



Impact of salicylic acid on the physiological and quality attributes of guava (*Psidium guajava*) fruits during storage at low temperature

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ABSTRACT

Guava (*Psidium guajava* L.) fruits of cv. Allahabad Safeda were treated with salicylic acid (SA) or 5-sulfosalicylic acid (SSA) at 1 mM and 2 mM concentration and stored at 10°C for 12 days. After storage, fruits were transferred to ambient conditions for 3 days shelf–life stimulation period and then observations were recorded up to 12+3 days. Results revealed that fruits treated with SA or SSA at 2 mM concentration showed minimum weight loss and colour change but maintained maximum firmness, total phenolics and ascorbic acid content. Fruits treated with SA or SSA @ 2 mM also showed suppressed and/or delayed the respiration and ethylene production and minimum increase in SSC as compared to untreated samples. Hence, SA or SSA 2 mM can be effectively used for maintenance of desired post-harvest quality and extending the market life of guava fruits during storage at 10°C followed by 3 days of stimulated shelf–life period.

Key words: Ascorbic acid, Ethylene evolution rate, Fruit firmness, Guava, Salicylic acid

Guava (*Psidium guajava* L.) is a climacteric fruit which ripens rapidly and is highly perishable and its shelf-life is only 2 to 3 days at the room temperature (Bassetto *et al.* 2005). The delicate nature, short postharvest life, and susceptibility to chilling injury and diseases, limits the potential for commercialisation of this important fruit. Researchers have worked on some expensive interventions such as the use of irradiation, controlled atmospheric storage, modified atmosphere packaging and application of fungicides to extend the storage life of guava (Singh and Pal 2008, Antala *et al.* 2015) but there is an urgent need to develop safe and affordable postharvest practices to increase its life while maintaining the quality. In the recent years, several generally regarded as safe (GRAS) compounds have been attempted in fruit crops, of which salicylic acid has given fruitful results (Asghari and Aghdam 2010). Salicylic acid, accepted as a safe and natural chemical compound for postharvest application on fruits has been used to delay the ripening and softening, reduce lipid peroxidation and chilling injury in fruits (Zhang *et al.* 2003 Barman and Asrey 2014). Hence, we investigated the effect of postharvest application of salicylic acid (SA) and 5-sulfosalicylic acid (SSA) (a derivative of SA) on physiological and quality attributes of guava fruits.

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MATERIALS AND METHODS

The study was conducted in the Division of Food Science and Postharvest Technology, IARI, New Delhi during the year 2014-15. Fully mature guava fruits of Allahabad Safeda variety were harvested from the orchard of Division of Fruits and Horticultural Technology, IARI, New Delhi, in the morning hours and immediately brought to the laboratory. Fruits of uniform size and maturity and without wounds or blemishes were selected and immersed in the 1 or 2 mM solution each of salicylic acid (SA) or 5-sulfosalicylic acid (SSA) for 5 minutes. The fruits of the control lot were dipped in distilled water only. After treatment, fruits were air-dried and stored at 10°C temperature and 85 ± 5% RH. After every 3 days of cold storage, fruits were transferred to ambient conditions (20 ± 2°C) for shelf–life simulation for three days every time and observations were recorded up to 12+3 days.

Per cent physiological loss in weight (PLW) was measured by subtracting the initial sample weight from the final weight at a particular time interval. Fruit firmness was measured using an Instron-Universal Testing Machine and expressed as Newton (N). Peel colour of the fruits was measured by Hunter Colour Lab Scan XE and the CIE L, a, b colour scale. Respiration rate of the fruits was measured by the static headspace technique using an auto gas analyser and expressed as mL CO₂/kg fresh weight/h (Singh and Pal 2008). Ethylene evolution rate was determined by a gas chromatograph and expressed in µL ethylene/kg/h (Singh and Pal 2008).

Soluble solids content (SSC) of samples was estimated using Fisher hand refractometer (0-50°B) and expressed as degree Brix (°B) at 20°C. Quantitative determination of ascorbic acid was done by a visual titration method, using 2, 6-dichlorophenolindophenol dye (Rangana 1999) and expressed as mg/100 g of fresh weight. Total phenolic content of the fruit extracts were determined by FC reagent method and expressed as mg gallic acid equiv./100 g (Singleton and Rossi 1965).

The experiments were laid out in factorial CRD design with each treatment consisting of 120 fruits, replicated thrice. The data so obtained were analysed by following standard procedures and the results were compared from ANOVA by calculating the CD (Panse and Sukhatme 1984).

RESULTS AND DISCUSSION

Physiological loss in weight is an important parameter, which is mainly responsible for quantitative as well as qualitative loss of produce. It is evident from the Fig 1A that PLW, irrespective of treatments, increased with the advancement of the storage period. Untreated fruits (control) showed significantly higher loss in weight (9.6%) from 3+3 days of storage that gradually increased with the advancement of storage period. It was observed that SA or SSA significantly prevented the loss in weight of the fruits during the entire storage period up to 12+3 days. After 12+3 days of storage, minimum PLW was recorded in fruits treated with 2 mM SA (9.37%) or SSA (8.89%), while the untreated guava fruits showed the highest weight loss (15.6%). Lower PLW in treated fruits might be due to the effect of salicylic acid in suppressing the metabolic activity with respect to respiration and ethylene evolution. Our results are in line with Han *et al.* (1997) and Razavi *et al.* (2014) who have also reported a reduced weight loss in salicylic acid treated apples and peach, respectively.

Reduction in firmness of fruits is a major quality change during ripening. Firmness of guava fruits during storage was found to be significantly influenced by the SA or SSA treatments (Fig 1B). A gradual decline of fruit firmness was observed with the increase in storage period under all the treatments. Untreated fruits showed a significantly higher loss in firmness as compared to SA or SSA treated fruits. SA or SSA (2 mM) showed higher fruit firmness (3.67 and 3.72 N, respectively) as compared to other treatments. The retention in firmness of SA or SSA treated fruits may be due to inhibition of cell wall and membrane degrading enzymes such as polygalacturonase, lipoxygenase, cellulase and pectin methyl esterase and also due to lower rate of ethylene production (Khademi and Ershadi 2013). Earlier, Lo'ay and Khateeb (2011) and Wang *et al.* (2006) have also reported similar results in guava and peach, respectively.

Hue angle represents green colour at 120° and yellow colour at 90° (McGuire 1992). The change of peel colour from green to yellow in guava fruits is an indicative of fruit ripening. In present investigation, it was observed that guava fruits treated with SA or SSA at 2 mM concentration did not turn completely yellow till 9+3 days

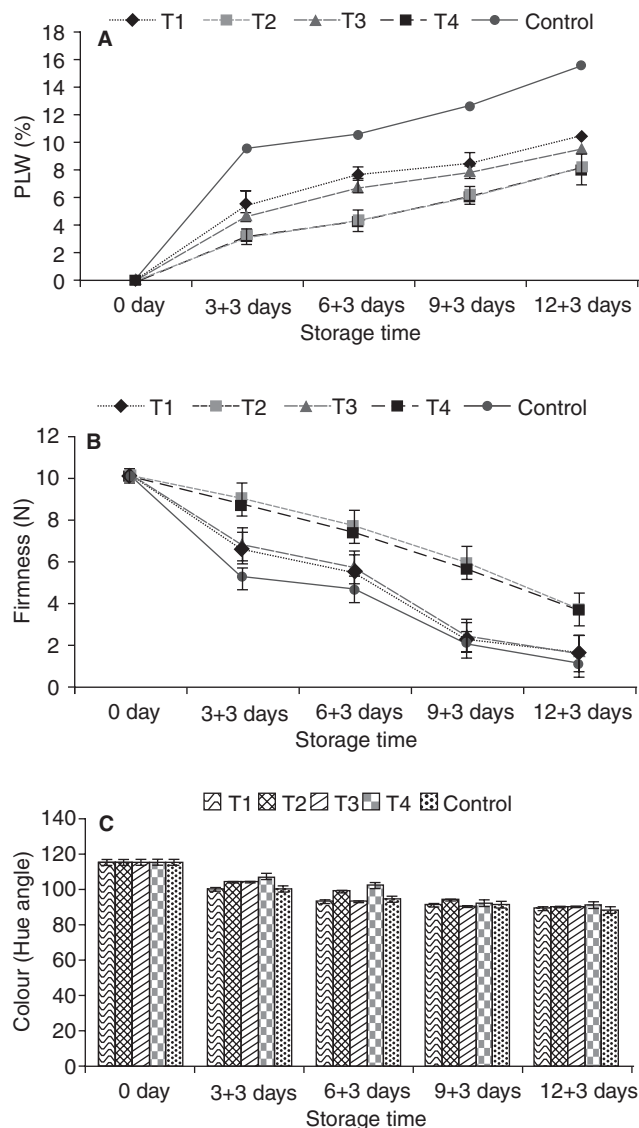


Fig 1 Effect of salicylic acid treatments on (A) PLW (%), (B) firmness and (C) colour (hue angle) of guava cv. Allahabad Safeda during storage at 10°C followed by transfer to ambient conditions for 3 days (T₁-SA @ 1 mM, T₂-SA @ 2 mM, T₃-SSA @ 1 mM, T₄-SA @ 2 mM and control). Data are the mean±SE of three replicates (n = 3).

of storage, whereas untreated fruits turned completely yellow even on 6+3 days of storage (Fig 1C). This indicates that postharvest application of SA or SSA has delayed the ripening process of guava fruits significantly, probably through inhibition of ethylene production. These results are supported by work done previously by Lo'ay and El Khateeb (2011) in guava fruits.

In untreated fruits, the rate of respiration was observed to increase rapidly with a typical climacteric peak after 3+3 days of storage. However, the salicylic acid treatments suppressed the respiration rate and also delayed the onset of the respiratory climacteric to 6+3 and 9+3 days of storage in 1 and 2 mM SA or SSA treatments, respectively. The reduction in respiration rate in SA or SSA treated fruits may be ascribed to delaying the ripening process as previously

reported by Barman and Asrey (2014) in mango, and Sahar and Wahab (2015) in apricot.

Different salicylic acid treatments significantly influenced the ethylene production rates of guava fruits during low temperature storage. Ethylene evolution increased rapidly in untreated fruits, which achieved a climacteric peak (13.06 $\mu\text{l/kg/h}$) on 3+3 days of storage. Further, the guava fruits treated with SA or SSA showed climacteric peak of ethylene on 6+3 and 9+3 days of storage at 1 and 2 mM, respectively. Suppression of ethylene production in fruits treated with SA or SSA may be associated with decreased 1-aminocyclopropane-1-carboxylic acid (ACC) synthase (Zhang *et al.* 2003) and/or ACC oxidase activity (Leslie and Romani 1988).

Soluble solids content of fruits increased in all the treatments with the advancement in storage period. However, untreated fruits showed significantly higher SSC (10.9 $^{\circ}\text{B}$) at the end of the storage period as compared to fruits treated with at 2 mM SA (9.2 $^{\circ}\text{B}$) or 2 mM SSA (8.8 $^{\circ}\text{B}$). The increase in SSC can be attributed to the conversion of starch to sugar during ripening of guava. Since, SA and SSA might have suppressed the catabolic processes such as respiration rate and ethylene production in treated guava fruits, the treated fruits showed a slow increase in SSC. Similar results were reported earlier by Aghdam *et al.* (2009) in peach and Sahar and Wahab (2015) in apricot.

In our study, we observed that ascorbic acid content in untreated guava fruits increased up to 3+3 days of storage but thereafter it showed a declining trend but SA or SSA treated fruits showed an increase in ascorbic acid up to 6 + 3 d of storage. However, at the end of storage, SSA (185 mg/100g) or SA (180 mg/100g) at 2 mM concentration exhibited significantly higher SSC content. Increase in ascorbic acid content in guava fruit is thought to be an indication that the fruit is still undergoing ripening, while a decrease indicates onset of senescence (Gonzalez-Aguilar *et al.* 2004). This delay in attaining maximum ascorbic acid content indicates that ripening process might have been delayed by SA and SAA in the treated guava fruits. In an earlier study, Tareen *et al.* (2012) also reported higher retention of ascorbic acid in peach fruits treated with salicylic acid.

There was a gradual decrease in total phenolic content with the progress in storage period. However, the decline was at a slower rate in fruits treated with SA or SSA as compared to untreated fruits. Significantly higher phenolic content was recorded in 2 mM SA (123 mg GAE/ 100 g) and SSA (126 mg GAE/ 100 g) treated fruits while it was lowest (94 mg/ 100 g) in untreated fruits at the end of the storage. Reduced loss of phenols in salicylic acid treated fruits may be due to delayed oxidation of phenolic substances by polyphenol oxidase (PPO). Similar findings were reported earlier by Khademi and Ershadi (2013) in peach and Sahar and Wahab (2015) in apricot.

This study revealed that postharvest application of salicylic acid (SA or SSA @ 2 mM) was effective in reducing PLW, loss of firmness, colour change and influenced respiration rate and ethylene production rate, which helped

in improving shelf-life and maintained the quality of guava fruits during storage.

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