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Postharvest Salicylic Acid Treatment Affects Weight Loss, Spoilage and Biochemical Attributes of Bartlett Pear Fruits

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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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ABSTRACT

The present study aimed to determine the effect of postharvest salicylic acid (SA) treatments on storability and biochemical quality of Bartlett pear fruits at ambient storage conditions. Freshly harvested fruits were treated with salicylic acid solution at 0 (control), 0.5, 1 or 2 mM and fruits were stored at ambient conditions (room temperature) for 21 days storage studies. Data on physiological loss in weight (PLW), fruit spoilage and biochemical quality of fruits (total soluble soils, titratable acidity, ascorbic acid, reducing and total sugars) were recorded. Results revealed that the salicylic acid treatments significantly minimized the PLW and fruit spoilage. At 21 days of storage at ambient conditions, the lowest PLW (13.76 %) and fruit spoilage (21.70 %) was noted with SA at 2 mM. All three SA treatments effectively retained the biochemical attributes of fruits i.e. total soluble soils, titratable acidity, ascorbic acid, reducing and total sugars as compared to control fruits. In conclusion, Salicylic acid at 2 mM treatment to the Bartlett pear fruits after harvest can be useful in minimizing the PLW and fruit spoilage and also maintaining the biochemical quality of fruits during ambient storage conditions.

Keywords: Ambient storage; bartlett; fruit quality; salicylic acid; pear; Pyrus spp.; storability.

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1. INTRODUCTION

Pears (*Pyrus* spp.; family Rosaceae sub family Pomoideae) are typical temperate fruit having its origin and domestication at two different regions i.e. China and Asia Minor extending to the Middle East [1-2]. Pears fruits extensively consumed as table fruit and they are less commonly processed than apples due to their lower acid content although, some pears cultivars are canned, chopped and processed into titbits, fruit mixes and puree. The Bartlett pear is the most often canned and also used for drying.

Among cultivated species, European pear (*Pyrus communis* L.) and Asian pear (*Pyrus pyrifolia* L.) are commercially significant and widely cultivated across the world where suitable climatic conditions prevail. European pears are commercially grown in temperate climate while Asian pears are more common in sub-temperate and mild subtropical regions [2]. According to FAO [3], around 23.9 million tonnes of pears are produced worldwide; China is the largest producer, having more than twice as much as the rest of the world combined pear production [3]. Other major pear growing countries are Argentina, Turkey, Italy, South Africa, the Netherlands, Belgium, and Spain. India ranks the tenth-largest producer of pears worldwide [3]. In India, pears are the second most significant temperate fruit crop after apples and are grown several parts of India, from the warm, humid subtropical plains to the cold, dry temperate regions. The bulk of pears grown in India are produced in the temperate areas of the country's northern states/UT of Jammu and Kashmir, Himachal Pradesh and some other subtropical regions such as Punjab and Tamil Nadu.

The fruit maturation level at the time of harvest influences both storability and fruit quality upon eating [4,5]. Pear is a climacteric fruit [6], showing rapid ripening after harvest that shortens their storage life [7]. Mechanical damage during harvest and postharvest handling, physiological degradation, water loss, and microbial spoilage rapidly reduce fruit quality, resulting in significant post-harvest losses of fruits [8]. In Kashmir valley, the Bartlett fruits are harvested in the months of August, when the temperature is rather hot, and so there are limitations in long distance transport and storage for an extended period of time under ambient circumstances. Common approach of low temperature storage (0-4°C) of Bartlett fruits for minimizing postharvest losses, yet, due to the scarcity of cool chain transportation and cold storage facilities, assuring adequate temperature control and storage after harvest is not always possible in the countries with poor postharvest logistic infrastructures.

The use of synthetic pesticides is primarily used in postharvest treatments to reduce postharvest losses and retain fruit quality during storage. Due to the detrimental effects of pesticides on both human health and the environment, the search for better fungicide alternatives led to the application of natural ingredients to improve storability and postharvest quality preservation. Salicylic acid has recently piqued the interest of researchers because it influences a variety of plant responses to biotic and abiotic stressors [9-11]. Salicylic acid activity has been connected to plant development, flowering, thermogenesis and senescence [12,13]. It affects fruit quality, some enzyme activity, and membrane permeability [14]. Endogenous salicylic acid levels and disease-prevention mechanisms in plants are well reported [15,16].

Previous studies on role of salicylic acid in fruits postharvest management showed positive effects on fruit's storage ability and quality preservation. Salicylic acid has the potential to be used for reducing freezing damage, delay, and increase antioxidant capacity in fruits to promote their health benefits [17]. It has been used to improve fruit quality, shelf life and storage in a variety of fruit crops like banana [18], kiwi [19], peach [20-23], strawberry [24,25], apple [26] and sweet cherry [27]. In Huang Kum pear fruit, Salicylic acid treatment at lower concentrations delays the senescence of fruits [28]. According to Bagheri et al. [29], Sebri pear fruits treated with SA (4 and 8 mM) and stored at 0.5°C and 85 % relative humidity exhibited reduced decay and maintained fruit firmness. To our knowledge, no research work on postharvest application of salicylic acid on Bartlett pears available worldwide, hence, keeping in view the above facts, the present investigation sought to determine the effect of postharvest SA treatment of European pear cv. Bartlett fruits on storability and fruit quality under ambient environments.

2. MATERIALS AND METHODS

The present experiment was carried out at Division of Horticulture, FOA (SKUAST-Kashmir) Wadura Campus, Sopore J&K (India) during 2017 & 2018. Salicylic acid at 0 (control), 0.5, 1 and 2 mM were used for postharvest treatment of pear cv. Bartlett fruits. Each treatment was repeated five times in the experiment, which was set up using a Complete Randomized Design. Individually selected fruit with their consistent size and colour were handpicked at maturity from a single tree and they were transported right away to the laboratory where they were held for 30 minutes to remove field heat under ambient conditions. For the salicylic acid treatments, 40 uniform-sized fruits were used in each treatment. For the initial data collection on the physio-chemical characteristics of untreated fruits, a different batch of 10 fruits was also utilized. For additional storage studies, treated fruits were stored under ambient temperatures. Fruits were examined for physiological loss in weight (PLW), fruit spoilage and fruit biochemical quality attributes (total soluble solids, titratable acidity, ascorbic acid, reducing sugars and non-reducing sugars) at 7, 14, and 21 days of storage.

The percent physiological loss in weight (PLW) was calculated by deducting the final weight from the initial weight of stored fruits, then dividing by the initial weight using the following equation:

PLW (%) = [(Initial weight – Final weight) × 100] / Initial weight

The percentages of fruits that were spoiled was determined were calculated by subtracting the number of rotten fruits from the total number of fruits stored and dividing by the total number of fruits stored using following equation:

Spoilage (%) = [(No. of stores fruits – No. of decay fruits) × 100] / Total no. of stored fruits

The total soluble solid (TSS) was estimated with help of Hand Refractometer (Erma, Japan). Titratable acidity was determined using phenolphthalein as an indicator, ascorbic acid with 2,6-dichlorophenol indophenol indicator, and Fehling's solutions were used for sugars (total and reducing sugars) determination [30].

The Randomized Complete Block Design methodological approach was used to analyse the data as per standard procedure given by Panse and Sukhatme [31]. Critical differences (CD) were used to evaluate the significance of the difference in treatment means at a 5% level of significance.

3. RESULTS AND DISCUSSION

Data revealed that PLW in pear cv. Bartlett was increased with increase in storage duration and noted the highest in un-treated fruit at all three dates i.e. 7, 14 and 21 days of storage. (Fig. 1). PLW noted at 7 days of storage was unaffected by salicylic acid application but at 14 and 21 days of storage, it was significantly lower in treated fruit compared to control (Fig. 1). Salicylic acid 2 mM exhibited the lowest PLW of 9.77 and 13.76 % at 14 and 21 days storage, respectively. PLW in fruits due to other SA treatment were also significantly lower than control. Fruit weight decreased physiologically as a result of moisture loss from fruits and the breakdown of the soluble solids that took place during fruit storage. By regulating cell wall deterioration and delaying ethylene production, respectively, salicylic acid has the ability to reduce transpiration and respiration [18]. Salicylic acid also has ability to block stomatal responses, which decreases transpiration and, in turn, weight loss [32]. Salicylic acid reduces ethylene levels during storage to stop softening and weight loss. Our findings are in agreement with those of Mahsa et al. [33], who reported that salicylic acid inhibited weight loss in strawberry. Salicylic acid application in apple [26] and Huang Kum pear [34] also resulted in a significant decrease in weight loss in fruit under low temperature storage conditions.

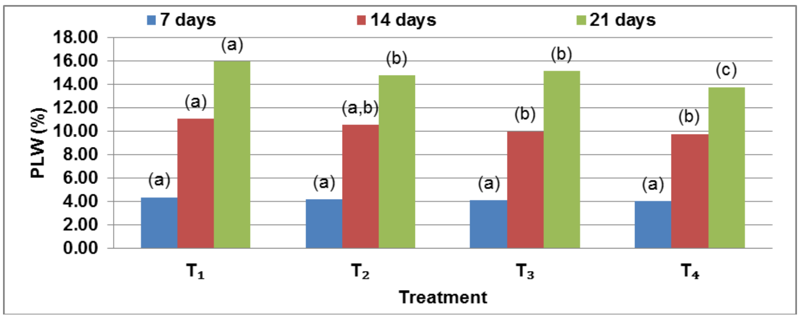

Fig. 1. Physiological Loss in Weight (PLW) of pear cv. Bartlett fruits as affected by postharvest application of salicylic acid. Salicylic acid concentration:- T_1: 0 mM (control), T_2: 0.5, T_3: 1.0 mM T_4: 2.0 mM. Bars with different letters at same days of storage differ significantly.

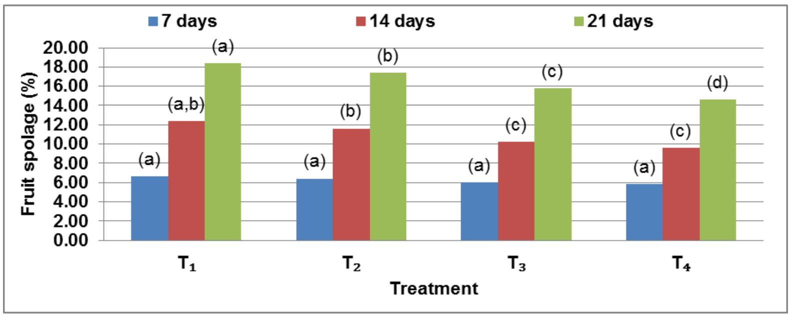

Fig. 2. Fruit spoilage (%) of pear cv. Bartlett fruits as affected by postharvest application of salicylic acid treatments. Salicylic acid concentration:- T_1: 0 mM (control), T_2: 0.5, T_3: 1.0 mM T_4: 2.0 mM. Bars with diffèrent letters at same days of storage differ significantly.

Fruit spoilage was observed to be increased with increase in storage duration and noted the highest untreated fruit at all three dates of observations (Fig. 2). At 7 days of storage, fruit spoilage was unaffected by salicylic acid application. At 14 and 21 days of storage, fruit spoilage was significantly lower in treated fruit compared to control (Fig. 1). Salicylic acid 2 mM provided the lowest PLW vales of 9.60 and 14.60 % at 14 and 21 days storage, respectively. Control fruit showed 18.40 % spoilage which was significantly highest compared to SA treatments. The salicylic acid's ability to induce the defense enzymes such as chitinase, POD, and PAL and reduce fungal and bacterial infections that lead to fruit rot may account for the lower rotting percentage in SA-treated fruits in our study [10,15]. according to Xu and Tian [35], salicylic acid activate the defense system by raising the activity of antioxidant enzymes, giving treated sweet cherry fruits higher resistance to fungal attack.

Fruit TSS at harvest ranged from 12.22 to 12.40 ^{0}Brix (Fig. 3). It increased with the progression of storage duration and rate of increase was higher in control fruits compared to salicylic acid treated fruits (Fig. 3). Results also indicated that all three salicylic acid doses had similar effects on TSS determined at 7 days of storage but 2 mM SA was superior to 0.5 mM at 14 and 21 days of storage study. At 21 days storage, the TSS with control, 0.5, 1 and 2 mM SA was 14.02, 13.77, 13.43 and 12.83 ^{o}Brix, respectively. The increased TSS value in control fruits might be attributed to a decrease in fruit water content and the conversion of cell wall components such as starch, protein, pectin, and hemicelluloses into simple soluble sugars during storage [40], results in increased value of fruit TSS. In Delicious apples, starch is hydrolyzed into mono and disaccharides that increase the soluble solid content [36]. Our results are in line with those of Sayyari et al. [17] and Salari et al. [37], who discovered that treatment with salicylic acid caused a noticeably slow increase in the total sugar content of pomegranate fruit during storage. Awad [22] claimed that the use of greater salicylic acid content caused the total sugar of Florida Prince Peaches to decrease under cold storage circumstances. Salicylic acid use has also been shown to decrease respiration, extending the increase in SSC content in bananas [18] and strawberries [25].

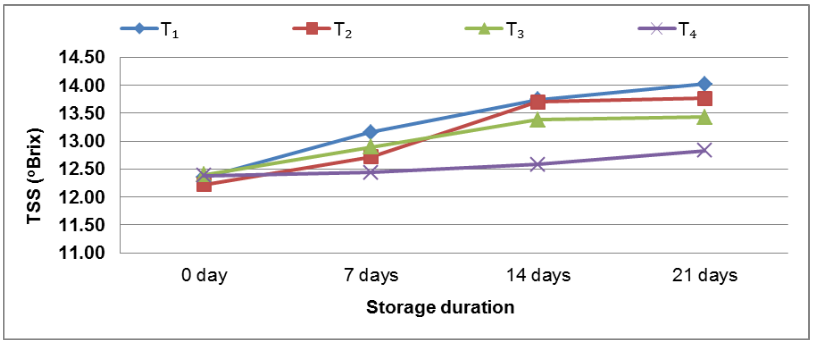

Fig. 3. Total soluble solids (TSS ^{o}Brix) of pear cv. Bartlett fruits as affected by postharvest application of salicylic acid. Salicylic acid concentration:- T_1: 0 mM (control), T_2: 0.5, T_3: 1.0 mM T_4: 2.0 mM

Table 1. Effect of postharvest application of salicylic acid on titratable acidity and ascorbic acid of pear cv. Bartlett fruits

Treatment	Titratable acidity (%)				Ascorbic acid (mg $100g^{-1}$)			
	0 day	7 days	14 days	21 days	0 days	7 days	14 days	21 days
T1-0.00 mM	0.409	0.359	0.290	0.253	3.30	2.48	2.39	2.16
T2-0.50 mM	0.405	0.372	0.318	0.279	3.26	2.50	2.46	2.24
T3-1.00 mM	0.405	0.367	0.348	0.298	3.31	2.64	2.51	2.34
T4-2.00 mM	0.403	0.379	0.347	0.302	3.30	2.70	2.56	2.39
SEd±	0.120	0.102	0.009	0.08	0.10	0.08	0.70	0.07
CD(0.05)	NS	0.240	0.201	0.18	NS	0.18	0.16	0.16

Table 2. Effect of postharvest application of salicylic acid on reducing sugars and total sugars of pear cv. Bartlett fruits

Treatment	Reducing sugars (%)				Total sugars (%)			
	0 days	7 days	14 days	21 days	0 day	7 day	14 days	21 days
T1-0.00 mM	4.77	5.42	5.92	6.14	7.91	8.47	9.16	9.90
T2-0.50 mM	4.77	5.32	5.55	5.86	7.94	8.19	8.59	9.37
T3-1.00 mM	4.79	5.21	5.53	5.66	8.06	8.21	8.51	9.20
T4-2.00 mM	4.78	5.09	5.27	5.44	8.00	8.13	8.29	9.06
SEd±	0.15	0.16	0.17	0.18	0.24	0.25	0.25	0.30
CD(0.05)	NS	NS	0.36	0.39	NS	NS	0.55	0.69

Titratable acidity in fruits at harvest ranged from 0.403 to 0.409 ^{0}Brix (Table 1). It decreased with the progression of storage duration and rate of decrease was slow in salicylic acid treated fruits compared to control (Table 1). At 7 day of storage, no significant different was found in fruit acidity due to salicylic acid treatment. At 14 and 21 days of storage, control fruits had significantly lowest acidity while SA treated fruits had higher values of acidity. The fruit acidity due to 1 and 2 mM salicylic acid treatments were statistically at par at both 14 and 21 days of storage (Table 1). The principal acid in pears is maleic acid, and during postharvest storage, organic acids are depleted during respiration. The reason that treated fruits have higher acidity values than control fruits may be due to the fact that fruits utilize acids during ripening and maturation; as a result, organic acids in fruits deteriorate during storage [22]. Salicylic acid helps decrease the rate of respiration and the conversion of acids into sugars while being stored because it prevents ethylene production [18]. Our results agree with those reported in the banana [18] and apple [27].

Fruit ascorbic acid content at harvest ranged from 3.26 to 3.31 mg 100 g^{-1} (Table 1). It decreased with the progression of storage duration and rate of decrease was higher in control fruits compared to salicylic acid treated fruits but salicylic acid treatment significantly minimized decrease of ascorbic acid in fruit (Table 1). at 7, 14 and 21 days of storage, Salicylic acid at 2 mM resulted the highest ascorbic acid content (59.42, 56.30 and 49.25 mg 100 g^{-1} at 7, 14 and 21 days of storage, respectively) however, it was statistically at par with 0.5 and 1 mM SA treatments, Control fruits had the lowest ascorbic acid concentration at all three study dates (Table 2). Awad et al. [22] found that as storage time increased, variations in fruit ascorbic acid content decreased fast. Salicylic acid post-harvest treatments have been demonstrated to be helpful in preserving fruit quality and prolonging strawberry storage life [38]. According to legend, salicylic acid treatment can effectively reduce ascorbic acid levels and stop ascorbic acid from evaporating during storage in pineapple [39].

Reducing sugar in fruit at harvest ranged from 4.77 to 4.89 % (Table 2). It increased with the progression of storage duration and rate of increase was higher in control than salicylic acid treated fruits (Table 2). At 7 days of storage, salicylic acid treatment didn't influenced the on reducing sugars in fruits but it had substantial impact later on 14 and 21 days on storage studies (Table 2). At 21 days of storage, the highest reducing sugars (6.14 %) in fruits was estimated in control fruits while in 0.5, 1 and 2 mM salicylic acid treated fruits, it was 5.86, 5.66 and 5.44 %, respectively (Table 2). Total sugars in fruit at harvest ranged from 7.91 to 8.06 % (Table 2). It increased with the progression of storage duration and rate of increase was higher in control than salicylic acid treated fruits (Table 2). The effect of salicylic acid significantly influenced the total sugars in fruits at 14 and 21 days of storage studies (Table 1). At 7, 14 and 21 days of storage, the highest total sugars 8.47, 9.16 and 9.90 %, respectively were observed in control fruits followed by salicylic acid treatment at 0.5 mM, 1 mM and 2 mM. At 21 days of storage, total sugars in fruits treated with 0.5, 1 and 2 mM salicylic acid were 9.37, 9.20 and 9.06 %, respectively, and the response of SA at 1 mM and 2 mM were at par (Table 2).

Salicylic acid slows respiration and the conversion of acid to sugar during storage because it prevents the synthesis of ethylene [40]. Fruits utilize their organic acids as they ripen and their levels drop while they are stored [41]. Our results are consistent with those in peach [23], strawberry [25] and apple [26].

4. CONCLUSION

Pears are a climacteric fruit with a short storage life due to their quick ripening after harvest. Significant postharvest losses of pear fruits occur due to weight loss, microbiological spoilage and deterioration of fruit's biochemical quality. Postharvest salicylic acid treatments of Bartlett pear fruit considerably reduced the PLW and fruit spoilage. After 21 days of ambient storage, SA at 2 mM showed the lowest PLW and fruit spoilage. All three SA treatments successfully preserved the biochemical quality of the Bartlett pear fruits. Hence, postharvest salicylic acid treatment of Bartlett pears fruits at 2 mM can help to reduce PLW and fruit spoilage while also maintaining the biochemical quality of the fruits under ambient storage conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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