Effect of Putrescine Application on Fruit Quality of Florida Prince and Early Grande Peaches during Cold Storage

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ABSTRACT

Peach(Prunus persica, L.) Florida Prince and Early Grande peach cvs. Postharvest treatments were conducted during two successive seasons of 2015 and 2016 to study the effect of dipping the two cvs. fruits in putrescine solution on fruit storability . Fruits of the two cvs. used in this study were harvested from trees about 12 years old, budded on Nemaguard rootstock and planted in a private orchard at 4x4 meter apart in sandy soil located in El-Nobaria region, El-Behira governorate.

Peach fruits of the two cultivars were harvested at the commercial maturity stage and immerged in putrescine solutions at 2, 3 and 4 mM for 5 mint. as well as distilled water(control). Postharvest storage quality of peach fruit cvs. were evaluated during storage at 0-1C° and 90-95 RH. for 28 days. Fruit quality parameters such as weight loss (%), decay (%), chilling injury (%), soluble solid content(SSC%), titratable acidity(%), fruit firmness(k/cm2), respiration rate and total sugars(%) were determined at harvest time and during the storage period every 7 days intervals . The results showed that, putrescine solution treatments extend postharvest storability of treated fruits of the both cvs. by inducing fruit resistance to decay and chilling injury compared to those of control . Moreover, putrescine solutions reduced fruit weight loss, chilling injury, soluble solids content, respiration rate and total sugars and maintained fruit firmness and acidity during storage for the two peach cvs. in the two study seasons . In this respect, 4 mM putrescine treatment was more effective than the other concentrations and control with the two cultivars . Thus quality and storability of peach fruits could be enhanced with putrescine treatments for its ability on delaying the ripening processes and extending postharvest fruit life.

Key words: polyamins,putrescine, fruit quality, Florida Prince, Early Grande peaches, storage.

INTRODUCTION

Florida Prince and Early Grande peach cvs. have been planted at a scale in Egypt especially in new reclaimed areas. They are a perishable product and many postharvest studies were carried out for enhancing fruit storability and extending the limited post harvest storage life of peach fruits.

Peaches shows a climacteric behavior and quickly deteriorate even at cold storage. The modern fruit industry needs more researches for promoting commercially fruit quality . Their storage life is contrary to other climacteric fruits, where it does not exceed more than 4-5 weeks (Lill et al., 1989; Lurie and Crisosto, 2005). So extended storage life is considered as a physiological goal. Peach storage period may be extended by using different postharvest methods (Bal 2013). Free forms of polyamines, reduced rate of respiration, delayed ethylene production, retarded colour changes, increased fruit firmness, induced mechanical resistance and reduced chilling symptoms (Valero et al., 2002). Putrescine was (a diamine) considered as the first polyamine in the biosynthetic pathway followed by spermidine (a triamine) and spermine (a tetraamine), which formed by additions of aminopropyl groups derived from decarboxylated S-adenosyl methionine. The role of putrescine, spermidine and spermine in plant are perform important functions in plant growth regulation, where it can affect DNA and RNA synthesis and degradation, inhibit activities of protease, regulate rates of transcription, ribonuclease, peroxidase and polygalactouronase, stabilize ribosomal structure and maintain cell membrane (Wang et al., 1993).

Putrescine, as a postharvest application, has been demonstrated to influence shelf-life and quality of many climacteric and non-climacteric fruit as apple(Wang et al., 1993), kiwifruit (Petkou et al., 2004), mango(Malik and Singh, 2005), pomegranate (Mirdehghnan et al., 2007; Ramezanian and Rahemi, 2010), peach(Martinez-Romero et al., 2000), plums (Vincente et al., 2002; Serrano et al., 2003; Khan et al., 2007) and apricot(Martinez-Romero et al., 2002; Khosroshahi and Esna-Ashari, 2007). Putrescine(PUT) can be catabolized by the enzyme diamine oxidase(DAO) to glutamate,y – amino biotyric acid(GABA) . Ornithine and arginine are substrates for the synthesis of PUT, but they are intermediates in the synthesis of proline and GABA, glutamate also being a precursor of proline, ornithine, arginine and GABA (Shelp et al., 2012) . However, it would be value in extending the storage life further. For that, it is necessary to down-regulate accelerated senescence of peach fruits. Therefore, the present study was conducted to clearify the effects of exogenous postharvest applications of

putrescine at concentrations of 0.0, 2.0, 3.0 and 4.0 mM, on maintaining quality and extending the postharvest life of Florida Prince and Early Grande Peachs during cold storage at 0 –1 C◦ and 90–95% RH.

MATERIALS AND METHODS

Postharvest treatments were conducted at Laboratory of Sakha Hort. Res. Station, Kafr El-Sheikh Governorate, Egypt, at Northern Delta region, during two successive seasons of 2015 and 2016. Fruits of both cultivars used in this study were harvested from trees about 12 years old, budded on Nemaguard rootstock and planted at 4x4 meter a part in sandy soil located in El-Nobaria region, El-Behira governorate at the commercially mature stage(SSC 11-12%) and sorted to eliminate damaged and immature fruits, and selected for uniform size and color. Fruits of each cultivar were divided into four groups. The first group was immersed in 20 L of distilled water at 20 C° for 5 min(control); the second, third and fourth groups were immersed in 20 L of 2.0, 3.0 and 4.0 mM of putrescine (dihydrochloride C4H12N2-HCl, Bestellen sie zum nulltarif, Germany) solution at 20 °C for 5 min., respectively(exogenous postharvest applications). After treatments, fruits were air-dried at 25 C° for approximately 30 min (Cao et al., 2010) . Fruits were then packed in carton boxes(50 × 30 × 15 cm) and samples were taken at the picking date and at 7-days intervals during storage to determining the following data:

1. Fruit weight loss (%)=

$$\frac{\text{Fruit weight now x100}}{\text{Fruit weight at initial time of storage}}$$

2. Fruit decay rate (%)=

$$\frac{\text{Number of decayed fruits x100}}{\text{Total number of stored fruits}}$$

3. Chilling injury (%) =

$$\frac{\text{Number of injuried fruits x100}}{\text{Total number of stored fruits}}$$

4. Fruit firmness (kg/cm2) : was recorded by using Lfra Texture analyzer instrument. The results were expressed as resistance force of the fruit to the penetrating tester according to Harold (1985).
5. Soluble solids content (SSC %): were determined by a hand refractometer
6. Titratable acidity(as malic acid%): was determined in filtered juice according to (A. O. A. C., 1990)
7. Respiration rate (mg kg^{-1} h_{-1}): the respiratory rate, expressed in CO2 mg of 1 kg fruit per 1 hour (mg /kg/h) it was determined by using 1 kg fruits which was placed in dessicator and connected to a tube contains 25 ml of 1.0 N KOH; Air CO_2 free was drown into the dessicator throughout the KOH for one hour, then KOH was titrated with 1.0 N HCl using thymolplue indicator, CO2 production was calculated as (mg.CO_2/ kg/ h.) (Demirdoven and Batu, 2004).
8. Total sugars (g /100 g-1): were extracted from 5 grams of mixed flesh of both fruits sample by using distilled water (Loomis and Stull, 1937).

The obtained data were analyzed as completely randomized design using M-statc software with two factors: treatments and cutivars . Differences among treatment means were compared with Duncan multiple range test at 5% level according Duncan (1955).

RESULTS AND DISCUSSION

1. Fruit weight loss (%):

In general, weight loss was increased by increasing storage period as shown in Table 1, moreover, there were significant differences between all treatments and control at all determine times in both cultivars.

The highest weight loss was recorded with control of the two cultivars and seasons at all storage time. However, the lowest weight loss of Florida Prince and Early Grande was noticed with fruits that were dipped in 4 mM of putrescine solution in the both seasons with a highly significant differences compared with untreated fruits and the others till the end of storage time (28 days) . Data regarded that, Early Grand treated fruits recorded the highest values of weight loss compared to its control than those of Florida Prince treated fruits and its control with a highly significant differences in the two seasons.

The results of weight loss in this study were similar to those for plum by (Serrano et al., 2003) who found that, putrescine showed significantly less weight loss as compared with untreated fruits. Moreover application of putrescine(0.5, 1, 2, 3 and 4 mM) resulted in a reduction in weight loss of peach fruits during storage (Reza et al., 2008); treatments had the lowest reduction of weight in apricot fruits, the lowest weight loss was recorded with 4 mM/l treatment compared the others and control (Davarynegad et al., 2012).

2. Fruit Decay rate (%):

The illustrated data in Table 2 indicated that, putrescine treatment resulted in an improvement in peach storability at 0-1°C. Fruit decay percentage markedly increased with the increase of storage period starting from 21 days for control with the two fruit cvs. during the two storage seasons till the end time. Decay symptoms as indicated by 2 mM putrescine for Florida prince and Early Grande in the second season, however the same trend was obvious with 2 and 3 PUT in the first season for Early Grand fruits.

Table 1: Effect of putrescine postharvest applications on weight loss (%) of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Weight loss (%)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	0.00	2.89 a	5.72 a	6.27 a	8.72 a	5.90 a	0.00	2.11 a	4.52 a	6.50 a	8.13 a	5.31 a
2 mM	0.00	2.01 b	3.29 b	4.65 b	5.49 b	3.86 b	0.00	1.81 b	3.18 b	4.25 b	5.36 b	3.65 b
3 mM	0.00	1.70 c	2.96 b	3.55 c	4.46 c	3.17 c	0.00	1.55 c	1.86 c	3.11 c	4.16 c	2.67 c
4 mM	0.00	1.52 d	2.02 c	3.47 c	4.33 c	2.84 c	0.00	1.20 d	1.32 c	2.54 d	4.02 c	2.27 d
Mean	0.00	2.03 d	3.50 c	4.49 b	5.75 a		0.00	1.67 d	2.72 c	4.10 b	5.32 a	
Early Grande												
Control	0.00	2.88 a	3.72 a	6.72 a	8.66 a	5.50 a	0.00	2.65 a	4.12a	7.22a	7.98 a	5.49 a
2 mM	0.00	1.84 b	2.63 b	4.92 b	6.81 b	4.05 b	0.00	2.00 b	2.81b	4.15 b	6.03 b	3.75 b
3 mM	0.00	1.51 c	2.45 b	4.39 c	5.74 c	3.52 c	0.00	1.62 c	2.48b	4.01b	4.56 c	3.17 c
4 mM	0.00	1.46 c	1.58 c	4.26 c	5.51 c	3.20 c	0.00	1.44 c	1.73c	3.86 c	4.67 c	2.93 c
Mean	0.00	1.92 d	2.60 c	5.07 b	6.68 a		0.00	1.93 d	2.79 c	4.81 b	5.81a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT.

Table 2: Effect of putrescine postharvest applications on decay(%) of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Decay (%)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	0.00	0.00	0.00	2.40a	11.93 a	2.87 a	0.00	0.00	0.00	1.65 a	9.73 a	2.28 a
2 mM	0.00	0.00	0.00	0.00 b	10.93 b	2.19 b	0.00	0.00	0.00	0.25 b	7.55 b	1.56 b
3 mM	0.00	0.00	0.00	0.00 b	0.16 c	0.03 c	0.00	0.00	0.00	0.00 d	0.58 c	0.12 c
4 mM	0.00	0.00	0.00	0.00 b	0.00 d	0.00 d	0.00	0.00	0.00	0.00 d	0.00 d	0.00 d
Mean	0.00c	0.00c	0.00c	0.60b	5.76a		0.00c	0.00cc	0.00c	0.48b	4.47a	
Early Grande												
Control	0.00	0.00	0.00	2.40 a	10.57 a	2.59a	0.00	0.00	0.00	1.62a	9.82a	2.29a
2 mM	0.00	0.00	0.00	0.67 b	3.17 b	0.77b	0.00	0.00	0.00	1.11b	1.89 b	0.60b
3 mM	0.00	0.00	0.00	0.19 c	2.32 c	0.50c	0.00	0.00	0.00	0.00c	0.87 c	0.17c
4 mM	0.00	0.00	0.00	0.00 d	0.00d	0d	0.00	0.00	0.00	0.00 c	0.00d	0.00d
Mean	0.00c	0.00c	0.00c	0.82b	4.02a		0.00c	0.00c	0.00c	0.68b	3.15a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT

The control fruits showed a highly significant differences of decay% when compared to the other putrescine treated fruits, that recorded 11.93 and 9.73% for Florida Prince and 10.57 and 9.82% for Early Grand at the end of storage in the two seasons, respectively. In contrast, 3 mM putrescine treatment recorded the lowest decay percentage, the values were 0.16 and 0.58% with Florida Prince and 2.32 and 0.87% with Early Grand fruits at the end of storage in the two seasons, respectively.

Fruits treated with 4 mM putrescine stored well till the end of storage (for 28 days) without any decay for both cultivars in the two seasons .These results agreed with that of (Reza, et. al. 2008) who reported that, exogenous putrescine showed an improvement of peach fruits storability at 2°C. Fruits treated with 0.5, 1, 2, 3 and 4 mM putrescine stored well for 14, 17, 19, 21 and 22 days, respectively, compared with the control which stored for only 11 days.

3. Chilling injury (%):

Data concerning chilling injury symptoms in the present study were tabulated in Table 3,they appeared in control fruits of the two peaches cvs. at 21 days of storage during the two seasons with appearance of featheriness and browning (Chilling injury symptoms, measured as browning area of the skin and internal breakdown). However, Florida

Prince peach fruits which were treated with all concentration(2, 3 and 4 mM/l) of putrescine did not show any chilling injury symptoms till 21 days of cold storage during the two seasons, but it was appeared on Early Grande cv. at 21 days storage with the control and the 2 and 3 mM putrescine in the first season and with 2 mM putrescine in the second seasone three concentrations of puterscine . A highly significant chilling injury symptoms were recorded in control fruits however, the fruits that were treated with 4 mM/l putrescine did not show any chilling injuries symptoms till 21 days of cold storage during the two study seasons.

At the end of storage period(28 days) control fruits showed the highest chilling injury values with highly significant differences compared with those treated with 2 and 3 putrescine treatments for the two peach fruit cvs. during the two seasons, it recorded 14.53 and 12.45 % with Florida Prince and 16.57 and 13.82% with Early Grande fruits compared the other two treatments . In this respect fruits treated with 4 mM/l putrescine did not showed any chilling injury symptoms till the end of cold storage for the two cultivar fruits in the two study seasons.

The above results in a harmony with that of(Marttinez– tellez et al., 2002) who found that, polyamines treatment by pressure infiltration increased the tolerance of squach to chilling injury, (Lurie and Crisosto, 2005) summarized that, in peaches and nectarines chilling injuries can increase fruit flesh browning, and softening, which is known as featheriness. such disorders were shown in peaches within 1or 2 wk of storage at 2-5 °C as compared with 3 or more wk at 0 °C by using putrescine alone or putrescine +ultrasound treatments. Also(Saba et al., 2012) reported that putrescine at 1mM/l treatment may help maintain the quality of two apricot fruit cultivars 'Bagheri' and 'Asgarabadi' during cold storage by inhibiting ripening and decreasing chilling injury incidence by protecting against chilling damage.

4. Fruit firmness (kg cm^{-2}:

Peaches can be harvested even if they are still firm but physiologically mature since they are climacteric fruit, it means they will continue to ripen after harvest. The decline in firmness as the storage period progresses is mainly due to enzymatic degradation of insoluble protopectins to more simple soluble pectin(Abd El-Migid, 1986). In this study, data in Table 4 cleared that, fruit firmness was decreased with the progress of storage time for the two cultivar fruits during the two study seasons.

Putrescine treated fruits with the two cvs. especially those dipped in 3 and 4 mM showed no significant effects with Florida Prince in the first season and Early Grand in the second season, respectively .

Untreated fruits showed the highest reduction in firmness as compared with the other treatments till the end of storage period for the two cultivars in the two seasons. this trend was found with Florida Prince compared to Early Grande fruits.

Generally, the best concentration of PUT was at 4 mM/L during storage period till the end storage(28 days) which recorded highest fruit firmness, significantly the lowest values was noticed in control treatment during the two seasons with the both peach cultivars.

Table 3: Effect of putrescine postharvest applications on Chilling injury(%)of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Chilling injury (%)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	0.00	0.00	0.00	3.50a	14.53a	3.61a	0.00	0.00	0.00	4.68a	12.45a	3.43a
2 mM	0.00	0.00	0.00	0.00b	2.87b	0.57b	0.00	0.00	0.00	0.00b	1.68b	0.34b
3 mM	0.00	0.00	0.00	0.00b	1.20c	0.24b	0.00	0.00	0.00	0.00b	0.57c	0.11b
4 mM	0.00	0.00	0.00	0.00b	0.00d	0.00c	0.00	0.00	0.00	0.00b	0.00d	0.00c
Mean	0.00c	0.00c	0.00c	0.88b	4.65a		0.00c	0.00c	0.00c	1.17b	3.68a	
Early Grande												
Control	0.00	0.00	0.00	3.72a	16.57a	4.06a	0.00	0.00	0.00	2.43a	13.82a	3.25a
2 mM	0.00	0.00	0.00	1.02b	2.40c	0.68b	0.00	0.00	0.00	1.35b	1.76b	0.62b
3 mM	0.00	0.00	0.00	1.70b	3.25b	0.99b	0.00	0.00	0.00	0.00c	0.76c	0.15b
4 mM	0.00	0.00	0.00	0.00c	0.00d	0.00c	0.00	0.00	0.00	0.00c	0.00d	0.00c
Mean	0.00c	0.00c	0.00c	1.61b	5.56a		0.00c	0.00c	0.00c	0.95b	4.09a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT.

Table 4: Effect of putrescine postharvest applications on fruit firmness of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Firmness (kg/cm^2)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	3.35 a	2.73 b	2.40 b	2.00 b	1.25 b	2.35 b	4.28 a	3.33 b	3.05 c	2.54 d	2.00 d	3.04 c
2 mM	3.26 a	2.95 a	2.78 a	2.62 a	2.36 a	2.79 a	4.36 a	4.25 a	4.08 b	3.58 c	3.10 c	3.87 b
3 mM	3.21 a	2.97 a	2.75 a	2.62 a	2.32 a	2.77 a	4.32 a	4.19 a	4.11 a	4.00 b	3.75 b	4.07 a
4 mM	3.36 a	3.01 a	2.95 a	2.76 a	2.41 a	2.90 a	4.33 a	4.21 a	4.18 a	4.11 a	4.00 a	4.17 a
Mean	3.30 a	2.92 ab	2.72 b	2.50c	2.09 d		4.32 a	4.00 b	3.86 bc	3.56 c	3.21d	
Early Grande												
Control	4.48 a	3.63 c	3.05 c	2.63 d	2.11 c	3.18 b	4.63 a	3.72 b	3.05 c	2.63 c	2.23 c	3.25 c
2 mM	4.33 a	4.01 b	3.68 b	3.41 c	3.15 b	3.72 a	4.55 a	4.11 a	3.86 b	3.18 b	3.07 b	3.75 b
3 mM	4.43 a	4.21 a	4.01 a	3.78 b	3.34 b	3.95 a	4.68 a	4.22 a	4.06 a	3.75 a	3.40 a	4.02 a
4 mM	4.45 a	4.38 a	4.20 a	4.08 a	3.82 a	4.19a	4.60 a	4.42 a	4.15 a	3.82 a	3.45 a	4.09 a
Mean	4.42 a	4.06 b	3.74 c	3.48 d	3.11 e		4.62 a	4.12 b	3.78 c	3.35 d	3.04 e	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT

This finding was in harmony with that of Khosroshahi and Enas-Ashari.(2007 and 2014), who reported that one of the main effects of polyamines during fruit and vegetable postharvest life is to maintain their flesh firmness and delay the ripening processes. Treatments with exogenous polyamines (putrescine) had showed an increase of flesh firmness in several fruits, including 'Golden Delicious' and 'McIntosh' apples. Reduced activity of fruit softening enzymes by postharvest dip treatment of polyamines was reported for plum (Khan et al., 2007). In addition, (Saba et al., 2012) reported that, putrescine at 1mM maintained the firmness and color of the of two apricot cultivars 'Bagheri' and 'Asgarabadi' fruits during cold storage. The best firmness values were observed with 4mM putrescine treatment during storage of apricot fruits.

5. Soluble solids content (%):

From data in Table 5, it could be noticed that, soluble solids content (SSC) increased in fruits of the two peach cvs. with the extending of storage period till 28 days of storage for all treated and untreated fruits as a result of dehydration and hydrolysis of polysaccharide into soluble solids.

The present data showed that, control fruits of the two cvs. showed the highest values of SSC% at the end of storage time during the two seasons with a highly significantly effects that, reached to16.13 and 16.22 % for Florida Prince fruits and 15.52 and 15.75 % for early Grande in both seasons. All putrescine treatments lowered the increase of SSC% during storage period for the two cultivar fruits and the lowest values were recorded with 4 mM putrescine treatment compared with the control in the two seasons with the two cvs. which recorded 14.47 and 14.15% for Florida Prince an 14.05 and 13.20% for Early Grand in the two seasons, respectively. There was no significant differences between the 3 and 4 mM putrescine treatments in the second season at the end of storage period of the two cultivar fruits . According to data of Table 5 we can say that, there was an inversely reaction between putrescine concentration and level of SSC% . This results are in accordance with that of (Khan et al., 2007) and (Bal, 2013) who reported that. putrescine-treated fruit stored at low temperatures exhibited lower soluble solids content. In contrast, (Baljit and Jawandha, 2014) summarized that, putrescine 3 mmol L−1 sprayed 10 days before harvesting of peach fruits registered high SSC% at the end of storage.

6. Titratable acidity (%):

components, but it significantly related to organoleptic quality combined with sugar and aromatic compounds(Wang, 1993). Data of Table 6 showed that, fruit titratable acidity of Florida prince and Early Grande fruit peach cvs,was significantly reduced with the prolonging of storage time. These observations were found to be in harmony with those of(Zaghloul,2004) . The results showed that, titratable acidity content recorded the high levels with purescine treatments during storage till the end of storage time compared to control fruits in the two seasons with the two peach cvs.. Petruscine treatment with 4mM showed the highest values of TA at the end of storage time with the two fruit cvs. in both seasons.

At the end of storage after 28 days, the lowest titratable acidity was recorded in the control fruits of the two cultivars in the two seasons.

Table 5: Effect of putrescine postharvest applications on SSC % of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	SSC %											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	11.13a	12.73a	13.97a	15.53a	16.13a	13.90a	11.93a	12.85a	13.77a	14.85a	16.22a	13.92a
2 mM	11.15a	12.53ab	13.70ab	14.97b	15.67b	13.60b	11.87a	12.43b	13.01b	13.63b	14.42b	13.07b
3 mM	11.12a	12.21b	13.27b	14.03c	15.33b	13.36b	11.97a	12.20c	12.45c	13.00c	14.12c	12.75c
4 mM	11.17a	11.73c	12.60c	13.27d	14.47c	12.65c	12.05a	12.19c	12.50c	13.10c	14.15c	12.58c
Mean	11.14	12.30	13.39	14.45	15.40		11.96	12.42	12.93	13.65	14.73	
Early Grande												
Control	11.37a	13.80a	14.42a	14.92a	15.52a	13.96a	11.84a	12.45a	13.83a	14.68a	15.79a	13.72a
2 mM	11.35a	12.17b	13.20b	13.72b	14.70b	13.03b	11.82a	12.15b	12.92b	13.11b	13.76b	12.75b
3 mM	11.40a	12.15b	13.09b	3.50bc	14.35c	12.91b	11.98a	12.00b	12.33c	13.00b	13.25c	12.51c
4 mM	11.45a	12.02b	13.05b	13.35c	14.05d	12.78b	12.11a	12.10b	12.37c	13.05b	13.20c	12.61c
Mean	11.39e	12.54d	13.44c	13.87b	14.66a		11.94d	12.18d	12.86c	13.46b	14.00a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT.

Table 6: Effect of putrescine postharvest applications on fruit acidity (%) rate of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Acidity (%)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	0.72a	0.64b	0.57 c	0.51c	0.45c	0.58c	0.81a	0.74 b	0.63b	0.47c	0.37 c	0.60b
2 mM	0.75a	0.69a	0.66b	0.60b	0.53b	0.65ab	0.80a	0.77 a	0.72a	0.60 b	0.54 b	0.70a
3 mM	0.73a	0.72a	0.71a	0.66a	0.56b	0.68a	0.79a	0.78a	0.71a	0.60b	0.53b	0.67a
4 mM	0.70a	0.71a	0.70a	0.67a	0.67a	0.69a	0.81a	0.77a	0.71a	0.65a	0.58a	0.67a
Mean	0.73a	0.69b	0.66b	0.61c	0.55d		0.80a	0.77ab	0.69b	0.58c	0.51d	
Early Grande												
Control	0.67 a	0.60b	0.51c	0.44 d	0.32 c	0.51c	0.75a	0.63 b	0.53b	0.40b	0.32b	0.53b
2 mM	0.65a	0.61b	0.53b	0.49c	0.44b	0.55b	0.73a	0.68 a	0.61a	0.55a	0.51a	0.62a
3 mM	0.63a	0.58b	0.55b	0.51b	0.45b	0.54b	0.74a	0.67a	0.63a	0.58a	0.53a	0.64a
4 mM	0.66a	0.68a	0.62a	0.58a	0.53a	0.61a	0.75a	0.67a	0.60a	0.55 a	0.51a	0.62a
Mean	0.65a	0.62a	0.55b	0.51c	0.44d		0.74a	0.66b	0.59c	0.52d	0.47e	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT.

Early Grande peach fruits recorded the lowest(TA) at the initial and the end time of storage in both seasons.

The above results was agreement with that of (Reza et.al. 2008) who concluded that, application of putrescine with 0.5, 1, 2, 3 and 4 mM putrescine resulted in reducing the decrease of titratable acidity with a much slower rate during storage compared to untreated fruits. This trend were also observed with the application of putrescine in all peach fruits . Agreement results were found by(Davarynejad et al., 2012) on apricot fruits during storage.

7. Total sugars (gm / 100gm):

Peaches edible quality related to a great extent on sweetness, which is depending on fruit total sugar content. The total sugars content values were increased with prolonged the storage time from the initial time till the end of storage (28 days) with the two cvs. during storage(Table7). All putrescine treatments reduced the increase in total sugars content compared with untreated fruits in the two seasons for the two cvs. as showen in Table 7. During storage, the increase rate of total sugars content was increased in control treatment as compared with all putrescine dipping treatments

(2.0, 3.0 and 4.0 mM) from 7 days to 28 days of storage. The total sugars content levels of control recorded 14.40 and 12.21 g /100 g-1 for Florida Prince fruits and 12.42 and 11.43 g /100 g-1 for Early Grande in the both seasons, respectively. The lowest value was recorded with 4.0 mM putrescine for the both cultivars in the two seasons. where it was 11.07 and 11.18 g /100 g-1 for Florida Prince fruits and 10.38 and 10.25 g /100 g-1 for Early Grande in both seasons, respectively at the end of storage (28 days) with a highly significantly effects .

Increasing of the total sugar levels are possibly due to enhanced fruit ripening and senescence. However, reducing sugars in putrescine applications may be because reduced losses by minimizing total sugar levels degradation of peaches (Bhagwan et al., 2000) and (Malik et al., 2003) reported that, postharvest putrescine treatments preserved sugars in tomatoes and mangoes when compared with the control. Also putrescine at 2 or 3 mmol L−1 sprayed 10 days before harvesting of peach fruits registered lower average of total sugars at the end of storage (Baljit and Jawandha 2014).

8. Respiration rate (mg CO2/kg/h.):

Data of Table 8 showed that, in general, fruit respiration rate was increased with the increase of storage time compared with harvest date. However, fruit respiration rate was reduced in descending order from 2 to 4 mM putrescine applications during all assessment intervals of storage with the two peach cvs. in the two seasons. The highest significantly respiration rate after was recorded with control compared the other PUT treatments during the two seasons with the two peach cvs. with a highly significant differences till the end of storage period, as it recorded 16.10 and 14.13 mg CO2/kg/h. with Florida Prince and 15.48 and 14.33 mg CO2/kg/h with Early Grande compared to 12.33 ; 10.42 and 11.5, 12.33 mg CO2/kg/h. at 4mM PUT treatment with the two cvs. in the two seasons, respectively However, the lowest values were noticed with 4 mM putrescine application in the both peach cvs. during the two seasons. The same trend was noticed after 28 days of storage in the both seasons and peach cultivar fruits.

The lowest respiration rate in putrescine treated fruits may be explained according to fruit respiration is considered as the major factor contributing to postharvest losses, it increasing the converts of stored sugars or starch into energy in the presence of the O2 and advances ripening (Day, 1990). Reduced fruit respiration retards softening and slowed down ripening (Kader, 1986) and slowing ripening through increases putrescine penetration in fruits which may reduce ethylene production. This result agreed with exogenous polyamines treatments decreased respiration rate in apricot (Martinez-Romero et al., 2002) and plum (Chen and Zhu, 2011). (Koushesla Saba et al.,2012), who reported positive effect of polyamines on reducing ethylene biothynthesis, which is the main trigger of ripening process by inhibiting ACC synthase and conversion of ACC to ethylene.

Table 7: Effect of putrescine postharvest applications on total sugars of Florida Prince and Early Grande peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Total sugars (%)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	7.83a	9.23a	10.46a	11.80a	12.40a	10.34a	8.13a	9.75a	11.16a	11.67a	12.21a	10.58a
2 mM	7.93a	8.87b	10.13b	11.43b	11.60b	9.99b	7.98a	8.32b	10.45b	10.94b	11.13b	9.76b
3 mM	8.06a	8.50c	10.03b	11.33b	11.53b	9.89b	8.15a	8.35b	9.64 c	10.85b	11.15b	9.63b
4 mM	7.73a	8.33c	9.33c	10.50c	11.07c	9.39c	8.17 a	8.23b	9.44 c	10.43c	11.18b	9.49b
Mean	7.89e	8.73d	9.99c	11.27b	11.65a		8.11e	8.66d	10.17c	10.97b	11.42a	
Early Grande												
Control	7.45a	9.13a	10.13a	10.95a	12.42 a	10.02a	8.15a	9.72a	0.39a	1.43a	2.52a	10.44a
2 mM	7.30a	8.90 b	9.90 b	10.20b	11.33b	9.53b	7.89a	8.51b	.66b	0.46b	1.45b	9.59b
3 mM	7.38a	8.65 c	9.18c	10.28b	11.37b	9.37b	8.17 a	8.56b	.63b	0.32b	1.15c	9.57b
4 mM	7.53 a	8.05d	8.55 d	9.03 c	10.38c	8.71c	7.97a	8.48c	.12 c	).54 c	0.25d	9.07c
Mean	7.42e	8.68d	9.44c	10.12b	1.38a		8.05e	.82d	.70c	0.44b	1.34a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT

Table 8: Effect of putrescine postharvest applications on Respiration rate of Florida Prince and Early Grande Peach cvs. fruits during cold storage at 0 – 1 C° and 90-95 RH. in 2014 and 2015 seasons.

Treat.	Respiration rate (mg/kg)											
	2014						2015					
	Storage periods						Storage periods					
	0 d	7 d	14 d	21 d	28 d	Mean	0 d	7 d	14 d	21 d	28 d	Mean
Florida prince												
Control	8.80 a	12.10 a	13.20 a	15.47 a	16.10 a	13.13 a	7.55 a	10.47 a	12.27 a	13.26 a	14.13 a	11.54 a
2 mM	8.77 a	10.40 b	12.57 b	13.46 b	14.13 b	11.87 b	7.47 a	8.85 b	9.24 b	11.24 b	12.35 b	9.83 b
3 mM	8.76 a	9.87 c	11.50 c	12.13 c	13.26 c	11.10 c	7.51 a	8.43 c	9.12 c	10.42 c	11.18 c	9.33 c
4 mM	8.68 a	9.10 d	10.20 d	11.53 d	12.33 d	10.37 d	7.63 a	8.23 c	8.72 d	9.77 d	10.42 d	8.95 d
Mean	8.75 e	10.37 d	11.87 c	13.14 b	13.96 a		7.54 e	9.00d	9.84 c	11.17 b	12.02 a	
Early Grande												
Control	10.45a	12.25a	13.20a	14.57a	15.48a	13.19a	8.53a	10.75a	11.73a	13.48a	14.33a	11.76a
2 mM	10.58a	11.42b	12.05b	12.73b	14.07b	12.17b	8.63a	9.75b	10.49b	11.43b	12.58b	10.58b
3 mM	10.50a	10.95c	11.42c	12.08c	12.65c	11.52c	8.48a	9.25c	10.02c	11.08c	12.25c	10.22c
4 mM	10.53a	10.95c	11.14c	11.35d	11.50d	11.09d	8.51a	9.14c	10.00c	11.02c	12.33c	10.20c
Mean	10.52e	11.39d	11.95c	12.68b	13.43a		8.54e	9.72d	10.56c	11.75b	12.87a	

In a column under each cultivar numbers flowed by the same litter are not significant at 5% by DMRT.

CONCLUSION

The present study showed that putrescine treatments especially at 4 mM/l was more effective to control chilling injury and decaying in Florida prince and Early Grande peach fruit cvs. and could delay the ripening process by inhibiting respiration rate. This treatment can be easily used as postharvest procedure to keep peach quality, storability and extending postharvest fruit life .

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الملخص العربي

تاثير البيوترسين على جودة ثمار الخوخ صنفى فلوريدا برنس و ايرلى جراند خلال التخزين المبرد

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أجريت معاملات البيوترسين بعد الحصاد على ثمار كلا صنفى خوخ الفلوريدا برنس والإيرلى جراند خلال موسمى ٢٠١٥ و٢٠١٦ وذلك لدراسة تأثير غمس الثمار فى محاليل البيوترسين على القدرة التخزينية لثمار كلا الصنفين. جمعت ثمار كلا الصنفين المستخدمة في هذه الدراسة من أشجار مزرعة خاصة عمر حوالى ١٢ سنة مطعومة علي أصل النيما جارد منزرعة على مسافات ٤ م نامية فى أرض رملية بمنطقة النوبارية بمحافظة البحيرة. جمعت ثمار كلا الصنفين فى مرحلة إكتمال النمو التسويقى وغمرت فى محاليل البيوترسين بتركيزات ٢ و٣ و٤ مللى مول لمدة ٥ دقائق بالإضافة إلى معاملة الماء العادى (الكنترول). قدرت صفات جودة ثمار كلا الصنفين والمخزنة علي درجة حرارة صفر – ١ °م ورطوبة نسبية من ٩٠ – ٩٥% والتغيرات فيها خلال ٢٨ يوم تخزين من فقد الوزن ونسبة التلف وأضرار البرودة ونسبة المواد الصلبة الذائبة الكلية ونسبة الحموضة وصلابة الثمار ومعدل التنفس ونسبة السكريات وذلك بداية من وقت الحصاد وأسبوعيا خلال فترة التخزين. أظهرت النتائج أن المعاملات بمحاليل البيوترسين حسنت من حياة الثمار فيما بعد الحصاد لكلا الصنفين عن طريق زيادة مقاومة الثمار للتلف وأضرار البرودة مقارنة بثمار الكنترول. الأكثر من ذلك فإن محاليل البيوترسين خفضت من الزيادة في نسبة فقد الوزن و المواد الصلبة الذائبة الكلية ومعدل التنفس والسكريات الكلية والمحافظة علي حموضة وصلابة الثمار خلال فترة التخزين لكلا الصنفين خلال موسمى الدراسة. كانت المعاملة بالبيوترسين بتركيز ٤ مللى مول الأكثر تأثيرا فى هذا المجال مقارنة بالتركيزات الأخري من البيوترسين وكذلك الكنترول لكلا الصنفين. وعلى ذلك فإنه يمكن المحافظة الجودة والقدرة التخزينية لثمار الخوخ بمعاملات البيوترسين وذلك لمقدرتها على تأخير عمليات النضج وإطالة فترة حياة الثمار بعد الحصاد.