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Effect of post-harvest treatment of different chemicals, plant growth regulators on physical and chemical parameters of Sapota fruits [*Manilkara achras* (Mill) Forsberg] cv. ‘Kalipatti’

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Abstract
The experiment was conducted at Department of Horticulture, College of Horticulture, Dr. Balasaheb Sawant konkan Krishi Vidyapeeth Dapoli (MS) during 2020-21 to study the effect of post-harvest treatments of different chemical and plant growth regulators on physical and chemical characteristics of sapota fruits cv. ‘Kalipatti’ during storage at ambient condition. Fast ripening of Sapota fruits during post-harvest stage results in their short shelf life which leads to deterioration of their quality. Among various chemicals, calcium has received considerable attention in recent year due to its desirable effects maintain the TSS, titratable acidity, reducing sugars, total sugars and ascorbic acids (Sharma *et al*., 1996) [8]. The fruits were treated with calcium chloride 20000 ppm was found very effective in specific gravity (1.09), PLW (12.76 %), fruit firmness (0.81 kg/cm^2) and minimum spoilage fruit (56.74%). The qualitative parameters such as titratable acidity (0.08), maximum TSS (22.34 ^{0}Brix), Reducing sugars (11.14 %), Total sugars (18.21 %) and ascorbic acid found (13.19 mg/100g) at 12th day of storage period.

Keywords: Sapota, calcium chloride, calcium nitrate, gibberellic acid, benzyl adenine, storage

Introduction

Sapota [*Manilkara achras* (Mill) Forsberg is a tropical fruit native to Mexico and Central America and belongs to the family Sapotaceae, popularly known as ‘Chiku’ in India. Sapota is evergreen, spreading habit and lives longer up to 100 years, it can be grown on wide range of soil and climatic conditions (Bose, 2002) [2]. After mango, banana, citrus and grapes, sapota ranks fifth both in production and consumption in India. Sapota is grown mainly in coastal areas such as Maharashtra, Gujarat, Karnataka and Tamilnadu. In India, sapota cultivation was taken up for the first time in Maharashtra in (1898) in a village named Gholwad (Cheema *et al*., 1954) [3]. It is consumed mostly indigenously sapota contains various important nutrients which has certain health benefits. (Anand *et al*., 2007) [1]. Sapota fruit is a fleshy berry, variable in shape, size and weight (75 to 150 g). The fruit when fully ripen is delicious and eaten as dessert fruit. The pulp is sweet and melting. The sapota fruits are a good source of sugars which ranges between 12 to 14 per cent.

Material and Methods:

Present investigation was conducted at Department of Horticulture, College of Horticulture, and Dapoli (M.S.) during 2020-21. The uniformly size sapota fruits (cv. Kalipatti) were selected for experiment. The experiment was conducted in completely randomized block design with three replications and nine treatments. Fruits wash with 100 ppm chlorinated water and dipped for 10 min in solution of calcium chloride 10000 and 20000 ppm, calcium nitrate 10000 and 20000 ppm, gibberellin acid 100 and 200 ppm, benzyl adenine 100 and 200 ppm and control fruit treated with distilled water and dried in air and kept at ambient temperature during storage. The fruits were assessed at two days interval for specific gravity, PLW, fruit firmness and at alternate day for ripening and spoilage pattern and two days interval chemical parameters such as TSS, titratable acidity, reducing sugars, total sugars and ascorbic acids.

Result and Discussion

The specific gravity was found to be non-significant at initial and 3rd day of storage presented in (Table 1). At the end of storage, the significantly maximum specific gravity (1.09) was found in fruits treated with calcium chloride 20000 ppm which was at par with calcium chloride 10000 ppm (1.08), gibberellic acid 200 ppm (1.08) and gibberellic acid 100 ppm (1.07) followed by calcium nitrate 10000 ppm (1.03). The minimum specific gravity (1.02) was estimated in control. The significant variation in fruit weight and volume eventually caused variation in specific gravity of sapota fruits. The similar result was reported by Khanvilkar *et al.* (2018) [6, 7] in sapota cv. 'Kalipatti' and Jain *et al.* (2019) [5] in sapota fruit.

Table 1: Effect of post-harvest treatments of different chemicals and plant growth regulators on specific gravity of sapota fruits cv. 'Kalipatti'

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	1.03	1.04	1.05	1.12	1.08
Calcium chloride 20000 ppm	1.04	1.03	1.06	1.10	1.09
Calcium nitrate 10000 ppm	1.03	1.05	1.04	1.04	1.03
Calcium nitrate 20000 ppm	1.03	1.04	1.04	1.05	1.03
Gibberellic acid 100 ppm	1.03	1.04	1.06	1.10	1.07
Gibberellic acid 200 ppm	1.02	1.03	1.05	1.08	1.08
Benzyl adenine 100 ppm	1.03	1.04	1.04	1.04	1.03
Benzyl adenine 200 ppm	1.03	1.03	1.04	1.04	1.03
Control (Distilled water)	1.04	1.05	1.06	1.03	1.02
Mean	1.03	1.04	1.05	1.07	1.05
SEm±1	0.009	0.006	0.006	0.009	0.007
CD at 5 %	NS	NS	0.019	0.028	0.021

The fruit treated with different chemical and plant growth regulators significantly influenced the PLW of sapota fruits is presented in (Table 2). On 3rd day of storage, the significantly minimum PLW (1.96 %) was observed in calcium chloride 10000 ppm which was at par with calcium chloride 20000 ppm (2.06 %) and gibberellic acid 100 ppm (2.22 %). The maximum PLW (4.71 %) was recorded in control.

At the 12th day of storage, the minimum PLW was recorded in fruit treated with calcium chloride 20000 ppm (12.76 %) which was at par with calcium chloride 10000 ppm (13.09 %), gibberellic acid 200 ppm (13.98 %) and gibberellic acid 100 ppm (14.53 %). The reduction in weight loss might be due to the maintenance of firmness of fruits by calcium as it is decreased the enzyme activity responsible for the disintegration of cellular structure, which decreased the gaseous exchange. The results obtained in the study agreed with the results of Khanvilkar *et al.* (2018) [6, 7] in 'Kalipatti' variety of sapota.

Table 2: Effect of post-harvest treatment of different chemicals and plant growth regulators on physiological loss in weight (%) of sapota fruits cv. Kalipatti

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	0	1.96	7.62	11.25	13.09
Calcium chloride 20000 ppm	0	2.06	7.48	10.25	12.76
Calcium nitrate 10000 ppm	0	3.88	10.11	13.53	20.61
Calcium nitrate 20000 ppm	0	3.63	10.72	13.69	20.89
Gibberellic acid 100 ppm	0	2.22	8.2	11.82	14.53
Gibberellic acid 200 ppm	0	2.61	8.23	11.76	13.98
Benzyl adenine 100 ppm	0	3.69	10.1	15.98	25.1
Benzyl adenine 200 ppm	0	3.85	11.09	14.32	27.16
Control (Distilled water)	0	4.71	12.52	17.38	33.69
Mean	0	3.17	9.56	13.33	20.18
Range	0	1.96-4.71	7.62-12.52	11.25-17.38	12.76-33.69
SE.±		0.20	0.40	0.67	0.90
CD at 5%		0.60	1.19	2.01	2.68

The change in fruit firmness (kg/cm^2) of sapota fruits influenced by different post-harvest treatments during storage at ambient condition is given in (Table 3). The initial day of storage i.e., 0 day the fruit firmness was found to be non-significant. On 3rd day of storage, the maximum fruit firmness was recorded in fruits treated with calcium chloride 20000 ppm (2.82 kg/cm^2) which was at par with gibberellic acid 100 ppm (2.81kg/cm^2), calcium nitrate 10000 ppm (2.73 kg/cm^2), gibberellic acid 200 ppm (2.59 kg/cm^2) and calcium chloride 10000 ppm (2.53 kg/cm^2). The minimum fruit firmness was observed in control (1.83 kg/cm^2).

At the end of storage significantly maximum fruit firmness was recorded in calcium chloride 20000 ppm (0.81 kg/cm^2) which was at par with calcium chloride 10000 ppm (0.63 kg/cm^2) followed by gibberellic acid 200 ppm (0.59 kg/cm^2) gibberellic acid 100 ppm (0.58 kg/cm^2). The minimum fruit firmness was indicated in control (0.21 kg/cm^2).

Fruit firmness in many fruits is an important characteristic that is used to determine stability and it is predominantly determined by cell wall composition and structure. $CaCl_2$ treatments have been known to delay the softening and improve the fruit quality. Similar results were obtained by Tsomu and Patel (2014) [9] in sapota fruits and Khanvilkar *et al*. (2018) [6, 7] in sapota cv. 'Kalipatti'.

Table 3: Effect of post-harvest treatment of different chemicals and plant growth regulators on fruit firmness (kg/cm^2) of sapota fruits cv. Kalipatti.

Treat.	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	2.99	2.53	2.07	1.21	0.63
Calcium chloride 20000 ppm	3.08	2.82	2.09	1.05	0.81
Calcium nitrate 10000 ppm	3.14	2.73	2.42	1.49	0.47
Calcium nitrate 20000 ppm	2.91	2.07	1.94	1.04	0.52
Gibberellic acid 100 ppm	3.02	2.81	2.21	1.31	0.58
Gibberellic acid 200 ppm	3.26	2.59	2.18	1.28	0.59
Benzyl adenine 100 ppm	2.96	1.98	2.04	1.44	0.42
Benzyl adenine 200 ppm	2.95	2.09	1.87	1.01	0.48
Control (Distilled water)	2.96	1.83	0.91	0.58	0.21
Mean	3.05	2.50	1.97	1.16	0.52
Range	2.91-3.26	1.83-2.82	0.91-2.42	0.58-1.49	0.57-0.81
SE.±	0.12	0.12	0.14	0.13	0.07
CD at 5%	NS	0.37	0.43	0.39	0.22

The experimental data presented in (Table 4) revealed that different chemical and plant growth regulators treatments significantly influenced the spoilage percentage of sapota fruits. The delaying ripening and spoilage of sapota fruits during storage could be due to slow release of free water on an effect of reduced metabolism and rate of transpiration in calcium treated fruits.

On 6th day of storage, the spoilage fruits were not observed in fruit treated with calcium chloride 10000 ppm, calcium chloride 20000 ppm, gibberellic acid 100 ppm and gibberellic acid 200 ppm whereas spoilage fruit were observed in treatment benzyl adenine 100 ppm (4.86 %), benzyl adenine 200 ppm (8.02%), calcium nitrate 20000 ppm (8.45 %) and calcium nitrate 10000 ppm (9.11 %). The fruit treated with distilled water found maximum spoilage fruit (10.56 %).

On 12th day of storage significantly minimum soilage fruit was observed in fruit treated with calcium chloride 20000 ppm (56.74 %) followed by calcium chloride 10000 ppm (59.48%), gibberellic acid 200 ppm (59.78%) and gibberellic acid 100 ppm (63.64%). The fruit treated with distilled water maximum spoilage fruit was observed (100 %). The fruit treated with calcium chloride 20000 ppm was recorded significantly found to be best for delaying ripening and spoilage. The above findings are in close conformity with the results obtained by Khanvilkar *et al*. (2018) [6, 7] in sapota cv. 'Kalipatti' and Jain *et al*. (2019) [5] in sapota fruits.

Table 4: Effect of post-harvest treatments of different chemicals and plant growth regulators on spoilage (%) of sapota fruits cv. Kalipatti.

Treatments	Days of storage				
	0 to 4	6	8	10	12
Calcium chloride 10000 ppm	0.0	0.0	26.68	46.74	59.48
Calcium chloride 20000 ppm	0.0	0.0	18.58	20.38	56.74
Calcium nitrate 10000 ppm	0.0	9.11	14.48	27.72	79.38
Calcium nitrate 20000 ppm	0.0	8.45	12.3	19.66	79.85
Gibberellic acid 100 ppm	0.0	0.0	22.1	35.32	63.64
Gibberellic acid 200 ppm	0.0	0.0	17.48	43.66	59.78
Benzyl adenine 100 ppm	0.0	4.86	8.96	23.78	77.24
Benzyl adenine 200 ppm	0.0	8.02	22.42	27.62	81.76
Control (Distilled water)	0.0	10.56	21.66	67.82	100

The rate of increase in TSS content was greatly influenced by different post-harvest treatments presented in Table 5. The Initially, TSS content was increased and after attaining a peak it showed a declining trend. On the 0 day of storage maximum TSS was observed in fruit treated with gibberellic acid 200 ppm (19.04 0Brix) which was at par with benzyl adenine 200 ppm (18.46 0Brix), benzyl adenine 100 ppm (18.31 0Brix), gibberellic acid 100 ppm (18.21 0Brix) whereas minimum was observed in calcium chloride 20000 ppm (16.81 0Brix).

At the 12th day of storage, the significantly maximum TSS was found in treatments calcium chloride 20000 ppm (22.34 ^{0}Brix) which was at par with calcium chloride 10000 ppm (21.58 ^{0}Brix) and gibberellic acid 200 ppm (21.49 ^{0}Brix) whereas, the minimum TSS (17.08 %) was noted in control treated with distilled water.

TSS is increase upto the 9th day of storage after that it decrease during further storage period i.e., 12th day of storage. It could be attributed to conversion of starch into sugars upto ripening stage and utilization of sugars for respiration towards the end of storage. The present investigation is in conformity with the results reported by Desai *et al*. (2017) [4] in sapota fruits cv. Kalipatti and Khanvilkar *et al*. (2018) [6, 7] in sapota fruits cv. Kalipatti.

Table 5: Effect of post-harvest treatments of different chemicals and plant growth regulators on TSS (^{0}Brix) of sapota fruits cv. Kalipatti.

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	17.41	19.41	24.92	25.36	21.58
Calcium chloride 20000 ppm	16.81	18.76	22.41	23.61	22.34
Calcium nitrate 10000 ppm	17.41	19.14	21.98	23.34	19.42
Calcium nitrate 20000 ppm	17.89	19.48	21.91	22.78	20.68
Gibberellic acid 100 ppm	18.21	22.14	23.74	24.47	20.61
Gibberellic acid 200 ppm	19.04	21.31	22.07	24.11	21.49
Benzyl adenine 100 ppm	18.31	21.12	23.26	22.17	19.36
Benzyl adenine 200 ppm	18.46	22.29	24.18	22.63	20.31
Control (Distilled water)	16.91	20.14	23.42	19.17	17.08
Mean	17.82	20.42	23.10	23.07	20.32
SEm±1	0.44	0.49	0.31	0.32	0.37
CD 5 %	1.31	1.47	0.94	0.97	1.12

Data presented in table 6 showed significant difference for acidity content among all the treatments during storage period. It was observed on 0 day of storage period minimum titratable acidity was found in calcium chloride 20000 ppm (0.17 %) which was at par with calcium chloride 10000 ppm (0.18 %) followed by gibberellic acid 100 ppm (0.19 %). The maximum titratable acidity was recorded in control (0.23 %). On 3rd day of storage period, significantly minimum titratable acidity was obtained in calcium chloride 20000 ppm (0.15 %) which was at par with calcium chloride 10000 ppm (0.16%), calcium nitrate 20000 ppm (0.16 %), gibberellic acid 100 ppm (0.16 %), gibberellic acid 200 ppm. The maximum titratable acidity was found in control (0.21 %).

On 12th day of storage, significantly minimum titratable acidity was observed calcium chloride 20000 ppm (0.08 %) which was at par with calcium chloride 10000 ppm (0.10 %), gibberellic acid 200 ppm (0.11%) and gibberellic acid 100 ppm (0.11 %). The maximum titratable acidity was found in control (0.15 %).

In all the treatments, the pattern of accumulation of titratable acidity (%) was decreased from 6th to 12th day of storage period. The results are in line with reported by Khanvilkar *et al.* (2018) [6, 7] in sapota cv. Kalipatti.

Table 6: Effect of post-harvest treatments of different chemicals and plant growth regulators on titratable acidity of sapota fruits cv. Kalipatti.

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	0.18	0.16	0.15	0.13	0.10
Calcium chloride 20000 ppm	0.17	0.15	0.14	0.12	0.08
Calcium nitrate 10000 ppm	0.21	0.19	0.17	0.14	0.12
Calcium nitrate 20000 ppm	0.20	0.16	0.15	0.13	0.12
Gibberellic acid 100 ppm	0.19	0.16	0.14	0.12	0.11
Gibberellic acid 200 ppm	0.21	0.17	0.15	0.12	0.11
Benzyl adenine 100 ppm	0.22	0.18	0.16	0.14	0.14
Benzyl adenine 200 ppm	0.22	0.17	0.14	0.14	0.12
Control (Distilled water)	0.23	0.21	0.18	0.17	0.15
Mean	0.20	0.18	0.15	0.13	0.12
SEm±1	0.006	0.008	0.007	0.006	0.010
CD 5 %	0.019	0.024	0.021	0.020	0.031

The data pertaining to the effect of post-harvest treatment understudy on reducing sugars of sapota fruits are presented in Table no. 7. On 0 day of the storage period, significantly maximum reducing sugars was observed in calcium chloride 10000 ppm (8.74 %) followed by calcium chloride 20000 ppm (7.68 %), gibberellic acid 200 ppm (7.21 %), gibberellic acid 100 ppm (6.89 %). The minimum reducing sugars was observed in control (5.78 %).

On 12th day of storage, significantly maximum reducing sugars was noted in calcium chloride 20000 ppm (11.14%) followed by calcium chloride 10000 ppm (9.92 %), gibberellic acid 200 ppm, gibberellic acid 100 ppm (9.14 %, respectively whereas minimum reducing sugars was observed in control (8.12 %).

The initial increase in reducing sugars might be due to the conversion of starch into reducing sugars and later on reduction could possibly might be due to the utilization of sugars in the process of respiration. The present results are in agreement with Tsomu *et al.* 201 who reported an increase in reducing sugars content of sapota fruit during ripening. However, decrease in reducing sugars content was also observed due to over ripening of fruits.

Table 7: Effect of post-harvest treatments of different chemicals and plant growth regulators on reducing sugars (%) of sapota fruits cv. Kalipatti.

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	8.74	10.21	11.02	12.16	9.92
Calcium chloride 20000 ppm	7.68	10.71	11.98	12.08	11.14
Calcium nitrate 10000 ppm	6.44	8.72	9.86	11.04	8.16
Calcium nitrate 20000 ppm	6.39	8.82	9.84	10.38	8.46
Gibberellic acid 100 ppm	6.89	9.54	11.76	11.93	9.14
Gibberellic acid 200 ppm	7.21	9.41	10.78	10.92	9.14
Benzyl adenine 100 ppm	6.61	8.91	10.08	11.62	8.81
Benzyl adenine 200 ppm	6.86	9.18	9.92	10.26	8.16
Control (Distilled water)	5.78	8.19	11.61	9.18	8.12
Mean	7.78	9.18	10.76	11.06	9.00
SEm±1	0.25	0.24	0.15	0.15	0.17
CD 5 %	0.75	0.73	0.46	0.45	0.53

Data presented in table 8 showed the maximum total sugars content at initial day of storage period was recorded in treatment calcium chloride 10000 ppm (15.88 %) which was at par with gibberellic acid 200 ppm (15.46 %), gibberellic acid 100 ppm (15.36 %), calcium chloride 20000 ppm (14.91 %) while it was minimum in the treatment calcium chloride 10000 ppm (12.36 %).

At the end of storage, significantly maximum total sugars observed in calcium chloride 20000 ppm (18.21 %) which was at par with calcium chloride 10000 ppm (18.12 %), gibberellic acid 200 ppm (17.64 %), gibberellic acid 100 ppm (17.25 %) while the minimum total sugars recorded in the treatment control treated with distilled water (15.32 %).

The accumulation of total sugars during the process of ripening is a consequence of starch hydrolysis. The results of this investigation are in agreement with the result obtained by (Tsomu *et al.*, 2015) who noticed an increasing trend with respect to total sugars content with advancement of storage period in sapota cv. Kalipatti under ambient storage. Similar findings were reported by Khanvilkar *et al.* (2018) [6, 7] and Desai *et al.* (2017) [4] in sapota cv. Kalipatti.

Table 8: Effect of post-harvest treatments of different chemicals and plant growth regulators on total sugars (%) of sapota fruits cv. Kalipatti

Treatments	Days of storage				
	0	3	6	9	12
Calcium chloride 10000 ppm	15.88	19.18	20.14	20.92	18.12
Calcium chloride 20000 ppm	14.91	16.17	19.64	20.18	18.21
Calcium nitrate 10000 ppm	12.36	15.61	17.44	19.59	16.54
Calcium nitrate 20000 ppm	13.26	15.78	18.12	19.00	16.12
Gibberellic acid 100 ppm	15.36	17.48	20.72	20.99	17.62
Gibberellic acid 200 ppm	15.46	16.68	19.72	21.55	17.64
Benzyl adenine 100 ppm	14.07	16.44	18.61	19.32	16.69
Benzyl adenine 200 ppm	13.16	15.22	19.13	21.19	17.25
Control (Distilled water)	14.47	15.72	18.12	17.36	15.32
Mean	14.33	16.48	19.07	20.01	17.06
SEm±1	0.37	0.24	0.21	0.32	0.30
CD 5 %	1.10	0.72	0.64	0.98	0.90

The data regarding the effect of various post-harvest treatments of chemicals and growth regulators on ascorbic acid in sapota cv. Kalipatti fruits is presented in Table 9.

On 0 day of storage period significantly maximum ascorbic acid was found in benzyl adenine 100 ppm (23.55 mg/100g pulp) followed by benzyl adenine 200 ppm (22.48 mg/100g pulp), calcium chloride 20000 ppm (22.44 mg/100g pulp). The minimum ascorbic acid was observed in control (19.59 mg/100g pulp).

On 12th day of storage period significantly maximum ascorbic acid was observed in calcium chloride 20000 ppm (13.19 mg/100g pulp) followed by calcium chloride 10000 ppm (10.12 mg/100g pulp), gibberellic acid 200 ppm (10.11 mg/100g pulp), gibberellic acid 100 ppm (9.66 mg/100g pulp). The minimum ascorbic acid was observed in control (6.68 mg/100g pulp).

The maximum level of ascorbic acid in calcium chloride treated fruit might reflect the low oxygen permeability, slowing down the respiration rate, which delays the deteriorative oxidation reaction of ascorbic acid of sapota fruits. The results are in line with the reported Tsomu *et al*. (2015) and Khanvilkar *et al*. (2018) [6, 7] in sapota cv. Kalipatti.

Table 9: Effect of post-harvest treatments of different chemicals and plant growth regulators on ascorbic acid (mg/ 100g) of sapota fruits cv. Kalipatti.

Treatments	Days of storage				
	0	**3**	**6**	**9**	**12**
Calcium chloride 10000 ppm	20.97	18.29	15.62	12.89	8.37
Calcium chloride 20000 ppm	22.44	21.46	16.72	15.32	10.12
Calcium nitrate 10000 ppm	20.22	17.68	13.33	11.42	8.78
Calcium nitrate 20000 ppm	21.11	18.91	16.32	12.37	9.12
Gibberellic acid 100 ppm	21.32	18.19	16.68	14.78	9.55
Gibberellic acid 200 ppm	19.66	17.72	15.44	14.89	10.11
Benzyl adenine 100 ppm	23.55	20.51	19.16	16.36	13.19
Benzyl adenine 200 ppm	22.48	20.65	18.25	15.16	12.10
Control (Distilled water)	19.59	15.34	11.19	9.32	6.68
Mean	21.26	18.75	15.86	13.61	9.78
SEm±1	0.32	0.35	0.27	0.24	0.20
CD 5 %	0.96	1.05	0.81	0.71	0.62

Conclusion

From the present experiment it is found that fruit treated with calcium chloride 20000 ppm effective help in maintaining physiological loss in weight, specific gravity, maximum fruit firmness and increase the shelf life and good maintenance of quality such as TSS, titratable acidity, reducing sugars, total sugars, ascorbic acid content up to 12th days of storage as compared to control. Hence it can be concluded that calcium chloride 20000 ppm effective of post-harvest treatments.

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