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Pre-harvest spray of calcium on physical parameters of sapota [*Manilkara achras* (Mill.) forsberg] fruits cv. Kalipatti

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Abstract
An experiment to evaluate pre-harvest spray of different calcium sources on quality and shelf life of sapota fruits cv. Kalipatti was carried out at Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *summer* 2016. Pre-harvest (three weeks before harvest) spraying of $CaCl_2$ @ 1.5% improved fruit weight and fruit volume of sapota fruits. While, the spraying of $CaCl_2$ @ 1% found effective for increasing fruit firmness, marketable fruits and shelf life with minimum physiological weight loss and spoilage loss of sapota fruits.

Keywords: Pre-harvest spray, calcium, physical parameters, sapota

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 spread 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 coastal 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) [10]. 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) [10]. 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) [12]. 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.

Mterials and Methods
The present experiment was carried out at Horticultural Research Farm and P. G. Laboratory, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during April, 2016. The experiment was laid 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 thirty fruits (15 fruits in two lots one lot kept for observations for physical parameters while other lot of 15 fruits kept for shelf life) were stored

at ambient condition. The observations like fruit weight, fruit volume, fruit firmness, physiological weight loss, spoilage loss, marketable fruits and shelf life were recorded during the storage period. The fruits were subjected to various quantitative and qualitative analysis at alternative day of storage period till 50% fruits is optimum ripening stage.

Results and Discusion

The results obtained from the present investigation on different physical parameters of sapota fruits are summarized below:

Table 1: Pre-harvest spray of calcium on fruit weight, fruit volume, fruit firmness and physiological loss in weight of sapota fruits

Treatments	Fruit weight (g)	Fruit volume (cc)	Fruit firmness (kg/cm^2)				Physiological loss in weight (%)					
			Days after harvesting									
			2nd	4th	6th	8th	10th	2nd	4th	6th	8th	10th
T_1 $CaCl_2$ @ 0.5%	71.59	65.44	9.03	7.33	4.03	2.80	0.76	3.30	5.10	7.60	10.50	13.00
T_2 $CaCl_2$ @ 1%	72.36	65.91	9.10	7.47	4.07	2.94	0.84	3.10	5.03	7.50	10.10	12.33
T_3 $CaCl_2$ @ 1.5%	72.61	66.97	8.90	6.90	4.00	2.75	0.66	3.50	5.50	7.90	12.00	14.21
T_4 $Ca(NO_3)_2$ @ 0.5%	68.50	61.06	8.83	6.67	3.73	2.60	0.60	4.00	6.30	8.58	12.71	14.86
T_5 $Ca(NO_3)_2$ @ 1%	68.79	62.62	8.87	6.83	3.87	2.70	0.64	3.80	6.03	8.47	12.20	14.33
T_6 $Ca(NO_3)_2$ @ 1.5%	70.94	63.09	8.50	6.63	3.63	2.54	0.54	4.15	6.32	8.63	13.10	16.50
T_7 $CaSO_4$@ 0.5%	66.45	58.23	7.60	6.30	3.27	1.90	0.46	4.53	6.52	9.10	15.10	18.61
T_8 $CaSO_4$ @ 1%	67.49	59.96	7.97	6.57	3.30	2.05	0.49	4.40	6.45	8.88	14.90	18.33
T_9 $CaSO_4$ @ 1.5%	68.25	60.63	8.13	6.60	3.60	2.34	0.51	4.30	6.40	8.85	14.80	18.10
T_{10} Control (Water spray)	56.85	51.39	7.30	5.63	3.07	1.55	0.43	5.80	7.20	10.10	16.60	19.27
S.Em. ±	2.63	1.85	0.36	0.29	0.21	0.09	0.03	0.17	0.23	0.24	0.31	0.39
C. D. (P=0.05)	7.75	5.45	1.05	0.86	0.62	0.28	0.08	0.50	0.68	0.71	0.91	1.15
C.V.%	6.65	5.20	7.32	7.51	9.95	6.75	7.76	7.21	6.60	4.85	4.04	4.24

Fruit weight

Fruit weight was influenced significantly by different pre-harvest treatments and found maximum fruit weight (72.61 g) with T_3 ($CaCl_2$ @ 1.5%) which was at par with all the treatments except T_{10} (Control). This increase in fruit weight might be due to the application of calcium and its effects on formation and changes of carbohydrates and carbohydrate enzymes, other reasons might be the reduction of abscission and the calcium influence in maintaining the middle lamella cells. The finding obtained in the present investigation can be compared to those obtained by Bhalerao *et al.* (2009) [2] in sapota and Karemera and Habimana (2014) [8] in mango.

Fruit Volume

Fruit volume was significantly influenced by different sources of calcium. The significantly maximum fruit volume (66.97 cc) was observed with T_3 ($CaCl_2$ @ 1.5%). This increase in fruit volume might have been an account of the overall improvement in the fruit growth due to the application of calcium which favourably increased physical parameters.
This result is in the close vicinity with the findings of Bhalerao *et al.* (2009) [2] in sapota and Vidya *et al.* (2014) [15] in mango.

Fruit firmness

The data (Table 1) revealed that different pre-harvest treatments exerted their significant effects on fruit firmness during storage period. The significantly maximum fruit firmness (9.10, 7.47, 4.07, 2.94 and 0.84 kg/cm^2) was recorded with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th, 8th and 10th day of storage period, respectively. This was probably due to the application of calcium which helped to maintain the structure and function of cell wall. It was observed that fruits having higher concentration of calcium compound in pre-harvest sprays retained higher firmness. This was probably due to the more calcium content in peel and pulp which helped to maintain the structure and function of cell wall. Calcium made the complex with pectin and formed calcium pectate and thereby increased the firmness of the fruits. The similar result was also obtained by Lakshmana and Reddy (1999) [9], Aradhya *et al*. (2006) [1] and Desai (2016) [6] in sapota, Rajkumar *et al*. (2006) [11] in papaya.

Table2: Pre-harvest spray of calcium on spoilage, marketable fruits and shelf life of sapota fruits

Treatments	Spoilage loss (%)					Marketable fruits (%)					Shelf life (Days)
	Days after harvesting										
	2nd	4th	6th	8th	10th	2nd	4th	6th	8th	10th	
T_1 $CaCl_2$ @ 0.5%	0.00	6.21	20.50	37.78	49.66	100	93.79	79.50	62.22	50.34	10.03
T_2 $CaCl_2$ @ 1%	0.00	6.19	20.00	34.06	47.82	100	93.81	80.00	65.94	52.18	10.20
T_3 $CaCl_2$ @ 1.5%	0.00	6.28	20.73	38.83	53.54	100	93.72	79.27	61.17	46.46	9.03
T_4 $Ca(NO_3)_2$ @ 0.5%	0.00	6.36	20.87	39.50	57.39	100	93.64	79.13	60.50	42.61	8.73
T_5 $Ca(NO_3)_2$ @ 1%	0.00	6.33	20.75	39.17	56.71	100	93.67	79.25	60.83	43.29	8.95
T_6 $Ca(NO_3)_2$ @ 1.5%	0.00	6.53	21.17	40.00	59.58	100	93.47	78.83	60.00	40.42	8.30
T_7 $CaSO_4$ @ 0.5%	0.00	13.06	36.19	56.28	71.11	100	86.94	63.81	43.72	28.89	7.02
T_8 $CaSO_4$ @ 1%	0.00	13.05	34.46	54.45	69.83	100	86.95	65.54	45.55	30.17	7.38
T_9 $CaSO_4$ @ 1.5%	0.00	12.72	30.45	52.40	69.50	100	87.28	69.55	47.60	30.50	7.60
T_{10} Control (Water spray)	0.00	13.34	38.85	61.19	75.55	100	86.66	61.15	38.81	24.45	6.80
S.Em. ±	-	0.37	1.37	2.15	2.30	-	0.37	1.37	2.15	2.30	0.39
C. D. (P=0.05)	-	1.08	4.04	6.35	6.79	-	1.08	4.04	6.35	6.79	1.16
C.V.%	-	7.03	8.98	8.22	7.45	-	0.70	3.22	6.82	10.92	8.10

Physiological loss in weight

The physiological loss in weight (3.10, 5.03, 7.50, 10.10 and 12.33%) was observed significantly lower with T_2 ($CaCl_2$ @ 1%) at 2nd, 4th, 6th, 8th and 10th day of storage period, respectively. This decrease in weight loss might be due to the retarding action of calcium on the rate of respiration, decay

and prevents cellular disintegration by maintaining protein and nucleic acid synthesis and thus, delays senescence. The increased weight loss in untreated fruits might be due to the increased storage break down associated with higher respiratory rate as compared to calcium treated fruits. The result of present study is in conformation with the findings of Bhalerao *et al.* (2009) [2] and Desai (2016) [6] in sapota, Rajkumar *et al*. (2006) [11] in papaya, Singh *et al.* (2012) [13] and Bhusan *et al*. (2015) [3] in mango.

Spoilage Loss

There was no spoilage loss of fruit observed on 2nd day of storage period. But on 4th, 6th, 8th and 10th day of storage period the significantly lowest spoilage loss (6.19, 20.00, 34.06 and 47.82%) was observed with T_2 ($CaCl_2$ @ 1%), respectively. Calcium treated fruits showed significantly lesser extent of rotting which might be due to the better fruit firmness and calcium content in peel, ultimately resulted stronger intracellular organization and rigidified cell wall. The present investigation is in conformity with the results reported by Lakshmana and Reddy (1999) [9], Aradhya *et al*. (2006) [1], Bhalerao *et al.* (2009) [2] and Desai (2016) [6] in sapota.

Marketable fruits

The data (Table 2) showed the significant effects of different chemicals on marketable fruits of sapota fruits at 2nd, 4th, 6th, 8th and 10th day of storage period. There was 100% marketable fruits observed on 2nd day of storage period. But on 4th, 6th, 8th and 10th day of storage period the significantly highest marketable fruits (93.81, 80.00, 65.94 and 52.18%) was observed with T_2 ($CaCl_2$ @ 1%), respectively. The increased in marketable fruits might be due to the increase in concentration of calcium in middle lamella of cell wall which provide physical strength to cell wall and improved the fruit colour development and appearance. Calcium treated fruits showed lower rotting or spoilage hence increase marketable fruits. The finding is in agreement with the results reported by Singh *et al.* (2012) [13] and Bhusan *et al*. (2015) [3] in mango.

Shelf Life

Shelf life was increase significantly by pre-harvest spray of different calcium sources. The significantly maximum shelf life (10.20 days) was observed with T_2 ($CaCl_2$ @ 1%) as compared to other pre-harvest treatments which was at par with T_1. Calcium treatments have better shelf life because of it helps in structural integrity of both the cell wall and plasma membrane which delaying ripening and extending storage life. The binding action of calcium in the cell wall suppresses ethylene production and retard ripening.

Effect of calcium chloride was found to be most effective to prolong shelf life by decreasing the respiration rate and improving the shelf life. The similar result on shelf life was also reported by Aradhya *et al*. (2006) [1], Sudha *et al*. (2007) [14], Bhalerao *et al.* (2009) [2] and Desai (2016) [6] in sapota, Rajkumar *et al*. (2006) [11] in papaya, Gill *et al.* (2005) [7] and Vidya *et al.* (2014) [15] in mango.

Conclusion

On the basis of findings, it can be concluded that pre-harvest (three weeks before harvest) spraying of $CaCl_2$ @ 1.5% improved weight and volume of sapota fruits. While, the spraying of $CaCl_2$ @ 1% found effective for increasing fruit firmness, marketable fruits and shelf life with minimum physiological loss in weight and spoilage loss of sapota fruits.

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