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Effect of pre-harvest application of calcium chloride and gibberellic acid on shelf-life and post-harvest quality of apricot (*Prunus armeniaca* L.) cv. Harcot

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ABSTRACT

Pre-harvest application of calcium chloride (0.5, 1.0, and 1.5 %) and gibberellic acid (10, 20 and 30 ppm) at 80% blooming, fruit-set and at 15 days before harvest were carried out on 5-year old trees of apricot cv. Harcot. All the treatments significantly reduced physiological loss in fruit weight, fruit diameter and spoilage percentage during storage. However, $CaCl_2$ @ 1.5% was found to be most effective in minimizing weight loss in fruits during storage compared to Control. Fruits quality (TSS, titrable acidity, TSS/TA, ascorbic acid, total sugar, etc.) was also found to be better (even at 8 days of storage at ambient condition with this treatment) compared to Control. Hence, it can be concluded that pre-harvest foliar application in apricot cv. Harcot with $CaCl_2$ @ 1.5% at three stages, i.e., 80% blooming, at fruit-set and 15 days before harvest, enhances shelf-life of the fruit from 3-5 days storage to 8 days storage, and can maintain good fruit quality under ambient storage-condition for up to 8 days.

Key Words : Pre-harvest, Harcot, calcium chloride, gibberellic acid, ambient condition storage

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is an important fruit crop of the mid-hill and dry temperate regions of the country. In India, apricot is grown on an area of 2400 ha producing 10000 MT annually, for table purpose as well as dehydrated products. Overall productivity is 4.1t/ha, which is very low in comparison to the global average of 7.11t/ha (FAO, 2008). In India, although J & K boasts of the highest productivity (2.89 t/ha), it is less than half that of the international figure. In this content, there is a need to improve quality, production and productivity to meet domestic and export demand. Apricot is a perishable fruit, having a short-shelf life (3-5 days) at ambient conditions (2-4 weeks shelf-life under cold storage). The short shelf-life of this fruit is due to its short shelf-period from commercial ripening to degradation processes like senescence (Egea *et al*, 2007; Agar and Polate, 1995). To increase the supply of apricot fruits, there is an urgent need to study ways in which its marketing period can be extended, while ensuring high-quality. An inverse relation exists between fruit tissue calcium levels and fruit respiration rate. By spraying calcium chloride solution fruits during their development, their rate of respiration at picking time can be reduced (Faust *et al*, 1972). Role of calcium in maintenance and modulation of various cell functions is based on its presence in the in membrane and in on cell-wall Ca^{2+} in an integral part of the cell wall where it provides stability, resulting in cell-wall rigidity. Haggag (1987) and El-Shemy (1998) reported that spraying 'Anna' apple fruits from mid-June to August with calcium nitrate or calcium chloride improved their keeping quality. Both treatments reduced fruit-softening, gave firm fruits and reduced the severity of physiological disorders during storage. Rease *et al* (1999) reported that calcium chloride sprays increased Ca^{2+} concentration in apricot fruits and improved their shelf-life by increasing fruit-firmness. Nutrient and plant growth regulators like GA_3 have been extensively used for improving quality, delaying degradation in storage and, thereby, increasing the shelf-life of various fruits (Kher *et al*, 2005). GA_3 on fruits and plants acts as an anti-senescence agent (Ahmed *et al*, 2001), in turn controlling transpiration and respiration rate (A.O.A.C., 1985) thus reducing fruit weight-loss during storage. Apricot cv. Harcot grown under the *karewa* condition of temperate region (characterized by low precipitation and high evapo-transpiration) suffers from nutrient deficiency, particularly calcium, due to its high fixing rate, besides low soil-fertility resulting from continuous and exhaustive growth of the fruit trees. Nutritional status of the tree has a striking and important role in controlling pre-

and post-harvest quality of fruits. With this view, the present study was conducted to evaluate pre- and post-harvest treatments with calcium chloride, and gibberellic acid as a pre-harvest treatment in maintenance of apricot cv. Harcot fruit quality under ambient storage conditions.

MATERIAL AND METHODS

The present research was carried out at the research farm of Central Institute of Temperate Horticulture (CITH), Srinagar, during the years 2008-09 and 2009-10. The experimental farm is situated at a latitude of 34°05N and a longitude of 74°50E at 1640m above mean sea level experiencing a maximum temperature of 19.63°C and a minimum of 6.52°C. Average annual rainfall is 60.72mm, relative humidity 58.35 % with evaporation rate of 2.45. The soil is clay-loam to silt-clay, pH 6.81 and EC 0.36 dSm^{-1} estimated the during growing seasons 2008-09 & 2009-10. The trees were spaced 3.5m x 3.5m along and across the rows, respectively. Trees were grown under drip irrigation and uniform cultural practices suitable for commercial fruit production. Commercially grown apricot cv. Haricot was selected for the study. Treatments comprising 0.5, 1.0 and 1.5 % $CaCl_2$ and GA_3 @ 10, 20 and 30 ppm were applied at 80% blooming, fruit-set and 15 days prior harvest in two successive seasons, 2008 and 2009. However, Control trees were treated with regular water. All the treatments were applied with a knapsack sprayer. Fruits were harvested at optimal (commercial) maturity stage. Healthy fruits free from physiological or pathological disorders were selected and washed with chlorine water, and air dried. Each treatment during the two seasons of the study was replicated three times; each replicate was represented by four boxes. Each box was lined with butter paper and contained three kg of fruit. Boxes were stored at ambient conditions (27-28°C) and 70-80% RH. Fruit spoilage % and percentage physiological loss in weight was determined every two days by examining for physical properties all fruits packed in the boxes. Determination of chemical constituents was also carried out every two days using four fruits per box. Titrable acidity (TA) was determined by titration to pH 8.1 with 0.1M NaOH solution and expressed as grams of citric acid per 100g of juice (A.O.A.C., 1984). Total soluble solids (TSS) were determined using Atago digital refractrometer, calibrated using distilled water, and recorded as °Brix at 22°C. Total sugars were estimated as per the method described by Ranganna (2001). Results were expressed as perentage. Ascorbic acid was determined employing the method described by Ruck (1963) and results were expressed as mg per 100g of juice. The data (average of 2 years) was statistically analyzed using FCRD by the Online Statistical Analysis Package (OPSTAT) by the Computer Section, CCS Haryana Agricultural University, Hisar.

RESULTS AND DISCUSSION

Effect of application of $CaCl_2$ and GA_3 on physical properties of apricot cv. Harcot stored at ambient conditions

Physiological loss in weight (PLW%): Data presented in Table 1 show the effect of $CaCl_2$ and GA_3 on percent weight-loss in apricot cv. Harcot fruits stored at ambient conditions during 2008 and 2009 seasons. Minimum percent physiological weight reduction (5.76) was recorded in with $CaCl_2$ 1.5%, followed by $CaCl_2$ 1% (6.65) and $CaCl_2$ 0.5% (6.73) compared to Control (8.11). These results are similar to the findings of Tomola *et al* (1998) and Tabatabaie and Malakouti (1998) who recorded minimum weight-loss in apple fruits treated with various concentrations of calcium chloride. Data on storage intervals showed that there was a gradual increase in weight loss percentage during storage in selected cultivar. The maximum physiological loss in weight (14.92 %) was found after 8 days of storage in all

Table 1. Effect of various concentrations of $CaCl_2$ and GA_3 on fruit PLW (%) and fruit spoilage (%)

	PLW (%)						Fruit spoilage (%)					
Treatment	0 day	2 days	4 days	6 days	8 days	Mean	0 day	2 days	4 days	6 days	8 days	Mean
$CaCl_2$ 0.5%	0	3.48	7.04	9.07	14.08	6.73	0	2.08	5.19	20.40	30.06	11.54
$CaCl_2$ 1%	0	3.30	6.52	9.18	14.25	6.65	0	1.54	5.72	19.57	30.46	11.46
$CaCl_2$ 1.5%	0	2.33	6.20	8.12	12.17	5.76	0	1.03	3.80	16.82	26.33	9.59
GA_3 10 ppm	0	4.03	6.64	9.62	15.37	7.13	0	1.70	5.62	22.00	31.04	12.07
GA_3 20 ppm	0	4.08	7.10	9.67	16.00	7.37	0	1.92	5.30	23.96	32.32	12.70
GA_3 30 ppm	0	5.15	7.29	9.22	15.03	7.34	0	1.72	5.52	23.29	34.66	13.03
Control	0	5.13	7.89	10.03	17.52	8..11	0	2.37	6.36	24.83	39.33	14.58
Mean	0	3.93	6.95	9.27	14.92		0	1.76	5.36	21.55	32.03	

Factors	C.D. (5%)	SE(d)	SE(m)	Factors	C.D. (5%)	SE(d)	SE(m)
Factor (T)	0.27	0.13	0.09	Factor (T)	0.50	0.25	0.18
Factor (D)	0.23	0.11	0.08	Factor (D)	0.42	0.21	0.15
Factor (T X D)	0.61	0.30	0.21	Factor (T×D)	1.13	0.56	0.40

T=Treatment, D=Days, T X D = Treatment X Days

the treatments as compared to 0 day of storage i.e., 0.0%. The increase in loss percentage of fruit weight with the increase in storage period was also reported by El-Shemy (1998) on "Canino" apricot. These results are also inline with the findings of Bidabe (1970) who found that there was a weight loss in apple fruits as the storage period was further prolonged.

Per cent fruit spoilage: Table (1) clearly indicates that there was an evident trend for decreasing fruit spoilage% due to the used treatments. Per cent fruit spoilage appeared to be increased with increasing the storage period. Minimum per cent fruit spoilage (9.59) was recorded in treatment $CaCl_2$ 1.5 % followed by $CaCl_2$ 1% (11.46) and $CaCl_2$ 0.5% (11.54) as compared to control (14.58) (Fig. 1-3). Elham *et al* (2007) also reported similar types of results in apricot fruits. Data regarding storage intervals showed that there was a gradual increase in fruit spoilage percentage during storage in selected variety. The maximum fruit spoilage (32.03 %) was found after 8 days of storage in all the treatments as compared to 0 day of storage i.e., 0.0%. Similar trend was previously obtained, by Fataliev (1985) who found that percent spoilage was increased with increasing of storage period in apple fruits.

Fruit diameter: Application of treatments significantly affected the fruit diameter during storage and maximum fruit diameter (44.62 mm) was recorded with treatment of $CaCl_2$ 1.5 % followed by $CaCl_2$ 1% (44.591 mm) and $CaCl_2$ 0.5 % (43.37 mm) (Table 2). The possible reason may be that calcium chloride at higher concentrations served as a semi-permeable membrane around the fruit-surface resulting in reduction in evapo-transpiration and in the rate of respiration. Data on storage interval showed a gradual decrease in fruit-diameter during storage, and minimum fruit diameter (37.62mm) was found at 8 days of storage in all the treatments compared to 0 day of storage (44.42mm). These results are in accordance with Kher *et al* (2005) who reported decreased fruit diameter with increase in storage-period.

Effect of application of $CaCl_2$ and GA_3 on chemical properties of apricot Cv. Harcot stored at ambient conditions

Total Soluble Solids (°Brix)

Comparison of treatment means (Table2) showed an increase in TSS in all the treatments, and maximum (19.59) T.S.S. °Brix in Control followed by $GA_3$20 ppm (17.73) and

Table 2. Effect of various concentrations of $CaCl_2$ and GA_3 on fruit diameter (mm) and TSS (° Brix)

	Fruit diameter (mm)						TSS (oBrix)					
Treatment	0 day	2 days	4 days	6 days	8 days	Mean	0 day	2 days	4 days	6 days	8 days	Mean
$CaCl_2$ 0.5%	47.14	45.85	43.23	41.63	39.00	43.37	14.99	15.91	16.04	16.63	14.833	15.682
$CaCl_2$ 1%	47.44	45.720	44.94	43.63	41.21	44.59	13.44	14.36	16.10	17.00	16.00	15.38
$CaCl_2$ 1.5%	47.70	46.45	44.96	43.19	40.79	44.62	18.51	15.53	15.66	16.33	16.00	16.40
GA_3 10 ppm	45.94	44.81	44.04	43.14	42.61	44.11	14.70	15.72	15.82	16.70	18.34	16.25
GA_3 20 ppm	44.43	43.03	42.45	40.65	38.70	41.85	17.13	18.36	17.65	17.18	18.33	17.73
GA_3 30 ppm	36.56	34.86	33.04	32.15	29.92	33.30	16.00	17.20	16.48	17.33	17.33	16.86
Control	41.75	40.07	37.07	35.27	31.09	37.05	17.73	17.59	19.07	21.08	22.47	19.59
Mean	44.42	42.97	41.39	39.95	37.6		16.07	16.38	16.69	17.46	17.61	

Factors	C.D. (5%)	SE(d)	SE(m)	Factors	C.D. (5%)	SE(d)	SE(m)
Factor (T)	1.05	0.52	0.37	Factor (T)	1.22	0.61	0.43
Factor (D)	0.88	0.44	0.31	Factor (D)	1.03	0.52	0.36
Factor (T X D)	N.S.	1.17	0.83	Factor (T X D)	N.S.	1.37	0.97

T=Treatment, D=Days, T X D= Treatment X Days

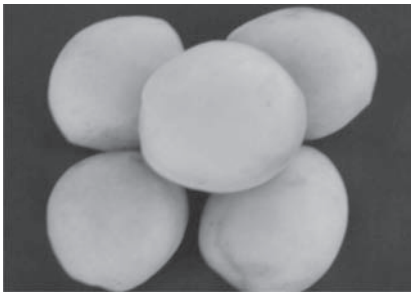

Fig 1. $CaCl_2$ 1.5% (8 Days after storage at ambient condition)

Fig 2. $CaCl_2$ 1% (8 Days after storage at ambient condition)

Fig 3. Control (8 Days after storage at ambient condition)

Table 3. Effect of different concentration of $CaCl_2$ and GA_3 on fruit Titrable Acidity (%) and Vitamin C (mg/100g juice)

	Titrable Acidity (%)						Vitamin C (mg/100gm pulp)					
Treatment	0 day	2 days	4 days	6 days	8 days	Mean	0 day	2 days	4 days	6 days	8 days	Mean
$CaCl_2$ 0.5%	1.31	1.24	1.15	1.19	1.05	1.22	11.83	11.60	11.30	10.83	10.20	11.15
$CaCl_2$ 1%	1.38	1.31	1.13	1.21	1.05	1.22	11.86	11.70	11.40	10.86	10.60	11.28
$CaCl_2$ 1.5%	1.38	1.32	1.11	1.25	1.05	1.24	12.10	11.80	11.50	11.20	10.90	11.50
GA_3 10 ppm	1.29	1.20	1.03	1.13	0.98	1.13	10.50	10.20	10.00	9.40	9.20	9.86
GA_3 20 ppm	1.38	1.31	1.20	1.25	1.10	1.192	10.43	10.30	9.73	9.20	8.90	9.71
GA_3 30 ppm	1.20	1.16	0.96	1.09	0.88	1.06	10.70	10.40	9.60	9.10	8.60	9.68
Control	1.19	1.11	0.96	1.03	0.88	1.03	10.33	10.20	9.10	8.26	7.90	9.16
Mean	1.30	1.24	1.16	1.08	1.00		11.11	10.88	10.37	9.83	9.47	

Factors	C.D. (5%)	SE(d)	SE(m)
Factor (A)	0.042	0.021	0.015
Factor (B)	0.036	0.018	0.012
Factor (A X B)	N.S.	0.047	0.033

Factors	C.D. (5%)	SE(d)	SE(m)
Factor (A)	0.079	0.039	0.028
Factor (B)	0.067	0.0337	0.023
Factor (A X B)	0.178	0.089	0.063

T=Treatment, D=Days, T X D= Treatment X Days

Table 4. Effect of different concentration of $CaCl_2$ and GA_3 on fruit TSS/Acid and Total sugar (%)

	TSS/Acid						Total sugar (%)					
Treatment	0 day	2 days	4 days	6 days	8 days	Mean	0 day	2 days	4 days	6 days	8 days	Mean
$CaCl_2$ 0.5%		13.61	13.42	12.47	12.73	13.24	11.36	11.53	12.10	12.33	12.63	11.99
$CaCl_2$ 1%	13.97	13.68	14.51	16.54	15.98	14.84	11.13	11.30	12.00	11.86	12.10	11.68
$CaCl_2$ 1.5%	13.49	16.47	15.80	16.43	5.633	16.25	11.43	11.50	12.33	12.53	12.93	12.14
GA_3 10 ppm	16.94	13.84	13.97	14.58	14.89	14.29	10.12	10.50	11.06	11.43	12.03	11.03
GA_3 20 ppm	14.17	12.66	14.51	13.27	13.72	13.62	10.15	10.33	11.06	11.83	12.28	11.13
GA_3 30 ppm	13.95	14.94	15.02	17.86	18.19	16.09	10.19	10.86	11.77	12.49	13.33	11.73
Control	14.44	14.93	15.21	16.22	17.17	15.38	10.41	10.53	11.16	11.46	11.83	11.08
Mean	13.40	14.30	14.63	15.34	15.47		10.68	10.93	11.64	11.99	12.45	

Factors:	C.D. (5%)	SE(d)	SE(m)
Factor (A)	1.22	0.61	0.43
Factor (B)	N.S.	0.51	0.36
Factor (A X B)	N.S.	1.37	0.97

Factors:	C.D. (5%)	SE(d)	SE(m)
Factor (A)	0.16	0.08	0.05
Factor (B)	0.13	0.06	0.04
Factor (A X B)	0.36	0.18	0.13

T=Treatment, D=Days, T X D= Treatment X Days

GA_3 30ppm (16.86); whereas, the minimum was recorded with $CaCl_2$ 1% (15.382) . This might be due to calcium chloride (1%) forming a thin layer on the surface of fruits thereby delaying the degradation process. It may have also reduced evaporation from the fruits preventing reduction in moisture and in hydrolysis of polysaccharides, resulting in a lower increase in T.S.S. These results are similar to the findings of Badshah *et al* (1994) and Hussain *et al* (2001). Data on storage-interval means depict a gradual increase in TSS percentage with increasing storage-interval. Maximum T.S.S. ^oBrix (17.61) was seen at 8 days of storage compared to 0 day of storage (6.07). This increasing trend in T.S.S. in response to prolonged storage was probably due to hydrolysis of polysaccharides and the concentrated juice resulting from dehydration. These results are in accordance with findings of Farooqi *et al* (1973) and Wills *et al* (1980) on apple fruits, who reported T.S.S. of apple fruits to increase during storage.

Titrable Acidity (%)

Data on titrable acidity (Table4) showed that treatment $CaCl_2$ 1.5% gave the highest value (1.249%), whereas lowest value (1.117%) was observed in Control. This may be due to lower oxidation in fruits, confirming the finding of Drake and Spayed (1983). They found 'Golden delicious' apples, when treated with $CaCl_2$ had higher titratable acidity than untreated apples. Calcium decreased the degradation of acids, thus maintaining integrity of the cells. These results are in accordance with findings of Hussain *et al* (2001) and Wojcik (2001). Data on storage interval showed an increase in acidity in all treatments during storage. On 0 day of storage, titrable acidity was 1.30%, which decreased to 1.00% at 8 days of storage.

Vitamin C (ascorbic acid mg/100g juice)

Comparison of different treatments and storage intervals in Table 4 depicts highest ascorbic acid content

(11.50mg/100g juice) in fruits treated with $CaCl_2$ 1.5%, and the lowest in Control (9.16mg/100gm pulp). Perhaps calcium chloride delayed oxidation in fruits, resulting in higher ascorbic acid content. These results are in accordance with Kropp and Ben (1985) on apples who found a slight decrease in ascorbic acid content in fruits treated with various coating and packaging materials compared to Control.

Data on storage-interval showed that in all the treatments, ascorbic acid content decreased as storage-period extended. These results are similar to those of Rana *et al* (1992) who reported juice and ascorbic acid content of apples to decrease with storage.

TSS / Titrable Acidity (TA)

Data on TSS/acid ratio are presented in Table 3. Maximum average TSS/TA ratio during storage was recorded with $CaCl_2$ 1.5% (16.257), followed by GA_3 20ppm (16.095). Kher *et al* (2000) too reported maximum average TSS/acid ratio in storage with 60ppm NAA (29.48), followed by 90ppm GA_3 (28.53) in guava. Data on storage-interval means showed a continuous increase in TSS/Acid ratio from the second day upto 8 days of storage. This increasing trend may have resulted from considerable decrease in acid content and low decrease in TSS of fruits during storage.

Total sugars (%): Total sugars showed an increasing trend in all the treatments (Table7). Maximum sugar percentage (12.14) was found with $CaCl_2$ 1.5% and minimum (11.03) with GA_3 10ppm followed by Control (11.08). Calcium pectate is an important component of the cell wall, therefore, adequate amounts of calcium may help reduce conversion of acids into sugars. These results are supported by the study of Bhadra and Sen (1997) on custard apple who reported a gradual increase in sugar content and decrease in acidity in fruits treated with calcium coating-materials. Sheikh *et al* (2000) and El-Shemy (1998) also reported calcium chloride as pre-harvest spray on 'Le Conte' pear fruits to result in higher levels of reducing sugars than in Control during storage.

Data on storage-interval means showed a continuous increase in total sugars from 0 day to 8 days of storage. This gradual increase in total sugar percentage may have occurred due to increased dehydration of fruits resulting in higher levels of concentrated juice. These results are supported by Badshah *et al* (1994) and Gul *et al* (1990) who found the sugar content in apple and mango to increase with storage.

Based on results of this study, it can be concluded that pre-harvest foliar application of $CaCl_2$ @ 1.5% in apricot cv. Harcot at three stages, i.e., 80% blooming, fruit-set, and 15 days prior to harvest enhances the shelf-life of fruits and results in better quality under ambient storage conditions, up from 3-5 days of storage to 8 days.

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