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Influence of pre-harvest spray of nutrients, growth regulators and low temperature storage on quality parameters of sapota under hill zone of Karnataka

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Abstract
An experiment was laid out to study the influence of foliar application of nutrients and plant growth regulators and low temperature storage of sapota fruits at Department of Fruit science, College of Horticulture-Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga during 2017-18. The experiment was laid out with fifteen treatments and three replications in randomized complete block design. The chemicals were sprayed on selected sapota trees at two intervals i.e. 40 days before the harvest and 20 days after the first spray and the harvested fruits were stored at 12±1˚C temperature in the cold storage. The study revealed that both pre-harvest application of $CaNO_3$ at 1% or $CaNO_3$ at 1.5% and low temperature found effective for increasing total soluble solids, total sugar, reducing sugar, non-reducing sugar, ascorbic acid with minimum acidity of sapota fruits.

Keywords: Sapota, pre-harvest, $CaNO_3$, total soluble solids, cold storage, acidity

Introduction
Sapota or sapodilla belongs to family sapotaceae, commonly known as chiku is a delicious fruit and valued for its mellow and sweet pulp mainly used for table purpose in India, which is the largest producer of sapota in the world. It is mainly grown in the states of Maharashtra, Karnataka and Gujarat. Being a climacteric fruit, the fruit ripens within 4 to 7 days after harvest with rapid bio-chemical changes occurring during this period which reduce the shelf life. The fruits are highly perishable and cannot be stored for long as it becomes over ripe and spoiled due to rapid degradative metabolism. Extension of post-harvest life and quality may be possible by checking the rate of respiration, transpiration and also retard by reducing microbial infection. These can be achieved to some extent by the use of growth regulators, chemicals and low temperature storage of fruits. Considering these facts, the present study was carried out.

Material and Methods
The present investigation was carried out at sapota orchard, College of Horticulture Mudigere, Chikamagalur during 2017-18. The experiment was laid out in randomized complete block design with three replications and fifteen treatments. The uniform sized sapota trees were marked and sprayed with different nutrients and plant growth regulators *viz*., T_1- control, T_2- GA_3 200ppm, T_3- GA_3 300ppm, T_4- Kinetin 50ppm, T_5- Kinetin 100ppm, T_6- 2,4-D 10ppm, T_7- 2,4-D 20ppm, T_8- Boron 0.2%, T_9- Boron 0.4%, T_{10}- $CaCl_2$ 1%, T_{11}- $CaCl_2$ 1.5%, T_{12}- $Ca(NO_3)_2$ 1%, T_{13}- $Ca(NO_3)_2$ 1.5%, T_{14}- KCl_2 0.5% and T_{15}- KCl_2 1% at two intervals i.e 40 days before harvest and 20 days after 1st spray. The fruits were harvested when colour of the fruit turned to light brown i.e potato colour. The harvested fruits were brought to the laboratory and two kilograms of sapota fruits for each treatment were kept for observation at 12±1˚C temperature in the cold storage. The fruits were assessed at every three days up to 27days of storage for biochemical parameters like TSS, acidity, total sugar, reducing sugar, non-reducing sugar and ascorbic acid.

Results and Discussion

In case of cold storage, initially the TSS increased up to 24th day of storage in all the treatments and later declined up to end of storage. The maximum fruit TSS from 3rd day to 27th day was observed in treatment T_{12} ($CaNO_3$ @ 1%) which was statistically on par with treatments T_{13} ($CaNO_3$ @ 1.5%). While, the minimum fruit TSS from 3rd day to 27thday of storage was noted in treatment T_1 (Control) from 3rd day to 18th day and 21st day onwards control fruits showed shrivelling and loss of appearance hence fruits were discarded. Increase in TSS during initial storage period might be due to hydrolysis of starch into sugar on complete hydrolysis of starch no further increase in TSS occur and subsequently decline in TSS is predictable. Similar findings have been reported by Bhalerao *et al.* (2010) [2] in sapota, Karemera and Habimana (2014) [7] in mango and Kirmani *et al.* (2015) [8] in Plum (Table-1).

The maximum reducing sugar (9.15 to 13.76%) was observed in treatment T_{12} ($CaNO_3$ @ 1%) from 3rd day to 27th day of cold storage period respectively (Table-2). Followed by treatment T_{13} ($CaNO_3$ @ 1.5%). The increase of reducing sugar content by calcium application might be due to the less utilization of sugar during respiration and conversion of starch in to sugar, while the subsequent decline was perhaps due to consumption of sugar for respiration during storage. The present investigation is in conformity with the results reported by Yadav *et al.* (2009) [12] in ber, Bhalerao *et al.* (2010) [2] in sapota, Alila and Achumi (2012) [1] in litchi, Bisen *et al.* (2014) [3] in guava and Kirmani *et al.* (2015) [8] in Plum.

The treatment T_{12} ($CaNO_3$ @ 1%) showed maximum non-reducing sugar (10.39%) up to 27th day of cold storage and it was on par with treatment T_{13} ($CaNO_3$ @ 1.5%) i.e 10.88% at 27th day of storage. The increase in non-reducing sugar during storage was due to the conversion of starch into sugar, while, the subsequent decrease in sugar was might be due to consumption of sugar for respiration during storage period. These results are in accordance with the findings of Bhalerao *et al.* (2010) [2] in sapota, Alila and Achumi (2012) [1] in litchi, Bisen *et al.* (2014) [3] in guava, Karemera and Habimana (2014) [7] in mango (Table-3).

The maximum fruit total sugar was observed in treatment T_{12} ($CaNO_3$ @ 1%) which was statistically on par with treatments T_{13} ($CaNO_3$ @ 1.5%). The increase in total sugar during initial storage period might be due to hydrolysis of starch into sugar as an 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 Alila and Achumi (2012) [1] in litchi, Karemera and Habimana (2014) [7] in mango, Bisen *et al.* (2014) [3] in guava and Kirmani *et al.* (2015) [8] in Plum (Table-4).

In cold storage, maximum ascorbic acid from 3rd day to 27th day (23.81 to 9.10 mg /100 g pulp) respectively was recorded in treatment T_{12} ($CaNO_3$ @ 1%) which, remained at par with treatment T_{13} ($CaNO_3$ @ 1.5%) i.e. 23.80 to 8.22 mg /100 g pulp from 3rd day to 27th day of cold storage period, respectively (Table-5). The gradual reduction in ascorbic acid content during entire storage period might be due to its degradation through enzymatic oxidation of L-ascorbic acid to dehydro ascorbic acid during metabolic processes. Similar observations was also recorded by Jawandha *et al.* (2007) [5] and Rajput *et al.* (2008) [10] and Ramezanian *et al.* (2009) [11] in pomegranate, and Lal *et al.* (2011) [9] in apricot

The data presented on acidity content showed non-significant differences among all the treatments under cold storage conditions of sapota fruit (Table 6). Nevertheless, acidity showed decrease during the storage period, the decline in acidity might be due to the conversion of acid into sugar. The similar result on acidity was also reported by Gupta *et al.* (1987) [4] in ber, Jayachandran *et al.* (2005) [6] in guava and Bhalerao *et al.* (2010) [2] in sapota.

Table 1: Effect of pre-harvest foliar application of nutrients and plant growth regulators on total soluble solids of sapota under cold storage at different days after harvest

Treatments	Total soluble solids (°Brix)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	14.73	18.17	18.97	19.53	20.07	19.54	--	--	--
T_2- GA_3 at 200 ppm	17.43	19.40	19.50	20.37	21.27	21.90	22.45	23.43	--
T_3- GA_3 at 300 ppm	17.27	19.20	19.37	20.30	21.25	21.87	22.33	23.37	--
T_4- Kinetin at 50 ppm	16.73	19.03	19.23	19.87	20.73	21.85	22.20	23.17	--
T_5- Kinetin at 100 ppm	16.60	19.02	18.40	19.57	20.53	21.57	21.97	23.00	--
T_6- 2,4-D at 10 ppm	17.83	19.60	19.90	20.50	21.40	22.00	22.70	23.63	--
T_7- 2,4-D at 20 ppm	17.73	19.59	19.80	20.53	21.33	21.97	22.47	23.57	--
T_8- Boron at 0.2%	18.47	19.93	20.10	21.00	21.67	22.50	23.40	24.23	--
T_9- Boron at 0.4%	18.40	19.91	20.07	20.87	21.57	22.43	23.10	--	--
T_{10}- $CaCl_2$ at 1%	19.00	20.23	20.33	21.07	21.77	23.07	23.83	24.47	22.83
T_{11}- $CaCl_2$ at 1.5%	18.97	20.20	20.27	21.05	21.74	22.53	23.67	24.30	22.71
T_{12}- $CaNO_3$ at 1%	19.13	21.03	20.70	21.23	22.07	23.13	24.33	24.83	23.80
T_{13}- $CaNO_3$ at 1.5%	19.10	20.33	20.50	21.13	22.03	23.10	24.10	24.67	23.12
T_{14}- KCl_2 at 0.5%	18.37	19.73	20.03	20.67	21.47	22.30	23.08	--	--
T_{15}- KCl_2 at 1%	18.07	19.70	20.00	20.53	21.42	22.17	22.77	--	--
S.Em ±	0.60	0.29	0.50	0.38	0.38	0.46	0.57	0.50	0.41
C.D at 1%	2.34	1.13	1.94	1.48	1.47	1.80	2.24	1.94	1.61

Note: Termination of shelf life

Table 2: Effect of pre-harvest foliar application of nutrients and plant growth regulators on reducing sugar content of sapota under cold storage at different days after harvest

Treatments	Reducing sugar (%)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	7.29	8.00	8.32	8.65	9.09	12.22	--	--	--
T_2- GA_3 at 200 ppm	8.08	8.48	9.58	9.88	11.69	12.97	13.66	12.29	--
T_3- GA_3 at 300 ppm	7.57	8.04	8.85	9.86	11.62	12.91	13.65	12.27	--
T_4- Kinetin at 50 ppm	7.56	8.15	9.00	9.23	11.04	12.85	13.30	12.19	--
T_5- Kinetin at 100 ppm	7.53	8.12	8.53	8.77	10.16	12.78	13.26	11.50	--
T_6- 2,4-D at 10 ppm	8.23	8.57	9.68	9.81	11.81	13.02	13.76	12.74	--
T_7- 2,4-D at 20 ppm	8.10	8.51	9.58	9.95	11.70	12.99	13.73	12.62	--
T_8- Boron at 0.2%	8.37	9.04	10.12	10.64	12.61	13.40	13.94	13.04	--
T_9- Boron at 0.4%	8.35	9.02	10.00	10.53	12.47	13.15	13.87	--	--
T_{10}- $CaCl_2$ at 1%	8.88	9.41	10.87	11.02	12.84	13.61	14.08	13.30	12.74
T_{11}- $CaCl_2$ at 1.5%	8.79	9.17	6.65	10.81	12.71	13.43	13.97	13.04	12.73
T_{12}- $CaNO_3$ at 1%	9.15	9.69	10.43	11.11	13.75	14.11	14.72	14.60	13.76
T_{13}- $CaNO_3$ at 1.5%	9.12	9.50	10.41	11.04	13.74	13.87	13.82	13.30	12.92
T_{14}- KCl_2 at 0.5%	8.33	8.65	9.91	10.48	12.06	13.10	13.21	--	--
T_{15}- KCl_2 at 1%	8.24	8.60	9.32	10.40	11.86	13.07	13.10	--	--
S.Em ±	0.10	0.12	0.14	0.13	0.67	0.09	0.07	0.04	0.01
C.D at 1%	0.40	0.46	0.54	0.52	2.63	0.36	0.27	0.15	0.04

Note: Termination of shelf life

Table 3: Effect of pre-harvest foliar application of nutrients and plant growth regulators on Non-reducing sugar content of sapota under cold storage at different days after harvest

Treatments	Non-reducing sugar (%)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	3.89	4.11	4.34	4.97	5.76	6.73	--	--	--
T_2- GA_3 at 200 ppm	4.02	4.17	5.32	5.83	6.88	7.92	9.47	9.90	--
T_3- GA_3 at 300 ppm	4.33	4.62	4.70	5.31	6.21	7.06	8.92	10.1	--
T_4- Kinetin at 50 ppm	4.15	4.19	4.88	5.56	6.48	7.04	8.87	9.21	--
T_5- Kinetin at 100 ppm	4.07	4.18	4.69	5.48	5.99	7.18	8.25	10.07	--
T_6- 2,4-D at 10 ppm	4.50	5.26	5.31	6.29	7.04	8.50	9.45	9.90	--
T_7- 2,4-D at 20 ppm	4.50	5.24	5.34	5.91	7.08	8.40	9.44	9.98	--
T_8- Boron at 0.2%	4.33	5.22	5.47	6.66	7.77	8.74	9.46	9.99	--
T_9- Boron at 0.4%	4.48	5.27	5.57	6.26	7.15	8.63	9.45	--	--
T_{10}- $CaCl_2$ at 1%	4.70	5.29	6.31	7.72	7.89	8.83	9.90	10.31	09.73
T_{11}- $CaCl_2$ at 1.5%	4.61	5.28	6.14	7.70	7.80	8.78	9.65	10.32	09.61
T_{12}- $CaNO_3$ at 1%	4.84	5.52	7.48	7.94	8.11	9.03	8.82	10.39	11.32
T_{13}- $CaNO_3$ at 1.5%	4.80	5.31	7.17	7.75	7.90	8.95	8.85	11.04	10.88
T_{14}- KCl_2 at 0.5%	4.54	5.23	5.52	5.75	7.04	8.59	8.79	10.03	--
T_{15}- KCl_2 at 1%	4.62	5.25	5.73	5.8	7.17	8.74	8.84	10.07	--
S.Em ±	0.06	0.16	0.05	0.05	0.05	0.05	0.03	0.03	0.04
C.D at 1%	0.23	0.63	0.20	0.20	0.19	0.18	0.12	0.13	0.17

Note: Termination of shelf life

Table 4: Effect of pre-harvest foliar application of nutrients and plant growth regulators on total sugar content of sapota under cold storage at different days after harvest

Treatments	Total sugar (%)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	11.18	12.11	12.66	13.62	14.85	18.95	--	--	--
T_2- GA_3 at 200 ppm	12.10	12.65	14.90	15.71	18.57	20.89	23.13	22.19	--
T_3- GA_3 at 300 ppm	11.90	12.66	13.55	15.17	17.83	19.97	22.57	22.37	--
T_4- Kinetin at 50 ppm	11.71	12.34	13.88	14.79	17.52	19.89	22.17	21.40	--
T_5- Kinetin at 100 ppm	11.60	12.30	13.22	14.25	16.15	19.96	21.51	21.57	--
T_6- 2,4-D at 10 ppm	12.73	13.83	14.99	16.10	18.85	21.52	23.21	22.64	--
T_7- 2,4-D at 20 ppm	12.60	13.75	14.92	15.86	18.78	21.39	23.17	22.60	--
T_8- Boron at 0.2%	12.70	14.26	15.59	17.30	20.38	22.14	23.40	23.03	--
T_9- Boron at 0.4%	12.83	14.29	15.57	16.79	19.62	21.78	23.32	--	--
T_{10}- $CaCl_2$ at 1%	13.58	14.70	17.18	18.74	20.73	22.44	23.98	23.61	22.47
T_{11}- $CaCl_2$ at 1.5%	13.40	14.45	12.79	18.51	20.51	22.21	23.62	23.36	22.34
T_{12}- $CaNO_3$ at 1%	13.99	15.21	17.91	19.05	21.86	23.14	23.54	25.08	24.99
T_{13}- $CaNO_3$ at 1.5%	13.92	14.81	17.58	18.79	21.64	22.82	22.67	24.34	23.80
T_{14}- KCl_2 at 0.5%	12.87	13.88	15.43	16.23	19.10	21.69	22.00	--	--
T_{15}- KCl_2 at 1%	12.86	13.85	15.05	16.20	19.03	21.81	21.94	--	--
S.Em ±	0.53	0.65	0.74	0.75	0.68	0.30	0.24	0.30	0.40
C.D at 1%	2.07	2.54	2.89	2.94	2.66	1.18	0.95	1.18	1.55

Note: Termination of shelf life

Table 5: Effect of pre-harvest foliar application of nutrients and plant growth regulators on Ascorbic acid content of sapota under cold storage at different days after harvest

Treatments	Ascorbic acid (mg/100g pulp)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	14.29	13.67	13.09	12.60	10.66	8.53	--	--	--
T_2- GA_3 at 200 ppm	19.03	17.81	15.80	12.73	11.51	9.72	6.12	5.32	--
T_3- GA_3 at 300 ppm	19.02	15.43	14.69	12.66	11.50	9.70	6.11	5.31	--
T_4- Kinetin at 50 ppm	14.29	13.80	13.11	12.63	11.52	9.67	6.10	5.30	--
T_5- Kinetin at 100 ppm	14.29	13.79	13.10	12.61	11.53	9.66	6.09	5.28	--
T_6- 2,4-D at 10 ppm	19.04	17.82	15.81	13.11	11.54	9.75	6.13	5.32	--
T_7- 2,4-D at 20 ppm	19.03	17.80	15.80	13.10	11.53	9.74	6.11	5.31	--
T_8- Boron at 0.2%	19.50	17.84	15.82	13.12	11.81	9.76	6.16	5.38	--
T_9- Boron at 0.4%	19.18	17.83	15.78	13.11	11.68	9.73	6.14	--	--
T_{10}- $CaCl_2$ at 1%	23.78	21.12	19.05	15.83	11.83	9.72	9.25	9.11	9.04
T_{11}- $CaCl_2$ at 1.5%	22.52	21.08	18.45	14.17	11.82	9.77	8.30	7.83	9.02
T_{12}- $CaNO_3$ at 1%	23.81	22.11	19.08	16.84	12.54	9.80	9.32	9.10	9.10
T_{13}- $CaNO_3$ at 1.5%	23.80	13.80	13.11	12.63	11.50	9.67	8.09	8.30	8.22
T_{14}- KCl_2 at 0.5%	19.05	13.79	13.10	12.61	11.49	9.66	6.08	--	--
T_{15}- KCl_2 at 1%	19.03	13.67	13.09	12.60	10.66	9.53	6.07	--	--
S.Em ±	0.02	0.49	0.43	0.15	0.15	0.04	0.32	0.32	0.04
C.D at 1%	0.08	1.91	1.36	0.59	0.58	0.15	1.23	1.27	0.16

Note: Termination of shelf life

Table 6: Effect of pre-harvest foliar application of nutrients and plant growth regulators on Titratable acidity (%) of sapota under cold storage at different days after harvest

Treatments	Titratable acidity (%)								
	3rd day	6th day	9th day	12th day	15th day	18th day	21st day	24th day	27th day
T_1- Control	0.39	0.29	0.24	0.24	0.19	0.14	--	--	--
T_2- GA_3 at 200 ppm	0.29	0.24	0.19	0.16	0.13	0.11	0.11	0.08	--
T_3- GA_3 at 300 ppm	0.29	0.25	0.19	0.16	0.13	0.13	0.11	0.07	--
T_4- Kinetin at 50 ppm	0.32	0.27	0.19	0.16	0.13	0.13	0.11	0.08	--
T_5- Kinetin at 100 ppm	0.35	0.27	0.19	0.16	0.14	0.13	0.11	0.06	--
T_6- 2,4-D at 10 ppm	0.27	0.21	0.16	0.14	0.13	0.11	0.11	0.08	--
T_7- 2,4-D at 20 ppm	0.27	0.24	0.16	0.14	0.13	0.11	0.11	0.07	--
T_8- Boron at 0.2%	0.24	0.21	0.16	0.13	0.13	0.11	0.08	0.08	--
T_9- Boron at 0.4%	0.24	0.21	0.16	0.13	0.13	0.11	0.08	--	--
T_{10}- $CaCl_2$ at 1%	0.24	0.19	0.16	0.13	0.12	0.11	0.09	0.05	0.03
T_{11}- $CaCl_2$ at 1.5%	0.24	0.21	0.16	0.13	0.11	0.11	0.08	0.08	0.03
T_{12}- $CaNO_3$ at 1%	0.21	0.16	0.14	0.11	0.08	0.08	0.08	0.05	0.03
T_{13}- $CaNO_3$ at 1.5%	0.21	0.19	0.14	0.13	0.11	0.11	0.07	0.08	0.03
T_{14}- KCl_2 at 0.5%	0.24	0.21	0.16	0.13	0.13	0.11	0.09	--	--
T_{15}- KCl_2 at 1%	0.27	0.21	0.16	0.13	0.13	0.11	0.11	--	--
S.Em ±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C.D at 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Termination of shelf life

Conclusion

Based on results, it can be concluded that both pre-harvest spraying of $CaNO_3$ at 1% or $CaNO_3$ at 1.5% and low temperature storage found effective for increasing total soluble solids, total sugar, reducing sugar, non-reducing sugar and ascorbic acid with minimum acidity of sapota fruits.

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