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Effect of preharvest application of calcium chloride ($CaCl_2$), Gibberlic acid (GA3) and Napthelenic acetic acid (NAA) on storage of Plum (*Prunus salicina* L.) cv. Santa Rosa under ambient storage conditions

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The present investigation was carried out in the experimental field of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during the year 2010 to 2011 with a view to study the various physical changes that occur during storage and to prolong the shelf life of plum under ambient storage conditions by preharvest application of various chemicals. Fruit size, weight and firmness recorded continuous decrease with the advancement of storage period. However, 0.5% calcium chloride ($CaCl_2$) proved to be more efficacious in minimizing these losses. Maximum increase in fruit size and weight at the time of harvest was recorded with the preharvest application of 60 ppm NAA. Physiological loss in weight (PLW) and spoilage followed continuously increasing trend with the advancement of storage period. Among the various preharvest treatments, 0.5% $CaCl_2$ applied 20 and 10 days before the expected date of harvest proved to be the most effective treatment in retaining the fruit quality during the entire storage period. Such fruits exhibited minimum loss in weight, maximum retention in firmness and minimum spoilage on each sampling date. In general, overall acceptability of fruits decreased with the passage of storage time. However, fruits treated with $CaCl_2$ were rated as most acceptable and it was followed by Gibberlic acid (GA_3) treatment at the end of storage period under ambient conditions.

Key words: Plum, quality, preharvest, calcium chloride ($CaCl_2$), Gibberlic acid (GA_3), napthelenic acetic acid (NAA), storage.

INTRODUCTION

Japanese Plum (*Prunus salicina* Lindl.) is one of the most important temperate zone stone fruit. It ranks next to peaches in economic importance (Westwood, 1993). Being a delicious juicy fruit, it is used both as fresh and in preserved form. Plum is prized both for its exquisite fresh flavour, aroma, and attractiveness and in fruit

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preservation industry. Besides having medicinal properties, it is a fairly good source of citric acid, sugars and Vitamin A (Ulrich, 1974).Plum is grown from subtropical plains to the temperate high hills. European plum thrives best at 1300 to 2000 m above mean sea level and require about 1000 to 1200 chilling hours (below 7.2°C) during winter to break rest period, whereas Japanese plum require 700 to 1000 chilling hours (below 7.2°C) which is met in mid hill areas located at an elevation of 1000 to 1600 m above mean sea level. Plum is important fruit of North Indian hills comprising Himachal Pradesh, Jammu and Kashmir, hilly areas of Uttar Pradesh and Assam besides being grown in Nilgiris between 1300 to 1600 m above sea level. 'Santa Rosa', a leading commercial cultivar of Japanese plum, known for its fair quality and characteristic flavour is widely grown in Kashmir valley.

Plum is a highly perishable fruit and cannot be stored for longer periods or transported over longer distances under ambient conditions. The post harvest losses of fruits during transportation and marketing are very high, particularly as slight bruises, hardly noticeable on freshly harvested crops, cause the fruits to rot during transportation under hot and humid conditions. Therefore, it is desirable to have a preharvest treatment, which would retard the deterioration in quality during transportation and storage.

Plum fruit is highly delicate and perishable and demands immediate disposal and utilization. After harvesting, biochemical changes in fruits are continuous which lead to fruit softening and spoilage. If these changes are reduced, the storage life of fresh fruits can be effectively increased and spoilage can be reduced. In recent years, plant growth regulators such as auxins like Napthelenic acetic acid (NAA), gibberellins like gibberellic acid (GA_3) and calcium chloride ($CaCl_2$) have been extensively used for improving the quality, delaying deterioration in storage and thereby increasing the shelf life of various fruits. In view of these perspectives, an attempt has been made to find out the suitable preharvest treatment which could enhance the storage life and improve the quality of plum fruit under ambient storage conditions out of preharvest application of spray of $CaCl_2$, GA_3 and NAA.

Low fruit calcium levels have been associated with reduced postharvest life and physiological disorders (Wills et al., 1998). For example, Asrey and Jain (2000) found that 0.05% calcium chloride proved to be best in respect of prolonging shelf life (9 days) and acceptability owing to their better appearance, when fully ripe fruits of strawberry cv.

Chandler were treated with different concentrations of calcium nitrate (0.5, 1.0, and 2.0%), calcium chloride (0.05, 0.10, and 0.20%) and ascorbic acid (0.01, 0.02 and 0.05%) at 10°C for five minutes (Asrey and Jain, 2000). Proebsting and Mills (1966) observed that early Italian prune sprayed with 10 ppm Gibberellic acid were firmer at harvest. Scott and Wills (1977) treated apple fruits with calcium chloride and observed retention of firmness during storage at ambient temperature.

Simnani (1995) observed that fruit firmness in peach was significantly affected by various concentrations of calcium application; the fruit firmness decreased gradually with the prolongation of storage period and was minimum with calcium treatment compared to control. Pawel (2001) found that "Dabrowicka prune" fruit sprayed with calcium were firmer and more resistant to infection after harvest than control fruits.

MATERIALS AND METHODS

The present investigation carried out in the experimental field/laboratory of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar situated at an altitude of 1390 m above MSL and between 34° 75' North latitude and 74° 50' East longitude, during the year 2010 to 2011. The experiment was conducted on 24 years old trees of plum cv. 'Santa Rosa' of uniform size and vigour which received uniform cultural operations. At the time of final bloom, uniform trees with uniform crop load were selected for experimental work. Treatments and replications were randomly assigned with a single plot size. The experiment consisted of 10 treatments, replicated thrice with a single tree size in a Randomized Block Design. Application of chemicals as spray solutions on plum fruits, $CaCl_2$ (Calcium Chloride, Hi Media) (0.1, 0.3 and 0.5%), GA_3 (Gibberlic acid-$C_{19}H_{22}O_6$-Hi Media, Central Drug House-New Delhi) (20, 40 and 60 ppm) and NAA (1-Napthalenic acetic acid-$C_{12}H_{10}O_2$-Hi Media, Central Drug House-New Delhi) (20, 40 and 60 ppm) was done twice, 20 and 10 days before harvest. After that the harvested fruits were stored under ambient conditions in the laboratory [At an ambient temperature (26 ± 2°C to 15 ± 2°C) and relative humidity (60 to 70%) during investigating storage period from 8 to 22 July, 2010] for studies on post harvest shelf life for a period of 15 days. The trees were sprayed twice at ten days interval, the first spray being carried out on 19th June (70 DAFB) and second spray on 29th June, 2010 (80 DAFB). At the time of first spray, all the twenty seven trees were sprayed and the control trees were left un-sprayed. The second spray was repeated in the similar way as the first application. The fruits of each treatment were harvested at optimum maturity (When 3/4th of colour of fruit changed to Red colour) (8th July, 2010) (90 DAFB) and immersed in running water to remove field heat and then air dried in shade. The uniformly matured fruits were selected (around 60 fruits from each treatment, 20 / Replication) and packed in standard wooden boxes of standard size for recording the fruit weight (g), fruit length (cm), fruit diameter (cm) and fruit volume (cm^3) during storage period and physical parameters such as fruit firmness (kg/cm^2), physiological loss in weight (%) and spoilage (%).

The length and diameter of 15 randomly selected fruits from each treatment was measured with the help of digital Vernier calliper (Aerospace) and the average expressed in cm. The weight of 15 randomly selected fruits from each treatment in each replication was taken on a top pan balance (Shimadzu- TX323L- Unibloc) and the average weight per fruit was expressed in grams (g). Volume of the fruit was measured by water displacement method using two litre measuring cylinder. A measuring cylinder was filled with water up to certain graduation and selected fifteen fruits, whose weight was recorded, were fully immersed in it. The difference between final and initial volume of water represented the total volume of fruits and the average fruit volume was expressed in cubic centimetre (cm^3) per fruit. Fruit firmness was determined by a pressure tester (penetrometer) (Toshiba-India-mod FT-011). The two readings were taken at shoulder of the fruit at sides and the average reading was expressed in kg/cm^2. For calculating physiological loss in weight (%), at random 15 fruits from each treatment were weighed, labelled and kept separate from other fruits at harvest. Periodical weight of labelled fruits was recorded after every 5 days and subsequent loss was worked out. For obtaining organoleptic rating, fruit samples taken at random from each treatment were put before a panel of four judges (trained panel) for organoleptic evaluation. Organoleptic scoring was done Least acceptable = 1, Less acceptable = 2, Acceptable = 3, and Highly acceptable = 4 on the basis of taste, firmness, crispness, colour, sweetness, etc. The spoilage percentage of each treatment and replication was calculated at the fixed intervals of storage at ambient temperature by the following formulae:

$$\text{Spoilage percentage} = \frac{\text{No. of spoiled fruits}}{\text{Total No. of fruits}} \times 100$$

Statistical analysis

The data generated from the present investigations were put to statistical analysis by using R-software. Treatment means were separated and compared using least significant differences (LSD) at P less or equal to 0.05 as per the procedures described by Cochran and Cox (1963).

RESULTS AND DISCUSSION

Fruit size in terms of fruit length and width decreased with the advancement of storage period. The effect of various treatments on the fruit length and fruit width during storage and also the effects of the interactions between storage interval and treatments were found to be non-significant (Table 1). The results have been found to be in conformity with those of Srivastava et al. (1972) who observed that NAA in the range of 10 to 50 ppm did not show any significant effect on fruit size in apricot cv. Kaisha. The fruits treated with 90 ppm NAA (T_9) had the highest mean volume (42.83 cm^3) after the storage period which was significantly superior to control which recorded lowest volume (39.51 cm^3). However, the rest of the treatments were on par with the control. The decline in fruit volume during storage intervals during the first 5 days of storage was found to be non-significant whereas afterwards a significant decrease in fruit volume was recorded during rest of storage intervals. Fruit weight was increased significantly by the application of all the treatments. The maximum increase at harvest was observed in response to 60 ppm NAA (43.20 g) (Table 1). Similar increase in fruit weight and volume have also been observed by Srivastava et al. (1973) in peach cv. Alexandra; Khokhar et al. (2004) in strawberry cv. Chandler, upon treatment of fruits with NAA. However, at the end of 15 days of storage 0.1% $CaCl_2$ (T_1) retained the maximum weight (37.52 g) followed by 0.3% $CaCl_2$ (T_2) (36.63 g) and 0.5% $CaCl_2$ (T_3) (36.60 g). Least mean fruit weight was recorded in control (T_{10}) (35.13 g). The decline in the fruit weight during storage was significant while the interactions between treatments and storage interval were found to be non-significant. Fruit growth is caused by cell division followed by cell enlargement. The application of NAA at the preharvest stage might have raised the auxin level in fruits which ultimately might have helped in the improvement of cell size and consequently fruit size, as a direct correlation between the auxin content and fruit growth, in several plants has been reported by Krishnamoorthy (1981). Both the weight and volume of fruits decreased significantly with the increase in storage period.

However, treated fruits maintained higher values of fruit volume and weight as compared to control. The decrease in both weight and volume during storage period may be due to the shrinking of transpiration resulting in retention of better sized fruits during storage. At the end of storage, themaximum weight and volume was observed with $CaCl_2$ 0.1% (T_1). The data shows a steady decrease in firmness commensurate with advance in the storage period (Table 2). The most firm fruits at harvest were obtained from trees receiving preharvest application of $CaCl_2$ 0.5% (T_3) (4.67 kg/cm^2) and were found to be on par with T_2 (4.60 kg/cm^2) and T_1 (4.58 kg/cm^2). These fruits also recorded the highest firmness values throughout the 15 days of storage period. The treatments T_5 (4.58 kg/cm^2), T_6 (4.57 kg/cm^2) and T_4 (4.56 kg/cm^2) were also significant as compared to the remaining treatments as well as the controls (Table 2). On an average, mean maximum fruit firmness was recorded in fruits treated with 0.5% $CaCl_2$ (T_3) (3.09 kg/cm^2). The control fruits on the other hand recorded the lowest average firmness (2.61 kg/cm^2) after the end of stipulated storage period. Interactions between treatments and storage intervals were found to be non-significant. The fruits treated with $CaCl_2$ maintained higher firmness as compared to GA_3 and control, at all storage intervals. 0.5% $CaCl_2$ (T_3) treated fruits demonstrated the best effect on maintaining fruit firmness and registered maximum mean fruit firmness (3.09 kg/cm^2) while the control fruits recorded the lowest mean fruit firmness (2.61 kg/cm^2) (Table 2).

Softening of fruits is caused either by breakdown of insoluble protopectin into soluble pectin or by hydrolysis of starch (Matto et al., 1975) or by cellular disintegration leading to increased membrane permeability (Oogaki et al., 1990). The loss of pectic substances in the middle lamellae of the cell wall is perhaps the key step in ripening process that leads to the loss of cell integrity or firmness (Solomes and Latics, 1973). Fruit firmness is one of the most crucial factors in determining the post harvest quality and physiology of fruits. With a decrease in fruit firmness, the tissue rigidity decreases, firstly as a result of hydrolysis of intercellular pectins and secondly by cell turgor pressure decreases due to an increase in permeability of cell membrane to water in the later stages of internal breakdown. The decrease in both the components of fruit firmness appears to contribute to

Table 1. Effect of pre-harvest sprays of various chemicals on fruit length (cm), fruit width (cm), fruit weight (g) and fruit volume (cm^3) during ambient storage in plum cv. Santa Rosa (*Prunus salicina* L.).

Treatments (T)	Fruit length (cm)					Fruit width (cm)					Fruit weight (g)					Fruit volume (cm^3)				
	Storage intervals in days (I)					Storage intervals in days (I)					Storage intervals in days (I)					Storage intervals in days (I)				
	0	5	10	15	Mean	0	5	10	15	Mean	0	5	10	15	Mean	0	5	10	15	Mean
T_1 $CaCl_2$ 0.1%	4.47	4.44	4.41	4.15	4.37	4.28	4.27	4.22	4.15	4.23	43.88	43.22	41.05	37.52	41.42^{a}	42.87	42.40	41.14	38.26	41.17^{d}
T_2 $CaCl_2$ 0.3%	4.33	4.30	4.28	4.13	4.26	4.27	4.24	4.21	4.15	4.22	42.44	41.87	39.90	36.63	40.21^{b}	41.32	41.01	40.00	37.14	39.87^{g}
T_3 $CaCl_2$ 0.5%	4.35	4.33	4.30	4.12	4.28	4.24	4.23	4.19	4.16	4.20	42.11	41.62	39.87	36.60	40.05^{b}	41.00	40.75	39.77	37.35	39.72^{h}
T_4 GA_3 20 ppm	4.49	4.48	4.33	4.18	4.37	4.27	4.25	4.20	4.14	4.21	43.55	42.76	40.00	35.97	40.57^{b}	42.85	42.30	40.00	37.44	40.65^{f}
T_5 GA_3 40 ppm	4.45	4.43	4.33	4.16	4.34	4.30	4.27	4.22	4.17	4.24	44.05	43.32	40.72	36.05	41.03^{b}	43.05	42.47	40.60	36.77	40.72^{e}
T_6 GA_3 60 ppm	4.51	4.50	4.31	4.16	4.37	4.33	4.29	4.22	4.18	4.25	45.15	44.36	40.48	36.35	41.58^{a}	44.30	43.66	40.14	37.36	41.44^{c}
T_7 NAA 20 ppm	4.52	4.50	4.36	4.17	4.38	4.38	4.31	4.23	4.15	4.27	46.80	45.75	40.85	35.94	42.33^{a}	45.87	44.25	40.75	36.59	41.86^{b}
T_8 NAA 40 ppm	4.52	4.49	4.35	4.16	4.38	4.40	4.33	4.24	4.16	4.28	47.00	45.59	40.58	35.70	42.22^{a}	46.31	44.03	41.05	36.45	41.96^{b}
T_9 NAA 60 ppm	4.54	4.48	4.30	4.18	4.37	4.41	4.33	4.24	4.18	4.29	49.20	46.71	41.34	35.55	43.20^{a}	47.70	44.90	41.56	37.17	42.83^{a}
T_{10} Control	4.34	4.29	4.25	4.17	4.26	4.22	4.21	4.18	4.15	4.19	38.77	38.00	34.27	29.47	35.13^{c}	41.00	40.70	39.38	36.97	39.51^{i}
Mean	4.44	4.42	4.32	4.15		4.31	4.27	4.21	4.16		44.30a	43.3a	41.05^{b}	35.5^{c}		43.6a	42.6b	40.4c	37.1^{d}	
Lsd ($P \leq 0.05$)	Treatment (T): NS					Treatment (T): NS					Treatment (T) : 2.14					Treatment (T): 0.11				
	Intervals (I): NS					Intervals (I): NS					Intervals (I): 1.35					Intervals (I): 0.07				
	T ×I: NS					T × I: NS					T × I: NS					T × I: NS				

Lowercase letters indicate statistical differences amongst the means.

tissue softening (Pollard, 1974).

The desired effect of calcium on maintaining fruit firmness may be due to the calcium binding to free carboxyl groups of polygalacturonate polymer, stabilizing and strengthening the cell wall (Rees, 1975). Calcium binding may strengthen tissue and make it more resistant to hydrolytic enzyme activity as reported in tomato (Wills and Rigney, 1979) where Ca inhibits the polygalacturonase activity in cell walls (Buescher and Hobson, 1982).

Effectiveness of GA_3 in maintaining fruit firmness may be due to the reason that might reduce various physiological activities related with softening of fruits (Rees, 1975). A similar reduction in the firmness loss following the pre-harvest application of $CaCl_2$ has been reported by Siddiqui and Bangerth (1995) in apples during storage; Simnani (1995) in peach. There was a continuous increase in physiological loss in weight (PLW) under all the treatments as the storage period progressed. There was a progressive and significant increase in PLW of fruits with an increase in storage duration for both treated and untreated fruits. However, the increase in PLW of calcium chloride treated fruits (T_3 - 4.53%, T_2 - 4.76% and T_1 - 5.04%) was relatively slower and consequently these fruits exhibited significantly lower overall losses as compared to other treatments and control (T_{10} - 9.66%). The treatment consisting of 0.5% $CaCl_2$ (T_3) proved to be the most effective in reducing PLW (4.53%) and it was found statistically at par with T_2 and T_1.

It was followed by T_5 (5.80%), T_4(6.26%) and T_6(6.87%), respectively. However, control fruits (T_{10}) exhibited highest PLW on each sampling date thereby recording the highest mean PLW (9.66%) which was significant in comparison to other treatments. Interactions between treatments and storage intervals were also found to be significant (Table 2). The results have been found to be in conformity with those of Gupta et al. (1984) who also reported that PLW during 9 days of storage in peach fruit was 31% with preharvest application of 1% $CaCl_2$ as compared to 36.90% under control. Preharvest spray of calcium chloride has also been reported to be effective in reducing PLW during storage of apple (Baneh et al., 2003).

Fresh fruits and vegetables can be regarded as water infancy and expensive packages, some of which may be lost during storage or marketing. This water loss leads to loss of weight and thus, is a direct loss in marketing. Fruits, in general, possess considerable resistance to moisture loss, as their water vapour pressure is lower than that of water at the same temperature because of

Table 2. Effect of preharvest sprays of various chemicals on fruit firmness (kg/cm^2), PLW(%), Organoleptic rating and spoilage(%) during ambient storage in plum cv. Santa Rosa (*Prunus salicina* L.) (lowercase letters are used to indicate statistical differences amongst the means).

Treatments (T)	Fruit firmness (kg/cm^2) Storage intervals in days (I)					Physiological loss in weight (%) Storage intervals in days (I)				Organoleptic rating Storage intervals in days (I)					Spoilage (%) Storage intervals in days (I)			
	0	5	10	15	Mean	5	10	15	Mean	0	5	10	15	Mean	5	10	15	Mean
T_1 $CaCl_2$ 0.1%	4.58	4.00	2.30	1.00	2.97^{b}	1.50 (1.22)	5.03 (2.22)	8.60 (2.92)	5.04 (2.12)^{a}	3.16	3.15	3.06	2.41	2.94^{b}	4.94 (2.22)	23.75 (4.87)	48.98 (6.99)	25.89 (5.09)^{c}
T_2 $CaCl_2$ 0.3%	4.60	4.08	2.40	1.08	3.05^{a}	1.35 (1.16)	4.71 (2.15)	8.22 (2.86)	4.76 (2.06)^{a}	3.21	3.20	3.11	2.46	2.99^{a}	2.72 (1.65)	20.95 (4.58)	46.21 (6.79)	23.29 (4.82)^{b}
T_3 $CaCl_2$ 0.5%	4.67	4.11	2.49	1.09	3.09^{a}	1.12 (1.06)	4.30 (2.04)	8.18 (2.85)	4.53 (1.98)^{a}	3.24	3.23	3.14	2.56	3.05^{a}	2.72 (1.65)	18.68 (4.32)	44.94 (6.70)	22.11 (4.70)^{a}
T_4 GA_3 20 ppm	4.56	3.88	2.18	0.85	2.87^{b}	1.85 (1.36)	6.60 (2.54)	10.33 (3.21)	6.26 (2.37)^{b}	3.18	3.17	3.09	1.90	2.83^{c}	4.94 (2.22)	26.69 (5.17)	52.11 (7.22)	27.91 (5.28)^{d}
T_5 GA_3 40 ppm	4.58	3.99	2.24	0.89	2.92^{b}	1.65 (1.28)	6.00 (2.42)	9.74 (3.11)	5.80 (2.27)^{b}	3.23	3.22	3.11	1.95	2.87^{c}	7.16 (2.67)	26.69 (5.17)	48.88 (6.99)	27.58 (5.25)^{d}
T_6 GA_3 60 ppm	4.57	3.94	2.20	0.86	2.89^{b}	1.80 (1.34)	8.60 (2.92)	10.20 (3.18)	6.87 (2.48)^{c}	3.25	3.22	3.15	2.00	2.90^{b}	4.94 (2.22)	21.43 (4.62)	47.56 (6.89)	24.64 (4.96)^{b}
T_7 NAA 20 ppm	4.44	3.61	1.89	0.66	2.65^{c}	2.00 (1.41)	9.80 (3.10)	12.00 (3.45)	7.93 (2.65)^{d}	3.13	3.11	3.06	1.80	2.77^{d}	2.72 (1.65)	27.77 (5.27)	53.62 (7.32)	28.03 (5.29)^{d}
T_8 NAA 40 ppm	4.41	3.60	1.89	0.64	2.63^{c}	2.25 (1.50)	10.70 (3.23)	13.00 (3.60)	8.65 (2.78)^{d}	3.16	3.12	3.08	1.70	2.76^{d}	4.94 (2.22)	28.40 (5.33)	52.11 (7.22)	28.48 (5.34)^{d}
T_9 NAA 60 ppm	4.41	3.59	1.87	0.60	2.62^{c}	3.00 (1.73)	11.00 (3.30)	14.00 (3.73)	9.33 (2.92)^{e}	3.25	3.15	3.08	1.66	2.77^{d}	7.16 (2.67)	31.45 (5.61)	55.67 (7.46)	31.42 (5.60)^{e}
T_{10} Control	4.40	3.56	1.88	0.60	2.61^{c}	3.50 (1.87)	11.50 (3.38)	14.01 (3.74)	9.66 (2.99)^{e}	3.13	3.05	3.05	1.60	2.71^{e}	7.16 (2.67)	33.80 (5.81)	61.21 (7.82)	34.06 (5.84)^{f}
Mean	4.52a	3.84b	2.13c	0.83d		2.00 (1.39)^{a}	7.82 (2.73)^{b}	10.83 (3.27)^{c}		3.19^{a}	3.15^{b}	3.1^{c}	1.9^{d}		2.00 (1.39)^{a}	5.14 (2.27)^{b}	25.96 (5.10)^{c}	51.13 (7.15)^{g}
Lsd ($P \leq 0.05$)			Treatment (T)	0.11			Treatment (T)	0.16				Treatment (T)	0.06			Treatment (T)	0.11	
			Intervals (I)	0.07			Intervals (I)	0.10				Intervals (I)	0.03			Intervals (I)	0.06	
			T X I	NS			T X I	0.09				T X I	0.08			T X I	0.18	

Data in parentheses is square root transformation of original data.

dissolved substances, mostly sugars. The entire weight loss is not due to water loss alone, for respiration may also account for a part of it. The average score for overall acceptability (organoleptic rating) at harvest was maximum (3.25) in response to 60 ppm GA_3 (T_6) and 60 ppm NAA (T_9) and these treatments were followed by T_3(3.24) and T_5(3.23). The data also indicates that that the score for overall acceptability decreased under all treatments during the entire 15 days of storage. The decrease in score was fastest in the control fruits (T_{10}) which therefore exhibited the lowest average score of only 2.71. However, 0.5% $CaCl_2$ (T_3) treatment resulted in maximum overall acceptability rating of fruit (3.05) during storage. Interactions between treatments and storage intervals were found to be significant. The extent of spoilage at an average was found to be lowest (22.11%) in fruits that had received a preharvest treatment of 0.5% $CaCl_2$ (T_3) and it was significant than all the other treatments. It was followed by treatments with concentrations of 0.3% $CaCl_2$ (23.29%) and 0.1% $CaCl_2$(25.89%) and 60 ppm GA_3 (24.64%) then by T_5(27.58%) and T_4(27.91) and NAA treatments with their effects being proportional to their concentrations applied. These treatments also caused significant reductions in spoilage as compared to control (T_{10}) (34.06%) where maximum spoilage was observed on all sampling days. Interactions between treatments and storage intervals were found to be significant (Table 2).

Calcium is known to act as an anti-senescent agent as it provides cellular disintegration by maintaining protein and nucleic acid synthesis (Faust and Klein, 1973). It is also reported to be effective in decreasing the respiration rates of several commodities (Faust, 1978). During the present study also calcium chloride treatments have been observed to be most effective in reducing PLW of fruits during storage whereas control fruits exhibited maximum loss. The increased weight loss in untreated fruits could be due to increased storage breakdown, which is associated with higher rate of respiration as compared to calcium treated fruits.

Conclusion

The objectives of the investigation were to study the effect of preharvest chemical treatment viz. $CaCl_2$, GA_3 and NAA on physical attributes of plum as well as on the storage life of plum fruits under ambient conditions. The results obtained during the course of investigation showed that maximum increase in fruit size, weight and volume were recorded with preharvest application of 60 ppm NAA. The fruit size and volume followed a declining trend commensurating with advancement in storage period. 0.5% $CaCl_2$ treatments proved to be more efficacious in minimizing the loss. The firmness of fruits showed a decline during storage, the decrease being minimum in 0.5% $CaCl_2$. There was an increase in physiological loss in weight of fruits during storage. However, preharvest application of 0.5% $CaCl_2$ proved to be efficacious in minimizing weight loss during storage. Preharvest application of 0.5% $CaCl_2$ resulted in better retention of sensory quality attributes during storage as a result of which fruits from these treatments were most acceptable at all storage intervals. Spoilage of the fruits was found to be substantially lower in fruits that were given $CaCl_2$ treatments. GA_3 treatments also resulted in lower spoilage compared to the control fruits.

From the studies, it may be concluded that storage life of plum fruits could be prolonged with the preharvest application of calcium chloride ($CaCl_2$). Preharvest application of $CaCl_2$ at 0.5% proved most beneficial in enhancement of quality in terms of improving fruit firmness stimulating organoleptic taste as well as prolonged shelf-life under ambient storage conditions. Hence, it represents the best preharvest treatment for getting better quality ‘Santa Rosa’ plum for better remuneration to the orchardist.

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