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HA Patel
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

MJ Patel
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Riddhi Vasara
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

NG Patel
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

NK Sutariya
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Correspondence
HA Patel
Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Effect of pre-harvest spray of calcium on bio-chemical parameters of sapota [*Manilkara achras* (Mill.) Forsberg] Fruits cv. Kalipatti

HA Patel, MJ Patel, Riddhi Vasara, NG Patel and NK Sutariya

Abstract
An experiment was carried out at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *summer* 2016. The experiment consisting of 10 treatments of chemicals like $CaCl_2$ @ 0.5, 1 and 1.5%; Ca $(NO_3)_2$ @ 0.5, 1 and 1.5%; $CaSO_4$ @ 0.5, 1 and 1.5% along with control (water) sprayed on 20 years old tree of sapota cv. Kalipatti three weeks before harvest and fruits were stored at ambient condition. The spraying of $CaCl_2$ @ 1% found effective for increasing total soluble solids, total sugar, reducing sugar, non-reducing sugar, ascorbic acid with minimum acidity and moisture content of sapota fruits. While, pre-harvest spraying of $CaCl_2$ @ 1.5% improved calcium content of sapota fruits.

Keywords: Pre-harvest spray, calcium, biochemical parameter, sapota

1. Introduction
Sapota [*Manilkara achras* (Mill.) Forsberg] belongs to family Sapotaceae, popularly known as chiku in India. It is native place to tropical America, most probably South Mexico or Central America. In India it was introduced probably in 1898 in Maharashtra in village name "Golwad" (Cheema *et al.,* 1954) [4]. Thereafter, it spreaded to the nearer states and now it occupies a significant position among the fruit crops in India. It has emerged as an important fruit crop of costal India especially the region between Mumbai and Surat in Gujarat (Chundawat, 1991) [5]. In India, sapota ranks fifth in both production and consumption next to mango, banana, citrus and grape. India is considered to be the largest producer of sapota in the world. It was cultivated under 177.0 thousand hectares area with a production of 1744.3 thousand MT and 9.9 MT/ha productivity (NHB, 2015). The major sapota growing states are Maharashtra, Gujarat, Tamil Nadu, Andra Pradesh, Karnataka, West Bengal, Uttar Pradesh, Punjab and Haryana. In Gujarat, it was grown under 28.6 thousand hectares area with a production of 297.0 thousand MT and 10.4 MT/ha productivity (NHB, 2015). The most popular variety grown in Gujarat state is 'Kalipatti'. Calcium has received considerable attention in recent years due to its desirable effect in delaying ripening and senescence, increase in firmness, vitamin C and phenolic contents, reduction in respiration and there by extending storage life due to reducing the incidence of physiological disorders and storage rots. Calcium is essential for structural integrity of both the cell wall and plasma membrane.
Calcium treatments have known to delay softening and improve the fruit quality. Exogenous application of 'Ca' has been shown to delay senescence of many fruit tissue slices, ethylene production in particular and the onset of lipid peroxidation (Sharma *et al.,* 1996) [14]. Calcium alters intracellular and extracellular processes which retard ripening exemplified by lower the rates of colour change, softening, CO_2 and ethylene production, increase in sugar and a reduction in total acid content.

Materials and Methods
An investigation entitled "Effect of pre-harvest spray of calcium on quality and shelf life of sapota [*Manilkara achras* (Mill.) Forsberg] fruits cv. Kalipatti'' was carried out at Horticultural Research Farm and P. G. Laboratory, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during March-April 2016.
The experiment was carried out in Completely Randomized Design with three repetitions comprising ten treatments. The 20 years old tree of sapota cv. Kalipatti were sprayed with different chemicals [$CaCl_2$ @ 0.5, 1 and 1.5%; $Ca(NO_3)_2$ @ 0.5,1 and 1.5%; $CaSO_4$ @ 0.5, 1 and 1.5%] along with control (water spray) three weeks before harvest and fruits were stored at ambient condition. The observations bio-chemical characters like total soluble solids, acidity,

total sugar, reducing sugar, non-reducing sugar, ascorbic acid, calcium content, moisture content and organoleptic score of the fruit were recorded during the storage period. The fruits were subjected to various quantitative and qualitative analyses at 2nd, 4th, 6th and 8th days of storage period. The data collected for different observations were subjected to statistical analysis by adopting 'Analysis of variance' techniques as described by Panse and Sukhatme (1967) [11].

Results and Discussion

The results obtained from the present investigation are summarized below:

Total soluble solids (°Brix)

The data revealed that during the entire storage period different chemicals exerted their significant effects on total soluble solids of fruit.

The significantly highest total soluble solids (21.67, 23.00, 24.97 and 22.83 °Brix) was recorded with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th and 8th day of storage period, respectively. The increased in TSS during storage period up to 6 days was due to the breakdown of complex polymers in to simple substances by hydrolytic enzymes, which at later storage period got utilized during respiration. Similar findings have been reported by Bhalerao *et al.* (2010) [1] and Desai (2016) [6] in sapota, Ramakrishna *et al*. (2001) [13] in papaya, Wahdan *et al.* (2011) [16], Vidya *et al.* (2014) [15] in mango.

Acidity (%)

The data revealed non-significant difference between treatments for acidity of sapota fruits at 2nd, 4th and 6th day of storage period. However, at 8th day of storage period the significantly minimum acidity (0.17%) was recorded with T_1 ($CaCl_2$ @ 0.5%) and T_2 ($CaCl_2$ @ 1%). The decline in acidity after some days may be due to the conversion of carbohydrate to sugar. The similar result on acidity was also reported by Bhanja and Lenka (1994), Bhalerao *et al.* (2010) [1] and Desai (2016) [6] in sapota, Jayachandran *et al.* (2005) [7], Karemera and Habimana (2014) [8] and Vidya *et al.* (2014) [15] in mango.

Total sugar (%)

The data revealed that at 2nd, 4th, 6th and 8th day of storage period different chemicals shows significant effect on the accumulation of total sugar. The significantly maximum total sugar (16.80, 20.03, 24.83 and 17.57%) was observed with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th and 8th day of storage period, respectively. The increase in total sugar during initial storage period might be due to the hydrolysis of starch into sugar as on complete hydrolysis of starch, no further increase occurs and subsequently a decline in total sugar is predictable. The present investigation is in conformity with the results reported by Lakshmana and Reddy (1999) [9], Bhalerao *et al.* (2010) [1] and Desai (2016) [6] in sapota, Rajkumar *et al*. (2006) [12] in papaya, Wahdan *et al.* (2011) [16] and Vidya *et al.* (2014) [15] in mango, Bisen *et al.* (2014) [3] in guava.

Table 1: Effect of pre-harvest spray of calcium on total soluble solids, acidity and total sugar of sapota fruits cv. Kalipatti

Treatments	Total soluble solids (°Brix)				Acidity (%)				Total sugar (%)			
	Days after harvesting											
	2nd	4th	6th	8th	2nd	4th	6th	8th	2nd	4th	6th	8th
T_1 ($CaCl_2$) @ 0.5%	20.67	22.83	24.17	22.17	0.21	0.20	0.19	0.17	15.70	19.00	23.60	17.10
T_2 ($CaCl_2$) @ 1%	21.67	23.00	24.97	22.83	0.21	0.20	0.18	0.17	16.80	20.03	24.83	17.57
T_3($CaCl_2$) @ 1.5%	20.60	22.50	23.83	21.67	0.22	0.21	0.19	0.18	15.37	18.77	22.47	17.03
T_4 [$Ca(NO_3)_2$] @ 0.5%	19.67	22.00	23.17	21.00	0.22	0.21	0.20	0.18	15.10	18.17	21.63	16.20
T_5 [$Ca(NO_3)_2$] @ 1%	20.33	22.17	23.67	21.50	0.22	0.21	0.19	0.18	15.30	18.57	21.77	16.73
T_6 [$Ca(NO_3)_2$] @ 1.5%	19.50	21.83	23.00	20.83	0.23	0.22	0.20	0.19	15.00	17.73	20.77	16.17
T_7 ($CaSO_4$) @ 0.5%	18.67	20.33	22.00	20.00	0.23	0.22	0.20	0.19	14.60	17.60	20.33	15.73
T_8 ($CaSO_4$) @ 1%	15.50	18.50	19.67	17.83	0.24	0.23	0.21	0.20	13.50	16.47	19.17	15.20
T_9 ($CaSO_4$) @ 1.5%	17.33	19.50	21.50	19.83	0.23	0.22	0.21	0.19	14.43	17.27	20.30	15.67
T_{10} Control (Water spray)	14.17	16.50	18.00	16.00	0.24	0.23	0.23	0.20	13.23	15.83	16.10	14.17
S.Em. ±	0.39	0.44	0.53	0.47	0.01	0.01	0.01	0.01	0.14	0.20	0.26	0.15
C. D. (P=0.05)	1.14	1.30	1.57	1.37	NS	NS	NS	0.02	0.41	0.58	0.78	0.44
C.V.%	3.57	3.65	4.11	3.96	6.69	7.50	8.13	5.92	1.63	1.91	2.17	1.61

Table 2: Effect of pre-harvest spray of calcium on reducing sugar, non-reducing sugar and ascorbic acid of sapota fruits cv. Kalipatti

Treatments	Reducing sugar (%)				Non-reducing sugar (%)				Ascorbic acid (mg/100 g pulp)			
	Days after harvesting											
	2nd	4th	6th	8th	2nd	4th	6th	8th	2nd	4th	6th	8th
T_1 ($CaCl_2$) @ 0.5%	6.80	8.50	10.23	9.97	8.90	10.50	13.37	7.13	22.50	20.60	19.13	17.23
T_2 ($CaCl_2$) @ 1%	7.07	8.53	10.57	10.17	9.73	11.50	14.40	7.40	22.53	20.83	19.77	18.00
T_3($CaCl_2$) @ 1.5%	6.67	8.47	9.43	9.17	8.70	10.30	13.03	7.87	22.10	20.17	18.83	17.10
T_4 [$Ca(NO_3)_2$] @ 0.5%	6.40	8.40	8.73	8.53	8.70	9.77	12.90	7.67	21.03	19.93	17.83	15.77
T_5 [$Ca(NO_3)_2$] @ 1%	6.53	8.43	9.17	8.73	8.77	10.13	12.60	8.00	21.67	20.07	18.67	16.57
T_6 [$Ca(NO_3)_2$] @ 1.5%	6.27	7.93	8.70	8.23	8.73	9.80	12.07	7.93	20.43	19.27	17.33	15.70
T_7 ($CaSO_4$) @ 0.5%	6.23	7.83	8.33	8.13	8.37	9.77	12.00	7.60	20.40	16.33	15.17	14.83
T_8 ($CaSO_4$) @ 1%	5.70	7.57	8.20	8.00	7.80	8.90	10.97	7.20	18.07	15.33	15.03	14.00
T_9 ($CaSO_4$) @ 1.5%	5.80	7.67	8.30	8.07	8.63	9.60	12.00	7.60	18.37	15.93	15.00	14.31
T_{10} Control (Water spray)	5.40	7.23	7.77	7.47	7.83	8.60	8.33	6.70	17.60	15.23	14.23	13.65
S.Em. ±	0.07	0.10	0.10	0.12	0.16	0.25	0.29	0.19	0.90	0.79	0.63	0.64
C. D. (P=0.05)	0.21	0.29	0.28	0.35	0.46	0.72	0.86	0.55	2.66	2.34	1.86	1.90
C.V.%	1.99	2.14	1.85	2.40	3.16	4.29	4.16	4.28	7.63	7.47	6.37	7.08

Table 3: Effect of pre-harvest spray of calcium on calcium content and moisture content of sapota fruits cv. Kalipatti

Treatments	Calcium content (mg/100 g pulp)				Moisture content (%)			
	Days after harvesting							
	2nd	4th	6th	8th	2nd	4th	6th	8th
T_1 ($CaCl_2$) @ 0.5%	7.80	7.60	6.00	5.82	64.01	68.26	70.53	71.15
T_2 ($CaCl_2$) @ 1%	9.13	8.67	6.87	6.43	63.78	67.55	69.85	70.60
T_3($CaCl_2$) @ 1.5%	9.90	9.67	8.40	8.10	65.75	68.66	70.63	71.81
T_4 [$Ca(NO_3)_2$] @ 0.5%	7.40	7.20	5.73	5.60	67.13	69.45	71.08	71.92
T_5 [$Ca(NO_3)_2$] @ 1%	8.60	8.33	6.67	6.33	66.15	69.29	70.98	71.86
T_6 [$Ca(NO_3)_2$] @ 1.5%	9.65	9.20	7.87	7.50	68.12	69.58	71.14	72.14
T_7 ($CaSO_4$) @ 0.5%	7.22	6.80	5.27	5.13	69.59	72.60	75.18	75.77
T_8 ($CaSO_4$) @ 1%	8.00	7.80	6.33	6.23	69.50	71.58	72.40	73.85
T_9 ($CaSO_4$) @ 1.5%	9.47	8.87	7.07	6.70	68.17	70.95	71.57	72.23
T_{10} Control (Water spray)	7.05	6.65	5.07	5.03	72.80	74.66	75.73	77.05
S.Em. ±	0.19	0.13	0.20	0.17	1.22	1.42	1.35	1.40
C. D. (P=0.05)	0.57	0.40	0.58	0.50	3.60	NS	NS	NS
C.V.%	3.95	2.88	5.17	4.66	3.13	3.50	3.26	3.33

Reducing sugar (%)

Similar trends was observed in case of reducing sugar (%) at 2nd, 4th, 6th and 8th day of storage period, different chemicals shows significant effect on the accumulation of reducing sugar. The significantly maximum reducing sugar (7.07, 8.53, 10.57 and 10.17%) was observed with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th and 8th day of storage period, respectively. The increase of reducing sugar content by calcium application might be due to the less utilization of sugar in respiration and conversion of starch into sugar, while the subsequent decline was perhaps due to consumption of sugar for respiration during storage. Similar findings have been reported by Bhalerao *et al.* (2010) [1] and Desai (2016) [6] in sapota, Karemera and Habimana (2014) [8] in mango.

Non–reducing sugar (%)

Likewise, non-reducing sugar was found significantly maximum with T_2 ($CaCl_2$ @ 1%) *i. e.* 9.73, 11.50 and 14.40 per cent at 2nd, 4th and 6th day of storage period, respectively. While, at 8th day of storage period the significantly maximum non-reducing sugar (8.00%) was found with T_5 [($Ca(NO_3)_2$ @ 1%]. The increase in non-reducing sugar during storage was due to the conversion of starch into sugar. While, decrease in sugar is may be due to the consumption of sugar for respiration during storage period. The findings obtained in the present investigation can be compared to those obtained by Bhalerao *et al.* (2010) [1] and Desai (2016) [6] in sapota, Karemera and Habimana (2014) [8] in mango, Bisen *et al.* (2014) [3] in guava.

Ascorbic acid (mg/100 g pulp)

The ascorbic acid content showed higher initially then subsequently decreases during storage period. The data revealed that at 2nd, 4th, 6th and 8th day of storage period, and different chemicals recorded significant effect on the accumulation of ascorbic acid (mg/100 g pulp). The significantly maximum ascorbic acid (22.53, 20.83, 19.77 and 18.00 mg/100 g pulp) was recorded with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th and 8th day of storage period, respectively The decline in ascorbic acid content may be due to the degradation through enzymatic oxidation of L-ascorbic acid to dehydro ascorbic acid during metabolic process.

The present investigation is in conformity with the results reported by Desai (2016) [6] in sapota, Bisen *et al.* (2014) [3] in guava.

Calcium content (mg/100 g pulp)

The data revealed that different calcium sources recorded significant effect on the accumulation of calcium content. The significantly maximum calcium content was recorded with T_3 ($CaCl_2$ @ 1.5%) *i. e.* 9.90, 9.67, 8.40 and 8.10 mg/100 g pulp at 2nd, 4th, 6th and 8th day of storage period, respectively. The increment in calcium content might be due to the pre-harvest foliar application of $CaCl_2$ @ 1.5% to sapota tree. The present investigation is in conformity with the results reported by Bisen *et al.* (2014) [3] in guava, and Wahdan *et al.* (2011) [16] in mango.

Moisture content (%)

The data observed non-significant difference between treatments for moisture content of sapota fruits at 4th, 6th and 8th day of storage period. While, at 2nd day of storage period the significantly minimum moisture content (63.78%) was recorded with T_2 ($CaCl_2$ @ 1%). which was at par with T_1, T_3, T_4 and T_5. This decrease in moisture content during storage was due to the either evaporation losses or utilization of water in various senescence processes, may have also resulted in reduced firmness of the fruits. The fruits sprayed with calcium chloride retained higher moisture content probably by delaying senescence or by reducing evaporation losses by stabilizing the membrane permeability and cell wall structure. The findings obtained in the present investigation can be compared to those obtained by Yadav *et al.* (2009) [17] in ber.

Conclusion

On the basis of findings, it can be concluded that effect of pre-harvest spraying of $CaCl_2$ @ 1% found effective for increasing total soluble solids, total sugar, reducing sugar, non-reducing sugar, ascorbic acid with minimum acidity and moisture content of sapota fruits. While, the spraying of $CaCl_2$ @ 1.5% improved calcium content of sapota fruits.

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