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Enhancement of postharvest quality of peach fruit by salicylic acid treatment

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Abstract

Salicylic acid (SA) is one of natural and safe signaling molecule used for postharvest quality maintenance of horticultural crops. The aim of this research was to determine the effects of various concentrations of SA (0, 0.5, 1 and 1.5 mmol L^{-1}) on the quality and antioxidant potential of peach fruit. Treatments were performed immediately after harvest. Weight loss, fruit flesh firmness, total acidity, total soluble solids, DPPH radical scavenging activity, total phenols and flavonoids, were determined in fruits stored at 1°C and 80–90% RH for 28 days. The SA treated fruits exhibited significantly lower levels of total soluble solids, pH and weight loss and higher levels of firmness and total acidity than controls. Also, fruits treated with SA exhibited significantly higher total phenols, flavonoids, as well as DPPH radical scavenging activity as compared with control fruits. These results suggested that SA treatment might be a powerful strategy to enhance antioxidant potential and quality of peach fruits.

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Introduction

Peach (*Prunus persica* L) is considered one of the most popular and common fruits in the world due to their nutrition value. In Iran the area of peaches increased recently and reached 47503 ha which produces 498346 tons according to the FAO, 2011. After harvest rapid ripening in peach fruits is responsible for short shelf life. Ripening can be retarded by cold storage. However, Cold storage of peach fruits can lead to the development of chilling injury symptoms and loss of quality (Jin *et al*., 2009). During postharvest storage, due to internal and external factors, chemical and physical changes occur in fruits and vegetables, which result in losses in nutritional quality. To prevent these adverse effects, use of environmentally friendly technologies such as salicylic acid (SA) as a natural and safe signaling molecule was recommended (Asghari and Aghdam., 2010). SAexhibits a high potential in enhancing quality, controlling postharvest losses and mitigating chilling injury in fruits and vegetables (Asghari and Aghdam., 2010; Aghdam and Bodbodak., 2013). SA has been involved in retarding pineapple browning (Lu *et al*., 2011), and delaying the ripening process in some fruits such as peach (Han *et al*., 2003), sugar apple (Mo *et al*., 2008), and plum fruit (Luo *et al*., 2011), through an inhibition of the ethylene biosynthesis. Also, postharvest treatment of SA can delay the senescence of different produces by stimulating the accumulation of biologically active compounds and antioxidant enzymes such as catalase (CAT), superoxide dismutase (SOD) and peroxidases (POD) leading to a decrease in free radical levels and lipid peroxidation (Huang *et al*., 2008; Gerailoo and Ghasemnezhad., 2011).

Tareen *et al*. (2012) reported that the SA treatment enhanced DPPH scavenging activity in peach fruit. Their results also demonstrated that the ROS scavenging activity increased by increasing SA concentrations. Recently, Dokhanieh *et al*. (2013) reported that the DPPH scavenging activity, total phenols, flavonoids, anthocyanins and ascorbic acid contents of the cornelian cherry fruits was significantly increased by SA treatment. They suggested that enhanced antioxidant potential of cornelian cherry fruits treated with SA might be due to the stimulation of Phenylalanine ammonia-lyase (PAL) enzyme activity and thus triggering the phenylpropanoid–flavonoids pathways. Taken together, these results demonstrated that SA as a safe signaling molecule could enhance nutritional quality and improved health promoting properties of fruits and vegetables. The objective of this study was to evaluate the effect of SA treatment on the flesh firmness, total acidity, total soluble solids, weight loss, total phenols and flavonoids contents, total antioxidant activity assayed by DPPH methods of peach fruits during storage.

Materials and methods

Fruit and SA treatment

Peach fruits (*Prunns persica* L.) Cultivar 'Anjiry maleky' was hand-harvested at physiologically mature stage from a commercial orchard in Azarbayzan, Iran. The fruit was packed in corrugated boxes and transported to laboratory immediately. The Fruit were screened based on uniformity of shape, size and peel color, and any defaced fruits were discarded. Fruit were divided into twelve groups of 40 fruits in each. Fruits were dipped in different concentrations of aqueous solutions of 0.5, 1 and 1.5 mM of SA for 10 min and control ones dipped in distilled water. All fruits were then air dried for approximately 60 min and stored at 1°C and 80–90% RH for 28 days. Samples were collected as 5 fruit at weekly intervals for the measurements of quality attributes and biochemical parameters. Samples were mixed and frozen immediately in liquid nitrogen, then stored at −80 °C.

Quality attributes evaluation

Flesh firmness was measured on two paired sides of each fruit, after the removal of the skin from both sides of the fruit, by an Effegi penetrometer (Model FT-011) with an 8 mm diameter flat probe. Total acidity (TA) was determined in the juice of the blended composite of peach slices (3 fruit per

replication). Ten milliliters of freshly extracted fruit juice were diluted with 20 ml distilled water and diluted juiced was titrated against 0.1N NaOH using phenolphthalein as an indicator of the endpoint by change in color to pink and expressed as malic acid equivalents (AOAC., 1984). Total soluble solids (TSS) were determined by measuring the refractive index of juice using a digital refractometer (Model PAL-1) at 20 °C. Weight loss was determined initially and weekly during storage. Weight loss was calculated as: weight loss= (W0 –Wf)/ W0 ×100, W0 being the initial sample weight and Wf the final sample weight. Results are reported as percentage weight loss.

DPPH radical scavenging activity

The DPPH radical scavenging activity of peach extracts was measured according to the method of Dehghan and Khoshkam. (2012) with some modifications. Fruit extract was added to 2 ml of DPPH solution (0.1 mM in methanol) and kept in the dark at room temperature for 30 min. Absorbance of the mixture (AS) was measured at 517 nm in a UV–visible spectrophotometer (T-60, PG Instrument UK). As a control, the absorbance of the blank solution of DPPH (2 ml) was also determined at 517 nm (AC). The percentage of radical scavenging activity (RSA %) was calculated according to the following equation:

$$RSA\ \% = \frac{100\,(A_C - A_S)}{A_C}$$

Total phenolic and flavonoid contents

The total phenolic content of the peach extract was measured according to the Folin- Ciocalteu method as described by Singliton and Rossi. (1965) with some modifications. Briefly, 0.1 ml of extract was transferred into a test tube and mixed with 2 ml of 2% Na2CO3 and allowed to stand for 2 min at room temperature. For each sample 0.1 ml of 50% (v/v) Folin-Ciocalteu reagent was added and the reaction mixture was mixed and allowed to stand for 30 min in the darkness. After incubation, absorbance was read at 720 nm. The absorbance values were converted to total phenolics and were expressed in mg equivalents of gallic acid (GAE) per 100 gFW. Different concentrations of gallic acid in 95% methanol were used as standards.

The total flavonoid concentration of the peach extract was determined using a colorimetric assay (Kaijv *et al.*, 2006). The absorbance of the solution was immediately measured versus a blank at 510 nm. The results were expressed as µmol of quercetine equivalents per 100 gFW.

Statistical analysis

The experiment was arranged as split plots in time on the basis of completely randomized design with three replications. Analysis of variance (ANOVA) carried out with SPSS software. Differences between means were assessed by Duncan's multiple range tests with differences being considered significancy at $P < 0.05$.

Results and discussion

Firmness

As shown in Table 2, the Fruit firmness in all peach fruits decreased during storage at 1◦C, but peach fruits treated with SA showed significantly higher levels ($P < 0.01$) than control fruits (Table 1).

Table 1. ANOVA for dependent variables for salicylic acid treatments, storage time and their interactions for peach fruit.

	Time	Treatment	Time × Treatment
Firmness	**	**	ns
Weigh loss	**	**	ns
TSS	*	**	ns
TA	**	**	ns
pH	**	**	ns
Total phenols (TP)	**	**	*
Total flavonoids (TF)	**	**	**
DPPH radical scavenging activity	**	**	ns

** and * represent significance at the 0.01, and 0.05 levels, respectively, and ns represents non-significance at P < 0.05.

Many studies have been reported that SA decreases ethylene production and inhibits cell wall and membrane degrading enzymes such as polygalacturonase (PG), pectinemethylesterase (PME) and cellulase leading to slowing the fruit softening rate (Srivastava and Dwivedi., 2000; Zhang *et al.*, 2003). Wang *et al.* (2006) reported that treatment of peach fruits with SA at 1mM was most effective in slowing the decline in firmness than lower concentration (0.35 and 0.7 mM). Postharvest application of SA in maintaining fruit firmness has been also reported in kiwifruit (Kazemi *et al.*, 2011; Zhang *et al.*, 2003), banana fruit (Srivastava and Dwivedi., 2000) and peach fruit (Tareen *et al.*, 2012).

Weight loss

The loss of fruit weight increased throughout storage for all treatments; although increases were significantly ($p < 0.01$) lower in SA treated peaches as compared with control (Table 1). The Least weight losses were observed in 1 and 1.5 mmol SA treated fruits (Table 2). The loss of fruit weight is principally due to the loss of water in transpiration and to a lesser extent to the loss of carbon in the respiration process. Zheng and Zhang. (2004) reported that SA postharvest applications can reduce fruit weight losses by closing stoma in mandarin fruits. Also, SA has been reported to effectively reduce the respiration rate in peach fruits (Han *et al.*, 2003). The role of SA in reducing Weight loss percentage has been reported in strawberry (Shafiee *et al.*, 2010) and peach (Tareen *et al.*, 2012).

TSS, pH and TA

TSS and pH increased and TA decreased for all treatments during storage. However, these changes were significantly lower in SA-treated fruits compared with the control (Table 1). The lowest TSS and the highest TA was observed in SA-treated fruits, but there was not a significant difference between various treatments. pH contents of the control fruits were higher than those of SA-applied fruits (Table, 2).

Table 2. Effect of salicylic acid on total antioxidant and overall quality in peach fruit during storage at 1°C.

Treatment Salicylic acid	Firmness	TSS	Weight loss	TA	pH	DPPH
Control	12.85^{d}	14.53^{a}	5.06^{a}	$.27^{b}$	5^{a}	17.78^{b}
0.5 mM	14.95^{c}	12.1^{b}	3.35^{c}	$.29^{b}$	4.76^{b}	18.28^{b}
1 mM	19.42^{a}	12.77^{b}	4.1^{b}	$.32^{a}$	4.79^{b}	21.33^{a}
1.5 mM	17.59^{b}	12.65^{b}	3.84^{bc}	$.34^{a}$	4.85^{b}	22.52^{a}

Mean values in each column followed by the same lower-case letters are not statistically different by Duncan's multiple range test ($P < 0.05$).

The loss of the TA and the increase of TSS and pH are commonly used to demonstrate the ripening stage of the fruits as well as to evaluate the fruit taste which is represented mainly by the balance between sweetness and acidity. SA treatment can delay the fruit ripening during storage and also enhance fruit quality attributes (Asghari and Aghdam., 2010). Aghdam *et al.* (2009) suggested that a lower TSS of kiwifruit treated with methyl salicylic acid was concomitant with reduced ethylene production. Similarly, Kazemi *et al.* (2011) reported that treatment of kiwifruit with SA maintained higher TA than control fruit during storage. Also, pre- and postharvest SA treatments maintained higher TA of winter pineapple (Lu *et al.*, 2011).

Bioactive compounds and total antioxidant activity (TAA)

The influence of SA on the antioxidant activity (DPPH), total phenolic and flavonoid content is shown in Table 1. During storage total phenol and flavonoid content gradually increased, but increases were significantly higher in SA treated peaches as compared with control. Peach fruits treated with higher concentration of SA (2 mM) had significantly higher phenol and flavonoid contents during storage period (Fig. 1, 2).

The antioxidant activity of control and SA treated fruits increased during storage compared to the initial value. The inhibition percentage (IP) of DPPH

radicals was higher in the fruits treated with 1 and 1.5 mM SA compared to control and .5 mM SA.

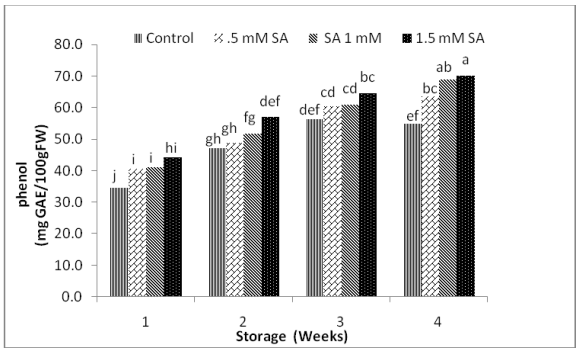

Fig. 1. The effect of 0, 0.5, 1 and 1.5 mM SA on total phenol content of peach fruit stored at 1 °C for 4 weeks. Data shown are mean values.

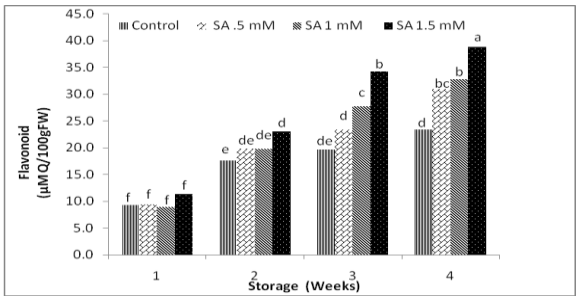

Fig. 2. The effect of 0, 0.5, 1 and 1.5 mM SA on total flavonoid content of peach fruit stored at 1 °C for 4 weeks. Data shown are mean values.

Hydroxycinnamates along with flavonoids are the main constituents of total phenolics in peaches (Tomas-Barberan *et al.*, 2001). Phenols contribute substantially to the antioxidant complement of peach fruits, having potential health effects (Gil *et al.*, 2002). Huang *et al.* (2008) showed that SA enhanced biosynthesis of nutritional components, including the increase in antioxidant activity, and the accumulation of biologically active compounds such as glutathione, ascorbic acid, total phenolic and flavonoid contents as a results antioxidant activity, in the 'Cara cara' navel orange. Additionally, Sarikhani *et al.* (2010) suggested that SA treatment induced much higher total phenolic contents in treated grape fruits. The accumulation of phenolic compounds in grapes by SA treatment could be induced through an increase in PAL activity, PAL is the first key enzyme involved in the biosynthesis of phenols in fruits (Chen *et al.*, 2006). The SA treatment also elevated total flavonoids that affected the antioxidant activity as indicated by the resultant increase in DPPH and ferric reducing antioxidant power (FRAP) in asparagus (Wei *et al.*, 2011). Asghari and aghdam. (2010) reported that SA, in a concentration dependent manner from 0 to 2 mmol L-1, enhanced the strawberry fruit total antioxidant potential and ascorbic acid content. Also in peach, SA treated fruits exhibited higher radical scavenging activity (RSA) in fruits stored at 0 °C (Tareen *et al.*, 2012).

In conclusion, application of SA effectively increased total phenol and flavonoid contents, as well as DPPH radical scavenging activity of peach fruits. Also, The SA treated fruits exhibited lower levels of pH, TSS and weight loss and higher levels of firmness and TA as compared with control fruits. These results suggested that SA treatment might be a powerful strategy to enhance antioxidant potential and quality of peach fruits.

References

Aghdam MS, Bodbodak S. 2013. Physiological and biochemical mechanisms regulating chilling tolerance in fruits and vegetables under postharvest salicylates and jasmonates treatments. Scientia Horticulture **156,** 73-85. http://dx.doi.org/10.1016/j.scienta.2013.03.028

Aghdam MS, Mostofi Y, Motallebiazar A, Ghasemneghad M, Fattahi Moghaddam J. 2009. Effects of MeSA vapor treatment on the postharvest quality of Hayward kiwifruit. In 6th International Postharvest Symposium Antalya Turkey.

AOAC. 1984. Official Methods of Analysis, 14. Association of Official Agricultural Chemists. Washington DC 844–847.

Asghari M, Aghdam MS. 2010. Impact of salicylic acid on post-harvest physiology of horticultural crops. Trends in Food Science and Technology **21,** 502–509. http://dx.doi.org/10.1016/j.tifs.2010.07.009

Chen J, Wen P, Kong W, Pan Q, Zhan J, Li J, Wan S, Huang W. 2006. Effect of salicylic acid on phenylpropanoids and phenylalanine ammonia-lyase in harvested grape berries. Postharvest Biology and Technology **40,** 64–72.
http://dx.doi.org/10.1016/j.postharvbio.2005.12.017

Dehghan G, Khoshkam Z. 2012. Tin(II)-quercetin complex: Synthesis, spectral characterization and antioxidant activity. Food Chemistry **131,** 422-427.

Dokhanieh AY, Aghdam MS, Rezapour Fard J, Hassanpour H. 2013. Postharvest salicylic acid treatment enhances antioxidant potential of cornelian cherry fruit. Scientia Horticulture **154,** 31-36.
http://dx.doi.org/10.1016/j.scienta.2013.01.025

FAO. 2010. FAOSTAT, FAO Statiscal Databases. http://faostat.fao.org.

Gerailoo S, Ghasemnezhad M. 2011. Effect of salicylic acid on antioxidant enzyme activity and petal senescence in Yellow Island' cut rose flowers. Journal of Fruit and Ornamental Plant Research **19,** 183–193.

Gil MI, Tomas-Barberan FA, Hess-Pierce B, Kader AA. 2002. Antioxidant capacities phenolic compounds carotenoids and vitamin C contents of nectarine peach and plum cultivars from California. Journal of Agriculture and Food Chemistry **50,** 4976–4982.
http://dx.doi.org/10.1021/jf020136b

Han T, Wang Y, Li L, Ge X. 2003. Effect of exogenous salicylic acid on postharvest physiology of peaches. Acta Horticulturae **628,** 583–589.

Huang R, Xia R, Lu Y, Hu L, Xu Y. 2008. Effect of pre-harvest salicylic acid spray treatment on post-harvest antioxidant in the pulp and peel of 'Cara cara' navel orange (*Citrus sinenisis* L. Osbeck). Journal of the Science of Food and Agriculture **88,** 229–236.
http://dx.doi.org/10.1002/jsfa.3076

Jin P, Zheng Y, Tang S, Rui H, Wang YW. 2009. A combination of hot air and methyl jasmonate vapor treatment alleviates chilling injury of peach fruit. Postharvest Biology and Technology **52,** 24-29.
http://dx.doi.org/10.1016/j.postharvbio.2008.09.011

Kaijv M, Sheng L, Chao C. 2006. Antioxidation of flavonoids of Green Rhizome. Food Science **27,** 110-115.

Kazemi M, Aran M, Zamani S. 2011. Effect of calcium chloride and salicylic acid treatment on quality characteristics of kiwifruit (*Actinidia deliciosa* cv. Hayward) during storage. American Journal of Plant Physiology **6,** 183–189.
http://dx.doi.org/10.3923/ajpp.2011.183.189

Lu X, Sun D, Li Y, Shi W, Sun G. 2011. Pre- and post-harvest salicylic acid treatments alleviate internal browning and maintain quality of winter pineapple fruit. Scientia Horticulturae **130,** 97–101.
http://dx.doi.org/10.1016/j.scienta.2011.06.017

Luo Z, Chen C, Xie J. 2011. Effect of salicylic acid treatment on alleviating postharvest chilling injury of 'Qingnai' plum fruit. Postharvest Biology and Technology **62,** 115–120.
http://dx.doi.org/10.1016/j.postharvbio.2011.05.012

Mo Y, Gong D, Liang G, Han R, Xie J, Li W. 2008. Enhanced preservation effects of sugar apple fruits by salicylic acid treatment during post-harvest storage. Journal of the Science of Food and Agriculture **88,** 2693–2699.
http://dx.doi.org/10.1002/jsfa.3395

Sarikhani H, Sasani-Homa R, Bakhshi D. 2010. Effect of salicylic acid and SO_2 generator pad on storage life and phenolic contents of grape (*Vitis vinifera* L. 'Bidaneh Sefid' and 'Bidaneh Ghermez'). Acta Horticulturae **877,** 1623–1630.

Shafiee M, Taghavi TS, Babalar M. 2010. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid and calcium dipping) improved

postharvest fruit quality of strawberry. Scientia Horticulturae **124,** 40–45.
http://dx.doi.org/10.1016/j.scienta.2009.12.004

Singleton VL, Rossi JA. 1965. Colorimetry of total phenolics with phosphomolybdic–phosphotungstic acid reagents. American Journal of Enology and Viticulture **16,** 144-158.

Srivastava MK, Dwivedi UN. 2000. Ripening of banana fruit by salicylic acid. Plant Science **158,** 87–96.
http://dx.doi.org/10.1016/S0168-9452(00)00304-6

Tareen MJ, Abbasi NA, Hafiz IA. 2012. Postharvest application of salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. Flordaking fruit during storage. Scientia Horticulturae **142,** 221- 228.
http://dx.doi.org/10.1016/j.scienta.2012.04.027

Tomas-Barberan FA, Gil MI, Cremin P, Waterhouse AL, Hess-Pierce B, Kader AA. 2001. HPLC–DAD–ESIMS analysis of phenolic compounds in nectarines peaches and plums. Journal of Agriculture and Food Chemistry **49,** 4748–4760.
http://dx.doi.org/10.1021/jf0104681

Wang L, Chen S, Kong W, Li S, Archbold D. 2006. Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. Postharvest Biology and Technology **41,** 244-251.
http://dx.doi.org/10.1016/j.postharvbio.2006.04.010

Wei Y, Liu Z, Su Y, Liu D, Ye X. 2011. Effect of salicylic acid treatment on postharvest quality antioxidant activities and free polyamines of asparagus. Journal of Food Science **76,** 126–132.
http://dx.doi.org/10.1111/j.1750-3841.2010.01987.x

Zhang Y, Chen K, Zhang S, Ferguson I. 2003. The role of salicylic acid in postharvest ripening of kiwifruit. Postharvest Biology and Technology **28,** 67–74.
http://dx.doi.org/10.1016/S0925-5214(02)00172-2

Zheng Y, Zhang Q. 2004. Effects of polyamines and salicylic acid postharvest storage of 'Ponkan' mandarin. Acta Horticulturae **632,** 317–320.