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EFFECT OF SALICYLIC ACID TREATMENTS ON STORAGE LIFE OF PEACH FRUITS CV. 'FLORDAKING'

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Abstract

In order to determine the effects of salicylic acid (SA) on postharvest life and quality of peach fruits, four different concentrations (0.5, 1.0, 1.5 or 2.0 mmol L^{-1}) were applied to peach fruits cv. 'Flordaking'. Fruits harvested at commercial maturity were washed, dipped for five minutes in SA solutions and stored at 0ºC with 90% RH on the same day for a period of five weeks. Lower SA concentrations did not offer any significant effect on quality parameters of peach fruits when compared with control. However, SA at 2.0 mmol L^{-1} concentration significantly exhibited less weight loss, higher flesh firmness, increased SSC, higher TA contents, higher skin luminosity and decreased *a** values compared with other treatments including control. Consequently, SA at 2.0 mmol L^{-1} concentration also showed a significant increase in ascorbic acid and total phenolics content while, relative electrical conductivity was reduced during five weeks of storage. Thus, the present results suggest that SA at 2.0 mmol L^{-1} concentration could be used commercially to preserve peach fruits for up to five weeks without any spoilage.

Introduction

Postharvest quality of peach fruits is greatly affected by several pre-and postharvest factors. Climacteric peach fruits face critical period after harvest and being highly perishable fruits are subjected to rapid deterioration. Generally, the magnitude of postharvest losses in fresh fruits and vegetables is extraordinarily high resulting in proportionately higher economic losses than that of pre-harvest losses (Salunkhe *et al*., 1991). Though, postharvest quality of any produce cannot be improved however, quality losses can be reduced. The pace of physiological deterioration of fruits is mainly due to respiration rate (Kader *et al*., 1989). Surface treatments protect fruits tissues from decay and also wash off enzymes and substrates released or oozed out from damaged cells. Dipping treatments in a solution, keep intact fruits from outside (surface) and retard infections and deteriorations that harmfully influence life and quality of a produce. Therefore, after harvest, it becomes necessary to keep peach fruits quality intact by using different treatments.

Salicylic acid (SA) is cosmically spread in plant realm (Raskin *et al*., 1990) and included in plant hormones group (Raskin, 1992). It is believed to have varied regulative functions in plant metabolism (Popova *et al*., 1997). SA being an endogenous growth regulator from phenolic group (Karlidag *et al*., 2009) has been extensively used for quality improvement in a number of crops (Peng & Jiang, 2006). Literature has impressively argued the role of phenolic compounds such as salicylic acid about their influence on physiological or biochemical processes including ion uptake, membrane permeability, enzymes activity, heat production, growth and development (Arberg, 1981). Salicylic acid has been quoted that its exogenous treatment carried away from the application surface to the other tissues to bring forth its response (Raskin, 1992). SA significantly reduced the quality loss in peaches (Wang *et al*., 2006), tomato (Ding *et al*., 2001), sweet peppers (Fung *et al*., 2004), and loquat fruits (Cai *et al*., 2005). SA and its derivatives are widely in use to enhance fruits postharvest life by controlling their firmness. Salicylic acid has been documented to enhance flesh firmness of harvested peaches during storage (Wang *et al*., 2006; Li and Han, 1999; Yan *et al*., 1998), and banana fruits during ripening (Srivastava & Dwivedi, 2000). Thus, salicylic acid has remarkable ability to maintain the fruits quality during storage life of fruits.

Keeping in view the perishable nature of peach fruits and effectiveness of postharvest salicylic acid application, an experiment was designed to evaluate the effects of salicylic acid applications on postharvest quality parameters such as weight loss, firmness, SSC, fruits skin color, content of ascorbic acid, total phenolics and relative electrolyte conductivity evaluation.

Materials and Methods

The present study was conducted at the Post Harvest Laboratory of Department of Horticulture, Pir Mehar Ali Shah, Arid Agriculture University Rawalpindi. Peach (*Prunus persica* L. Batsch) fruits of cv. 'Flordaking' engrafted on wild rootstock, handpicked from Sangral Fruit Farm (33˚ 50' 51.08" N latitude and 72˚ 26' 20.75" E longitude) at Madrotta district Attock. Fruits were harvested at commercial mature stage (SSC 8.87 and 9.13; N 72.86 and 69.76 respectively). Fruits were kept under shade to remove field heat then immediately transported to the laboratory in an air conditioned vehicle. Peach fruits were sorted and over or under ripened, bruised and damaged fruits were disposed off. Distilled water was used to wash away any residual material or dust from the surface of selected fruits and dipped for five minutes in different concentrations of salicylic acid aqueous solutions (0.5, 1.0, 1.5 and 2.0 mmol L^{-1}) along with untreated control (dipped in distilled water).

Each treatment consisted of 225 fruits and was replicated thrice. After treatments application the fruits were packed in cardboard corrugated boxes and stored at 0 ±0.3 ºC, 90 ±4% RH for five weeks. Twelve fruits were randomly selected from each replication of all treatments on day first and at each sampling week during storage. These peach fruits were used to analyze following parameters:

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Fruit weight loss: Fresh weight of peach fruits was recorded soon after harvest. Separately kept fruits of all treatments were used for the evaluation of percent weight loss till end of the trial. Fruit weight loss (%) was recorded at each sampling week and computed by following formula:

$$\text{Weight loss (\%)} = [(A-B)/A] \times 100$$

Fruit firmness: Fruit firmness was recorded using a penetrometer (Wagner Fruit Firmness Tester model FT-327). After removing the epidermis at two equatorial sites an 8mm plunger tip was used to measure the fruits firmness. Data was recorded on day one and subsequently at weekly intervals till the end of experiment. Readings were expressed in Newton (N).

Soluble solids content: The soluble solids content in ºBrix% was ascertained with the help of a digital refractometer (Atago-Palette PR 101; Atago Co., Itabashi-Ku, Tokyo, Japan). Wedge shaped pieces and homogeneous in size from twelve fruits per replication in all treatments were juiced for a composite sample with the help of a high speed juicer machine. SSC data was calculated from the homogenized juice.

Titratable acidity: Juice was extracted by filtration of 10 g peach fruits pulp blended with 40 mL distilled water. Titration method was used to ascertain the titratable acidity in peach fruits. The obtained peach fruits juice was titrated against 0.1N NaOH (sodium hydroxide). The titration of juice was done till pH of the juice stabilized at 8.2 then reading was noted. The data was recorded from all the three replications of each treatment. The results were expressed as percent mallic acid with the help of following formula:

$$\text{Percent TA} = \frac{\text{(mL NaOH used) (Normality of NaOH) (Equi. weight of mallic acid)}}{\text{(Weight of sample) (Volume of aliquot taken)}} \times 100$$

Fruit skin color: In order to assess how the treatments affected the changes in peach fruits skin/peel color. In this regard data was recorded with the help of chromameter (CR- 400 Konica Minolta Sensing, Inc., Japan). Separately kept fruits were used for the measurement of skin color. Fruit skin color parameters including *L** (higher positive values indicate more lightness while negative readings indicate darkness), *a** (greenish is indicated by negative readings while redness is indicated by positive values) and *b** (negative readings are indicative of blueness and higher positive readings are indicative of yellowness) were measured during storage period at weekly intervals from two opposite sides of each fruit.

Ascorbic acid content: Peach fruits ascorbic acid content was evaluated according to the method of Hans (1992). Peach pulp of 5g was randomly collected from ten fruits and blended with (5 mL) 1.0% (w/v) hydrochloric acid and centrifuged at 10,000 x *g* for 10 min. The absorbance (243 nm) of the supernatant (ascorbic acid extract) was recorded by using a spectrophotometer. Prior to the recording of readings spectrophotometer was calibrated by preparing standard solutions of ascorbic acid in same manner. The content of vitamin C (ascorbic acid) was computed as mg/100g edible portion.

Total phenolics content: Peach fruits juice was used to determine total phenolics content with Folin-Ciocalteu reagent (Slinkard & Singleton, 1977) according to the method of Piga *et al*., (2003). Each composite sample (5g) from twelve peach fruits per replication of each treatment was homogenized. The same was subjected to centrifuge at 4,000 x g for 15 minutes followed by filtration. A sample of 1 mL from same extract, 5 mL Folin-Ciocalteu reagent, 10 mL of 7 percent Na_2CO_3 solution and distilled water was added after one hour incubation. Then the absorbance was recorded against the blank containing reagent at 760 nm. All treatments were replicated thrice thus conducted three times. To draw a standard curve for total phenolics content, gallic acid standard solution was used. For calibration gallic acid solution (0-100 mg/L) was employed and run as per above procedure. The resultants were expressed in mg of gallic acid equivalents (GAE) per 100g of dry matter and were computed using following formula:

$$C = c.\ V/m$$

Where: C = total content of phenolics compound mg per g plant extract in GAE

c = the concentration of gallic acid established from the calibration curve mg/mL
V = the volume of extract (mL)
m = the weight of fruit pulp (g)

Relative electrical conductivity: Relative electrical conductivity or membrane leakage was measured by the method mentioned by Fan and Sokorai (2005). Pieces of fruit flesh were excised (with the help of a 10 mm diameter stainless steel cork borer) from nine peaches of each replication of all treatments. The same discs were washed with distilled water, let dried and put in to flat bottomed flasks (100 mL) contained distilled water (50 mL). Electrolyte leakage as readings was initially recorded with the help of an EC meter (Orion $420A^+$ Thermo Electron Corp., USA). First readings were noted at 1 minute (C 60) of incubation. Then the same flasks contained the samples were sterilized in an autoclave for 25 min at 121°C. After this flasks were left at room temperature to let them cool and the volume of same was maintained 50 mL with DW. Then bathing solution's total electrical conductivity was recorded. Resultants relative electrical conductivity (%) was computed using the following formula:

$$\text{REC (\%)} = (C60 - C1) / CT \times 100$$

Statistical analysis: A complete randomized design (CRD) was used with two factorial arrangement. The

comparison between means was done by Duncan's Multiple Range Test (alpha 5% level of significance). All the parameters were replicated three times per treatment.

Results and Discussion

Fruit weight loss: The highest weight loss was recorded in control followed by lower SA concentrations (0.5 or 1.0 mmol L^{-1}) while lowest loss occurred in fruits treated with 2.0 mmol L^{-1} SA (Table 1). A consistent increase in weight loss was observed in all the treatments throughout the storage period (Fig. 1). Weight loss is mainly regulated by respiration, transpiration and metabolic activities in fruits. SA has been reported to close stomata which results in suppressed respiration rate and minimized weight loss of fruits (Manthe *et al*., 1992; Zheng and Zhang, 2004). Similarly, peach fruits cv. 'Delicia' treated with SA exhibited less weight loss than control (Abbasi *et al*., 2010). Thus, the results of this study suggest that SA might have reduced respiration and transpiration which concomitantly delayed senescence.

Table 1. Effects of different salicylic acid (SA) treatments on fruit firmness, soluble solids content (SSC), titratable acidity, ascorbic acid and skin color (*L, *a** and *b**) of peach fruits cv. 'Flordaking' during five weeks of storage (0 ºC, 90% RH).**

SA (mmol)	Fruit firmness (N)	SSC (% ºBrix)	Titratable acidity	Ascorbic acid	*L**	*a**	*b**
DW Dip	55.84e	10.11d	0.30d	4.95b	30.77d	26.75a	21.60a
0.5	58.60d	10.26c	0.36c	5.18b	31.84cd	21.89b	21.54a
1.0	59.88c	10.30c	0.37c	5.20b	32.50bc	21.32bc	21.37ab
1.5	62.13b	10.43b	0.39b	5.25b	34.69a	20.51cd	20.83ab
2.0	63.85a	10.66a	0.44a	5.61a	33.53ab	20.02d	20.27b
LSD	0.7184	0.0897	0.0212	0.3264	1.1835	1.0756	1.1656

DW: distilled water (control)

Means within a column followed by different letters are significantly different at $p < 0.05$ level using Duncan's Multiple Range Test. Means of five weeks have been presented in the above table

Fruit firmness: Fruit firmness is one of the most important physical parameter to monitor the ripening progress. Thus, the effect of salicylic acid on flesh firmness of peach fruits, to assess the storage life, has been examined. Maximum fruit flesh firmness was recorded in 2.0 mmol L^{-1} followed by 1.5 mmol L^{-1} SA as compared with control and lower concentrations (0.5 or 1.0 mmol L^{-1}) of SA (Fig. 1). Higher firmness in treated fruits might be attributed to the reduced hydrolysis of soluble starch. Delayed ripening process in SA treated fruits was concentration dependant.

Soluble solids content: A general increase was observed in SSC of all treatments however, 2.0 mmol L^{-1} SA had the highest SSC during five weeks of storage. Minimum SSC was recorded in control followed by 0.5 and 1.0 mmol L^{-1} SA concentrations and showed no significant difference between them at alpha $p < 0.05$ (Table 1). The perishable nature of peach fruits leads to depreciated quality of the fruit and it is associated with rapid loss in SSC. SA treatment significantly maintained higher SSC in a concentration dependant manner. Peach fruits are needed to be higher with SSC (sweet) consumer acceptability (Crisosto *et al*., 2003). Similar results have also been reported by Han & Li (1997) that apple fruits had increased SSC without decreasing firmness when treated with SA.

Titratable acidity: A gradual decrease for titratable acidity was found in all treatments (Table 1). SA 2.0 mmol L^{-1} retained higher content of TA during the entire storage period. Minimum TA content was found in untreated fruits (control) when compared with SA concentrations. It is matter of fact that fruit taste is mainly made up of sugars and acids combination. It has been suggested that TA decreases in fruits in result of breakup of acids to sugars during respiration (Ball, 1997). Han & Li (1997) have also reported that apple fruits treated with SA had increased TA content at the end of storage.

Fruit skin color: Salicylic acid treatments significantly affected skin color of peach fruits during five weeks of storage period. A higher luminosity (*L**) and lower *a** (anthocyanins) values were recorded in fruits treated with 1.5 mmol L^{-1} SA when compared with control and other treatments. While, least *b** values were noted in 2.0 mmol SA treated fruits (Table 1). Least *L** values were found in control fruits skin which gave dark appearance to the fruits. The color of peach fruits shifts from green to yellow in result of decline in chlorophyll and carotenoids start increasing (Addoms *et al*., 1930). Highest *a** (redness or anthocyanins) and *b** (yellow color) values were recorded in control fruits. This may be correlated with physiological status of the fruits which was advancing towards deterioration and quality loss. SA treated strawberry fruits showed less *a** values (Shafiee *et al.,* 2010).

Ascorbic acid content: All the treatments showed a gradual decrease in ascorbic acid level during the entire five weeks storage period (Table 1). However, 2.0 mmol L^{-1} SA treated peach fruits maintained higher ascorbic acid content as compared with control while, rest of the SA treatments and control remained non-significant. Human diet consists of about 91% of ascorbic acid comes from fruits and vegetables. It is very sensitive to degradation ascribable to its oxidation in comparison to other nutrients during processing and storage (Akhtar *et al*., 2010). Our results showed that SA had significant effect on maintaining higher content of AA in peach fruits. Kalarani *et al*., (2002) have also reported that tomato fruits treated with SA were observed with maximum AA content.

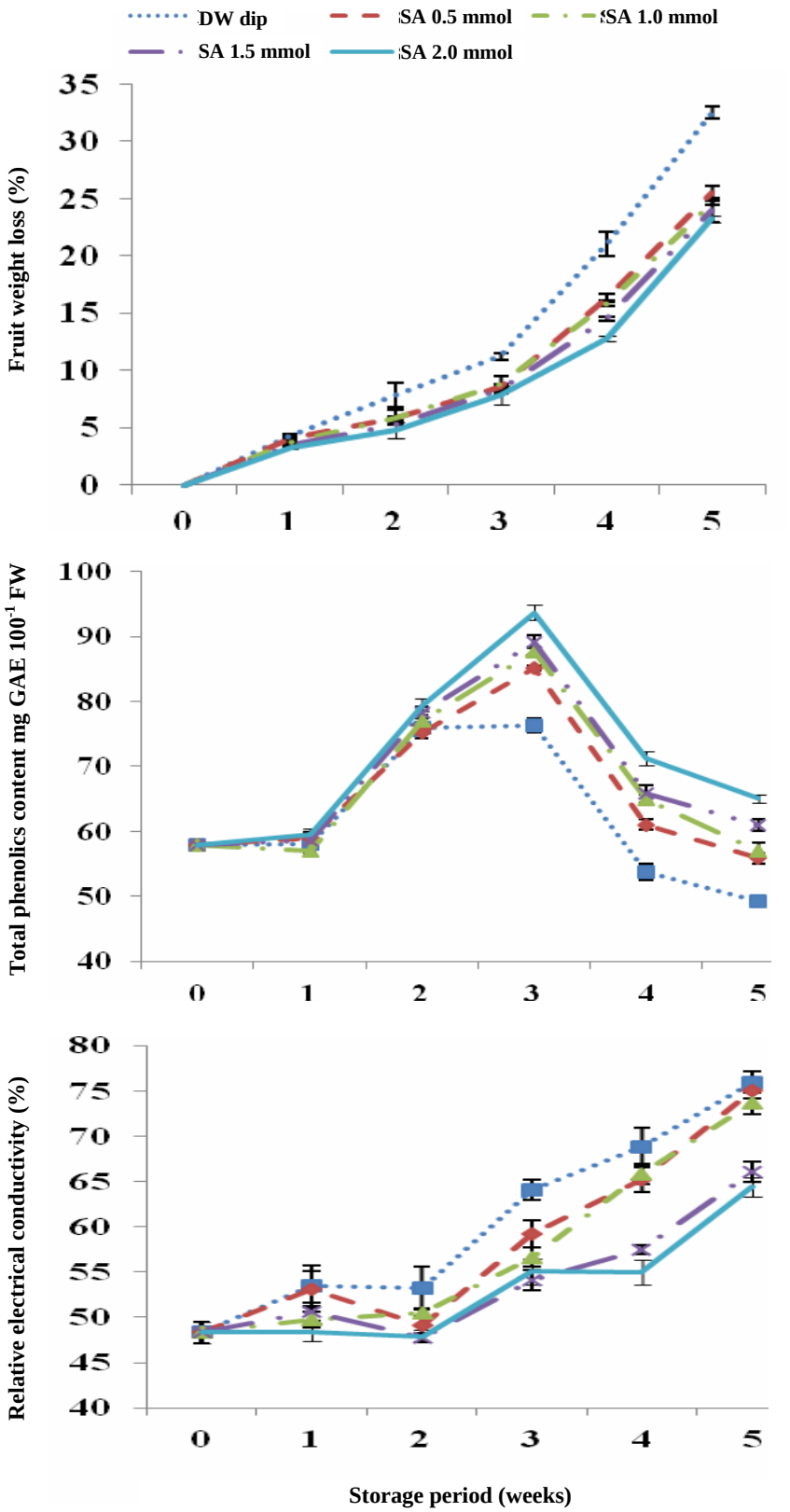

Fig. 1. Effects of different salicylic acid (SA) treatments on quality parameters of peach fruits cv. 'Flordaking' during five weeks of storage (0 ºC, 90% RH). Vertical bars represent the standard error of means for three replicates.

Total phenolics content: Effect of salicylic acid on total phenolics content (mg GAE per 100g) of peach fruits has been investigated during five weeks of storage period (Fig. 1). Total phenolics content started increasing during week one till week three and then began to decrease till end of the experiment. Total phenolics content was found maximum in fruits treated with 2.0 mmol L^{-1} followed by 1.5 mmol L^{-1} SA as compared with control. Phenolics being secondary plant metabolites are synthesized by all plants. They are responsible for the flavor and color of fruit products (Jeong *et al*., 2008). They exist generally as flavonols in fruits peel (Hamauzu, 2006). Salicylic acid treated 'Cara cara' navel oranges had increased total phenolic content and higher SA concentration was observed with further profound effect in this respect (Huang *et al*., 2008).

Relative electrical conductivity: The highest relative electrical conductivity (REC) was observed in control fruits (Fig. 1). Whereas the lowest REC was found in fruits treated with 2.0 mmol L^{-1} SA treatment and lower SA treatments remained non-significant but significantly lower than that of control fruits. There were no differences among all the treatments during first two weeks. Later on control fruits had increased levels of REC than SA treated fruits. At later stage SA might have contributed in inhibiting senescence which has also been similarly documented by Han *et al*. (2003). Electrolyte leakage is an index which can quantify the damage conceived by plant cell membrane. During postharvest physiological changes, membrane leakage is the key factor which causes a surge of biochemical reactions (Maragoni *et al*., 1996). Due to damage mediated by increased free radical and loss of membrane integrity which results in more ion leakage characterized by plant tissue senescence and ripening in fruits (Stanley, 1991; Ferrie *et al*., 1994; Palma *et al.,* 1995) further these damages lead to deteriorated cell wall texture (Powell & Bennett, 2002). SA (1 mM) pretreatment of grain before sowing significantly decreased electrolyte leakage in barley seedlings under salt stress condition (El-Tayeb, 2005). In this study lowest REC in SA treated peach fruits might be ascribed to less plasma lemma membranes damage as reported by Meng *et al*., (2009), and the increased solidity of membranous cells (Demarty *et al*., 1984).

Conclusion

The results of present study conclusively showed that 2.0 mmol L^{-1} salicylic acid had significant effect on quality parameters of peach fruits cv. 'Flordaking' during five weeks of storage period. While, lower SA concentrations did not affect significantly and performed nearly to that of control fruits. Fruits treated with 2.0 mmol L^{-1} SA retained maximum firmness, higher levels of SSC, increased contents of ascorbic acid and total phenolics and reduced REC.

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