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Postharvest treatment of salicylic acid on guava to enhance the shelf life at ambient temperature

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Abstract

Post harvest losses in fruit crops ranges from 25-40%. Highly profits can be fetched out in distinct markets by maintaining the quality of fruits and reducing their losses through different postharvest applications. In present study guava fruits were treated with different concentration of salicylic acid (0, 400, 500, 600 and 700 µmol) and stored at room temperature for attributes evaluation. Data for fruit color, weight loss%, fruit weight, decay%, fruit firmness, TSS, TA, ascorbic acid contents, total sugars, reducing sugars, non-reducing sugars, total phenolic contents and total antioxidents were calculated at five days interval at ambient storage condition. Results depicted that treated fruits with 600 µmol had lower values for color loss 1.5, fruit decay 14.97% and weight loss 20.03% as compared to other SA concentrations. Utmost values for TSS 7.24 °Brix, total titerable acidity 0.35%, total sugars 20.08%, non-reducing sugars 11.37%, reducing sugars 6.05%, ascorbic acid contents 7.95 (mg100gm-1), total phenolic compound 304.82 (µgmL-1FW) and total antioxidants 161.18 (IC50µgml-1) were noticed in fruits which were treated with (Salicylic Acid) 600 µmol. The study exposed that the 600 µmol Salicylic acid concentration is a beneficial postharvest treatment to increase the shelf life of guava fruit during short term storage.

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Introduction

Guava (*Psidium guajava* L.) is one of important fruits in the world and belongs to Myrtaceae family having 150 species. It is considered as the "poor man's fruit" or apple of the tropics" (Kosky *et al.*, 2005) and also rich source of vitamin C (260mg/100g fruit), as compared to citrus. This fruit also has a large amount of citric, lactic, malic, oxalic and acetic acids (Rahman *et al.*, 2003). Ripening is important processes that carried out in the fruits which involve chemical and physical property. The changes occur during ripening stage are color, flavor, and texture and these changes gives a physical appearance and so that become most acceptable for edible purpose (Amanullah *et al.*, 2016). In climacteric fruits for instance guava ripens quickly and it is enormously perishable fruit. Guava shelf-life normally 2-3 days at room temperatures therefore fruit cannot maintain the quality parameter during transportation for distant market (Bassetto *et al.*, 2005). During fruit ripening many physiological, biochemical and composition changes occur which encourage starch degradation or other polysaccharides to produce sugars, synthesis of pigment volatile compounds and the solubilization of cell walls well (Jain *et al.*, 2003). Salicylic acid (SA) is an assembly of phenolic compounds, which is frequently disseminated in plants and it is playing a significant function in variable a big variety of physiological processes (Zavala *et al.*, 2004).

In addition, dietary salicylates commencing fruit and vegetables are described as bioactive compounds during health care prospective (Hooper and Cassidy, 2006). Lately, it has been experimental that salicylic acid (SA) treatment might be used to decrease decline and chilling injury symptoms in some fruit (Wang *et al.*, 2006).

During pre and postharvest management SA treatments have been reported successful in fruit quality preservation and storage life expansion of strawberry (Babalare *et al.*, 2007). If we applied application of salicylic acid before harvest the fruit has created resistance alongside pathogens in pear (Jiankang *et al.*, 2006).

Function of exogenous SA at non-toxic concentrations has been exposed to decrease the ripening and softening of banana (Srivastava and Dwivedi, 2000) and it has also been used for different crops to prolong their shelf life. So, the aim of study was to assess out the salicylic acid role as exogenous application for enhancing the shelf life of guava.

Materials and methods

For the proposed study different salicylic acid treatments were imposed on guava and 12 fruit / replication were considered. The treatments were applied: T_0= (No application of Salicylic acid), T_1= Salicyclic acid 400 µmol, T_2= Salicyclic acid 500 µmol, T_3= Salicyclic acid 600 µmol, T_4= Salicyclic acid 700 µmol.

Physical quality assessment

Fruit color (score)

Fruit color was carefully examined of each fruit in all the replications using horticultural chart and scoring was done and then average was calculated. The information about the comparison of scores assigned to fruit color (light green=1, Yellow green=2, Yellow=3) by the application of four different level of S.A concentration.

Fruit firmness (Nm²)

Fruit firmness was measured with the help of penetrometer and expressed pressure necessary to force a plunger of specified size into the pulp of the fruit then average reading was calculated in the fruit.

Fruit decay (%).

Fruit rot during the storage was estimated by using the following formula.

$$\text{Fruit decay (\%)} = \frac{\text{Number of affected fruits per treatment}}{\text{Initial weightTotal number of fruits per treatment}} \times 100$$

Fruit weight loss (%)

Ten fruits (n=10) were randomly selected from each treatment unit. These fruits were weighted as fresh and at 10 days internal during the storage period and weight was calculated using the following formula of Takur, (1999).

$$\text{Fruit decay (\%)} = \frac{\text{Original fruit weight} - \text{Final fruit weight after storage}}{\text{Average fruit weight}} \times 100$$

Fruit biochemical quality assessment

At ripened stage, biochemical components were determined. For this, all fruits of each replication were peeled off with a stainless steel knife. The juice was extracted from fruits sample and homogenized to study the different biochemical parameters i.e. total soluble solids (TSS), titratable acidity (TA), ascorbic acid, sugars contents (total sugars, reducing and non-reducing sugars) and pulp was used for determination of antioxidants, phenolic contents and total carotenoids by following the process (AOAC, 2000; Chapman and Parker, 1961).

Statistical analysis

The experiment was laid out according to CRD-Factorial Design. Data was analyzed statistically by using MSTAT-C software (Russel and Eisensmith, 1983).

Results and discussion

Fruit color (score)

Data regarding fruit color showed momentous differences among all salicylic acid treatments, days and interactions (Table 1).

Table 1. Effect of different concentrations of salicylic acid on fruit color (score).

Treatments	5 day	10day	Means
Control	2.09^{a}	2.34^{a}	2.21^{a}
400 µmol	1.93^{b}	2.09^{a}	2.01^{a}
500 µmol	1.86^{b}	2.08^{a}	1.97^{b}
600 µmol	1.59^{c}	1.87^{b}	1.73^{c}
700 µmol	1.81^{b}	2.21^{a}	1.96^{b}
Means	1.85^{b}	2.11^{b}	

Note: fruit color at initial stage (1.09).

Table 2. Effect of different concentrations of salicylic acid on fruit weight loss (%).

Treatments	5 day	10day	Means
Control	22.74^{b}	30.54^{a}	26.64^{a}
400µM	19.33^{c}	21.91^{c}	20.62^{c}
500 µM	19.44^{c}	22.06^{b}	20.75^{b}
600 µM	18.28^{c}	21.79^{c}	20.03^{d}
700 µM	19.11^{b}	23.22^{a}	21.16^{c}
Means	19.78^{b}	23.90^{a}	

Note: fruit weight loss at initial stage (17.83).

Data showed that lowest color score 1.73 was observed in fruits those were treated with 600 µmol salicylic acid followed by fruits of color score 1.96 those were treated with 700µmol.

Highest color score of fruit 2.21 was observed in control. Data regarding days showed significant differences in color of fruit. Fruit color score (1.85) was observed at 5 day which was highest then zero day. Highest values of color score 2.11 were observed in tenth day.

Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10.

Data showed that color break of fruit with 600 µmol at day 5 was lowest having color score of 1.59 followed by salicylic acid concentrations of 700 µmol at day 5 having color score of 1.81.

Table 3. Effect of different concentrations of salicylic acid on fruit Decay (%).

Treatments	5 day	10day	Means
Control	18.27[c]	23.35a	20.81[a]
400 µmol	15.74[d]	16.14[d]	15.94[b]
500 µmol	15.21[d]	17.41[c]	16.31[b]
600 µmol	13.07[d]	16.88[c]	14.97[c]
700 µmol	14.74[d]	21.27[a]	18.05[a]
Means	15.40[b]	19.01[a]	

Note: Fruit decay at initial stage (13.65).

Highest color break 2.09 was observed with control at 5 day. Lolaei *et al.* (2012) reported that coatings based on salicylic acid are capable of delaying external color changes in strawberries. He found that strawberries coated with 2mM salicylic acid darkened slightly as compared to control. Lim and khoo, (1990) found that during fruit ripening, chlorophyll content decrease with a concomitant increase in the carotenoids content, causing skin color to change from green to yellow. The flesh color also changes to creamy white, yellow, pink or salmon red depending on the cultivar (Wilson, 1980).

Zeng *et al.* (2008) reported slightly retarded peel degreening and inhibited respiration rate in fruits of mango treated with salicylic 11 acids. Lolaei *et al.* (2012) investigated the effect of salicylic acid as pre and post-harvest treatments on the strawberry cv. Camarosa fruit quality and reported that both the treatments of SA delayed the ripening of strawberry fruits as evident by reduction of redness than control. Ber trees sprayed with Salicylic acid four times (30, 60, 90, and 110DAFB) significantly delayed the change of index in fruit skin color from green-to-red by 34.2%, after 60 days in cold storage (Cao *et al.* 2013).

Table 4. Effect of different concentrations of salicylic acid on fruit firmness (score).

Treatments	5 day	10day	Means
Control	30.12[a]	24.18[d]	27.15[c]
400 µmol	32.97[a]	28.19[c]	30.58[b]
500 µmol	34.51[a]	29.4[c]	31.95[a]
600 µmol	35.39[a]	33.29[a]	34.34[a]
700 µmol	34.18[a]	28.52[c]	31.35[a]
Means	33.43[a]	28.71[b]	

Note: fruit firmness at initial stage (36.12).

Fruit weight loss (%)

Data regarding fruit weight loss showed significant differences among all salicylic acid treatments, days and interactions (Table 2). Data showed that lowest weight loss 20.03 was observed in fruits those were treated with 600 µM salicylic acid followed of fruits weight loss 21.16 those were treated with 700 µmol. The utmost weight loss 26.64 was observed in control. Data regarding days showed significant differences in weight loss of fruit. Fruit weight loss 19.78 was observed at day 5, highest values of weight loss 23.90 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10.

Table 5. Effect of different concentrations of salicylic acid on fruit Total soluble solid (°Brix).

Treatments	5 day	10day	Means
Control	5.15[c]	7.23[a]	6.19[c]
400 µmol	6.19[b]	6.97[b]	6.58[b]
500 µmol	6.13[b]	7.19[a]	6.66[b]
600 µmol	7.03[a]	7.45[a]	7.24[a]
700 µmol	6.39[b]	7.26[a]	6.82[a]
Means	6.17[b]	7.22[a]	

Note: Total soluble solid at initial stage (5.30)

Data showed that lowest weight loss of fruit 18.28 was observed at 600 µmol at day 5, followed by having weight loss 19.11 was observed salicylic acid 700 µmol at day 5. Highest weight loss 22.74 was observed with control at day 5.

Our results are in line with zheng and zhang, (2004) those reported that SA application maintains the fruit weight during storage. Salicylic acid has also been reported to effectively reduce the respiration rate in peach fruits (Han *et al*., 2003).

Table 6. Effect of different concentrations of salicylic acid on fruit Total titerable acidity (%).

Treatments	5 day	10 day	Means
Control	0.52^{a}	0.38^{b}	0.45^{a}
400 µmol	0.47^{a}	0.33^{c}	0.40^{b}
500 µmol	0.46^{a}	0.39^{b}	0.42^{a}
600 µmol	0.39^{b}	0.32^{c}	0.35^{c}
700 µmol	0.47^{a}	0.33^{c}	0.40^{b}
Means	0.46^{a}	0.35^{b}	

Note: Total titerable acidity at initial stage (0.52).

The role of SA in reducing weight loss percentage has been reported in strawberry (shafiee *et al*., 2010) and peach (Tareen *et al*., 2012). Abbasi *et al. (*2010) found that after 6 week storage of peach fruit at 1°C, the average weight loss was minimum in 1mM salicylic acid treated fruits as compared to control. Similar results were reported by Brar *et al*. (2014) in peach fruits that salicylic acid 200 ppm significantly reduce the physiological loss as compare to control. Grapes treated ascorbic acid 1000 ppm recorded lower cumulative physiological loss in weight (Ramparasad *et al*. 2004). (Mahajan *et al*. 2009) also noticed that weight loss of 5% during storage is the maximum permissible limit in the case of fruits, above which the fruits show shriveling and become unmarketable.

Table 7. Effect of different concentrations of salicylic acid on fruit ascorbic acid (mg 100gm-1).

Treatments	5 day	10day	Means
Control	4.27^{e}	5.73^{d}	5^{d}
400 µmol	6.67^{c}	7.81^{b}	7.24^{b}
500 µmol	7.5^{b}	7.15^{b}	7.32^{b}
600 µmol	6.98^{c}	8.92^{a}	7.95^{a}
700 µmol	6.04^{c}	8.09^{a}	7.06^{c}
Means	6.29^{b}	7.54^{a}	

Note: Fruit ascorbic acid at initial stage (5.82).

Fruit Decay (%)

Data regarding fruit decay (%) showed significant differences among all salicylic acid treatments, days and interactions (Table 3). Data showed that lowest fruit decay 14.97 was observed in fruits those were treated with 600 µM salicylic acid followed decay 18.05 was observed of fruits those was treated with 700 µmol. Highest decay 20.81 was observed in control.

Data regarding days showed significant differences in decay % of fruit. Fruit decay 15.40 was observed at day 5, Highest values of decay 19.01 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that lowest decay of fruit 13.07 was observed at 600 µmol at day 5, followed by 700 µmol at 5 days having decay was observed 14.74; highest decay 18.27 was observed with control at day 5.

These results are in agreement with Wang *et al.* (2006); Sayyari *et al.* (2009), those represent in peach and pomegranates where the higher concentration of SA was more effective than lower ones to control the weight loss, chilling injury and fruit decay under storage as compare to control treatment.

Ding *et al.* (2007) attributed the effect of SA on decreasing weight loss, chilling injury in mango fruit to more reducing status of ascorbate and glutathione, less O_2 accumulation and more H_2O_2 accumulation. Also, the effect of SA on controlling CI of peaches was attributed to its ability to induce antioxidant systems and heat shock protein (HSPs) (Wang *et al.* 2006).

Table 7. Effect of different concentrations of salicylic acid on fruit ascorbic acid (mg 100gm-1).

Treatments	5 day	10day	Means
Control	4.27[e]	5.73[d]	5[d]
400 µmol	6.67[c]	7.81[b]	7.24[b]
500 µmol	7.5[b]	7.15[b]	7.32[b]
600 µmol	6.98[c]	8.92[a]	7.95[a]
700 µmol	6.04[c]	8.09[a]	7.06[c]
Means	6.29[b]	7.54[a]	

Note: Fruit ascorbic acid at initial stage (5.82).

Moreover it is also reported that SA treatment strengthens defense system through enhancing activites of antioxidant enzymes that improve the resistance in treated fruits against the fungal attack (Xu and Tian, 2008). Zhulong and Shiping, (2006) reported that sweet cherry fruits immersed in *Pichia* 12 *membranefaciens* at a concentration of 5 x 107 cells ml-1 or in salicylic acid (SA) at 0.5mM for 10 min registered reduced incidence of decay and lesions caused by *Pencillium expansum* during storage. Strawberry fruits dipped in salicylic acid solution had less decay incidence and higher firmness than control (Shafiee *et al.* 2010). Limin and Fenfen, (2011) noticed that post harvest treatments with salicylic acid (0.5 g/L for 10 min.) resulted in decreased spoilage per cent in chestnut. Abbasi *et al.* (2012) reported SA (2.0mM) to be the most effective in keeping peach fruit quality intact along with delayed fruit decay during storage.

Table 8. Effect of different concentrations of salicylic acid on fruit total sugar (%).

Treatments	5 day	10day	Means
Control	9.51[b]	19.66[a]	14.58[c]
400 µmol	10.79[b]	19.21[a]	15[c]
500 µmol	10.71[b]	20.42[a]	15.56[b]
600 µmol	19.29[a]	20.88[a]	20.08[a]
700 µmol	11.16[b]	20.51[a]	15.83[b]
Means	12.29[b]	20.13[a]	

Note: Fruit total sugar at initial stage 9.52.

The salicylic acid (5 mM) treated fruits had the lowest post harvest decay incidence of devastating fungal pathogen *Penicillium digitatum* Sacc, the causal agent of green mold disease of blood orange (Aminifard *et al.* 2013).

Fruit firmness (score)

Data regarding fruit Firmness (score) showed significant differences among all salicylic acid treatments, days and interactions (Table 4).

Data showed that highest fruit firmness 34.34 was observed in fruits those were treated with 600 µmol salicylic acid, followed by firmness of fruit 31.35 was observed in fruits those were treated with 700 µmol. lowest firmness of fruit 27.15 was observed in control. Data regarding days showed significant differences in firmness of fruit.

Fruit firmness 33.43 was observed in fruits a day 5 that is lower than 0 day. Lowest firmness of fruit 28.71 was observed at day 10. Data showed that highest firmness 35.39 was observed in fruits those were treated with 600 µmol at day 5 followed by 700 µmol firmness 34.18 was observed in fruits at 5 day. Lowest firmness 30.12 was observed in control at day 5.

Table 9. Effect of different concentrations of salicylic acid on fruit reducing sugar (%).

Treatments	5 day	10day	Means
Control	5.44c	6.01a	5.72c
400 µmol	5.76b	5.82b	5.79b
500 µmol	5.71c	6.04a	5.87b
600 µmol	5.9b	6.23a	6.06a
700 µmol	5.87b	6.09a	5.98a
Means	5.73b	6.03a	

Note: fruit reducing sugar at initial stage 5.52.

In recent years, application of exogenous SA at non-toxic concentration to fruits has been show to be effective at retarding the ripening and firmness of banana (Srivastava and Dwivedi, 2000) and kiwifruit (Zhang *et al.* 2003). Wang *et al.* (2006) reported that treatment of peach fruits with SA at higher concentration (1mM) was most effective in slowing the decline in firmness in lower concentration (0.35 and 0.7mM).

Cao *et al.* (2009) reported that the dip application of salicylic acid (0.5mM) was most effective in reducing chilling injury and maintained significantly higher fruit firmness in cucumber as compared with untreated controls. Gholami *et al.* (2010) investigated that there is significant increase in anthocyanin content, flesh firmness and stem freshness of fruits with application of salicylic acid in 'Mashhad' sweet cherry (*Prunus avium* L.).

Table 10. Effect of different concentrations of salicylic acid on fruit non- reducing sugar (%).

Treatments	5 day	10day	Means
Control	7.9^{c}	9.77^{b}	8.83^{c}
400 µmol	8.81^{b}	9.31^{b}	9.06^{b}
500 µmol	8.89^{b}	9.27^{b}	9.08^{b}
600 µmol	9.35^{b}	13.4^{a}	11.37^{a}
700 µmol	9.19^{a}	11.97^{a}	10.58^{a}
Means	8.82^{b}	10.45^{a}	

Note: Fruit non reducing sugar at initial stage 7.12.

The peach (*Prunus persica* L.) 'Maria Delicia' fruit harvested at commercial maturity and dipped in solutions 1mM salicylic acid registered maximum fruit firmness (3.9 kgf), while minimum firmness (3.0 kgf) recorded in control fruit when stored at 1°C and 95 % RH as reported by Abbasi *et al.* (2010). Pre and post-harvest treatment of salicylic acid maintained fruit firmness and delayed ripening during storage studies in cherry (Gholami *et al.* 2010). Similar results were reported in kiwifruit by Srivastava and Dwivedi, (2000) in 9 bananas. Lu *et al.* (2010) also reported that pre and post-harvest salicylic acid treatments significantly reduced internal browning incidence and intensity in pineapple.

Total soluble solid (°Brix)

Data regarding fruit TSS/acid ratio showed significant differences among all salicylic acid treatments, days and interactions (Table 5). Data showed that higher TSS/acid ratio 7.24 was observed in fruits those were treated with 600 µmol salicylic acid followed TSS/acid ratio 6.82 of fruit those were treated with 700 µmol. lowest TSS/acid ratio 6.19 was observed in control (Table 5). Data regarding days showed significant differences in TSS/acid ratio of fruit. Fruit TSS/acid ratio 6.17 was observed a day 5 that is higher than 0 day highest values of TSS/acid ratio 7.26 was observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that highest TSS/acid ratio 7.03 was observed of fruit at 600 µmol at day 5, followed by 700 µmol at day 5 was observed 6.39 Lowest TSS/acid ratio 5.15 was observed with control at day 5. Similar results were also reported for SSC in strawberry fruits, were increased when plants were sprayed with SA than control (karlidag *et al.* 2009).

Table 11. Effect of different concentrations of salicylic acid on fruit total phenolic compound (µgmL-1 FW).

Treatments	5 day	10day	Means
Control	261.78^{b}	263.06^{c}	262.42^{c}
400 µmol	257.98^{c}	301.42^{a}	279.7^{b}
500 µmol	262.62^{c}	300.14^{a}	281.38^{b}
600 µmol	300.66^{a}	308.99^{a}	304.825^{a}
700 µmol	282.38^{a}	308.23^{a}	295.30^{b}
Means	273.08^{b}	296.36^{a}	

Note: Fruit total phenolic compound at initial stage (257.23).

It is understood that soluble solids concentration is increased during storage period as a result of insoluble starch conversion into soluble solid. This change in soluble solids concentration may be correlated with hydrolytic regulation of starch concentration during postharvest storage which ultimately results in starch conversion (breakdown) to sugars which is key fruit ripening indicator process Kays, (1991). Increase in TSS in fruits also might be due to reduction of the activities of various enzymes and by delaying the senescence, disorganization of cellular structure and checking of microbial activities Lougheed *et al.* (1979). The total soluble solids (TSS) and sugars increase during storage may be due to hydrolysis of starch into sugars as on complete hydrolysis of starch no further increase occurs and subsequently a decline in TSS is predictable as they along with other organic acids are primarily substrate for respiration (Wills *et al.* 1980). Similar to our results Abbasi *et al.* (2012) also reported that 2.0 mmolL-1 SA treated fruits have highest soluble solid content than control after 5 week of storage in peach fruits.

Han and Li. (1997) reported similar results in apple fruits that soluble solids had increased without decreasing firmness when treated with salicylic acid. In contrast to this, Brar *et al.* (2014) reported that control fruits exhibited higher TSS content than salicylic acid treated fruits. These results also disagree with those mentioned by Kazemi *et al.* (2011) who reported that, apple fruits treated with salicylic acid solution for 5 minutes had lower TSS than untreated fruits.

Total titerable acidity (%)

Data regarding fruit acidity showed significant differences among all salicylic acid treatments, days and interactions (Table 6). Data showed that lowest acidity 0.35 was observed in fruits those were treated with 600 µmol salicylic acid, followed of fruit acidity 0.4 those were treated with 700 µmol. highest acidity 0.45 was observed in control. Data regarding days showed significant differences in acidity of fruit. Fruit acidity 0.46 was observed at day 5. Lowest values of acidity 0.35 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10.

Data showed that lowest total titerable acidity 0.39 was observed of fruit at 600 µmol at day 5, followed by total titerable acidity was obserbed 0.47 at 700 µmol at day 5. Uppermost total titerable acidity 0.52 was observed with control at day 5 (Table 6). Our results are in line with Pesis *et al.* (1999) who reported that a decrease in titratable acidity and increase in pH of fruit during the whole storage period in lemon fruit. In another study, during prolonged storage lime fruits, pH was enhanced (Verma and Dashora, 2000). Awad, (2013) reported that in peach post harvest application of salicylic acid had significant effect on the acid content of the fruit as it increased gradually with the increasing concentration from 0 to 1.5 mM.

Yeganeh *et al.* (2013) noticed that in pre and post-harvest salicylic acid treatment significantly improved the post-harvest performance of berries in all studied traits including: dry matter, sugar: acid ratio, acidity and fruit overall quality in grapes during cold storage. Salari *et al.* (2013) revealed that 'Paros' strawberries treated with salicylic acid (2 mM) was superior over the other cultivars with respect to most quantitative and qualitative traits as this treatment had optimum acidity, and TSS:Acid ratio. The salicylic acid (5 mM) treated 'blood orange' fruits had the highest acidity, anthocyanin and antioxidant content and better storability (Aminifard *et al.,* 2013). Similar results also reported by Brar *et al.* (2014) in peach fruits.

Table 12. Effect of different concentrations of salicylic acid on fruit antioxidants (IC 50 µg mL-1).

Treatments	5 day	10day	Means
Control	116.74^{d}	160.07^{a}	138.40^{c}
400 µmol	136.68^{c}	158.23^{a}	147.45^{b}
500 µmol	135.39^{c}	164.69^{a}	150.04^{b}
600 µmol	159.52^{a}	162.85^{a}	161.18^{a}
700 µmol	140.02^{b}	161.36^{a}	150.69^{b}
Means	137.67^{b}	161.44^{a}	

Note: Fruit antioxidants at initial stage (119.57).

Ascorbic acid (mg 100gm-1)

Data regarding fruit vitamin c showed significant differences among all salicylic acid treatments, days and interactions (Table 7). Data showed that maximum Ascorbic acid 7.95 was observed in fruits those were treated with 600 µmol salicylic acid, followed of Ascorbic acid 7.06 was observed in fruit those were treated with 700 µmol. The lowest ascorbic acid 5 was observed in control. Data regarding days showed significant differences in ascorbic acid of fruit. Fruit Ascorbic acid was observed 6.29 at day 5 that is higher than 0 day. Highest values of Ascorbic acid 7.54 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that Ascorbic acid 6.98 was observed of fruit at 600 µmol at day 5, followed by 700 µmol Ascorbic acid 6.04 was observed at day 5.

Lowest Ascorbic acid 4.27 was observed with control at day 5. These findings are very much in accordance with results of Akhtar *et al.* (2010) who reported that vitamin C in loquat fruits was reduced constantly to a great extent during ten weeks storage period. Similarly Kalarani *et al.* (2002) observed that tomoto fruits possessed higher ascorbic acid concentrations when treated with SA. Recently Amanullah *et al.* (2016) conducted *Aloe* edible coating experiment on shelf life of eggplant and founded ascorbic acid increased during storage but coated has significant impact on increment of ascorbic acid in storage condition.

Total sugars (%)

Data regarding fruit total sugar contents showed significant differences among all salicylic acid treatments, days and interactions (Table 8). Data showed that maximum fruit total sugar 20.08 was observed in fruits those were treated with 600 µmol salicylic acid followed total sugar 15.83 in fruit those were treated with 700 µmol. Lowest total sugar contents 14.58 was observed in control Data regarding days showed significant differences in total sugar contents of fruit. Fruit total sugar contents 12.29 was observed at 5 day that is higher than 0 day. Highest values of total sugar contents 20.13 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that highest Total sugars 19.29 was observed in fruit those were treated with 600 µmol at day 5 , followed by 700 µm Total sugars 11.16 was observed at day 5. A lowest total sugar 9.51 was observed with control at day 5 The results of our study are in agreement with Stahl and Champ, (1971) who reported that the increase in total sugars in all treatments under cold storage was probably due to dehydration, because fruits exhibited highest physiological losses in weight in most of the treatments resulting higher proportion of total sugars. They also had reported that during prolong storage period certain cell wall material such as pectin and hemicelluloses might be converted into reducing substances. In contrast to our results, Abbasi *et al.* (2010) reported that minimum sugar concentrations (reducing, non-reducing and total sugars) occurred in 1mM salicylic acid treated fruit. Mohamed *et al.* (2012) also reported that there is increase in total sugars content in salicylic acid treated navel orange fruits as compare to untreated fruits.

Reducing sugars (%)

Data regarding fruit reducing sugar contents showed significant differences among all salicylic acid treatments, days and interactions (Table 9). Data showed that maximum reducing sugar contents 6.05 was observed in fruits those were treated with 600 µmol salicylic acid followed reducing sugar contents 5.99 of fruit those were treated with 700 µmol. Minimum non-reducing sugar contents 5.72 was observed in control. Data regarding days showed significant differences in reducing sugar contents of fruit. Reducing sugar contents 5.73 was observed at day 5 that is higher than 0 day. Highest values of reducing sugar contents 6.03 were observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that highest Reducing sugars 5.9 was observed in fruit those were treated with 600 µmol at day 5 followed by 700 µm concentration reducing sugar 5.87 at day 5. Lowest Reducing sugars 5.44 were observed with control at day 5. The reason was same as described in total sugar. Actually, Guava fruit has different physiology than non-climacteric fruits as the sugar content undergoes up to higher levels after a few days of storage due to hydrolysis of starch. But this rise of sugar content ultimately declined because respiratory substances get exhausted with the storage life. Paliyath and Subramanian, (2008) suggested that SA is well known phenol which can prevent ACO activity. Manoj and Upendra, (2000) also reported similar results in banana fruit; they suggested that salicylic acid treated fruits registered increase in reducing sugar level in concentration manner.

Non-reducing sugars (%)

Data regarding fruit non-reducing sugar contents showed significant differences among all salicylic acid treatments, days and interactions (Table 10). Data showed that maximum non-reducing sugar contents 11.37 was observed in fruits those were treated with 600 µmol salicylic acid, followed non-reducing sugar contents 10.58 was observed in fruit those were treated with 700 µmol. Minimum non-reducing sugar contents 8.83 was observed in control. Data regarding days showed significant differences in non-reducing sugar contents. Non-reducing sugar contents 8.82 were observed at day 5 that is higher than 0 day. Highest values of non-reducing sugar contents 10.45 was observed at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that highest Non-reducing sugars 9.35 were observed in fruit those were treated with 600 µmol at day 5, followed by non-reducing sugars 9.19 was observed in fruit those were treated with 700 µm at day. Lowest non-reducing sugars 7.9 was observed in control at day 5. Increase in non-reducing was due to dehydration and hydrolysis of the polysaccharides of the fruits.

Similar to our results, Srivastava and Dwivedi, (2000) also reported the increasing trend of non-reducing sugars in banana fruit treated with 500 and 1000mM salicylic acid.

Total Phenolic compound (µgmL-1 FW)

Data regarding fruit total phenolic contents showed significant differences among all salicylic acid treatments, days and interactions (Table 11). Data showed that maximum total phenolic contents 304.82 was observed in fruits those were treated with 600 µmol salicylic acid ,followed total phenolic contents 295.36 was observed in fruit those were treated with 700 µmol . A minimum total phenolic content 279.7 was observed in control. Data regarding days showed significant differences in total phenolic contents of fruit. Fruit total phenolic contents 273.08 were observed in fruits at day 5 that is higher than 0 day. Highest values of total phenolic contents 296.36 were observed in fruits at day 10. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that highest Total Phenolic compound 300.66 was observed in fruit those were treated with 600 µmol at day 5, followed by 700µm concentration total phenolic compound 282.38 at days 5. Lowest total phenolic compound 257.98 was observed in control. The loss of phenolic compounds during storage can be associated with several enzymatic and non- enzymatic reactions, ethylene production being superior (McDonald, 1992). Similar findings have also been described by Huang *et al.* (2008) who reported SA treated Cara cara navel oranges showed increased total phenolic content, higher concentration of SA having more profound effect in this respect. In our study the increase in phenolics are in line with Yao and Tian, (2005) who demonstrated that SA stimulates phenylalanine ammonia lyase activity with consequent production of the main phenolic compound and the synthesis of new polyphenolic substances in sweet cherry fruit.

Total antioxidants (IC 50 µg mL-1)

Data regarding fruit total antioxidants showed significant differences among all salicylic acid treatments, days and interactions (Table 12). Data showed that maximum total antioxidants 161.18 was observed in fruits those were treated with 600 µmol salicylic acid, followed total antioxidants of fruit 150.69 was observed in fruits those were treated with 700 µmol. lowest total antioxidants 138.40 was observed in control. Data regarding days showed significant differences in total antioxidants of fruit. Fruit total antioxidants 137.67 were observed in fruits at day 5 that is higher than 0 day.

Highest values of total antioxidants 161.44 were observed in fruit at day 5. Data regarding interactions also showed significant differences among all combinations of salicylic acid with days 10. Data showed that higher total antioxidants 159.52 was observed in fruit those were treated with 600 µmol at day 5, followed by 700 µM concentration total antioxidants 140.02 at day 5. Lowest total antioxidant 116.74 was observed with control at day 5. Antioxidants are compound capable of quenching ROS without undergoing conversion, themselves, to destructive radicals (Hodges, 2003). To ascertain dietary importance of fruits and vegetables it is also important to estimate their antioxidant activity. There is also evident that exogenously applied SA with suitable dose enhanced the efficiency of antioxidant system in plants (Hayat *et al.*, 2010).

Conclusion

SA has potential to maintain the physico-chemical properties by delaying the ripening process and retarding the internal gaseous changes which occurs during storage. It is concluded from the current experiment that salicylic acid is a valuable postharvest treatment for enhancing the shelf life of guava fruit. Furthermore, it could be suggested for usage in international markets as well as local for extending of horticultural product.

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