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Effect of Different Concentrations of Salicylic Acid as Post-harvest Treatment on Physicochemical Properties and Shelf Life of Mango (*Mangifera indica* cv. Bombay green)

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Abstract This study was undertaken at the Horticulture Laboratory of College of Natural Resource Management Bardibas, Mahottari, Nepal in 2023. Physiological loss in weight, fruit firmness, shelf life, pulp pH, Total soluble solids (TSS), Titratable acidity (TA), and TSS: TA ratio were to be determined for the study. The study contained 5 different concentrations of salicylic acid as five treatments (0 ppm, 50 ppm, 100 ppm, 150 ppm and 200 ppm) with four replications of each on a Completely Randomized Design (CRD). For each treatment destructive and non-destructive sample were prepared. Data obtained from various biochemical analyses of physicochemical properties (physiological loss in weight, total soluble solids, titratable acidity, pulp pH, TSS: TSS ratio, and shelf life of mango) were recorded and statistically analyzed by using Gen-Stat software. The fruits were evaluated at the three-day interval after the initial reading taken on the day of storage and further data were recorded after 3,6,9,12, and 15 days of storage. Among all the salicylic acid treatments, @200 ppm recorded the minimum physiological loss in weight, the highest total soluble solids (21.44^{o}Brix), maximum fruit firmness (1.91 kg/cm^2), highest titratable acidity (0.166%), highest TSS: TA ratio (129.4), and minimum pulp PH (6.00). The longest shelf life was observed with fruit treated with a 200 ppm concentration of salicylic acid (15.71 days) which was similar to 150 ppm of salicylic acid (15.35 Days). Salicylic acid at 200 ppm showed the best performance in retarding the changes in physicochemical properties and prolonging the shelf life of mango fruits.

Keywords Post-harvest treatment; Bombay green; Shelf life; Physicochemical properties; Salicylic acid

Introduction

The mango (*Mangifera indica* L.) is a dicotyledonous plant of the family Anacardiaceae, generally cultivated in tropical and subtropical climatic zones. The mango is referred to as the ‘king of fruits’ (particularly in India) due to its nutritional benefits, excellent exotic flavor and versatile uses. Mango is a pulpy, sweet, climacteric drupe fruit. It is mostly eaten when it is fresh and ripe. Alternatively, processed mangoes are also consumed in the form of juices, nectars, pickles, jams and fruit creams, among others. Consumer acceptance of mango fruit relies on both external and internal quality. More than 150 varieties of mango are cultivated worldwide. Mango is considered to have originated from southern Asia, and more specifically from eastern India, Burma and the Andaman Islands (Alkan and Kumar, 2018).

Mango delivers nutritional value. Providing about 64-86 calories of energy per 100 g of mango play a vital role in balancing the human diet (Abdel Salam et al., 2022). Mango is also an excellent source of vitamins and minerals such as potassium, calcium, magnesium, etc. Insufficient arrangements for post-harvest management such as storage, processing, marketing infrastructures, and preservation lead to post-harvest losses (Mitrannavar, 2012). Therefore, appropriate measures should be adopted to prolong the shelf life of mangoes. The post-harvest life of mango is very less in Nepal because of the insufficiency of cold storage, transport facilities, and a sound marketing system (Hoa et al., 2002). Optimal post-harvest treatments seek to slow down the physiological processes of senescence and maturation, inhibit the development of physiological disorders and minimize the risk of microbial growth. Several post-harvest treatments such as physical, chemical, and gaseous treatments such as heat treatment, edible coating, Nitric oxide, Antimicrobial, ethylene, controlled and atmosphere storage are used to extend the shelf life of fruits (Chhetri and Ghimire, 2023).

One such plant growth regulator compound is salicylic acid (SA) which plays an important role in regulating a variety of physiological processes in plants. The effect of SA on delaying fruit ripening, softening, and reducing disease resistance and reducing disease incidence were discussed by various researchers (Raskin, 1992). Thus, in order to study the beneficial carryover effects of post-harvest application of SA on the post-harvest quality during storage, the current experiment was designed with five different concentrations of SA with four replications (Reddy and Sharma, 2016). Salicylic acid inhibits ethylene production and/or activity and forms complexes with organic molecules in the cell wall of epidermal cells, conferring resistance to degrading enzymes. Salicylic acid extends storage life by decreasing ethylene biosynthesis, respiration, and transpiration, as well as water loss and decays infection through stomatal closure of the fruit surface, preserving firmness, and delaying the Senescence stage by preventing polyphenol oxidase activity (Abdel Salam et al., 2022).

1 Materials and Methods

The cultivar used for this study was Bombay green and it was carried out in the Horticulture lab of the CNRM Bardibas in, Bardibas Mahottari, Nepal. The location falls in the Terai region of Madhesh Province of Nepal. The research region was located at an elevation of 165 masl at a latitude between 26.8762°N and a longitude between 85.8077°E. The experiment was conducted from 4th June 2023 to 18th June 2023. 80% mature mango cv. Bombay green free from disease and bruises collected from farmer’s field Mithila Municipality, Dhanusha. Then, the fruits were washed in water to remove any foreign particles like dust, mud and allowed to dry.

1.1 Preparation of the salicylic acid

Salicylic acid of 300 mg, 600 mg, 900 mg, and 1,200 mg, were weighed with the help of a digital weighing machine and were dissolved in 10 mL of ethanol at a mild warm state and produced up to 5 liters with distilled water to create solutions of 50 ppm,100 ppm, 150 ppm, and 200 ppm.

1.2 Design of experiment

In terms of experimental design, a completely randomized design (CRD) was employed with five treatment combinations and four replicates. The details of the treatments are as follows: the control group (T1) was treated with distilled water, while experimental treatments received varying concentrations of salicylic acid. T2 received 50 ppm of salicylic acid, T3 received 100 ppm, T4 received 150 ppm, and T5 received 200 ppm of salicylic acid. These treatment combinations were chosen to assess the effects of salicylic acid on the experimental subjects, aiming to elucidate its potential roles in plant growth and physiological responses. The use of CRD ensured random allocation of treatments, thereby minimizing external factors' influence on experimental outcomes and enhancing the reliability and accuracy of the data obtained.

1.3 Atmospheric condition of the laboratory

In the laboratory, atmospheric conditions were monitored three times daily—8:00 am, 1:00 pm, and 5:00 pm—using a thermo-hygrometer (Figure 1). This allowed for a comprehensive assessment of the environment's temperature and relative humidity throughout the experimental period.

On June 4th, 2023, the laboratory experienced an average maximum temperature of 31.7 °C and a minimum of 26.4 °C. Similarly, on June 18th, 2023, the average maximum temperature recorded was 31.7 °C, with a minimum of 26.4 °C. These fluctuations in temperature were accompanied by varying levels of relative humidity, reaching an average maximum of 85% and a minimum of 95% on the same dates.

These conditions are crucial for understanding the environmental factors that could potentially influence the outcomes of the experiment. By consistently monitoring temperature and relative humidity, we aimed to maintain stable experimental conditions and minimize any confounding effects on the experimental results.

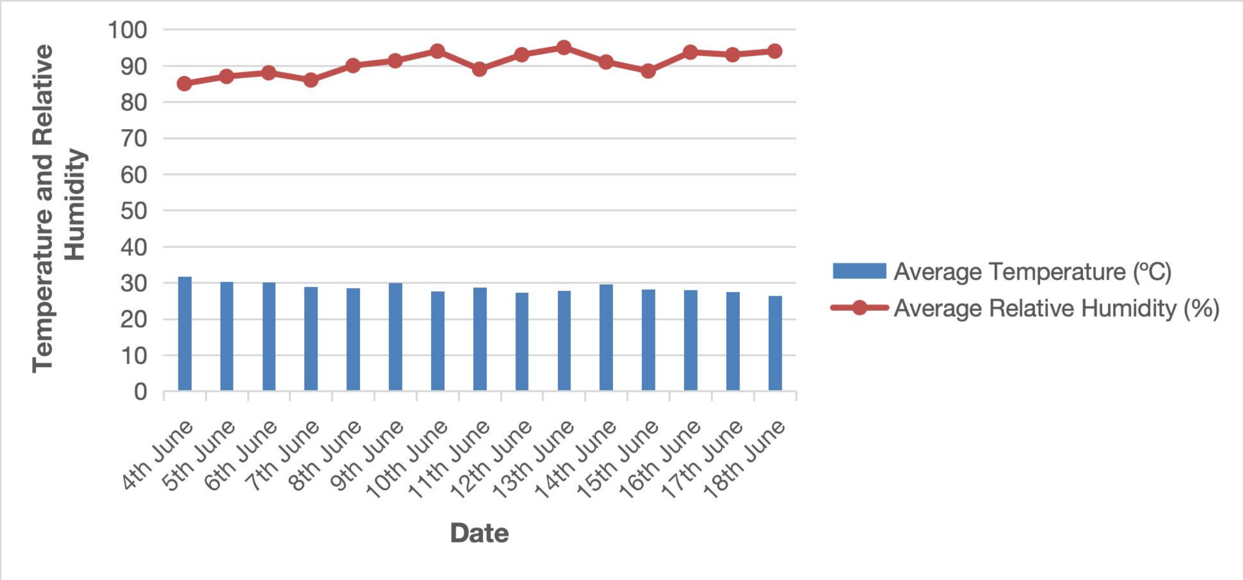

Figure 1 Environmental conditions of the laboratory during the experimental period

1.4 Data collection

Two parameters viz. physical and chemical were recorded for observation at an interval of 2 days starting from the days of storage till the shelf life of the fruits. The following data were collected in this experiment.

1.4.1 Physical observations

Three fruits of non-destructive sample from each treatment combination of every replication were kept recording the shelf life of the fruit, physiological loss in weight (PLW), and fruit firmness.

1.4.2 Chemical observations

10 fruits of destructive sample from each treatment and each replication were chemically analyzed to record the total soluble solids (TSS), titratable acidity (TA), pulp pH, and TSS: TA ratio.

1.5 Method of recording observation

1.5.1 Physiological loss in weight (%) PLW

Physiological loss in weight was determined at every 3-day interval from non-destructive sampling. An electronic digital balance was used to measure the fruit weight. Initial weight was recorded at the 1st days of storage from the freshly harvested fruits. Physiological weight loss was determined by using the following formulae (Moneruzzaman et al., 2009).

PLW (%) = (IW-FW) *100/IW

Where, PLW=Physiological loss in weight; IW=Initial weight (g); FW=Final weight (g)

1.5.2 Fruit firmness (kg/cm^2)

The firmness of the fruits will be taken after treatment at 3-day intervals with the use of an instrument penetrometer (Model GY-3, No. 400102024). The peak puncture force (g) was used as a measure of the firmness of fruits (Meng et al., 2014). With the help of a penetrometer, firmness will be taken from two points from the fruit and the average of these values will be considered as the actual firmness.

1.5.3 Total soluble solids (ºBrix) TSS

TSS of mango fruit was measured by using a handheld refractometer. The measurement is done by dripping the fruit juice on the prism of the refractometer with the help of a clean pipette. TSS value is expressed by %Brix. The reading was recorded at room temperature. The Refractometer was cleaned with water and muslin cloth after every use.

1.5.4 Titratable acidity (%) TA

Titratable acidity was examined by the titration of diluted fruit juice (5 mL) with 100 mL distilled water and 2 drops of phenolphthalein indicator (Ranganna, 1979) against base 0.1 N NaOH solutions. The following formula was used to compute the percent titratable acidity.

TA (%) = (0.1N NaOH * mL of NaOH consumed * EA * 100)/VS

Where, TA =Titratable acidity; N NaOH =Normality of NaOH; NaOH=Sodium hydroxide; m.eq.wt. =Mill equivalent weight of predominant acid=0.067; VS= volume of sample i.e. 5 mL

1.5.5 TSS: TA ratio

The TSS: TA ratio serves as a critical indicator in determining the balance between total soluble solids and titratable acidity in the samples analyzed. Total soluble solids represent the concentration of sugars, organic acids, and other soluble substances, while titratable acidity measures the acidity present in the solution. The calculated TSS: TA ratio provides insights into the sensory attributes and quality characteristics of the samples, helping to assess their suitability for various applications, such as food processing or agricultural product evaluation. TSS: TA ratio was evaluated by using the following formula:

TSS: TA= Total soluble solid/Titratable acidity

1.5.6 Pulp pH

The pH of mango fruit juice was determined by using an automatic digital pH meter (Hanna instruments, pHep). Firstly, the pH meter was calibrated with a neutral buffer solution with a pH of 4.0 or 7.0 and then checks the pH of the pulp juice.

1.5.7 Shelf life (Days)

Shelf life was calculated by counting the period between the first day of storage after treatment and the end of the edible life of fruits. The shelf life was counted until the mangoes were less than 50% deteriorate of each treatment and each replication.

1.6 Statistical analysis

All collected data were entered into MS-Excel for statistical analysis and subjected to Analysis of variance (ANOVA) using the GenStat 15th edition. Duncan's Multiple Range Test at a 5%level of significance (DMRT) was used to separate the means of treatments that were significantly different.

2 Results and Analysis

2.1 Physiological loss in weight (%) PLW

The effect of different concentrations of salicylic acid on physiological loss in weight of mango fruits during storage is presented in Table 1 and Figure 2. Data presented in Table 1 clearly shows that there was a progressive increase in physiological loss in weight in all treatments with an increase in storage period. Minimum physiological weight loss was observed in the fruits treated with 200 ppm salicylic acid of 200 ppm concentration followed by the fruits treated with 150 ppm of SA ,100 ppm of SA, and 150 ppm of SA where the highest physiological loss in weight was recorded for control fruits on each sampling at 9 days after storage.

2.2 Fruit firmness

The results clearly indicated that mango fruits fruit firmness significantly decreased with the advancement storage period (Table 2; Figure 3) The lowest fruit firmness was obtained in untreated fruits while the highest fruit firmness was obtained in 200 ppm salicylic acid followed by 150,100 and 50 ppm of salicylic acid. Salicylic acid decreased the rate of fruit softening as it delays the progress of some components of the ripening of fruit, preventing some changes as triggered by ethylene.

Table 1 Effect of different concentrations of salicylic acid on physiological loss in weight of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Physiological loss in weight (%) PLW				
	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	15.44[a]	24.30[a]	32.47[a]	-	-
50 ppm SA	12.81[b]	22.59[ab]	31.48[a]	38.12[a]	-
100 ppm SA	10.95[c]	21.73[b]	29.92[ab]	37.40[a]	51.44[a]
150 ppm SA	10.49[c]	21.23[b]	29.38[ab]	36.28[a]	50.00[a]
200 ppm SA	9.20[c]	19.24[c]	28.23[b]	32.60[b]	38.58[b]
Grand mean	11.78	21.82	30.30	36.10	46.67
CV%	9.8	5.5	6.5	6.6	6.9
SEM (±)	0.58	0.60	0.98	1.19	1.60
LSD	1.74	1.81	2.96	3.68	5.13
F-Test	***	***	*	*	***

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at (p<0.05), ** = highly significant different at (p<0.01), *** = very significantly different at (p<0.001)

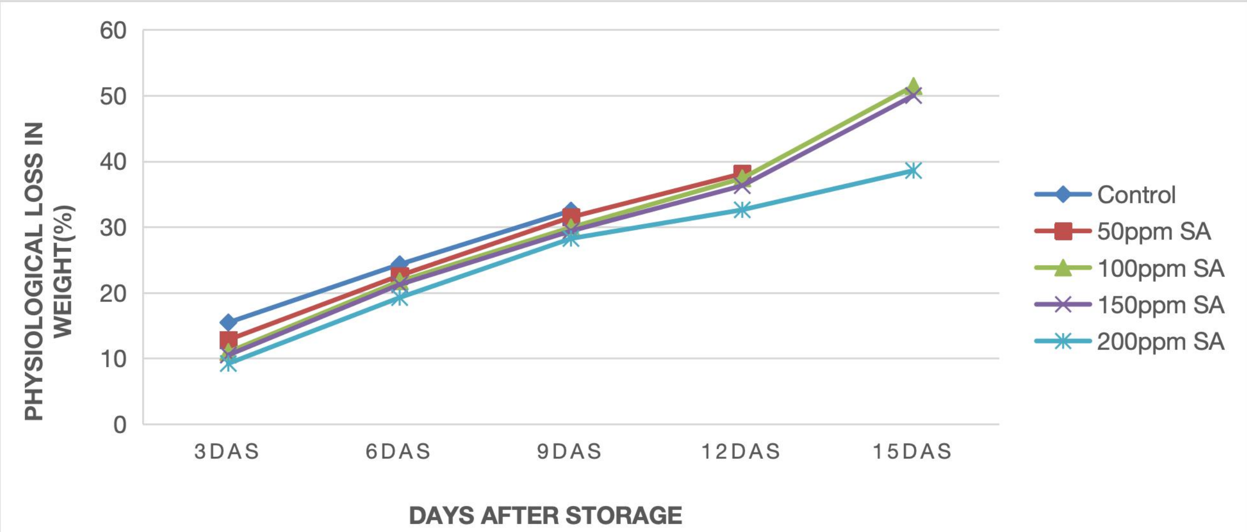

Figure 2 Post-harvest treatments of salicylic acid on PLW of mango

Table 2 Effect of different concentrations of salicylic acid on fruit firmness of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Fruit firmness (kg/cm^2)					
	Initial	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	8.1	4.58[d]	3.25[d]	2.30[d]	-	-
50 ppm SA	8.1	5.35[c]	3.53[d]	2.51[cd]	2.19[b]	-
100 ppm SA	8.1	5.77[bc]	4.23[c]	2.95[c]	2.41[b]	1.48[b]
150 ppm SA	8.1	6.25[ab]	4.91[c]	3.48[b]	2.61[ab]	1.69[ab]
200 ppm SA	8.1	6.49[a]	5.43[a]	4.21[a]	2.97[a]	1.91[a]
Grand mean	8.1	5.69	4.27	3.09	2.55	1.69
CV%	8.1	7.9	5.0	9.3	10.3	10.0
SEM (±)	-	0.22	0.10	0.14	0.13	0.08
LSD	-	0.68	0.31	0.43	0.40	0.27
F-test	-	***	***	***	**	*

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at (p<0.05), ** = highly significant different at (p<0.01), *** = very significantly different at (p<0.001)

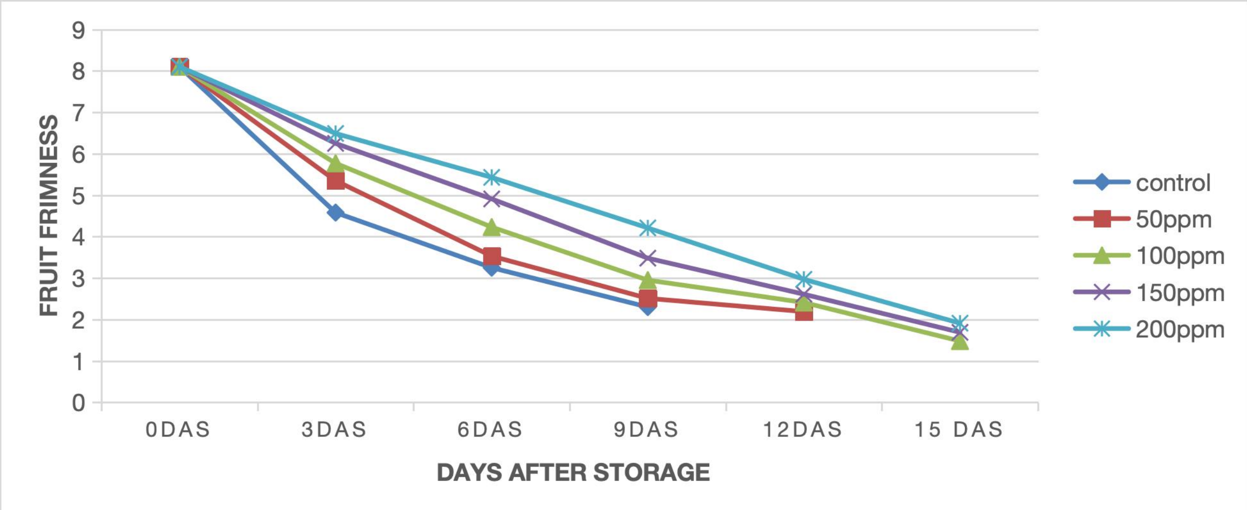

Figure 3 Post-harvest treatments of salicylic acid on fruit firmness of mango

2.3 Total soluble solids (TSS)

The effect of salicylic acid on the TSS of mango fruits has been investigated and showed a significant difference ($p \leq 0.001$) throughout the storage period with (Table 3; Figure 4). The total soluble solids increased from control mango fruits (untreated) from the initial to 9th days and then, it declined. Similarly, the other treatments such as 100, 150 and 200 ppm salicylic acid also increasingly provided TSS from the initial to 12th days and afterward, 100 ppm SA treated fruits decreased at 15 days. Hydrolysis of starch and other insoluble carbohydrates into sugar was the reason for an initial increase in the TSS of fruits whereas a slight decrease in the later stage was due to the utilization of soluble solids in the respiratory process. Fruits treated with 200 ppm of salicylic acid were the slowest to reach their TSS peak. This happened possibly due to the slowdown of ripening resulting in lower TSS accumulation.

Table 3 Effect of different concentrations of salicylic acid on total soluble solids of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Total Soluble Solids (ºBrix) TSS					
	Initial	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	8.3	17.46^{a}	19.23^{a}	20.47^{a}	-	-
50 ppm SA	8.3	15.25^{b}	18.38^{b}	19.48^{ab}	20.01^{a}	-
100 ppm SA	8.3	14.25^{b}	17.38^{b}	18.94^{b}	19.97^{a}	18.84^{b}
150 ppm SA	8.3	12.87^{c}	15.16^{c}	18.73^{b}	19.61^{ab}	20.12^{ab}
200 ppm SA	8.3	11.24^{d}	13.43^{d}	16.82^{c}	18.42^{b}	21.44^{a}
Grand mean	8.3	14.21	16.71	18.89	19.50	20.13
CV%	-	5.3	3.9	4.9	4.1	7.2
SEM (±)	-	0.37	0.32	0.65	0.40	0.72
LSD	-	1.13	0.99	1.38	1.23	2.30
F-value	-	***	***	***	*	**

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at ($p<0.05$), ** = highly significant different at ($p<0.01$), *** = very significantly different at ($p<0.001$)

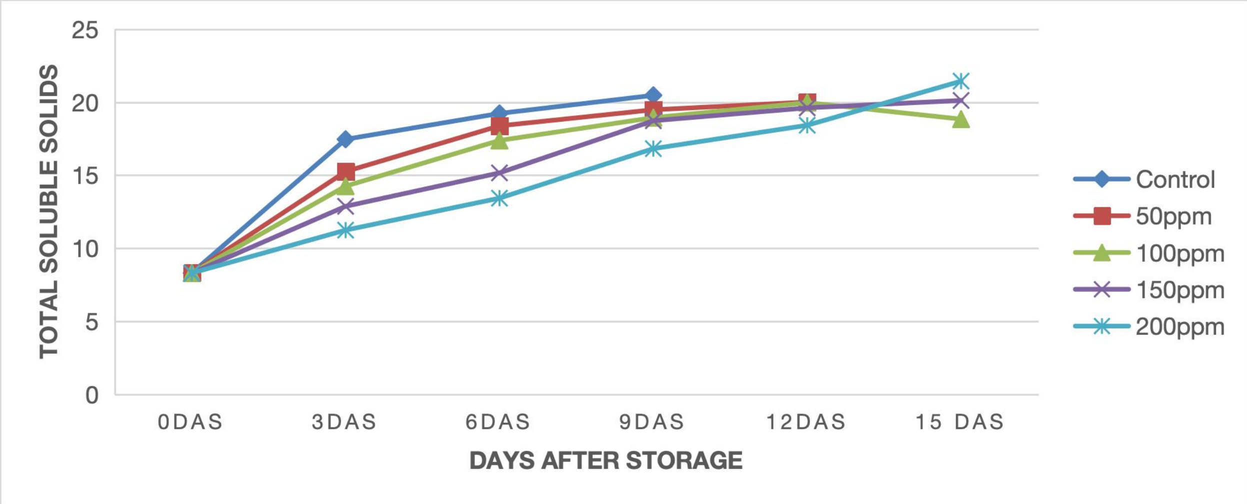

Figure 4 Post-harvest treatments of salicylic acid on total soluble solids of mango

2.4 Titratable acidity (TA)

The data related to the titratable acidity of postharvest treated fruits and their mean value is presented in Table 4 and Figure 5. It is explored that the diminishing rate was very fast from the initial to 6th day and there after its trend was comparatively slower with (Table 4). The highest titratable acidity was noticed with @SA 200 ppm followed by the fruits treated with 150 ppm of SA, 100 ppm of SA, and 50 ppm SA whereas the lowest titratable acidity was obtained in untreated fruits.

Table 4 Effect of different concentrations of salicylic acid on Titratable acidity of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Titratable acidity (%) (TA)					
	Initial	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	2.11	1.26^{b}	0.36^{d}	0.12^{c}	-	-
50 ppm SA	2.11	1.6^{a}	0.57^{c}	0.26^{c}	0.24^{c}	-
100 ppm SA	2.11	1.63^{a}	0.69^{bc}	0.28^{c}	0.25^{bc}	0.147^{b}
150 ppm SA	2.11	1.67^{a}	0.73^{b}	0.48^{b}	0.27^{b}	0.164^{a}
200 ppm SA	2.11	1.72^{a}	0.967^{a}	0.55^{a}	0.3^{a}	0.166^{a}
Grand mean	2.11	1.58	0.66	0.34	0.27	0.15
CV%	-	6.1	13.9	13.5	5.4	5.2
SEM (±)	-	0.04	0.04	0.02	0.007	0.005
LSD	-	0.14	0.13	0.03	0.02	0.013
F-value	-	***	***	***	**	*

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at (p<0.05), ** = highly significant different at (p<0.01), *** = very significantly different at (p<0.001)

2.5 TSS: TA ratio

The result showed that there were significant differences between the concentrations of salicylic acid on the TSS: TA ratio of mango during storage with (Table 5). It is explored that mango fruits of TSS: TA ratio progressively increased with the advancement storage period. The highest TSS: TA ratio was recorded in 200 ppm salicylic acid (121.1).

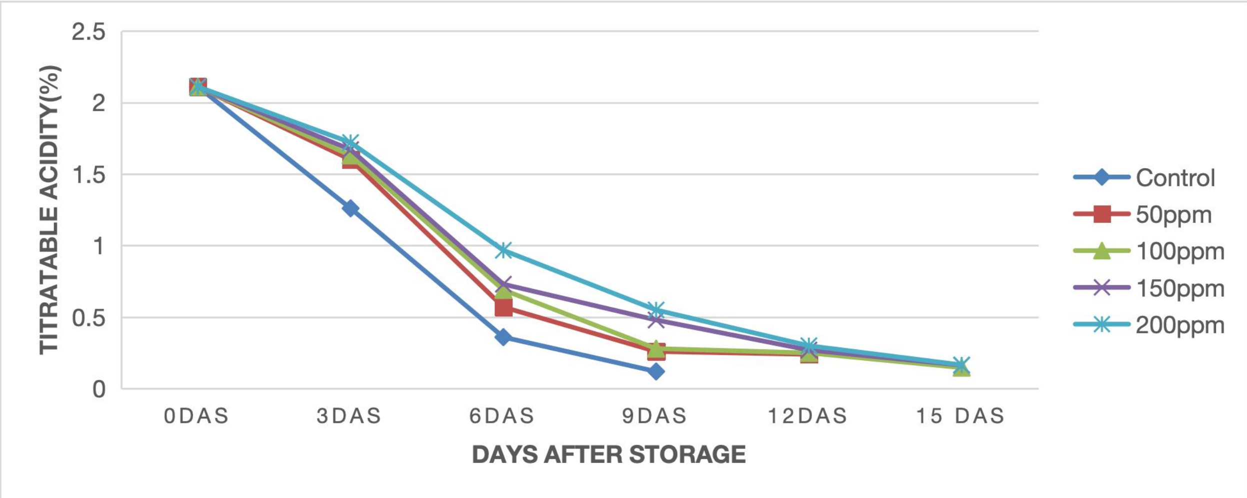

Figure 5 Post-harvest treatments of salicylic acid on Titratable acidity of mango

Table 5 Effect of different concentrations of salicylic acid on the TSS: TA ratio of mango (*Mangifera indic*a L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	TSS: TA					
	Initial	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	3.93	13.80[a]	52.66[a]	87.83[a]	-	-
50 ppm SA	3.93	9.53[b]	32.23[b]	75.48[b]	80.56[a]	-
100 ppm SA	3.93	8.74[bc]	25.86[bc]	61.00[c]	78.48[ab]	99.8[c]
150 ppm SA	3.93	7.75[cd]	21.12[c]	40.28[d]	71.09[b]	116.5[b]
200 ppm SA	3.93	6.51[d]	13.91[d]	30.63	61.45[c]	129.4[a]
Grand mean	3.93	9.27	29.16	59.04	72.9	110.3
CV%	-	9.1	14.9	5.6	6.9	5.3
SEM (±)	-	0.42	2.17	1.65	2.53	2.95
LSD	-	1.27	6.56	4.99	7.80	9.43
F-value	-	***	***	***	***	**

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at (p<0.05), ** = highly significant different at (p<0.01), *** = very significantly different at (p<0.001)

2.6 Pulp pH

The effect of different concentrations of salicylic acid shows a significant difference in the pulp pH of mango (p) during the storage with (Table 6; Figure 6). Highest pH was observed in control fruits at all stages of the storage period followed by the fruit treated with 50,100,150 and 200 ppm of SA. Fruits treated with salicylic acid maintained lower pH which could be attributed to the effect of SA on fruits, which lead to a slowdown of respiration. Pulp pH declines this phenomenon is due to the oxidation of acid during storage. The application of salicylic acid of 200 ppm concentration had the lowest pH as compared to the control fruits in this study.

2.7 Shelf life of fruits

The shelf life of fruits was significantly influenced by different concentrations of salicylic acid (SA) during storage with (Table 7; Figure 7). Shelf life is the period required to be fully ripe to retain optimum marketing and eating qualities where the damage should not exceed more than 50%. The shelf life ranged from 9.27 to 15.71 days were recorded from different concentrations of salicylic acid. The longest shelf life (15.71 day) was observed from the fruits treated with 200 ppm SA followed by the fruits treated with 150 ppm SA (15.35 day), 100 ppm (15.22 day), and 50 ppm SA (12.25 day) while the shortest shelf life (9.27 day) was observed in control.

Table 6 Effect of different concentrations of salicylic acid on pulp PH of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Pulp PH					
	Initial	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
Control	4.6	5.18[a]	5.77[a]	6.25[a]	-	-
50 ppm SA	4.6	5.06[a]	5.47[b]	5.85[b]	6.95[a]	-
100 ppm SA	4.6	4.84[b]	5.25[c]	5.57[c]	6.67[b]	6.85[a]
150 ppm SA	4.6	4.77[b]	4.97[d]	5.35[c]	6.05[c]	6.27[b]
200 ppm SA	4.6	4.75[b]	4.85[d]	5.32[c]	5.85[c]	6.00[b]
Grand mean	4.6	4.92	5.26	5.67	6.38	6.37
CV%	-	2.1	2.3	3.2	2.6	2.8
SEM (±)	-	0.05	0.06	0.08	0.08	0.08
LSD	-	0.15	0.18	0.26	0.25	0.28
F-value	-	***	***	***	***	***

Notes: Treatment means in a column with same letters are not significantly different (p=0.05) according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS= Days after Storage, * = significantly different at (p<0.05), ** = highly significant different at (*p*<0.01), *** = very significantly different at (*p*<0.001)

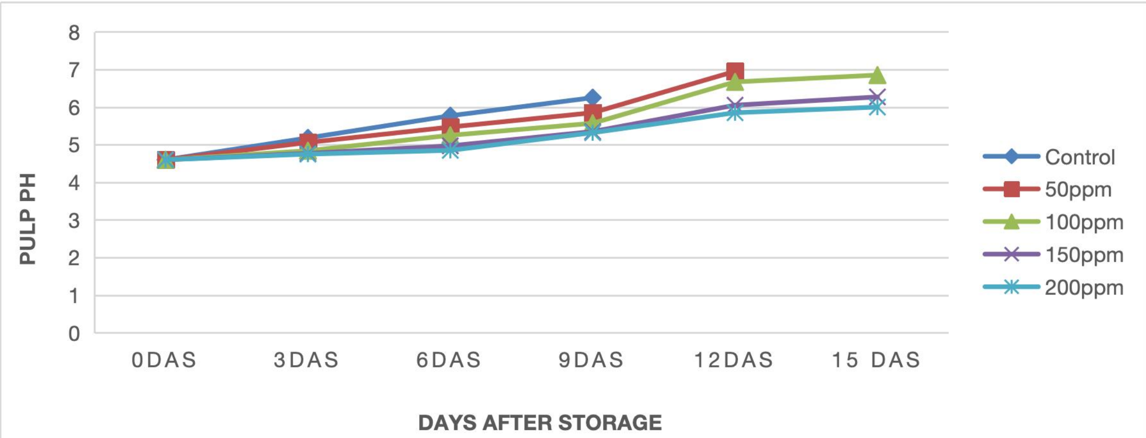

Figure 6 Post-harvest treatments of salicylic acid on pulp PH of mango

Table 7 Effect of different concentrations of salicylic acid on the shelf life of mango (*Mangifera indica* L.cv. Bombay green) in Bardibas, Mahottari, 2023

Treatments	Shelf life
Control	9.27[c]
50 ppm SA	12.25[b]
100 ppm SA	15.22[a]
150 ppm SA	15.35[a]
200 ppm SA	15.71[a]
Grand mean	13.56
CV%	9.3
SEM (±)	0.62
LSD	1.89
F-value	<0.001***

Notes: Treatment means in a column with same letters are not significantly different according to DMRT at 5% level of significance, CV = Coefficient of Variation, LSD = Least Significant Difference, SEM (±) = Standard Errors of Means, DAS=Days after Storage, * = significantly different at (*p*<0.05), ** = highly significant different at (*p*<0.01), *** = very significantly different at (*p*<0.001)

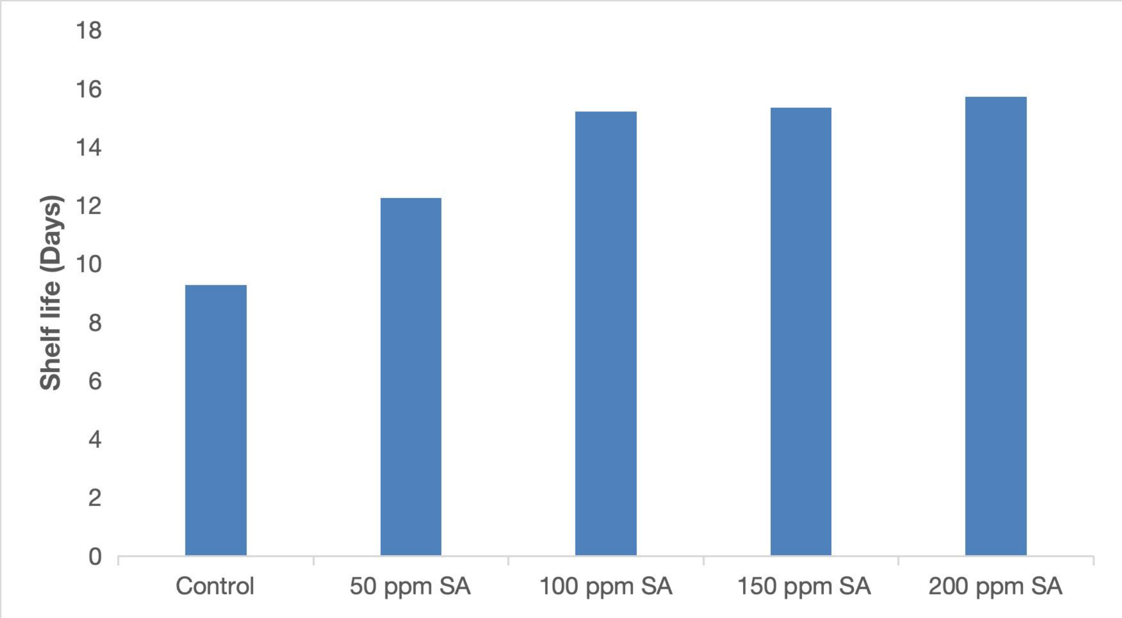

Figure 7 Salicylic acid effect on shelf life of mango

3 Discussion

Salicylic acid resulted in delaying the rate of respiration by inhibiting CO_2 production, decreasing the permeability of tissue thereby reducing the rate of water loss in the form of evaporation. Salicylic acid reduced weight loss by reducing metabolic, and enzymatic activities (Islam, 2001). Salicylic acid decreased the rate of fruit softening as it delays the progress of some components of the ripening of fruit, preventing some changes as triggered by ethylene. The total soluble solids (TSS) of mango fruits had increased gradually upto certain period and then decreased progressively with increase in storage period.

However, in the fruits treated with SA (150 ppm and 200 ppm), the TSS has showed a continual increasing trend towards the end of storage life. The higher retention of total soluble solids in the treated mango fruits might be due to delayed ripening process caused by suppressed ethylene production. The higher acidity in pulp provides the better keeping and storage quality, thus it is a desirable character The reduction in acidity during storage after attainment of maturity and ripening might be due to the utilization of organic acids as a substrate for respiration next to the sugars. Titratable acidity abated with the advancement in storage period. The abating trend was rapid from the initial to 6th day and, thereafter, it was slower. Similar findings have also been reported by Reddy and Sharma (2016). The fruits treated SA @ 200 ppm retained higher TA compared to other treatments or untreated mangoes, which might be due to delayed ripening and senescence processes resulting in the reduction of acid oxidation. The conversion of organic acids into sugar and their utilization in the respiration process leads to a decrease in organic acids which ultimately leads to a decline in titratable acidity. A decrease in titratable acidity was observed in the present investigation.

The maximum TSS: TA ratio was obtained in fruits treated with 200 ppm of salicylic acid which is due to the fruit degradation because of the hydrolysis of starch into soluble sugars and accumulation of these sugars in the fruits. Salicylic acid extends storage life by decreasing ethylene biosynthesis, respiration, and transpiration, as well as water loss and decays infection through stomatal closure of the fruit surface, preserving firmness, and delaying the Senescence stage by preventing polyphenol oxidase activity (Abdel Salam et al., 2022).

4 Concluding Remarks

According to this research, it has been found that physicochemical properties like physiological loss in weight, total soluble solids, pulp pH, and TSS: TA ratio were rapidly increased while titratable acidity and fruit firmness were decreased faster in control fruits compared to treated fruits. According to this study, it was observed that the shelf life of mango can be extended with different concentrations of salicylic acid as it delays senescence, retarded ethylene production which leads to a slowdown of the ripening process, increase the shelf life of fruits from 9.27 to 15.71 days. Salicylic acid at 200 ppm showed better results in delaying the change in the post- harvest quality and prolonging the shelf life of mango. Further research on the effects of salicylic acid under different temperature and humidity conditions, or it's potential in commercial applications, could be considered.

Authors' contributions

SS conceptualized and methodologized the study, formally analyzed data, investigated, curated data, wrote the original draft, and visualized. AC formally analyzed data, investigated, resourced, wrote (reviewed and edited), and visualized. PA investigated, resourced, wrote (reviewed and edited), and visualized. NB investigated, resourced, wrote (reviewed and edited), and visualized. SA investigated, resourced, wrote (reviewed and edited), and visualized. All authors read and approved the final manuscript.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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