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Ethrel induced ripening optimally modulates physicochemical quality, antioxidant properties and shelf life of sapota (*Manilkara zapota* L.) cv. Cricket Ball

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ABSTRACT: The present study was carried out during 2023–24 at GBPUAT, Pantnagar, Uttarakhand. The study was conducted to evaluate the effect of ethrel on ripening, fruit quality, antioxidant properties and shelf-life of sapota fruits. The experiment was conducted in a factorial Completely Randomized Design (CRD) with seven treatments and three replications. Mature fruits of sapota cv. Cricket Ball were treated with different concentrations of ethrel (500, 1000, 1500, 2000 and 2500 ppm), calcium carbide @ 10 g kg^{-1} fruits, untreated control and stored under ambient conditions. Observations were recorded at 3, 6, 9 and 12 days after treatment. Significant differences were observed among treatments for physiological loss in weight, firmness, total soluble solids, total sugars, ascorbic acid, total phenolic content, total antioxidant activity and shelf-life. Fruits treated with Ethrel @ 1000 ppm showed more uniform ripening, higher TSS and total sugars, acceptable firmness, better antioxidant retention. The higher shelf-life was recorded with ethrel @ 500 ppm (10.50 days), which was statistically at par with ethrel @ 1000 ppm (10.33 days). However, CaC_2 treated fruits showed rapid deterioration, poor quality retention and lowest shelf-life. Overall, ethrel @ 1000 ppm provided a favourable balance between ripening uniformity, TSS and sugar accumulation, antioxidant retention and acceptable shelf-life under the ambient storage conditions of the study.

Keywords: Artificial ripening, CaC_2, Ethrel, Fruit quality, Sapota, Shelf-life

Sapota (*Manilkara zapota* L), popularly known as chikoo or sapodilla belongs to Sapotaceae family, is an important tropical evergreen fruit. It was originated from Southern Mexico and Central America and widely cultivated in tropical and subtropical regions of the world (Baskar *et al., 2020*). India is one of the largest producers of sapota globally, covering an area of about 69.85 thousand hectares and production exceeding 861 thousand metric tonnes annually (MoA&FW, 2025). Gujarat, Karnataka, Maharashtra Andhra Pradesh, Tamil Nadu and Telangana are major sapota growing states of India. Important cultivars like Cricket Ball, Kalipatti, Jhumari, Pala and Kirthibarthi are widely cultivated because of superior fruit quality and market demand (Rekha*, 2024*). They are valued for their superior taste, pleasing aroma with high nutritional composition. It holds good amounts of sugars, proteins, minerals, carotenoids, phenolic compounds and antioxidants, which contribute significantly to their nutraceutical and health promoting properties (Kaur *et al.,* 2020). Sapota holds an important rank among fruit crops in local as well as international markets due to its nutritional wealth and consumer suitability (Srivastava *et al.,* 2017).

It holds immense commercial importance but sapota fruits are highly perishable due to its climacteric nature and fast ripening behaviour after harvest. It exhibits quick climacteric respiratory pattern with high ethylene production during ripening (Baidya *et al.,* 2020). Due to which it suffers from fast ripening after harvest resulting in softening, high physiological loss in weight, biochemical alteration, microbial infection and accelerated senescence which reduces it shelf life and market suitability (Madani *et al.,* 2018). Sapota fruits were generally stored for 5-6 days after harvest under ambient conditions (Kaur *et al.,* 2020). However, considerable postharvest losses ranging between 20–35% have been reported during post-harvest

handling and marketing (*Baidya et al., 2020*).

In commercial fruit markets of developing countries, calcium carbide (CaC_2) is still used as a low-cost ripening method despite its ban and associated health issue. It produces acetylene gas in the presence of moisture, which replicates the action of ethylene and induces rapid ripening (Vidhya *et al.,* 2025). Fruits ripened with CaC_2 shows reduced flavour, lower nutritional quality, extreme softening, quick senescence and reduced storage life (Deshi *et al.,* 2024). Furthermore, CaC_2 available in local market contains harmful impurities like arsenic and phosphorus compounds that carries serious health risks to human health (*Oladipupo et al.,* 2022). There have been several studies on artificial ripening on climacteric fruits like mango, banana, papaya but with limited information available on sapota with various concentration of ethrel and CaC_2 on ripening, storage life and fruit quality.

Therefore, the present study was conducted to study the effect of different ethrel concentrations on ripening, fruit quality and shelf life of sapota cv. Cricket Ball under ambient conditions. The study also aimed to identify a suitable ethrel concentration for uniform ripening, better fruit quality and longer shelf-life and to compare its effects with calcium carbide ripening.

MATERIAL AND METHODS

Experimental Site and Plant Material

The study was conducted during 2023-24 at the Horticulture Research Centre, Patharchatta and the Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. During May–June 2024, ambient temperature ranged from 34.1–42.6 °C (maximum) and 17.8–27.9 °C (minimum), while relative humidity ranged from 51.4–80.7% (maximum) and 14.1–65.0% (minimum). Physiologically mature fruits of sapota (*Manilkara zapota* L.) cv. Cricket Ball were harvested from healthy and uniformly managed trees. Fruits were selected based on uniform size, shape and maturity characteristics.

Experimental Design and Treatments

The experiment was conducted under ambient laboratory conditions in a two-factorial Completely Randomized Design (CRD) with three replications. Seven post-harvest ripening treatments were evaluated namely ethrel at 500 ppm (T_1), 1000 ppm (T_2), 1500 ppm (T_3), 2000 ppm (T_4) and 2500 ppm (T_5), calcium carbide at 10 g kg^{-1} fruit (T_6) and control (T_7). Each treatment in each replication consisted of 12 fruits, with three fruits used for evaluation at each storage interval (3rd, 6th, 9th and 12th day). Different fruits were used at each storage interval.

Fruits treated with different ethrel treatments were dipped in freshly prepared ethrel solutions for 5 min, air dried for 1 hour, packed in cardboard boxes and stored under ambient conditions. Calcium carbide treated fruits were packed in cardboard boxes with calcium carbide @ 10 g kg^{-1} fruit wrapped in newspaper and placed separately from the fruits to avoid direct contact, whereas control fruits were stored without treatment.

Determination of Quality Parameters

Physiological Loss in Weight (PLW) (%)

PLW was determined using an electronic balance and expressed as percentage loss relative to initial fruit weight using the formula:

$$\text{PLW (\%)} = \frac{\text{Initial fruit weight} - \text{Fruit weight on observation day}}{\text{Initial fruit weight}} \times 100$$

Fruit Firmness (N)

Fruit firmness was measured using a Texture Analyzer (TA. XT Plus, Stable Micro Systems, UK) fitted with a 2 mm probe. The force required to penetrate the fruit pulp to a depth of 10 mm was recorded and expressed in Newton (N).

Total Soluble Solids (TSS) (°Brix)

Total soluble solids were estimated using a hand refractometer and expressed as °Brix. Fresh fruit juice was placed on the prism surface and readings were recorded directly.

Ascorbic Acid (mg/100 g)

Ascorbic acid content was estimated by the 2,6-dichlorophenol indophenol dye titration method and calculated using the following formula:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot taken} \times \text{Weight of sample}} \times 100$$

Total Sugars (%)

Total sugars were estimated by the Lane and Eynon method using Fehling's solution and methylene blue indicator. Total sugars were calculated using the formula:

$$\text{Total sugars (\%)} = \frac{\text{Factor for Fehling's solution} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{Weight of sample}}$$

Total Phenolic Content (mg GAE/100 g FW)

Total phenolic content was determined by the Folin–Ciocalteu colorimetric method. Absorbance was measured at 760 nm using a UV–Visible spectrophotometer and results were expressed as mg gallic acid equivalents (GAE) per 100 g fresh weight using a gallic acid standard curve.

Total Antioxidant Activity (%)

Total antioxidant activity was estimated using the DPPH free radical scavenging assay and calculated using the following formula:

$$\text{DPPH scavenging activity (\%)} = \left(1 - \frac{\text{Absorbance of sample}}{\text{Absorbance of control}}\right) \times 100$$

Shelf-life (Days)

Shelf life was determined based on visual assessment of marketability, including deve'opment of shrivelling, excessive softening and decay symptoms. It was expressed as the number of days fruits remained acceptable under ambient storage conditions.

Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA) for a 7 × 4 factorial Completely Randomized Design (CRD), considering ripening treatment, storage interval and their interaction (T × I). The significance of treatment, storage interval and T × I interaction was tested at the 5% probability level. Treatment means were compared using the critical difference (CD) at P = 0.05 following Snedecor and Cochran (1987).

RESULTS AND DISCUSSION

Physiological Loss in Weight (%)

Physiological loss in weight (PLW) of sapota cv. Cricket Ball was significantly influenced by ripening treatments, storage duration and their interaction (Fig. 1). PLW increased progressively with increasing concentrations of ethrel and advancement of storage period. Among the treatments, maximum PLW (16.70%) was recorded in calcium carbide treated fruits (T_6), followed by ethrel @ 2500 ppm (T_5) with 14.34%, whereas minimum PLW (6.13%) was observed in untreated control fruits (T_7). PLW increased significantly from the 3rd day (5.37%) to the 12th day (18.51%) across storage periods. Interaction effects were also significant, with the highest PLW (26.03%) recorded in calcium carbide treated fruits on the 12th day of storage, while the lowest PLW (1.85%) was observed in control fruits on the 3rd day. Lower ethrel concentrations, particularly 500 ppm (T_1) and 1000 ppm (T_2), maintained comparatively lower PLW throughout storage. The continuous increase in PLW during storage because of higher respiration, transpiration losses and fast consumption of stored metabolites during ripening (Rana *et al.,* 2021). Application of exogenous ethylene from ethrel hastens respiratory action, permeability of membrane and moisture loss which leads to higher fruit weight reduction (Tipu and Sherif, 2024). Fruit treated with CaC_2 displayed higher PLW due to acetylene induced quick ripening, tissue softening and accelerated desiccation (Vidhya *et al.,* 2025). Artificial ripening agents significantly enhanced metabolic activity and postharvest moisture loss as reported by Palpandian *et al.* (2019) in mango and Muthal *et al.* (2019) in banana.

Fruit Firmness (N)

Fruit firmness of sapota cv. Cricket Ball was significantly influenced by ripening treatments,

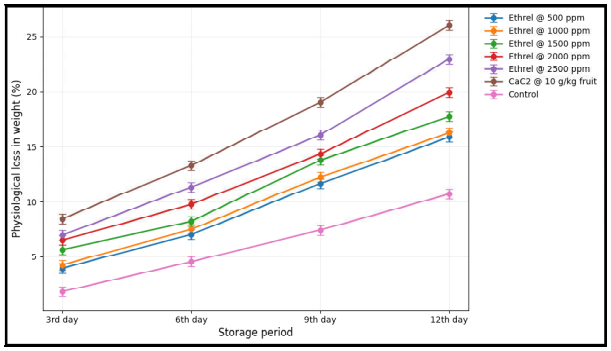

Fig. 1: Effect of post-harvest ethrel treatments and storage duration on physiological loss in weight (PLW, %) of sapota cv. Cricket Ball during ripening

Table 1: Effect of post-harvest ethrel treatments on total soluble solids (TSS), ascorbic acid and total sugar of sapota cv. Cricket Ball during ripening at different storage interval

Treatments	TSS (°Brix)				Ascorbic Acid (mg/100 g)				Total Sugars (%)			
	3rd day	6th day	9th day	12th day	3rd day	6th day	9th day	12th day	3rd day	6th day	9th day	12th day
T_1: Ethrel @ 500 ppm	16.57	18.93	21.23	18.03	22.30	18.36	15.98	11.76	11.02	13.19	15.59	13.36
T_2: Ethrel @ 1000 ppm	17.00	19.40	22.03	19.03	22.00	17.94	14.90	11.44	11.52	13.72	15.91	13.96
T_3: Ethrel @ 1500 ppm	17.17	20.63	19.03	16.37	21.83	16.71	14.10	10.13	11.83	14.64	12.75	12.01
T_4: Ethrel @ 2000 ppm	17.43	21.77	18.50	15.17	20.84	15.64	13.94	9.80	12.22	15.32	12.11	11.15
T_5: Ethrel @ 2500 ppm	17.80	21.97	18.00	14.83	20.00	14.87	12.06	9.15	12.54	15.76	11.85	10.20
T_6: CaC, @ 10 g/kg fruit	18.93	17.50	15.57	13.20	18.50	12.93	10.26	6.21	13.88	12.95	10.85	9.39
T_7: Control	13.70	16.50	17.67	15.20	24.17	19.32	16.14	14.23	9.68	11.47	12.23	11.49
Mean	16.94	19.53	18.86	15.98	21.38	16.54	13.91	10.39	11.82	13.86	13.04	11.65
Parameters	Treatments (T)				Storage Intervals (I)				T × I			
TSS (°Brix)	0.50				0.38				0.99			
Ascorbic Acid (mg/100 g)	0.43				0.32				0.85			
Total Sugars (%)	0.40				0.30				0.79			

storage duration and their interaction (Fig. 2). Untreated control fruits (T_7) recorded the highest firmness (4.99 N), whereas CaC_2 treated fruits (T_6) exhibited the lowest firmness (1.45 N), followed by ethrel @ 2500 ppm (T_5) with 1.72 N among the treatments. Fruit firmness decreased significantly with advancement of storage period from 5.56 N on the 3rd day to 0.77 N on the 12th day, irrespective of treatments. The interaction effect was also significant, with maximum firmness (8.22 N) observed in control fruits on the 3rd day, while minimum firmness (0.27 N) was recorded in CaC_2 treated fruits on the 12th day, which was statistically at par with ethrel @ 2500 ppm. A rapid decline in firmness was observed in fruits treated with higher ethrel concentrations and CaC_2, indicating accelerated ripening and tissue softening (Vidhya *et al.,* 2025). More than 80% reduction in firmness occurred within six days in T_4, T_5 and T_6 treatments,

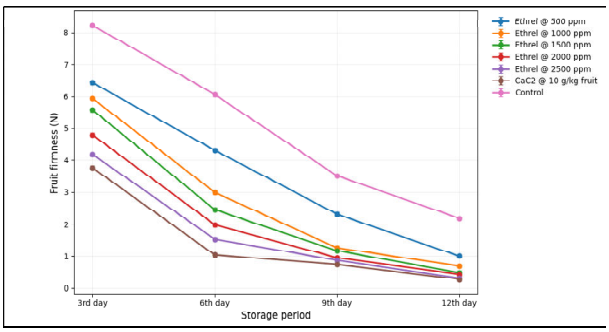

Fig. 2: Effect of post-harvest ethrel treatments and storage duration on fruit firmness (N) of sapota cv. Cricket Ball during ripening

coinciding with the climacteric rise in respiration. Softening of fruits due to higher degradation of cell wall polysaccharides, conversion of protopectin into soluble pectin and increased activities of cell wall degrading enzymes such as polygalacturonase, pectin methyl esterase and ²-galactosidase (Liu *et al.,* 2026). Higher ethrel concentrations intensified enzymatic hydrolysis of structural carbohydrates, results in rapid softening of tissue and over ripening (Xia *et al.,* 2024). Similar findings were reported by Padmaja *et al.* (2015), Menezes and Athmaselvi (2016) and Vidhya *et al.* (2017) in sapota fruits.

Total Soluble Solids (°Brix)

Total soluble solids (TSS) of sapota cv. Cricket Ball was significantly influenced by ripening treatments, storage duration and their interaction (Table 1). Among the treatments, fruits treated with ethrel @ 1000 ppm (T_2) recorded the higher TSS (19.37 °Brix), followed by ethrel @ 500 ppm (T_1) with 18.69 °Brix, although control fruits (T_7) showed the lowest TSS (15.77 °Brix). Storage period significantly affected TSS, which increased from 16.94 °Brix on the 3rd day to 19.53 °Brix on the 6th day, followed by a gradual decline to 15.98 °Brix on the 12th day of storage. The interaction effect was also significant, with maximum TSS (22.03 °Brix) observed in fruits treated with ethrel @ 1000 ppm on the 9th day of storage. Minimum TSS (13.20 °Brix) was recorded in CaC_2 treated fruits on the 12th day. The increase in TSS during ripening might be

due to enzymatic hydrolysis of starch, pectic substances and complex carbohydrates into soluble sugars, whereas the subsequent decline could be associated with utilization of sugars during respiration (Yu *et al.,* 2022). Fruits treated with ethrel showed higher TSS due to enhanced ethylene facilitated activation of hydrolytic enzymes responsible for rapid carbohydrate conversion (Tipu and Sherif*,* 2024). Optimum concentrations of ethrel maintained higher TSS for a extended period, demonstrating balanced ripening and delayed senescence (Ghimire *et al.,* 2021). Similar findings were reported by Bons *et al.* (2016) in sapota, Muthal *et al.* (2019) in banana and Meiyarasan *et al.* (2025) in mango.

Ascorbic Acid (mg/100 g)

Ripening treatments, storage duration, and their interaction significantly influenced the ascorbic acid content of sapota cv. Cricket Ball (Table 1). Among the treatments, untreated control fruits (T_7) recorded the higher ascorbic acid content (18.46 mg/100 g), whereas CaC_2 treated fruits (T_6) showed the minimum value (11.97 mg/100 g). A significant decline in ascorbic acid was observed with advancement of storage period, decreasing from 21.38 mg/100 g on the 3rd day to 10.39 mg/100 g on the 12th day of storage. Interaction effects were also significant, with maximum ascorbic acid (24.17 mg/100 g) observed in control fruits on the 3rd day and minimum (6.21 mg/100 g) in CaC_2 treated fruits on the 12th day. Among ethrel treatments, fruits treated with ethrel @ 500 ppm maintained relatively higher ascorbic acid content throughout storage period. The gradual decline in ascorbic acid during ripening and storage due to greater oxidative breakdown and rapid consumption of antioxidants during climacteric respiration (Pareek, 2016). Fruits treated with ethrel showed earlier exhaustion of ascorbic acid due to accelerated ethylene mediated ripening and increased activity of oxidative enzymes responsible for conversion of ascorbic acid into dehydroascorbic acid (Asrey *et al.,* 2023). Lower retention of ascorbic acid in CaC_2 treated fruits because of acetylene induced metabolic stress and rapid senescence (Vidhya *et al.,* 2025). Similar findings were reported by Tsomu *et al.* (2015) in sapota, Adeyemi *et al.* (2018) in banana, pawpaw and mango and Orisa and Usoroh *(*2020) in pawpaw fruits.

Total Sugars (%)

A significant effect of ripening treatments, storage period, and their interaction on the total sugars content of sapota cv. Cricket Ball was observed (Table 1). Among the treatments, fruits treated with ethrel @ 1000 ppm (T_2) recorded the highest total sugars (13.78%), followed by ethrel @ 500 ppm (T_1) with 13.29%, whereas untreated control fruits showed the lowest value (11.22%). Storage duration significantly affected total sugars, which increased from 11.82% on the 3rd day to 13.86% on the 6th day, followed by a gradual decline to 11.65% on the 12th day of storage. The interaction effect was also significant, with maximum total sugars (15.91%) observed in fruits treated with ethrel @ 1000 ppm on the 9th day, while minimum total sugars (9.39%) were recorded in CaC_2 treated fruits on the 12th day of storage. Ethrel @ 1000 ppm maintained comparatively higher sugar content even at the end of storage. The initial increase in total sugars during the process of ripening due to enzymatic hydrolysis of starch and polysaccharides into simple sugars, whereas the following decline was associated with utilization of sugars during respiration and senescence (Yu *et al.,* 2022). Ethrel treated fruits showed higher sugar accumulation due to enhanced ethylene mediated activation of ripening enzymes and improved conversion of reserve carbohydrates into soluble sugars (Tipu and Sherif, 2024). Moderate ethrel concentrations maintained higher sugar levels for longer duration, indicating balanced ripening and delayed metabolic depletion (Wardani *et al.,* 2026). Similar findings were reported by Tsomu *et al.* (2015), Kaur *et al.* (2017) while in mango by Palpandian *et al.* (2019).

Total Phenolic Content (mg GAE/100g FW)

Total phenolic content (TPC) of sapota cv. Cricket Ball was significantly influenced by ripening treatments, storage duration and their interaction (Fig. 3a). Among the treatments, untreated control fruits (T_7) recorded the highest phenolic content (135.10 mg GAE/100g FW), followed by ethrel @ 500 ppm (T_1), whereas CaC_2 treated fruits (T_6)

exhibited the lowest value (106.97 mg GAE/100g FW). Storage period significantly affected TPC, which declined progressively from 135.37 mg GAE/ 100g FW on the 3rd day to 105.57 mg GAE/100g FW on the 12th day of storage. The significant treatment × storage interaction indicated that the extent of change in TPC during storage varied among the ripening treatments. A gradual decline in TPC was observed throughout the ripening period, with CaC_2 treated fruits showed reduction compared to other treatments, while control fruits maintained comparatively higher phenolic content during storage. The decline in phenolic content during ripening and storage which may be attributed to enhanced oxidative degradation and polymerization of phenolic compounds during senescence (Zhang *et al.,* 2023). Ethrel and calcium carbide treatments accelerated ripening, thereby increasing the activity of oxidative enzymes such as polyphenol oxidase and peroxidase responsible for rapid oxidation of phenolic constituents (Vidhya *et al.,* 2025; Chandar and Smith*,* 2019). Reduction in soluble tannins and conversion of phenolics into insoluble forms during ripening also contributed to lower detectable phenolic content (Shahidi and Hossain, 2023). Similar findings were reported by Torres Rodriguez *et al.* (2011) in sapote, Fernando *et al.* (2014) in banana, Rastegar *et al.* (2015) in sapota fruits.

Total Antioxidant Activity (%)

Total antioxidant activity of sapota cv. Cricket Ball was significantly influenced by ripening treatments, storage duration and their interaction (Fig. 3b). Among the treatments, untreated control fruits (T_7) recorded the maximum antioxidant activity (43.14%), followed by ethrel @ 500 ppm (T_1) with 37.19%, whereas CaC_2 treated fruits (T_6) exhibited the minimum value (20.85%). Storage duration significantly affected antioxidant activity, which declined progressively from 48.27% on the 3rd day to 18.95% on the 12th day of storage. The interaction effect was also significant, with maximum antioxidant activity (61.28%) observed in control fruits on the 3rd day, while the minimum value (12.09%) was recorded in CaC_2 treated fruits on the 12th day of storage. A continuous reduction in antioxidant activity was observed throughout ripening, with CaC_2 treated fruits showing a sharper decline compared to other treatments. The reduction in antioxidant activity during ripening and storage attributed to degradation and oxidation of antioxidant compounds such as ascorbic acid, phenolics, carotenoids and other bioactive metabolites during senescence (de Souza *et al., 2021*). Accelerated ripening induced by ethrel and calcium carbide enhanced oxidative metabolism and increased utilization of antioxidant constituents, leading to rapid decline in radical scavenging capacity (Vidhya *et al.,* 2025*;* Singh *et al.,* 2013). Lower antioxidant retention in CaC_2 fruits due to stress induced decline and enhanced oxidative enzyme activity (Mode *et al., 2026*).

Shelf-life

Shelf-life of sapota cv. Cricket Ball was significantly influenced by different ripening treatments (Plates 1a & 1b). Among the treatments, fruits treated with ethrel @ 500 ppm (T_1) recorded the maximum shelf-life (10.50 days), which was statistically at par with ethrel @ 1000 ppm (T_2) exhibiting 10.33 days. However, CaC_2 treated fruits (T_6) showed the minimum shelf-life (6.50 days), differing

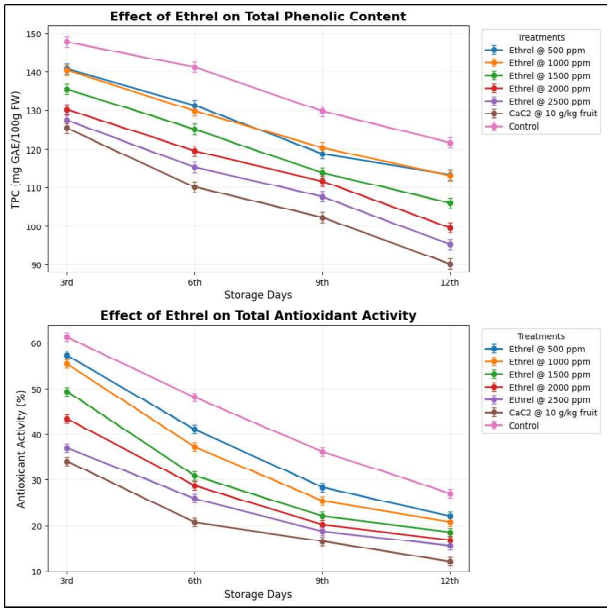

Fig. 3: Effect of post-harvest ethrel treatments and storage duration on a. total phenolic content (TPC) b. total antioxidant activity of sapota cv. Cricket Ball during ripening

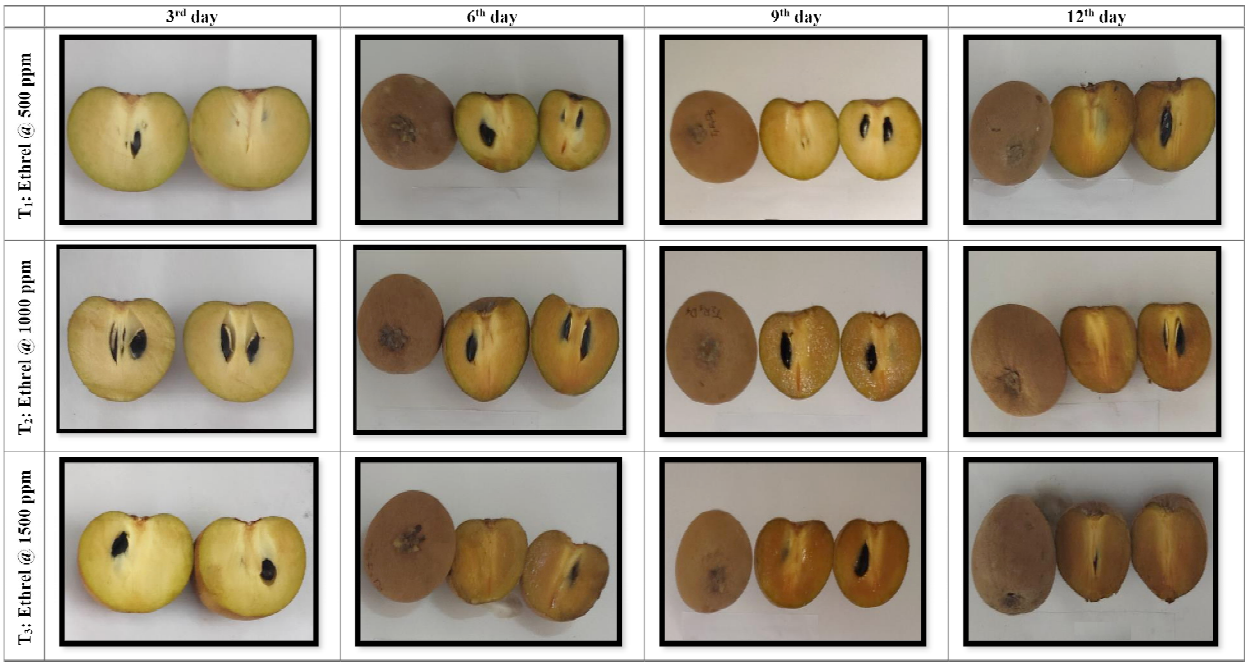

Plate 1(a): Visual condition of sapota fruits at different storage intervals as affected by different treatments

Plate 1(b): Visual condition of sapota fruits at different storage intervals as affected by different treatments

significantly from all other treatments. Shelf life decreased progressively with increasing concentrations of ethrel (Ran *et al.,* 2022). The reduction in shelf life at higher ethrel concentrations because of accelerated ethylene mediated ripening, increased respiration rate, rapid moisture loss and enhanced metabolic degradation of fruit tissues (Zhang *et al.,* 2017). Excessive ethylene exposure hastened softening, senescence and deterioration of quality parameters such as firmness, sugars and acidity, thereby shortening marketable life (Nagaraja *et al.,* 2026). However, lower concentrations of ethrel maintained a balanced ripening process, ensuring desirable fruit quality with comparatively extended shelf-life. Untreated fruits retained firmness for longer duration but failed to attain acceptable ripening and marketable quality during storage. Although ethrel @ 500 ppm recorded the highest shelf-life, ethrel @ 1000 ppm was statistically at par and provided comparatively higher TSS and total sugar accumulation with acceptable fruit quality. Calcium carbide treated fruits exhibited the minimum shelf life due to rapid acetylene persuaded ripening, excessive tissue breakdown and faster senescence (Vidhya *et al.,* 2025).

CONCLUSION

The present study confirmed that postharvest application of ethrel significantly influenced the ripening behaviour, physicochemical quality, antioxidant properties and shelf-life of sapota cv. Cricket Ball under ambient storage conditions. Ethrel treated fruits exhibited faster and more uniform ripening compared to untreated fruits, but calcium carbide treatment resulted in rapid deterioration and poor storage quality. Among the treatments, ethrel @ 1000 ppm (T_2) was found to be the most effective, as it produced fruits with superior total soluble solids, higher total sugar, desirable ripening characteristics and better eating quality. However, the maximum shelf-life was recorded with ethrel @ 500 ppm (T_1) but it was statistically at par with T_2. Additionally, T_2 maintained acceptable antioxidant properties and overall fruit quality throughout the storage period. Therefore, post-harvest application of ethrel @ 1000 ppm is recommended for achieving uniform ripening, improved fruit quality and satisfactory shelf life in sapota fruits under ambient conditions.

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