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Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on physical parameters, post-harvest losses and shelf life of sapota [*Manilkara achras* (Mill.) Forsberg] fruits cv. Kalipatti

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Abstract
Investigation was conducted to study the "Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on physical parameters, post-harvest losses and shelf life of sapota fruits cv. Kalipatti". Pre-harvest spraying treatments comprises different chemicals (Calcium chloride @ 2 %, Calcium nitrate @ 2 %, Calcium sulphate @ 2 % and Potassium chloride @ 2 %) and different level of plant growth regulators (GA_3 @ 50 and 100 mg / l, NAA @ 50 and 100 mg / l) with control (Water spray and Absolute). After harvest fruits were stored at room temperature. Fruit weight and fruit volume was significantly increase when trees were sprayed with GA_3 @ 100 mg / l one month before harvest. However, minimum physiological loss in weight and spoilage percentage were noticed under $CaCl_2$ @ 2 % treatment followed by treatment T_2 [$Ca(NO_3)_2$]. These treatments also improves the fruit firmness, shelf life and day taken to ripening of the sapota fruits during storage.

Keywords: Sapota, pre-harvest, Calcium chloride, Calcium nitrate, Calcium sulphate and Potassium chloride, GA_3, NAA

Introduction
Sapota [*Manilkara achras* (Mill.) Forsberg] popularly known as chiku in India. It is native to tropical America belongs to family Sapotaceae. Several varieties are grown in India out of which Kalipatti is one of the most popular and commercially important variety grown in Maharashtra, Karnataka and Gujarat states. South Gujarat is a horticulture belt were Kalipatti variety is grown on large area. However, sapota is highly perishable; the post-harvest life is very short. Being a climacteric fruit, sapota ripens within 3 to 4 days after harvest and soon after full ripened stage, rapid bio-chemical changes reduced the shelf life. To increase the shelf life through pre-harvest treatments is considered one of the major attempts in sapota cultivation. Various chemicals have been used to hasten or delay ripening, to reduce losses and to improve and maintain colour and quality by slowing down the metabolic activities of fruit. These chemicals arrest the growth and spread of microorganism by reducing the shriveling which ultimately leads to an increased shelf life and maintain the marketability of the fruit for a longer period. Therefore, the present investigation was carried out to find the "Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on physical parameters post-harvest losses and shelf life of sapota [*Manilkara achras* (Mill.) Forsberg] fruits cv. Kalipatti".

Materials and Methods
The present investigation was carried out during the year 2015 at Horticultural Research Farm and P. G. Laboratory, Deparment of Horticulture, Anand Agricultural University, Anand. Thirty uniform sapota trees of Kalipatti variety were marked and sprayed with different chemicals (Calcium chloride @ 2%, Calcium nitrate @ %, Calcium sulphate @ 2 % and Potassium chloride @ 2 %) and different level of plant growth regulators (GA_3 @ 50 and 100 mg / l, NAA @ 50 and 100 mg / l) with Control (Water spray and Absolute) at one month before harvest. There were three replication comprising one plant per replication. Fruits were harvested at optimum maturity stage from the representative trees. Two kg fruit from each replication of each treatment was stored at room temperature. The fruits were examined for shelf life and days taken to ripening and also assessed at 6th, 9^{th} and 12^{th} day of storage for physiological loss in weight, spoilage loss, fruit firmness. Physiological loss in weight of stored fruits was calculated by subtracting final weight from the initial weight of the fruits and express in percent.

The spoilage percentage was recorded by counting the number of fruits showing the decay symptoms and expressed as percentage of spoil fruits over total number of fruits. Fruit firmness was measured by penetometer. The experimental was laid out in completely randomized design with three repetitions and the data were analyzed accordingly.

Results and Discussion

The pre-harvest spray of different chemicals and plant growth regulators showed significant result (Table 1). The maximum fruit weight and fruit volume (89.85 g and 79.30 cc) was observed by treatments T_6 (GA_3 100 mg/l) followed by treatments T_8 (NAA 100 mg/l) i.e. 85.97 g and 78.42 cc, respectively. Increase in fruit weight and fruit volume might be due to the application of GA_3 which promotes cell elongation, cell enlargement and increase number of cell which ultimately increasing fruit weight and volume. Similar results were also obtained by Debaje *et al.* (2011) [2] and Jagtap *et al.* (2013) [3] in acid lime and Lal *et al*. (2013) [5] in guava. The maximum number of days (9.00) taken to ripening was recorded with treatment T_1 ($CaCl_2$ @ 2 %) followed by treatments T_2 [Ca $(NO_3)_2$ @ 2 %] and T_6 (GA_3 @ 100 mg/l) i.e. 8.67 and 8.33 days, respectively. The delay of ripening by $CaCl_2$ might be due to higher fruit calcium levels, it slowed down the process of ripening by retarding the pre-climacteric respiration rate and ethylene production. The present investigation is in conformity with the results obtained by Karemera and Habimana (2014) [4] in mango and Tsomu and Patel (2014) [10] in sapota. It is seen from the result presented in Table 1 that maximum shelf life (13.66 days) was recorded with treatment T_1 ($CaCl_2$ @ 2 %) followed by treatment T_2 [Ca $(NO_3)_2$ @ 2 %] i.e. 13.33 days. While minimum shelf life (8.67 days) was recorded in treatment T_{10} [Control (Absolute)]. 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. Similar results were also found by Rajput *et al.* (2008) [8] in guava and Tsomu and Patel (2014) [10] in sapota.

Data presented in Table 2 showed significant differences on fruit firmness during storage period. Treatment T_1 ($CaCl_2$ @ 2 %) recorded significantly, the highest fruit firmness (3.04, 1.91 and 0.66 kg/cm^2) at 6th, 9th and 12th day of storage period, respectively which, remained at par with T_2 [$Ca(NO_2)_3$ @ 2 %] at 12th day of storage period (0.61 kg/cm^2). The increase in fruit firmness by calcium spray probably due to calcium helped to maintain cell wall integrity as a consequence of influx of calcium that could helped in thickening of calcium pectate in the cell wall and thus assist in prolong shelf life (Rajkumar *et al.* 2006) [7]. Such types of results were also observed by Bisen *et al.* (2014) [1] in guava and Tsomu and Patel (2014) [10] in sapota.

The physiological loss in weight of sapota fruits was increased as the storage period advanced irrespective of any treatment. However, treatment T_1 ($CaCl_2$ @ 2 %) recorded significantly, the lowest physiological loss in weight (4.61, 6.38 and 10.11 %) at 6th, 9th and 12th day of storage period, respectively which, remained par with treatment T_2 [$Ca(NO_3)_2$ @ 2 %] i.e. 4.91, 6.97 and 10.28 %. The reduction in weight loss might be due to the maintenance of firmness of fruits by calcium which decreased the enzyme activity responsible for disintegration of cellular structure and decreases the gaseous exchange. The present investigation is in conformity with the results reported by Singh *et al*. (2013) [9] in ber and Tsomu and Patel (2014) [10] in sapota. The perusal of analysis (Table 2) showed significantly, the lowest spoilage loss (5.00, 38.33 and 65.00 %) in treatment T_1 ($CaCl_2$ @ 2 %) at 6th, 9th and 12th day of storage period, respectively followed by treatment T_2 ($Ca(NO_3)_2$ @ 2 %) i.e. 6.66, 41.67 and 68.33 %. Calcium treated fruits showed significantly lesser extent of spoilage loss which might be due to the higher fruit flesh and calcium content in peel, which resulted stronger intracellular organization and rigidified cell wall. The finding is agreement with the results reported of Lal *et al.* (2011) [6] in apricot and Tsomu and Patel (2014) [10] in sapota.

Table 1: Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on initial fruit weight, fruit volume, days taken to ripening and shelf life

Sr. No.	Treatments	Initial fruit weight (g)	Fruit volume (cc)	Day taken to ripening (Days)	Shelf life (Days)
1	T_1- $CaCl_2$ @ 2 %	80.30	73.69	9.00	13.66
2	T_2- $Ca(NO_3)_2$ @ 2 %	80.12	72.03	8.67	13.33
3	T_3- $CaSO_4$ @ 2 %	79.07	69.42	6.33	10.67
4	T_4- KCl @ 2 %	80.09	71.00	6.00	10.00
5	T_5- GA_3 @ 50 mg / l	81.22	74.09	8.00	12.00
6	T_6- GA_3 @ 100 mg / l	89.85	79.30	8.33	12.33
7	T_7- NAA @ 50 mg / l	81.02	73.78	7.33	11.33
8	T_8- NAA @ 100 mg / l	85.97	78.42	7.67	11.67
9	T_9- Control (Water spray)	77.01	69.30	5.00	9.33
10	T_{10}- Control (Absolute)	75.11	64.86	4.67	8.67
S.Em. ±		2.51	1.75	0.26	0.39
C.D. (P = 0.05)		7.40	5.16	0.76	1.16
C.V. %		5.36	4.17	6.30	6.04

Table 2: Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on fruit firmness, physiological loss in weight and spoilage loss during storage

Sr. No.	Parameters	Treatments	6th Day	9th Day	12th Day
1.	Fruit firmness (kg /cm^2)	T_1- $CaCl_2$ @ 2 %	3.04	1.91	0.66
		T_2- $Ca(NO_3)_2$ @ 2 %	2.54	1.10	0.61
		T_3- $CaSO_4$ @ 2 %	1.53	0.72	0.43
		T_4- KCl @ 2 %	1.34	0.58	0.42
		T_5- GA_3 @ 50 mg / l	2.33	0.93	0.53
		T_6- GA_3 @ 100 mg / l	2.47	0.98	0.55
		T_7- NAA @ 50 mg / l	1.97	0.78	0.47
		T_8- NAA @ 100 mg / l	2.12	0.82	0.48

		T_9- Control (Water spray)	1.14	0.53	0.35
		T_{10}- Control (Absolute)	1.02	0.48	0.30
		S.Em. ±	0.09	0.04	0.02
		C.D. (P = 0.05)	0.26	0.11	0.07
		C.V. %	7.70	7.07	8.53
2.	Physiological loss in weight (%)	T_1- $CaCl_2$ @ 2 %	4.61	6.38	10.11
		T_2- $Ca(NO_3)_2$ @ 2 %	4.91	6.97	10.28
		T_3- $CaSO_4$ @ 2 %	9.12	12.34	17.57
		T_4- KCl @ 2 %	9.84	13.57	18.52
		T_5- GA_3 @ 50 mg / l	7.29	11.11	16.41
		T_6- GA_3 @ 100 mg / l	6.40	9.78	13.75
		T_7- NAA @ 50 mg / l	8.50	11.34	15.77
		T_8- NAA @ 100 mg / l	7.90	10.91	15.17
		T_9- Control (Water spray)	10.56	14.97	19.99
		T_{10}- Control (Absolute)	13.11	17.11	23.35
		S.Em. ±	0.40	0.52	0.62
		C.D. (P = 0.05)	1.08	1.53	1.82
		C.V. %	7.71	7.84	6.65
3.	Spoilage loss (%)	T_1- $CaCl_2$ @ 2 %	5.00	38.33	65.00
		T_2- $Ca(NO_3)_2$ @ 2 %	6.66	41.67	68.33
		T_3- $CaSO_4$ @ 2 %	20.00	55.00	80.00
		T_4- KCl @ 2 %	18.33	56.67	81.67
		T_5- GA_3 @ 50 mg / l	11.66	50.00	75.00
		T_6- GA_3 @ 100 mg / l	10.00	48.33	73.33
		T_7- NAA @ 50 mg / l	16.66	53.33	78.33
		T_8- NAA @ 100 mg / l	15.00	51.67	76.67
		T_9- Control (Water spray)	23.33	61.66	83.33
		T_{10}- Control (Absolute)	25.00	63.33	85.00
		S.Em. ±	1.17	2.69	2.42
		C.D. (P = 0.05)	3.48	7.93	7.12
		C.V. %	13.46	8.95	5.45

Conclusion

In the light of the results obtained from investigation it can be concluded that pre-harvest (one month) spraying of GA_3 @ 100 mg/l increase the fruit weight and fruit volume of sapota fruit. While spraying of $CaCl_2$ @ 2 % or Ca $(NO_3)_2$ @ 2 % is effective and found promising for increasing fruit firmness, days taken to ripening and shelf life of sapota fruits with minimum physiological loss in weight and spoilage loss.

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