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Pre and Postharvest Treatments to Improve Ponkan Mandarin Fruit Quality
2. Extending Shelf Life of Fruits under Room Temperature Conditions

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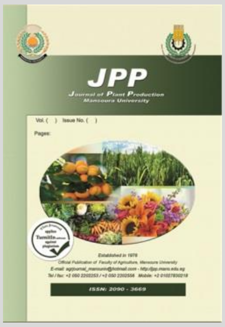

ABSTRACT

The present study was intended to find a treatment that maintains the quality of the Ponkan mandarin fruits (*Citrus reticulata*, Blanco) and extends the marketing period under the room conditions. So, nine treatments were arranged in a complete randomized design of three replicates to study the effect of pre-harvest application of putrescine at 0 , 50 and 100 ppm and post- harvested application of salicylic acid at 0 , 200 and 400 ppm, alone or in combinations on fruit characteristics of Ponkan mandarin during storage under room temperature conditions. The obtained results revealed that, salicylic acid and putrescine applications reduced the weight loss (%) and fruit decay (%) and maintained fruit quality in terms of fruit firmness, SSC (%), acidity, SSC/acid ratio and vitamin C during storage at room conditions. Moreover, pre-harvest application of putrescine at 50 ppm plus post-harvest dipping of salicylic acid at 200 ppm or 400ppm (T_6 and T_7) were able to maintain fruits with acceptable qualities and good appearance during storage under room conditions. So, it can be concluded that using 400 ppm salicylic acid as post- harvest application, alone or in combination with 50 ppm putrescine as pre-harvest application is a beneficial treatment to increase the shelf life period of Ponkan mandarin fruits during short term storage.

Keywords: putrescine, salicylic acid, Ponkan, mandarin, fruit quality.

INTRODUCTION

Ponkan mandarin (*Citrus reticulata*, Blanco) is a leading variety of mandarin cultivated in Egypt due to its high productivity and early yield. Fruits have a high nutritive value such as vitamin C and A as well as it contains small amounts of vitamin B_6, carbohydrates and proteins (Yehia *et al.*, 2009 and Ennab, 2017). Despite its attributes and commercial importance, Ponkan cannot be sustained for long period owing to its poor shelf life. It's known that, the mandarin fruit is often subjected to enormous losses from orchards to consumers which causing significant economic loss for growers and retailers (Obenland *et al.*, 2011). Pre and postharvest applications of salicylic acid and putrescine have extended the shelf life of many fruits through their effects on maintenance of cell wall structure and firmness, and reducing respiration rates, protein breakdown and decay (Serrano *et al.*, 2003; Zheng and Zhang, 2004; Wang and Li, 2008; Davarynejad *et al.*, 2015; Zhu *et al.*, 2016; Abbasi *et al.*, 2017 and Al Barzinji *et al.*, 2017).

So, the present study was designed to study the effect of pre-harvest application of putrescine at 50 and 100 ppm, and post-harvest application of salicylic acid at 200 and 400 ppm individually or in combinations on fruit properties during storage under room temperature conditions.

MATERIALS AND METHODS

This study was conducted during 2017 and 2018 seasons on 10 years old Ponkan mandarin trees (*Citrus reticulata*, Blanco), budded on Volkamer lemon (*Citrus volkameriana* Ten and Pasq) rootstock, planted at 3.5 × 3.5 meters apart in the experimental farm of Faculty of Agriculture, Kafr El-Sheikh University, Kafr El-Sheikh governorate, Egypt. Trees are grown in clay soil under flood irrigation system. Fifteen vigorous and uniform in growth trees were selected and divided into three groups, each group was sprayed ten days before harvest date with one of the following solutions: distill water (control), putrescine at 50 and 100 ppm. Pre-harvest spray with putrascine was carried out at ten days before harvest. Harvesting of fruits was done 14^{th} and 20^{th} October in the two seasons, respectively. A fruits sample similar in size, color and free from physical injuries and insect attack was randomly taken from each treatment and directly transported to the laboratory of Sakha Horticulture Research Station. The fruit of each group were divided into three sub group. Fruits were cleaned and dipped for 5 minutes in the different concentrations of salicylic acid solution or distilled water (control). Salicylic acid(SA) was prepared, by dissolving SA powder in ethanol alcohol 1% (v/v).The experiment was layout in randomized complete block design with nine treatments as follows:

Abbreviations	Pre-harvest treatments (Spraying)		Post-harvest treatments (Fruit dipping)
T_1(Cont.)	Distilled water	+	Distilled water
T_2	Distilled water	+	Salicylic acid at 200ppm
T_3	Distilled water	+	Salicylic acid at 400ppm
T_4	Putrascine at 50ppm	+	Distilled water
T_5	Putrascine at 100ppm	+	Distilled water
T_6	Putrascine at 50ppm	+	Salicylic acid at 200ppm
T_7	Putrascine at 50ppm	+	Salicylic acid at 400ppm
T_8	Putrascine at 100ppm	+	Salicylic acid at 200ppm
T_9	Putrascine at 100ppm	+	Salicylic acid at 400ppm

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Treated fruits were divided into two groups; the first one was used to achieve the initial quality parameters at the picking date. However, the second one was packed in 40 x25 x15 cm dimensions carton boxes. Each treatment was represented by three carton boxes for each date. Each carton box contains 2kg of mandarin fruits. All boxes were stored at room temperature 21±1 °C and 60 ± 5 % RH for 36 days

During the storage period, the variables were measured at 12 day intervals as follow:

1. **Fruit weight loss (%):**

All fruits were weighed and labeled at zero time (beginning) and 12 days intervals during the storage period. Fruit weight was recorded, then the percentages of weight loss were calculated according to the following equation:

Fruit weight loss %= $(W_I - W_S) / W_I \times 100$

Where, W_I = fruit weight at zero time. **Ws** = fruit weight at sampling period.

2. **Fruits decay (%):**

The percentage of fruit decay was recorded at 12 day periodicals during the storage period and it was calculated according to the following equation:

$$\text{Decay } \% = \frac{\text{Number of decayed fruits}}{\text{Initial number of stored fruits}}\ x\ 100$$

3. **Fruit firmness:**

Fruit firmness was examined in two sides of the fruit using a pressure tester (Model FT 011 USA) and expressed as force Newton according to Reyes and Paull, (1995).

4. **Soluble solids content (SSC%):** It was determined using a hand refractometer according to A.O.A.C. (1995).
5. **Titratable acidity (%):**

It was estimated by titrating against standard alkali solution (0.1N NaOH) using the phenolphthalein indicator and expressed as percentage of citric acid/100 ml of juice according to (Ranganna, 1986).

6. **SSC/acid ratio:** SSC/acid ratio was estimated.
7. **Ascorbic acid content:**

Ascorbic acid concentration (vitamin C) in fruit juice was determined by using 2,6- dichlorophenol indophenol solution as described by (A.O.A.C., 1995). Vitamin C content was calculated as mg / 100 ml juice.

8. **Pectin methylesterase activity (PME):**

It was determined as described by Anthon and Barrett (2006).

9. **Statistical analysis:**

The experiment treatments were arranged in randomized complete block design with three replicates, and the data were analyzed of variance according to Snedecor and Cochran (1980). The treatment means were compared using Duncan's multiple range test DMRT (Duncan, 1955).

RESULTS AND DISCUSSION

1. Weight loss (%)

The results presented in Table (1) show that all treatments reduced the percentage of fruit weight loss during storage under the room conditions compared to control in both seasons. The best treatment in this respect was the combination between pre-harvest foliar application with putrescine at 50 ppm and post-harvest dipping in salicylic acid solution at 400 ppm (T_7) followed by fruits dipping in salicylic acid solution at 400 ppm solely (T_3).

On the other hand, control treatment (T_1) showed the highest percentage of fruit weight loss compared with the other treatments in both seasons. This result is in harmony with that of Ali *et al.,* (2014); Khosroshahi and Esna-Ashari (2008) and *Lu et al.,* (2011) In this respect, Amanullah *et al.,* (2017) revealed that, salicylic acid applications reduced the weight loss of pineapple and peach fruits during storage and maintaining fruit quality.

Table 1. Impact of putrescine and salicylic acid on weight loss (%) of Ponkan mandarin fruits stored under room temperature conditions during 2017 and 2018seasons

Treatments	2017 season				
	0 day	**12 day**	**24 day**	**36 day**	**Mean**
T_1 :Control	0.00	7.56 a	12.95 a	18.35 a	9.71 a
T_2 :SA 200 ppm	0.00	5.68 cd	10.53 cd	13.97 b	7.55 cd
T_3 :SA 400 ppm	0.00	5.45 d	10.30 d	13.72 b	7.37 d
T_4: Put. 50 ppm	0.00	6.17 b	11.58 b	15.00 b	8.19 b
T_5: Put. 100 ppm	0.00	5.93 bc	11.05 bc	14.66 b	7.91 bc
T_6 : Put.50+ SA 200	0.00	5.86 c	10.90 cd	14.21 b	7.74 cd
T_7 : Put.50+ SA 400	0.00	5.14 e	8.94 e	11.60 c	6.42 e
T_8 : Put.100+SA 200	0.00	5.83 c	10.81 cd	14.09 b	7.68 cd
T_9 : Put.100+SA 400	0.00	5.86 c	10.91 cd	14.25 b	7.75 cd
Mean	0.00	5.94 c	10.89 b	14.43 a	--
	2018 season				
T_1 :Control	0.00	7.12 a	12.74 a	16.80 a	9.16 a
T_2 :SA 200 ppm	0.00	5.88 d	10.91 cd	14.08 bcd	7.72 c
T_3 :SA 400 ppm	0.00	5.86 d	10.25 de	13.39 d	7.38 d
T_4: Put. 50 ppm	0.00	6.96 b	11.93 ab	14.87 b	8.44 b
T_5: Put. 100 ppm	0.00	6.30 c	11.32 bc	14.33 bc	7.99 c
T_6 : Put.50+ SA 200	0.00	6.18 c	10.90 cd	13.85 cd	7.73 c
T_7 : Put.50+ SA 400	0.00	5.28 e	9.74 e	12.50 e	6.88 e
T_8 : Put.100+SA 200	0.00	5.96 d	11.09 bcd	14.29 bc	7.84 c
T_9 : Put.100+SA 400	0.00	6.00 d	11.11 bcd	14.64 bc	7.94 c
Mean	0.00	6.17 c	11.11 b	14.31 a	--

Means followed by the same letter within a column in same season are not significantly different using DMRT at $P \leq 0.05$

Moreover, Putrescine applications were effective in decreasing weight loss of Ponkan mandarin fruits (Zheng and Zhang 2004). This beneficial effect of salicylic acid and putrescine application might be ascribed to increasing fruit firmness which resulted in the decrease in both transpiration and respiration rate (Valero *et al.*, 1998).

2. Fruit decay (%)

Data presented in Table (2) clear that, increasing storage periods under room conditions increased the decay (%) of Ponkan mandarin fruits in both seasons. The results also indicated that the using treatments of pre-harvest putrescine spraying at 50 ppm plus post-harvest dipping in salicylic acid at 400 ppm (T_7), pre-harvest putrescine spraying at 100 ppm plus post-harvest fruits dipping in salicylic acid solution at 200 ppm (T_8), and pre-harvest putrescine spraying at 100 ppm plus post-harvest dipping in salicylic acid solution at 400 ppm (T_9) resulted in a significant decrease in decay (%) compared with control. Similar results were obtained by Amanullah *et al.*, (2017) and Bassiony *et al.*, (2018). This beneficial effect of putrescine and salicylic acid application on decreasing fruit decay percentages might be due to the effects on increasing fruit firmness, delaying senescence and inducing an increase of phenolic compounds which play the important defence against microorganism's attack of fruits (Bregoli *et al.,* 2002 and Mirdehghan *et al.,* 2013).

Table 2. Impact of putrescine and salicylic acid on decay (%) of Ponkan mandarin fruits stored at room temperature conditions during 2017 and 2018seasons

Treatments	2017 season				
	0 day	**12 day**	**24 day**	**36 day**	**Mean**
T_1 :Control	0.00	3.22 a	5.00 a	6.68 a	3.73 a
T_2 :SA 200 ppm	0.00	2.42 d	4.04 d	5.63 d	3.02 d
T_3 :SA 400 ppm	0.00	2.18 e	3.72 e	5.55 e	2.86 e
T_4: Put. 50 ppm	0.00	3.07 b	4.72 b	6.35 b	3.54 b
T_5: Put. 100 ppm	0.00	2.71 c	4.33 c	5.97 c	3.25 c
T_6 : Put.50+ SA 200	0.00	2.10 f	3.70 ef	5.37 f	2.79 f
T_7 : Put.50+ SA 400	0.00	2.03 f	3.65 fg	5.21 g	2.72 g
T_8 : Put.100+SA 200	0.00	1.90 g	3.60 g	5.21 g	2.68 g
T_9 : Put.100+SA 400	0.00	1.80 h	3.50 h	5.12 h	2.61 h
Mean	0.00	2.38 c	4.03 b	5.68	--
	2018 season				
T_1 :Control	0.00	2.95 a	4.42 b	6.62 a	3.50 a
T_2 :SA 200 ppm	0.00	2.52 d	4.17 d	5.77 d	3.12 d
T_3 :SA 400 ppm	0.00	1.98 e	3.85 e	5.52 e	2.84 g
T_4: Put. 50 ppm	0.00	2.72 b	4.50 a	6.28 b	3.38 b
T_5: Put. 100 ppm	0.00	2.58 c	4.29 c	5.95 c	3.21 c
T_6 : Put.50+ SA 200	0.00	1.80 f	3.63 f	5.38 f	2.70 e
T_7 : Put.50+ SA 400	0.00	1.73 g	3.42 h	5.18 g	2.58 e
T_8 : Put.100+SA 200	0.00	1.72 gh	3.51 g	5.10 h	2.58 e
T_9 : Put.100+SA 400	0.00	1.67 h	3.35 i	4.97 i	2.50 f
Mean	0.00	2.19 c	3.90 b	5.64 a	--

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$.

3. Fruit firmness (Newton):

Results presented in Table (3) indicate that, firmness of Ponkan mandarin fruits decreased gradually as storage period progressed. Also, the highest fruit firmness was observed in fruits treated with pre-harvest putrescine spraying at 50 ppm and post-harvest salicylic acid dipping at 400 ppm (T_7), followed by T_3 and T_8 in both seasons, respectively. Whereas, the lowest firmness of fruit was observed in control (T_1).

Putrescine and salicylic acid applications showed to be effective in retarding the ripening and firmness of banana (Srivastava and Dwivedi, 2000) and kiwifruit (Zhang *et al.,* 2003). In this respect, Mirdehghan *et al.*, (2013) reported that the dipping application of salicylic acid was most effective in reducing chilling injury and significantly maintained higher fruit firmness in guava as compared with untreated controls. Bal, (2013) investigated that there is a significant increase in anthocyanin content and flesh firmness of peach fruits with application of polyamines. Therefore, Pre and post-harvest treatment of putrescine and salicylic acid maintained fruit firmness and delayed ripening during storage. Such conclusion was reported by Malik *et al.,* (2005), Ali *et al.,* (2014) and Abbasi *et al.,* (2017).

4. Soluble solids content (SSC%):

The results presented Table (4) show that in general, the percentage of soluble solids content was increased by increasing the storage period under room conditions. The highest values of SSC% during storage at room conditions come from the control compared with other tested treatments. A similar trend was observed by Obenland *et al.*, (2011). At start of the storage period, the fruits treated by post-harvest dipping in salicylic acid at 400 and 200 ppm (T_3 and T_2) or in combination (T_7, T_8 and T_9) gave the lowest values of SSC% in fruits juice compared with other treatments.

These results are agree with the findings of Lo'ay, (2017) who showed that, application of salicylic acid at 4 mM maintained total solids content (SSC%) during shelf life and was effective in delaying cluster ripening of 'Superior seedless' grapes. Also, Champa *et al.* (2015) reported that, "Flame Seedless" grape berries treated with putrescine showed the lowest SSC% as compared with control during 60 days of cold storage. These were due to the role of salicylic acid in maintaining the lowest metabolic activity and reduce ethylene production which reflected on delaying the fruits ripening process during storage (Srivastava and Dwivedi, 2000 and Davarynejad *et al.*, 2015).

Table 3. Impact of putrescine and salicylic on firmness (Newton) of Ponkan mandarin fruits stored under room temperature conditions during 2017 and 2018 seasons

Treatments	2017 season				
	0 day	**12 day**	**24 day**	**36 day**	**Mean**
T_1 :Control	18.22 ab	12.56 h	9.72 f	7.86 e	12.09 f
T_2 :SA 200 ppm	17.85 ab	15.08 d	13.38 c	11.56 b	14.47 ab
T_3 :SA 400 ppm	18.43 a	15.76 b	13.72 b	11.89 b	14.95 a
T_4: Put. 50 ppm	18.61 a	13.39 g	12.35e	9.43 d	13.45 e
T_5: Put. 100 ppm	18.77 a	13.52 g	12.73 d	10.18 cd	13.80 de
T_6 : Put.50+ SA 200	17.23 ab	13.90 f	13.29 c	11.05 bc	13.87 cde
T_7 : Put.50+ SA 400	16.32 b	16.12 a	14.23 a	13.30 a	14.99 a
T_8 : Put.100+SA 200	16.82 ab	15.42 c	13.92 ab	11.24 b	14.35 bc
T_9 : Put.100+SA 400	17.85 ab	14.39 e	12.62 de	11.09 bc	13.99 bcd
Mean	17.79 a	14.46 b	12.88 c	10.84d	--
	2018 season				
T_1 :Control	17.88ab	11.98h	9.97i	7.66i	11.88f
T_2 :SA 200 ppm	17.09ab	14.49c	13.07d	10.67e	13.83c
T_3 :SA 400 ppm	17.00ab	15.25a	13.45b	11.57b	14.32b
T_4: Put. 50 ppm	18.27ab	12.37g	10.28h	9.10h	12.50e
T_5: Put. 100 ppm	18.38a	13.09f	11.33g	9.29g	13.02d
T_6 : Put.50+ SA 200	16.63b	13.76e	12.48f	10.46f	13.33d
T_7 : Put.50+ SA 400	17.57ab	15.24a	13.90a	12.34a	14.76a
T_8 : Put.100+SA 200	16.81ab	14.61b	13.24c	11.39c	14.01bc
T_9 : Put.100+SA 400	17.75ab	14.25d	12.75e	11.17d	13.98bc
Mean	17.49a	13.89b	12.28c	10.41d	--

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$.

Table 4. Impact of putrescine and salicylic acid on SSC (%) of Ponkan mandarin fruits stored under room temperature conditions during 2017 and 2018 seasons

Treatments	2017 season				
	0 day	**12 day**	**24 day**	**36 day**	**Mean**
T_1 :Control	9.73b	12.11a	13.25a	13.33a	12.10a
T_2 :SA 200 ppm	9.94a	11.69e	12.16e	12.72f	11.63f
T_3 :SA 400 ppm	9.88a	11.14f	12.01f	12.53g	11.39g
T_4: Put. 50 ppm	9.78b	12.07b	12.73b	13.09b	11.92b
T_5: Put. 100 ppm	9.49c	12.03c	12.61c	13.04 c	11.79c
T_6 : Put.50+ SA 200	9.51c	11.90d	12.29d	13.00d	11.68e
T_7 : Put.50+ SA 400	9.93a	10.97g	11.81g	12.47h	11.30h
T_8 : Put.100+SA 200	9.95a	11.70e	12.13e	12.94e	11.68e
T_9 : Put.100+SA 400	9.90a	11.70 e	12.22de	13.06c	11.72d
Mean	9.79d	11.70c	12.36b	12.91a	--
	2018 season				
T_1 :Control	9.14b	12.05a	12.63a	12.69a	11.63a
T_2 :SA 200 ppm	9.15b	11.43e	11.68de	12.24d	11.12fg
T_3 :SA 400 ppm	9.29a	11.27g	11.61e	12.13e	11.07g
T_4: Put. 50 ppm	9.12b	12.00b	12.28ab	12.67a	11.51b
T_5: Put. 100 ppm	9.16b	11.81c	12.20b	12.41b	11.40c
T_6 : Put.50+ SA 200	9.17b	11.48d	12.13bc	12.31c	11.27d
T_7 : Put.50+ SA 400	9.28a	11.01h	11.48e	12.07f	10.96h
T_8 : Put.100+SA 200	9.28a	11.32f	11.80cde	12.27cd	11.17ef
T_9 : Put.100+SA 400	9.15b	11.42e	12.02bcd	12.28cd	11.22de
Mean	9.19d	11.53c	11.98b	12.34a	--

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$.

5. Titratable acidity

Data presented in Table (5) reveale that all treatments slightly increased titratable acidity in mandarin fruits during storage period compared with control. In addition titratable acidity values were gradually decreased with increasing storage period at room conditions in both seasons. On the other hand, the post-harvest dipping in 200 and 400 ppm salicylic acid individually or in combination with putrescine at 50 ppm (T_2, T_3 and T_7) resulted in a significant increase in fruit juice acidity during storage under room conditions compared with other treatments. These results were similar with those reported by Ali *et al.*, (2014) and Bassiony *et al.*, (2018). This means more decomposition of organic contents in the untreated stored fruits. In addition, the major organic acids in citrus fruits are oxalic, tartaric, malic, lactic, citric, ascorbic, whereas, citric acids account for the most abundant acid of the total acid constituents of the juice. As the fruits ripening developed, a reduction in titratable acidity is observed. The decreasing in acid content was due to its use as a source of energy and the conversion of organic acids to form sugar (Burton, 1985).

Table 5. Impact of putrescine and salicylic acid on acidity (%) of Ponkan mandarin fruits stored under room temperature conditions during 2017 and 2018 seasons

Treatments	0 day	12 day	24 day	36 day	Mean
	2017 season				
T_1 :Control	1.23a	1.02c	0.91d	0.85a	1.00e
T_2 :SA 200 ppm	1.22a	1.11a	1.04a	0.90a	1.07ab
T_3 :SA 400 ppm	1.25a	1.10ab	1.01ab	0.88a	1.06abc
T_4: Put. 50 ppm	1.28a	1.02c	0.92cd	0.86a	1.02de
T_5: Put. 100 ppm	1.29a	1.03c	0.95bcd	0.86a	1.03cd
T_6 : Put.50+ SA 200	1.26a	1.04c	0.97bc	0.87a	1.04cd
T_7 : Put.50+ SA 400	1.24a	1.12a	1.05a	0.90a	1.08a
T_8 : Put.100+SA 200	1.27a	1.07abc	0.98bc	0.88a	1.05bc
T_9 : Put.100+SA 400	1.25a	1.05bc	0.96bcd	0.87a	1.03cd
Mean	1.26a	1.06b	0.98c	0.87d	--
	2018 season				
T_1 :Control	1.26a	1.09d	0.93e	0.84e	1.03c
T_2 :SA 200 ppm	1.27a	1.15b	1.01b	0.90b	1.08ab
T_3 :SA 400 ppm	1.29a	1.18a	1.00b	0.90b	1.09ab
T_4: Put. 50 ppm	1.32a	1.09d	0.95d	0.85de	1.05bc
T_5: Put. 100 ppm	1.33a	1.11c	0.97c	0.86d	1.07bc
T_6 : Put.50+ SA 200	1.30a	1.14b	0.97c	0.88c	1.07ab
T_7 : Put.50+ SA 400	1.28a	1.19a	1.05a	0.92a	1.11a
T_8 : Put.100+SA 200	1.31a	1.14b	0.98c	0.90b	1.08ab
T_9 : Put.100+SA 400	1.29a	1.12c	0.98c	0.88c	1.07bc
Mean	1.29a	1.14b	0.98c	0.88d	--

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$.

6. SSC/acid ratio:

The results presented in Table (6) reveale that as the storage period progressed, the SSC/acid ratio significantly increased. Also, the values of SSC/acid ratio were significantly affected by salicylic acid, putrescine and their combinations specially spraying fruits with putrescine at 50 ppm plus dipping in salicylic acid at 400 ppm (T_7) .Meanwhile, T_2 and T_3 recorded the lowest values in this respect So, salicylic acid was more effective as a postharvest treatment in changing of SSC/acid ratio values during ambient storage. The increment in SSC/acid ratio during the storage period may be due to increasing of SSC content and the reduction in total acidity in fruit juice as the storage period was advanced. The obtained results were in the same line with those reported by Khademi and Ershadi (2013) and Amanullah *et al.*, (2017).

Table 6. Impact of putrescine and salicylic acid on SSC/acid ratio of Ponkan mandarin fruits stored under room temperature conditions during 2017 and 2018seasons

Treatments	0 day	12 day	24 day	36 day	Mean
	2017 season				
T_1 :Control	7.91ab	11.87a	14.41a	15.68a	12.47a
T_2 :SA 200 ppm	8.15a	10.53de	12.00e	14.10cd	11.20ef
T_3 :SA 400 ppm	7.92ab	10.12ef	12.02e	14.24cd	11.08f
T_4: Put. 50 ppm	7.64ab	11.84a	13.54b	15.21ab	12.06b
T_5: Put. 100 ppm	7.34b	11.67ab	13.09bc	15.18ab	11.82bc
T_6 : Put.50+ SA 200	7.59ab	11.46abc	12.29de	14.95b	11.57cd
T_7 : Put.50+ SA 400	8.01a	9.76f	11.24f	13.85d	10.72g
T_8 : Put.100+SA 200	7.85ab	10.93cd	12.33de	14.71bc	11.46de
T_9 : Put.100+SA 400	7.92ab	11.15bc	12.73cd	15.01ab	11.71cd
Mean	7.81d	11.04c	12.63b	14.77a	--
	2018 season				
T_1 :Control	7.25a	11.02a	13.22a	15.10a	11.65a
T_2 :SA 200 ppm	7.20a	9.93c	11.56e	13.59de	10.57d
T_3 :SA 400 ppm	7.20a	9.55d	11.61e	13.48e	10.46d
T_4: Put. 50 ppm	6.93a	11.01a	12.92ab	14.88a	11.44a
T_5: Put. 100 ppm	6.91a	10.64b	12.57bc	14.43b	11.14b
T_6 : Put.50+ SA 200	7.05a	10.07c	12.50bc	13.98c	10.90c
T_7 : Put.50+ SA 400	7.25a	9.25e	10.93f	13.12f	10.14e
T_8 : Put.100+SA 200	7.12a	9.93c	12.02de	13.63cde	10.68cd
T_9 : Put.100+SA 400	7.13a	10.19c	12.27cd	13.95cd	10.89c
Mean	7.12d	10.18c	12.18b	14.02a	--

Means followed by the same letter within a column are not significantly different using DMRT at $P \leq 0.05$.

7. Vitamin C content:

Data presented in Table (7) showed that, vitamin C content of Ponkan mandarin fruits stored under room conditions, decreased gradually as storage period was prolonged. Moreover, most of the tested treatments maintained the higher concentration of vitamin C in fruit juice than the control during storage periods up to 36 days. In this respect, the highest ascorbic acid content was observed in treatment of pre-harvest application of putrescine at 50 ppm plus post-harvest application of salicylic acid solution at 400 ppm (T_7), whereas, control treatment had lower value of ascorbic acid compared to other treatments in both seasons. So, it can be concluded that pre and postharvest application of putrescine at 50 ppm and salicylic acid at 400 ppm were most effective in preventing ascorbic acid losses from fruits during storage under room conditions. The same trend was also observed in the previous studies by Orabi *et al.,* (2018) and Abo-Mostafa *et al.,* (2019).

Table 7. Impact of putrescine and salicylic acid on vitamin C content of Ponkan mandarin fruits stored under room temperature conditios during 2017 and 2018 seasons

Treatments	2017 season				
	0 day	**12 day**	**24 day**	**36 day**	**Mean**
T_1 :Control	34.73i	30.28c	26.86b	23.21d	28.77e
T_2 :SA 200 ppm	37.62c	33.45ab	29.45ab	25.54abc	31.51ab
T_3 :SA 400 ppm	37.83b	33.65ab	29.55ab	25.80ab	31.71ab
T_4: Put. 50 ppm	36.44h	32.42b	27.35ab	23.65d	29.96d
T_5: Put. 100 ppm	36.65g	32.52ab	27.40ab	23.72d	30.07d
T_6 : Put.50+ SA 200	36.70f	32.98ab	27.90ab	23.75d	30.33cd
T_7 : Put.50+ SA 400	38.08a	33.96a	29.95a	26.36a	32.09a
T_8 : Put.100+SA 200	36.99d	33.49ab	28.40ab	25.24bc	31.03bc
T_9 : Put.100+SA 400	36.73e	32.93ab	27.89ab	24.75c	30.57cd
Mean	36.86a	32.85b	28.31c	24.67d	--
	2018 season				
T_1 :Control	35.20i	31.17f	27.84a	23.37d	29.40f
T_2 :SA 200 ppm	38.10c	34.93bc	29.39a	26.36a	32.20b
T_3 :SA 400 ppm	38.42b	35.70ab	29.44a	26.46a	32.51ab
T_4: Put. 50 ppm	35.70h	33.40e	27.98a	23.88cd	30.24e
T_5: Put. 100 ppm	36.00g	33.88de	28.36a	24.30cd	30.64de
T_6 : Put.50+ SA 200	36.77f	34.42cde	28.40a	24.43bc	31.01cd
T_7 : Put.50+ SA 400	38.76a	36.48a	29.65a	26.97a	32.97a
T_8 : Put.100+SA 200	37.18d	34.42cde	28.88a	25.40b	31.47c
T_9 : Put.100+SA 400	37.00e	34.45cd	28.87a	24.81bc	31.28c
Mean	37.01a	34.32b	28.76c	25.11d	--

Means followed by the same letter within a column are not significantly different using DMRT at *P* ≤0.05.

8. Pectin Methylesterase activity (PME):

Pectin methyl esterase activity was increased progressively with increasing in storage period (Fig. 1).

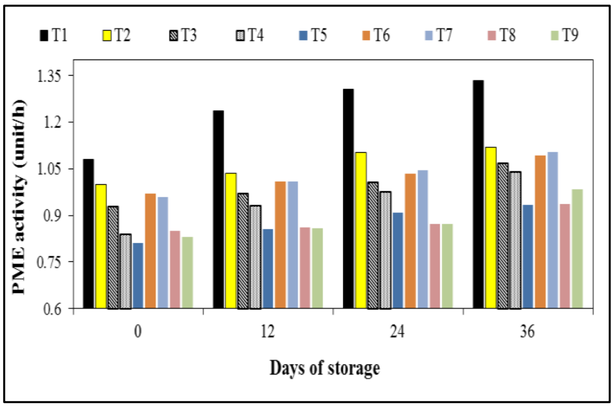

Fig. 1. Impact of putrescine and salicylic acid on pectin methyl esterase activity (PME) of Ponkan mandarin fruits stored under room temperature (average of 2017 and 2018 seasons)..

PME is responsible for desertification of pectin compound and its activity increased as the storage period increased. So, increased activity of PME resulted in cell wall softening in Ponkan fruits. A continuous increase in PME activity during storage was reported by Goulao *et al.,* (2007) on Apple, Carvalho *et al.,* (2009) on Guava and Ahlawat *et al.,* (2018) on Kinnow mandarin. Pre and postharvest treatments of putrescine and salicylic acid increased PME activity but the level of this increasing was less as compared with control. Minimum values of PME activity was observed with T_7, T_8 and T_9 but the highest values were found in control. This may be due to the suppression of the enzymatic activity of pectin methyl esterase by this treatments. Similar results were reported by Majeed (2014), Champa *et al.,* (2015) and Bassiony *et al.,* (2018).

CONCLUSION

Based on the obtained results from this study it can concluded that spraying Ponkan mandarin trees ten days before harvest with putrescine at 50 ppm as pre-harvest application plus dipping the harvested fruit in 400 ppm salicylic acid as post-harvest application which regarded the best treatment in the ability to reduce the potential loss after harvest and during storage, as well as maintaining the quality of stored fruits, by increasing the length of validity of fruits in the market and also create the opportunity for export to distant markets. As well as to increase the net income of farmers and producers of Ponkan mandarin.

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معاملات قبل وبعد الحصاد لتحسين صفات جودة ثمار اليوسفى بونكان أثناء التخزين
٢. زيادة فترة صلاحية الثمار فى درجة حرارة الغرفة

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تم اجراء هذه الدراسة لإيجاد معاملة تحافظ على جودة ثمار اليوسفى بونكان مع اطالة فترة التسويق في ظل ظروف الغرفة. لذلك ، تم توزيع تسعة معاملات في تصميم قطاعات كاملة العشوائية فى ثلاث مكررات لتقييم تأثير معاملات الرش ما قبل الجمع بمحلول البوتريسين بتركيز ٠ و ٥٠ و ١٠٠ جزء في المليون والغمر بعد الجمع في محلول حامض الساليسيليك بتركيز ٠ و ٢٠٠ و ٤٠٠ جزء في المليون لمدة ٥ دقائق ، بمفردها أو في توليفات على سلوك بعض خصائص الثمار الهامة لليوسفى صنف بونكان أثناء التخزين على درجة حرارة الغرفة (٢١±١°) كشفت النتائج التي تم الحصول عليها أن غمر الثمار فى حامض الساليسيليك والبوتريسين قللت من فقد الوزن وتدهور الثمار والمحافظة على جودة الثمار من حيث الصلابة ونسبة المواد الصلبة الذائبة٪ والحموضة ونسبة المواد الصلبة الذائبة / الحامض وفيتامين ج أثناء التخزين في ظروف الغرفة. علاوة على ذلك ، فإن معاملة الثمار بحامض الساليسيليك بمعدل ٢٠٠ و ٤٠٠ جزء في المليون بمفرده أو بالاشتراك مع البوتريسين بتركيز ٥٠ جزء في المليون قادرة على إنتاج ثمار تتمتع بصفات مقبولة أثناء فترة التخزين مقارنة بمعاملة الكنترول وغيرها من المعاملات . أفضل معاملة هى رش الاشجار قبل الجمع بمحلول البوتريسين عند ٥٠ جزء في المليون بالإضافة إلى غمر الثمار بعد الجمع في محلول حامض الساليسيليك عند ٤٠٠ جزء في المليون (المعاملة رقم ٧) للحفاظ على جودة الثمار أثناء التخزين على درجة حرارة الغرفة.لذلك ، يمكن الاستنتاج أن استخدام ٤٠٠ جزء من المليون من حامض الساليسيليك ، منفردا أو بالاشتراك مع ٥٠ جزء في المليون من البوتريسين ، يعد معاملة مفيدة لزيادة فترة حياة الرف لثمار اليوسفى صنف بونكان أثناء التخزين تحت ظروف الغرفة (٢١±١°).