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Research Article
Using Ringing Branches Technique and Natural Lipids to Enhance Quality and Storability of Florida Prince Peach Fruits During Cold Storage

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Abstract
Background: In Egypt, Florida prince peach an early harvest cultivar that adapt to local environmental conditions and potential for exportation. Color is variable as the global maturity indicator in peaches. **Materials and Methods:** In this respect, influence of ringing main branches technique at the beginning of coloring (4 weeks before harvest) with pre-harvest application of lysophosphatidylethanolamine (LPE) 2 weeks before harvest on quality and storability of Florida prince peach fruits were investigated during two successive seasons 2016 and 2017. The fruits were stored 30 days at 0°C±1 with 90-95% RH and fruit quality was evaluated at harvest and during cold storage. **Results:** At harvest, all treatments were more effective to increase fruit firmness, total soluble solids, total sugars content, color hue angle (h°) compared to the control in both seasons. While, produced a lower total acidity, total phenols, the activity of peroxidase and polyphenol oxidase. Results showed that by increasing the storage periods weight loss, decay, total soluble solids and total sugars content, the activity of peroxidase and polyphenol oxidase significantly increased. Whereas, fruit firmness, total acidity, color hue angle (h°) and total phenols significantly decreased. The best results obtained by sprayed LPE at 150 mg L^{-1} with ringing main branches after 30 days of cold storage which decreased fruits weight loss, decay, delayed the changes in total acidity, total phenols, activity of peroxidase and activity of polyphenol oxidase. Moreover, the same treatment produced a higher value of total soluble solids, total sugars and color hue angle (h°) compared with all treated fruits or the untreated ones. **Conclusion:** The study suggested that these treatments might be a promising candidate as to maintain peach quality and extending post-harvest life especially after cold storage.

Key words: Florida prince peach, pre-harvest sprays, ringing, fruit quality, lysophosphatidylethanolamine (LPE), post-harvest

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Peach is one of the main deciduous fruit trees growing in Egypt. The total harvest were attained about 80609 feddans with a production of about 273156 t according to the last statistics of Ministry of Agriculture and Land Reclamation[1]. Florida prince peach is one of the early ripening cultivars and it exhibited a high adaptation with the local environmental conditions and potential for export. Whereas, Florida prince fruits suffer from accelerated, softened fruits and therefore, the fruits exhibit short handling period which limits its commercial potential. Accordingly, there is a great need to decrease fruit deterioration after harvest and to enhance fruit quality in order to prolong the handling season with acceptable quality. During growth and development of peach fruits, there were many factors which have a direct effect on fruit quality and their postharvest behavior, among these factors are the lipids which play a specific role of ripening, anthocyanin accumulation and quality of fruits.

Soy lecithin consists of three types of phospholipids, phosphatidylcholine (PC), phosphatidylethanolamine (PE) and phosphatidylinositol (PI). It is extracted from soybean oil and is generally used as a natural emulsifier or stabilizer in various food applications[2]. Lysophosphatidylethanolamine (LPE) is a natural product, which is present in egg yolk and soy lecithin. LPE is a membrane of phospholipid metabolism and is formed from phosphatidylethanolamine (PE) by action of phospholipase A2 and remains in the lipid phase because LPE has a hydrophobic group such as fatty acid. It has beneficial effects on plants by protecting against stress-related injuries, improving keeping quality during storage and shelf-life and delaying senescence. This research was conducted to determine the influence of ringing main branches. The LPE retards fruit softening, reduction of injury from stress, anthocyanin accumulation and stimulus of ethylene synthesis[3]. These results suggested a specific role of LPE both in ripening, anthocyanin accumulation and quality of fruits. The LPE has been shown to enhance ripening and extend the shelf life of certain fruits by increasing ethylene production and keeping the fruit respiration low. So, LPE can accelerate ripening of fruits and prolong shelf life at the same time by inhibiting the activity of enzymes involved in fruit softening. The LPE has been shown to enhance ripening and extend the shelf life of certain fruits by increasing ethylene production without increasing respiration. The precise mode of action is unknown, but LPE has been shown to enhance ripening and extend the shelf life of certain fruits by increasing ethylene production without increasing respiration.

Lysophosphatidylethanolamine (LPE) is a secondary component of cell membranes, which play a role in cell-mediated cell signaling and activation of other enzymes. The use of LPE in agricultural to regulate plant growth such as plant health, color, sugar content and increase storage without side effects.

Also, it can inhibit the activity of phospholipase D (PLD), a membrane degrading enzyme, of which active is increased during senescence and increase fruit qualities[4]. Moreover, LPE treated banana fruit may improve shelf life by maintaining membrane integrity, reducing respiration and slowing the breakdown of starch and cell walls during ripening and senescence of banana fruit tissue. Results of the experiments indicated that a postharvest dip treatment with LPE may improve shelf life of banana fruit by 1-2 days[2].

Ringing (removal of a strip of bark tissue) is a horticultural practice to advance maturity and to improve fruit size and quality. Ringing branches at pit hardening resulted in larger fruits and enhanced fruit coloring of peaches and nectarines. Because both together determine the time of harvest, fruit from ringed trees were picked earlier. Chanana and Gill[5] reported that girdling had a great impact on fruit quality in peach cv. Florida prince and observed that girdling done 15 days after full bloom. Agusti *et al.*[6] studied the effect of ringing of branches on fruit size and maturity of peach and nectarine cultivars and obtained larger and better color fruits with enhanced fruit ripening when branches were ringed at pit hardening stage significantly increased total sugars by 24.58%. Kumar[7] observed higher total soluble solids in both trunk and limb girdling done 14 days after full bloom in peach cv. Florida prince. Hamada *et al.*[8] observed callus bridge formation in 6 weeks, 20-25 days and 14 days after girdling (width 5 mm), scoring and strangulation, respectively in Japanese persimmon. This research aimed to study the influence of ringing main branches and lysophoshatidylethanolamine (LPE) as pre-harvest treatments for improve quality, storage life and storability of Florida prince peach fruits during harvest and after cold storag.

MATERIALS AND METHODS

The present investigation was conducted during the two successive seasons of 2016-2017 on Florida prince peach cultivar to evaluate the effect of ringing branches and spraying fruits with lysophosphatidylethanolamine (LPE) on fruit quality at harvest and storage under cold storage condition. Forty eight trees almost uniform in growth and vigor and in good physical conditions were selected for this study. The trees were about 8 years old and grafted on Nemagard rootstock. They were planted at 3.5×5 m apart and grown in sandy soil under drip irrigation system in a private orchard located at Cairo-Alexandria desert road, Egypt. Treatments were replicated three times, each replicate represented by two trees in a complete randomized block design to represent the treatments as follows in Table 1.

Table 1: Applied treatments

Number	Treatments used
1	Spraying fruits with LPE at 50 mg L^{-1}
2	Spraying fruits with LPE at 50 mg L^{-1}+main branches ringing
3	Spraying fruits with LPE at 100 mg L^{-1}
4	Spraying fruits with LPE at 100 mg L^{-1}+main branches ringing
5	Spraying fruits with LPE at 150 mg L^{-1}
6	Spraying fruits with LPE at 150 mg L^{-1}+main branches ringing
7	Main branches ringing
8	Control (spraying fruits with tap water)

Ringing was performed at the onset of coloring (4 weeks before harvest) according to Carreno *et al.*[9] as a complete ring around the main branches with a double bladed knife (3/16 inches).

Lysophosphatidylethanolamine (LPE) solution was prepared in 1% (v/v) ethanol. Tween-20 (0.1%) as a wetting agent was added at the rate of 40 cm /100 L water to the foliar solution in order to obtain best penetration results. The foliar application was applied 2 weeks before harvest directly to trees with a handheld sprayer until runoff in the early morning.

Harvest time was adjusted when the firmness reaches 14.0-16.0 lb $inch^{-2}$ according to Shaltout[10]. Fruits were picked at morning and immediately transported to the Laboratory of post-harvest at Horticulture Research Institute Mansoura, Egypt. At harvest, fresh fruits apparently free from physical damage and diseases were artificially wounded, additional three replicates (5 fruits of each) were collected for initial quality measurements as described below.

For storage study, fruits were sorted to remove any infected then weighted and placed in three performed carton boxes (40×30×20 cm) for each treatment. All boxes were stored 30 days at 0°C±1 with 90-95% RH. Fruit sample was taken 15 days and the following parameters were recorded:

Quality assessments of fruit

Determination of physical and chemical properties

Loss in fruit weight: It was determined according to the following equation:

$$\text{Loss in fruit weight (\%)} = \frac{\text{Initial weight-Weight at sampling date}}{\text{Initial fruit weight}} \times 100$$

Decay: It was determined according to the following equation:

$$\text{Decay (\%)} = \frac{\text{Weight of decayed fruits}}{\text{Initial fruit weight}} \times 100$$

Fruit firmness: It was measured on 10 fruits for each replicate by using a hand Effegi-Penetrometer supplemented with a plunger 8.1 mm tip by removing a small exocarp segment on the two opposite sides. The average was estimated as lb $inch^{-2}$ [11].

Soluble solids content (SSC%): Soluble solids content in fruit juice was measured using a Carl-Zeiss hand refractometer[12].

Total titratable acidity (TA%): It was determined in fruit juice by titration using 0.1 N sodium hydroxide and calculated as malic acid[12].

Skin hue color (h°): Skin color was measured using a hand-held colorimeter (CR-10, Minolta Co., Ltd., Osaka, Japan) and Spectra-Match software, set to L*, a*, b* mode. The colorimeter has a beam diameter of 8 mm. Values obtained from each fruit at the time of sampling represent average L*, a*, b* and h° values calculated from three separate light pulses from the colorimeter. The light pulses were timed to allow movement of the colorimeter to 3 locations on each fruit. Color changes from green to yellow were indicated by calculating the hue angle (h°), from (a*, b*) using the methods described by McGuire[13] as the following equation:

$$(h^\circ) = \tan^{-1}\left(\frac{b}{a}\right)$$

Where:

a = Interval of colors between green (-) and red (+)
b = Interval of colors between blue (+) and yellow (-)
h° = Skin hue color

Total sugars (100 µg mL^{-1} of glucose): Total sugars were determined on crude fruit dried from each treatment by using phenol 18% and sulphuric acid 96% and the absorbance was recorded with spectrophotometer at 490 nm, according to the method described by Sadasivam and Manickam[14].

A standard curve was prepared by plotting the known concentrations of glucose solution (100 µg mL^{-1} of glucose) against respective optical density (OD) value of each. From the standard curve, the amount of total sugars actually present in the sample is determined.

Total phenols content (mg/100 g fresh weight): The total phenolics were determined by the folin-ciocalteu method as described by Singleton *et al.*[15] with minor modifications, based on colorimetric oxidation/reduction reaction of phenols.

Polyphenols extraction was carried out by adding 10 mL methanol (85%) to 1 g fine grind of peach tissue. Then, 250 μL of sterile distilled water was added to 250 μL of extract and then 2.5 mL of diluted folin-ciocalteu reagent (10%) and 2 mL of 7.5% sodium carbonate were added. The samples were shaked for 1.5-2 h. The absorbance of samples was measured at 765 nm by a PG Instruments Ltd-T80+UV/VIS spectrophotometer. Gallic acid was used for calibration curve. Results were expressed as mg gallic acid/100 g fresh weight (FW).

Peroxidase (POX) (U mg^{-1} protein min^{-1}): The activity of POX was expressed as unit per milligram of protein per minute. One unit of POX activity was taken as the changes of 1.0 unit of optical density per minute according to Urbanek *et al.*[16].

Polyphenol oxidase (PPO) (U mg^{-1}): The specific activity was expressed as unit per milligram according to Meng *et al.*[17].

Statistical analysis: Data of both seasons were statistically analyzed as a randomized complete design by analysis of variance (ANOVA) technique procedure of CoStat v6.4 program. Differences among treatment means were compared by the Duncan's multiple range tests at p<0.05 level of probability in the two investigated seasons[18].

RESULTS

At harvest assessments: Data in Table 2 showed that the use of preharvest application played a significant influence on increasing fruit weight, fruit firmness and fruit color. Moreover, the highest significant values of fruit weight was recorded in Florida prince trees sprayed by LPE at 150 mg L^{-1} with ringing main branches followed by LPE at 100 mg L^{-1} with ringing main branches then, main branches ringing compared with the control as it gave the lowest values of fruit weight in both seasons.

It is clear from Table 2 that all treatments increased the values of fruit firmness than the control at harvest during both seasons. Furthermore, main branches ringing gave a higher fruit firmness (14.95 and 15.86 lb inch^{-2}) than the other treatments used during both seasons.

With regard to the effect on fruit color the data also in Table 2 revealed that all treatments used gave a somewhat increment in the values of fruit color in fruit skin than the control in both seasons. However, spraying fruits with LPE at 150 mg L^{-1} with ringing gave higher hue angle (h°) of fruit color (59.66 and 60.33 h°) during both seasons, respectively.

Regarding to the effect on SSC% of Florida prince fruits, data from Table 3 revealed that spraying fruits with LPE at 150 mg L^{-1} with ringing gave somewhat higher values of SSC in fruit juice (9.96 and 10.16%) than all treatments used during

Table 2: Effect of ringing branches technique and preharvest sprays of LPE on fruit weight, fruit firmness and fruit color of Florida prince fruits at harvest during 2016 and 2017 seasons

	Fruit weight (g)		Fruit firmness (lb inch^{-2})		Fruit color hue angle (h°)	
Treatments	2016	2017	2016	2017	2016	2017
Spraying fruits with LPE at 50 mg L^{-1}	97.66^{e}	100.33^{h}	13.43^{e}	13.51^{f}	54.66^{cd}	53.66^{de}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	108.66^{d}	114.33^{e}	13.74^{d}	14.06^{d}	55.66^{c}	55.33^{bc}
Spraying fruits with LPE at 100 mg L^{-1}	113.66^{c}	112.66^{f}	14.40^{c}	13.45^{f}	55.66^{c}	54.33^{cd}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	119.33^{b}	125.33^{b}	13.63^{d}	13.70^{e}	55.66^{c}	55.33^{bc}
Spraying fruits with LPE at 150 mg L^{-1}	113.33^{c}	120.66^{d}	14.50^{c}	14.80^{c}	54.33^{d}	52.66^{e}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	122.66^{a}	129.33^{a}	14.73^{b}	15.30^{b}	59.66^{a}	60.33^{a}
Main branches ringing	119.31^{b}	122.66^{c}	14.95^{a}	15.86^{a}	57.00^{b}	56.33^{b}
Control (Spraying fruits with tap water)	94.66^{f}	111.33^{g}	13.21^{f}	13.23^{g}	52.00^{e}	50.33^{f}

Means not sharing the same letter(s) within each column, are significantly different at 0.05 level of probability

Table 3: Effect of ringing branches technique and preharvest sprays of LPE on SSC%, titratable acidity% and total sugar (100 μg mL^{-1} of glucose) of Florida prince fruits at harvest during 2016 and 2017 seasons

	SSC (%)		Titratable acidity (%)		Total sugars (100 μg mL^{-1} of glucose)	
Treatments	2016	2017	2016	2017	2016	2017
Spraying fruits with LPE at 50 mg L^{-1}	9.53^{b}	9.26^{e}	0.836^{f}	0.910^{b}	5.96^{d}	5.96^{f}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	9.26^{c}	9.26^{e}	0.878^{c}	0.853^{f}	6.10c	6.25^{c}
Spraying fruits with LPE at 100 mg L^{-1}	9.03^{e}	9.43^{d}	0.861^{e}	0.867^{d}	6.13^{c}	6.21^{d}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	9.13^{de}	9.63^{b}	0.900^{b}	0.902^{c}	6.17^{b}	6.14^{e}
Spraying fruits with LPE at 150 mg L^{-1}	8.83^{f}	9.11^{f}	0.868^{d}	0.861^{e}	6.13^{c}	6.25^{c}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	9.96^{a}	10.16^{a}	0.861^{e}	0.900^{c}	6.18^{b}	6.29^{b}
Main branches ringing	9.16^{cd}	9.53^{c}	0.839^{f}	0.831^{g}	6.24^{a}	6.46^{a}
Control (Spraying fruits with tap water)	8.51^{g}	8.30^{g}	0.918^{a}	0.997^{a}	5.87^{e}	5.82^{g}

Means not sharing the same letter(s) within each column, are significantly different at 0.05 level of probability the two seasons under the study. The data also disclose that, control fruits gave less SSC% (8.51 and 8.30%) than all treatments used in both seasons.

Data from Table 3 demonstrated that control fruits gave a higher value of total acidity in fruit juice (0.918 and 0.997%) than all treatments used during the two seasons under the study. Moreover, main branches ringing treatment gave lower percent of titratable acidity in fruit juice which ranged 0.839 and 0.831% during the two seasons under the study.

Considering to the effect on total sugar, data in Table 3 revealed that, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches produced a higher value of total sugar at harvest averaged about 6.24 and 6.46% while, untreated ones presented lower values of this trend (5.87 and 5.82%) under the two seasons, respectively.

Data from Table 4 demonstrated that control fruits at harvest gave a higher value of total phenols (1.43 and 1.33 mg/100 g FW) than all treatments used during the two seasons under the study. Moreover, ringing main branches gave a lower percent of total phenols in fruit tissue which ranged 1.34 and 1.26 mg/100 g FW during the two seasons under the study.

Results in Table 4 showed that the all the applied treatments reduced the activity of peroxides (POX) in fruit significantly than the control at harvest. Since, the POX activity in control fruits were 0.162 and 0.163 U mg^{-1} in both seasons, respectively. Furthermore, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches was more effective in reducing the activity of POX in peach fruits compared with all treatments used. The value of POX at harvest due to this treatment was about 0.140 and 0.141 U mg^{-1}, respectively in both seasons.

Data presented in Table 4 showed the activity of polyphenol oxidase (PPO) in Florida prince fruits sprayed with LPE at 150 mg L^{-1} with ringing main branches decrease the residual activity of PPO at harvest which ranged 0.051 and 0.065 unit mg^{-1} of two seasons, respectively. The untreated fruits gave a higher residual activity of PPO at harvest was 0.066 and 0.078 unit mg^{-1} during the two seasons, respectively.

Table 4: Effect of ringing branches technique and preharvest sprays of LPE on total phenol, peroxidase and polyphenol oxidase of Florida prince fruits at harvest during 2016 and 2017 seasons

Treatments	Total phenol (mg/100 g FW)		Peroxidase (O.D g^{-1} min^{-1})		Polyphenoloxidase (O.D g^{-1} min^{-1})	
	2016	2017	2016	2017	2016	2017
Spraying fruits with LPE at 50 mg L^{-1}	1.41^{ab}	1.32^{ab}	0.149^{e}	0.152^{l}	0.065^{ab}	0.074^{n}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	1.40^{b}	1.31^{bc}	0.148^{e}	0.162^{j}	0.060^{c}	0.072
Spraying fruits with LPE at 100 mg L^{-1}	1.40^{b}	1.33^{a}	0.154^{m}	0.158^{k}	0.064^{ab}	0.069^{q}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	1.38^{c}	1.29^{d}	0.156^{c}	0.159^{k}	0.064^{b}	0.071^{op}
Spraying fruits with LPE at 150 mg L^{-1}	1.35^{de}	1.27^{e}	0.157^{b}	0.142^{n}	0.059^{c}	0.076^{m}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	1.36^{cd}	1.29^{d}	0.140^{g}	0.141^{n}	0.051^{d}	0.065^{r}
Main branches ringing	1.34^{e}	1.26^{e}	0.144^{f}	0.145^{m}	0.052^{d}	0.070^{p}
Control (Spraying fruits with tap water)	1.43^{a}	1.33^{a}	0.162^{a}	0.163^{i}	0.066^{a}	0.078^{l}

Means not sharing the same letter(s) within each column, are significantly different at 0.05 level of probability

Table 5: Effect of ringing branches technique and preharvest sprays of LPE on weight loss percentage of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

Treatments	Storage period (days)					
	2016			2017		
	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	0.00^{l}	2.08^{i}	6.83^{b}	0.00^{l}	2.11^{i}	6.85^{b}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	0.00^{l}	2.05^{i}	6.50^{c}	0.00^{l}	2.04^{i}	6.47^{c}
Spraying fruits with LPE at 100 mg L^{-1}	0.00^{l}	2.29^{h}	6.83^{b}	0.00^{l}	2.36^{h}	6.91^{b}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	0.00^{l}	2.14^{i}	6.81^{b}	0.00^{l}	2.09^{i}	6.89^{b}
Spraying fruits with LPE at 150 mg L^{-1}	0.00^{l}	1.84^{j}	6.29^{d}	0.00^{l}	1.90^{j}	6.28^{d}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	0.00^{l}	1.68^{k}	5.65^{f}	0.00^{l}	1.82^{j}	5.45^{f}
Main branches ringing	0.00^{l}	1.65^{k}	6.05^{e}	0.00^{l}	1.69^{k}	5.73^{e}
Control (Spraying fruits with tap water)	0.00^{l}	2.50^{g}	7.05^{a}	0.00^{l}	2.66^{g}	7.10^{a}
Means	0.00^{c}	2.03^{b}	6.50^{a}	0.00^{c}	2.08^{b}	6.46^{a}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Storability assessments

Loss in fruit weight%: Data from Table 5 showed that the loss in fruit weight had a positive relationship with storage periods, meaning that it was gradually increased as storage period prolonged. So, this may be due to shrinkage of the fruit during the storage period.

The data also disclose that all applied treatments significantly reduced the percent of loss in fruit weight than the control after 30 days of cold storage during the two seasons of this study. Seeing as, the percent of loss in fruit weight at the untreated ones were 7.05 and 7.10% in both seasons, correspondingly. In addition, the lowest loss percentage in fruit weight were recorded significantly by spraying fruits with LPE at 150 mg L^{-1} with ringing in both seasons after 30 days of cold storage compared with the untreated or other treated fruits, hence, it presented about 5.65 and 5.45% in the two seasons, respectively.

Decay percentage: It is cleared from Table 6 that the most treated fruits did not present any decayed fruits till 15 days of cold storage, except the untreated fruits which started to damage after 15 days of cold storage. Thus, the percent of decayed fruits for the untreated fruits were 10.22 and 10.11% after 30 days of cold storage in both seasons, equally.

Furthermore, ringing main branches had the lowest decayed fruits percentage (4.32 and 4.10%) in both seasons after 30 days of cold storage evaluating with the untreated or other treated fruits. Also, decay percentage had a positive relationship with storage periods, meaning that it was gradually increased as storage period prolonged. Moreover, all the applied treatments reduced significantly the percent of decayed fruits than the untreated ones during the both seasons of this study.

As well, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches reduced decayed fruits percentage offered about 4.37 and 4.24% decayed fruits than those sprayed with LPE at all concentrations used under 30 days of cold storage in both seasons, respectively.

Color hue angle (h°): The decline in hue angle occurred rapidly with storage period advanced during cold storage. The losses of the color in peach fruits skin were expressed as lower hue angle (h°). Table 7 data presented that all applied treatments had a delay in the development of fruits skin color when compared with the untreated ones during the both seasons of this study.

In control fruits, hue angle decreased rapidly during cold storage (40.66 and 42.32 h°) at 30 days of cold storage. Moreover, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches produced a higher hue angle (h°) than all treatments or the control after 30 days of cold storage in both season. The increment due to using these treatment reached about 48.66 and 50.0 h° after 30 days of cold storage, respectively during both seasons.

Fruit firmness (lb inch^{-2}): Fruit firmness is one of the most important physical parameter to monitor the ripening progress and senescence of most fruits. For this reason it used as maturity index to indicate time to harvest or when fruits are eating ripe.

Data from Table 8 showed that fruits firmness in Florida prince peach was significantly reduced from harvest till 30 days under cold storage. Seeing as, all treatments used significantly maintained the values of fruit firmness than the control. Whereas, significant better fruit flesh firmness (9.50 and 9.63 lb inch^{-2}) were recorded within main branches ringing as compared with all treatments used or the control at 30 days of cold storage during both seasons.

Table 6: Effect of ringing branches technique and preharvest sprays of LPE on decay percentage of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	0.00^{g}	0.00^{g}	5.61^{c}	0.00^{i}	0.00^{i}	5.61^{c}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	0.00^{g}	0.00^{g}	5.40^{d}	0.00^{i}	0.00^{i}	5.44^{d}
Spraying fruits with LPE at 100 mg L^{-1}	0.00^{g}	0.00^{g}	7.75^{b}	0.00^{i}	0.00^{i}	7.71^{b}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	0.00^{g}	0.00^{g}	5.41^{d}	0.00^{i}	0.00^{i}	5.38^{d}
Spraying fruits with LPE at 150 mg L^{-1}	0.00^{g}	0.00^{g}	5.34^{d}	0.00^{i}	0.00^{i}	5.26^{e}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	0.00^{g}	0.00^{g}	4.37^{e}	0.00^{i}	0.00^{i}	4.24^{f}
Main branches ringing	0.00^{g}	0.00^{g}	4.32^{e}	00.0^{i}	00.0^{i}	4.10^{g}
Control (Spraying fruits with tap water)	0.00^{g}	2.46^{f}	10.22^{a}	0.00^{i}	2.41^{h}	10.11^{a}
Means	0.00^{c}	0.30^{b}	6.05^{a}	0.00^{c}	0.30^{b}	5.98^{a}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Table 7: Effect of ringing branches technique and preharvest sprays of LPE on fruit external color hue angle (h°) of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	54.66^{d}	51.33^{g}	42.33^{m}	53.66^{d}	48.33^{h}	44.33^{k}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	55.66^{c}	52.66^{ef}	43.66^{l}	55.33^{c}	51.66^{f}	45.33^{j}
Spraying fruits with LPE at 100 mg L^{-1}	55.66^{c}	51.33^{g}	42.33^{m}	54.33^{d}	52.66^{e}	44.33^{k}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	55.66^{c}	50.33^{h}	43.00^{lm}	55.33^{c}	51.66^{f}	45.66^{ij}
Spraying fruits with LPE at 150 mg L^{-1}	54.33^{d}	51.66^{g}	42.33^{m}	52.66^{e}	50.66^{g}	42.33^{m}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	59.66^{a}	55.66^{c}	48.66^{i}	60.33^{a}	56.33^{b}	50.00^{g}
Main branches ringing	57.00^{b}	53.00^{e}	45.00^{k}	56.33^{b}	51.66^{f}	46.33^{i}
Control (Spraying fruits with tap water)	52.00^{fg}	46.66^{j}	40.66^{n}	50.33^{g}	43.33^{l}	42.32^{m}
Means	55.83^{a}	51.58^{b}	43.50^{c}	54.79^{a}	50.79^{b}	45.08^{c}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Table 8: Effect of ringing branches technique and preharvest sprays of LPE on firmness (lb $inch^{-2}$) of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	13.43^{g}	11.72^{k}	7.81^{o}	13.51^{fg}	12.23^{k}	7.93^{r}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	13.74^{e}	12.21^{j}	8.34^{n}	14.06^{d}	12.18^{kl}	8.36^{q}
Spraying fruits with (LPE) at 100 mg L^{-1}	14.40^{c}	13.03^{i}	8.81^{m}	13.45^{g}	12.90^{i}	8.66^{p}
Spraying fruits with (LPE) at 100 mg L^{-1} with ringing	13.63^{ef}	11.78^{k}	7.63^{p}	13.70^{e}	12.07^{lm}	8.03^{r}
Spraying fruits with LPE at 150 mg L^{-1}	14.50^{c}	13.98^{d}	8.96^{m}	14.80^{c}	12.36^{j}	9.56^{o}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	14.73^{b}	13.36^{g}	8.93^{m}	15.30^{b}	13.62^{ef}	8.00^{r}
Main branches ringing	14.95^{a}	13.51^{fg}	9.50^{l}	15.86^{a}	12.03^{m}	9.63^{o}
Control (Spraying fruits with tap water)	13.21^{h}	11.72^{k}	7.53^{p}	13.23^{h}	11.66^{n}	7.51^{s}
Means	14.07^{a}	12.66^{b}	8.44^{c}	14.24^{a}	12.38^{b}	8.46^{c}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Table 9: Effect of ringing branches technique and preharvest sprays of LPE on soluble solids content (SSC) % of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	9.53^{fg}	9.28^{ij}	9.66^{e}	9.26^{m}	9.56j^{k}	9.73^{gh}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	9.26^{ij}	9.56^{f}	10.03^{d}	9.26^{m}	9.66^{hi}	9.86^{e}
Spraying fruits with LPE at 100 mg L^{-1}	9.03^{m}	9.26^{ij}	9.73^{e}	9.43^{l}	9.73^{gh}	9.86^{e}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	9.13^{l}	9.46^{g}	10.13^{c}	9.63^{ij}	10.06^{d}	10.16^{c}
Spraying fruits with LPE at 150 mg L^{-1}	8.83^{n}	9.33^{hi}	9.73^{e}	9.11^{n}	9.60^{ijk}	9.76^{fg}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	9.96^{d}	10.27^{b}	10.76^{a}	10.16^{c}	10.60^{b}	10.93^{a}
Main branches ringing	9.16^{kl}	9.36^{h}	10.00^{d}	9.53^{k}	9.83^{ef}	10.03^{d}
Control (Spraying fruits with tap water)	8.51^{o}	9.23j^{k}	9.66^{e}	8.30^{o}	9.16^{n}	9.43^{l}
Means	9.18^{c}	9.47^{b}	9.96^{a}	9.33^{c}	9.77^{b}	9.97^{a}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Total soluble solids (SSC%): From Table 9 the percent of SSC in fruit juice was gradually increased as a storage period advanced throughout cold storage. This may be due to the losses in water through the respiration and evaporation at cold storage. The data also disclose that, all treatments used significantly maintained values of SSC in fruit juice than the untreated fruits during the two seasons under the study. Conversely, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches had the highest significant SSC values (10.76 and 10.93%) during 30 days of cold storage. In contrast, minimum significant SSC values were recorded in control (9.66 and 9.43%) during the two seasons under the study.

Table 10: Effect of ringing branches technique and preharvest sprays of LPE on titratable acidity (%) of florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	0.836^{f}	0.720^{m}	0.679^{o}	0.910^{b}	0.731^{h}	0.651^{k}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	0.878^{c}	0.770^{j}	0.661^{q}	0.853^{d}	0.700^{i}	0.641^{kl}
Spraying fruits with LPE at 100 mg L^{-1}	0.861^{e}	0.750^{k}	0.669^{p}	0.867^{c}	0.728^{h}	0.631^{m}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	0.900^{b}	0.788^{i}	0.617^{t}	0.902^{b}	0.731^{h}	0.616^{no}
Spraying fruits with LPE at 150 mg L^{-1}	0.868^{d}	0.798^{h}	0.644^{s}	0.861^{cd}	0.752^{g}	0.624^{mn}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	0.861^{e}	0.742^{l}	0.601^{u}	0.900^{b}	0.771^{f}	0.611^{o}
Main branches ringing	0.839^{f}	0.817^{g}	0.648^{r}	0.831^{e}	0.706^{i}	0.623^{mno}
Control (Spraying fruits with tap water)	0.918^{a}	0.749^{k}	0.700^{n}	0.997^{a}	0.701^{i}	0.681^{j}
Means	0.870^{a}	0.767^{b}	0.652^{c}	0.890^{a}	0.727^{b}	0.635^{c}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Table 11: Effect of ringing branches technique and preharvest sprays of LPE on total sugars (100 µg mL^{-1} of glucose) of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	5.96^{n}	6.36^{g}	6.70^{d}	5.96^{p}	6.46^{jk}	6.74^{d}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	6.10^{m}	6.44^{f}	6.71^{d}	6.25^{m}	6.53^{g}	6.77^{c}
Spraying fruits with LPE at 100 mg L^{-1}	6.13^{l}	6.31^{h}	6.71^{d}	6.21^{n}	6.54^{g}	6.79^{b}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	6.17^{jk}	6.31^{h}	6.75^{c}	6.14^{o}	6.48^{i}	6.79^{b}
Spraying fruits with LPE at 150 mg L^{-1}	6.13^{l}	6.29^{h}	6.87^{b}	6.25^{m}	6.56^{f}	6.77^{c}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	6.18^{jk}	6.36^{g}	6.92^{a}	6.29^{l}	6.45^{k}	6.85^{a}
Main branches ringing	6.24^{i}	6.19^{j}	6.91^{a}	6.46^{ij}	6.49^{h}	6.79^{b}
Control (Spraying fruits with tap water)	5.87^{o}	6.17^{k}	6.59^{e}	5.82^{q}	6.67^{e}	6.73^{d}
Means	6.10^{c}	6.31^{b}	6.77^{a}	6.17^{c}	6.52^{b}	6.78^{a}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

Titratable acidity % (TA): It is matter of fact that fruit taste is mainly made up of sugars and acids combination. It has been suggested that TA decreases in fruits as result of breakdown of acids to sugars during respiration. A gradual decrease for titratable acidity was found in all treatments used from harvest till 30 days at cold storage. Data from Table 10 showed that, untreated fruits retained higher significant percent of TA which presented 0.700% and 0.681, respectively, in the two seasons. Commonly, minimum percent of TA was found in fruits spraying with LPE at 150 mg L^{-1} with ringing main branches (0.601 and 0.611%) during the two seasons, followed spraying fruits with LPE at 100 mg L^{-1} (0.617 and 0.616%) during the two seasons under the study.

Total sugars (%): Results in Table 11 showed that total sugars were increased gradually according to the increase of storage period. At the end of storage period, fruits of control samples had significantly the lowest level of total sugars values being 6.59 and 6.73 µg mL^{-1} in the first and second seasons, respectively. Conversely, spraying fruits by LPE at 150 mg L^{-1} with ringing main branches had the highest significant SSC values (6.92 and 6.85 µg mL^{-1}) during 30 days of cold storage.

Total phenol content (mg/100 g FW): Results presented in Table 12 revealed that, in both experimental seasons, a gradual decline in total phenols was observed with the advancement of storage period. This reduction may be due to polyphenol oxidase oxidize total phenols in peach fruit during cold storage.

Significantly higher values in total phenols content was detected in control fruits (1.32 and 1.20 mg/100 g FW) in both seasons, respectively. Furthermore, spraying fruits with LPE at 150 mg L^{-1} with ringing main branches attained the minimum values after 30 days of cold storage in peach fruits compared with all treatments used. The value of total phenol due to this treatment was (1.15 and 1.08 mg/100 g FW) after 30 days during cold storage, respectively, in both seasons.

Table12: Effect of ringing branches technique and preharvest sprays of LPE on total phenol (mg/100g FW) of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017

	Storage period (days)					
	2016			2017		
Treatments	0	15	30	0	15	30
Spraying fruits with LPE at 50 mg L^{-1}	1.41^{ab}	1.38^{cd}	1.26^{l}	1.32^{ab}	1.32^{ab}	1.14^{jk}
Spraying fruits with LPE at 50 mg L^{-1} with ringing	1.40^{bc}	1.38^{de}	1.26^{l}	1.31^{bc}	1.24^{f}	1.16^{i}
Spraying fruits with LPE at 100 mg L^{-1}	1.40^{bc}	1.38^{cd}	1.31^{jk}	1.33^{a}	1.28^{d}	1.15^{j}
Spraying fruits with LPE at 100 mg L^{-1} with ringing	1.38^{de}	1.36^{ef}	1.22^{m}	1.29^{d}	1.29^{d}	1.18^{h}
Spraying fruits with LPE at 150 mg L^{-1}	1.35^{fg}	1.29^{k}	1.17^{n}	1.27^{e}	1.25^{f}	1.13^{l}
Spraying fruits with LPE at 150 mg L^{-1} with ringing	1.36^{ef}	1.31^{j}	1.15^{o}	1.29^{d}	1.31^{c}	1.08^{m}
Main branches ringing	1.34^{gh}	1.33^{hi}	1.25^{l}	1.26^{e}	1.28^{d}	1.13^{kl}
Control (Spraying fruits with tap water)	1.43^{a}	1.38^{cd}	1.32^{ij}	1.33^{a}	1.29^{d}	1.20^{g}
Means	1.38^{a}	1.35^{b}	1.24^{c}	1.30^{a}	1.28^{b}	1.14^{c}

Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels of probability

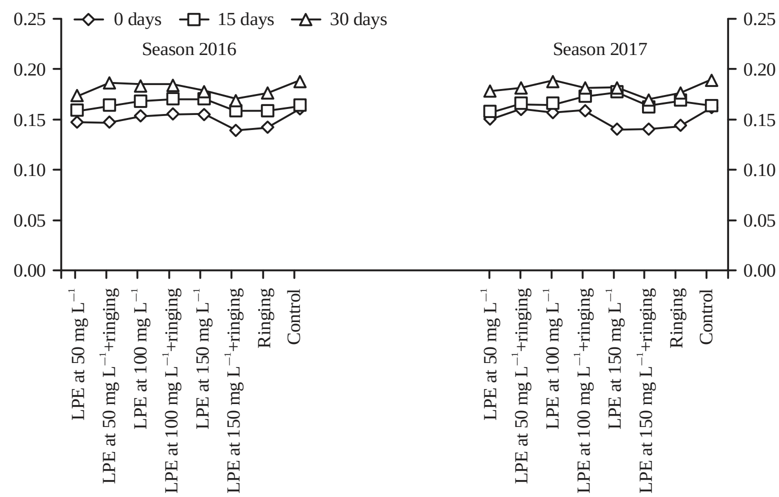

Fig. 1: Peroxidase activity (O.D g^{-1} min^{-1}) of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

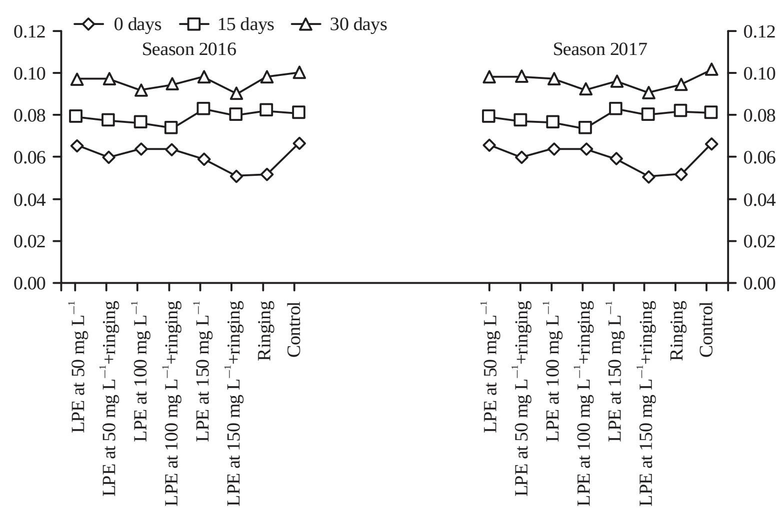

Fig. 2: Polyphenol oxidase activity (PPO) unit mg^{-1} of Florida prince fruits under cold storage at 0±1°C during 2016 and 2017 seasons

Peroxidase activity (POX) (units mg^{-1} protein min^{-1}): The results in Fig. 1 showed that the prolonging storage period of peach fruits significantly increased the activity of peroxidase enzyme. Moreover, all the applied treatments reduced the activity of POX in fruit significantly than the control fruits stored for 30 days at cold storage. Since, the percent in control fruits were 0.189 and 0.191 U mg^{-1} in both seasons, respectively. Furthermore spraying fruits with LPE at 150 mg L^{-1} with ringing main branches was more effective in reducing the activity of POX in peach fruits compared with all treatments used. The value of POX due to this treatment was about 0.172 U mg^{-1} after 30 days during cold storage, respectively, in both seasons.

Polyphenol oxidase (PPO unit mg^{-1}): The inactivation and reactivation of PPO residual activity in the flesh of Florida prince fruits juice was showed in Fig. 2. The activity of PPO in Florida prince fruits sprayed with LPE at 150 mg L^{-1} with ringing main branches showed a statistically significant decrease with the storage period advanced, the residual activity of PPO was 0.090 and 0.091 unit mg^{-1} after 30 days under cold storage of two seasons, respectively. The higher residual activity of PPO was (0.100 and 0.102 unit mg^{-1}) after 30 days under cold storage at the untreated ones during the two seasons, respectively.

DISCUSSION

In present study, fruits sprayed with LPE at 150 mg L^{-1} with ringing main branches showed the best significant effect on various estimated parameters under this study compared with the other treatments used or the control. The overall results showed that pre-harvest sprayed with LPE either alone or with ringing main branches had more pronounced effect on quality parameters of Florida prince peach fruits as reduced fruit loss weight, decay and delaying physical and chemical changes at harvest and 30 days after cold storage at 0°C±1 with 90-95% RH.

The roles of LPE on fruit weight were presented by Ozgen *et al.*[19], who reported that preharvest applications of LPE resulted in significant improvement in both pomological and phytochemical attributes at harvest. In general, weight loss is mostly depend on the relative humidity surrounding the fruit, but can be also associated with a slight reduction in flesh firmness[20].

In climacteric fruit, the ethylene signal is known to trigger many plant processes including ethylene production, fruit softening, color change and increases flavor and aroma associated with fruit ripening[21]. The LPE is a naturally occurring lipid with regulatory effects in senescence and ripening. The LPE is a water insoluble phospholipid. When applied exogenously to horticultural crops, LPE affects growth, development and postharvest longevity. It also can accelerate ripening of fruits and prolong shelf-life at the same time.

Additionally, weight loss is of great importance because it can cause fruit shriveling and advance senescence.

It has been found that in a ripened fruit, LPE inhibited ethylene production to prolong shelf life and maintain fruit firmness. While, retards polygalacturonase, mediated fruit softening[3], membrane leakiness[22] and the inhibition of lipid breakdown by LPE resulting in the protection of membrane integrity during ripening or senescence.

'McIntosh' apple fruit sprayed with LPE (50-100 mg L^{-1}) 2 weeks before harvest had higher anthocyanin content in the peel, better color uniformity and retained higher firmness during storage. The LPE enhance diffusion across the plant cuticle[23].

Additionally, the physiological changes that the fruit displays during its ripening, the accumulation of soluble solids and changes in color and aroma are very relevant for consumer acceptability. These attributes are severely affected in fruit that has been exposed to low temperatures for a prolonged amount of time[24]. Farag and Palta[25] found that LPE is able to stimulate ethylene production in apple and cranberry fruit while keeping the respiration rate low.

Lysophosphatidylethanolamine (LPE) treatment was shown to delay fruit softening when used as postharvest treatment. The LPE inhibited PLD activity and that inhibition of PLD was associated with reduced ethylene evolution and delayed senescence.

The increase in soluble solid content is expected due to moisture evaporation (weight loss) and thereby enhancement in SSC (%) during storage[26]. Peach fruits are needed to be higher with SSC (sweet) consumer acceptability[27]. It is well known that sugars and simple acids are the respiration substrates. The longer time of fruit respiration, the higher rates of sugars and acids consumption.

According to Voca *et al.*[28], the relationship between total soluble solids and total acidity is very important parameter in determining fruit quality, because it provides information on the sugar/acids balance in the fruits.

Moreover, color improvement in LPE-treated fruits has been attributed to enhanced carotenoid accumulation[29].

Preharvest spray solution of LPE resulted in significant improvement on both pomological (fruit weight, size, color) and phytochemical (total phenolic content, antioxidant capacity) attributes of sweet cherry[19]. Although the mechanism of action by LPE was not exactly understood, earlier application of LPE may responsible for cell enlargement of sweet cherries.

The LPE treatment has also been found to increase anthocyanin accumulation and stimulate ethylene synthesis[3]. Color improvement in LPE-treated fruits has been attributed to enhance phenylalanine ammonia lyase (PAL) activity and anthocyanin accumulation[30].

Phenolic compounds are those that are the most common in fruits and have a strong antioxidant capacity[31]. These compounds can protect foods from oxidative deterioration in low concentrations and can take part in modifying the food's coloring at high concentrations because some of them are substrates for undesirable browning reactions, which are catalyzed by the polyphenol oxidase (PPO) enzyme. Thus, varieties that have a balance of high phenolic compound content and low PPO activity can be very attractive[32].

Polyphenol oxidases and peroxidases are among the most studied enzymes in fruits and vegetables. Owing to the deleterious effects of discoloration and off-flavor formation induced by their actions, phospholipids are a major and vital component of all biological membranes and play a key role in processes such as signal transduction, cytoskeletal rearrangement and in membrane trafficking.

Lysophosphatidylethanolamine (LPE), an inhibitor of phospholipase D (PLD) is reported to inhibit PLD activity, reduce ethylene production and extend shelf-life of many horticultural commodities. The PLD is a key enzyme in the metabolism of membrane lipids in that it mediates first step in accelerated phospholipid breakdown[33], generating lipids that are involved in signal transduction, cell proliferation, signaling pathways and in senescence. In addition to the inhibition of PLD, this effect has been attributed to a decrease in ethylene biosynthesis or reduced ethylene action induced by LPE[34].

Girdling at the beginning of the ripening phase enhances skin color and fruit ripening[9]. The immediate effect of a complete girdle is to interrupt the movement through the phloem of photosynthates produced by leaves. This increases foliar carbohydrates (sugars and starch) and plant hormones in vine parts above the girdled position at the expense of the trunk and root system[34].

Girdling treatment increased the accumulation of carbohydrate content in the upper part of girdle which act as precursors of anthocyanins, flavonoids and other coloring substances and improved the color of the fruits[35]. The increase in carbohydrate level in the leaves a well correlated with the fruit retention. Verreynne *et al.*[36] reported that girdling enhanced fruit color, total soluble solids and total sugar content in Marisol' Clementine's. Fruits from the girdle branch yielded the higher amount total sugars which may be due to carbohydrate availability and starch content high in upper part of girdle.

Casanova *et al.*[37] reported that scoring (one type of girdling) significantly increased the total sugar content in grape. It has been reported that girdling increased the levels of total and individual anthocyanins in the berry skin of crimson seedless grapes[38].

Phenolic compounds in fruits are important, because they can exhibit antioxidant properties. Kubota *et al.*[39] reported that girdling significantly increased the PAL enzyme activity and total phenolic content in the peach fruits. Girdling enhanced color development, ripening and also had positive effects on anthocyanin accumulation in the fruits[40].

CONCLUSION

It is concluded that pre-harvest sprayed with LPE either alone or with ringing main branches had more prominent effect on quality parameters of Florida prince peach fruits as reduced fruit loss weight, decay and delaying physical and chemical changes at harvest and 30 days after cold storage at $0°C \pm 1$ with 90-95% RH. Fruits sprayed with LPE at 150 mg L^{-1} with ringing main branches showed the best significant effect on various estimated parameters under this study compared with the other treatments used or the control. In this respect, pre-harvest treatments suggested being a good recommendation for keeping fruit quality and accelerate fruit coloring as well as extending postharvest life of "Florida prince" peach fruits.

SIGNIFICANCE STATEMENT

This study discovers the possible effect of the ringing technique and natural lipids that can be beneficial to enhance quality and storability of fruits. This study will help the researchers to accelerate fruit coloring, enhancing storage life, improve fruit quality and storability during harvest and after cold storage by retarding senescence.

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