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Effect of post-harvest salicylic acid treatments on fruit quality of peach cv. "Flordaprince" during cold storage.

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Abstract: Peach [*Prunus persica* (L.) Bastch.] "cv. Flordaprince" fruits at commercial maturity were immersed in 0, 0.5, 1.0 and 1.5 mM salicylic acid (SA) solution for 10 min, stored at 0 ◦ C for 28 days, then moved to 20 ◦C for 3 days to simulate shelf life. Fruit weight losses, firmness, TSS, acidity, Vit.C, sugars, anthocyanin, total phenols and two enzymes namely peroxidase and polyphenol oxidase activities of fruit were measured at the end of shelf life. The results showed the interaction effects between salicylic acid and storage period, also the effect of salicylic acid treatments and effect of storage period. It was noticed that the highest values of fruit losses weight were achieved with increasing storage period to 28 days and decreasing SA concentrations from 1.5 to 0.5 mM, firmness of fruit treated with SA was significantly greater than that of control fruit after 28 days of cold storage. Fruits receiving all postharvest treatments produced the firmest fruits, while the control plants (without receiving SA) had the softest fruits. Moreover, Regarding SA treatments, data revealed that, decreasing in fruit T.S.S contents were observed with increasing SA concentration in both seasons. No significant difference was found between T_2 and T_3 treatments on fruit T.S.S contents in both seasons. The three salicylic acid treatments maintained a significantly lower reducing and total sugars, anthocyanin and enzymes activity(peroxidase and polyphenol oxidase) than control. Acidity, Vit. C, total phenols content in fruits increased gradually with increasing SA concentrations. In the same time, prolonging periods of storage in both seasons, generally decreased vit. C and total phenols. In contrast, reducing and total sugars, anthocyanin, peroxidase and polyphenol oxidase activities increased. In the first season only, fruit reducing sugar content at 0 day has significantly high value compared to 7 days.

Key words: Salicylic acid; Postharvest; Peach; Cold storage; Fruit quality.

INTRODUCTION

The peach (*Prunus persica* (L.) Batsch) belongs to the family "Rosaceae" originated in China. Peach is one of the most popular fruit in the world because of its high nutrient level and pleasant flavor. Peaches ripen and deteriorate quickly at ambient temperature. Therefore, cold storage has always been used as the main method to slow these processes as well as decay development, but chilling injury (CI) limits peach storage life at low temperatures (Wang *et al*., 2006). Peach fruit exposed to conventional cold storage at 0–1 ◦C for up to 2 weeks normally suffer chilling injury, although this disorder is strongly dependent on cultivar and maturity at harvest (Morris, 1982). The appearance of internal browning in the fruit flesh also occurs at low temperature, which may be related to tissue deterioration resulting from membrane lipid oxidation (Lurie and Crisosto, 2005).Salicylic acid (SA), which belongs to a group of phenolic compounds, is widely distributed in plants and it is now considered as a hormonal substance, playing an important role in regulating a large variety of physiological processes (Zavala *et al* ., 2004). Salicylic acid (SA) is considered as a plant hormone (Raskin, 1992) because of its role in regulating some aspects of disease resistance in plants. Moreover, dietary salicylates from fruit and vegetables are described as bioactive compounds with health care potential (Hooper and Cassidy, 2006), and considered as generally recognized as safe (GRAS). Recently, it has been observed that salicylic acid (SA) treatment could be used to reduce deterioration and chilling injury symptoms in some fruit (Wang *et al*., 2006 and Sayyari *et al*., 2009). Both pre- and post-harvest SA treatments have been reported as being effective in fruit quality maintenance and storage life extension of strawberry (Babalare *et al*., 2007). Preharvest application of salicylic acid has induced resistance against pathogens in pear (Jiankang *et al* ., 2006) and decreased disease development in cherry (Yao and Tian, 2005). Application of exogenous SA at non-toxic concentrations to fruit has been shown to delay the ripening and softening of banana (Srivastava and Dwivedi, 2000) and kiwifruit (Zhang *et al*., 2003), reduce lipid peroxidation of navel orange (Huang *et al*., 2008), and increase host resistance to postharvest diseases of sweet cherry (Qin *et al*., 2003). In recent years, a few studies have reported the effects of SA on chilling injury, showing that SA and methyl salicylate (MeSA) treatments increase resistance to postharvest chilling injury in horticultural crops, including tomato (Ding *et al*., 2001), loquat (Cai *et al*., 2006), mango (Ding *et al*., 2007), peach (Wang *et al* ., 2006) and (Cao *et al*., 2010), pomegranate (Sayyari *et al*., 2009), and pineapple (Lu *et al*., 2010). On the other hand, SA application either preharvest (Yao and Tian, 2005) or postharvest reduced fungal decay in sweet cherry through induction of the defense resistance system (Chan and Tian, 2006) and stimulation of antioxidant enzymes (Xu and Tian, 2008).

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They also reported the reversible effect of SA and suggested plant SA treatment in all different growth stages like vegetative, fruit development and postharvest stage. Salicylic acid also prevented softening of banana and kiwifruit during ripening (Srivastava and Dwivedi, 2000 and Zhang *et al*., 2003). Thus, this investigation was carried out to study the effect of SA on related physiological and chemical changes and internal browning enzymes of peach fruits during cold storage.

MATERIALS AND METHODS

This investigation was carried out on fruits of Flordaprince peach cultivar (*Prunus persica* (L.) Batsch) collected from trees with age 10 years old, budded on Nemaguard peach rootstock, spaced 5X 6 meters grown in a private orchard; El- Behera Governorate. At harvest time [i. e., April 16 th,2010 and April 19th, 2011] , fruits uniform in shape and size and free of fungal infection were selected with range of 8.5± 1 % T.S.S and Firmness 15± 1 (lb/in^2), the following treatments were used, control (T0) and salicylic acid at 0.5 (T1), 1.0 (T2) or 1.5 (T3) mM. Another batch of 15 fruits was used to determine fruit properties at day 0. For each treatment and replicate, fruits were dipped in a fresh 25 Litre solution for 10 min. Following treatments, fruits were allowed to completely dry at room temperature before storage at 0 °C and 85-90% RH for 28 days of cold storage, fruits were moved to room temperature at 20 ◦C for 3 days (simulating shelf life).

2. 1. Physical Fruit Analysis:

The percentage of physiological fruit weight loss was determined as follows:

$$\text{Weight loss (\%)} = \frac{\text{Average loss in fruit weight}}{\text{Average initial fruit weight}} \times 100$$

Fruit firmness (lb/in^2) was determined by Magness and Taylor (1925) pressure tester using a 5/16 plunger. Two readings were taken at two opposite sides on the flesh of each fruit after peeling.

2.2. Chemical Fruit Analysis:

T.S.S (%) was determined in fruit juice by a hand refractometer. Fruit juice acidity was determined according to the A.O.A.C (1980) by titration with 0.1 N sodium hydroxide using phenolphthalein as an indicator and expressed as malic acid percentage. Vitamin C content was determined in fruit juice using 2, 6-dichlorophenol- blue dye as mg ascorbic acid per 100 ml juice (A.O.A.C.,1980). Total sugar (%) was determined calorimetrically using phenol and sulphuric acid, according to Malik and Singh (1980). The reducing sugars (%) were determined by Nelson arsenate- molybdate colorimetric method (Dubois *et al*., 1956). Anthocyanin was determined (mg/ 100 g fresh weight) according to the method of Rabino *et al*. (1977). Total phenolic compounds were determined according to the method of Swain and Hillis (1959) using the Folin-Denis reagent. The optical density of the samples was read at 725 nm and the amounts of total phenols were calculated against a standard curve of tannic acid. The amount of total phenols were expressed as mg per g fresh weight. Peroxidase activity was spectrophotometrically determined by Chance and Maehly (1955) and Polyphenol oxidase activity by Matta and Dimond (1963), and expressed as (O.D/g/min)).

2.3. Statistical Analysis:

Data from the analytical determinations were subjected to analysis of variance (ANOVA). The experiment was designed as randomized complete block design with 3 (SA concentration) and control, 5(time of storage period) with 5 replicates (Steel and Torrie, 1980). Mean comparisons were performed using Least Significant Difference (LSD) Test. Differences among means of data were compared by Differences at 0.05 were considered significant. All analyses were performed with SAS software package.

RESULTS AND DISCUSSION

3.1. Physical Fruit Analysis:

3.1.1. Weight Losses (%):

As for salicylic acid treatments, regardless storage period, data in Table (1) revealed that the two higher salicylic acid treatments significantly decreased fruit weight loss as compared with control and T_1. No significant difference was found between T_2 and T_3 in both seasons. Regarding the effect of storage period, regardless SA treatments, on the changes in fruit weight loss, the data of both experimental seasons showed significantly increased with increasing time of storage from 0 times to 28 days. Concerning the interaction effects between salicylic acid and storage period treatments, data noticed that the highest values of fruit losses were achieved with increasing storage period to 28 days and decreasing SA concentrations from 1.5 to 0.5 mM. Data recorded by Wolucka *et al*. (2005) are in line with previous results. They reported that fruits which received SA in their nutrient solution had smaller weight loss than fruits without SA in their nutrient solution,

weight loss are due to metabolic activity, respiration and transpiration. Also, salicylic acid as an electron donor produces free radical which prevents normal respiration and SA can also decrease respiration rate and fruit weight loss by stoma closing (Manthe *et al*., 1992 and Zheng and Zhang, 2004). Furthermore, Shafiee *et al.* (2010) reported that, fruits of strawberry dipped in salicylic acid solution had less weight loss than control.

3.1.2. Fruit firmness (lb/in^2):

In the present study, it was shown that treatment with SA effective in slowing the decline in firmness. The effects of the various salicylic acid and storage period treatments, on flesh firmness of peach cultivar are exhibited in Table (1). As for SA treatments the firmness was significantly increased with increasing the salicylic acid concentrations compared to control in both seasons. Significant differences were also found among the three concentrations of SA and noticed that T_3 treatment gave the highest value of fruit firmness, in both experimental seasons. As for storage period, regardless SA treatments fruit firmness showed significantly decreased with the time progress. It was, also, found that fruit firmness significantly decreased with increasing storage period. Significant differences were found among the different storage periods. Firmness of fruit treated with SA was significantly greater than that of control fruit after 28 days of cold storage. Fruitsreceiving all postharvest treatments produced the firmest fruits, while the control plants (without receiving SA) had the softest fruits. SA prevents fruit softening according to Srivastava and Dwivedi (2000), Zhang *et al*. (2003) and Wang *et al* . (2006). They found that rapid softening of fruits during ripening was simultaneous with rapid decrease in endogenous SA of fruits. SA effects cell swelling which leads to higher firmness of fruits (Zhang *et al*., 2003 and Shafiee *et al*., 2010).

3.2. Chemical Fruit Analysis:

3.2.1. Total Soluble Solids (T.S.S %):

The results illustrated in Table (1) showed that the three salicylic acid treatments maintained a significantly lower T.S.S than the control fruits in both seasons. At storage period, regardless SA treatments, data showed that fruit T.S.S. content significantly increased with prolonging time of storage from 0 to 28 days, in both seasons. Regarding SA treatments, data in revealed that, decreasing in fruit T.S.S contents were observed with increasing SA rates in both seasons. No significant difference was found between T2 and T3 treatments on fruit T.S.S contents in both seasons.

As for interaction effects between storage period and SA treatments on T.S.S contents, data showed that, generally, the increasing of SA and prolonging time of storage increased T.S.S contents in fruits in both seasons. SA treatment effectively decreased ethylene production in fruit and noticeable decrease in metabolic activity which delays fruit senescence process (Wills *et al*., 1998).

3.2.2. Acidity (%):

The results in Table (2) showed that the two higher salicylic acid concentrations maintained a significantly higher acidity (%) than control and lowest concentration. At storage period, data showed that fruit acidity content significantly decreased with prolonging time of storage, in both seasons, except between 0 and 7 days in first season only. Both pre- and post-harvest SA treatments have been reported as being effective in fruit quality maintenance and storage life extension of strawberry (Babalare *et al*.,2007). No significant changes were observed in TSS and TA during storage for any treatments, with the exception of TA in 1.4mM SA-treated fruit, which was rather high in pomegranates (Sayyari *et al*., 2009). Moreover, study on pineapple indicated the beneficial effect of SA by pre- harvest spray and/or post-harvest immersion fruit quality (Lu *et al*., 2011). Also, salicylic acid had a significant effect on apple titratable acids and total soluble solids (Shirzadeh and Kazemi, 2012)

3.2.3. Vitamin C (Vit. C) (mg / 100 ml juice):

The results presented in Table (2) indicated that, in both experimental seasons, ascorbic acid content (Vit. C) generally increased with salicylic acid treatments. It was found that T2 and T3 gave the highest significant values of Vit C compared to control (T_0). No significant difference was found between T_1 and control in two seasons. As for the changes in fruit ascorbic acid content during storage, results showed that there was a significant decrease in the juice ascorbic acid content with prolonging the storage time in both seasons. Generally, it was noticed that Vit. C content in fruits increased gradually with increasing SA rates at all periods of storage while, decreased sharply with increasing the time of storage in both seasons. SA treatments could be used to reduce deterioration and chilling injury symptoms in some fruit (Wang *et al*., 2006; Babalare *et al*., 2007 and Sayyari *et al*., 2009). Both pre- and post-harvest SA treatments have been reported as being effective in fruit quality maintenance and storage life extension of strawberry (Shafiee *et al* ., 2010). Lu *et al*(2011) reported that SA delayed the decline of ascorbic acid (AsA) content and prevented AsA destruction, so high contents of AsA in treated pineapple could improve the fruit quality.

3.2.4. Sugars (%):

As for reducing and total sugars %, generally, data in Table (2) revealed that a significant increase by increasing storage period from 0 to 28 days under different SA treatments, while in the first season only fruit reducing sugar content at 0 day has significantly high value compared to 7 days. Furthermore, data showed that increasing concentrations of SA led to decreasing in reducing and total sugars % in fruits in both seasons. The differences were mostly significant as compared with control. Significant difference was found between T2 and T3 in the second season for reducing sugar (Table 2). Lu *et al*. (2011) revealed that quality is also an important factor to assess the storage effect and. Similar results were also reported by Sayyari *et al*. (2009) in post-harvest pomegranate fruit treated by SA.

3.2.5. Anthocyanin (mg/100g):

The results presented in Table (3) indicated that, in both experimental seasons, anthocyanin (mg/100g) generally decreased with increasing salicylic acid concentrations. It was found that T_2 and T_3 gave the lowest significant values of anthocyanin (mg/100g) compared to control (T_0). No significant difference was found between T_1 and control in the second season. As for the changes in fruit anthocyanin (mg/100g) content during storage, results showed that there was a significant increase in the anthocyanin (mg/100g) content with prolonging the storage time in both seasons. Furthermore, it was noticed that anthocyanin (mg/100g) content in fruits increased with decreasing SA rates and prolonging periods of storage treatments in both seasons. The 28 days storage time treatment significantly increased anthocyanin (mg/100g) in fruits at all SA treatments as compared with other storage periods in both seasons. Shafiee *et al*. (2010) found that, addition of SA to nutrient solution was not effective on fruit color in comparison with control, postharvest treatments were not effective on lightness and the effect of SA may be due to decreased respiration which prevents fruit senescence during storage. They additive that no reports on SA and Ca dipping on changing strawberry a value. It seems that these compounds prevent enzymatic activities which have a role in anthocyanin synthesis.

3.2.6. Total phenols (mg / g fresh weight):

Results presented in Table (3) revealed that, in both experimental seasons, total phenol (mg/g) increased with increasing salicylic acid concentrations. Also, It was noticed that no significant differences were reported among T_1, T_2 and T_3 treatments in both seasons in total phenol (mg/g). No significant difference was found between T_1 and control in the two seasons in content of total phenol (mg/g) in fruits. As for the effect of storage period, regardless SA treatments, data revealed that total phenol (mg/g) content during storage, decreased with prolonging the storage time in both seasons. Furthermore, it was noticed that total phenol (mg/g) content in fruits increased with increasing SA rates and decreased by prolonging periods of storage treatments in both seasons. The 28 days storage time had significantly decreased total phenol (mg/g) in fruits as compared with other storage periods in both seasons. Lu *et al*. (2011) reported that SA did not affect total phenolics (TP) content. The study indicated the beneficial effect of SA by pre-harvest spray and/or post-harvest immersion on pineapple fruit quality. Also, they suggest that the chilling stimulates the biosynthesis of phenolics by enhancing PAL activity and PPO synthesis. Further characterization of the browning substrates involved would help to better understand the specific biosynthetic pathway associated with IB development. Moreover, SA treatments inhibited the activities of PPO and PAL, thus reduced TP content production and delayed conversion (Luo *et al*., 2011).

3.2.7. Enzymes activity (peroxidase and polyphenol oxidase (O.D/g/min)):

The results in Table (3) showed that the prolonging of storage period of peach fruits from 0 to 28 days significantly increased the activity of peroxidase and polyphenol oxidase enzymes. At the same time, increasing SA concentrations generally significantly decreased peroxidase and polyphenol oxidase enzymes in fruits in both seasons. The same trend was reported as for interaction effects between storage period and SA treatments on peroxidase and polyphenol oxidase enzymes in fruits in both seasons. It is generally found that browning is due to the oxidation of phenolics caused by PPO and POD, resulting in the formation of brown substances (Martinez and Whitake, 1995). PPO is a key enzyme for enzymatic browning in many fruit (Mayer, 1987). POD can oxidize phenols to quinones, then condense tannins to brown polymers in the presence of H2O2, which may then contribute to enzymatic browning (Subramanian *et al*., 1999 and Luo *et al*., 2011). Also, POD and PPO have a synergistic effect on the formation of the brown polymers (Martinez and Whitake, 1995). Moreover, PPO activity of SA-treated fruit was reduced ($P < 0.05$). Suppression of PPO activity by SA treatment has been found in apple (Mo *et al* ., 2008) and pineapple fruit (Lu *et al*., 2010). POD activity showed similar patterns in SA-treated and control fruit and activity of control fruit increased quickly and reached a maximum value at 45 days. POD activity was inhibited by the SA treatment ($P < 0.05$). Retardation of POD activity by of SA treatment has also been reported for loquat (Cai *et al*., 2006). Also, Lu *et al*. (2011) reported that SA significantly inhibited PPO and PAL activities. The study indicated the beneficial effect of SA by pre-harvest spray and/or post-harvest immersion on pineapple fruit quality.

Conclusion

In conclusion, SA treatment maintained greater firmness, reduced T.S.S, acidity, sugars and fruit losses in "cv. Flordaprince" peach fruit during cold storage. The effect of SA on alleviating chilling injury of peaches during cold storage may be attributed to its ability to induce antioxidant systems. Pre-storage application of SA may provide a useful means of extending peach postharvest life during cold storage.

Table 1: Effect of salicylic acid treatments, storage period and interactions on firmness, weight losses and T.S.S % in fruits of peach "Flordaprince" in 2010 and 2011 seasons.

Storage period	Treatments	Weight loss(%)		Firmness (lb/in^2)		T.S.S(%)	
(days)	Salicylic acid (mM)	2010	2011	2010	2011	2010	2011
0		-	-	15.60 ^{a}	15.00 ^{a}	8.98 ^{e}	8.90 ^{d}
7	T_0 (0.0)	3.05	2.80	14.79	13.71	9.27	9.20
	T_1 (0.5)	3.00	2.77	14.89	13.88	9.23	9.15
	T2 (1.0)	2.73	2.60	15.20	14.51	9.16	9.12
	T3 (1.5)	2.70	2.58	15.50	14.79	9.12	9.12
Column Mean		2.87 ^{d}	2.68 ^{d}	15.09 ^{b}	14.22 ^{b}	9.20 ^{d}	9.15 ^{c}
14	T_0 (0.0)	5.14	4.90	12.31	11.45	9.48	9.31
	T_1 (0.5)	5.07	4.83	12.95	11.78	9.33	9.17
	T2 (1.0)	4.93	4.71	13.71	12.76	9.23	9.10
	T3 (1.5)	4.90	4.60	13.82	12.95	9.21	9.07
Column Mean		5.01 ^{c}	4.76 ^{c}	13.19 ^{c}	12.23^{c}	9.31 ^{c}	9.16 ^{c}
21	T_0 (0.0)	7.50	7.86	10.10	9.80	9.61	9.61
	T_1 (0.5)	7.43	7.80	10.97	10.11	9.53	9.50
	T2 (1.0)	7.31	7.70	12.01	10.61	9.36	9.32
	T3 (1.5)	7.32	7.72	12.51	11.19	9.40	9.33
Column Mean		7.39^{b}	7.77^{b}	11.39^{d}	10.42^{d}	9.47 ^{b}	9.44 ^{b}
28	T_0 (0.0)	11.10	10.90	7.25	7.18	9.86	9.81
	T_1 (0.5)	11.01	10.82	7.51	8.00	9.73	9.70
	T2 (1.0)	10.90	10.70	8.66	8.62	9.59	9.53
	T3 (1.5)	10.93	10.73	8.93	8.82	9.57	9.50
Column Mean		10.98^{a}	10.78 ^{a}	8.08^{e}	8.15^{e}	9.68^{a}	9.63^{a}
Treatments Mean							
T_0 (0.0)		6.69^{a}	6.61^{a}	12.01^{d}	11.42^{d}	9.44^{a}	9.36^{a}
T_1 (0.5)		6.62^{a}	6.55^{a}	12.38^{c}	11.75^{c}	9.36^{b}	9.28^{b}
T2 (1.0)		6.46^{b}	6.42^{b}	13.03^{b}	12.30^{b}	9.26^{c}	9.19^{c}
T3 (1.5)		6.46^{b}	6.40^{b}	13.27^{a}	12.55^{a}	9.25^{c}	9.18^{c}
Treat.X stor.		n.s	n.s	***	***	n.s	*

Means followed by the same letter(s) within a separate column are not significantly different at (P< 0.05).n.s not significant.* significant at 0.05 level of probability. ** Significant at 0.01 level of probability and *** Significant at 0.001 level of probability.

Table 2: Effect of salicylic acid treatments, storage period and interactions on acidity, Vit.C, reducing and total sugars in fruits of peach "Flordaprince" in 2010 and 2011 seasons.

Storage period	Treatments	Acidity (%)		Vitamin C (mg /100 ml juice)		Reducing sugars (%)		Total sugars(%	
(days)	Salicylic acid (mM)	2010	2011	2010	2011	2010	2011	2010	2011
0		0.973 ^{a}	1.004 ^{a}	18.16 ^{a}	19.05 ^{a}	1.74 ^{d}	1.61 ^{e}	4.88 ^{e}	4.95 ^{e}
7	T_0 (0.0)	0.940	0.955	17.10	18.00	1.81	1.85	5.25	5.33
	T_1 (0.5)	0.941	0.960	16.95	18.20	1.70	1.80	5.20	5.30
	T2 (1.0)	0.952	0.972	17.34	18.51	1.61	1.78	5.15	5.18
	T3 (1.5)	0.961	0.980	17.42	18.59	1.58	1.73	5.14	5.12
Column Mean		0.948 ^{a}	0.966 ^{b}	17.19 ^{b}	18.33 ^{b}	1.68 ^{e}	1.79 ^{d}	5.18 ^{d}	5.23 ^{d}
14	T_0 (0.0)	0.830	0.890	14.33	14.12	2.05	2.01	5.46	5.52
	T_1 (0.5)	0.833	0.890	14.34	14.19	1.92	1.96	5.40	5.50
	T2 (1.0)	0.853	0.907	14.59	14.50	1.88	1.90	5.30	5.42
	T3 (1.5)	0.861	0.916	14.65	14.49	1.80	1.83	5.33	5.40
Column Mean		0.819 ^{b}	0.900 ^{c}	14.46 ^{c}	14.33 ^{c}	1.91 ^{c}	1.93 ^{c}	5.37 ^{c}	5.46 ^{c}
21	T_0 (0.0)	0.731	0.850	10.60	10.66	2.21	2.21	5.71	5.76
	T_1 (0.5)	0.731	0.854	10.68	10.71	2.11	2.05	5.62	5.70
	T2 (1.0)	0.740	0.861	10.91	10.88	2.02	2.00	5.43	5.59
	T3 (1.5)	0.751	0.871	10.95	10.86	1.96	1.90	5.41	5.52
Column Mean		0.738 ^{c}	0.859 ^{d}	10.79^{d}	10.77^{d}	2.08 ^{b}	2.04 ^{b}	5.54 ^{b}	5.64 ^{b}
28	T_0 (0.0)	0.660	0.784	7.81	7.95	2.48	2.33	5.92	5.89
	T_1 (0.5)	0.663	0.783	7.92	7.99	2.26	2.31	5.70	5.80
	T2 (1.0)	0.682	0.792	8.22	8.16	2.20	2.27	5.60	5.65
	T3 (1.5)	0.691	0.800	8.25	8.15	2.16	2.20	5.63	5.58
Column Mean		0.674^{d}	0.789^{e}	8.05^{e}	8.06^{e}	2.27^{a}	2.28^{a}	5.71 ^{a}	5.73 ^{a}
Treatments Mean									
T_0 (0.0)		0.826^{c}	0.896^{c}	13.59^{c}	13.96^{b}	2.058 ^{a}	2.00^{a}	5.44 ^{a}	5.49 ^{a}
T_1 (0.5)		0.828^{c}	0.898^{c}	13.60^{c}	14.02^{ab}	1.94^{b}	1.95^{b}	5.36 ^{b}	5.45 ^{a}
T2 (1.0)		0.840^{b}	0.907^{b}	13.84^{b}	14.22^{a}	1.89^{c}	1.91^{b}	5.28 ^{c}	5.35 ^{b}
T3 (1.5)		0.847^{a}	0.914^{a}	13.89^{a}	14.23^{a}	1.85^{c}	1.85^{c}	5.27 ^{c}	5.31 ^{b}
Treat.X stor.		n.s	n.s	***	n.s	*	n.s	n.s	n.s

Means followed by the same letter(s) within separate column are not significantly different at (P< 0.05). n.s not significant, * significant at 0.05 level of probability, ** significant at 0.01, *** significant at 0.001

Table 3: Effect of salicylic acid treatments, storage period and interactions on anthocyanin, total phenols, peroxidase and polyphenol oxidase in fruits of peach "Flordaprince" in 2010 and 2011 seasons.

Storage Period(days)	Treatments Salicylic acid (mM)	Anthocyanin (mg/100g)		Total phenols (mg/g)		Peroxidase activity(O.D/g/min)		Polyphenol oxidase activity(O.D/g/min)	
		2010	2011	2010	2011	2010	2011	2010	2011
0		14.14 ^{d}	13.98 ^{e}	1.35 ^{a}	1.25 ^{a}	0.134 ^{d}	0.165^{c}	0.056 ^{e}	0.066 ^{d}
7	T_0 (0.0)	14.68	14.77	1.30	1.20	0.148	0.179	0.068	0.075
	T_1 (0.5)	14.29	14.35	1.30	1.21	0.146	0.178	0.064	0.074
	T_2 (1.0)	14.00	14.18	1.33	1.24	0.138	0.170	0.056	0.070
	T_3 (1.5)	13.96	14.10	1.33	1.24	0.141	0.172	0.058	0.068
Column Mean		14.23 ^{d}	14.35 ^{d}	1.31 ^{ab}	1.22 ^{a}	0.143 ^{c}	0.169^{c}	0.061 ^{d}	0.071 ^{c}
14	T_0 (0.0)	15.98	15.91	1.22	1.12	0.158	0.183	0.081	0.089
	T_1 (0.5)	15.41	15.39	1.24	1.15	0.152	0.180	0.076	0.090
	T_2 (1.0)	15.05	15.10	1.28	1.18	0.143	0.171	0.070	0.080
	T_3 (1.5)	15.00	15.10	1.31	1.22	0.145	0.173	0.070	0.079
Column Mean		15.36 ^{c}	15.37 ^{c}	1.26 ^{bc}	1.16 ^{b}	0.149 ^{bc}	0.176^{bc}	0.074 ^{c}	0.084 ^{b}
21	T_0 (0.0)	17.64	17.73	1.18	1.07	0.165	0.188	0.086	0.093
	T_1 (0.5)	17.33	17.41	1.23	1.14	0.156	0.187	0.086	0.090
	T2 (1.0)	17.01	17.00	1.29	1.17	0.150	0.180	0.080	0.082
	T3 (1.5)	17.11	17.05	1.28	1.20	0.151	0.182	0.075	0.084
Column Mean		17.27 ^{b}	17.29 ^{b}	1.24 ^{c}	1.14 ^{b}	0.155 ^{b}	0.184^{ab}	0.081 ^{b}	0.087 ^{b}
28	T_0 (0.0)	18.30	18.21	1.10	1.00	0.175	0.203	0.101	0.098
	T_1 (0.5)	18.25	18.15	1.15	1.07	0.166	0.201	0.096	0.095
	T_2 (1.0)	18.00	18.01	1.20	1.10	0.160	0.192	0.090	0.088
	T_3 (1.5)	18.07	17.96	1.22	1.12	0.160	0.190	0.091	0.086
Column Mean		18.15 ^{a}	18.08^{a}	1.16 ^{d}	1.07 ^{c}	0.165^{a}	0.192^{a}	0.094^{a}	0.091 ^{a}
Treatments Mean									
T_0 (0.0)		16.14^{a}	16.11^{a}	1.22 ^{b}	1.12 ^{b}	0.156^{a}	0.183^{a}	0.078^{a}	0.084 ^{a}
T_1 (0.5)		15.88^{ab}	15.85^{b}	1.25 $^{a\ b}$	1.15 ^{ab}	0.150^{ab}	0.182^{ab}	0.075^{a}	0.083 ^{a}
T_2 (1.0)		15.65^{b}	15.65^{c}	1.29 ^{a}	1.18 ^{ab}	0.145^{b}	0.172^{ab}	0.070^{b}	0.077 ^{b}
T_3 (1.5)		15.64^{b}	15.63^{c}	1.29 ^{a}	1.20 ^{a}	0.146^{b}	0.171^{b}	0.070^{b}	0.076 ^{b}
Treat. X stor.		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

Means followed by the same letter(s) within a separate column are not significantly different at (P‹ 0.05).n.s not significant.* significant at 0.05 level of probability. ** Significant at 0.01 level of probability, *** Significant at 0.001 level of probability.

REFERENCES

Association of Official Agriculture Chemists (A.O.A.C), 1980. Official methods of analytical Chemists Washington, D.C., U.S.A..

Babalare, M., M. Asghari, A. Talaei and A. Khosroshahi, 2007. Effect of pre- and postharvest salicylic acid treatment on ethylene production, fungal decay and overall quality of Selva strawberry fruit, Food Chem., 105: 449-453.

Cai, C., X. Li and K.S. Chen, 2006. Acetylsalicylic acid alleviates chilling injury of postharvest loquat (Eriobotrya japonica Lindl.) fruit, Eur. Food Res. Technol., 223: 533-539.

Cao, S.F., Z.C. Hu, Y.H. Zheng and B.H. Lu, 2010. Synergistic effect of heat treatment and salicylic acid on alleviating internal browning in cold-stored peach fruit, Postharvest Biol. Technol., 58: 93-97.

Chan, Z. and S. Tian, 2006. Induction of H2O2-metabolizing enzymes and total protein synthesis by antagonist and salicylic acid in harvested sweet cherry fruit, Postharvest Biol. Technol., 39: 314-320.

Chance, B. and A.C. Maehly, 1955. Assay of catalases and peroxidases. In methods of enzymology. II Ed. pp. 773. Colowick, S.P. and Kaplan, N.O., Academic Press, New York and London.

Ding, C.K., C.Y. Wang, K.C. Gross and D.L. Smith, 2001. Reduction of chilling injury and transcript accumulation of heat shock proteins in tomato fruit by methyl jasmonate and methyl salicylate, Plant Sci., 161: 1153-1159.

Ding, Z.S., S.P. Tian, X.L. Zheng, Z.W. Zhou and Y. Xu, 2007. Responses of reactive oxygen metabolism and quality in mango fruit to exogenous oxalic acid or salicylic acid under chilling temperature stress, Physiol. Plant., 130: 112-121.

Dubois, M., K.A. Cilles, J.K. Hamilton, P.A. Rober and F. Smith, 1956. Colorimetric method for determination of sugar and related substances. Anal. Chem., 28: 350- 356.

Hooper, L. and A. Cassidy, 2006. A review of the health care potential of bioactive compounds, J. Sci. Food Agric., 86: 1805-1813.

Huang, R.H., J.H. Liu, Y.M. Lu and R.X. Xia, 2008. Effect of salicylic acid on the antioxidant system in the pulp of 'Cara cara' navel orange (Citrus sinensis L Osbeck) at different storage temperatures, Postharvest Biol. Technol., 47: 168-175.

Jiankang, C., Z. Kaifang and J. Weibo, 2006. Enhancement of postharvest disease resistance in Ya Li pear (pyrus bretschneideri) fruit by salicylic acid sprays on the trees during fruit growth, European J. Plant Pathol., 114: 363-378.

Lu, X.H., D.Q. Sun, Y.W. Mo, J.G. Xi and G.M. Sun, 2010. Effects of post-harvest salicylic acid treatment on fruit quality and anti-oxidant metabolism in pineapple during cold storage, J. Hort. Sci. Biotechnol., 85: 454-458.

Lu, X., D. Sun, Y. Li, W. Shi and G. Sun, 2011. Pre- and Post- harvest salicylic acid treatments alleviate internal browning and maintain quality of winter pineapple fruit. Scientia Horticulturae: 130: 97-101.

Luo, Z., C. Chen and J. Xie, 2011. Effect of salicylic acid treatment on alleviating postharvest chilling injury of "Qingnai" plum fruit. Postharvest Biol and Technol., 62: 115-120.

Lurie, S., C.H. Crisosto, 2005. Chilling injury in peach and nectarine. Postharvest Biol. Technol., 37: 195-208.

Magness, J.R. and C.F. Taylor, 1925. An improved type of pressure tester for the determination of fruit maturity. U.S. Dept. Agric. Circ. No. 350, pp. 8.

Malik, C.P. and M.B. Singh, 1980. Plant enzymology and histoenzymology. A text Manual Kalyani Pubishers, New Delhi.

Manthe, B., M. Schulz and H. Schnabl, 1992. Effects of salicylic acid on growth and stomatal movements of Vicia faba L.: evidence for salicylic acid metabolization, J. Chem. Ecol., 18: 1525-1539.

Martinez, M.V. and J.R. Whitake, 1995. The biochemistry and control of enzymatic browning, Trends Food Sci. Technol., 6: 195-200.

Matta, A. and A.E. Dimond, 1963. Symptoms of Fusarium in relation to quality of fungus and enzyme activity in tomato stems. Phytopathology, 53: 574-575.

Mayer, A.M., 1987. Polyphenol oxidase and peroxidase in plants recent progress, Phytochemistry, 26: 11-20.

Mo, Y., D. Gong, G. Liang, R. Han, J. Xie and W. Li, 2008. Enhanced preservation effects of sugar apple fruits by salicylic acid treatment during postharvest storage, J. Sci. Food Agric., 88: 2693-2699.

Morris, L.L.,1982. Chilling injury of horticultural crop an overview. Hort Science, 17: 161-162.

Qin, G.Z., S.P. Tian, Y. Xu and Y.K. Wan, 2003. Enhancement of biocontrol efficiency of antagonistic yeasts by salicylic acid in sweet cherry fruit, Physiol. Mol. Plant Pathol., 62: 147-154.

Rabino, I., L. Alberto and M. Monrad, 1977. Photocontrol of anthocyanin synthesis. J. Plant Physiol., 59: 569-573.

Raskin, I., 1992. Salicylate, a new plant hormone, Plant Physiol., 99: 799-803.

Sayyari, M., M. Babalar, S. Kalantari, M. Serrano and D. Valero, 2009. Effect of salicylic acid treatment on reducing chilling injury in stored pomegranates, Postharvest Biol. Technol., 53: 152-154.

Shafiee, M., T.S. Taghavi and M. Babalar, 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.

Shirzadeh, E. and M. Kazemi, 2012. Effect of salicylic acid and essential oils treatments on quality characteristics of apple (Malus domestica Var. Granny Smith) fruits during storage. Asian Journal of Biochemistry, 7(3): 165-170.

Srivastava, M.K. and U.N. Dwivedi, 2000. Ripening of banana fruit by salicylic acid, Plant Science, 158: 87-96.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics: 2nd ed., Mc Graw- Hill, Hogakusha, Ltd., Japan.

Subramanian, N., P. Venkatesh, S. Ganguli and V.P. Sinkar, 1999. Role of polyphenol oxidase and peroxidase in the generation of black tea theaflavins, J. Sci. Food Agric., 47: 2571-2578.

Swain, T. and W.E. Hillis, 1959. The phenolic constituents of Prunus domestica. 1- The quantitative analysis of phenolic constituents. J. Sci. Fd. Agric., 10: 63-68.

Wang, L.J., S.J. Chen, W.F. Kong, S.H. Li and D.D. Archbold, 2006. Salicylic acid pretreatment alleviates chilling injury and effects the anti-oxidant system and heat shock proteins of peaches during cold storage, Postharvest Biol. Technol., 41: 244-251.

Wills, R., B. McGlasson, D. Graham and D. Joyce, 1998. Postharvest, and introduction to the physiology and handling of fruit and vegetables and ornamentals(Fourth ed.). Sydney 2050, Australia:University of New South Wales Press Ltd., University of New South Wales.

Wolucka, B.A., A. Goossens and D. Inzé, 2005. Methyl jasmonate stimulates the de novo biosynthesis of vitamin C in plant cell suspensions, J. Exp. Bot., 56: 2527-2538.

Xu, X. and S. Tian, 2008. Salicylic acid alleviated pathogen-induced oxidative stress in harvested sweet cherry fruit, Postharvest Biol. Technol., 49: 379-385.

Yao, H. and S. Tian, 2005. Effects of pre- and post-harvest application of salicylic acid or methyl jasmonate on inducing disease resistance of sweet cherry fruit storage, Postharvest Biol. Technol., 35: 253-262.

Zavala, J.F.A., S.Y. Wang, C.Y. Wang and G.A.G. Aguilar, 2004. Effects of Storage Temperatures on Antioxidant Capacity and Aroma Compounds in Strawberry Fruit, Elsevier Ltd. on behalf of Swiss Society of Food Science & Technology.

Zhang, Y., K. Chen, S. Zhang and I. Ferguson, 2003. The role of salicylic acid in postharvest ripening of kiwifruit, Postharvest Biol. Technol., 28 (1): 67-74.

Zheng Y. and Q. Zhang, 2004. Effects of polyamines and salicylic acid postharvest storage of 'Ponkan' mandarin, Acta. Hort., 632: 317-320.