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Physico-chemical and enzymatic changes in low temperature stored plum fruits in response to putrescine application

Amandeep Kaur*, S.K. Jawandha and Harminder Singh
Department of Fruit Science, Punjab Agricultural University, Ludhiana 141004

ABSTRACT

Plum is a perishable fruit and its ripening coincides with the hot and dry summer months under north Indian conditions. It has very short storage life at ambient temperature and high postharvest losses. An experiment was planned to extend the post-harvest life of plum fruits with putrescine application under cold storage conditions. Physiologically mature and uniform fruits of plum cv. Satluj Purple were dipped in different concentrations of putrescine (0.0, 1.0, 2.0 and 3.0 mmol l^{-1}) for 5 min. Treated fruits were air-dried in shade and packed in corrugated fiber board boxes with paper lining before storage at 0-1˚C and 90-95% RH for 35 days. Results revealed that fruits treated with putrescine @ 3.0 mmol l^{-1} retained the acceptable quality by reducing physiological loss in weight, spoilage, pectin methyl esterase activity and maintaining the fruit firmness, sensory quality, total soluble solids, titrable acidity, total sugars, reducing sugars and non-reducing sugars up to 28 days of storage.

Key words: Cold storage, plum, postharvest, putrescine.

INTRODUCTION

Plum belongs to genus *Prunus* and family *Rosaceae*. It includes European (*Prunus domestica* L.) and Japanese species (*Prunus salicina* Lindl.). Japanese plum is native to China that bears the edible juicy fruits. Under sub-tropical conditions of north India it ripens in the first fortnight of May. Hot and dry weather during this period leads to short post-harvest life of plum fruits. Plum is a climacteric fruit and its storage life is limited even at low temperature because of high susceptibility to physiological disorders. Several chemicals have been reported to delay ripening and extend the shelf-life of fruits. Polyamines have also been found to be anti-senescence agents and the concentration of polyamines decreases during tissue senescence with accelerated ethylene production (Valero *et al*., 12). Novita and Purvoko (10) studied that in papaya fruits polyamine infiltration inhibited the change of colour and reduced the physiological loss in fruit weight and fruit softening process. Inhibition of ethylene production, low respiration rate and higher flesh firmness was also reported in 'Hayward' kiwi fruit with the application of 1 mM putrescine treatment (Wen *et al*., 13). Hence, the present investigation was carried out to study the effect of post-harvest treatments of putrescine on physico-chemical and enzymatic changes of cv. Satluj Purple plum fruits under low temperature storage.

MATERIALS AND METHODS

Physiologically mature and uniform fruits of plum cv. Satluj Purple were harvested from Fruit Research Farm, Punjab Agricultural University, Ludhiana. Selected fruits were treated with aqueous solutions of different concentrations of putrescine @ 1.0 (T_1), 2.0 (T_2), 3.0 (T_3) and 0.0 mmol l^{-1} (T_4). Each treatment was replicated thrice and comprised of 1.0 kg fruit/replication. Treated fruits were air-dried in shade and packed in corrugated fibre board (CFB) boxes with paper lining. Packed fruits were kept at 0-1°C and 90-95% RH for 35 days. Stored fruits were analysed at weekly interval for various physico-chemical and enzymatic changes. The percent loss in weight after each interval of cold storage was calculated by subtracting final weight from the initial weight of the fruits and then converted into percentage value. The fruit colour was recorded with the help of Color Flex EZ spectrophotometer (Hunter Lab) and expressed as a^* value (Hunter, 3). Firmness of randomly selected fruits was measured with the help of a penetrometer (Model FT-327, USA) using stainless steel probe. About one square centimeter of the peel from both sides of each fruit was removed with the help of peeler and firmness was expressed in terms of lbf. Sensory quality evaluation of fruits was conducted by a panel of five judges following the Hedonic scale (1-9) as described by Amerine *et al.* (2). Spoilage percentage of fruits was also calculated. Total soluble solids (TSS) were determined with the help of hand refractrometer at room temperature and expressed in per cent. These readings were corrected with the help of temperature correction chart at 20°C temperature. The tritratable acidity, total sugars, reducing sugars and non-reducing sugars were estimated by the

*Corresponding author's E-mail: adhillon76@gmail.com

standard methods described by AOAC (1). Pectin methyl esterase enzyme activity was determined by using method of Mahadevan and Sridhar (6). The data obtained were subjected to statistical analysis by following Factorial Completely Randomized Design (CRD) as described by Singh *et al*. (11).

RESULTS AND DISCUSSION

Physiological loss in weight (PLW) of plum fruits increased with extension in storage period (Table 1). The maximum PLW (6.84%) was recorded in untreated fruits, whereas minimum (4.87%) PLW was observed in putrescine @ 3.0 mmol l^{-1} treated fruits after 35 days of storage. All the treatments showed significantly less PLW as compared to control. Physiological loss in weight is due to various metabolic activities, *i.e.* respiration and transpiration processes. Polyamine treatments reduced the weight loss of fruits during storage, which might be due to lower rate of respiration in treated fruit as compared to control. Similarly, putrescine treated lemon fruit showed lower weight loss than untreated fruit during storage (Valero *et al*., 12). Polyamines infiltration reduced the loss of fruit weight during ripening process in papaya fruits (Novita and Purvoko, 10).

Plum fruit colour is associated with the accumulation of carotenoids and anthocyanins. Both groups of pigments are more abundant in the peel but anthocyanins are mainly responsible for the surface colour of the fruit. The colour development was improved with the advancement of storage period. After 35 days, maximum *a** value (25.72) was recorded in untreated fruits, whereas minimum a^* value (23.92) was observed in putrescine @ 3.0 mmol l^{-1} treated fruits (Table 1). Similarly, Malik *et al*. (9) also observed that both pre- and post-harvest putrescine applications retarded fruit colour development of mango fruits.

Spoilage during storage leads to quantitative and qualitative losses of fruits. Putrescine application significantly reduced the spoilage in fruits during storage. After 14 days of cold storage only untreated fruits showed the rotting. However, the putrescine treated fruits showed a little spoilage only after 35 days of storage. At the end of storage, maximum (9.02%) spoilage was noticed in control fruits and minimum (0.35%) spoilage was observed in fruits treated with putrescine @ 3.0 mmol l^{-1} (Table 1). Zheng and Zheng (14) also reported a reduced decay percentage with postharvest treatment of polyamines, *viz*., putrescine, spermidine, spermine and salicylic acid in 'Ponkan' mandarin as compared to control.

Fruit softening is a suitable predictor of potential shelf-life for plums. The decrease in fruit firmness

Table 1. Effect of of putrescine treatments on physiological loss in weight (PLW), fruit colour and spoilage of cold stored plum fruits.

Treatment	PLW (%)						Fruit colour (*a** value)						Spoilage (%)					
Days	7	14	21	28	35	Mean	7	14	21	28	35	Mean	7	14	21	28	35	Mean
T_1	1.65	1.84	2.57	4.47	5.00	3.10	8.92	16.88	18.92	20.79	24.42	17.98	0.00	0.00	0.00	0.00	0.60	0.12
T_2	1.52	1.82	2.49	4.20	4.92	2.99	8.72	16.72	18.79	20.59	24.01	17.76	0.00	0.00	0.00	0.00	0.48	0.09
T_3	1.38	1.80	2.36	4.15	4.87	2.91	8.68	16.68	18.58	20.42	23.92	17.65	0.00	0.00	0.00	0.00	0.35	0.07
T_4	2.97	3.98	4.23	5.74	6.84	4.75	9.42	18.02	19.88	21.61	25.72	18.93	0.00	1.92	5.23	6.86	9.02	4.60
Mean	1.88	2.36	2.91	4.64	5.07		8.93	17.07	19.04	20.85	24.51		0.00	0.48	1.30	1.71	2.61	
$CD_{0.05}$																		
Treatment (T)			0.02						0.07						0.17			
Storage interval (S)			0.03						0.08						0.19			
T × S			0.04						0.16						0.39			

during storage was inhibited significantly by postharvest treatments of putrescine. Putrescine application suppressed and delayed the softness of plum fruits during storage. Reduction in fruit firmness was progressively decreased with increase in putrescine concentration (Fig. 1A). The reduction in fruit softening with putrescine application may be due to decrease in PLW and cell wall degenerating enzyme (PME) activity. At the end of storage, the putrescine @ 3.0 mmol l^{-1} treated fruits retained the maximum (2.42 lbf) fruit firmness and the minimum (1.03 lbf) fruit firmness was recorded in untreated fruits. Softening of fruits is caused either by the breakdown of insoluble protopectins into soluble pectins or by the cellular disintegration leading to increased membrane permeability.

Post-harvest treatment of putrescine @ 3 mmol l^{-1} significantly lowered the pectin methyl esterase (PME) activity as compared to control fruits. After 21 days of storage, the maximum (2.26 ml 0.02 N NaOH used) PME activity was recorded in control fruits and the minimum (1.68 ml 0.02 N NaOH used) was noticed in putrescine @ 3 mmol l^{-1} treated fruits (Fig. 1B). But after 28th and 35th days of storage the trend was reversed, and at the end of storage maximum (1.52 ml 0.02N NaOH used) PME activity was registered in fruits treated with putrescine @ 3 mmol l^{-1}, while the minimum (1.22 ml 0.02 N NaOH used) PME activity was noticed in the reference fruits. This might be due to the presence of high substrate level for PME activity at later stages of storage in putrescine @ 3 mmol l^{-1} treated fruits, which was already decomposed to the higher extent at the early stages of storage in other treatments. The decrease in PME activity at later stage of storage was also reported by Jawandha *et al.* (4) in *ber* fruits.

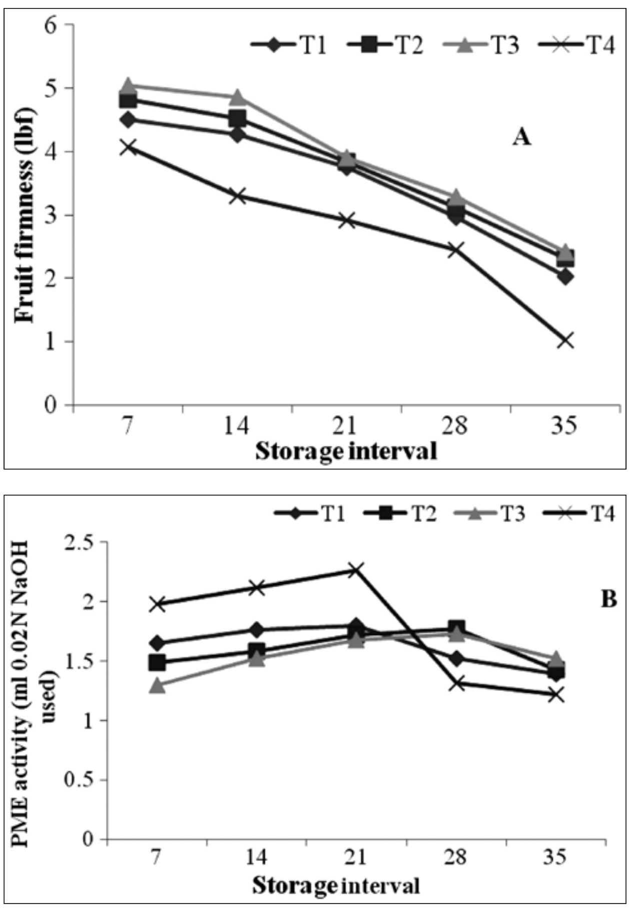

Fig. 1. Effect of putrescine treatments on firmness (A) and PME activity and (B) of cold stored plum fruits.

The data pertaining to sensory quality of plum fruits during storage is given in (Table 2). Sensory quality of stored fruits was improved up to three weeks of storage in all the treatments, afterwards a decline was noticed in T_1 and T_4. After 14 days of storage, highest (7.73) sensory quality was recorded in untreated fruits, whereas, after 28 days of storage highest (8.43) sensory quality was recorded in putrescine @ 3.0 mmol l^{-1} treated fruits. Putrescine treated fruits retained acceptable appearance, flavour and taste for longer period of storage that might be due to the fact that putrescine treatments retarded the moisture, respiration and transpiration losses. Similarly, Malik and Singh (7) also reported a higher sensory quality rating in putrescine treated mango fruits as compared to control.

Total soluble solids content is an important indicator to judge the quality of fruits. TSS content of plum fruits increased upto 21 days of storage in all the treatments, afterwards a decrease in TSS content was observed during storage (Table 2). The mean minimum (12.61%) TSS content was recorded in fruits treated with putrescine @ 3.0 mmol l^{-1} and the mean maximum (13.09%) TSS content was noticed in control fruits. The increase in TSS with advancement of storage period may be due to numerous metabolic processes taking place in the fruits during ripening and senescence processes. The increase in TSS could also be attributed to water loss and hydrolysis of complex polysaccharides to simple sugars. The results on TSS in the present study are in agreement with the findings of Malik *et al*. (8) who reported a slow increase in total soluble solids in 'Kensington Pride' mango fruits treated with putrescine as compared to control.

The titratable acidity of plum fruits showed a declining with an advancement of storage period. During storage the mean maximum (0.85%) titratable acidity was maintained by the fruits treated with putrescine @ 3.0 mmol l^{-1} and the mean minimum (0.52%) acidity was observed in control fruits (Table 2).

Table 2. Effect of putrescine treatments on sensory quality rating, total soluble solids and titratable acidity of cold stored plum fruits.

Treatment	Sensory quality rating (1-9 scale)						Total soluble solids (%)						Titratable acidity (%)					
Days	7	14	21	28	35	Mean	7	14	21	28	35	Mean	7	14	21	28	35	Mean
T_1	7.02	7.29	7.93	7.38	5.87	7.09	12.31	12.70	13.12	13.00	12.61	12.74	0.92	0.81	0.73	0.63	0.55	0.72
T_2	6.82	7.06	7.55	7.88	6.59	7.18	12.07	12.50	12.74	13.19	12.82	12.66	1.05	0.92	0.79	0.69	0.62	0.81
T_3	6.70	6.93	7.29	8.43	6.70	7.21	12.01	12.43	12.60	13.13	12.90	12.61	1.09	0.99	0.81	0.73	0.65	0.85
T_4	7.49	7.73	7.80	5.63	4.91	6.71	13.28	13.59	13.85	12.59	12.18	13.09	0.64	0.59	0.53	0.46	0.41	0.52
Mean	7.00	7.05	7.64	7.33	6.01		12.41	12.80	13.07	12.97	12.62		0.92	0.82	0.71	0.62	0.56	
$CD_{0.05}$																		
Treatment (T)			0.17						0.02						0.02			
Storage interval (S)			0.19						0.03						0.03			
T × S			0.39						0.06						0.04			

Table 3. Effect of putrescine treatments on total sugars, reducing sugars and non-reducing sugars of cold stored plum fruits.

Treatment	Total sugars (%)						Reducing sugars (%)						Non-reducing sugars (%)					
Days	7	14	21	28	35	Mean	7	14	21	28	35	Mean	7	14	21	28	35	Mean
T_1	9.21	9.49	9.68	9.50	8.76	9.32	6.46	6.64	6.78	6.63	6.13	6.52	2.55	2.65	2.69	2.66	2.44	2.59
T_2	8.92	9.24	9.43	9.67	9.00	9.25	6.36	6.48	6.60	6.76	6.30	6.50	2.47	2.56	2.63	2.70	2.51	2.57
T_3	8.90	9.12	9.37	9.63	9.12	9.22	6.26	6.38	6.56	6.73	6.38	6.46	2.45	2.54	2.60	2.69	2.55	2.56
T_4	9.87	10.22	10.42	9.18	8.47	9.63	6.98	7.12	7.28	6.41	5.93	6.74	2.68	2.88	2.92	2.57	2.36	2.68
Mean	9.22	9.51	9.72	9.49	8.83		6.98	7.12	7.28	6.41	5.93		2.53	2.65	2.71	2.65	2.46	
$CD_{0.05}$																		
Treatment (T)			0.10						0.04						0.03			
Storage interval (S)			0.11						0.04						0.04			
T × S			0.23						0.09						0.08			

Decrease in fruit acidity with the progress of storage is due to the utilization of acids in respiration and other metabolic processes (Khader *et al*., 5). The main sugars found in fresh plums are glucose, fructose and sucrose; although sorbitol (a sugar alcohol) is also present. In untreated fruits, total sugars (10.42%), reducing sugars (7.28%) and non-reducing sugars (2.92%) increased upto 21 days of cold storage, but in putrescine @ 2 and 3 mmol l^{-1} treated fruits this increase was recorded upto 28 days of storage (Table 3). Similarly, total and non-reducing sugars were found less in 'Kensington Pride' mango fruits after pre- and post-harvest application of putrescine as compared to control (Malik *et al*., 8). From present study, it can be concluded that 'Satluj Purple' plum fruits, harvested at colour break stage, followed by postharvest treatment of putrescine @ 3.0 mmol l^{-1} for five minutes retained acceptable quality upto 28 days under cold storage conditions (0-1˚C and 90- 95% RH).

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