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Effect of Pre-harvest Salicylic Acid Spray on Shelf Life and Biochemical Changes of Litchi during Storage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

An experiment was conducted on litchi cv. China at Horticulture garden in the Department of Horticulture (Fruit and Fruit Technology), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, to show the shelf life and biochemical changes of litchi during storage. The experiment was laid out in randomized block design with five treatments and four replications. Salicylic acid was sprayed twice i.e. 15 days and 30 days before anticipated harvesting time with different concentrations of salicylic acid (T_1- 50 ppm, T_2-100 ppm, T_3-150 ppm, T_4-200 ppm and T_5-control). Different concentrations have different effect on shelf life and biochemical parameters. Salicylic acid with T_3-150 ppm has increased TSS (20.02 ^{0}Brix), total sugar (13.10%), ascorbic acid (38.21 mg/100 g pulp), anthocyanin (8.06 mg/100g pulp) and shelf life (4 days) on the 6th day of storage at ambient condition.

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Keywords: Litchi; salicylic acid; biochemical parameters; shelf life.

1. INTRODUCTION

As India has such a diverse climate, it is ideal for cultivation of different varieties of litchi. Litchi (*Litchi chinensis* Sonn.) belongs to sapindaceae family. It is native of Southern China. Its chromosome no. 2n=30 and type of fruit is one seeded nut and its edible part is fleshy aril. It is highly cross pollinated crop. Its name is derived from Chinese word "lee chee" which means "one who gives the pleasure of life". It is grown in tropical and sub tropical regions. Due to its bright red peel colour and pleasant flavoured juicy aril this fruit is highly valued in national and international markets. Litchi fruit is very much liked as a table fruit as well as in dried and canned forms. Jam, jelly, squash and cordial are also prepared from this fruit. It is very nutritious and good source of vitamin C (64 mg/100 g pulp). It also contains vitamin E, B complex and trace amount of protein (0.7%), fat (0.3%) and minerals like phosphorous, calcium and iron. It is non climacteric type fruit; it does not ripe after harvesting from plants so it is harvested at ripe stage. Litchi is grown in different countries like China, West Indies, Myanmar, Japan, South Africa, Florida, Hawaii, etc. in the world; India is one among them. China is first and India is second largest producer of litchi fruits in the world. Litchi is very perishable in nature and it has very short shelf life. Litchi being non climacteric in nature it is harvested at ripe stage. Generally, the harvest maturity of the fruit is judged by the development of red colour on epicarp and flattened of the tubercles. After harvesting, the fruit turn brown within a couple of days due to loss of water from the pericarp. Panwar et al. [1] reported that salicylic acid decreases respiration rate by the closure of stomata. Salicylic acid (SA) is a natural plant hormone and it acts as signaling molecule. It makes the plants resistance against biotic and abiotic stress [2]. SA helps in plant growth, ion uptake and nutrient transport in plants. It is phenolic compound, and in plants it provides systemic resistance to fungal pathogens [3]. "Pre harvest application of various chemicals have been reported to enhance the shelf life of fruits by reducing physiological loss in weight and decay losses during storage" [4].

2. MATERIALS AND METHODS

The present investigation was carried out at the Horticulture Garden under the Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur during the year of 2021-2022 with a view to study the pre-harvest application of salicylic acid on shelf life and biochemical changes in litchi during storage. Variety used for this experiment was "China". The experiment was laid out with five treatments (T_1-50 ppm SA, T_2- 100 ppm SA, T_3- 150 ppm SA, T_4- 200 ppm SA and T_5- control) and four replications in randomized block design. Bihar Agricultural College Sabour is situated 25°50' N latitude and 87°19' E longitude at an altitude of 52.73 m above mean sea level. It has an average annual rainfall of 1348 mm precipitating mostly in between middle of June to middle of October.

Biochemical parameters namely titrable acidity (%) was calculated by the given titration method [5], ascorbic acidity (mg/100 g pulp) was estimated by using 2-6-dichlorophenol indophenols dye method [6], TSS (^{o}Brix) was recorded with the help of digital hand refractometer, TSS: Acid ratio was calculated by dividing TSS with titrable acidity, total sugar (%) was estimate by Lane and Eyon [7] copper titration method, anthocyanin (mg/100 g pulp) was calculated by peel pH- differential method [8] using two different buffer systems: potassium chloride buffer (0.025 M, pH 1.0) and sodium acetate buffer (0.4 M, pH 4.5), antioxidant (μ mol Trolox Eq. /g pulp) was determined by cupric reducing antioxidant capacity (CUPRAC) method [9].

2.1 Statistical Analysis

The experiment was laid out in RBD. Statistical analysis was performed in two way factorial RBD method. Least significant difference was calculated following significant F-test ($p \leq 0.05$). Effect of different treatments on various parameters and their interactions were assessed with ANOVA. Standard errors were computed by MS-Excel. This RBD design was adopted as suggested by Panse and Sukhatme [10].

3. RESULTS AND DISCUSSION

3.1 Total Soluble Solids (^{o}Brix)

Maximum (20.99 ^{0}Brix) TSS was in T_3-150 ppm while minimum (10.20) in T_5- control. It was found that untreated (control) 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. The rapid and higher TSS in control fruits might be due to faster ripening associated with the hydrolysis of starch into simple sugars. The delayed increase of TSS in SA treated fruits might be due to inhibition of ethylene biosynthesis. A delayed increase in TSS of SA treated fruits was reported in kiwifruit [11], peach [12] and persimmon [13].

3.2 Total Sugar (%)

Total sugar increased with increase in storage period. Among all the treatments fruits treated with T_3-150 ppm salicylic acid recorded highest (18.90 %) sugar as compared to other treatments, while lowest (9.30 %) in control. “The increase in total sugars of fruits with SA may be due to loss of water from the fruits and conversion of polysaccharides and pectic substances in sugars. The higher rate of acceleration in SA treated fruits may be due to retardation in the rate of normal changes of polysaccharides to total sugars because of its low rate of respiration and oxidation in treated fruits” reported by Roe and Brummer [14] and Yuvraj et al. [15] in mango fruits.

3.3 Titrable Acidity (%)

The highest (0.569 %) titrable acidity was observed in treatment T_5-control whereas lowest (0.255 %) in T_3-150 ppm. A continual decrease in titrable acidity was noticed during storage at ambient conditions. SA treated fruits shown a significant slower decline over the untreated fruits. The reduction in acidity during storage after attainment of maturity and ripening may be due to utilization of organic acids as a substrate [16]. Similar results of greater titrable acidity in mango fruits were also reported by Barman [17].

3.4 Ascorbic Acid (mg/100 g pulp)

Highest (10.10 mg/100g pulp) ascorbic acid was in treatment T_{3}-150 ppm salicylic acid whereas lowest in T_5-control. Ascorbic acid was decreased with advancement of storage period. “It was revealed that decrease in ascorbic acid was significantly higher throughout the storage period in the fruits treated with SA compared to untreated ones. It could be possible due to retardation of oxidation process and slow rate of conversion of L-ascorbic acid into dehydroascorbic acid (DHA) by ascorbic acid oxidase. DHA concentration was maintained at higher levels in salicylic acid treated fruits than in controls, leading to higher concentration in ascorbic acid throughout the storage period” [18].

3.5 Anthocyanin (mg/100 g pulp)

Highest (8.06 mg/100 g pulp) anthocyanin was found in treatment T_4-200 ppm salicylic acid treated fruits whereas lowest (1.50 mg/100 g pulp) was found in untreated fruits. “SA maintained fruit colour by retarding the degradation of chlorophyll that declined skin colour changes throughout the storage and retarding senescence rate in table grapes” [19]. Similar results were recorded by Ullah and Jawandha [20], SA showed a slow rate of conversion from green to yellow and chlorophyll degradation in peach fruits.

3.6 PLW (Physiological Loss in Weight) (%)

The lowest (13.97%) physiological loss in weight was observed in treatment T_4-200 ppm while highest (19.21%) was in T_5-control. The higher PLW in untreated fruits might be due to active metabolism such as respiration and transpiration, which might have led to greater loss of water during storage in ‘Amrapali’ mango fruits [21]. SA is an electron donor produces free radicals which prevent normal respiration thus leading to lower weight loss [22]. The lower PLW per cent in SA treated fruits is due to reduced respiration, transpiration and ethylene production [23].

3.7 Spoilage (%)

“Fruits treated with different concentrations of SA significantly lowered decay incidence than control. Highest decay (48.02 %) was in T_5-control whereas lowest (17.20%) in T_3-150 ppm SA treated fruits. Salicylic acid helped in enhancement of expression of genes that control the production of phenolic compounds by activating the phenylalanine ammonialyase enzyme, increases resistance to infection” [24]. “Dipping of pear fruit in the SA solution, effectively controlled fruit decay during 5 months of cold storage” [25]. “SA application had a positive effect in reducing berry decay” [26].

3.8 Shelf Life (Days)

Different concentrations of SA have different effect on shelf life of litchi. Maximum (4 days) shelf life of litchi was observed in T_3-150 ppm concentration over control. This enhancement effect on shelf life period might be due to the role of SA reducing physiological weight loss of fruits, the activity of oxidative enzymes and retarding fruit softening. Also, SA increased phenolic compounds and enhanced resistant against pest and diseases. These results are same as those of Perez-Vicente et al. [27] who reported that, “exogenous polyamines applications delayed color changes, reduced mechanical damage, chilling injury susceptibility and increase shelf life in both climacteric and non-climacteric fruits”. “The maximum shelf life in SA treated fruits might be due to its ability to serve as a physical barrier around the fruit which reduce transpiration and respiration activity along with delay in ethylene production. The positive effect of SA on storage life could probably be due to the modifying the atmosphere. The modified atmosphere created could, therefore, delay the ripening by delaying ethylene production and by reducing the level of internal oxygen and consequently prolonging the storage life of fruit” [28].

Table 1. Effect of pre harvest spray of salicylic acid on TSS (°Brix) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	19.21	19.31	19.88	18.61	19.25
T_2-SA100 ppm	19.56	19.68	20.16	20.00	19.85
T_3-150 ppm	20.02	20.16	20.78	20.99	20.49
T_4-200 ppm	19.85	19.98	20.69	20.64	20.29
T_5-Control	18.75	18.86	16.11	10.20	15.98
Mean	19.49	19.60	19.52	18.09	19.17
CD(p≤0.05)	T				0.50
	D				0.45
	T*D				0.99
CV (%)					7.35

Table 2. Effect of pre harvest spray of salicylic acid on total sugar (%) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	11.66	12.92	13.59	17.98	14.03
T_2-SA100 ppm	12.75	13.36	14.72	18.06	14.72
T_3- SA150 ppm	13.10	14.46	16.01	18.90	15.62
T_4- SA 200 ppm	12.86	13.85	15.26	18.10	15.02
T_5-Control	10.84	11.91	10.22	9.30	10.57
Mean	12.24	13.30	13.96	16.47	13.99
CD(p≤0.05)	T				0.26
	D				0.24
	T*D				0.53
CV (%)					5.34

Table 3. Effect of pre harvest spray of salicylic acid on Titrable acidity (%) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	0.605	0.533	0.449	0.317	0.476
T_2-SA100 ppm	0.580	0.512	0.435	0.310	0.459
T_3-150 ppm	0.440	0.428	0.324	0.255	0.362
T_4-200 ppm	0.520	0.493	0.356	0.312	0.420
T_5-Control	0.760	0.682	0.568	0.569	0.645
Mean	0.581	0.530	0.427	0.352	0.472
CD (p≤0.05)	T				0.011
	D				0.010
	T*D				0.022
CV (%)					6.70

Table 4. Effect of pre harvest spray of salicylic acid on Ascorbic Acid (mg/100 g pulp) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	34.86	27.26	22.51	8.44	23.27
T_2-SA100 ppm	35.44	28.55	22.91	8.73	23.91
T_3-150 ppm	38.21	31.90	24.52	10.10	26.18
T_4-200 ppm	36.15	30.16	23.30	8.81	24.61
T_5-Control	33.01	26.00	19.00	0.00	19.50
Mean	35.54	28.77	22.45	7.22	23.49
CD ($p \le 0.05$)	T				0.50
	D				0.45
	TxD				1.00
CV (%)					6.07

Table 5. Effect of pre harvest spray of salicylic acid on anthocyanin of peel (mg/100 g pulp) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	19.54	18.74	14.61	6.76	14.91
T_2-SA100 ppm	19.96	18.93	14.70	7.66	15.31
T_3- SA150 ppm	20.88	19.66	15.11	8.06	15.92
T_4- SA 200 ppm	21.54	20.33	16.07	7.75	16.42
T_5-Control	18.72	16.58	6.07	1.50	10.72
Mean	20.12	18.85	13.31	6.35	14.66
CD ($p \le 0.05$)	T				0.30
	D				0.26
	TxD				0.59
CV (%)					5.70

Table 6. Effect of pre harvest spray of salicylic acid on PLW (%) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	-	5.35 (21.41)	10.70 (42.81)	15.52 (62.08)	10.53
T_2-SA100 ppm	-	4.99 (19.95)	10.35 (41.40)	14.07 (56.26)	9.80
T_3- SA150 ppm	-	4.42(17.67)	9.80 (39.18)	14.29 (57.16)	9.50
T_4- SA 200 ppm	-	4.10 (16.40)	9.64 (38.57)	13.97 (55.86)	9.24
T_5-Control	-	7.92 (31.67)	13.85 (55.40)	19.21 (76.84)	13.66
Mean	-	5.36	10.87	15.41	10.54
CD($p \le 0.05$)	T				0.26
	D				0.24
	TxD				0.53
CV (%)					7.06

Table 7. Effect of pre harvest spray of salicylic acid on Spoilage (%) during storage at ambient condition

Treatment	Days of observation				
	Day 0	**Day 2**	**Day 4**	**Day 6**	**Mean**
T_1-SA 50 ppm	-	-	18.43 (73.72)	29.16 (116.64)	23.80
T_2-SA100 ppm	-	-	17.20 (68.81)	24.72 (98.90)	20.96
T_3- SA150 ppm	-	-	14.47 (57.90)	17.20 (68.81)	15.84
T_4- SA 200 ppm	-	-	15.17 (60.68)	21.76 (87.04)	18.46
T_5-Control	-	-	45.72 (182.87)	48.02 (192.07)	46.87
Mean	-	-	22.20	28.17	25.19
CD($p \le 0.05$)	T				0.44
	D				0.28
	TxD				0.62
CV (%)					3.49

Table 8. Effect of pre harvest spray of salicylic acid on shelf life (days) during storage at ambient condition

Treatment	Shelf life enhanced	Shelf life extended over control
T_1-SA 50 ppm	4	2
T_2-SA100 ppm	4	2
T_3- SA150 ppm	6	4
T_4- SA 200 ppm	4	2
T_5-Control	2	-

4. CONCLUSION

From the above findings it may be concluded that pre-harvest spray of salicylic acid on litchi plant can enhance the shelf life and biochemical properties of fruits. Spray of salicylic acid T_3-150 ppm concentration was found superior in biochemical parameters and shelf life during storage at ambient condition. Biochemical parameters such as total soluble solids, total sugar, titrable acidity, ascorbic acid, anthocyanin and shelf life, physiological loss in weight (PLW) and spoilage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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