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PRE-HARVEST TREATMENT WITH PUTRESCINE, SALICYLIC ACID AND CALCIUM CHLORIDE: A STRATEGY TO IMPROVE POSTHARVEST PHYSICAL QUALITY OF PLUM CV. SATLUJ PURPLE UNDER AMBIENT STORAGE

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ABSTRACT

The present experiment entitled pre-harvest treatment with putrescine, salicylic acid and calcium chloride: a strategy to improve postharvest physical quality of plum cv. Satluj Purple under ambient storage was performed at Horticulture Research Centre, Pattharchatta and Postharvest Laboratory of Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand during 2023 and 2024. The experiment was conducted in Factorial Randomized Block Design with three replications. Foliar application of three different chemicals viz. putrescine (1.0, 1.5, 2.0 and 2.5 mM/L), salicylic acid (1.0, 1.5, 2.0 and 2.5 mM/L) and calcium chloride (1.0, 1.5, 2.0 and 2.5%) with Tween-20 (0.01%) as a surfactant was applied approximately 2 week before the anticipated harvesting. Harvested fruits for quality attributes were observed on 0, 3, 6 and 9th day under ambient storage. Among all treatments 2.0 mM of putrescine was found superior, followed by 2.5 mM of salicylic acid with respect to minimum change in fruit physical quality attributes like fruit length, width, weight, per cent weight loss, per cent shrinkage and per cent decay.
***Keywords* :** Pre-harvest, Plum, Putrescine, Salicylic Acid, Calcium Chloride, Shrinkage, Decay.

Introduction

Plum is an important stone fruit, mostly grown in the temperate or cool subtropical regions of the world. The perishable nature of fruit with short postharvest life makes it vulnerable to bruising and damage during harvesting, transportation or handling. Damaged areas on the fruit surface provide an entry points for pathogens like bacteria and fungi, accelerating the decomposition process. Ethylene is the hormone which is responsible for triggering some physico-chemical changes associated with ripening, such as changes in colour, aroma, texture and flavour in climacteric fruits while in non-climacteric fruits, it has little or no effect on the ripening process (Giovannoni, 2001). After picking, ripening proceeds and fruit lose sensory quality attributes very quickly. Some strategies have been proposed to increase the shelf life of fruit, such as cold storage and treatments with heat, calcium, polyamines, salicylic acid, etc. (Luna-Guzman *et al.,* 1999).

Putrescine, a type of polyamine plays a significant role in regulating the quality of fruits and their post-harvest life. It is known to influence a range of biochemical and cellular functions that can affect fruit quality and its shelf life after harvest. In fruit crops application of putrescine may change cell wall stability by promoting the synthesis of proteins that stabilize cell membranes and protect them from damage by delaying this process (Messiaen *et al.,* 1997). Other beneficial effects, such as delayed colour changes, reduced mechanical damage, delay in senescence process, enhanced stress tolerance, modulation of ethylene production and chilling injury susceptibility with increased shelf life, have been reported for both climacteric and non-climacteric fruits (Serrano *et al.,* 1996). Similarly salicylic acid (SA) also shows a potential effectiveness in maintaining fruit quality and extension of shelf life by delaying fruit ripening and softening, decreasing decay and maintaining the flavour of fruit (Baswal *et al.,* 2020, Hazarika and Marak, 2022). According to Asghari and Aghdam (2010), salicylic acid is a safe and natural phenolic chemical, having a great potential to reduce postharvest losses in horticulture crops. Calcium is an essential plant nutrient closely related to quality and firmness of fruits (Sams, 1999), as the divalent cation (Ca^{2+}) is required for various structural roles in the cell wall and membranes. It acts as a counter-cation for inorganic and organic anions in the vacuole and an intracellular messenger in the cytosol (Marschner, 1995).

The maintenance of postharvest life with prevention of postharvest losses became critical for ensuring the quality, safety and sustainability of food supply chains. The reduction of postharvest losses not only helps in reducing wastages but also ensures that consumers have access to fresh and nutritious produce. Investment in efficient pre and postharvest management practices is crucial for both economic and environmental sustainability. Ample information regarding the postharvest application of these chemicals is available but very limited information for pre-harvest application and its effect on postharvest quality is available which is yet to be explored. Hence, the aim of the present study was to investigate the role of pre-harvest application of putrescine, salicylic acid and calcium chloride on postharvest physical quality of plum fruits (cv. Satluj Purple) under ambient storage condition.

Materials and Methods

Experimental site: The present experiment entitled pre-harvest treatment with putrescine, salicylic acid and calcium chloride: a strategy to improve postharvest physical quality of plum cv. Satluj Purple under ambient storage condition was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experimental site is situated in the *Tarai* region of Uttarakhand, where the soil classified as Mollisol".

Experimental material and details: Eighteen years old plum trees cv. Satluj Purple was selected having uniform size and vigour at Horticultural Research Centre Pattharchatta. The experiment was consisted of thirteen treatments including control with three replications. Pre-harvest application were sprayed with an aqueous solution containing different concentrations of putrescine (1.0, 1.5, 2.0 and 2.5 mM/L), salicylic acid (1.0, 1.5, 2.0 and 2.5 mM/L) and calcium chloride (1.0, 1.5, 2.0 and 2.5%) with Tween-20 (0.01%) as a surfactant, approximately 2 week before of the anticipated harvesting. Mature fruits harvested, which were free from visual symptoms of any disease or blemishes and transported to the post-harvest laboratory. After pre-cooling, diseased, blemished and irregular in size, shape or colour fruits were manually removed. The remaining samples were gently washed to eliminate surface contaminants, blotted dry with sterile muslin cloth and air-dried at room temperature under a ceiling fan. Finally, they were packed in polythene bags and stored under ambient conditions according to the treatment details and replications.

Observation recorded: Observations of fruit physical parameters like- fruit length, width, weight, per cent weight loss, per cent shrinkage and per cent decay were recorded on 0, 3, 6 and 9th day of ambient storage for both 2023 and 2024. The mean values for each parameter across both years are presented here.

Fruit length

Length of each fruit was measured with the help of vernier caliper and recorded at each storage interval in millimeters.

Fruit width

Width of each fruit was measured with the help of vernier caliper and recorded at each storage interval in millimeters.

Fruit weight

At each storage interval, fruit weight was measured using a digital weighing balance and recorded in grams.

Weight loss (%)

Per cent loss in weight was calculated at each storage interval as the cumulative reduction in fruit weight relative to the initial weight recorded before storage, using the following formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of fruits} - \text{Weight of fruits on the day of observation}}{\text{Initial weight of fruits}} \times 100$$

Shrinkage (%)

Shrinkage in fruit diameter was calculated at each storage interval as a cumulative reduction in diameter of fruits under various treatments based on the initial fruit diameter before storage.

$$\text{Shrinkage(\%)} = \frac{\text{Initial diameter of fruits} - \text{Diameter of fruits on the day of observation}}{\text{Initial diameter of fruits}} \times 100$$

Decay (%)

The number of fruits exhibiting visible signs of decay or rotting was counted separately for each treatment at every storage interval. The incidence of decay was expressed as a percentage of total fruits decayed.

$$\text{Decay (\%)} = \frac{\text{Number of decayed fruits}}{\text{Number of total fruits}} \times 100$$

Results and Discussion

Fruit length

Storage of climacteric fruit for prolongs storage period leads to reduction in size of any fruits, which occur naturally and hamper the consumer acceptance. The pre-harvest application of these treatments exhibited significant difference with respect to change in fruit length in both years (2023 and 2024) and their mean values are summarised in Table 1 and Figure 1. The results revealed significant difference among the treatments and storage interval. Fruit length significantly reduced from 40.87 mm to 35.98 mm, from initial day of observation to till last day of observation, indicating that reduction in length of fruit is a natural phenomenon while, storing the fruit in ambient storage. However, each treatment showed a different rate in fruit length reduction throughout the storage. The maximum reduction of length (17.12%) recorded with untreated fruit (T_{13}), followed by 13.98% in 1.5 mM of salicylic acid (T_6), however the minimum reduction of 7.11% was noted in 2.0 mM of putrescine (T_3) and followed by 8.24% in 2.5 mM of salicylic acid (T_8). The least reduction with pre-harvest application of putrescine application (2.0 mM) may be due to the role of putrescine in inhibiting the activity of cell wall degradation enzymes like pectin methylesterase and cellulase (Dibble *et al.*, 1988; Kramer *et al.,* 1991), which maintain the fruit firmness for longer time as well as the fruit length for longer period. Beside putrescine salicylic acid at higher concentration (2.5 mM) also showed effectiveness to retain the size to some extent. A phenolic phytohormone, which provides defence against various biotic and abiotic stresses (Peng *et al*., 2021; Meng *et al*., 2023) as well as exert an antagonistic role with ethylene, which leads to delayed senescence (Madhav *et al.,* 2021; Zhang *et al.,* 2021) and may show minimum reduction in fruit length. However, the least concentration of these chemical are not sufficient to maintain the fruit size. Similar supporting research was reported by in 'Angelino' plum, Serrano *et al*. (2003), Khan *et al.* (2008) and Davaryenjad *et al.* (2015) in plum and Archana *et al.* (2015) in banana cv. grand naine.

Fruit width

The data pertaining on effect of different foliar treatments and storage duration on width of plum (cv. Satluj Purple) fruits under ambient storage conditions presented in Table 1 and Figure 2. The observation regarding fruit width showed a significant difference among the different treatment. The minimum reduction of 7.58% was noted in 2.0 mM of putrescine (T_3), closely followed by 7.97% in 2.5 mM of salicylic acid (T_8). In contrast, maximum decrease in fruit width (20.54%) was recorded in control treatment (T_{13}) throughout the storage. The possible reason behind reduction in fruit width during storage is might be due to continuous ripening after harvest. Ethylene helps in activation of ripening-related genes as well as increases the respiration rate and accelerates transpiration. The minimal reduction in fruit width may be attributed to delay ripening with reduced respiration rate induced by the putrescine treatment (Khan and Ali, 2018). The probable reason behind this may be that both putrescine and ethylene share common biosynthesis precursor SAM (S-adenosyl methionine) and which impart inimical impact on ripening (Valero *et al*., 2002). After putrescine, salicylic acid also showed significantly maintained fruit width throughout the storage period. The probable reason behind this may be its potential role in maintain the cell integrity and reduced chilling injury symptoms though out the storage (Haider *et al.,* 2020). Our findings were allied with previous studied of Davaryenjad *et al.* (2015) in plum cv. Santa Rosa, Hussain *et al.* (2021) in loquat fruit as well as Amanullah *et al.* (2017) in guava fruits.

Table 1: Effect of different treatments and storage interval on length and width of plum (cv. Satluj Purple) fruits during ambient storage

Treatments (T)	Fruit length (mm)						Fruit width (mm)					
	Storage interval (D)						Storage interval (D)					
	D_0	D_3	D_6	D_9	Mean	% decrease	D_0	D_3	D_6	D_9	Mean	% decrease
T_1 (1.0 mM PUT)	40.82	39.42	37.80	36.02	**38.51**	**11.77**	40.58	39.31	37.40	35.60	**38.22**	**12.27**
T_2 (1.5 mM PUT)	41.03	39.60	37.99	36.16	**38.70**	**11.87**	40.89	39.67	37.93	36.06	**38.64**	**11.81**
T_3 (2.0 mM PUT)	41.91	41.21	40.20	38.93	**40.56**	**7.11**	42.34	41.62	40.41	39.13	**40.87**	**7.58**
T_4 (2.5 mM PUT)	40.96	39.76	38.22	36.11	**38.76**	**11.83**	41.34	39.93	38.09	36.44	**38.95**	**11.85**
T_5 (1.0 mM SA)	40.28	38.66	36.81	34.70	**37.61**	**13.85**	40.13	38.80	36.69	34.36	**37.50**	**14.38**

T_6 (1.5 mM SA)	40.23	38.32	36.44	34.61	**37.40**	**13.98**	40.21	38.62	36.57	34.03	**37.36**	**15.37**
T_7 (2.0 mM SA)	41.60	39.97	38.19	36.24	**39.00**	**12.88**	41.04	39.91	38.22	36.31	**38.87**	**11.53**
T_8 (2.5 mM SA)	41.57	40.67	39.67	38.15	**40.01**	**8.24**	41.76	40.83	39.35	38.43	**40.09**	**7.97**
T_9 (1.0% $CaCl_2$)	40.65	38.84	37.20	35.26	**37.99**	**13.25**	40.63	39.00	36.73	34.80	**37.79**	**14.35**
T_{10} (1.5% $CaCl_2$)	40.66	39.10	37.50	35.72	**38.24**	**12.16**	41.02	39.59	37.68	35.25	**38.39**	**14.07**
T_{11} (2.0% $CaCl_2$)	41.19	39.68	37.76	35.78	**38.60**	**13.14**	40.95	39.79	37.94	35.73	**38.60**	**12.75**
T_{12} (2.5% $CaCl_2$)	41.01	39.95	38.68	37.32	**39.24**	**9.00**	41.49	39.85	38.26	37.01	**39.15**	**10.80**
T_{13} (Control)	39.45	37.39	35.12	32.70	**36.17**	**17.12**	40.06	38.03	35.37	31.83	**36.32**	**20.54**
Mean	**40.87**	**39.43**	**37.81**	**35.98**			**40.96**	**39.61**	**37.74**	**35.77**		

Factors	**C.D. at 5%**	**SE(m)**	**Factors**	**C.D. at 5%**	**SE(m)**
Factor (T)	0.80	0.29	**Factor (T)**	0.50	0.18
Factor (D)	0.44	0.16	**Factor (D)**	0.28	0.10
Factor (T x D)	N/A	0.57	**Factor (T x D)**	1.01	0.36

Where, PUT= Putrescine, SA= Salicylic acid and $CaCl_2$= Calcium Chloride

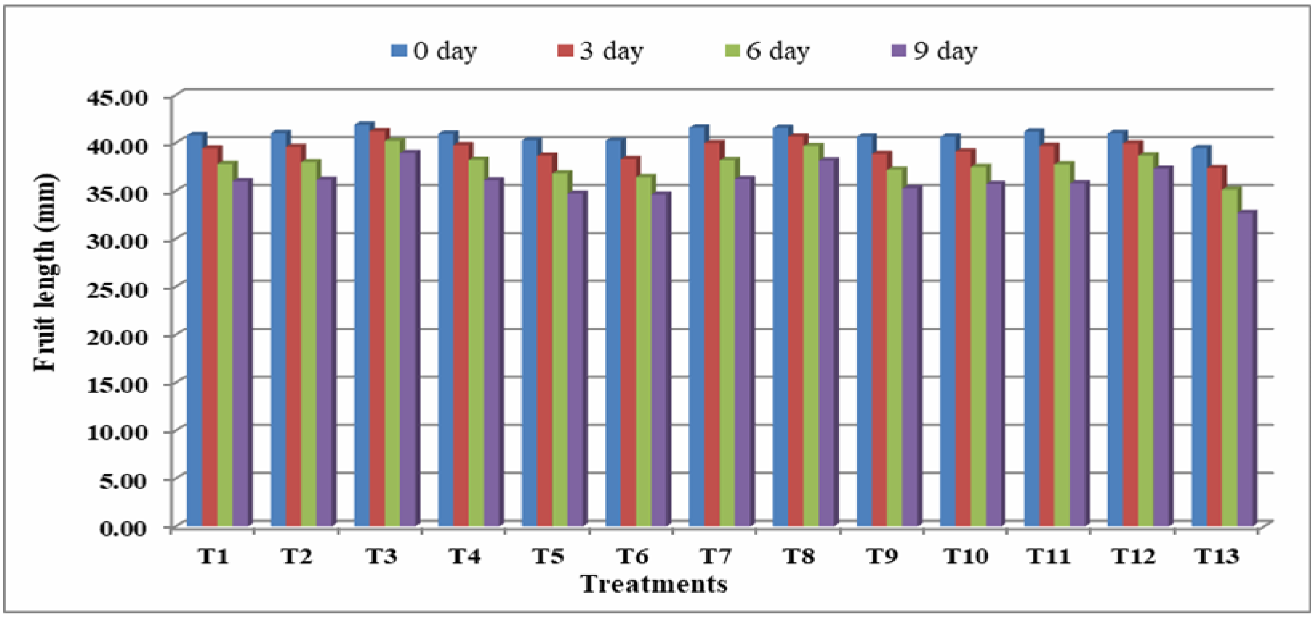

Fig. 1: Effect of different treatments and storage interval on length of plum (cv. Satluj Purple) fruits during ambient storage

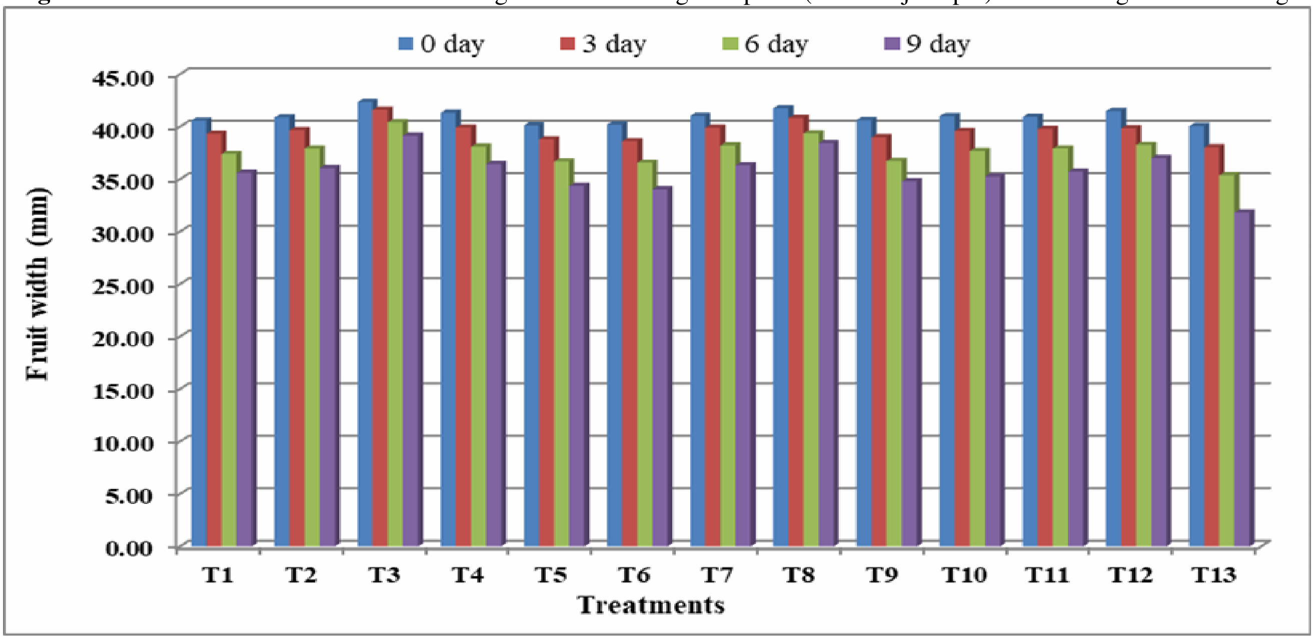

Fig. 2: Effect of different treatments and storage interval on width of plum (cv. Satluj Purple) fruits during ambient storage

Fruit weight

Effect of pre-harvest foliar spray of different treatments and storage interval on weight of plum (cv. Satluj Purple) fruits under ambient storage conditions showed significant difference and presented in Table 2 and Figure 3. Among different treatments, a maximum decrease in weight (24.55%) was noted in control, followed by 19.56% in T_5 (1.0 mM of salicylic acid). In contrast, minimum decrease of 9.41 and 10.83% was observed in T_3 (2.0 mM of putrescine) and T_8 (2.5 mM of salicylic acid), respectively. Escape of water through surface transpiration, ripening and respiration after harvest starts consuming stored sugars and degradation of cell membrane which leads to loss in fruit weight and resulted into withering, shrinkage and a reduction in fruit firmness (Chen *et al.,* 2024), which decreases the quality of fruits, their shelf life and marketing value as well as consumer acceptance (Shibairo *et al.,* 2002). Application of putrescine reported minimum loss in weight, might be due to reduced metabolic breakdowns with slow senescence related processes, which results into less conversion of stored compounds with minimum dry matter loss. Our findings are in agreement with the work reported by Hosseini *et al.* (2017) in pear cv. Spadona, Serrano *et al*. (2003) in plum, Anju *et al.* (2014) in mango, Archana *et al.* (2015) in banana, Tareen *et al.* (2012) in peach cv. Florida King and Awad (2013) in peach cv. Florida Prince. Martinez□Romero *et al.* (2002) also found that putrescine treated fruits showed minimum fruit weight loss than controls.

Weight loss

The observation regarding per cent loss in weight of plum (cv. Satluj Purple) fruits during ambient storage (Table 2 and Figure 4) showed that all treatment had a significant impact on the per cent loss in fruit weight. Among different treatments the untreated fruit showed maximum loss of fruit weight (25.36%) during storage period, when comparing with other treatment. However treatment T_3 (2.0 mM of putrescine) followed by T_8 (2.5 mM of salicylic acid) showed significantly lower weight loss i.e. 9.37 and 10.76% respectively. The acceleration driven by cellular breakdown of the plum fruits may be the reason for weight reduction throughout the storage period. Under the ambient storage, foliar application of putrescine at 2.0 mM significantly reduces the weight loss. Putrescine helps to maintain membrane integrity and reduces water loss via better control over cuticle and cell wall leakage and slows down the respiration process (Martinez-Romero *et al.,* 2002). Delayed ripening or aging processes with slow down ethylene production leads to delayed softening, delaying chlorophyll degradation, etc. with application of putrescine, keeps the fruit fresh for longer period. After putrescine, foliar application of salicylic acid also effectively reduced physiological weight loss, although lower concentrations of salicylic acid (1.0 and 1.5 mM) were less efficacious. This may be because higher concentrations of salicylic acid better reduce transpiration rates, which might be linked to decreased activity of hydrolytic cell-wall enzymes (Ilic *et al.,* 2001). Similar findings were noted by Kaur and Kaur (2025) in plum cv. Satluj Purple, Gupta *et al.* (2010) in peach cv. Earli Grande, Bajaj (2004) in Baggugosha pear, Singh (2005) in ber cv. Umran, Malik *et al.* (2005) in mango cv. Kensington Pride as well as Jawandha *et al.* (2012) in mango.

Table 2: Effect of different treatments and storage interval on weight and per cent weight loss of plum (cv. Satluj Purple) fruits during ambient storage

Treatments (T)	Fruit weight (g)						Weight loss (%)				
	Storage interval (D)						Storage interval (D)				
	D_0	D_3	D_6	D_9	Mean	% decrease	D_0	D_3	D_6	D_9	Mean
T_1 (1.0 mM PUT)	38.61	36.97	35.00	32.16	**35.69**	**16.71**	0.00	4.26	9.36	16.73	**7.59**
T_2 (1.5 mM PUT)	39.22	37.75	35.82	33.17	**36.49**	**15.43**	0.00	3.76	8.63	15.32	**6.93**
T_3 (2.0 mM PUT)	41.36	40.46	39.27	37.47	**39.64**	**9.41**	0.00	2.16	5.07	9.37	**4.15**
T_4 (2.5 mM PUT)	39.59	38.38	36.43	34.01	**37.10**	**14.09**	0.00	3.04	7.98	14.07	**6.27**
T_5 (1.0 mM SA)	38.66	36.53	34.37	31.10	**35.17**	**19.56**	0.00	5.51	11.17	19.58	**9.07**
T_6 (1.5 mM SA)	39.05	37.08	34.58	31.47	**35.54**	**19.41**	0.00	5.02	11.47	19.41	**8.97**
T_7 (2.0 mM SA)	39.44	38.06	36.44	34.00	**36.99**	**13.79**	0.00	3.49	7.57	13.77	**6.21**
T_8 (2.5 mM SA)	41.28	40.24	38.86	36.81	**39.29**	**10.83**	0.00	2.52	5.88	10.76	**4.79**
T_9 (1.0% $CaCl_2$)	38.31	36.85	34.66	31.74	**35.39**	**17.15**	0.00	3.80	9.48	17.11	**7.60**
T_{10} (1.5% $CaCl_2$)	39.88	37.91	35.77	32.99	**36.64**	**17.28**	0.00	4.89	10.25	17.25	**8.10**
T_{11} (2.0% $CaCl_2$)	40.30	38.84	36.68	33.96	**37.44**	**15.73**	0.00	3.62	8.96	15.69	**7.07**
T_{12} (2.5% $CaCl_2$)	39.97	38.65	37.05	34.67	**37.59**	**13.26**	0.00	3.28	7.26	13.25	**5.95**
T_{13} (Control)	38.29	35.90	33.03	28.89	**34.03**	**24.55**	0.00	6.23	13.77	25.36	**11.34**

Mean	39.54	37.97	36.00	33.26			0.00	3.97	8.99	15.97	
Factors	**C.D. at 5%**				**SE(m)**		**Factors**		**C.D. at 5%**		**SE(m)**
Factor (T)	1.12				0.40		**Factor (T)**		0.97		0.34
Factor (D)	0.62				0.22		**Factor (D)**		0.54		0.19
Factor (T x D)	N/A				0.80		**Factor (T x D)**		1.93		0.69

Where, PUT= Putrescine, SA= Salicylic acid and $CaCl_2$= Calcium Chloride

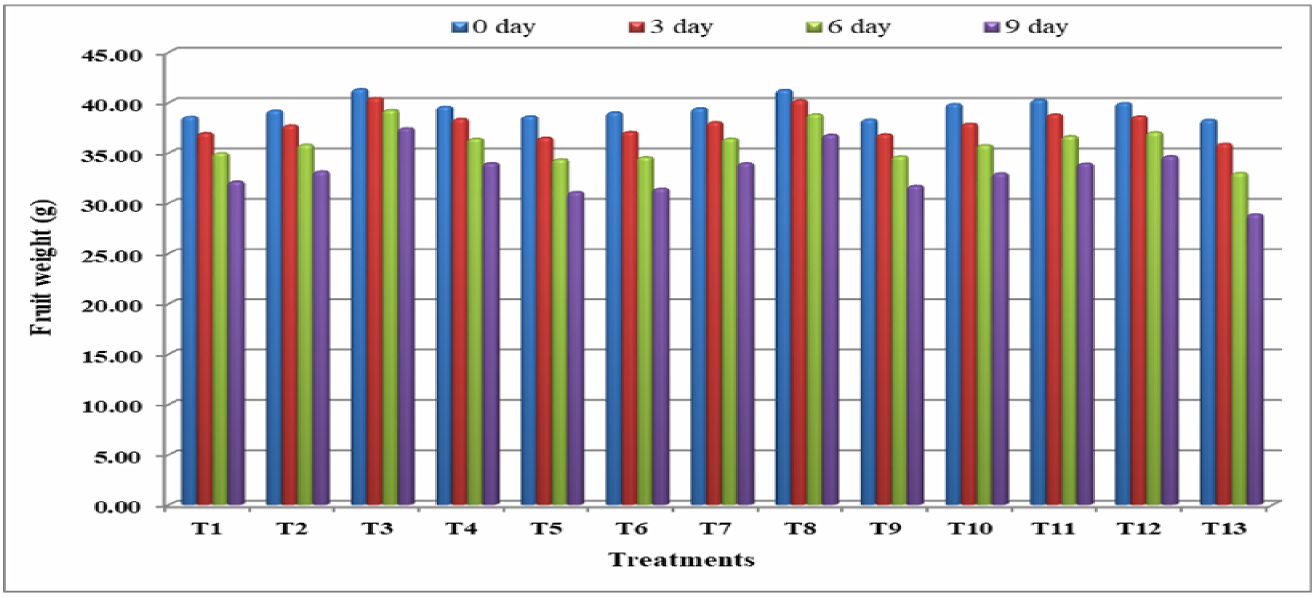

Fig. 3: Effect of pre-harvest treatments and storage interval on fruit weight of plum (cv. Satluj Purple) fruits during ambient storage

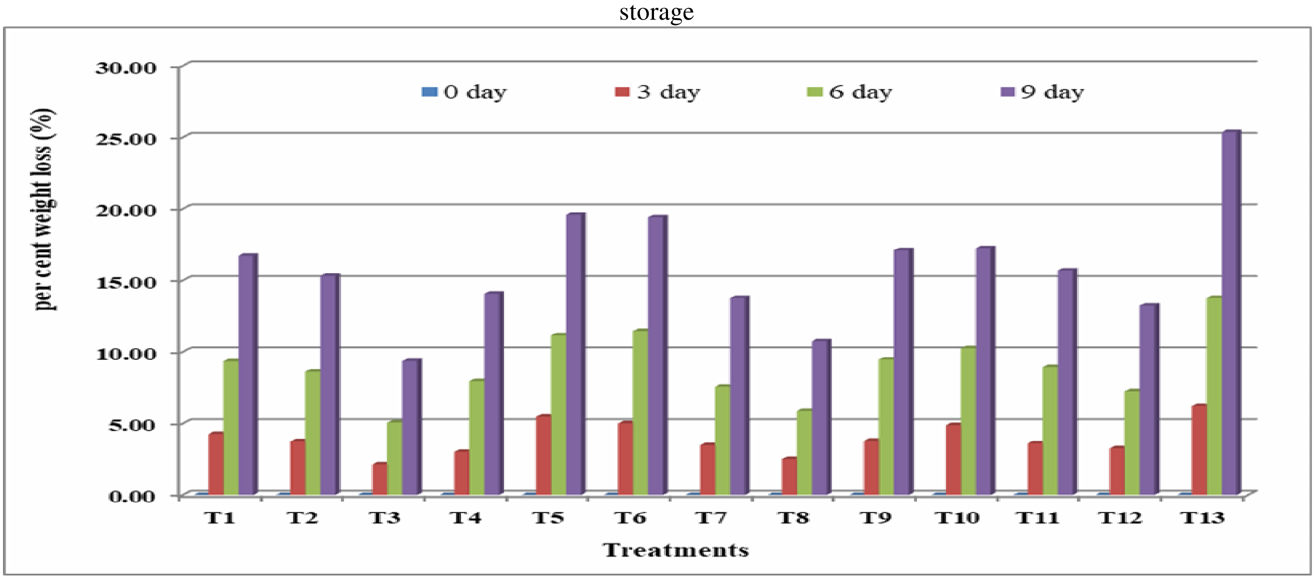

Fig. 4: Effect of pre-harvest treatments and storage interval on per cent weight loss of plum (cv. Satluj Purple) fruits during ambient storage

Shrinkage

The data related to shrinkage of plum fruit cv. Satluj Purple during ambient storage presented in Table 3 and Figure 5. Significant differences were found among treatments. Treatments T_3 (2.0 mM of putrescine) recorded the lowest fruit shrinkage (7.56%) on last day of observation, which was statistically *at par* with T_8 (2.5 mM of salicylic acid) at 7.94%, followed by T_{12} (2.5% of calcium chloride) with 10.80%. However, T_{13} (control) exhibited the highest fruit shrinkage (20.53%), highlighting the beneficial impact of pre-harvest foliar applications in reducing shrinkage during extended storage. With respect to storage intervals, a consistent increase in shrinkage was observed over the period of time. After harvesting of fruits, fruits continue to undergo transpiration until senescence. These physiological changes result in a wrinkled appearance and reduced market quality of the fruit (Gidado *et al.,* 2024). Fruits physiological and physical attributes are also responsible for susceptibility to water loss, factors such as thickness of skin, cuticular composition, internal structure as well as metabolic activity (Konarska, 2015). The application of putrescine and higher concentrations of salicylic acid resulted in the lowest shrinkage percentage, likely due to their roles in maintaining membrane integrity, suppressing ethylene production and slowing senescence-related metabolic activity (i.e. anti-senescence properties), which help to reduce the rate of respiration and delay the ripening process, thereby extending the shelf life and minimizing shrivelling during storage. The untreated fruit as well as lower concentrations underwent the rapid ripening process, which causes the more shrinkage per cent during the storage. Similar trend is corroborated by previous studies, Kaur and Kaur (2025) in plum cv. Satluj purple, Tareen *et al.* (2012) and Khademi and Ershadi (2013) in peach fruits cv. Florda King and cv. Elberta.

Decay

The data regarding the percentage of fruit decay in plum cv. Satluj Purple during ambient storage tabulated in Table 3 and Figure 6. The results showed statistically significant variations among the treatments. Among the various treatments, on last day of observation the lowest decay (16.67%) was recorded in T_3, closely followed by T_8 (22.22%), whereas the highest value (73.33%) was observed in T_{13}, demonstrating that pre-harvest foliar applications can substantially reduce decay progression, especially during extended storage. As storage duration advanced, decay percentage increased markedly. It rose steadily from 4.02% on day 3 to 15.81% on day 6 and reached a peak of 36.92% on the 9^{th} day, highlighting the role of storage length in promoting fruit deterioration. Fruit decay during storage is primarily caused by a combination of physiological breakdown and microbial activity. Loss of water during storage leads to tissue softening and skin collapse, making the fruit more vulnerable to infection (Coggins *et al.,* 1969). As ripening progresses, the cell wall structure degrades, sugar levels increase and natural defence mechanisms weaken, thereby creating favourable conditions for pathogen invasion. These processes result in visible symptoms of decay such as rotting, discoloration and shrivelling. Supportive evidences were reported by Zaghloul *et al.* (2016) in peach, Hosseini *et al.* (2017) in pear and Martinez-Romero *et al.* (1999) in lemon. Application of salicylic acid also noted to reduces the postharvest chilling and rotting like appearance in mango (Zainuri *et al.* 2001) and apple (Krishna *et al.,* 2012).

Table 3: Effect of different treatments and storage interval on per cent shrinkage and per cent decay of plum (cv. Satluj Purple) fruits during ambient storage

Treatment (T)	Shrinkage (%)					Decay (%)				
	Storage interval (D)					Storage interval (D)				
	D_0	D_3	D_6	D_9	Mean	D_0	D_3	D_6	D_9	Mean
T_1 (1.0 mM PUT)	0.00	3.14	7.83	12.22	**5.80**	0.00	3.33	13.33	40.00	**14.17**
T_2 (1.5 mM PUT)	0.00	2.98	7.25	11.83	**5.51**	0.00	2.22	12.22	30.00	**11.11**
T_3 (2.0 mM PUT)	0.00	1.70	4.56	7.56	**3.45**	0.00	0.00	5.56	16.67	**5.56**
T_4 (2.5 mM PUT)	0.00	3.42	7.86	11.85	**5.78**	0.00	2.22	20.00	25.56	**11.94**
T_5 (1.0 mM SA)	0.00	3.31	8.57	14.39	**6.57**	0.00	2.22	13.33	47.78	**15.83**
T_6 (1.5 mM SA)	0.00	3.93	9.02	15.33	**7.07**	0.00	6.67	16.67	31.11	**13.61**
T_7 (2.0 mM SA)	0.00	2.77	6.90	11.53	**5.30**	0.00	2.22	12.22	37.78	**13.06**
T_8 (2.5 mM SA)	0.00	2.20	5.75	7.94	**3.98**	0.00	0.00	5.56	22.22	**6.94**
T_9 (1.0% $CaCl_2$)	0.00	4.01	9.61	14.36	**6.99**	0.00	6.67	17.78	37.78	**15.56**
T_{10} (1.5% $CaCl_2$)	0.00	3.47	8.13	14.05	**6.41**	0.00	2.22	16.67	43.33	**15.56**
T_{11} (2.0% $CaCl_2$)	0.00	2.81	7.29	12.65	**5.69**	0.00	5.56	18.89	41.11	**16.39**
T_{12} (2.5% $CaCl_2$)	0.00	3.96	7.79	10.80	**5.64**	0.00	3.33	17.78	33.33	**13.61**
T_{13} (Control)	0.00	5.06	11.69	20.53	**9.32**	0.00	15.56	35.56	73.33	**31.11**
Mean	**0.00**	**3.29**	**7.86**	**12.70**		**0.00**	**4.02**	**15.81**	**36.92**	

Factors	C.D. at 5%	SE(m)	Factors	C.D. at 5%	SE(m)
Factor (T)	0.73	0.26	**Factor (T)**	3.97	1.41
Factor (D)	0.40	0.14	**Factor (D)**	2.20	0.78
Factor (T x D)	1.45	0.52	**Factor (T x D)**	7.94	2.83

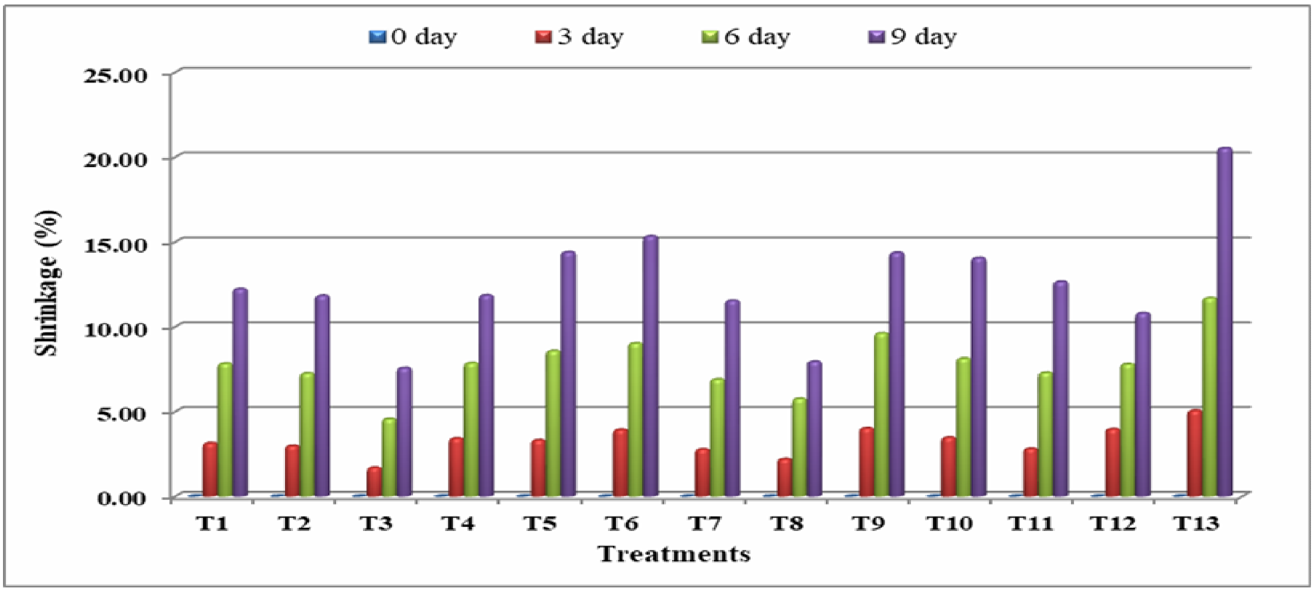

Fig. 5: Effect of pre-harvest treatments and storage interval on per cent shrinkage of plum (cv. Satluj Purple) fruits during ambient storage

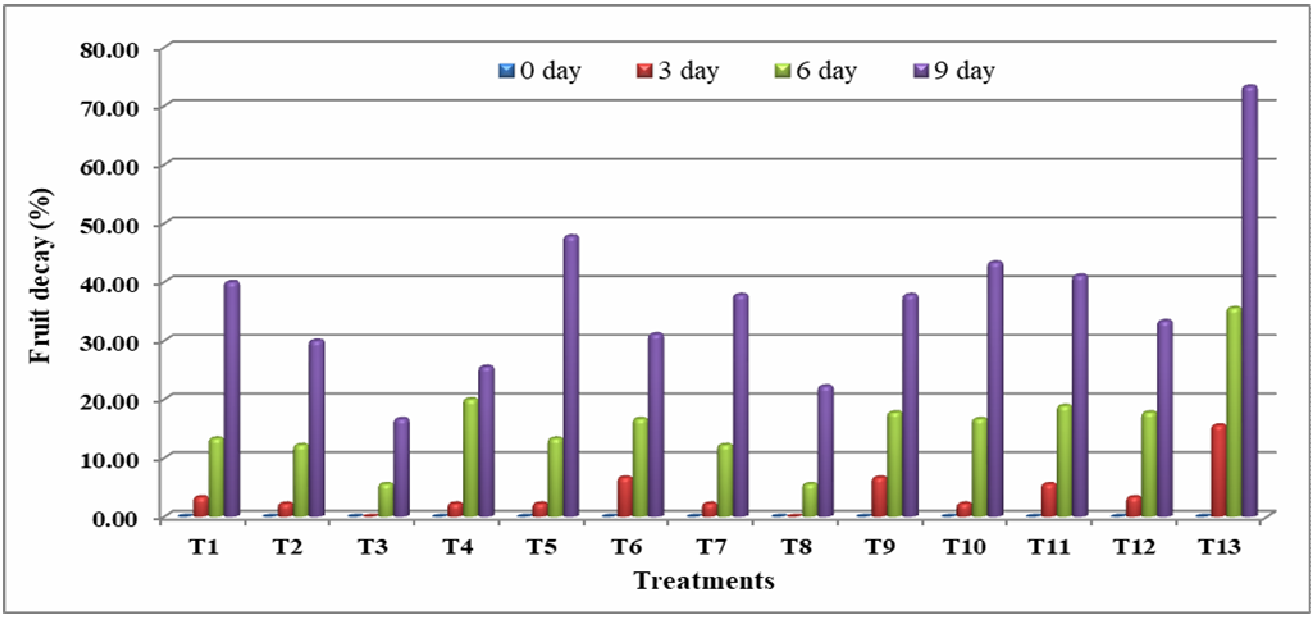

Fig. 6: Effect of pre-harvest treatments and storage interval on per cent decay (%) of plum (cv. Satluj Purple) fruits under ambient storage conditions

Conclusion

The results of above experimental finding revealed that among different treatments 2.0 mM of putrescine was found superior with respect to most of the quality attributes like fruit length, width, weight, per cent weight loss, per cent shrinkage and per cent decay, which was followed by 2.5 mM of salicylic acid. Conversely, the minimum values for all the parameters were observed in untreated fruits (control).

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