Effect of pre-harvest application of salicylic acid on postharvest behaviour of 'Amrapali' mango fruits during storage

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ABSTRACT

Mango is a highly perishable and deteriorates at a very fast rate during storage. In contrast to the common practice of postharvest application of growth regulators, we have studied the effect of pre-harvest application of the ethylene biosynthesis inhibitor, *viz.* salicylic acid (SA) at three different concentrations (75, 150 and 200 ppm) on 'Amrapali' mango fruits. The results indicate that pre-harvest application of salicylic acid, one week before the commercial harvest could effectively modulate the postharvest behaviour of the mango fruits during storage at ambient conditions (30 ± 5°C and 50 ± 5% RH). Although the mango was responsive to all the treatments, SA (200 ppm) was found to be effective in delaying the ripening cum senescence processes through suppression of respiration rate (105.43 ml CO_2 $kg^{-1}h^{-1}$) and ethylene production rates (0.20 µl C_2H_4 kg^{-1} h^{-1}) and retention of high firmness (21.76 N), colour (26.31 ΔE), TSS (27.72°B) and titratable acidity (0.53%) compared to untreated fruits.

Key words: Mango, salicylic acid, pre-harvest, application, storage.

INTRODUCTION

Mango is the most economic fruit crop grown in tropical and sub-tropical regions of our country. Due to its excellent flavour and delicious taste it is popularly known as "King of fruits". It is domestically consumed as well as exported to international markets. The harvested mangoes ripen quickly and deteriorate fast at ambient temperature (Ding *et al*., 6) leading to short storage life and less distance transportability. For many years synthetic chemicals were used to control fruit ripening and decay but the public concerns about chemical residues in fresh horticultural crops and the harmful effects of these chemicals on human health and environment caused scientists to search for new alternatives to synthetic chemicals (Babalar *et al*., 3). Recent studies have shown that salicylic acid (SA) can be introduced as a potent alternative to those chemicals in delaying the ripening process and controlling the postharvest losses. Basically, SA belongs to the group of phenolic compounds that are ubiquitous in plants, which is now considered as a plant hormone (Raskin, 17). It plays an important role in regulating a variety of physiological processes in plants, and its effects on delaying fruit ripening, softening, and reducing disease resistance and reducing disease incidence have been discussed by various researchers.

Pre-harvest exogenous application of various growth regulators such as gibberellic acid, putrescine,

salicylic acid *etc.*, have been tried and proven to be effective in extending shelf-life and reducing postharvest losses either by delaying ripening and senescence or by preventing pathogenic infections in many fruit species (Lurie *et al*., 14). Thus, in order to study the beneficial carry-over effects of pre-harvest application of SA on the postharvest quality of mango during storage, the current experiment was designed with three different concentrations of SA applied one week before the commercial date of harvest.

MATERIALS AND METHODS

The studies were conducted in the Division of Food Science and Postharvest Technology, IARI, New Delhi-12 during 2014-15. Ten-year-old 'Amrapali' mango trees were randomly selected in the orchard of Division of Fruits and Hort. Technology, IARI, New Delhi for the pre-harvest application of different concentrations of ethylene bio-synthesis inhibitor, salicylic acid (SA) @ 75, 150 and 200 ppm. The spray chemical was mixed with surfactant (1% Triton-X) for increasing the surface adhesiveness and applied on trees using a hand operated mist sprayer. The control fruits were sprayed with distilled water. The spraying was done one week (7 days) before the commercial harvest and it was done on all sides of the fruit as well as to the foliage surrounding the fruit. The fruits were harvested carefully along with stalk using secateurs and then transported to the laboratory. Later, the fruits were de-sapped and then cleaned using tap water and were air-dried under fan for 15 min. The fruits

were then packed in ventilated CFB boxes and stored under ambient conditions (30 ± 5°C and 50 ± 5% RH). During storage, the postharvest behaviour was observed at 3 day interval in terms of physiological loss in weight (PLW), total colour change, texture, respiration rate, ethylene evolution rate, total soluble solids, titratable acidity *etc*.

The fruit peel colour was measured with a Hunter LAB colorimeter (model Miniscan XE Plus) and total colour change was calculated using the formulae:

Total Colour Change (ΔE) = $(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2$

Where L_0, a_0 and b_0 are initial values and L, a and b are final values), flesh firmness was measured as the force required for puncturing the fruits using a texture analyzer (Model: TA + Di, Stable Microsystems, UK). A probe of 2 mm diameter was used, set at a cross head speed of 0.5 mm sec^{-1} using a 500 kg load cell. Values of respiration rate and ethylene production were determined by headspace gas analysis using auto gas analyzer (Make: Checkmate 9900 O_2/CO_2, Denmark) and Hewlett Packard gas chromatograph (Model 5890 Series II) respectively. The fruits were evaluated for total soluble solids and titratable acidity using the standard methods (Ranganna, 16). The results obtained were statistically analyzed using Factorial Completely Randomized Design (CRD) for interpretation of results through analysis of variance.

RESULTS AND DISCUSSION

The minimum physiological loss in weight, PLW (11.06%) was observed in mango fruits treated with SA (200 ppm), while the maximum PLW (16.55%) was recorded in the untreated control mango fruits at the end of storage period, *i.e.* 9th day after storage (Fig. 1). The higher PLW in untreated (control) mango fruits might be due to their active metabolism in terms of respiration and transpiration, which might have led to greater loss of water during storage resulting in visually perceptible shriveling of 'Amrapali' mango fruits (Singh and Tiwari, 19). The lower PLW in the SA treated mango fruits can be directly correlated with reduced respiration (Fig. 2A), transpiration and suppressed ethylene production (Fig. 2B). This suggests that SA might have reduced respiration and transpiration, which concomitantly delayed senescence of the treated mango fruits.

The total colour change (ΔE) has improved gradually with increase in the storage period. However, the rate of colour change was more rapid in the untreated (control) fruits compared to all other treatments (Table 1). Irrespective of the treatments, the highest colour change was observed at the end of storage period. Likewise, the total colour change was maximum (34.93 ΔE) in the untreated fruits and
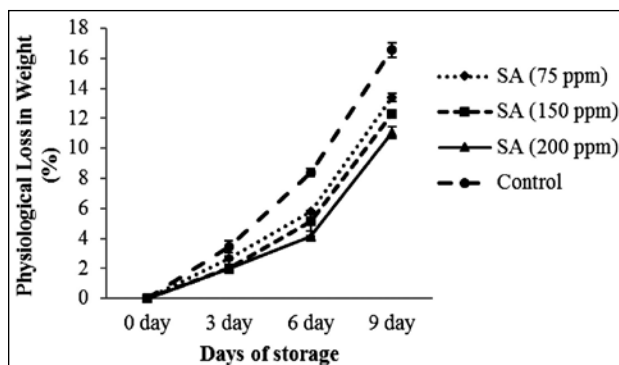

Fig. 1. Physiological loss in weight (%) of the 'Ámrapali' mango fruits as influenced by pre-harvest treatment of salicylic acid (SA).
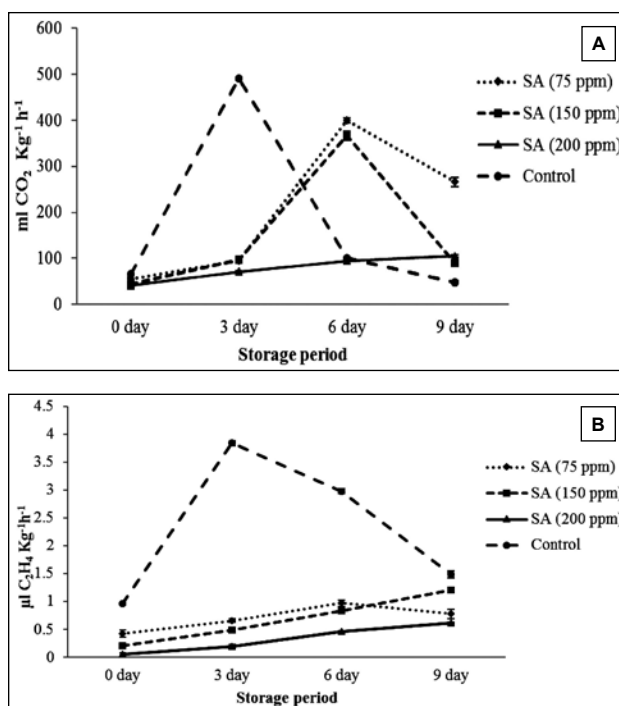

Fig. 2. Effect of pre-harvest treatment of salicylic acid (SA) on respiration rate (A) and ethylene production (B) of the 'Amrapali' mango fruits during storage.

lowest (26.31 ΔE) in the treatment SA @ 200 ppm. The interaction, treatment × storage period (T × S) was also significant as the highest (34.93 ΔE) colour change was observed in the untreated fruits at the end of storage period and the lowest (2.62 ΔE) colour change was observed in the treatment SA @ 200 ppm on the 3rd day of storage (Table 1). The slower and low colour change in the SA-treated mango fruits may due to suppression of ethylene production and consequently reduced degeneration of chlorophyll and reduced biosynthesis of carotenoids, particularly

Table 1. Influence of pre-harvest application of salicylic acid (SA) on total colour change and firmness of 'Amrapali' mango fruits during storage.

Treatment	Storage period (days)									
	Total colour change (ΔE)					Fruit firmness (N)				
	0 d	3 d	6 d	9 d	Mean	0 d	3 d	6 d	9 d	Mean
SA (75 ppm)	0.00	3.42	18.51	29.96	12.97	21.18	14.49	9.93	5.38	12.75
SA (150 ppm)	0.00	2.80	15.76	27.63	11.55	26.06	20.63	14.08	7.04	16.95
SA (200 ppm)	0.00	2.62	12.38	26.31	10.33	32.52	25.34	19.51	9.67	21.76
Control	0.00	6.47	18.95	34.93	15.09	13.03	9.99	8.22	5.14	9.09
Mean	0.00	3.87	16.40	29.71		23.19	17.61	12.94	6.81	
		CD					CD			
Treatment (T)		0.26					0.17			
Storage period (S)		0.26					0.17			
T × S		0.52					0.34			

in the peel, as also reported in mango cv. Kensingten Pride (Zaharah and Singh, 21) and banana (Cheng *et al.*, 5).

The fruit firmness has shown a declining trend with the progressive increase in storage period. Irrespective of the treatment, the firmness of mango fruit was highest on the day of harvest (23.19 N) and lowest at the end of storage period (6.81 N) (Table 1). While, among the treatments the maximum fruit firmness (21.76 N) was observed in the Amrapali fruits treated with SA (200 ppm) and minimum in the control fruits (9.09 N).The fruit softening is generally related to the extent of dissolution and solubilization of pectin and hemicelluloses by the cell wall hydrolyzing enzymes during ripening (Ali *et al.*, 1) and is triggered by the ethylene (Medlicott *et al.*, 15). The reduction in fruit softening and maintenance of pulp texture in SA treated mango fruits might be due to suppressed and delayed ethylene production and reduced activities of fruit softening enzymes such as polygalacturonase (Lazan *et al.*, 12), galactosidases (Ali *et al.*, 2), pectin esterase and β-1,4-glucanase (Ali *et al.*, 1) during ripening.

The current study reveals that treated as well as untreated fruits 'Amrapali' mango exhibited a typical respiratory climacteric upsurge during storage at ambient conditions. In general, the respiration rate in treated as well as untreated fruits initially increased, but after achieving a peak, it showed a declining trend (Fig. 2A). The respiratory climacteric peak in untreated fruits was observed on 3rd day of harvest (490.47 ml CO_2 kg^{-1} h^{-1}), whereas this upsurge was shifted to 6th day after harvest in the treated mango fruits but with varying level of CO_2 evolution (Fig. 2A). Further, the respiration rate was suppressed (105.43 ml CO_2 kg^{-1}h^{-1}) to a greater extent in the fruits treated

with SA (200 ppm) till the end of storage period. The differential reduction in fruit respiration rates during ripening and storage with different concentrations of SA might be ascribed to the corresponding reduction in ethylene biosynthesis (Fig. 2B).

Although, the pattern of ethylene evolution rate in 'Amrapali' mango fruits was almost similar to the pattern exhibited by respiration rate, the quantity of ethylene production was relatively low compared to other climacteric fruits. Ethylene evolution rate increased rapidly in the control (untreated) fruits, which achieved its peak (3.84 µl C_2H_4 kg^{-1}h^{-1}) on 3rd day of storage and then it declined slowly (1.49 µl C_2H_4 kg^{-1}h^{-1}) towards the end of storage period (Fig. 2B). The ethylene peak was delayed to 6th day in fruits treated with SA (75 ppm) and to 9th day in those treated with SA (150 and 200 ppm). Such suppression in ethylene production in SA-treated mango fruit might be associated with the decreased ACC synthase (Srivastava and Dwivedi, 20) and /or ACC oxidase activity as reported in banana (Srivastava and Dwivedi, 20), apple (Shirzadeh and Kazemi, 18), plum (Luo *et al.*, 13), and strawberry (Babalar *et al.*, 3).

It was observed that the untreated (control) mango fruits exhibited a rapid increase in total soluble solids (TSS) from the day of harvest and a sharp decline, thereafter during storage at ambient conditions compared to the treated ones (Fig. 3). The rapid and higher TSS in control fruits might be due to faster ripening associated with the hydrolysis of starch into simple sugars. The quicker decline thereafter might be due to higher respiration rate utilizing the simple sugars initially and the organic acids thereafter. Towards the end of storage life, highest TSS (27.72°B) was recorded in SA (200 ppm) treated fruits (Fig. 3). The delayed increase of TSS
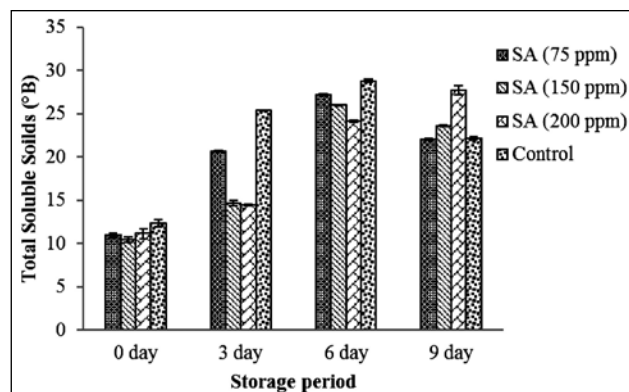
Fig. 3. Total soluble solids (°B) of the 'Amrapali' mango fruits as influenced by the pre-harvest application of salicylic acid.

in SA-treated fruits might be due to slower ripening in such fruits, which might be caused by inhibition of ethylene biosynthesis (Fig. 2B). A delayed increase in TSS of SA-treated fruits was reported in kiwifruit (Kazemi *et al.*, 8), apple (Kazemi *et al.*, 9), peach (Khademi and Ershadi, 11) and persimmon (Khademi *et al.*, 10).

A continual decrease in the titratable acidity (TA) was noticed during storage of 'Ámrapali' mango fruits at ambient conditions. However, the SA-treated fruits have shown a significant slower decline over the untreated (control) mango fruits. The highest and lowest TA (0.53 and 0.06%) were observed in SA (200 ppm) treated and untreated fruits, respectively, irrespective of the storage period (Fig. 4). The reduction in acidity during storage after attainment of maturity and ripening may probably be due to the utilization of organic acids as a substrate for respiration next to the sugars (Islam *et al.*, 7). Retention of higher TA in the SA-treated mangos
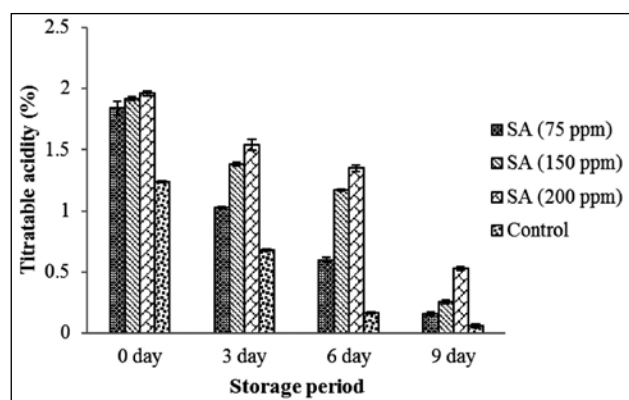

Fig. 4. Effect of pre-harvest application of salicylic acid (SA) on titratable acidity (%) of the 'Amrapali' mango fruits during storage.

might be due to delayed ripening and senescence processes in such fruits, which is responsible for the reduction of acid oxidation. Similar results of greater TA retention in mango fruits were also reported by Barman (4).

From the current studies, it can be concluded that pre-harvest application of salicylic acid could effectively modulate the postharvest behaviour of the 'Amrapali' mango fruits during storage at ambient conditions (30 ± 5°C and 50 ± 5% RH). Although, the mango was responsive to all the treatments, yet SA (200 ppm) was found to be effective dose/ concentration in delaying the ripening-cum-senescence processes through suppression of respiration and ethylene production rates and retention of firmness, colour, TSS and titratable acidity.

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