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Thakriya HR
Department of Fruit Science, ACHF, NAU, Navsari, Gujarat, India

Tandel YN
Department of Fruit Science, ACHF, NAU, Navsari, Gujarat, India

Saravaiya SN
Department of Vegetable Science, ACHF, NAU, Navsari, Gujarat, India

Ahlawat TR
Department of Fruit Science, ACHF, NAU, Navsari, Gujarat, India

Viyol SH
Department of Natural Resource Management, COF, NAU, Navsari, Gujarat

Jinal Tandel
Department of Fruit Science, ACHF, NAU, Navsari, Gujarat, India

Corresponding Author:
Thakriya HR
Department of Fruit Science, ACHF, NAU, Navsari, Gujarat, India

Influence of 1-MCP and storage conditions on physical properties of sapota

Thakriya HR, Tandel YN, Saravaiya SN, Ahlawat TR, Viyol SH and Jinal Tandel

Abstract
Sapota is a climacteric fruit so it necessitates careful postharvest handling to reduce losses, future hindering the storage and distribution of fruits. Postharvest life of fruits depends on harvesting time, chemical applications and storage conditions. With a view to the perishable nature of sapota fruits and for extending the postharvest life, the experiment was laid out at Centre of Excellence on Post Harvest Technology, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during the year 2020-21. The fruits treated with different concentration of 1-MCP and stored under ambient temperature and low temperature (12.0 ± 0.5 °C) *viz.*, T_1 (1-MCP @ 0 nL L^{-1} + ambient temperature), T_2 (1-MCP @ 0 nL L^{-1} + low temperature), T_3 (1-MCP @ 20 nL L^{-1} + ambient temperature), T_4 (1-MCP @ 20 nL L^{-1} + low temperature), T_5 (1-MCP @ 40 nL L^{-1} + ambient temperature), T_6 (1-MCP @ 40 nL L^{-1} + low temperature), T_7 (1-MCP @ 60 nL L^{-1} + ambient temperature), T_8 (1-MCP @ 60 nL L^{-1} + low temperature), T_9 (1-MCP @ 80 nL L^{-1} + ambient temperature), T_{10} (1-MCP @ 80 nL L^{-1} + low temperature), T_{11} (1-MCP @ 100 nL L^{-1} + ambient temperature) and T_{12} (1-MCP @ 100 nL L^{-1} + low temperature). The physical and physiological parameters of sapota fruit were assessed at five days interval. The result revealed that the sapota fruits fumigated with 1-MCP @ 100 nL L^{-1} and stored under low temperature (12.0 ± 0.5 °C) had recorded maximum marketable fruits and minimum PLW, spoiled fruit, ethylene production and respiratory activity with more firm fruits at 20^{th} day of storage. The highest shelf life (22.39 days) was noted in fruits which treated with 1-MCP at 100 nL L^{-1} and stored at low temperature 12.0 ± 0.5 °C.

Keywords: 1-MCP, storage conditions, sapota, Kalipatti

Introduction
Sapota [*Manilkara achras* (Mill.) Fosberg] is common name denominating a popular evergreen and ever fruiting tropical fruit tree of the family Sapotaceae and the order Ericales. It is one of an important fruit crop of the tropical region. Being a climacteric fruit, it is highly perishable and the postharvest life is very short. The fruit ripens within 4 to 7 days after harvest with rapid bio-chemical changes occurring during this period which reduce the shelf life. In addition, the climacteric nature of sapota fruits necessitates careful post-harvest handling to reduce losses, further hindering the storage and distribution of sapota. The ethylene inhibitors are marking their presence by delaying the ripening which is becoming common practice now-a-days. The use of ethylene antagonists has been an important tool in clarifying the physiological role of ethylene in the process of fruit ripening and also as a postharvest treatment to broaden the conservation potential of fruits. 1-Methylcyclopropene (1-MCP) is the best known and studied amongst ethylene inhibitors (Blankenship and Dole, 2003) [1]. It is a compound employed as inhibitor of ethylene and plant growth regulator for many fruits, showing to be highly effective for fruit ripening and senescence control. It has a non-toxic mode of action which retains a negligible residue, active at very low concentrations and non-toxic for humans and environment (Luo *et al.*, 2009) [13]. The usage of 1-MCP has been studied in a wide range of fruits with the objective of delaying the ripening process, prolonging shelf life and maintaining quality; for example, in apple (Kashimura *et al.*, 2010) [11], papaya (Manenoi *et al.*, 2007) [14], pear (Calvo and Sozzi, 2009) [3], plum (Luo *et al.*, 2009) [13] and mangosteen (Piriyavinit *et al.*, 2011). Therefore, to know the effectiveness of this non-sophisticated technology to extend the shelf life of sapota at ambient and low temperature storage conditions with minimal impacts on the environment.

Materials and Methods

The present investigation was carried out at Centre of Excellence on Post Harvest Technology, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during the year 2020-21 on cv. Kalipatti. The fruits treated with different concentration of 1-MCP and stored under ambient temperature and low temperature (12.0 ± 0.5 °C) *viz.*, T_1 (1-MCP @ 0 nL L^{-1} + ambient temperature), T_2 (1-MCP @ 0 nL L^{-1} + low temperature), T_3 (1-MCP @ 20 nL L^{-1} + ambient temperature), T_4 (1-MCP @ 20 nL L^{-1} + low temperature), T_5 (1-MCP @ 40 nL L^{-1} + ambient temperature), T_6 (1-MCP @ 40 nL L^{-1} + low temperature), T_7 (1-MCP @ 60 nL L^{-1} + ambient temperature), T_8 (1-MCP @ 60 nL L^{-1} + low temperature), T_9 (1-MCP @ 80 nL L^{-1} + ambient temperature), T_{10} (1-MCP @ 80 nL L^{-1} + low temperature), T_{11} (1-MCP @ 100 nL L^{-1} + ambient temperature) and T_{12} (1-MCP @ 100 nL L^{-1} + low temperature). All the twelve treatments were repeated thrice. The data was recorded at five days interval. Recorded data were analyzed by the method advocated by Panse and Sukhatme (1985) [16]. Fruits stored under ambient temperature were discarded 10 days onwards due to over ripening.

Application of 1-MCP

Sapota fruits were treated with gaseous 1-MCP. The solution was prepared by diluting 1 mg of 1-MCP powder in 1 L of distilled water to obtain the concentration of 1000 nL L^{-1} (98 % active ingredient). The different concentrations of 1-MCP such as 20, 40, 60, 80 and 100 nL L^{-1} were prepared in same manner. Solution was used within 10 minutes after preparation. The fruits were packed in air-tight plastic polythene (25 micron) containers along with cup of solution containing known concentrations of 1-MCP and then kept at low temperature (20 °C) for 24 hours. The treated fruits then shifted for storage.

Storage of Fruit

All fruits were kept in corrugated fibre board (CFB) box after imposing treatment of 1-MCP and then stored at ambient temperature and low temperature (12.0 ± 0.5 °C with 80-85 %) in Centre of Excellence on Post-Harvest Technology, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari.

Results and Discussion

Physiological loss in weight (%)

It is observed from Fig. 1 that the physiological loss in weight (%) of sapota fruits increased as the storage period advanced. PLW was registered lower in higher dose of 1-MCP among all treatments. However, the minimum PLW was recorded in treatment T_{12} (7.63 %) at 20th day of storage and maximum in T_1 (13.43 %) at 10th day of storage. The reduction in weight loss in 1-MCP treated fruits stored under low temperature may be attributed to slow respiration rate and maintenance of tissue rigidity of the fruits. The present findings thus agreed with Moo-Huchin *et al.* (2013) [15] in sapota, Deaquiz *et al.* (2014) [7] in dragon fruit and Reddy *et al.* (2017) [20] in mango.

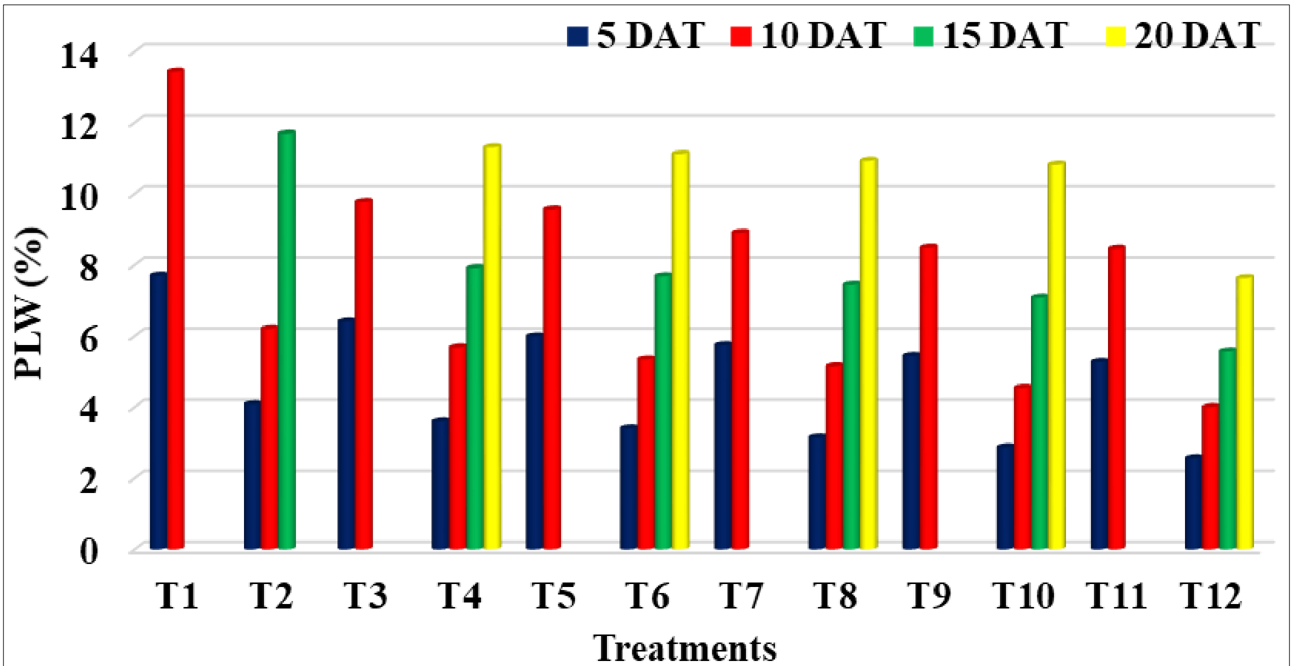

Fig 1: Effect of 1-MCP and storage conditions on physiological loss in weight (%) of sapota cv. Kalipatti

Marketable fruits (%) and Spoiled fruit (%)

It was evident from the Fig. 2 and 3 that marketable fruits and spoiled fruits were significantly decreased and increased with prolonging storage, respectively. 1-MCP significantly increased marketable fruits and decreased spoiled fruits as compared to non-treated fruits during storage. Maximum marketable fruits (75.61 %) and minimum spoiled fruit (24.40 %) was observed in T_{12} at 20th day of storage. It might be due to the application of 1-MCP reduced chilling injury, peel pitting, decayed fruits and increased marketable fruits percentage during cold storage. Lower storage temperature condition also retarded the ripening changes and resulted in higher number of marketable fruits with lesser spoiled fruit. Results established by Tandel (2009) [22] and Rathva *et al.* (2017) [18] in sapota and El-Abbasy and Chutichudet *et al.* (2016) in mango.

Ethylene production (ppm) and Respiratory activity (mg CO_2 kg^{-1} hr^{-1})

From the Fig. 4 and 5, the fruit exposed to 1-MCP under lower temperature had a lower ethylene production and respiration rate than control fruits during storage. It was observed that the increase in concentration of 1-MCP inhibited the ethylene production and respiration rate. Minimum ethylene production (6.53 ppm) and respiratory activity (52.94 mg CO_2 kg^{-1} hr^{-1}) was recorded in T_{12} at 20th day of storage. 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. Storage of fruits in cold storage delaying of the metabolic and other physiological activities of fruit. The present findings thus agreed with Devanesan *et al.* (2011) [8] and Lei Yi *et al.* (2019) [12] in mango and Seema *et al.* (2020) [21] in Sapota.

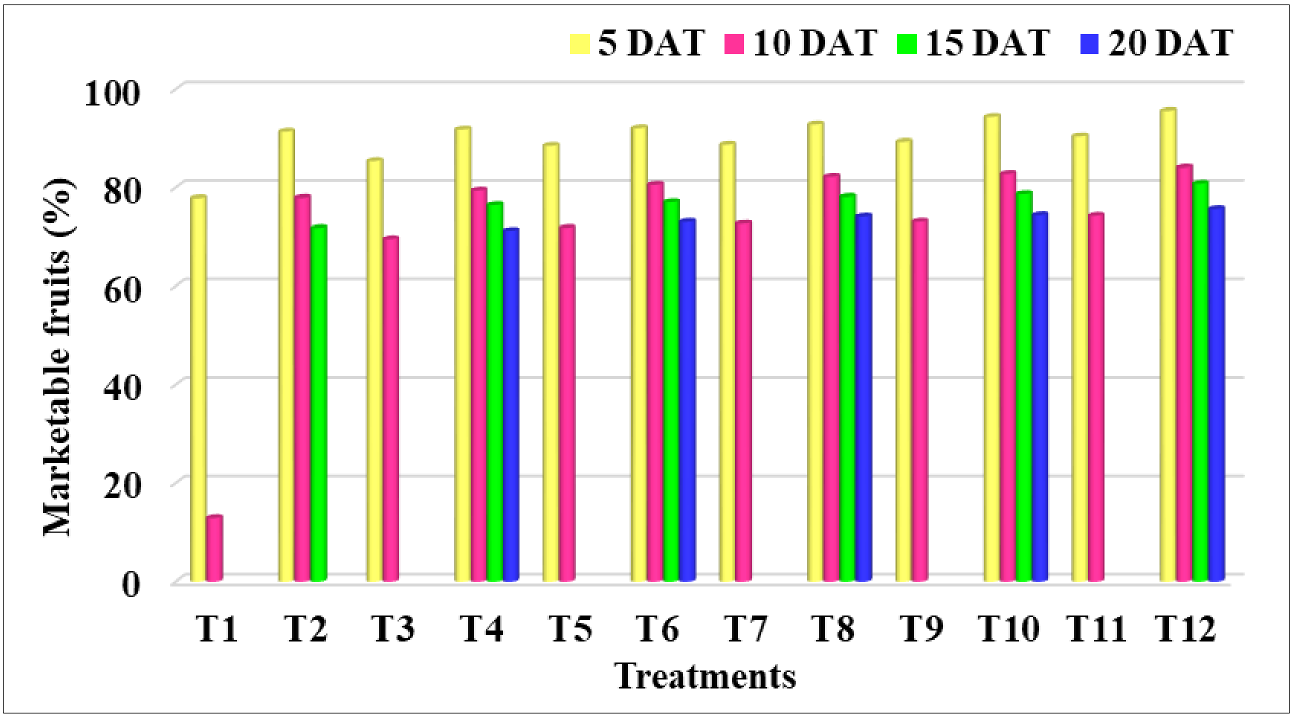

Fig 2: Effect of 1-MCP and storage conditions on marketable fruits (%) of sapota cv. Kalipatti

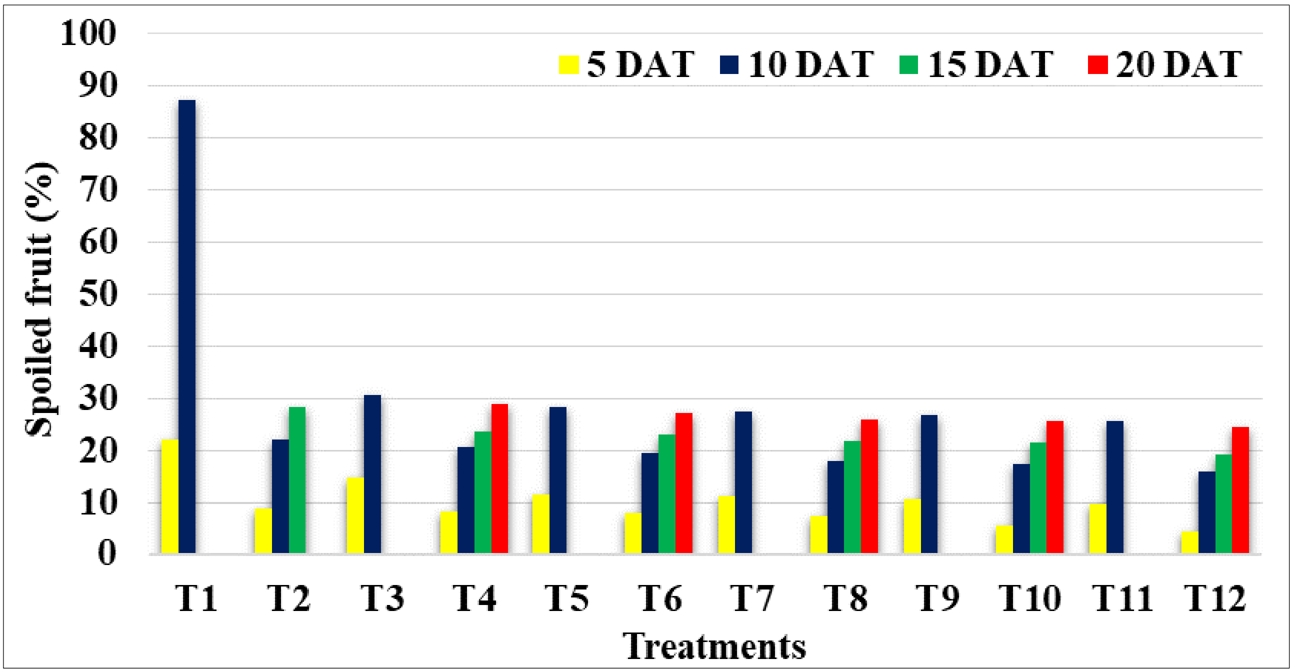

Fig 3: Effect of 1-MCP and storage conditions on spoiled fruit (%) of sapota cv. Kalipatti

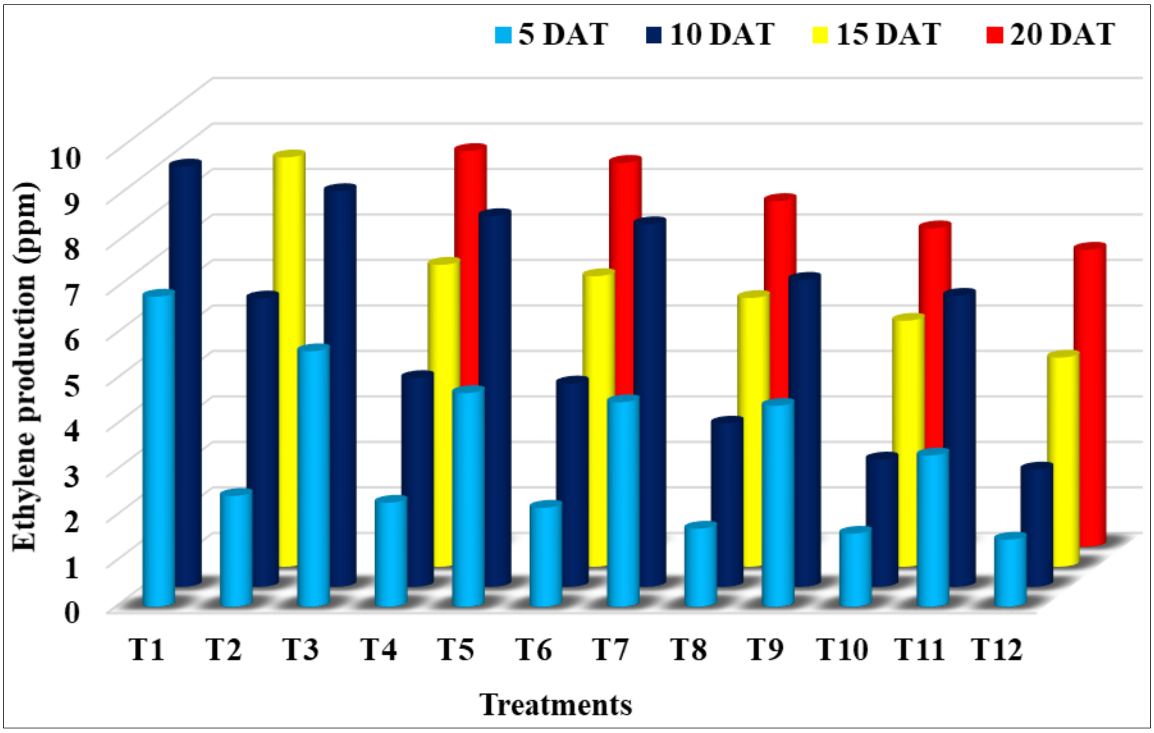

Fig 4: Effect of 1-MCP and storage conditions on ethylene production (ppm) of sapota cv. Kalipatti

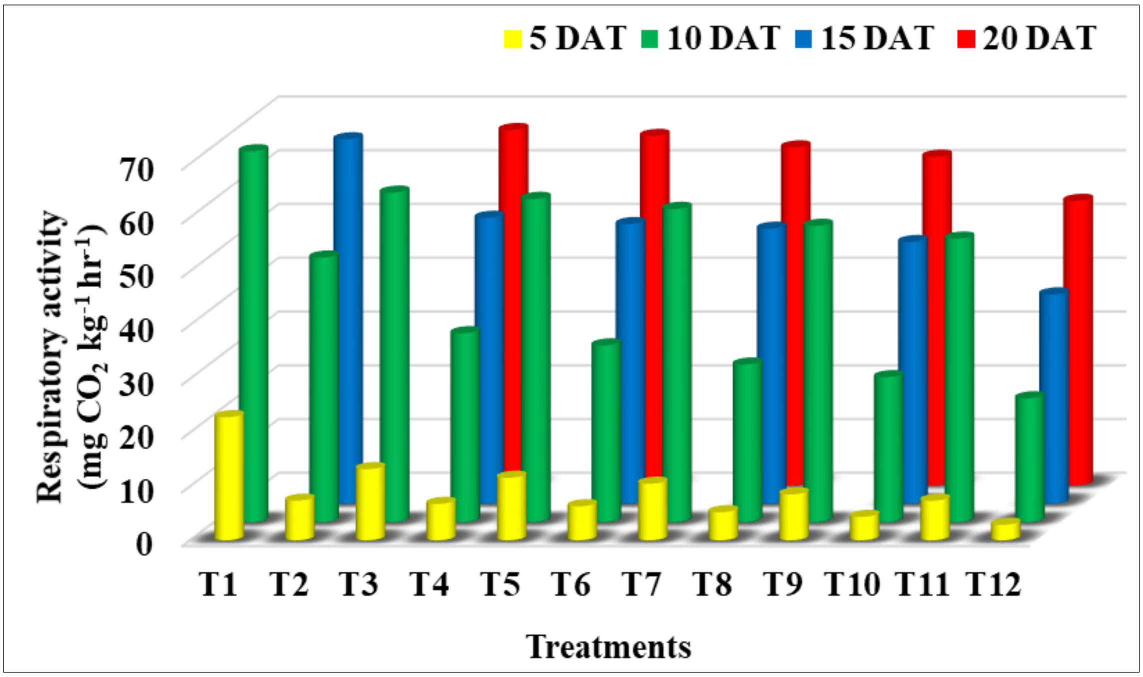

Fig 5: Effect of 1-MCP and storage conditions on respiratory activity (mg CO_2 kg^{-1} hr^{-1}) of sapota cv. Kalipatti

Shelf life (days)
It is obvious from the Fig. 6 that the effect of 1-MCP at 100 nL L^{-1} under low temperature 12.0 ± 0.5 °C had maximum shelf life (22.39 days). 1-MCP is compound that is capable of preventing ethylene action and has also shown to be effective in reducing the post-harvest deterioration of rate of fruits, and thus presents an enormous potential for extending the shelf life of fruit (Moo-Huchin *et al.*, 2013) [15]. The positive effect of 1-MCP on shelf life of fruits was also observed Penchaiya *et al*. (2006) [17], Ayele *et al.* (2012) [1] and Faasema *et al*. (2014) [10] in mango.

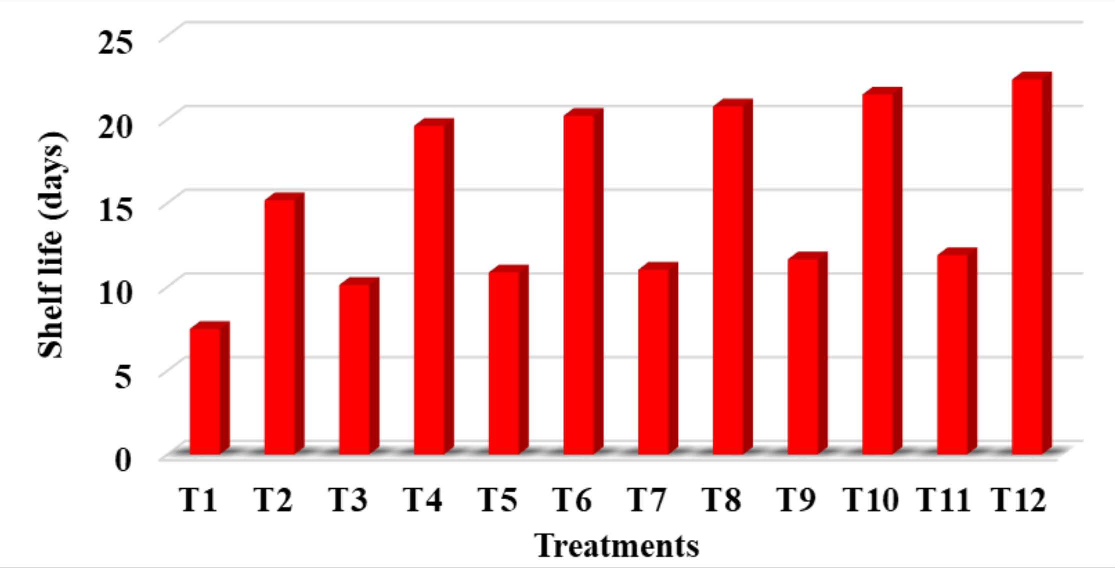

Fig 6: Effect of 1-MCP and storage conditions on shelf life (days) of sapota cv. Kalipatti

Fruit firmness (kg cm^{-2})

The higher dose of 1-MCP with low storage maintaining the fruit firmness (Fig. 7). The maximum fruit firmness (1.91 kg cm^{-2}) was observed in treatment T_{12} at 20th day of storage. The delay in softening observed in 1-MCP treated fruits stored under lower temperature at the end of storage. The delay in loss of firmness of treated fruits with 1-MCP may be due to the inhibition of hydrolysis in enzymes such as polygalacturonase (PG), cellulose and pectin methyl esterase. Similar results finding by De Morais *et al.* (2008) [6] in sapota, Razzaq *et al*. (2015) [19] in mango, Cheng *et al*. (2020) [4] in ber and Trivedi (2020) [23] in banana.

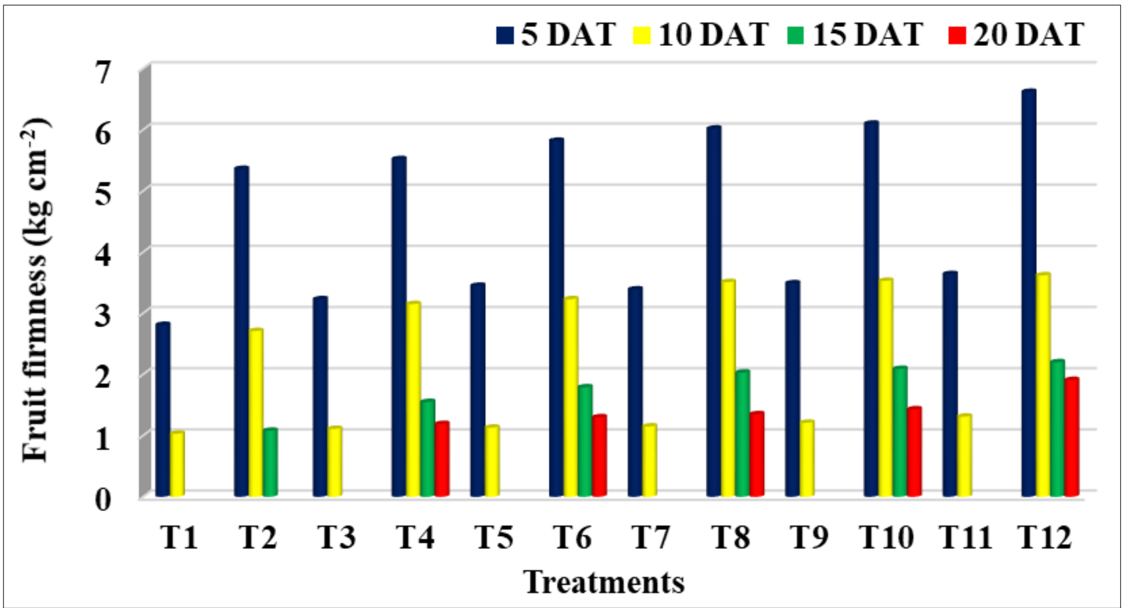

Fig 7: Effect of 1-MCP and storage conditions on fruit firmness (kg cm^{-2}) of sapota cv. Kalipatti

Conclusions

On the basis of results obtained from the investigation, it can be concluded that the among all the treatments, fumigation of 1-MCP at 100 nL L^{-1} under low temperature (20 °C for 24 hours) and subsequently stored at 12 ± 5 °C (T_{12}) found to be best for extending the shelf life and increasing the marketable fruits. It also minimized PLW, spoiled fruit, ethylene production and respiratory activity with maintaining fruit firmness.

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