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Effect of Pre-Harvest Treatments on Physical, Yield and Shelf-life of Sapota Fruits cv. Kalipatti

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***Abstract*:** The pre-harvest treatments were applied during two seasons *viz.,* winter (season-1) (Salicylic acid during 1st week of October and $CaCl_2$ during 2nd week of November) and summer (season-2) (Salicylic acid during 1st week of January and $CaCl_2$during 2nd week of February) in 'Kalipatti' cultivar of sapota. The results of the study revealed that pre-harvest application of 2000 ppm salicylic acid + 1.5 % $CaCl_2$significantly influenced physical parameters like fruit weight (89.78 and 88.34g), fruit length (5.73 and 5.66cm), fruit diameter (5.61 and 5.58cm), fruit volume (83.88 and 82.76cc), pulp weight (77.80 and 76.18g), peel weight (9.59 and 9.46g) and seed: pulp ratio (0.022 and 0.022) during winter and summer seasons, respectively. Same treatment recorded highest yield (165.90 kg $tree^{-1}$) and shelf-life (10.46 and 10.35 days) during winter and summer seasons. Whereas, highest benefit:cost ratio was recorded in treatment 2000 ppm salicylic acid + 1.0 % $CaCl_2$ (1.64) which followed by 1000 ppm Salicylic acid + 1.0 % $CaCl_2$(1.60) and 2000 ppm Salicylic acid + 1.5 % $CaCl_2$(1.56).

Keywords: Shelf-life, Pre-harvest, Climacteric, Salicylic acid, Calcium chloride

Sapota [*Manilkara achras* (Mill.) Fosberg] also called as "*Chickoo*" or "Sapodilla", which is an evergreen tree and belongs to the family Sapotaceae. It is a crop of the tropical region, native to Mexico and Central America. In India, it was first time introduced at Gholwad village of Maharashtra state in 1898 (Chadha 1992). It occupies a significant position among the fruit crops in India. The states that are growing sapota on a commercial scale in India are Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, West Bengal and parts of Punjab and Haryana (Cheema et al 1954, Purseglove 1968, Singh 1969). India is considered to be the largest producer of sapota in the world occupying an area of 83 thousand ha with annual production of10.03 lakh MT (Anon. 2020a). In Gujarat, the area under sapota cultivation is 27.83 thousand ha with production of 3.1 lakh MT with productivity of 11.06 MT/ha (Anonymous 2020b). Among several varieties grown in India, Kalipatti is a leading cultivar which is grown in states like Maharashtra, Gujarat and North Karnataka. Although sapota is rich in nutritional value, lower shelf life and lack of quality production limit its' cultivation in India.

Fruit condition at harvest is essential for post-harvest performance. This necessitates an appropriate maturity stage, but also involves other aspects like nutritional status of harvested fruits. For this reason, application of pre-harvest chemical substances is considered as one of the most innovative methods to extend the commercial storage life of fruits and vegetables. Accordingly, use of particular agro-chemical substances has been found to delay ripening, decrease post-harvest losses, enhances and maintain fruit quality by reducing the speed of metabolic activities at harvest or during storage (Shafiee et al 2010). Similarly, role of some chemicals could cause an increase in shelf-life of sapota fruit and maintain its marketability for a longer term by arresting the growth and spread of micro-organisms (Sudha et al 2007). Keeping this in view, this experiment was carried out to enhance the physical properties, yield as well as post-harvest life of sapota.

MATERIAL AND METHODS

The study was carried out during 2020-21 at Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari and Centre of Excellence Department of Post-Harvest Technology, Navsari Agricultural University, Navsari. Experiment was conducted on 31 years old tree planted at spacing of 10 m × 10 m with 10 treatments. Treatment comprises; T_1: 1000 ppm Salicylic acid, T_2: 2000 ppm Salicylic acid, T_3: 3000 ppm Salicylic acid, T_4: 1000 ppm Salicylic acid + 1.0 % $CaCl_2$, T_5: 2000 ppm Salicylic acid + 1.0 % $CaCl_2$, T_6: 3000 ppm Salicylic acid + 1.0 % $CaCl_2$, T_7: 1000 ppm Salicylic acid + 1.5 % $CaCl_2$, T_8: 2000 ppm Salicylic acid + 1.5 % $CaCl_2$, T_9: 3000 ppm Salicylic acid + 1.5 % $CaCl_2$ and T_{10}: Control. Four uniform trees were selected for each treatment. Treatments were applied in two consecutive seasons (Table 1).

Five randomly selected fruits from each treatment were used for estimation of physical parameters like fruit weight, length, diameter, volume, specific gravity, pulp weight, peel weight, number of seeds and weight of seeds during both seasons. Seed: pulp ratio was estimated after separation of seeds and pulp from individual ripen fruit, weight of the seeds and weight of pulp were recorded and seed: pulp ratio was calculated.

The yield was calculated at each picking and averaged of two consecutive seasons. The shelf-life of fruits was noted by keeping the fruits at room temperature and the days taken from harvesting to optimal eating stage. Fruits surviving for longest duration after harvesting were taken into consideration.

RESULTS AND DISCUSSION

Physical parameters: During the winter (season-1) and summer (season-2) seasons of investigation, treatment T_8 (2000 ppm Salicylic acid + 1.5 % $CaCl_2$) recorded highest fruit weight (89.78 g and 88.34 g), length (5.73 cm and 5.66 cm), diameter (5.61 cm and 5.58 cm),volume (83.88 cc and 82.76 cc), pulp weight (77.80 g and 76.18 g) and peel weight (9.59 g and 9.46 g) (Table 1 and Table 2).A perusal of data revealed that various pre-harvest treatments did not have a significant influence on specific gravity, number of seeds per fruit and weight of seed. Seed: pulp ratio was affected significantly by different pre-harvest treatments during winter (season-1) but during summer (season-2) was found non-significant. During winter (season-1) the minimum seed: pulp ratio (0.022) was found in T_8 (2000 ppm Salicylic acid + 1.5% $CaCl_2$) while, the maximum seed: pulp ratio (0.026) was observed in treatment T_{10} (Control) (Table 2).

Table 1. Spraying frequencies of different treatments

Seasons	Spraying time
Season-1 (Oct.-Nov.)	Salicylic acid was sprayed in the first week of October
	$CaCl_2$ was applied in second week of November
Season-2 (Jan.-Feb.)	Salicylic acid was sprayed in the first week of January
	$CaCl_2$ was applied in second week of November

The significant increase in fruit physical attributes due to pre-harvest application of salicylic acid due to this chemical act as plant growth regulator which plays a significant role in regulating stress responses and plant development processes; including chlorophyll content in leaves, photosynthesis, stomatal conductance, transpiration, ion uptake and transport, crop yield and glycolysis (Asghari and Aghdam 2010). This chemical also has reversion effects of ABA on leaf and fruit abscission and modifying the activity of some important enzymes (Hayat et al. 2010). The increase in fruit physical parameters could also be attributed due to pre harvest spray of $CaCl_2$ which affects the formation and changes of carbohydrates and carbohydrate enzymes, other reasons might be reduction in formation of abscission layer and calcium influence in maintaining the middle lamella of cells (Karemera et al 2014). The present investigation is in conformity with the results reported by Bhalerao et al (2009) and Patel et al. (2017) in sapota.

Yield attributes: The results pertaining to fruit yield (kg $tree^{-1}$) were significantly influenced by different pre-harvest treatments which is presented in Figure 1. The maximum fruit yield (165.90kg $tree^{-1}$) was observed in T_8 (2000 ppm Salicylic acid + 1.5% $CaCl_2$), which was at par with T_5 (2000 ppm Salicylic acid + 1.0% $CaCl_2$) (163.40kg $tree^{-1}$). Whereas, the

Table 2. Effect of different pre-harvest treatments on physical attributes of sapota cv. Kalipatti

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit volume (cc)		Specific gravity	
	Season-1	Season -2	Season -1	Season -2	Season -1	Season -2	Season -1	Season -2	Season -1	Season -2
T_1	79.12	78.42	5.16	5.04	5.05	4.91	72.60	73.18	1.10	1.08
T_2	81.79	80.60	5.20	5.12	5.13	5.00	75.50	74.58	1.08	1.08
T_3	80.05	79.10	5.16	5.10	5.09	4.98	73.30	73.64	1.09	1.08
T_4	83.10	82.14	5.41	5.35	5.25	5.14	77.26	75.96	1.08	1.09
T_5	88.68	86.74	5.62	5.58	5.52	5.41	83.45	81.24	1.07	1.07
T_6	82.12	81.03	5.25	5.18	5.14	5.01	76.06	75.16	1.08	1.08
T_7	83.22	82.21	5.62	5.54	5.43	5.37	77.38	76.68	1.08	1.07
T_8	89.78	88.34	5.73	5.66	5.61	5.58	83.88	82.76	1.07	1.07
T_9	82.91	81.90	5.32	5.24	5.14	5.08	76.69	75.50	1.08	1.09
T_{10}	70.12	68.50	5.06	4.97	4.89	4.77	64.76	63.48	1.08	1.08
S. Em. ±	1.68	1.69	0.125	0.127	0.118	0.119	1.70	1.52	0.029	0.030
CD (p=0.05)	4.87	4.88	0.362	0.367	0.340	0.345	4.90	4.40	NS	NS

minimum fruit yield (114.97kg tree^{-1}) was recorded in T_{10} (control).

Pre-harvest application of Salicylic acid showed significant difference in yield parameters this might be due to Salicylic acid treatments are known to promote cell division and expansion (Hayat et al. 2010). The positive effect of Salicylic acid on the growth and yield may be due to its effect on plant hormones (Shakirova 2007). Salicylic acid treatment increased photosynthetic pigments and total carbohydrates (Mady 2009). In addition, it is reported that Salicylic acid treatments increased the net photosynthesis rate, intrinsic CO_2 concentration and water usage effectiveness (Fariduddin et al 2003).

The significant increase in yield due to pre-harvest $CaCl_2$ application is due to role of this chemical in photosynthesis parameters like rate of photosynthesis, transpiration rate and stomatal conductance. Calcium increases photosynthetic performance by maintaining the osmotic strength of cytoplasm in plants (Yang et al 2016).

The present findings are in accordance with results reported by Patel et al (2020) in mango, Champa et al. (2014) and Abbasi et al. (2020) in grape and Erogul and Ozsoydan (2020) in peach.

Shelf-life: During the winter (season-1) and summer (season-2) seasons of investigation, maximum shelf-life (10.46 and 10.35 days, respectively) was observed in treatment T_8 (2000 ppm Salicylic acid + 1.5 % $CaCl_2$), which was statistically at par with T_5 (2000 ppm SA + 1.0 % $CaCl_2$) (10.15 and 10.04 days) and T_7 (1000 ppm Salicylic acid + 1.5 % $CaCl_2$) (10.00 and 9.86 days). While, minimum shelf life 8.73 and 8.65 days was observed in treatment T_{10} (Control) during winter (season-1) and summer (season-2) seasons, respectively.

The present study revealed that pre-harvest spray of

Table 3. Effect of different pre-harvest treatments on physical attributes of sapota cv. Kalipatti

Treatments	Pulp weight (g)		Peel weight (g)		Number of seeds /fruit		Weight of seed (g)		Seed: pulp ratio	
	Season-1	Season -2	Season -1	Season -2	Season -1	Season -2	Season -1	Season -2	Season -1	Season -2
T_1	69.98	69.14	8.10	8.01	2.00	2.20	1.76	1.72	0.025	0.025
T_2	71.99	70.27	8.33	8.18	2.25	2.00	1.74	1.77	0.024	0.025
T_3	72.11	71.34	8.59	8.36	2.20	2.25	1.82	1.75	0.025	0.025
T_4	73.00	72.06	8.69	8.61	2.25	2.25	1.77	1.82	0.024	0.025
T_5	77.08	75.40	9.30	9.08	2.30	2.20	1.68	1.72	0.022	0.023
T_6	72.98	71.68	8.63	8.42	2.05	2.30	1.82	1.77	0.025	0.025
T_7	73.93	73.02	9.02	8.99	2.15	2.05	1.76	1.78	0.024	0.025
T_8	77.80	76.18	9.59	9.46	2.25	2.10	1.68	1.67	0.022	0.022
T_9	73.08	72.15	8.93	8.70	2.15	2.15	1.78	1.81	0.025	0.025
T_{10}	66.98	66.23	7.91	7.84	2.15	2.10	1.73	1.71	0.026	0.026
S. Em. ±	1.39	1.37	0.207	0.195	0.103	0.100	0.048	0.046	0.0008	0.0008
CD (p=0.05)	4.02	3.96	0.599	0.563	NS	NS	NS	NS	2.39	NS

Table 4. Economics of various treatments imposed

Treatments	Total cost (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit: cost ratio
T_1	94354	240180	145826	1.55
T_2	98803	253220	154417	1.56
T_3	98404	244760	146356	1.49
T_4	117885	306380	188495	1.60
T_5	123998	326800	202802	1.64
T_6	117597	291720	174123	1.48
T_7	122678	308560	185882	1.52
T_8	129427	331800	202373	1.56
T_9	124983	305400	180417	1.44
T_{10}	90536	229940	139404	1.54

Total cost= cost of cultivation + treatment cost + Harvesting cost

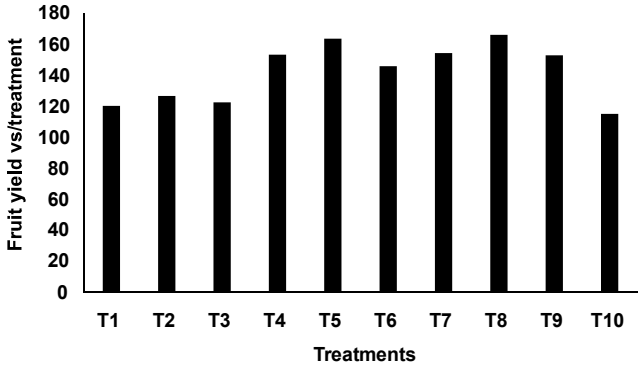

Fig. 1. Effect of different pre-harvest treatments on yield attributes of sapota cv. Kalipatti

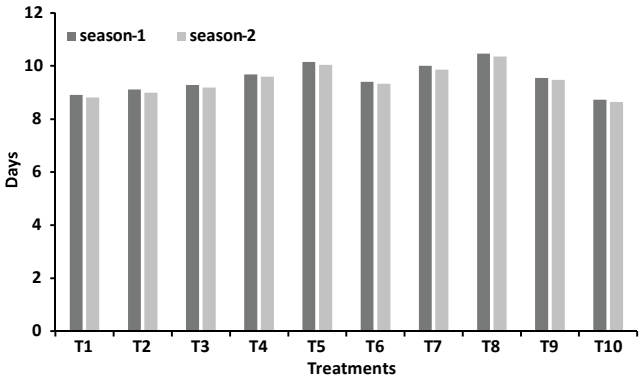

Fig. 2. Effect of different pre-harvest treatments on shelf-life of sapota cv. Kalipatti

Salicylic acid and $CaCl_2$ significantly influenced the shelf life. The positive effect of Salicylic acid which might be due to Salicylic acid slows down the process of ethylene biosynthesis and effectively reduces the transpiration and respiration rate through controlling degradation of cell wall. The exogenous Salicylic acid application also delays the ripening of apple (Yan et al 1998) and banana (Srivastava and Dwivedi 2000). Calcium also plays significant role in extending days taken to ripening and shelf life which might be due to calcium helps in structural integrity and influence cellular organization of the cell wall and plasma membrane, thereby controlling respiratory breakdown which delays ripening and extends storage life. Also, higher calcium levels in fruits leads to the reduction of respiration and ethylene production rates thus delay the ripening of fruits (Karemera et al 2014).

The present investigation is in conformity with the results reported by Sudha et al. (2007), Bhalerao et al (2009), Gondaliya (2016), Desai et al (2017), Patel et al (2017) in sapota as well as Patel et al (2020) and Vidya et al (2014) in mango and Ramesh et al (2014) in papaya.

CONCLUSION

Pre-harvest spray of 2000 ppm salicylic acid (1st week of October and 1st week of January) + 1.5 % $CaCl_2$ (2nd week of November and 2nd week of February) turned out to be the best treatment to reveal improvement in physical, yield and shelf-life of sapota during both the seasons. Salicylic acid (2000 ppm) and $CaCl_2$(1.5 %) could be utilized for enhancing the shelf-life of different cultivars of sapota.

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