 200 mg/L, Ethrel at 250 mg/L and Ethrel at 500 mg/L caused a higher effect in increasing anthocyanin at green cheek than those other treatments and the differences were big enough to be significant. In addition, data indicated that, at red cheek, the differences of Ethrel at 500 mg/L were big enough to be significant compared with LPE and phenylalanine treatments in both seasons. These results are in harmony with those obtained by Derhab (2015) worked on "Anna" apple fruit and they reported that, after 30 days of cold storage at 2^{o} C, the fruits were treated before harvest with Ethephon, they still had greater anthocyanin content at the end of cold storage as compared with the control or the individually-treated fruits with other treatments in both seasons. Also, the changes in anthocyanin content of “Kelsey” plums after shelf life were reported by Farag and Attia (2016) and the data indicated that, the highest anthocyanin content was found in Ethrel-treated fruits.

Moreover, Ibrahim (1994) and Makarem *et al*. (1995) on “Anna” apple reported that, treated fruits with Ethephon had a large color area than control during storage period.

4.2. Chlorophyll a and b:

Data of studying the effect of pre-harvest spraying of LPE, phenylalanine and Ethrel on chlorophyll a and b at red and green cheeks of "Anna" apple fruit after 30 days of cold storage, in 2017 and 2018 seasons are reported in Table (7). Data showed that, in general, all enhanced treatments caused a significant decrease in chlorophyll a and b at red and green cheeks compared with the control in both seasons. Moreover, statistical analysis of the present data indicated that, phenylalanine and Ethrel treatments caused a higher effect in decreasing chlorophyll a and b at red and green cheeks than those other treatments. These results are in agreement with those obtained by Derhab (2015) worked on "Anna" apple fruit and they reported that, after 30 days of cold storage at 2^{o} C, Ethephon caused a significant reduction in chlorophyll a and b content at red cheek as compared with the control, also, the lowest chlorophyll a and b content at green cheek was found with Ethephon treated apples. In the same trend, the response of chlorophyll a and b content in “kelsey” plums to Ethrel and lisophos after 7 days of storage was reported by Farag and Attia (2016) and the data revealed that, the significant reduction in chlorophyll a in “Kelsey” fruit skin was found in Ethrel-treated ones as compared with the control. Furthermore, both either lisophos or oleic acid treatment caused a significant reduction in chlorophyll a when compared with the control. Similar trend of results was obtained with chlorophyll b.

4.3. Acidity:

The response of acidity content of "Anna" apple fruits after 30 days of cold storage to pre-harvest spraying of LPE, phenylalanine and Ethrel in 2017 and 2018 seasons was reported in Table (8). The data revealed that acidity content of "Anna" apple fruits was significantly decreased by all treatments as a compared with control in two seasons of study. In addition, in both seasons, results indicated that phenylalanine and Ethrel treatments caused a higher effect in decreasing fruit acidity contents than those other treatments and the differences were big enough to be significant. In harmony with these results are those obtained by Derhab (2015) worked on "Anna" apple fruit and they reported that, after 30 days of cold storage at 2^{o} C, there was a significant reduction in the acidity of Ethephon treated "Anna" apples relative to the control. Farag and Attia (2016) also, indicated that, after 7 days of storage, treated plums with Ethrel had a significant reduction in fruit acidity compared with the control in both seasons. The results are in line with Smith *et al.*, (1985) and Makarem *et al.* (1995) on apple and Hussein (2014) on banana they noticed that treated fruits with ethylene had less acidity compared to control during storage period.

4.4. Total soluble solids:

Change in total soluble solids of "Anna" apple fruits as a response to preharvest various treatments after 30 days of cold storage at 2^{o} C in 2017 and 2018 seasons were recorded in Table (8). The data revealed that, in both seasons, all treatments significantly increase fruit total soluble solids content compared with control. Moreover, in both seasons, results indicated that phenylalanine at 200 mg/L, Ethrel at 250 mg/L and Ethrel at 500 mg/L treatments caused a higher effect in increasing fruit TSS contents than those of other treatments and the differences were big enough to be significant. At the end of cold storage, increase in fruit content of total soluble solids was probably due to concentrated juice content as a result of dehydration and hydrolysis of polysaccharides. In agreement with these results are those obtained by Derhab (2015) who found that, after 30 days of cold storage at 2^{o} C, there was a significant increase in "Anna" apples TSS content with the treatment of Ethephon as compared with control in both seasons. In addition, Farag and

Attia (2016) indicated that, after 7 days of storage, treated plums with Ethrel had higher TSS content than that of lisophos and control. Where, on contrary with our results, they found that, in both seasons, lisophos treated plums fruit did not have a significant change in TSS as compared with the control.

4.5. Vitamin C:

The influence of preharvest applications of various used treatments were reported in Table (8) in terms of their influence on vitamin C contents of "Anna" apple fruits after 30 days of cold storage at 2^{o} C in 2017 and 2018 seasons. Results indicated that, in two seasons, all treatments significantly increased fruit vitamin C contents compared with control. In addition, LPE at 125 mg/L and LPE at 250 mg/L treatments were more effective in increasing ascorbic acid contents than other treatments and the differences were big enough to be significant. On contrary with these results are reported by Derhab (2015) found that the application of ethephon alone did not result in any significant change after 30 days of cold storage in "Anna" apples vitamin C in a consistent manner in both seasons.

4.6. Total sugars:

Preharvest applications of various used treatments were reported in Table (8) in terms of their influence on total sugar contents of "Anna" apple fruits after 30 days of cold storage at 2^{o} C in 2017 and 2018 seasons. Results revealed that, in both seasons, all treatments significantly increased fruit total sugar contents compared with control. Moreover, phenylalanine and Ethrel treatments were more effective in increasing total sugar than other treatments and the differences were big enough to be significant. In agreement with these results are those obtained by Derhab (2015) found that, treated fruits with Ethephon increased total sugar content after 30 days of cold storage at 2^{o} C, in both seasons. In addition, Farag and Attia (2016) worked on “Kelsey” plums fruits and the data provided evidence that, after 7 days of storage, there was a significant increase in total sugars by Ethrel treatment in both seasons relative to the control. However, the applications of lisophos did not have a significant impact on total sugars of “Kelsey” cultivar in a consistent manner as compared with control. Moreover, Ethrel-treated fruits had significant increase in total sugars when compared with those of lisophos treated fruits.

Table (5). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on weight loss percentage and disorders percentage of “Anna” apple fruit after 30 days of cold storage in 2017 and 2018 seasons

Treatments	Fruit Weight Loss (%)		Fruit Disorders (%)	
	2017	2018	2017	2018
Control	2.72	2.56	0.70	0.71
LPE at 125 mg/L	1.51	1.48	0.75	0.73
LPE at 250 mg/L	1.47	1.44	0.60	0.59
Ethrel at 250 mg/L	2.91	2.98	0.78	0.77
Ethrel at 500 mg/L	2.77	2.81	1.40	1.51
Phenylalanine at 100 mg/L	1.60	1.63	0.77	0.79
Phenylalanine at 200 mg/L	1.55	1.53	0.66	0.67
LSD at $_{0.05}$	**0.10**	**0.09**	**0.09**	**0.08**

Table (6). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on anthocyanin (at red and green cheeks) and firmness (at red and green cheeks) of "Anna" apple fruits after 30 days of cold storage in 2017 and 2018 seasons

Treatments	Anthocyanin at Red Cheek (mg/100g)		Anthocyanin at Green Cheek (mg/100g)		Firmness of Red Cheek (Newton)		Firmness of Green Cheek (Newton)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	17.85	19.10	2.53	2.77	49.87	50.82	53.40	53.65
LPE at 125 mg/L	20.28	21.75	2.84	3.02	53.85	54.08	54.67	55.32
LPE at 250 mg/L	21.95	22.35	3.21	3.26	55.32	55.72	56.35	56.82
Ethrel at 250 mg/L	23.24	23.42	3.60	3.68	43.85	43.90	43.32	43.78
Ethrel at 500 mg/L	23.44	23.54	3.70	3.73	44.27	44.71	44.60	44.98
Phenylalanine at 100 mg/L	22.42	22.68	3.37	3.50	49.48	50.28	52.33	52.45
Phenylalanine at 200 mg/L	23.05	23.19	3.44	3.64	50.32	50.57	53.28	53.06
LSD at $_{0.05}$	**0.71**	**0.54**	**0.21**	**0.26**	**0.72**	**0.92**	**1.01**	**1.12**

Table (7). Effects of preharvest spraying application of LPE, phenylalanine and Ethrel on chlorophyll a (at red and green cheeks) and chlorophyll b (at red and green cheeks) of "Anna" apple fruits after 30 days of cold storage in 2017 and 2018 seasons.

Treatments	Chlorophyll a at Red Cheek (mg/100g)		Chlorophyll a at Green Cheek (mg/100g)		Chlorophyll b at Red Cheek (mg/100g)		Chlorophyll b at Green Cheek (mg/100g)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	0.935	0.968	1.025	1.045	0.392	0.432	0.438	0.445
LPE at 125 mg/L	0.668	0.691	0.685	0.693	0.328	0.353	0.353	0.356
LPE at 250 mg/L	0.617	0.657	0.624	0.637	0.294	0.308	0.312	0.324
Ethrel at 250 mg/L	0.548	0.558	0.565	0.573	0.245	0.269	0.365	0.276
Ethrel at 500 mg/L	0.527	0.531	0.535	0.544	0.236	0.250	0.245	0.255
Phenylalanine at 100 mg/L	0.641	0.651	0.652	0.656	0.268	0.284	0.290	0.299
Phenylalanine at 200 mg/L	0.584	0.591	0.594	0.601	0.244	0.269	0.262	0.272
LSD at $_{0.05}$	**0.056**	**0.058**	**0.057**	**0.054**	**0.046**	**0.046**	**0.054**	**0.043**

Table (8). Effects of preharvest spraying application of LPE, Phenylalanine and Ethrel on acidity, total soluble solids, vitamin C and total sugars of "Anna" apple fruits after 30 days of cold storage in 2017 and 2018 seasons

Treatments	Acidity (%)		TSS (%)		Vitamin. C (mg/100 ml)		Total Sugars (%)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	0.57	0.55	11.51	11.80	4.45	4.64	8.48	8.63
LPE at 125 mg/L	0.46	0.44	12.45	12.61	4.99	5.08	9.03	9.15
LPE at 250 mg/L mg/L	0.42	0.41	12.64	12.76	5.12	5.19	9.21	9.25
Ethrel at 250 mg/L mg/L	0.29	0.28	13.37	13.48	4.79	4.81	9.83	9.87
Ethrel at 500 mg/L	0.26	0.25	13.56	13.65	4.86	4.87	9.89	9.93
Phenylalanine at 100 mg/L	0.35	0.37	12.85	12.97	4.81	4.85	9.68	9.77
Phenylalanine at 200 mg/L	0.32	0.31	13.13	13.34	4.91	4.94	9.79	9.86
LSD at $_{0.05}$	**0.01**	**0.01**	**0.18**	**0.15**	**0.10**	**0.12**	**0.11**	**0.05**

CONCLUSION

Generally, it could be concluded that the treatments of LPE and phenylalanine as a pre-harvest spraying on "Anna" apple trees had more pronounce effect on fruit physical properties at harvest time as a compared with Ethrel. Furthermore, LPE led to marked increase in fruit firmness, also, highly minimized weight loss percentage and fruit disorders percentage compared with others. In additions, at harvest and the end of cold storage, results indicated that Ethrel more effective on improving TSS, total sugars, vitamin C and red skin color compared with LPE and phenylalanine treatments.

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الملخص العربي

تأثير الرش ببعض المركبات الطبيعية على جودة وتسويق ثمار التفاح صنف "أنا"

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أجريت هذه الدراسة خلال موسمين متتاليين (٢٠١٧/٢٠١٨) لدراسة تأثير بعض المواد الطبيعية رشا قبل الحصاد على جودة الثمار والقدرة التسويقية للتفاح صنف "آنا" مطعوم على أصل مالص ومنزرعة فى تربة رملية تحت نظام الرى بالتنقيط بمنطقة النوبارية – محافظة البحيرة. وتم معاملة الأشجار مرتين فى ١٥ , ٢٢ مايو خلال ٢٠١٧ , ٢٠١٨ على التوالى. وكانت المعاملات عبارة عن معاملة الكنترول "الرش بالماء فقط", ليزوفسفوتيدايل إيثانول أمين (١٢٥ , ٢٥٠) مجم/لتر, فينيل ألانين (١٠٠ , ٢٠٠) مجم/لتر, الأثيريل (٢٥٠ , ٥٠٠) مجم/لتر.

أوضحت النتائج أنه عند الحصاد فإن معاملات ليزوفسفوتيدايل إيثانول أمين والفينيل ألانين كانت الأكثر تأثيرا فى زيادة الصفات الفيزيقية مثل وزن الثمار, حجم الثمار وكذلك طول وعرض الثمار فى كلا من موسمى الدراسة مقارنة بباقى المعاملات فى حين أن معاملة الأيثريل عند كلا التركيزين ليس لها أى تأثير على هذه الصفات, هذا بالأضافة إلى أن معاملة ليزوفسفوتيدايل ايثانول أمين كانت الأفضل فى زيادة صلابة الثمار مقارنة بباقى المعاملات. وعلى العكس فأن معاملات الفينيل ألانين والأيثيريل قد قللت من صلابة الثمار حيث كانت المتوسطات غير معنوية فى كلا الموسمين مقارنة بمعاملة الكنترول فيما عدا معاملة الفينيل ألانين بتركيز ٢٠٠ مجم/لتر.

أدت المعاملات إلى تحسين اللون الأحمر لسطح الثمار كما أدت إلى تقليل محتوى الثمار من الحموضة وكلوروفيل أ , ب. كما أتضح أن إستخدم الأيثيريل بالتركيزات (٢٥٠ , ٥٠٠) مجم/لتر قد أعطى زيادة معنوية فى محتوى الثمار من المواد الصلبة الذائبة الكلية فى كلا الموسمين مقارنة بباقى المعاملات فيما عدا معاملة الأيثيريل بتركيز ٢٥٠ مجم/لتر فى الموسم الثانى. هذا بالأضافة إلى ان ليزوفسفوتيدايل إيثانول أمين بتركيز ٥٠٠ مجم/لتر قد زاد

من محتوى الثمار من فيتامين ج فى كلا الموسمين مقارنة بباقى المعاملات. أيضا معاملات الفينيل ألانين والأيثيريل قد أعطت تأثيرا أعلى فى زيادة محتوى الثمار من السكريات الكلية مقارنة بباقى المعاملات.

فيما يتعلق بفترة التخزين المبرد, نجد أن رش الأيثيريل بالتركيزات (٢٥٠ , ٥٠٠) مجم/لتر سبب نقصان فى محتوى الثمار من الحموضة وكلوروفيل (أ , ب) مقارنة بباقى المعاملات فى كلا الموسمين. أيضا نسبة الفقد فى الوزن ونسبة الثمار المصابة بالأمراض الفطرية والفسيولوجية قد قلت بإستخدام معاملات ليزوفسفوتيدايل إيثانول أمين فى كلا الموسمين, فى حين وجد ان هناك علاقة إيجابية بين زيادة الفقد فى وزن الثمار ومعاملات الأيثيريل. المعاملة بالأيثيريل رشا قبل الحصاد أعطت أعلى القيم فى محتوى الثمار من المواد الصلبة الذائبة الكلية والسكريات الكلية فى حين أن فيتامين ج فإنه يتبع نمط مماثل إلى حد ما لتلك النتيجة عند الحصاد.

مما سبق يمكن الاستنتاج بأن الرش قبل الحصاد بالليزوفسفوتيدايل إيثانول أمين والفينيل ألانين يزيد من خصائص الثمار الفيزيقية ويحسن التلوين ويقلل من الثمار المصابة بالأمراض الفطرية او الفسيولوجية ويؤدى الى إطالة فترة تخزين ثمار التفاح صنف " آنا ".