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Preharvest Application of Salicylic Acid, Calcium Acetate and Proline for Improving Fruit Quality and Shelf Life of "Early Swelling" Peaches

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THE effects of preharvest foliar application of salicylic acid, calcium acetate and proline alone or in combinations on fruit quality and storability of "Early Sweet" peaches cultivar were investigated during 2020 and 2021 seasons. The results showed that preharvest application of all treatments increased fruit flesh firmness as compared with control treatment. Salicylic acid treatment increased fruit weight, size and diameter. Moreover, decreased total sugars and fruit weight loss after storage. The results also showed that, calcium acetate treatment enhanced physical and chemical properties of fruits especially fruit firmness before and after harvest. Proline treatment increased fruit weight, fruit diameter, flesh firmness, TSS, peel anthocyanin content and total sugars. Furthermore, decreased fruit acidity and weight loss after storage on room temperature. In conclusion, the results of the present study recommended using the combination of salicylic acid plus calcium acetate and proline to enhance fruit quality and shelf life of peaches.

Keywords: Quality, Peaches, Salicylic acid, Calcium acetate, Proline, Shelf life.

Introduction

"Early Swelling" peach cultivar is one of the important early cultivar in Egypt. It has a good appearance, high TSS, low acidity, high level of anthocyanin in the peel and good flavor. On the other hand, fruits have higher respiration rate, soft tissue and low storage ability. Under Egyptian conditions, farmers complain about the lack of firmness and short shelf life of the "Early swelling" peach cultivar. Salicylic acid (2-hydroxy benzoic acid) is safe, simple and natural plant phenolic compound plays many important physiological roles such as inhibit ethylene biosynthesis, delays fruit ripening, enhance flesh firmness, prolong postharvest life of fruits and increase fruit total antioxidant (Asghari and Aghdam, 2010, Tareen et al., 2012). Preharvest application of salicylic acid at 25 or 50 ppm during fruit development of "Canino" apricot fruits enhanced fruit quality parameters and fruit firmness at harvest (Attia, 2022). Calcium is one of the essential nutrient element for maintaining cell wall and membrane structure and function,

decreasing respiration rate, ethylene synthesis, protein breakdown and fruit weight loss (Faust & shear, 1972 and Abrol et al., 2017). Preharvest application of calcium plays an important role in keeping quality of soft fruit and vegetable crops (Huber, 1983). Preharvest application of calcium during fruit growth of "Thompson seedless" and "Anna" apples maintained fruit quality at harvest and during storage (Attia and Farag, 2017, Farag and Attia, 2018). Proline is safe, natural and environmentally friendly amino acid which naturally rises under undesirable environmental conditions. Proline plays an important role in maintaining the structure and function of enzymes and membrane (Kumar et al., 2010: Trovato et al., 2019). Preharvest foliar application of proline at 15 mM on "Maleiki" peaches maintained nutritional quality and storability of fruits (Gohari et al., 2021). Thus, the aim of this experiment was to investigate the effects of preharvest application of salicylic acid, calcium acetate and proline on fruit quality and storability of "Early Swelling" peaches cultivar.

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Material and Methods

Plant materials and preharvest treatments

The present experiment was carried out during 2020 and 2021 seasons at El Hamam region, Matrouh governorate, Egypt on seven years old "Early Swelling" peach trees (Prunus persica L) budded on nemagard rootstock. The soil was sandy and drip irrigation system was adopted. Trees were planted at $4 \times 5m$ spacing. The experiment was designed as a completely randomized blocks design (RCBD) with three replication in the field. The following foliar treatments were used: T1: control (water only). T2: salicylic acid at 50 ppm. T3: calcium acetate at 100 ppm. T4: proline at 50 ppm. T5: salicylic acid plus calcium acetate (T6: salicylic acid plus proline T7: salicylic acid plus calcium acetate and proline. All treatments were applied at three different stage times of fruit development (after fruit set, at pit hardening and at 15 days before harvesting), during 2020 and 2021 seasons, respectively.

Fruit physical and chemical quality analysis at harvest

At harvest time, (16 and 1 of June during 2020 and 2021 seasons, respectively). Ten fruits were harvested from each replicate to determine the following quality parameters: fruit firmness was measured as Ib/inch² using Effigi pressure tester (mod. FT 011). fruit size (cm³), fruit weight (g), flesh weight (g), stone weight (g), fruit diameter (cm), fruit length (cm), total soluble solids (TSS) in fruit juice were measured using hand refractometer, titratable acidity as maleic acid was determined according to A. O. A. C, (1985), TSS/ Acidity (ratio) was calculated, total sugars was extracted according to Egan et al. (1981) and measured according to Smith, (1956) and peel anthocyanin content was determined according to Fuleki and Francis (1968).

Assessment of fruit quality after three days of harvest on shelf

To investigate the effect of salicylic acid, calcium acetate and proline on fruit storability of "Early Swelling" peaches cultivar. Ten fruits from each replicate was kept at room condition $(20\pm 2C^0)$ for three days (to simulate shelf life), fruit firmness (Ib/inch²) and fruit weight loss (%) were determined.

Statistical analysis

The experiment was designed as a randomized completely blocks design (RCBD) with three replicate (7 treatments* 3 replicates). Data were subjected to analysis of variance (ANOVA) using the statistical program (SAS, 2000) with three replications. Treatments means were compared by LSD at 5 % level of probability according to Sendecor and Cochran (1980).

Results

Fruit firmness of "Earl Swelling" peaches is an important indication of fruit quality at harvest and during storage. Data in Table (1) illustrated clearly that "Early Swelling" peaches treated with calcium acetate, salicylic acid or in combinations increased fruit firmness as compared with control. Data also showed that all treatments increased fruit firmness as compared with control treatment. The highest value of fruit firmness was obtained with preharvest application of the combination contained salicylic acid, calcium acetate and proline (8.2 and 8.43) and the lowest value was obtained by control (6.13 and 6.26) during both seasons of study.

Data in Table (1) showed that fruit size, weight and flesh weight of "Early Swelling" peaches were increased significantly in treated fruits as compared with untreated fruits. The data of both seasons showed a significant increase in all determined properties by all preharvest treatments as compared with untreated (control). The maximum fruit size, weight and flesh weight were obtained by the combination of salicylic acid, calcium acetate and proline. A similar trend of results was obtained for stone weight in both seasons of study.

Data in Table (1) indicated that fruit diameter and length of "Early Swelling" peaches were increased in treated fruits in both seasons. Moreover, the highest value of fruit diameter and length were obtained by the combination contained salicylic acid, calcium acetate and proline in one formulation. The lowest value was obtained by control treatment.

Data in Table (2) indicated that the highest value of anthocyanin content was obtained by proline and control treatments in both seasons as compared with all other treatments. The lowest anthocyanin content was obtained by the combination contained salicylic acid, calcium acetate and proline.

Data in Table (2) showed that preharvest application of proline at 50ppm induced higher fruit total sugar and TSS in both seasons as compared with different treatments in both seasons of study. A similar trend of results was obtained for TSS in both seasons of study.

Treatments	Firmness (Ib/inch²)		Fruit Size (cm ³)		Fruit Weight (g)		Flesh weight (g)		Stone weight (g)		Fruit Diameter (cm)		Fruit Length (cm)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
*T1	**6.13d	6.26f	95.93f	98.73f	93.03f	95.10g	89.00f	90.87g	4.03e	4.75e	5.17d	5.23e	5.53e	5.77d
T2	7.78c	7.43d	100.47d	105.89d	96.09d	99.52e	91.26d	94.05e	4.83d	5.47d	5.36c	5.43d	5.64d	6.00c
Т3	7.97b	7.9bc	105.77b	110.40c	101.24b	106.21c	95.20b	99.81c	6.03b	6.40c	5.47b	5.73c	5.70c	6.14b
T4	7.47d	7.27e	97.40e	102.13e	94.03e	96.89f	89.98e	92.56f	4.03e	4.33f	5.20d	5.30e	5.57e	5.8d
Т5	8.18a	8.03b	106.07b	112.70b	101.77b	107.93b	95.73b	101.40b	6.03b	6.53b	5.36a	5.83b	5.89b	6.13b
Т6	7.77c	7.83c	101.57c	105.83d	97.14c	102.10d	92.10c	96.74d	5.03c	5.37d	5.33c	5.41d	5.70c	6.00c
Τ7	8.20a	8.43a	110.27a	115.73a	103.40a	111.11a	96.90a	104.38a	6.50a	6.73a	5.63a	5.97a	5.93a	6.47a
LSD	0.102	0.159	0.937	0.597	0.504	0.782	0.568	0.813	0.184	0.103	0.084	0.098	0.063	0.108

 TABLE 1. Effects of preharvest foliar spray of salicylic acid, calcium acetate and proline on some physical properties of "Early Swelling" peaches during 2020 and 2021 seasons.

*T1: Control (water only). T2: Salicylic acid at 50 ppm. T3: Calcium acetate at 100 ppm. T4: Proline at 50 ppm. T5: Salicylic acid plus calcium acetate. T6: Salicylic acid plus proline T7: Salicylic acid plus calcium acetate and proline. **Values, within each column, of similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

 TABLE 2. Effects of preharvest foliar spray of salicylic acid, calcium acetate and proline on some chemical properties of "Early Swelling" peaches during 2020 and 2021 seasons.

Treatments	Anthocyanin Fruit Peel (mg/100g)		Total Sugars (fresh pulp) (%)		TSS (%) In fruit juice		Titratable Acidity (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
*T1	**25.94a	26.93a	15.50a	15.35a	14.17a	14.40a	0.51d	0.60c
T2	22.09bc	22.81bc	13.65d	14.15cd	12.93e	13.03cd	0.55b	0.64b
Т3	23.52b	22.09cd	14.15cd	14.00d	13.70c	13.77c	0.53c	0.64b
T4	27.09a	27.80a	15.00ab	15.35a	14.00b	13.97b	0.50d	0.60c
Τ5	22.81bc	22.09cd	13.85d	14.50bc	13.00e	12.90f	0.60a	0.71a
Т6	22.81bc	23.52b	14.50bc	14.65b	13.70d	13.10d	0.53c	0.64b
Τ7	21.83c	21.38d	14.00d	14.00d	12.90e	12.97ef	0.61a	0.70a
LSD	1.805	1.267	0.50	0.395	0.112	0.099	0.01	0.013

*T1: Control (water only). T2: Salicylic acid at 50 ppm. T3: Calcium acetate at 100 ppm. T4: Proline at 50 ppm. T5: Salicylic acid plus calcium acetate. T6: Salicylic acid plus proline T7: Salicylic acid plus calcium acetate and proline. **Values, within each column, of similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

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Salicylic acid and calcium acetate or its combinations showed highest fruit acidity percentage as compared with control and proline treatments (Table 2).

Data in Table (3) proved that preharvest applications of salicylic acid plus calcium acetate, salicylic acid plus calcium acetate and proline achieved the lowest weight loss of "Early Swelling" peaches after storage on room conditions as compared with control. On the other hand, the highest fruit weight loss was obtained by control in both seasons. Preharvest application of salicylic acid, calcium acetate and proline alone or in combinations after fruit set, at pit hardening and at 15 days before harvesting keep fruit firmness of "Early Swelling" peaches after storage on room temperature for three days (simulating shelf life) during the two seasons of study. The highest value of fruit firmness after storage was obtained by the combination contained salicylic acid, calcium acetate and proline while the lowest value was obtained by control treatment (Table 3).

TABLE 3. Effects of preharvest foliar spray of salicylic acid, calcium acetate and proline on fruit firmness and
weight loss percentage of "Early Swelling" peaches after shelf life for three days on room conditions
(20± 2C⁰) during 2020 and 2021 seasons.

Treatments	Weight lo	088 (%)	Flesh Firmness (Ib/inch ²)		
	2020	2021	2020	2021	
*T1	**12.51a	12.45a	4.47f	4.07e	
T2	4.41cd	5.15c	5.33d	5.17c	
Т3	2.66e	2.66d	6.03b	6.07b	
Τ4	8.22b	6.92b	4.90e	4.53d	
T5	2.98de	3.26d	6.13b	6.03b	
Т6	4.49c	6.47bc	5.73c	5.27c	
Τ7	2.60e	2.28d	6.40a	6.23a	
LSD	1.445	1.566	0.171	0.103	

*T1: Control (water only). T2: Salicylic acid at 50 ppm. T3: Calcium acetate at 100 ppm. T4: Proline at 50 ppm. T5: Salicylic acid plus calcium chloride. T6: Salicylic acid plus proline T7: Salicylic acid plus calcium chloride and proline. **Values, within each column, of similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

Discussion

Enhancing fruit quality and shelf life of "Early swelling" peaches is one of the important objectives of world growers and Egyptian growers specially. The increased of fruit flesh firmness treated with salicylic acid and calcium acetate or their combinations might be attributed to its influence on structure and function of membranes, lowered respiration rate, alleviating stress and inhibit fruit softening enzyme activities (Conway et al., 1994 and Gang et al., 2014). Preharvest application of calcium and salicylic acid on "Florida king" peaches increased fruit firmness as compared with control treatment (Ali et al., 2014). Similar results were obtained by Ali et al. (2021 and Abd El-Aziz et al. (2021).

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Preharvest application of salicylic acid, calcium acetate and proline treatments enhanced physical characteristics of "Early swelling" peaches such as fruit size, weight, flesh weight, diameter and length (Table 1). The improvement of fruit physical properties indicated in this study could be attributed to their roles in alleviating stress impacts, preserving osmotic balance, protecting the photosynthetic products, scavenging free radicals and improving fruit development during growth stages (Galston et al., 1997, Ismail et al., 2014, Ali, 2014 and Trovato et al., 2019). Shahid et al. (2020) showed that preharvest application of calcium chloride during fruit growth stages increased fruit weight, diameter and flesh weight. Furthermore, preharvest application of salicylic acid enhanced physical characteristics of "Canino" apricots such as fruit weight and size (Attia, 2022).

Data in Table 2 showed that preharvest application of salicylic acid, calcium acetate and their combination decreased fruit TSS, total sugars and peel anthocyanin content. The results of this study are in consistent with Kassem et al. (2011), Awad, (2013), El-Shazly et al. (2013) and Gohari et al. (2021). Preharvest application of calcium and salicylic acid before harvest increased fruit acidity, peel chlorophyll a, b and decreased fruit TSS of "Florida king" peaches (Ali et al., 2014).

Preharvest application of salicylic acid, calcium acetate and proline treatments showed an overall enhanced in flesh firmness after storage on room temperature (Table 3). The good effect of preharvest applied treatments might be attributed to its role in maintain the structure of plasma membrane, alleviating stress and increasing rigidity of cell wall (Conway, 1994, Kumar et al., 2010, Trovato et al., 2019 and Mohammad et al., 2019).

Data in (Table 3) illustrated that the lowest value of weight loss percentage was obtained by combination treatment of salicylic acid, calcium acetate and proline followed by salicylic acid and calcium acetate. The positive role of salicylic acid, calcium acetate and proline on reducing weight loss could be attributed to its influence on stabilizing the structure of membranes, enhancing antioxidant system, postponing the senescence process, decreased electrolyte leakage (Kumar et al., 2010, Awad, 2013, Gang et al., 2014, Aly et al., 2019 and Mohammad et al., 2019). Exogenous application of proline at 15 mM on "Flat peach" fruit during the cold storage showed higher activity of phenylalanine ammonia lyase (PAL) and conversely lower activity of polyphenol oxidase (PPO), which led to a higher accumulation of total phenols and flavonoids which reflects on peel anthocyanin contents (Gohari et al., 2021).

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Conflict of interest

The author declared that present study was performed in absence of any conflict of interest.

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تحسين صفات جودة ثمار الخوخ صنف ايرلي سويت وحياتها علي الرف بواسطة حمض السالسيليك،أسيتات الكالسيوم والبرولين

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تم دراسة تأثير الرش الورقي قبل الجمع خلال موسمي ٢٠٢٠، ٢٠٢١ بكلا من حمض السالسيليك، خلات الكالسيوم والبرولين على صفات الجودة والقدرة التخزينية لثمار الخوخ صنف ايرلي سويت. وأوضحت النتائج أن كل المعاملات قبل الجمع قد أدت لزيادة صلابة لحم الثمار مقارنة بالكنترول. كما أدت المعاملة بحمض السالسيليك الي زيادة وزن الثمار ، حجمها وقطرها، كما أدت الي نقص السكريات الكلية والفقد في الوزن. وتشير النتائج ايضا الي أن المعاملة باسيتات الكالسيوم أدت لتحسين الصفات الفيزيائية والكيميائية للثمار وخاصة الصلابة قبل وبعد الجمع. بينما أدت المعاملة بالبرولين الي زيادة وزن الثمار مقطرها ووزن اللحم والمواد الصلبة الذائبة ومحتوي القشرة من صبغة الانثوسيانين ، علاوة علي ذلك أدت الي نقص الحموضة والفقد في الوزن بعد التخزين علي درجة حرارة الغرفة . وتوصي الدراسة باستخدام الخليط المكون من حمض السالسيليك ، أسيتات

الكلمات الدالة: الجودة ، الخوخ ، حمض السالسيليك ، أسيتات الكالسيوم ، حياة الثمار على الرف