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Effect of different storage condition on quality and shelf life of sapota (*Manilkara achras*) fruits

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Abstract

Sapota fruits are subjected to different storage temperature (cold [8°C] and ambient conditions) and chemicals (Potassium permanganate absorbent and salicylic acid) at different concentration to maintain the quality of fruits. The fruits were dipped in 1.5 mM of salicylic acid and KMnO₄ then packed in CFB boxes and stored at cold and ambient condition evaluated for their effect on fruit quality. The change of chemical constituents was found to be slower in fruit stored at 8°C as compared to control. The minimum PLW (13.78%), respiration rate (54.81 ml CO₂ kg⁻¹ h⁻¹), maximum firmness (73.21 N) and minimum PG enzyme activity (46.97 μg -galatouronic acid-FW g⁻¹ h⁻¹) was recorded in C1M3 (8°C + KMnO₄ in CFB box) followed by C1M2 (8°C + salicylic acid) interactions and then concluded that fruits kept in CFB boxes with KMnO₄ stored at 8°C could prolong the shelf life of sapota.

Keywords: Salicylic acid *Manilkara achras* Potassium permanganate Polygalactouranase activity (PG) Electrolyte leakage

1. Introduction

Sapota (*Manilkara zapota*) is a tropical fruit native to Central America and belongs to family Sapotaceae. In India, its cultivation was first reported in Maharashtra in 1898 (Cheema *et al.*, 1954). The fruit is much valued for its sweet and delicious nature which is primarily used as dessert fruit. The major sapota growing states in India are Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, West Bengal, Odisha and Chhattisgarh. Fully ripe sapota flesh is honey brown in colour, soft and granular in texture and sweet in taste with a slight astringent flavor. Latex is also tapped from the bark for chukle gum, the base for chewing gum

Sapota is one among those fruits which contribute aesthetic appeal and essential nutritional requirement to the human diet. It is a good source of digestible sugar, which ranges from 12 to 20 per cent (Bose and Mitra, 1990) [3]. The fruits have an good amount of protein (0.70%), fat (1.10%), fibre (2.60%), calcium (28mg / 100g), phosphorus (27mg / 100g), iron (2mg / 100g), carotene (97μg / 100g) and vitamin C (6mg / 100g). It is also rich in bio-iron required for the formation of haemoglobin (Gurusharan Singh, 2001) [2]. The fruit skin can also be eaten, since it is richer in nutritive value than the pulp. Sapota is also used for many indigenous medicines because of the tannin content present in it, young fruits are boiled and the decoction is consumed to stop diarrhea. An infusion of the young fruits and the flowers is drunk to relieve pulmonary complaints. But one of the limiting factors of sapota fruit which influences their economic value is its relatively short ripening period and reduced post-harvest shelf life. Physiologically, sapota is a climacteric fruit and exhibits sudden spurt in respiration during post-harvest, ripening within 3 to 7 days after harvest at ambient conditions, thereafter; they are hardly marketable for 2-3 days. Although the fruit can be stored under refrigeration but the fact is, it is susceptible to chilling injury. Further, according to Broughton and Wong (1979) [4] the storage life of at 15°C as it becomes over ripe and spoiled within 5 days due to rapid degradative metabolism. The fully ripe fruit become soft and such fruit are very difficult to be handled and transported. Extension of post-harvest life and quality may be possible by checking the rate of respiration, transpiration and also retard by microbial infection.

These can be achieved to some extent by the use of proper packaging, novel chemicals and low temperature storage of fruits (Banik *et al.*, 1988)^[5].

2. Materials and methods:

2.1 Materials and treatments

The present investigation was carried out for extending the post harvest life and to know the biochemical changes of sapota fruits at Dept of Post-Harvest Technology, University of Horticultural Sciences, Bagalkot, India during the year 2016-17. Fruits of cricket ball are large sized, which are round in shape, less seeded (1-4 seeds). Pulp is gritty and granular and not very sweet. Fruits were procured from Kaladagi, a place known for production of sapota, near Bagalkot. Fruits of uniform size, shape and maturity free from any visible damage, scratch and decay were manually selected for the experiment to maintain the uniformity. The experiment was laid out in a Completely Randomized Block Design with factorial concept (FCRD) with four repetitions comprised cold storage temperature *viz.* fruits stored at cold (8°C) and ambient temperature (32 to 35°C) with post harvest dipping of KMnO₄ and salicylic acid 1.5mM. The data were recorded on every 2 days intervals.

2.2 Physiological loss in weight (%)

To determine the physiological loss in weight (PLW), sapota fruits from each replication were weighed at beginning of storage which was recorded as initial weight. On subsequent dates of observation during storage, the fruits were reweighed and recorded as final weight on every 2 days intervals. PLW was calculated by using following formula and expressed in percentage.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}} \times 100$$

2.3 Fruit firmness

Fruit firmness was determined using texture analyzer using shear test. The sapota fruit were cut using a cutting/shear probe by programmed setting.

Mode: measure shear force

Pre speed: 5.0 mm/s

Test speed: 5.0 mm/s

Post test speed: 10.0 mm/s

Distance: 38 mm

Firmness was defined as maximum force (kgf) required during the cut, which was expressed in Newtons (N)

2.4 Respiration rate (ml CO₂ kg⁻¹h⁻¹)

Respiration rate was measured by using auto gas analyzer (Model: Checkmate 9900 O₂/CO₂, PBI Dansensor, Denmark) and expressed as ml CO₂ kg⁻¹ h⁻¹. For this, two sapota fruits were trapped in 500 ml airtight containers having twist-top lid fitted with a silicone rubber septum at the center of the lid. The containers were kept at 25°C for 1h for accumulation of respiratory gases at the headspace. After specified time, the head space gas was sucked to the sensor of the analyzer through the hypodermic hollow needle and the displayed value of evolution rate of CO₂ concentration (%) was recorded. Rate of respiration was calculated on the basis of rate of evolution of CO₂ from the sample per unit weight per unit time using the following formula.

$$\text{Rate of respiration (CO}_2\text{/kg/h)} = \frac{\text{CO}_2\text{ (\%)} \times \text{Head space}}{100 \times \text{weight of fruit (kg)} \times \text{Time (hr)}}$$

2.5 Polygalactouronase (PG) activity

Polygalactouronase (PG) activity in sapota was measured following the method of Lazan *et al.* (1989)^[6] with minor modifications.

Reagents

- Sodium acetate buffer 0.2M Ph (6.0)
- 0.4% sodium acetate buffer (pH 3.8)
- 5% phenol solution
- PG enzyme assay mixture For the preparation of enzyme assay mixture, 0.45 g of pectin and 0.1g casein were dissolved in 0.4% sodium acetate buffer (pH 3.8) and then the solution was diluted to 100 ml with 0.4% sodium acetate buffer (pH 3.8) Preparation of enzyme extract One gram of sapota pulp was weighed and homogenized in 10 ml sodium acetate buffer (0.2 M; pH 6.0) with a pinch of Na₂S₂O₄ and polyvinylpyrrolidone in chilled mortar. The homogenate was centrifuged at 15000 *g* for 20 min at 4°C and supernatant was used for the assay of Polygalactouronase (PG) activity.

PG enzyme assay

For measuring the PG enzyme activity, 0.2ml of enzyme extract was added to 2ml of assay mixture and incubated at 37°C for 2 h. From this incubated mixture, 0.05 ml was added to 1ml 5% phenol; followed by 5 ml of 96% H₂SO₄ was poured over a mixture and allowed to react for 15 min. the content was diluted with 5 ml distilled water, thoroughly mixed and cooled to room temperature. The absorbance was recorded at 490nm in spectrophotometer. Blank was prepared by adding distilled water instead of enzyme extract in the assay mixture.

Calculation

PG activity was expressed as (288.07^{OD}) “μg galactouronic acid FW g⁻¹ h⁻¹”

2.6 Electrolyte leakage (%)

Fifteen freshly cut fruit discs (0.5 cm² each) were rinsed 3 times (2-3 min) with demineralised water and subsequently floated on 10 mL of demineralised water. The electrolyte leakage in the solution was measured after 22 h of floating at room 33° temperature using a conductimeter (Crison 522, Crison Instruments, S.A., Spain). Total conductivity was obtained after keeping the flasks in an oven (90 °C) for 2 h. Results were expressed as percentage of total conductivity.

2.7 Total soluble solids (°Brix)

The juice extracted by crushing the pulp of the sapota and strained through muslin cloth was used for measuring total soluble solids. Total soluble solids were estimated using FISHER Hand Refractometer (0 -50). The results were expressed as degree brix.

2.8 Experimental design and data analysis

The experiment was carried out with 6 treatments and the experiment was repeated 4 times and pooled data was subjected to statistical analysis. Fruits were arranged in Factorial-Complete Randomised Design. Randomly selected fruits were taken to analyse physiological loss in weight, respiration rate, TSS, firmness, Polygalactouronase activity and Electrolyte leakage. Statistical analyses were performed using Web Agri Stat Package (WASP) Version 2. Significant differences among means at P = 0.05 were determined by post hoc tests using Duncan's multiple range test.

3. Results

3.1 Physiological loss in weight (PLW) (%)

There was a significant increase in PLW with prolonged in storage with PLW being least on 2nd day and highest on 20th day in cold storage temperature and maximum acceptable was reached on 6th day itself. The data revealed that there was a significant difference among the treatments and storage temperature and their interaction effect on 2, 4 and 6 DAS (Table 1). Among the different storage temperatures, the maximum mean PLW was in T₂ (10.42%, 14.85%, and 22.02%). The minimum was recorded in T₁ (3.81%, 5.03%, and 6.84%). Among the post harvest treatments, significantly maximum mean value recorded was in M₁ (9.37%, 13.78%, 19.71%) and the minimum in M₃ (5.66%, 7.06% and 10.06%). On 10 and 14 DAS, among the different storage temperature, the minimum PLW was recorded in T₁ (10.03%

and 13.26%) and fruit loss was 100% in ambient condition on 8th day of storage. Among the post-harvest treatments, minimum PLW was recorded in M₃ (3.64% and 5.28%) whereas, maximum was in M₁ (6.73% and 8.28%). The interaction effect between the treatments and storage temperature was found to be significant. The highest PLW was noticed in T₁M₁ (13.46% and 16.56%) whereas lowest was recorded in T₁M₃ (7.27% and 8.28%). On 18 and 20 DAS, the minimum PLW was in M₃ (6.89% and 8.24%) whereas, maximum was noticed in M₁ (8.1% and 14.88%). Among the interaction effect the minimum PLW was noticed in T₁M₃ (13.78% and 16.47%) which was significantly followed by T₁M₂ (16.36% and 19.66%) whereas maximum was recorded in T₁M₁ (21.46% and 29.75%). The interaction between treatments and storage intervals was found to be significant.

Table 1: Effect of different storage temperature and post-harvest treatments on physiological loss in weight (%) of sapota cv. Cricket ball

| Physiological loss in weight (PLW %) | | | | | | | | | | | | | | | | |
|--------------------------------------|-------|------|----------|-------|-------|-------|----------|-------|-------|-------|----------|-------|-------|-----|----------|------|
| Treatments | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 5.37 | 3.27 | 2.79 | 3.81 | 7.33 | 4.29 | 3.47 | 5.03 | 9.48 | 6.48 | 4.56 | 6.84 | 10.34 | 7.8 | 5.37 | 7.84 |
| T ₂ | 13.39 | 9.37 | 8.52 | 10.42 | 20.22 | 13.66 | 10.65 | 14.85 | 29.94 | 20.56 | 15.56 | 22.02 | 0 | 0 | 0 | 0 |
| Mean | 9.37 | 6.33 | 5.66 | | 13.78 | 8.97 | 7.06 | | 19.71 | 13.52 | 10.06 | | 5.17 | 3.9 | 2.69 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.06 | | 0.253 | | 0.05 | | 0.238 | | 0.01 | | 0.025 | | 0.03 | | 0.254 | |
| M | 0.08 | | 0.309 | | 0.07 | | 0.291 | | 0.05 | | 0.031 | | 0.08 | | 0.311 | |
| T×M | 0.11 | | 0.437 | | 0.10 | | 0.412 | | 0.09 | | 0.043 | | 0.11 | | 0.440 | |

| Physiological loss in weight (PLW %) | | | | | | | | | | | | | | | | |
|--------------------------------------|--------|------|----------|-------|--------|-------|----------|-------|--------|-------|----------|-------|--------|-------|----------|-------|
| Treatments | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 13.46 | 9.36 | 7.27 | 10.03 | 15.31 | 11.46 | 9.37 | 12.05 | 16.56 | 12.66 | 10.57 | 13.26 | 18.66 | 13.46 | 11.67 | 14.59 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 00 |
| Mean | 6.73 | 4.68 | 3.64 | | 7.66 | 5.73 | 4.68 | | 8.28 | 6.33 | 5.28 | 8.28 | 9.33 | 6.73 | 5.84 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.012 | | 0.039 | | 0.035 | | 0.106 | | 0.05 | | 0.18 | | 0.077 | | 0.231 | |
| M | 0.024 | | 0.075 | | 0.071 | | 0.213 | | 0.073 | | 0.219 | | 0.058 | | 0.174 | |
| T×M | 0.023 | | 0.071 | | 0.012 | | 0.410 | | 0.023 | | 0.069 | | 0.17 | | 0.510 | |

| Physiological loss in weight (PLW %) | | | | | | | | |
|--------------------------------------|--------|-------|----------|------|--------|-------|----------|-------|
| Treatments | 18 DAS | | | | 20 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 21.46 | 16.36 | 13.78 | 17.2 | 29.75 | 19.66 | 16.47 | 21.96 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 10.73 | 8.18 | 6.89 | | 14.88 | 9.83 | 8.24 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.025 | | 0.075 | | 0.07 | | 0.215 | |
| M | 0.016 | | 0.048 | | 0.089 | | 0.269 | |
| T×M | 0.067 | | 0.201 | | 0.091 | | 0.293 | |

T₁: Cold storage condition

T₂: Ambient condition

M₁: Fruits packed in CFB box

M₂: Salicylic acid at 1.5mM

M₃: KMnO₄ (papers shreds impregnated in CFB box)

3.2 Firmness (N)

The data revealed that there was a significant difference among the treatments, storage temperature and their interaction effect on 2, 4 and 6 DAS (Table 2). Among the different storage temperatures, the maximum firmness were recorded in T₁ (73.21 N, 68.78 N and 63.06 N). The minimum firmness was recorded in T₂ (68.53 N, 64.72 N and 59.50 N). Among the post harvest treatments, significantly maximum firmness was recorded in M₃ (72.63 N, 70.75 N and 63.33 N) and the minimum firmness was recorded in M₁ (64.87 N, 63.61 N and 44.23 N). On 10 and 14 DAS, the minimum firmness was noticed in M₁ (24.58 N and 22.41 N)

followed by M₂ (27.18 N and 24.70) whereas, maximum was noticed in M₃ (29.16 N and 26.59 N). The interaction effect between the treatments and storage temperature was also found significant. The significant highest firmness was noticed in T₁M₃ (58.53N and 47.83 N) which was significantly followed by T₁M₂ (54.02 N and 43.81N). Whereas lowest was recorded in T₁M₁ (49.18 N and 38.59 N). On 18 and 20 DAS, the minimum firmness was noticed in M₁ (14.23 N and 11.35 N) followed by M₂ (16.74 N and 15.37 N) whereas, maximum was noticed in M₃ (18.55 N and 17.46 N). Among the interaction effect the minimum firmness was noticed in T₁M₁ (28.46 N and 22.69 N) which was

followed by T1M2 (33.48 N and 30.73 N) whereas maximum was recorded in T1M1 (37.09 N and 34.92 N). The interaction

between treatments and storage intervals was found to be significant.

Table 2: Effect of different storage temperature and post-harvest treatments on fruit firmness of sapota fruits cv. Cricket ball

| Treatments | Fruit firmness (N) | | | | | | | | | | | | | | | |
|----------------|--------------------|-------|----------|-------|----------|-------|----------|-------|--------|-------|----------|-------|----------|-------|----------|-------|
| | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 70.06 | 73.51 | 76.06 | 73.21 | 64.16 | 69.27 | 72.92 | 68.78 | 58.57 | 63.47 | 67.15 | 63.06 | 52.55 | 58.44 | 61.62 | 57.54 |
| T ₂ | 63.06 | 67.97 | 74.57 | 68.53 | 59.95 | 65.02 | 69.19 | 64.72 | 29.89 | 41.10 | 59.50 | 43.49 | 0 | 0 | 0 | 0 |
| Mean | 64.87 | 69.27 | 72.63 | | 63.61 | 68.62 | 70.75 | | 44.23 | 52.29 | 63.33 | | 26.28 | 29.22 | 30.81 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| Initial value | 78.91 (N) | | | | | | | | | | | | | | | |
| T | 0.04 | | 0.16 | | 0.18 | | 0.58 | | 0.01 | | 0.39 | | 0.06 | | 0.254 | |
| M | 0.05 | | 0.20 | | 0.07 | | 0.29 | | 0.09 | | 0.27 | | 0.08 | | 0.311 | |
| T×M | 0.07 | | 0.28 | | 0.10 | | 0.41 | | 0.11 | | 0.43 | | 0.11 | | 0.440 | |
| Treatments | Fruit firmness (N) | | | | | | | | | | | | | | | |
| | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 49.18 | 54.37 | 58.53 | 54.02 | 44.82 | 49.40 | 53.19 | 49.14 | 38.59 | 43.81 | 47.83 | 43.41 | 32.73 | 38.4 | 42.81 | 37.98 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 24.58 | 27.18 | 29.16 | | 22.41 | 24.70 | 26.59 | | 19.29 | 21.91 | 23.96 | | 16.37 | 19.20 | 21.41 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.04 | | 0.16 | | | | 0.238 | | 0.01 | | 0.025 | | 0.06 | | 0.254 | |
| M | 0.05 | | 0.20 | | 0.07 | | 0.291 | | 0.01 | | 0.031 | | 0.08 | | 0.311 | |
| T×M | 0.07 | | 0.28 | | 0.10 | | 0.412 | | 0.01 | | 0.043 | | 0.11 | | 0.440 | |
| Treatments | Fruit firmness (N) | | | | | | | | | | | | | | | |
| | 18 DAS | | | | | | | | 20 DAS | | | | | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 28.46 | 33.48 | 37.09 | 33.01 | 22.69 | 30.73 | 34.92 | 29.45 | | | | | | | | |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | |
| Mean | 14.23 | 16.74 | 18.55 | | 11.35 | 15.37 | 17.46 | | | | | | | | | |
| | S.Em± | | | | CD at 1% | | | | S.Em± | | | | CD at 1% | | | |
| T | 0.005 | | | | 0.012 | | | | 0.001 | | | | 0.08 | | | |
| M | 0.006 | | | | 0.014 | | | | 0.002 | | | | 0.09 | | | |
| T×M | 0.009 | | | | 0.019 | | | | 0.003 | | | | 0.012 | | | |

T₁: Cold storage condition

T₂: Ambient condition

M₁: Fruits packed in CFB box

M₂: Salicylic acid at 1.5mM

M₃: KMnO₄ (papers shreds impregnated in CFB box)

3.3 Respiration rate (ml CO₂/kg/hr)

In general, respiration rate of sapota fruits increased as the storage period progressed in all the treatments and thereafter declined in respiration peak on 4th day in ambient condition and in cold storage increasing n increase respiration in slower rate. The data revealed that there was a significant difference among the treatments, storage temperature and their interaction effect on 2, 4 and 6 DAS (Table 3). Among the different storage temperatures, the maximum respiration rate were recorded in T₂ (63.49, 80.13 and 74.29 ml CO₂/kg/hr). The minimum respiration rate was recorded in T₁ (54.40 ml CO₂/kg/hr, 63.03 and 54.17 ml CO₂/kg/hr). Among the post harvest treatments, significantly maximum respiration rate value were recorded in M₃ (63.59 ml CO₂/kg/hr, 80.13 ml CO₂/kg/hr 74.94 ml CO₂/kg/h and minimum respiration rate was recorded in M₃ (54.81,57.15 ml CO₂/kg/hr) On 10 and

14 DAS, the minimum respiration rate was noticed in M₃ (66.53 and 35.56 ml CO₂/kg/hr) whereas, maximum was noticed in M₁ (40.46 and 47.00 ml CO₂/kg/hr). The interaction effect between the treatments and storage temperature was also found significant. The significant highest respiration rate was noticed in T₁M₁ (80.83 and 94.01 ml CO₂/kg/hr) whereas lowest was recorded in T₁M₃ (69.57 and 74.83 ml CO₂/kg/hr). On 18 and 20 DAS, the minimum respiration rate was noticed in M₃ (42.05 and 33.62 ml CO₂/kg/hr) whereas, maximum was noticed in M₁ (84.09 and 38.35 ml CO₂/kg/hr) Among the interaction effect the minimum respiration rate was noticed in T₁M₁ (38.35 61.48 and 67.23 ml CO₂/kg/hr) whereas maximum was recorded in T₁M₃ (61.48 and 67.23 ml CO₂/kg/hr). The interaction between treatments and storage intervals was found to be significant.

Table 3: Effect of different storage temperature and post-harvest treatments on respiration rate of sapota fruits cv. Cricket ball

| Treatments | Respiration rate (ml CO ₂ /kg/hr) | | | | | | | | | | | | | | | |
|----------------|--|-------|----------|-------|-------|-------|----------|-------|-------|-------|----------|-------|-------|-------|----------|-------|
| | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 58.22 | 54.17 | 50.83 | 54.40 | 60.03 | 58.07 | 54.92 | 57.67 | 64.95 | 60.90 | 57.15 | 61.00 | 68.71 | 64.42 | 60.62 | 64.58 |
| T ₂ | 69.00 | 62.80 | 58.80 | 63.49 | 89.90 | 77.70 | 72.80 | 80.13 | 57.70 | 86.30 | 78.90 | 74.29 | 0 | 0 | 0 | 0 |
| Mean | 63.59 | 58.46 | 54.81 | | 74.94 | 67.89 | 63.87 | | 61.34 | 73.58 | 68.00 | | 34.35 | 32.21 | 30.31 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| Initial value | 52.56 (ml CO ₂ /kg/hr) | | | | | | | | | | | | | | | |
| T | 0.04 | | 0.16 | | 0.08 | | 0.28 | | 0.18 | | 0.59 | | 0.06 | | 0.25 | |
| M | 0.05 | | 0.20 | | 0.07 | | 0.29 | | 0.13 | | 0.41 | | 0.08 | | 0.31 | |
| T×M | 0.07 | | 0.28 | | 0.10 | | 0.41 | | 0.24 | | 0.78 | | 0.11 | | 0.44 | |

| Treatments | Respiration rate(ml CO ₂ /kg/hr) | | | | | | | | | | | | | | | |
|----------------|---|-------|----------|-------|--------|-------|----------|--------------|--------|-------|----------|----------|--------|-------|----------|--------------|
| | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 72.47 | 69.71 | 66.53 | 69.57 | 80.83 | 76.5 | 76.5 | 76.15 | 94.01 | 79.18 | 74.83 | 82.67 | 82.62 | 84.93 | 78.81 | 82.12 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 36.24 | 34.86 | 33.26 | | 40.46 | 38.25 | 35.56 | | 47.00 | 39.59 | 37.42 | | 41.31 | 42.47 | 39.41 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.09 | | 0.29 | | 0.023 | | 0.072 | | 0.018 | | 0.025 | | 0.09 | | 0.234 | |
| M | 0.08 | | 0.32 | | 0.07 | | 0.291 | | 0.019 | | 0.061 | | 0.07 | | 0.311 | |
| T×M | 0.03 | | 0.28 | | 0.10 | | 0.412 | | 0.021 | | 0.069 | | 0.15 | | 0.491 | |

| Treatments | Respiration rate(ml CO ₂ /kg/hr) | | | | | | | |
|----------------|---|-------|----------|-------|--------|-------|----------|-------|
| | 18 DAS | | | | 20 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 90.50 | 84.09 | 61.48 | 78.69 | 38.35 | 55.50 | 67.23 | 53.69 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 45.25 | 42.05 | 30.74 | | 19.18 | 27.75 | 33.62 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.15 | | 0.49 | | 0.01 | | 0.08 | |
| M | 0.19 | | 0.64 | | 0.05 | | 0.19 | |
| T×M | 0.31 | | 0.98 | | 0.09 | | 0.32 | |

T₁: Cold storage condition

T₂: Ambient condition

M₁: Fruits packed in CFB box

M₂: Salicylic acid at 1.5mM

M₃: KMnO₄ (papers shreds impregnated in CFB box)

3.4 Polygalactouranase (PG) enzyme activity

Irrespective of any treatment, PG activity increased significantly from 2nd day storage to 6th day storage in ambient condition and then increased up to 20 days storage in cold storage condition. The data revealed that there was a significant difference among the treatments, storage temperature and their interaction effect on 2, 4 and 6 DAS (Table 4). Among the different storage temperatures, the maximum polygalactouranase enzyme activity were recorded in T₂ (46.52, 75.21 and 62.49 µg-galatouronic acid-FW g⁻¹ h⁻¹). The minimum polygalactouranase enzyme activity was recorded in T₁ (45.22, 51.12 and 59.73 µg-galatouronic acid-FW g⁻¹ h⁻¹). Among the post harvest treatments, significantly maximum polygalactouranase enzyme activity value were recorded in M₁ (48.51, 60.87 and 70.04 (µg-galatouronic acid-FW g⁻¹ h⁻¹)) and minimum polygalactouranase enzyme activity was recorded in M₃ (41.64, 60.87 and 70.04 (µg-galatouronic acid-FW g⁻¹ h⁻¹)). On 10 and 12 DAS, the minimum polygalactouranase enzyme activity was noticed in M₃ (35.27 and 38.0 µg-galatouronic

acid-FW g⁻¹ h⁻¹) followed by M₂ (37.19 and 39.20 (µg-galatouronic acid-FW g⁻¹ h⁻¹)) whereas, maximum was noticed in M₁ (38.59 and 41.41 µg-galatouronic acid-FW g⁻¹ h⁻¹). The interaction effect between the treatments and storage temperature was also found significant. The significant maximum polygalactouranase enzyme activity was noticed in T₁M₁ (77.17 and 82.82 µg-galatouronic acid-FW g⁻¹ h⁻¹) whereas minimum was recorded in T₁M₃ (70.53 and 76.19 µg-galatouronic acid-FW g⁻¹ h⁻¹) On 18 and 20 DAS, the minimum polygalactouranase enzyme activity was noticed in M₃ (46.95 and 38.75 µg-galatouronic acid-FW g⁻¹ h⁻¹) whereas, maximum was noticed in M₁ (49.23 and 11.34 (µg-galatouronic acid-FW g⁻¹ h⁻¹)). Among the interaction effect the minimum polygalactouranase enzyme activity was noticed in T₁M₃ (93.90 and 77.50 µg-galatouronic acid-FW g⁻¹ h⁻¹) whereas maximum was recorded in T₁M₁ (98.46 and 92.69 µg-galatouronic acid-FW g⁻¹ h⁻¹). The interaction between treatments and storage intervals was found to be significant.

Table 4: Effect of different storage temperature and post-harvest treatments on polygalactouranase enzyme activity of sapota fruits cv. Cricket ball

| Polygalactouranase enzyme activity ($\mu\text{g galactouronic acid FW g}^{-1} \text{h}^{-1}$) | | | | | | | | | | | | | | | | |
|---|--|-------|----------|-------|------------|-------|----------|-------|------------|-------|----------|-------|------------|-------|----------|-------|
| Treatments | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 49.06 | 45.53 | 41.07 | 45.22 | 54.16 | 51.27 | 47.92 | 51.12 | 62.57 | 59.47 | 57.15 | 59.73 | 69.55 | 65.44 | 62.62 | 65.87 |
| T ₂ | 47.95 | 45.02 | 42.20 | 45.06 | 88.07 | 69.98 | 67.57 | 75.21 | 29.90 | 80.10 | 77.5 | 62.49 | 0 | 0 | 0 | 0 |
| Mean | 48.51 | 45.28 | 41.64 | | 60.87 | 60.63 | 67.99 | | 70.04 | 69.79 | 43.52 | | 34.78 | 32.72 | 31.31 | |
| | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | |
| Initial value | 36.38 ($\mu\text{g galactouronic acid FW g}^{-1} \text{h}^{-1}$) | | | | | | | | | | | | | | | |
| T | 0.08 | | 0.26 | | 0.07 | | 0.23 | | 0.09 | | 0.45 | | 0.18 | | 0.54 | |
| M | 0.09 | | 0.33 | | 0.11 | | 0.39 | | 0.11 | | 0.51 | | 0.08 | | 0.31 | |
| T \times M | 0.17 | | 0.59 | | 0.21 | | 0.72 | | 0.18 | | 0.733 | | 0.15 | | 0.49 | |

| Polygalactouranase enzyme activity ($\mu\text{g galactouronic acid FW g}^{-1} \text{h}^{-1}$) | | | | | | | | | | | | | | | | |
|---|------------|-------|----------|-------|------------|-------|----------|-------|------------|-------|----------|-------|------------|-------|----------|-------|
| Treatments | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 77.17 | 74.37 | 70.53 | 74.02 | 82.82 | 78.40 | 76.19 | 79.14 | 88.59 | 85.81 | 82.83 | 85.74 | 94.73 | 91.40 | 89.21 | 91.78 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 38.59 | 37.19 | 35.27 | | 41.41 | 39.20 | 38.09 | | 44.29 | 42.91 | 41.42 | | 47.37 | 45.70 | 44.61 | |
| | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | |
| T | 0.07 | | 0.28 | | 0.32 | | 0.98 | | 0.06 | | 0.25 | | 0.07 | | 0.25 | |
| M | 0.05 | | 0.75 | | 0.17 | | 0.63 | | 0.17 | | 0.71 | | 0.12 | | 0.51 | |
| T \times M | 0.02 | | 0.98 | | 0.19 | | 0.65 | | 0.12 | | 0.43 | | 0.17 | | 0.64 | |

| Polygalactouranase enzyme activity ($\mu\text{g galactouronic acid FW g}^{-1} \text{h}^{-1}$) | | | | | | | | | |
|---|------------|-------|----------|-------|------------|-------|----------|-------|--|
| Treatments | 18 DAS | | | | 20 DAS | | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | |
| T ₁ | 98.46 | 96.48 | 93.90 | 96.28 | 22.69 | 80.10 | 77.50 | 60.09 | |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mean | 49.23 | 48.24 | 46.95 | | 11.34 | 40.05 | 38.75 | | |
| | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | |
| T | 0.005 | | 0.012 | | 0.001 | | 0.08 | | |
| M | 0.006 | | 0.014 | | 0.002 | | 0.09 | | |
| T \times M | 0.009 | | 0.019 | | 0.003 | | 0.012 | | |

T₁: Cold storage conditionT₂: Ambient conditionM₁: Fruits packed in CFB boxM₂: Salicylic acid at 1.5mMM₃: KMnO₄ (papers shreds impregnated in CFB box)

3.5 Electrolyte leakage (%)

Irrespective of all treatments, the electrolyte leakage increased as the storage prolonged. Similarly, irrespective of different storage temperatures, the maximum electrolyte leakage was recorded in T₂ (4.64, 10.42 and 20.85%). The minimum electrolyte leakage was recorded in T₁ (3.21, 4.54 and 4.13%). Among the post harvest treatments, significantly maximum electrolyte leakage value were recorded in M₁ (5.36, 9.63 and 14.76%) and minimum electrolyte leakage was recorded in M₃ (2.74, 5.20 and 10.31%) on 2, 4 and 6th DAS. On 10 and 12 DAS, the minimum electrolyte leakage was noticed in M₃ (3.15 and 3.67%) followed by M₂ (3.67 and 4.22%) whereas, maximum was noticed in M₁ (4.38 and

5.44%). The interaction effect between the treatments and storage temperature was also found significant (Table 5). The significant maximum electrolyte leakage was noticed in TIM₁ (8.76 and 10.88%) whereas minimum was recorded in TIM₃ (6.29 and 7.35%). On 18 and 20 DAS, the minimum electrolyte leakage was noticed in M₃ (6.88 and 8.44%) followed by M₂ (7.94 and 9.49%) whereas, maximum was noticed in M₁ (9.69 and 11.74%). Among the interaction effect the minimum electrolyte leakage was noticed in TIM₃ (13.77 and 16.88%) whereas maximum was recorded in TIM₁ (19.38 and 23.47%). The interaction between treatments and storage intervals was found to be significant.

Table 5: Effect of different storage temperature and post harvest treatments on electrolyte leakage of sapota fruits cv. Cricket ball

| Electrolyte leakage (%) | | | | | | | | | | | | | | | | |
|-------------------------|------------|------|----------|------|------------|------|----------|-------|------------|-------|----------|-------|------------|------|----------|------|
| Treatments | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 4.95 | 2.73 | 1.95 | 3.21 | 5.38 | 3.85 | 2.76 | 3.99 | 4.54 | 3.99 | 3.88 | 4.13 | 7.67 | 6.25 | 5.20 | 6.37 |
| T ₂ | 5.77 | 4.63 | 3.53 | 4.64 | 13.88 | 9.75 | 7.64 | 10.42 | 24.97 | 20.85 | 16.73 | 20.85 | 0 | 0 | 0 | 0 |
| Mean | 5.36 | 3.68 | 2.74 | | 9.63 | 6.80 | 5.20 | | 14.76 | 12.42 | 10.31 | | 3.84 | 3.13 | 2.60 | |
| | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | | S.Em \pm | | CD at 1% | |
| Initial value | 3.39% | | | | | | | | | | | | | | | |
| T | 0.19 | | 0.59 | | 0.12 | | 0.42 | | 0.12 | | 0.45 | | 0.06 | | 0.254 | |
| M | 0.08 | | 0.34 | | 0.15 | | 0.291 | | 0.18 | | 0.63 | | 0.08 | | 0.311 | |
| T \times M | 0.11 | | 0.38 | | 0.13 | | 0.412 | | 0.21 | | 0.73 | | 0.11 | | 0.440 | |

| Electrolyte leakage (%) | | | | | | | | | | | | | | | | |
|-------------------------|--------|------|----------|-------|--------|------|----------|------|--------|-------|----------|-------|--------|-------|----------|-------|
| Treatments | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 8.76 | 7.33 | 6.29 | 89.52 | 10.88 | 8.44 | 7.35 | 8.89 | 13.95 | 10.54 | 8.44 | 10.97 | 17.26 | 12.76 | 11.56 | 13.86 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 4.38 | 3.67 | 3.15 | | | 5.44 | 4.22 | 3.67 | 6.97 | 5.27 | 4.22 | | 8.63 | 6.38 | 5.78 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.05 | | 0.19 | | 0.01 | | 0.38 | | 0.21 | | 0.75 | | 0.05 | | 0.19 | |
| M | 0.12 | | 0.43 | | 0.07 | | 0.29 | | 0.13 | | 0.41 | | 0.09 | | 0.37 | |
| T×M | 0.07 | | 0.28 | | 0.14 | | 0.49 | | 0.14 | | 0.48 | | 0.14 | | 0.49 | |

| Electrolyte leakage (%) | | | | | | | | | |
|-------------------------|--------|-------|----------|-------|--------|-------|----------|-------|--|
| Treatments | 18 DAS | | | | 20 DAS | | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | |
| T ₁ | 19.38 | 15.88 | 13.77 | 16.34 | 23.47 | 18.98 | 16.88 | 19.78 | |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mean | 9.69 | 7.94 | 6.88 | | 11.74 | 9.49 | 8.44 | | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | |
| T | 0.05 | | 0.19 | | 0.01 | | 0.08 | | |
| M | 0.06 | | 0.34 | | 0.09 | | 0.32 | | |
| T×M | 0.09 | | 0.43 | | 0.14 | | 0.56 | | |

T₁: Cold storage condition

T₂: Ambient condition

M₁: Fruits packed in CFB box

M₂: Salicylic acid at 1.5mM

M₃: KMnO₄ (papers shreds impregnated in CFB box)

3.6 Total soluble solids (TSS)

The data revealed that there was a significant difference among the different storage temperature and treatments with respect to TSS of sapota fruits during different storage intervals. Interestingly, untreated fruits showed highest TSS but thereafter, it declined, whereas, treated fruits it went on increasing up till 20th day of storage but at slower rate. Among the treatments, storage temperature and their interaction effect on 2, 4 and 6 DAS (Table 6). Among the different storage temperatures, the maximum TSS were recorded in T₂ (18.35, 21.65 and 21.78°B). The minimum TSS was recorded in T₁ (16.37, 17.29 and 18.44°B). Among the post harvest treatments, significantly maximum TSS were recorded in M₁ (18.36, 21.21 and 9.44°B) and minimum TSS was recorded in M₃ (16.45, 18.17 and 21.78°B). The interaction effect between the treatments and storage temperature was also found significant. The significant

maximum TSS was noticed in T₂M₁ (19.04, 23.95 and 19.96°B) whereas minimum was recorded in T₂M₃ (14.99, 16.30 and 17.12°B). On 10 and 12 DAS, the minimum TSS was noticed in M₃ (9.77 and 10.15°B) followed by M₂ (10.21 and 10.97°B) whereas, maximum was noticed in M₁ (10.92 and 11.58°B). The interaction effect between the treatments and storage temperature was also found significant. The significant maximum TSS was noticed in T₁M₁ (21.84 and 23.15 °B) whereas minimum was recorded in T₁M₃ (19.53 and 20.29 °B). On 18 and 20 DAS, the minimum TSS was noticed in M₁ (%) followed by M₂ (%) whereas, maximum was noticed in M₃ (%). Among the interaction effect the maximum TSS was noticed in T₁M₃ (%) which was statistically on par with T₁M₂ (%) whereas minimum was recorded in T₁M₁ (%). The interaction between treatments and storage intervals was found to be significant.

Table 6: Effect of different storage temperature and post harvest treatments on TSS (°B) of sapota fruits cv. Cricket ball

| TSS (°B) | | | | | | | | | | | | | | | | |
|----------------|------------|-------|----------|-------|-------|-------|----------|-------|-------|-------|----------|-------|-------|-------|----------|-------|
| Treatments | 2 DAS | | | | 4 DAS | | | | 6 DAS | | | | 8 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 17.67 | 16.45 | 14.99 | 16.37 | 18.46 | 17.12 | 16.30 | 17.29 | 19.96 | 18.25 | 17.12 | 18.44 | 20.76 | 19.33 | 18.45 | 19.51 |
| T ₂ | 19.04 | 18.12 | 17.90 | 18.35 | 23.95 | 20.96 | 20.04 | 21.65 | 18.91 | 22.53 | 23.91 | 21.78 | 0 | 0 | 0 | 0 |
| Mean | 18.36 | 17.28 | 16.45 | | 21.21 | 19.04 | 18.17 | | 19.44 | 20.39 | 20.52 | | 10.38 | 9.67 | 9.23 | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| Initial value | 16.34 (°B) | | | | | | | | | | | | | | | |
| T | 0.03 | | 0.12 | | 0.13 | | 0.45 | | 0.21 | | 0.73 | | 0.32 | | 0.98 | |
| M | 0.05 | | 0.19 | | 0.16 | | 0.54 | | 0.12 | | 0.41 | | 0.14 | | 0.49 | |
| T×M | 0.09 | | 0.23 | | 0.21 | | 0.67 | | 0.14 | | 0.48 | | 0.15 | | 0.54 | |

| TSS (°B) | | | | | | | | | | | | | | | | |
|----------------|--------|-------|----------|-------|--------|-------|----------|-------|--------|-------|----------|-------|--------|-------|----------|-------|
| Treatments | 10 DAS | | | | 12 DAS | | | | 14 DAS | | | | 16 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 21.84 | 20.41 | 19.53 | 20.59 | 23.15 | 21.94 | 20.29 | 21.79 | 23.95 | 22.07 | 21.28 | 22.43 | 21.84 | 22.62 | 24.01 | 22.82 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 10.92 | 10.21 | 9.77 | | 11.58 | 10.97 | 10.15 | | 11.97 | 11.04 | 10.64 | 10.92 | 11.31 | 12.00 | | |
| | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.12 | | 0.39 | | 0.24 | | 0.72 | | 0.16 | | 0.57 | | 0.17 | | 0.59 | |
| M | 0.17 | | 0.57 | | 0.16 | | 0.57 | | 0.18 | | 0.67 | | 0.21 | | 0.69 | |
| T×M | 0.17 | | 0.67 | | 0.17 | | 0.61 | | 0.21 | | 0.71 | | 0.19 | | 0.65 | |

| Treatments | TSS (°B) | | | | | | | |
|----------------|----------|-------|----------|-------|--------|-------|----------|-------|
| | 18 DAS | | | | 20 DAS | | | |
| | M1 | M2 | M3 | Mean | M1 | M2 | M3 | Mean |
| T ₁ | 20.08 | 21.07 | 22.85 | 21.33 | 19.04 | 20.33 | 21.98 | 15.86 |
| T ₂ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 10.04 | 10.56 | 11.43 | | 7.57 | 8.00 | 8.22 | |
| | S. Em± | | CD at 1% | | S.Em± | | CD at 1% | |
| T | 0.13 | | 0.47 | | 0.18 | | 0.59 | |
| M | 0.19 | | 0.64 | | 0.16 | | 0.53 | |
| T×M | 0.21 | | 0.69 | | 0.23 | | 0.72 | |

T₁: Cold storage condition

T₂: Ambient condition

M₁: Fruits packed in CFB box

M₂: Salicylic acid at 1.5mM

M₃: KMnO₄ (papers shreds impregnated in CFB box)

4. Discussion

4.1 Physiological loss in weight (PLW) (%)

Physiological loss in weight is one of the most important character, which governs the post-harvest quality of fruits. Any loss in weight of fruits is likely to reduce the quality of product drastically. In general, weight loss in sapota was increased with the advancement of storage periods, rather slowly in the beginning but at an increasing rate as the storage period advanced. Among the different storage temperatures, the minimum PLW was recorded in cold temperature whereas, the maximum PLW were recorded in ambient condition. This might be due to loss water from fruits due to transpiration and respiration attributed to loss of fruit weight. These findings are in agreement with the earlier reports on these aspects by Sanjay (1996) [20] and Sharma *et al.*, 2011. Among the post harvest treatments, the decreased physiological loss in weight during prolonged storage might be due to KMnO₄ decreases respiration and delays ripening by maintaining ethylene at a low level for a long period Wills *et al.* (1989) [25]. These findings are in agreement with the earlier reports on these aspects by Fageria *et al.* (2007) [11] in ber and Kumar *et al.* (2011) [15] in guava.

4.2 Firmness (N)

At low temperatures, the retention of the firmness was more compared to the ambient conditions that can be attributed to reduced activity of fruit softening enzymes like polygalacturonase, pectinase and cellulase. Sharma *et al.* (2012) [22]. In general, the progressive decrease in the fruit firmness with the advancement of storage may be due to the breakdown of insoluble protopectins into soluble pectin or by hydrolysis of starch Mattoo *et al.* (1975) [16]. The loss of pectic substances in the middle lamella of the cell wall is perhaps the key step in the ripening process that leads to the loss of cell wall integrity thereby causing loss of firmness and softening. These results are in agreement with similar findings by Hussain *et al.* (2015) [13] in sweet orange fruits as well as in kiwifruit by Changhoo *et al.* (2001) [8]. The lower rate of softening in cold stored+CFB+ KMnO₄ packed fruits might be due to the effect of the combination of package, KMnO₄ and temperature in lowering the rate of respiration, delaying the ripening process and reduction in moisture loss; such synergistic effect was not witnessed in case of fruits stored in ambient storage thus leading to a quicker decrease in fruit firmness.

4.3 Respiration rate (ml CO₂/kg/hr)

Fruit stored at low temperature showed 1-fold and 1.5-fold less respiration rate during ripening period as compared to the ambient condition. Among the post harvest treatments,

significantly maximum respiration rate value were recorded in M₃ (63.59 ml CO₂/kg/hr, 80.13 ml CO₂/kg/hr 74.94 ml CO₂/kg/h and minimum respiration rate was recorded in M₃ (54.81, 57.15 ml CO₂/kg/hr). This might be due to their action of scavenging the ethylene, which is known to trigger respiration in fruits, especially in climacteric types and also it delays in climacteric peak of respiration and retards the ripening by maintaining ethylene at a low level for a long period Wills *et al.* (1989) [25]. Storage of fruits in cold storage in CFB+KMnO₄ slowed down the ripening and also checked the microbial infection permeability, which retards water vapour and other gases exchange. Further, the inhibitory effect of cold storage in CFB+KMnO₄ on respiration rate on sapota fruits might be due to the delaying of the metabolic and other physiological activities of fruit. These results are in agreement with the findings of Elamin and Abu-Goukh. (2010) [10], Abu-Goukh. (2003) [1].

4.4 Polygalactouranase (PG) activity

One of the most characteristic changes during ripening of fleshy fruits is softening of fruits peel as well as pulp. Our study indicated that untreated fruits exhibited very high PG activity than the treated fruits, which is attributed to the role of cold storage in CFB+KMnO₄ in combination on suppression of ethylene evolution, which might have delayed ripening and lowered down the PG activity (Taylor *et al.*, 1995; Khan and Singh, 2007) [24, 14]. Our study indicated that fruits stored at low temperature exhibited very low PG activity than the ambient conditions, which may be ascribed to delay in ripening and also the enzyme activities which are storage temperature dependent. Similar result of reduced fruit softening at low temperatures was reported by Roberto *et al.* (1990) [19] in guava. Among the post harvest treatments, KMnO₄ (packed in CFB box) treated fruits showed least PG activity followed by salicylic acid @ 1.5 mm. This is due to KMnO₄ absorbed some amount of evolved ethylene from fruits, which might have delayed ripening and prevented the trigger of the ripening related events and hence slowed down the PG activity. The similar results were reported by Sharma *et al.* (2012) [22] in Japanese plum, Elamin and Abou Ghoukh. (2010) [10].

4.5 Electrolyte leakage

Electrolyte leakage increased significantly from 2nd day (5.49%) to 8th day (14.36%). Similarly, untreated fruits showed very higher electrolyte leakage (12.16%) than the pretreated fruits. Electrolyte leakage in the untreated fruit found maximum and in treated fruit, electrolyte leakage was minimum compared to other treatments, which may linked to membrane selective permeability loss related to color

development and pulp consistency loss. KMnO₄ treated fruits that maintained membrane selective permeability was also efficient in delaying color development and in reducing pulp consistency loss. The results pointed to an effect of KMnO₄ in delaying fruit senescence. The similar results were reported by Silva *et al.* (2012)^[23].

4.6 Total soluble solids

Increase in TSS as the fruit ripens in all treatments. The TSS content increased slowly and steadily as storage proceeds while in control, sharp the TSS increase was noticed. The initial increase in TSS was mainly due to conversion of starch to soluble forms of sugars. A similar result of initial rise in the TSS contents was reported by Gupta and Jawandha (2012)^[12]. Increase of TSS is an important trait of hydrolysis of starch into soluble sugars such as glucose, sucrose and fructose. This increase was reported by Correa *et al.* (2005)^[9] in papaya. Among the post harvest treatments, significantly maximum TSS were recorded in M1 (18.36, 21.21 and 9.44[°]B) and minimum TSS was recorded in M3 (16.45, 18.17 and 21.78[°]B). This is might be due to low temperature had a slow and gradual accumulation of TSS compared to ambient temperature. The slowdown of delayed respiration was the causes for delayed TSS to reach peak. Similar results were reported by Nikam and Waskar.(1995)^[17] in sapota, Padmavathi. (1999)^[18] in banana, Baviskar *et al.* (1995)^[7] in ber Among the post harvest treatments, significantly maximum firmness was recorded in KMnO₄ treated fruits followed by salicylic acid at 1.5 mm. The reason for delaying the metabolic activity of fruits during storage due to delay in ethylene production with consequent delay in ripening.

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6. References

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