Changes in Biochemical Composition of Mango in Response to Pre-Harvest Gibberellic Acid Spray

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Summary

Mango (*Mangifera indica* L.) is an important fruit of the world owing to its pleasant aroma and taste. In this investigation, the influence of gibberellic acid (GA_3) at concentrations of 0, 50, 100 and 150 mg·l^{-1} water sprayed 20 days before commercial harvest on postharvest behavior and quality of mango cv. 'Himsagar' was studied under ambient storage conditions. GA_3 (100 and 150 mg·l^{-1}) delayed the onset of ripening and caused a reduction in respiration rate as compared to the untreated fruits and retained the total chlorophyll content of fruit peel. Pre-harvest spray of GA_3 at 100 mg·l^{-1} significantly delayed the onset of the climacteric rise of CO_2 production, which depicted delayed ripening over control. The treated fruits also remained firmer and maintained the freshness during storage. Treatment with 100 mg·l^{-1} GA_3 could be a useful method to extend postharvest life and availability of mango with appreciable quality.

Key words

mango, pre-harvest spray, gibberellic acid, ripening, postharvest quality

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Aim

Being a climacteric fruit, mango comes under the category of highly perishable horticultural commodities. There are more than a thousand mango varieties in India. However, only about 30 varieties are grown on a commercial scale in different states. Post-harvest loss of mango in India has been estimated to be 25–40% from harvesting to consumption (Rekha and Goswami, 2007), mainly because of lack of improved technology and instrumentation for getting reliable harvest indices and monitoring its quality during ripening and transportation (Jha *et al*., 2010). 'Himsagar' is one of the most important commercial mango cultivars of India. It has a luscious and pleasant taste, but owing to its early senescent feature, it can not be stored for a long time. The fruit develops blackish stains and spoils within a very short period with a maximum storage duration of five to seven days. It most likely fails to tolerate minimum transportation hazards (Siddiqui, 2008; Siddiqui and Dhua, 2009). Pre-harvest treatments of calcium salts such as chlorides, nitrates, sulphates and phosphates (Gupta *et al*., 1987; Sudha *et al*., 2007) and growth promoting substances like gibberellic acid (GA_3) (Sudha *et al*., 2007; Jawandha *et al*., 2009) influence physical (firmness and colour development), physiological (transpiration, respiration and ethylene evolution) and bio-chemical attributes of fruits and increase the postharvest life during storage (Rao, 2004; Siddiqui and Dhua, 2010). GA_3 can potentially regulate the physiology of the fruit ripening by retarding or delaying derogatory developmental pigment changes and fruit softening in mango cv, 'Baneshan' (Sudhavani and Shankar, 2002), acid lime cv. 'Balaji' (Madhavi and Haribabu, 2009), ber cv. 'Umran' (Jawandha *et al*., 2009).

In addition, pre-harvest application of GA_3 has been reported to delay softening, color changes/development, as well as occurrence of rind disorders in various citrus fruits (Kawase *et al*., 1981; Ladaniya, 1997). Pre-harvest sprays of acid lime cv. 'Balaji' with some chemicals including GA_3 (20-40 mg·l^{-1}) influenced the changes in mineral composition (Ca, Mg and K) and antioxidant enzyme activity. Fruits pre-sprayed with benzyladenine at 30 mg·l^{-1} followed by GA_3 40 mg·l^{-1} better preserved nutrients and had lower antioxidant enzyme activity than fruits from other treatments (Madhavi and Haribabu, 2009). Pre-harvest spray of GA_3 in combination with carbendazim, 20 days ahead of harvest delayed ripening of mango cv. 'Beneshan' by 22 days when stored at 10- 12^{0}C (Sudhavani and Shankar, 2002).

Postharvest application of GA_3 also delayed ripening of mango cvs. 'Alphonso' and 'Langra' (Krishna Murthy and Rao, 1982) and banana (Ahmed and Tingwa, 1995; Osman and Abu-Goukh, 2008). The aim of the present investigation was to determine the potential of using gibberellic acid (GA_3) as pre-harvest spray for maintaining the postharvest quality of 'Himsagar' mango.

Materials and methods

The experiment was carried out in the experimental plantation of mango cv. 'Himsagar' spaced at 10 m x 10 m, receiving identical cultural practices. Fruits were sprayed 20 days ahead of commercial harvest with GA_3 at concentrations of 0, 50, 100 or 150 mg·l^{-1} of. water. Fruits in commercial maturity (30 per treatment) were harvested with 10 mm stalk and brought in the laboratory after desapping. Fruits were wrapped in newspaper and kept in wooden boxes separately for ripening at a room temperature of 28 ± 2^{0}C and relative humidity of 74-83%. The fruits from each treatment were taken at 6, 9, and 12 days of storage for analysis.

The fruit CO_2 production was assessed daily by the Pattenkoffer method as devised by Mitra *et al*. (2000). Hand refractometer (Model No. RHB-32) was used to measure the total soluble solid contents of fruits. The fruit firmness was measured using fruit penetrometer (Effegi Model No. FT- 327) having a plunger of 0.5 cm (Ranganna, 2000). Titratable acidity, alcohol insoluble solids, and chlorophyll content of fruits were estimated by AOAC (1990) methods.

The experiment was designed as a factorial completely randomized design with four treatments, four storage periods and three replicates. The interaction effect (treatments x days in storage) was also studied and the least significant difference (LSD) at 5% for interaction is determined.

Results and Discussion

Fruit firmness

Irrespective of the treatment of mango with GA_3, firmness of the fruits declined and weight loss increased steadily during storage. The initial level of firmness was 12.4 kg·cm^{-2}. Along with an increase in storage time, the control fruits had the fastest softening rate, losing about 71.1% of their firmness only after three days of storage as depicted in Figure 1(a). The fruits treated with 50, 100 or 150 mg·l^{-1} GA_3 also showed decreased firmness, but to a significantly lesser extent as compared to control. Among treatments, 100 mg·l^{-1} GA_3 treated fruits showed maximum firmness (6.5 kg·cm^{-2}), losing only 46.7% of their initial firmness even at the end of storage (12th day). After 9th day of storage there was no significant difference between control and GA_3 treatments.

Our findings are consistent with previous reports for mango (Khader, 1992), banana (Osman and Abu-Goukh, 2008), sapota (Sudha *et al*., 2007) and Nagpur mandarin fruits (Ladaniya, 1997). Delay in softening by GA_3 during on tree-storage of grapefruit and tight skin oranges is reported by Ferguson *et al*. (1982). Mehta *et al*. (1986) reported that GA_3 (100 mg·l^{-1}) significantly suppresses the succinate activities of malate-dehydrogenase in papaya and cellulase activity in ber (Jawandha *et al*., 2009) during post-harvest ripening thus increasing shelf life. It has an antagonistic effect on the biosynthesis of endogenous ethylene, the compound that at threshold level triggers the ripening process in climacteric fruits (Burg and Burg, 1962; Ben-Arie *et al*., 1996; Ben-Arie *et al*., 1986). The mechanism of delaying softening and other degradative changes due to GA_3 application is also supported by Lewis *et al*. (1967) in the studies on Navel Orange peel involving calcium metabolism in cell wall and vegetative tissue, sites responsive to GA_3's effects (Jona *et al*., 1989; Ben-Arie *et al*., 1996). Because cellulose micro fibrils provide the structure and support for all the components of plant cell walls (Greve and Labavitch, 1991; Carpita and Gibeaut, 1993), the increase in cellulose would increase fruit firmness. Ben-Arie *et al*. (1996) suggested that the greater firmness of GA_3 treated fruit accounts for the 37% higher cellulose content in the cell walls of the treated fruit. Both factors, such as cellulose synthesis and hydrolytic activity, probably affect fruit firmness as determined by GA_3 treatment.

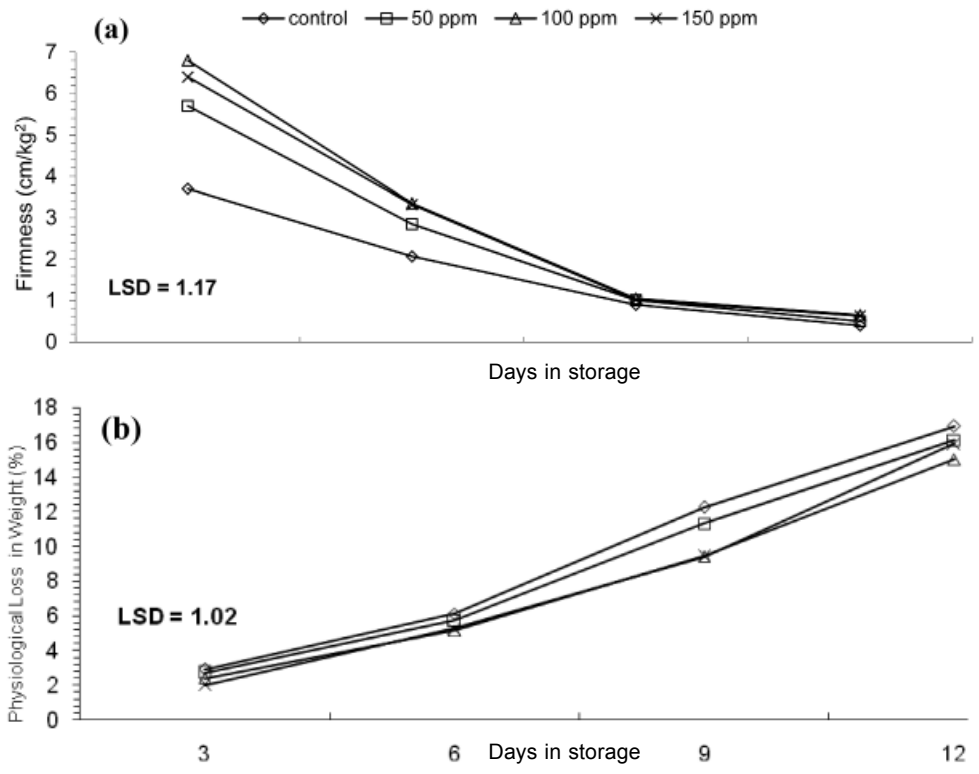

Figure 1. Changes in (a) fruit firmness and (b) physiological loss in weight of fruits during storage. LSD represents the least significant difference (treatment x storage; $p = 0.05$). Each data point represents the mean of triplicates ($n = 3$)

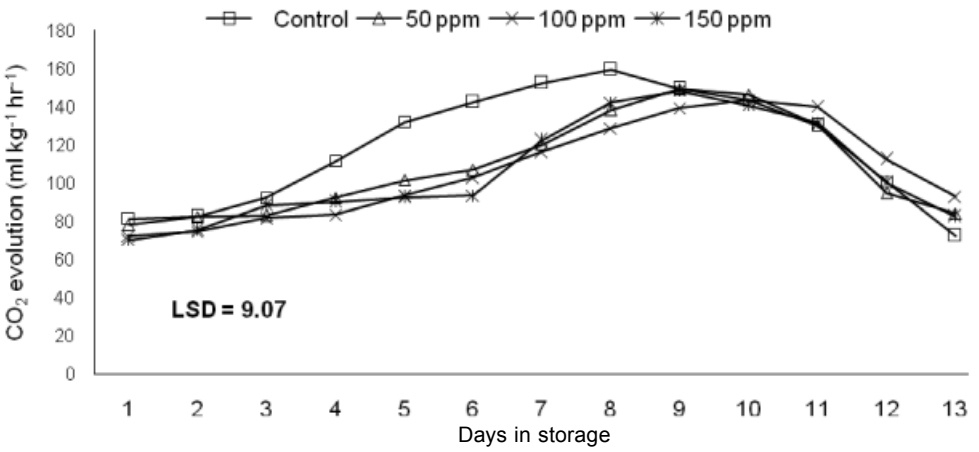

Figure 2. Carbon dioxide production of fruits during storage. LSD represents the least significant difference (treatment x storage; $p = 0.05$). Each data point represents the mean of triplicates ($n = 3$)

Physiological loss in weight

The physiological loss in weight throughout the storage time in the control and treated fruits is shown in Figure 1(b). The weight loss progressively increased during storage. The highest weight loss (16.92%) was observed in control fruits throughout the whole storage period. The treated fruits had relatively lesser physiological loss in weight as compared to control ones. The minimum weight loss (i.e. 15.02%) was recorded in fruits treated with 100 mg·l^{-1} GA_3. The physical appearance of the treated fruits was better in relation to control ones at the end of storage. Fruit treated with 100 mg·l^{-1} GA_3 had good firmness and had bright greenish yellow colour with excellent flavour up to twelfth day of storage (data not shown). These findings are in accordance with those reported by Sudhavani and Shankar (2002), where physiological loss in weight was reduced in GA_3- treated mango cv. 'Baneshan' fruits. It has also been reported for other fruits like Nagpur mandarin, Clementine mandarin and Washington Navel Oranges (El-Otmani and Coggins, 1991; Ladaniya, 1997), sapota (Sudha *et al.*, 2007) and banana (Osman and Abu-Goukh, 2008). The reduced loss in weight in GA_3-treated fruits could be attributed to their increased affinity to water. For that reason fruit retain more water against the force of evapo-transpiration, resulting in lesser weight loss during storage. Other contributing factors might be changes in some of the proteinaceous constituents of cell (Yadav and Shukla, 2009), as well as inhibition of respiration (Figure 2). In relation to physical appearance (data not shown), loss of water from fresh produce is one of the most important factors affecting freshness (Siddiqui *et al.*, 2011).

Respiration behaviour

In general, respiration rate of both treated and untreated fruits increased initially and then declined progressively, leading to senescence as shown in Figure 2. Untreated and treated fruits (particularly those treated with 100 mg·l^{-1} GA_3) reached a climacteric peak after seventh and ninth days of storage, respectively. The fruits treated with GA_3 had lower rates of respiration both at climacteric (ripening) and post climacteric (end of shelf life) stages and significantly delayed the onset of the climacteric rise as compared to control ones. The results are in agreement with earlier reports that GA_3 delayed the onset of climacteric peak in mango (Sudhavani and Shankar, 2002), banana (Ahmed and Tingwa, 1995; Osman and Abu-Goukh, 2008), and inhibited respiration

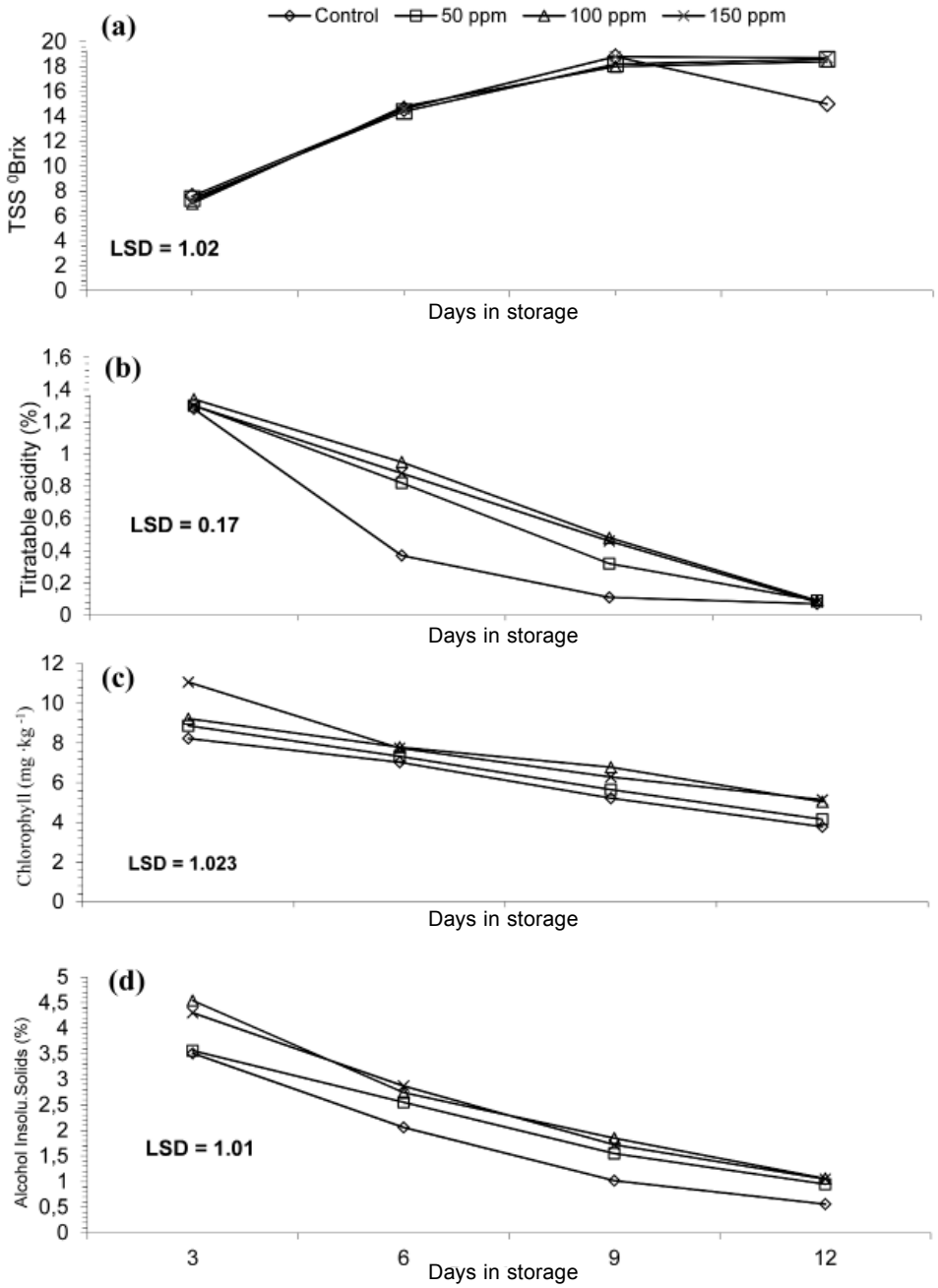

Figure 3. Changes in (a) total soluble solids, (b) titratable acidity, (c) total chlorophyll and (d) alcohol insoluble solid contents of fruits during storage. LSD represents the least significant difference (treatment x storage; p = 0.05). Each data point represents the mean of triplicates (n=3)

rate in apple (Lu and Lu, 1992). Lewis *et al*. (1967) reported that GA_3 lowers the rate of oxygen uptake in oranges, and the treated fruits have a lower ratio of monovalent to divalent cations and a higher phosphorus level than the control. They suggested that the integrity of the mitochondrial membranes was affected by GA_3. Tangizade and Gasanov (1975) have also observed similar decreased rate of respiration with GA_3 in grapes.

Biochemical constituents

The pattern of changes in biochemical constituents like total soluble solids (TSS), titratable acidity (expressed as citric acid), chlorophyll contents, and alcohol insoluble solids are depicted in Figure 3(a-d). The total soluble solid contents in all treatments increased to maximum at ninth day of storage. The differences among treatments were not significant. However, a declining trend was observed with titratable acidity, chlorophyll contents, and alcohol insoluble solids (AIS). The trend was slower in GA_3 treated fruits, but the highest retention was recorded with 100 mg·l^{-1}. An effect of GA_3 on the biochemical constituents of mango during the early stages of fruit ripening in terms of total soluble solids and titratable acidity were in line with the previous studies, suggesting the retardation of ripening of mango (Sudhavani and Shankar, 2002), and banana (Osman and Abu-Goukh, 2008). GA_3 is also known to delay senescence and retain chlorophyll in persimmon (Gross *et al*., 1984) for long periods, possibly by promotion of chlorophyll synthesis. The similar chlorophyll retention was also observed in GA_3 treated banana by Ahmed and Tingwa (1995) and Osman and Abu-Goukh (2008). Different workers have reported the decrease in AIS contents in several fruits during ripening (Abu-Goukh *et al*., 2005; Inari *et al*., 2002). In this study, the AIS contents of fruits tended to decrease during storage irrespective of treatment but the decrease was slower in fruit treated with GA_3.

Conclusions

The results of the present study clearly indicate that, the retardation of ripening, softening and decay, as well as improvements in quality of mango cv. 'Himsagar' during storage at ambient conditions could be achieved by pre-harvest treatment with 100 mg·l^{-1} GA_3. This finding can be used to extend the postharvest life of 'Himsagar' mango to some extent, thus facilitating its commercial application to avail fruits longer in the domestic market.

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