Review Article

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Post-harvest management of sapota: a review

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ABSTRACT

Sapota (*Manilkara achras*) is a tropical fruit tree that grows slowly and is evergreen. When fully mature, it is commonly eaten as a dessert fruit and is grown commercially in several countries, including India, Sri Lanka, the Philippines, Venezuela, and Mexico. However, because of its short shelf life and highly perishable nature, sapota has limited availability in the market. The main challenge in post-harvest management of sapota is its quick ripening, which significantly reduces its shelf life. To address this issue, various techniques and technologies have been explored, such as the use of chemicals, plant growth regulators (PGRs), packaging materials, wax coating, and irradiation. This review aims to explore post-harvest solutions that can increase the availability of sapota fruits in the market for longer periods and maintain their quality throughout storage by extending their shelf life. By improving the shelf life of sapota through pre-harvest treatment and various storage applications, this study seeks to reduce post-harvest losses, increase availability, and ensure the economic sustainability of this horticultural crop.

Introduction

Sapota (*Manilkara achras* (Mill.) Fosberg) is an evergreen fruit tree belonging to the family Sapotaceae. In India, it is popularly known as "*Chiku*" and is one of the delicious fruits of humid tropical and subtropical regions. It is a good source of digestible sugar which ranges from 12 to 18 per cent and has appreciable amounts of protein, fibre, minerals, calcium, phosphorus and iron. The major sapota-producing states in India are Karnataka, Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu. Sapota is a hardy tropical fruit crop that prefers warm but moist weather and can grow in both dry and humid areas. Under the warm (10 to 38 °C) and humid (70 % relative humidity) climate, it flowers and fruits throughout the year. The pulp of sapota is sweet and melting. Value-added products of sapota are jam, juice, squash, slices, candy, powder, nectar, milkshakes and chocolate. Kalipatti is the leading variety in Maharashtra, Gujarat and North Karnataka (Pawar *et al.*, 2011). Other important cultivars that farmers use for cultivation are Cricket ball, Gutthi, Kirthibarthi and Pala. Fruits are harvested at the full maturity stage.

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Sapota is a climacteric fruit crop and is a very high ethylene-evolving fruit. At ambient conditions, it takes about 6 to 7 days for ripening of fruits. The storage life is minimal at ambient room temperature because of is highly perishable due to its high respiration rate and faster softening. It cannot be stored longer than 5 days due to rapid metabolic activities (Beikhosia and Rawat, 2020). If not managed correctly after harvesting, it overmature in a day or two at room temperature. After harvesting, if not handled properly, it becomes over-mature within a day or two at ambient temperature. Fermentation of the fruit pulp is of common occurrence and thus it is highly needed to manage its post-harvest shelf life. Improving fruit availability on the market for a longer period and preserving sapota fruit quality during storage through longer shelf life are discussed in this article.

Methods and technologies to enhance the post-harvest life of sapota fruits

Significant losses in sapota fruit have been reported due to poor post-harvest management practices, highlighting the need for better techniques to increase shelf life. The extension of shelf life can be achieved by reducing the rate of transpiration, respiration, and ethylene evolution, which can be accomplished through proper storage and post-harvest practices (Seema *et al.*, 2021). The use of appropriate chemicals during pre- and post-harvest stages can also help protect fruits and vegetables from microbial and environmental damage, extending their availability over a longer period. Controlled and modified atmospheres can also be used to store fruits and vegetables at low temperatures, along with appropriate chemical treatments to delay senescence and inhibit microbial decay (Ramjan and Ansari, 2018). Proper post-harvest management practices, including both pre-harvest and post-harvest treatments, are crucial to increase the post-harvest life and maintain the quality of fruits (Baidya *et al.*, 2020).

Storage and packaging material

Sapotas are stored in cool and dry conditions to prevent spoilage. It's important to control temperature and humidity levels to avoid excess moisture or dehydration. This slows down the ripening process and reduces the growth of pathogens. Proper ventilation is also vital to prevent the build-up of ethylene gas, which can accelerate ripening. To maintain humidity levels and prevent physical damage, it's recommended to wrap individual fruits in paper or store them in perforated plastic bags. By following these storage conditions carefully, you can significantly extend the shelf life of sapota fruits, reducing post-harvest losses and allowing for longer storage periods. Packaging is a process that reduces the respiration rate, ripening process, ethylene sensitivity, and ethylene production. It also minimizes the softening of texture. As a result of these activities, the shelf life of the product is extended. Packaging helps in extending shelf life by minimizing shrinkage, weight loss, and other quality parameters (Pratap *et al.*, 2018). A few of the successful methods are listed in Table 1.

Chemicals and plant growth regulators

Chemicals can be used to improve the shelf life of sapota fruits by slowing down metabolic activities, preventing ripening, and preserving their colour and consistency. These chemicals are also effective in inhibiting the growth and spread of microorganisms, preventing shrivelling (Shivani *et al.*, 2022). Plant growth regulators such as 1-MCP can be applied shortly after harvest to delay the ripening and senescence processes by inhibiting ethylene action. GA_3 is another growth regulator that can help slow down the ripening process and enhance fruit firmness, thus maintaining the structural integrity of the fruits during storage. A few of the successful methods are discussed in Table 2.

Edible coatings

Edible coatings provide a natural and eco-friendly solution to increase the shelf life of sapota fruits by tackling issues such as moisture loss, gas exchange, microbial contamination, and oxidative deterioration. If applied correctly, these coatings can significantly extend the storage life of sapota fruits while preserving their quality, freshness, and nutritional value. This protective layer helps preserve the fruit's quality, appearance, and texture over an extended period, making it more appealing to consumers and reducing food waste. Additionally, some edible coatings can be formulated with antioxidant properties, which can further contribute to delaying oxidative processes and prolonging the shelf life of sapota. A few of the practical examples are listed in Table 3.

Irradiation

Irradiation is an effective method to kill bacteria, moulds, and insects that are present on the surface and inside fruits. This methodcan also delay the natural ripening process of sapota by suppressing the activity of enzymes responsible for fruit softening and deterioration.. This prolongs the shelf life of fruits. Importantly, irradiation does not leave any harmful residues and does not induce radioactivity. Therefore, it is a safe and reliable method for extending the shelf life of fruits. With proper irradiation treatment and handling practices, sapota can maintain its freshness and appeal for an extended duration, providing consumers with a high-quality product that has an increased shelf life compared to untreated fruits. A few of the successful methods are discussed in Table 4.

Table 1. Storage and packaging material to enhance post-harvest shelf life of sapota

S.No.	Materials	Details	Treatment time/ Place	Treatment Method	Results	References
1.	Modified atmosphere packaging (MAP) of polybags with gas concentration and stored temperature	25 μ LDPE bags with gas concentration 5% O_2+10% CO_2 and stored at 6°C temperature	Freshly harvested and fully matured sapota fruit stored in ambient condition	On the postharvest MAP	The shelf life of fruit could be increased up to 49 days	Antala *et al.*, 2014
2.	Polyethylene bags	100-gauge thickness having 1.2 per cent ventilations	Freshly harvested fruit stored at room temperature	Packaging treatment at room temperature	Prolonged the shelf life of sapota up to 9th day of storage compared to other packaging materials.	Awasarmal *et al.*, 2011
3.	Packaging of polybags with ventilation and storage temperature	200-gauge LDPE bags with 2.1% ventilation and 12±1°C temperature	Stored in a cold chamber and the temperature was maintained at 12±1°C and RH 85-90%	On the postharvest packaging of freshly harvested sapota fruits in polythene bags with ventilation	Recorded a maximum shelf life of 31.83 days and higher quality in terms of fruit firmness (2.1 kg/cm^2), organoleptic score (9.93), TSS (20.11°Brix), ascorbic acid (22.34 mg/100 g), titratable acidity (0.23%), reducing sugars (8.21%) and total sugars (12.31%)	Bindu *et al.*, 2012
4.	Storage condition+chemical +packaging material	8°C+$KMnO_4$ 1.5 mM in CFB box	After harvest fruit stored at Cold storage	Cold storage Temperature (8°C) with post-harvest dipping of $KMnO_4$	Prolong the shelf life	Seema *et al.*, 2020
5.	Packaging material	Corrugated fibre board (CFB) box	Skin colour of the fruits changed from light brown to dark brown (Potato like colour) and brown scale like structure on the surface of fruit	On the postharvest packaging	Reducing physiological loss in weight and fruit decay with minimum changes in chemical constituents	Seema *et al.*, 2021

Table 2. Chemical treatments to enhance post-harvest shelf life of sapota

S.No.	Chemicals/ materials	Details	Treatment time/ Place	Treatment Method	Results	References
Pre-Harvest Application						
1.	CPPU	6 ppm	Sprayed twice i.e., in the months of November and January	Foliar application	To extend shelf life	Barkule *et al.*, 2017
2.	$CaCl_2$	1 %	Three weeks before harvest	Pre-harvest spraying	Increasing fruit firmness, marketable fruits and Maximum shelf life (10 days) with minimum physiological weight loss and spoilage loss	Patel *et al.*, 2014

Post-Harvest Application						
3.	$CaCl_2$	5,000 ppm	After harvest stored at room temperature	Post-harvest 10-minute dip treatment	Improves the fruit firmness, shelf life and ripening period of the sapota up to 12 days of storage.	Tsomu and Patel, 2014
4.	$CaCl_2$ and storage conditions	10,000 ppm	Treated fruits were stored in the cold storage	Post-harvest 5-minute dip treatment	Treated with $CaCl_2$ 10,000 mg/l (23.67 days)	Patel *et al.*, 2020
5.	1-MCP and storage conditions	100 nL L^{-1} and low temperature 12.0±0.5°C	Post-harvest storage condition	Fruits fumigated with 1-MCP	Best for extending the shelf life and increasing the marketable fruits	Thakriya *et al.*, 2022
6.	2,4-D and Storage conditions	2,4-D @ 4 ppm	Fruits storage at low temperature (12°C)	Post-harvest dip treatment for 5 minutes	Exhibited the longest shelf life of 32 days	Madhavi and Srihari, 2002

Table 3. Enhancement of shelf life of sapota using edible coating

S.No.	Chemicals/ materials	Details	Treatment time/Place	Treatment Method	Results	References
1.	Soyabean starch based edible coatings	Cultivar PDKV-AMS 1001 was used for the extraction of starch	Coated sapota were stored at refrigerated condition	Refrigerated dipped treatment	Enhanced the shelf-life of sapota fruit by 2 weeks in comparison to the control	Chettri *et al.* 2023
2.	Coated with corn starch	2.5 %	Fully matured, uniform size sapota fruits	Stored at ambient storage	Extends the shelf life and also preserves the ascorbic acid and phenol content during storage	Dey *et al.*, 2014
3.	Pectin coating	3 %	Post-harvest application under cooled to room temperature storage	Post-harvest edible coating	The pectin based edible coating extended the shelf life of sapota fruits upto 11 days by delaying the changes in the physico chemical parameters such as weight loss, TSS, pH, total acidity, ascorbic acid, firmness and colour	Menezes and Athmaselvi, 2016
4.	Growth regulator and coating	GA_3 200 ppm and coating of fruits with wax 6 %	Post-harvest treatment at ambient temperature	Dipped and coated	Maximum shelf-life (9.17 days)	Patel and Patel, 2016
5.	Coating of *Aloe vera* gel with water	Ratio of 1:2 and 7 minutes dipping time	Freshly harvested fruit coated with maintaining 15±2°C temperature	Post-harvest dip treatment	Extended the storage life of sapota up to 20 days	Padmaja and John, 2014
6.	Methyl cellulose and palm oil	15 g L^{-1} and 11.25 g L^{-1}	Fruit stored at 24±1°C and 65±5% RH	Post-harvest edible coating	Increased shelf-life of 3 days at near ambient environmental storage conditions	Vishwasrao and Ananthanarayan, 2017
7.	Green grass jelly edible coating	0.4 %	Coated sapota were stored at room temperature	Post-harvest edible Coating	Extend the shelf life of sapota fruit two days longer than the control treatment.	Setiawan *et al.*, 2023

Table 4. Enhancement of shelf life of sapota using irradiation

S.No	Chemicals/ materials	Details	Treatment time/ Place	Treatment Method	Results	References
1.	Packaging material+irradiation	Packaging of 100 gauge with 0.1% performation+0.2% kGy gamma radiation	Fruit stored at 15°C for 20 days	Irradiation	Increased post-harvest life of fruits by 26 days over control 5 days	Srinu *et al.*, 2015
2.	Growth regulator and irradiation	GA_3 200 ppm and 0.20 k Gy	At Post Harvest Technology lab and irradiation unit	Post-harvest treatment of PGR and Irradiation	The fruits had lower PLW (12.82%), higher firmness (2.21 kg/cm^2), lower ripening (56.50%), lower spoilage (35.50%) and enhanced the shelf life up to 12 days	Yadav *et al.*, 2012

Conclusion

The quick ripening and short shelf-life of sapota can cause significant losses and hinder its economic viability and long-term market availability. However, various pre-harvest and post-harvest techniques can be used to extend its shelf life and improve its market availability. These techniques include the use of storage and packaging materials, chemicals and plant growth regulators, edible coatings, and irradiation. Although these methods may have some challenges, such as being cost-effective and scalable, further research and development efforts are necessary to optimize them for broader adoption and sustainability. It is essential to maximize the shelf life of sapota through comprehensive post-harvest management to ensure food security, reduce waste, and promote economic prosperity in the horticultural sector.

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