Environment and Ecology 36 (4) : 1057—1062, October—December 2018
Website: environmentandecology.com ISSN 0970-0420

Post-Harvest Application of Salicylic Acid Enhanced Shelf Life and Maintained Quality of Local Mango cv Rangkuai of Mizoram at Ambient Storage Condition

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Received 19 May 2018; Accepted 23 June 2018; Published on 11 July 2018

Abstract Fresh ripe mangoes are premier table fruit for its high nutritive and calorific value, excellent taste and flavor. But, the fruit which is in reasonable amount consumed raw; faced high post-harvest losses. Present study involved different concentration of salicylic acid (SA, 0.5-3.0 mM) as exogenous post-harvest fruit dip to test its influence on quality and shelf life at ambient condition. Results revealed that at 15 days after storage fruits treated with SA 2.0 mM caused minimum weight loss (21.08%) with having low Total soluble solid : Acid ratio (41.57) and maintained ascorbic acid (19.60 mg $100g^{-1}$). Fruits treated with SA 1.5 mM had high ascorbic acid (18.45 mg $100g^{-1}$) retention with low fruit decay (16.25%) compared to control (35.40%). SA at 2.0 mM showed maximum shelf life (20.25 days) followed by SA 1.5 mM (19.25 days)compared with control (15.35 days). Hence, SA at 1.5-2.0 mM can be considered as potential post-harvest treatment in extending shelf life of mangoes at ambient storage.

Keywords Mango, Rangkuai, Mizoram, Salicylic acid, Shelf life.

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Introduction

Mango is an evergreen fruit tree of Anacardiaceae family bears fruit of luscious taste and attractive color, originated in Indo-Myanmar region. This delicious fruit is known as King of Fruits as its rich in carbohydrate, vitamins, minerals and high calorific value. Commercial cultivation of mango is in more than 80 countries of the world, whereas, in India it is cultivated since 4000 years ago. India ranks first in world mango production covering an area of 2516 thousand ha with production of around 18.43 million tons, contributing 45.11% of the world production of Mango (Saxena 2015). Various parts of the plants are used as antiseptic astringent, diaphoretic, stornachic, vemifuge, laxative and diuretic (Shah et al. 2010). Mangiferin of mango stem bark is belived to have anti-cancer effect (Selles et al. 2016). Ripe mango fruits are considered to be invigorating and refreshing and thus a bulk amount is consumed as table fruit. However, overall post-harvest losses in fresh mangoes at harvesting, wholesale, retail market and wire houses were accounted for 34.49% (Moula et al. 2017).

Salicylic acid, an endogenous plant growth regulator has been found to generate a wide range of metabolic and physiological responses in plants which is reported as a natural and safe phenolic compound exhibiting a high potential in controlling loss of post-harvest of horticultural crops and delay in ripening through inhibition of ethylene biosynthesis or action (Asghari and Aghdam 2010). Salicylic acid has potential reports for alleviating chilling injury in sweet orange (Ahmad et al. 2013) and strawberry (Babalar et al. 2007) and extending shelf life by maintaining physico-chemical qualities at ambient storage (Mandal et al. 2016). Therefore, the present study was taken up to evaluate the response of post-harvest application of salicylic acid on shelf life and quality of mango in ambient storage.

Materials and Methods

Location of experiment

The experiment was carried out during May-June, 2017, at Research Laboratory, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University; with freshly harvested fruits of mango cv Rangkuai obtained from a local mango grower of Kawlchaw E village, Siaha district of Mizoram. Fully mature green mangoes were collected.

Treatments

Seven post-harvest treatments viz. fruit dipping in salicylic acid (SA) at 0.5 mML^{-1} (T_1), SA at 1.0 mM L^{-1} (T_2), SA at 1.5 mM L^{-1}(T_3), SA at 2.0 mM L^{-1} (T_4), SA at 2.5 mML^{-1} (T_5), SA at 3.0 mM L^{-1} (T_6) and control (treated with water: T_7) with four replications were used and statistical analysis was done by following, complete randomized design. The entire experiment was conducted at ambient condition (20-25 ^{0}C with 65-85% relative humidity).

Weight loss

Fruits for each treatment were tagged and weighed at 5 days interval using a digital electronic balance. The percentage weight loss was calculated by the following equation :

$$\text{Percentage weight loss at } n^{th} \text{ day} = \frac{\text{weight loss (0 day} - n^{th} \text{ day)}}{\text{Weight at 0 day}} \times 100$$

Biochemical parameters

The fruits were prepared for analysis by cutting and macerating the flesh with mortar and pestle and strained with clean muslin cloth. Analysis were carried out immediately for total soluble solids (TSS), total sugar, reducing sugar, titrable acidity, TSS: Acid ratio and ascorbic acid content.

Total soluble solids (TSS)

The total soluble solids of the fruits were determined with the help of hand refractometer calibrated in ^{0}Brix at 20^{0}C with necessary correction factor.

Total sugar and reducing sugar

The total sugar and reducing sugar content of fruit juice were estimated by standard procedure using Fehlings A and Fehlings B re-agents with methylene blue as an indicator through copper reduction method (AOAC 2012).

Titrable acidity

Total titrable acidity was determined by titrating the extracted juice against N/10 NaOH (sodium hydroxide) using phenolphthalein as indicator and expressed in percentage (AOAC 2012).

TSS/acid ratio

The ratio for fruit juice under each treatment was calculated by dividing TSS value by titrable acidity content of fruit.

Ascorbic acid

2, 6 dichlorophenol indophenols dye titration method

Table 1. Effect of post-harvest treatments on percentage of weight loss, decay and shelf life of mango fruits.

Treatments	Percentage of weight loss (%)			Fruit decay (%)	Shelf life (Days)
	3 DAS	10 DAS	15 DAS	15 DAS	
T_1 : SA 0.5 mM L^{-1}	10.40	17.78	25.83	24.40	18.25
T_2 : SA 1.0 mM L^{-1}	5.59	17.50	23.33	21.50	19.00
T_3 : SA 1.5 mM L^{-1}	3.70	16.67	23.08	16.25	19.25
T_4 : SA 2.0 mM L^{-1}	3.08	14.15	21.08	10.25	20.25
T_5 : SA 2.5 mM L^{-1}	10.83	24.60	28.83	27.25	18.00
T_6 : SA 3.0 mM L^{-1}	11.67	25.44	30.80	30.50	17.50
T_7 : Control	12.59	26.67	36.93	35.40	15.35
SEm (±)	0.5015	1.2150	0.7304	0.9152	0.6180
CD at 5%	0.8832	2.1396	1.2862	1.6116	1.0883

was used to estimate the ascorbic acid content of fruit (AOAC 2012) and expressed as mg/100 g of fruit.

Carotenoids

Carotene content of the fruit was determined by using acetone, hexane and magnesium carbonate following the standard procedure (Sadasivam and Manickam 2008). Determination was done by calculating carotene (mg/100 g) in the sample using standard curve prepared with different concentration of β-carotene standard and measuring absorbance at 434 nm wave length using a digital spectrophotometer.

Peel and pulp color

Determination of color of mango peel and pulp was done using digital handheld color meter (Konica Minolta, USA). It was expressed as three munerical values, L* for the lightness and a* and b* for the green-red and blue-yellow color components.

Fruit decay

The decay or rotting of the stored mango fruits were determined by their visual observations. Decacy percentage of mango fruits was calculated as the number of decayed fruit divided by initial number of all fruits (Pila et al. 2010, Mondal et al. 2016).

Shelf life of fruit

Optimum shelf life (days) of fruit under different treatment in refrigerated condition were evaluated depending on the visual observation of chilling injury, fruit physico - chemical parameters and counting the days from harvest to the day with maximum edible and marketable quality (Pila et al. 2010, Moneruzzaman et al. 2009, Mandal et al. 2015).

Results and Discussion

Physiological weight loss significantly increased during storage because of enhanced respiration and loss of water due to transpiration, dehydration and metabolic activity. After 5 DAS, physiological weight loss was ranged between 3.08 to 12.59%, while after 10 DAS it ranged between 14.15 to 26.67% (Table 1). At 15 DAS, maximum weight loss was found in case of control fruits (36.93%) whereas; it was found minimum at fruits treated with SA at 2.0 mM (21.08%). It was reported that kiwi fruits treated with SA at 0.2 mM showed lowest loss in fruit weight (Tareen et al. 2012). SA has been reported to close stomata which results in suppressed respiration rate and minimize weight loss of fruits (Mandal et al. 2016).

TSS and TSS : Acid ratio was increased during storage as the fruits gained TSS during the period while acidity markedly dropped. It was found that TSS which was ranged between 8.33 to 10.07 ^{0}Brix at 5 DAS was increased and ranged between 9.63 to 12.47 ^{0}Brix at 15 DAS, whereas, acidity that ranged between 1.86 to 3.27% at 4 DAS, dropped and ranged between

Table 2. Effect of post-harvest treatments on Total soluble solids (TSS) content, titrable acidity and TSS : Acid ratio of mango fruits.

Treatments	TSS (^{0}Brix)			Titrable acidity (%)			TSS : Acid ratio		
	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
T_1 : SA 0.5 mM L^{-1}	9.33	12.07	10.67	2.19	0.49	0.20	4.26	24.63	53.35
T_2 : SA 1.0 mM L^{-1}	9.07	10.73	11.00	2.28	0.85	0.21	3.98	12.62	52.38
T_3 : SA 1.5 mM L^{-1}	9.00	10.47	11.13	2.88	0.88	0.23	3.13	11.90	48.39
T_4 : SA 2.0 mM L^{-1}	8.33	10.33	12.47	3.27	1.47	0.30	2.55	7.03	41.57
T_5 : SA 2.5 mM L^{-1}	9.67	11.60	9.63	2.16	0.43	0.19	4.48	26.98	50.68
T_6 : SA 3.0 mM L^{-1}	9.67	11.73	9.70	1.95	0.36	0.19	4.96	32.58	51.05
T_7 : Control	10.07	12.27	10.13	1.86	0.26	0.17	5.41	47.19	59.59
SEm (±)	0.1374	0.2560	0.2948	0.2479	0.1176	0.0156	0.1500	0.9543	1.3207
CD at 5%	0.2420	0.4509	0.5191	0.4365	0.2071	0.0275	0.2642	1.6805	2.3258

0.17 to 0.30% at 15 DAS (Table 2). At 15 DAS, it was found that fruits at control got maximum TSS : Acid ratio (59.59) compared with the fruits treated with SA at 2.0 mM (41.57). Both the sugar percentage i.e. reducing and total sugar got increased during storage up to 10 DAS. After that it was found that fruits treated with SA at 0.5 or 2.5 to 3.0 mM had reduction of sugar post 10 DAS (Table 3). It was found that at 15 DAS, total sugar was maximum in fruits at SA 2.0 mM (10.21%) compared with the fruits treated with SA at 3.0 mM (8.24%). Reducing sugar content was minimum in case of fruits treated with SA at 2.5 mM (2.58%) compared with SA 2.0 mM (4.11%) at 15 DAS. Treatment of kiwi fruit with Me SA of 32 µl L^{-1} maintained a lower TSS content than the control fruits at the end of cold storage (Aghdam et al. 2010). It was opined that SA can decrease the degradation rate of starch to soluble sugar in banana during storage, which may be the potential reason behind low TSS content even at 8 DAS, as sugar considered to the major contributor in fruit TSS value (Hu et al. 2009). Scientists suggested that enhanced invertase activity manifested into breakdown of starch to sugar (Mandal et al. 2016).

Ascorbic acid content of fruit gradually decreased during storage period because of oxidation. It was recorded that ascorbic acid ranged between 25.48 to 37.24 mg $100g^{-1}$ at 5 DAS which decreased and ranged between 11.16 and 19.60 mg $100g^{-1}$ at 15 DAS.After 15 days of ambient storage, it was found that SA at 2.0 mM treated fruits had maximum amount of ascorbic acid content 19.60 mg $100g^{-1}$ compared to control (11.16 mg $100g^{-1}$). However, fruits treated with SA at 1.5 mM also had high ascorbic acid content 18.45 mg 100 g^{-1} at 12 DAS Ascorbic acid content generally reduced at storage because of its oxidative process (Mandal et al. 2016). It was reported that application of SA was found to be effective in reducing the rate of respiration and ethylene production and maintaining higher amount of ascorbic acid (Renhua et al. 2008).

Table 3. Effect of post-harvest treatments on percentage of total sugar, reducing sugar and ascorbic acid content of mango fruits.

Treatments	Total sugar (%)			Reducing sugar (%)			TSS : Acid ratio		
	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
T_1 : SA 0.5 mM L^{-1}	7.20	9.81	8.32	3.08	4.25	3.06	31.60	25.18	15.50
T_2 : SA 1.0 mM L^{-1}	7.04	8.92	9.36	2.96	3.46	3.68	32.34	26.67	16.75
T_3 : SA 1.5 mM L^{-1}	6.89	8.68	9.78	2.58	3.27	3.74	34.16	28.33	18.45
T_4 : SA 2.0 mM L^{-1}	6.32	5.36	10.21	2.12	2.98	4.11	37.24	31.67	19.60
T_5 : SA 2.5 mM L^{-1}	7.24	9.05	7.08	3.14	3.92	2.58	27.44	24.49	15.25
T_6 : SA 3.0 mM L^{-1}	7.45	9.38	7.25	3.28	4.08	2.96	26.46	24.25	14.49
T_7 : SA Control	8.21	10.69	8.24	3.98	4.79	3.14	25.48	23.33	11.16
SEm (±)	0.1781	0.2498	0.2771	0.1681	0.1595	0.1283	1.7170	0.9917	0.7881
CD at 5%	0.3136	0.4400	0.4880	0.2960	0.2809	0.2260	3.0237	1.7463	1.3878

Table 4. Effect of post-harvest treatments on carotenoids contens, peel and pulp color of mango fruits.

Treatments	Carotenoids (mg $100g^{-1}$)			Peel color at 15 DAS			Pulp color at 15 DAS		
	5 DAS	10 DAS	15 DAS	L	a	b	L	a	b
T_1 : SA 0.5 mM L^{-1}	3.12	4.29	4.38	48.24	-10.99	44.50	74.61	21.98	58.58
T_2 : SA 1.0 mM L^{-1}	2.65	3.98	4.45	49.73	-11.30	38.78	52.20	25.57	50.96
T_3 : SA 1.5 mM L^{-1}	2.04	3.46	4.72	32.36	-9.89	31.01	51.30	18.67	50.19
T_4 : SA 2.0 mM L^{-1}	1.62	3.12	4.87	31.73	-11.04	32.49	64.48	15.19	61.15
T_5 : SA 2.5 mM L^{-1}	3.28	5.32	3.46	44.09	-3.66	46.50	67.81	25.65	60.82
T_6 : SA 3.0 mM L^{-1}	3.45	5.40	3.27	56.36	-13.04	44.58	58.95	26.99	52.14
T_7 : Control	3.78	5.89	3.07	61.12	-18.72	43.26	56.37	30.98	54.63
SEm (±)	0.2337	0.2423	0.2663	-	-	-	-	-	-
CD at 5%	0.4116	0.4266	0.4690	-	-	-	-	-	-

It was observed that carotenoids content of mango fruits consistently increased for all the treatments up 10 DAS. It was found that carotenoids which was ranged between 1.62 to 3.78 mg $100g^{-1}$ at 5 DAS increased and ranged between 3.12 to 5.89 mg 100 g^{-1} at 10 DAS (Table 4). However, fruits which was treated with SA at 0.5-2.0 mM got further increased up to 15 DAS, whereas, for rest of the treatments it got deceased after 10 DAS. At 15 DAS, carotenoids was found highest 4.87 mg $100g^{-1}$ at fruits treated with SA at 2.0 mM compared with control (3.07 mg $100g^{-1}$). It was found that tomato fruits had low carotenoids and lycopene accumulation (29.35 and 28.57 µg g^{-1}) during storage when treated with SA at 0.4 mM (Pila et al. 2010).

Present study showed that at 15 DAS peel color was remained green. But, the fruit treated with SA at 2.0 mM was remained dark green color (L : 31.73, a : -11.04, b : 32.49), whereas, fruits at control had slightly light green color with yellowness (L : 61.12, a : -18.72, b : 43.26) (Table 4). For the pulp color, it was clearly found that SA at 2.0 mM treated fruit was slightly yellowish orange (L: 64.48, a: 15.19, b : 61.15) whereas, fruits at control had completely dark orange color pulp (L : 56.37, a : 30.98, b : 54.63). SA treated strawberry fruits showed delaying in color development at post-harvest storage (Shafiee et al. 2010). Moreover, scientists found that peach fruit developed less red and yellow color when treated with SA at 1.5-2 mM during post-harvest cold storage (Tareen et al. 2012). They opined that color of peach fruit shifts from green to yellow in result to decline in chlorophyll and carotenoids start increasing.

After 15 days of ambient storage fruits treated with SA at 2.0 mM had the minimum fruit decay (10.25%) followed by fruits treated with SA at 1.5 mM (16.25%) whereas, fruits at control had the maximum fruit decay (35.40%) (Table 1). Exogenous application of SA at non-toxic concentration to susceptible fruits and vegetables could enhance resistance to pathogen and delay post-harvest decay (Asghari and Aghdam 2010). It was reported that SA AT 2.5 mM caused minimum fruit decay (6.25%) at ambient storage of papaya (Mandal et al. 2017).

Shelf life of the stored mango was highest for SA at 2.0 mM treated fruits (20.25 days) followed by the fruits treated with SA at 1.5 mM (19.25 days) whereas, it was minimum (15.35 days) for the fruits at control (Table 1). Treatment with SA at 2.0 mM increased the shelf life of the fruits by 5 more days compared to control in room condition. SA treatments delayed ripening and adjoining physico-chemical changes in mango as it delayed respiration climacteric and reduced ethylene production. Moreover, decaying was found less in SA treated fruits. These are to be considered behind the high shelf life of SA treated fruits. Similar results were found by the others (Hu et al. 2009, Mondal et al. 2016).

Conclusion

The results of the present experiment showed that SA at 1.5-2.0 mM may be the effective post-harvest treatment to extend shelf life while maintaining the fruit physico-chemical qualities of local mango cv

Rangkuai of Mizoram during storage at room temperature.

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