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.
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 × 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 lb/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± 2°C) for three days (to simulate shelf life), fruit firmness (lb/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 “Ear 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.

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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.

| Treatments | Firmness (lb/inch²) | Fruit Size (cm³) | Fruit Weight (g) | Flesh weight (g) | Stone weight (g) | Fruit Diameter (cm) | Fruit Length (cm) |
|------------|---------------------|-----------------|-----------------|-----------------|-----------------|--------------------|------------------|
|            | 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         | 105.80d         | 96.09d 99.52e   | 91.26d 94.05e     | 5.47d 5.36c       |
| T3         | 7.97b               | 7.9bc           | 105.77b         | 110.40c         | 101.24b 106.21c | 95.20b 99.81c     | 6.03b 6.40c       |
| T4         | 7.47d               | 7.27e           | 97.40e           | 102.13e         | 94.03e 96.89f   | 89.98e 92.56f     | 4.03e 4.33f       |
| T5         | 8.18a               | 8.03b           | 106.07b         | 112.70b         | 101.77b 107.93b | 95.73b 101.40b    | 6.03b 6.53b       |
| T6         | 7.77c               | 7.83c           | 101.57c         | 105.83d         | 97.14c 102.10d | 92.10c 96.74d     | 5.03c 5.37d       |
| T7         | 8.20a               | 8.43a           | 110.27a         | 115.73a         | 103.40a 111.1a | 96.90a 104.38a    | 6.50a 6.73a       |
| LSD        | 0.102               | 0.159           | 0.937           | 0.597           | 0.504 0.782     | 0.568 0.568       | 0.813 0.184       |

*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            |
| *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     |
| T3         | 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     |
| T5         | 22.81bc 22.09cd      | 13.85d 14.50bc    | 13.00e 12.90f     | 0.60a 0.71a     |
| T6         | 22.81bc 23.52d       | 14.50bc 14.65b    | 13.70d 13.10d     | 0.53c 0.64b     |
| T7         | 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.

**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± 2°C) during 2020 and 2021 seasons.**

| Treatments | Weight loss (%) | Flesh Firmness (lb/inch²) |
|------------|-----------------|---------------------------|
|            | 2020 | 2021 | 2020 | 2021 |
| *T1*       | **12.51a** | 12.45a | 4.47f | 4.07e |
| T2         | 4.41cd | 5.15c | 5.33d | 5.17c |
| T3         | 2.66e  | 2.66d | 6.03b | 6.07b |
| T4         | 8.22b  | 6.92b | 4.90e | 4.53d |
| T5         | 2.98de | 3.26d | 6.13b | 6.03b |
| T6         | 4.49c  | 6.47bc | 5.73c | 5.27c |
| T7         | 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).

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).

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“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, Gang et al., 2014, Aly et al., 2019 and Mohammad et al., 2019).


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

References
A. O. A. C. (1985) Official Methods of Analysis of the Association of Official Analytical Chemists. Washington D C, USA, 14th ed.

Abd El-Aziz, M.H., Soliman, M.A. and Ennab, H.A. (2021) Effect of potassium silicate and chelated calcium sprays on yield, quality and storage of peach fruits cv. “Dessert red”. Menoufia J. Plant Prod., 6, 119-135.

Abrol, G.S., Thakur, K.S., Pal, R. and Punetha, S. (2017) Role of calcium in maintenance of postharvest quality of horticultural crops. Int. J. Econ. Plants, 4(2), 88-93.

Ali, I., Abbasi, N.A. and Hafiz, I.A. (2014). Physiological response and quality attributes of peach fruit cv. Florida king as affected by different treatments of calcium chloride, putrescine and salicylic acid. Pakistan Journal of Agricultural Sciences, 51(1), 33-39.

Ali, I., Abbasi, N. A. and Hafiz, I. (2021) Application of calcium chloride at different phenological stages alleviates chilling injury and delays climacteric ripening in peach fruit during low-temperature storage. International Journal of Fruit Science, 21(1), 1040-1058.

Aly, M.A. Ezz, Thanaa M. Abd El-Gawad M.G. and Buazizah M.H.S. (2019) Enhancement quality and storability of “Anna” apple fruits by some pre-harvest foliar applications. Middle East Journal of Agriculture Research. 8(1), 66-81.

Asghari, M. and Aghdam, M.S. (2010) Impact of salicylic acid on post-harvest physiology of horticultural crops. Trends Food Sci. Technol., 21, 502–509. doi: 10.1016/j.tifs.2010.07.009.

Attia, S.M. (2022) Effects of plant biostimulants and forchlorfenuron on fruit set and quality of “Canino” apricot fruits. Egypt. J. Hort., 49(1), 95-101. DOI: 10.21608/cjoh.2022.121265.1191.

Attia, S.M. and Farag K.M. (2017) Effect of Some Preharvest Treatments on the Incidence of Waterberry Disorder and on Fruit Quality Characteristics of “Thompson Seedless” Table Grapes. American-Eurasian J. Agric. & Environ. Sci., 17(5), 392-400. DOI: 10.5829/idosi.aejaes.2017.392.400.

Awad, R.M. (2013). Effect of post-harvest salicylic acid treatments on fruit quality of peach cv.”Flordaprinco” during cold storage. Australian J. Basic and App. Sci., 7(7), 920-927.

Egypt. J. Hort. Vol. 49, No. 2 (2022)
Conway, W.S. Sams, C.E. and Watada, A.E. (1994) Relationship between total and cell wall bound calcium in apples following postharvest pressure infiltration of calcium chloride. *Postharvest Physiology of Fruits* 398, 31-40.

Egan, H. Kirk, R.S and Sawyer, R. (1981) Pearson’s chemical analysis of food: Churchill Livingstone, *Edinburgh London, Melbourne and New York*, pp591.

El-Shazly, S.M.A.M. Eisa. A.M.H. Moảtamed and H. Conway, W.S. Sams, C.E. and Watada, A.E. (1994) Relationship between total and cell wall bound calcium in apples following postharvest pressure infiltration of calcium chloride. *Postharvest Horticulturae* 71, 104-69.

F. Lorenzo, J.M. Juárez-Maldonado, A. (2021) Preservation treatments on storage quality and chilling injury of ‘Anna’ apple fruits. *Acta Scientiarum Polonorum Hortorum Cultus*, 14, 347-358.

Gohari, G. Molaei, S. Kheiry, A. Ghafouri, M. Razavi, A. and Huber, G. (2013) Effect of calcium Foliar Application on yield and fruit quality of “Swelling” peach trees. *Alex. J. Agric. Res.*, 58(3), 219-229.

Faust, M. and Shear, C.P. (1972) The effect of calcium on respiration of apples. *Journal of the American Society for Horticulture Science*, 97, 437-439.

El-Shazly, S.M.A.M. Eisa. A.M.H. Moảtamed and H. Conway, W.S. Sams, C.E. and Watada, A.E. (1994) Relationship between total and cell wall bound calcium in apples following postharvest pressure infiltration of calcium chloride. *Postharvest Physiology of Fruits* 398, 31-40.

Kassem, H.A. Al-Obayd, R.S. Ahmed, M.A. and Omar, A.K.H. (2011) Productivity, fruit quality and profitability of jujube trees improvement by preharvest application of agro-chemicals. *Middle-East J. Sci. Res.*, 9(5), 628-637.

Kumar, N. Pal, M. Singh, A. SailRam, R.K. Srivastava, G.C. (2010) Exogenous proline alleviates oxidative stress and increase vase life in rose (Rosa hybrida L. ‘Grand Gala’). *Sci. Hortic.*, 127, 79-85.

Mohammad, S., Hajilou, J., Rezanejad, F. and Zaare-Nahandi, F. (2019) Assessment of exogenous application of proline on antioxidant compounds in three Citrus species under low temperature stress. *J. Plant Interact.*, 14, 347-358.

SAS (2000) JMP: User’s Guide, Version 4, SAS Institute, Inc.: Cary, NC, USA.

Shahid, M.O. Muhmood, A. Ihtisham, M. Rahman, M. Amjad, N. Sajid, M. and Ali, A. (2020) Fruit yield and quality of ‘Florida King’ peaches subjected to foliar calcium chloride sprays at different growth stages. *Acta Scientiarum Polonorum Hortorum Cultus*, 9(1), 131-139.

Smith, F. (1956) Colorimetric method for determination of sugar and related substance. *Analytical Chemistry*, 28, 350-356.

Smiciklas, J. and Byers, J. (1968) Quantitative methods for anthocyanins. 1- Extraction and determination of total anthocyanin in cranberries. *Journal of Food Science*, 33, 72-77.

Tareen, M.J. Abbasi, N.A., and Hafiz, I.A. (2012) Proline metabolism and its functions in development and stress tolerance. In *Osmoprotectant-Mediated abiotic stress tolerance* (eds. Kaur, Fuleki, T. and Francis, F.J.). *Springer: Berlin/Heidelberg, Germany*, pp. 41-72.
PREHARVEST APPLICATION OF SALICYLIC ACID, CALCIUM ACETATE AND …

Hamdy Mohammed Saeed, Faculty of Agriculture, Damanhour University, (Egypt - Fruits), BSc. 2020, 2021, and thornless cherry, cultivar Sweet Amberly, quality traits, salicylic acid, calcium acetate and proline.

The results showed that the application of the mixtures of salicylic acid, calcium acetate, and proline before harvest increased the quality traits of the thornless cherry, cultivar Sweet Amberly, before storage and its ability, chemical and physical traits for improvement. This study recommends the storage temperature at the cold room.

Keywords: Quality traits, thornless cherry, salicylic acid, calcium acetate, proline, life cycle.