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Innovations in Achras Sapota Linn Processing: From Fresh Fruit to Value-Added Products: A Review

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Abstract

This review systematically explores the multifaceted attributes of *Manilkara zapota L.* (sapota), highlighting its comprehensive nutritional profile, medicinal uses, cosmetic value, ethnomedicinal significance. Rich in essential macro and micronutrients, phytochemicals, and antioxidants, sapota demonstrates substantial therapeutic potential, including anti-inflammatory, antimicrobial, and anticarcinogenic properties. The fruits complex nutraceutical phytochemicals and biochemical composition, comprising of necessary sugars, proteins, amino acids, vitamins, and bioactive compounds such as, polyphenols, flavonoids, carotenoids, sterols, saponins, terpenes and vitamins etc underpin its high good health promoting effects. Due to its limited postharvest shelf life, sapota is predominantly processed into value-added products such as jams, jellies, chutneys, and fruit bars, expanding its utility in the food industry. Furthermore, ethnomedicinal uses highlight its role in managing ailments like cough, fever, and metabolic disorders., helping in increase and strengthen the bones quality, providing relief during constipation, lowering blood pressure, stress relief, immune system boosting properties, and beneficial effects on cardiovascular health as well. The latent potential of sapota in cosmetic formulations by the presence of certain vitamins which have moisturising effect, that helps in reducing the wrinkles and help in making the skin healthy, marking its importance as a resilient, health enhancing tropical fruit. This review amalgamates scientific investigations spanning nutritional analysis, pharmacological insights, and food technology innovations, fostering a deeper understanding of sapota's role in promoting health and its diverse applications, which could inspire future research and development initiatives in nutrition, medicine, and agribusiness sectors.

Keywords: Sapodilla, Nutrition, Medicinal Properties, Sapota Bar, Sapota Powder

Introduction

Sapota (Chikoo or Sapodilla) is a fruit which usually grows in the tropical regions of the world. Originally growing across the West Indies, tropical America, and southern Florida, it seems to have originated on the Yucatan peninsula and its neighboring territories, including southern Mexico, northern Belize, and northeastern Guatemala.During the colonial era, Spanish explorers introduced it to the Philippines, from where it spread across the Old-World tropic regions. It eventually became a widely consumed and exported fruit in Southeast Asia, reaching Sri Lanka first by 1802 and then reached India by 1892. Today, Sapota is cultivated and consumed in numerous tropical and sub tropica regions globally, including Africa, the East Indies, Philippines, Malaysia, Thailand and both the Americas (1).

Sapota plant thrives in the optimum environments of tropical but can also grow best in semi- tropical environments by adapting to it, in greenhouse settings. The plant can flourish as high as 1200 meters above sea level. Being a tropical fruit, it requires a warm climate with humidity levels of roughly 70% and temperatures between 100 and 360 degrees Celsius. Alluvial, sandy, loamy, red laterite, and medium black soils with an acidic to neutral pH and good drainage are ideal soil types. For optimal

yields, fertilisers are used which are rich in Nitrogen (6-8%), Phosphoric acid (2-4%) and potash (6-8%) should be applied every 2-3 months during th initial growth phase of the plant, gradually increased to 250g per plant. After the second year, two or three applications annually are generally sufficient (2).

Sapota is among the 700 species that belong to the Sapotaceae family of plants. *Manilkara zapota (L.)* Its scientific name is P. Royen, although it is commonly called sapodilla or chikoo. The word "sapodilla" comes from the Spanish word "zapotilla," which refers to a soft, edible fruit. Over the years, various synonyms have been utilized to refer to the fruit, including *Manilkara achras (Miller) Fosberg and Sapota zapotilla (Jacq.) Achras zapota L. var. zapotilla Jacq., Achras mammosa L.*, and *Sapota achras Miller* [3, 4]. Sapota provides a rich combination of proteins and amino acids, as well as strong antioxidants such as carotenoids, catechins, chlorogenic acid, gallic acid, and vitamin C. Additionally, it serves as an excellent source of essential minerals like iron, potassium, copper, and calcium. Due to these beneficial phytochemicals, sapota is recognized for its antioxidant properties and has been widely utilized in traditional Indian medicine.

A notable small fruit crop, sapota can be considered one of the healthiest fruits due to its abundance of beneficial nutrients. It is a delicious fruit with a granular texture, a pleasant scent, and a soft, sweet pulp. Its thin skin is yellowish with a dull brown color, and its pulp is red or light brown (Siddiqui *et al*., 2014) [7]. Many phytochemicals, including saponin, sapotin, and sapotinine, are found in sapota seeds. The seeds contain toxic prussic acid and must be removed before consumption (Cortez *et al*., 2013) [8]. Fruits are widely used to combat oxidative stress as they are known to be abundant antioxidants. The reason fruits are good for your health is because they contain a lot of polyphenols, carotenoids, sterols, saponins, terpenes, and vitamins, among other nutraceutical phytochemicals (McCarty 2004) [9].

Despite the fact that *Manilkara zapota* is highly valued for its nutritional and therapeutic qualities, research on phytochemistry, pharmacology, and processing is still fragmented. Research rarely compares cultivars or molecular features and employs inconsistent methodologies. This prevents us from fully appreciating the fruit's potential. As a result, this review incorporates current research and pinpoints important gaps that impact its best use and value addition.

Morphology of *A. sapota*

Reaching up to 20 meters in height, the medium-sized, branching Sapota tree produces milky sap. Hairy, rusty, bark-brown to blackish-brown, rough, longitudinally fissured stems grow from the base of the tender sections to form an umbrella-shaped dome. The outer leaves are glossy, dark green and glabrous. The inside is oval, round, or rounded-ovate, leathery, and pale green in color.In tropical regions, small, simple, dull white flowers bloom in the axilla almost all year round.Six free, tomentose corollas, six brittle stamens that alternate with petaloid staminodes, and six sepals in two whorls are present. The superior ovary: divided, protogynous, with 10 -12 cells [10].

Trees or Shrubs: They are occasionally spiny, but are rarely geoxylic suffrutices or lianas. Typically, branching is sympodial. The trunk and branches nearly always have latex on them.

Fruits: Usually white, they can also be yellow or blue. The indumentum is typically made up of malpighiaceous hairs, which are simple in Delpydora. Fruit: globose to oval, meaty berry with yellow-brown flesh that is rough, rusty, brown, or grey.

Seeds: 0–12, round, ovate, hard, glossy black, 1.5–2.5 cm long, thick right away. thick, separated from pulp right away.

Leaves: Leaves can be simple, whole, distichous, spirally arranged, alternating, often parallel or verticillate, and very infrequently spinous-toothed.

Stem: It usually consists of a pair of small + or 0 stipules.

Flower: Flowers may be solitary, axillary, ramiflorous, or cauliflorous, or the inflorescence may be fasciculate; fascicles may occasionally be grouped along short, panicle-like, axillary shoots that lack leaves. The base of the fascicle can occasionally develop into short, thickly scaly brachyblasts. Bisexual "Sapotaceae" flowers. Dicotyledons: Ericales, Cornales, Rosales, Oxalidales, and Celastrales are flowering plants. Actinomorphic, sexual (monoecious or dioecious), calyx: one whorl of four to six free or partially connected, imbricate, often quincuncial sepals, or flower: two whorls of two to four sepals; or six to eleven sepals in a closely imbricate spiral; the outer whorl is either slightly brittle or valvate. The flower is twisted, sympetalous, and cyathiform, or tubular.The tube's length is less than, equal to, or longer than the petals. The petals can be whole, lobed, or partially divided, and they range in size from 4 to 18. The entire central section, as well as the lateral and dorsal segments can be shallowly or deeply divided, laciniate, or complete. The stamens are 4-35 (- 43), often free, and attached to the base of the lobes or the upper or lower portion of the corolla tube. When there are multiple corolla lobes, the stamens can be different, alternate with the corolla lobes, or occasionally be arranged in two or three alternate whorls inside the corolla tube, exserted or attached, or in a single spiral opposite each lobe. Rarely are filaments fused into a staminal tube or partially bonded to the staminodes; instead, they are typically free and developing in bud.

Anthers: They tend to act in an extrorse way. Simple or frequently lobed, toothed or divided, and occasionally petaloid, staminodes 0–8 (−12) are found in a single loop that alternates with its stamens or is positioned in the corolla lobe sinuses. The ovary base is surrounded by the annular or patelliform disk, which may be absent or fused with it. he ovary superior is l-15(−30) locular, and it is often uniovulate but frequently 2–5 ovulate. Simple or slightly lobed style-head; simple, covered, or exserted style; axial, basi-ventral, or basal placentation.

Fruit: The fruit is a berry, a single lateral valve, drupe, or dehiscent; the seeds are one to many, globose, ellipsoid, oblong, and usually strongly horizontally flattened; and the pericarp is either fleshy or, less frequently, leathery or woody.

Testa: They typically follow the pericarp and are smooth, glossy, and devoid of the pericarp. They are less frequently pitted, creased, or roughened. Hilum may be small or wide, adaxial, basi-ventral, or basal, and can cover the most of the seed; The radicle is either present or exserted, the endosperm is either positive or negative, and the embryo is oriented vertically, obliquely, or horizontally with thin

foliaceous or thick flat or plano-convex cotyledons that are normally free. x = 10, 11, 12, 13, and 14 [11].

Fig 1: Sapota tree

Fig 2: Sapota Fruit

Fig 3: Sapota flower

Fig 4: Sapota seeds

Biological Classification of A. sapota

- **Kingdom:** Plantae
- **Class:** Magnoliopsida
- **Order:** Ericales
- **Family:** Sapotaceae
- **Genus:** Manilkara
- **Species:** M. zapota [12].

Chemical Constituents (Achras sapota Linn)

Phytochemicals like triterpenes, alkaloids, flavonoids, glycosides, carbohydrates, and tannins are abundant in the plant. High concentrations of proteins, amino acids, ascorbic acid, phenols, carotenoids, and essential minerals like calcium, potassium, iron, copper, and zinc are also present [13]. Carbohydrates are among the most crucial components of sapota fruit. Three main organic acids are present in mature sapota fruit: citric (8.30 mg g–1), tartaric (2.69 mg g–1), and malic (18.25 mg g–1). Only during the phases of development and ripening are other organic acids, such as fumaric, oxalic, and gluconic acids, present [14, 15, 16]. Although the ascorbic acid content of sapota fruit is high, it rapidly drops at room temperature [17-21].

Studies consistently show that sapota is a nutrient-rich fruit with antioxidant, antimicrobial, anti-inflammatory, and antidiabetic properties. It contains polyphenols, flavonoids, carotenoids, dietary fiber, sugars, and vitamins A, C, and E. According to horticultural studies, it is a climacteric fruit with a short shelf life due to enzymatic browning and quick softening. Pharmacological studies investigate its therapeutic potential, while food science research highlights its use in value-added products like jams, bars, and chutneys because of its poor storability. Sapota exhibits considerable industrial and nutraceutical potential overall, but current research is still dispersed, underscoring the need for an integrated review [22-26].

Uses

1. Fresh Fruit: Sapota is a popular fruit in Central America and is regarded as one of the best. The flesh of ripe sapota fruit is typically eaten with a spoon after the fruit has been cut in half. Additionally, the flesh is added to ice cream, milk shakes, sherbets, and salads or fruit cups. Ripe fruit can be transformed into a delicious sauce by mashing the pulp, mixing in orange juice, and then topping it with whipped cream (Peiris 2007) [27].

2. Medical Uses: In many cultures, sapota fruit has been utilized as an indigenous traditional medicine (Lim 2013) [28].

Boiling the immature fruit, rich in tannins, may aid in alleviating diarrhoea. There have also been reports of young fruit infusions to alleviate lung issues (Peiris 2007; Kulkarni *et al*. 2007) [29].

It is additionally effective as a cough and fever treatment. (Sari *et al*., 2018) [23]. The sapota fruit also has positive effects on leptin and insulin levels, as well as glycemia and plasma lipids (Barbalho *et al*., 2015) [30].

3. Cosmetic Value of Sapota: Since it contains a lot of nutrients. It can be used as a herbal treatment for skin infections, particularly to improve appearance. Because of its moisturizing properties, the fruit Achras sapota's vitamins E, A, and C promote healthy skin. Antioxidants like flavonoids, polyphenols, and ascorbic acid can reduce wrinkles. Fungal growth and skin warts get eliminated by the milky sap of the sapota plant. The seed oil hydrates the scalp and softens hair. When it comes to managing curly hair, it produces positive outcomes. Sapota seed oil can be used to treat seborrheic dermatitis-related hair loss [31].

4. Ethnomedicinal Values: Sapota is a fruit that contains a number of bioactive compounds, including compounds with potent antioxidant qualities, such as polyphenols, flavonoids, tannins, and phenolic acids. Its high vitamin A and C content boosts its antioxidant capacity even more, promoting healthy skin and a strong immune system. Additionally, these bioactive compounds have antibacterial, antimicrobial, antipyretic, antiviral, antidiarrheal, antihyperglycemic, antiparasitic, antibiotics, anticancer, antitumor, analgesic, diuretic, pulmonary disease, hypercholesteraemic, haemorrhoids, blood pressure, constipation, HIV infection, blood pressure, stress relief, immune system boosting properties, and positive effects on cardiovascular health. The pulp of the sapota fruit is a great way to get bowel movements and is a great source of dietary fiber [32].

5. Food Industry Applications: Because the sapota fruit is rich in nutrients, including vitamins A, C, and E that enhance beauty, It can be used in cosmetics and skin care products as a herbal cure. The skin is hydrated by the three vitamins. Because vitamins C and E are naturally occurring antioxidants, anti-aging treatments use them to minimize wrinkles and fine lines. (Kaur *et al*., 2020) [33].

Sapota Fruit Jam: The sapota fruit jam was made by Ahmed *et al*. (2011). Before the skin was removed with a knife, the sapota was thoroughly cleaned with drinkable water. It was perfectly fresh, ripe, and healthy. The sapota fruit was combined with the seeds in a blending machine. To preserve it, the resulting pulp was frozen. One kilogram of sapota jam needed 450 grams of sapota pulp or juice, 550 grams of sugar, 5 grams of pectin, and 5 grams of citric acid. In a stainless-steel saucepan, pectin and sugar were mixed, then sapota pulp or juice was added and stirred. The mixture was then heated using a gas burner until the Total Soluble Solids, the concentration of total soluble solids (TSS) was nearly 65%. Citric acid was introduced at that time. When TSS approached 67%, the heater was turned off. The last steps were bottling and parafining. After then, this jam was stored for three months [34].

Sapota Fruit Bars: Salleh *et al*. (2017) made sapota fruit bars. Over low heat, 250 grams of sapota pulp were cooked for ten minutes. To prevent scorching the bottom, a mixture of 30% sugar, 1% pectin, 6% milk powder, 0.6% citric acid, and a pinch of salt was added to the cooked pulp while it was being continuously mixed. After heating the mixture until it was uniform, it was spread thinly on aluminum trays and allowed to dry for eight hours in a convection air dryer. After cooling, the fruit bars were cut into rectangles. The fruit bars were kept at room temperature in a dry location. The fruit bars received varying amounts of pectin (0–3%) [35].

Sapota Chutney: A tangy, sweet, and spicy condiment that improves the flavor of rice, snacks, and bread, sapota chutney adds flavor to a wide range of foods, particularly in Indian cooking. The article emphasizes that sapota chutney is a traditional and well-liked processed product that is created by combining a variety of spices and condiments, including finger, garlic, chili, cumin, vinegar, salt, and sugar, with sapota pulp. In order to guarantee appropriate gel formation and preservation, the process also involves regulating heating to reach a particular TSS (~65%). The aforementioned procedure guarantees that the chutney preserves all of the essential nutritional components and characteristics of the sapota, including flavonoids, antioxidants, minerals, and so forth. Once the sapota chutney is sterile and sealed, the preparation process comes to an end and the product's shelf life is increased. It also contributes to its health benefits by serving as a source of antioxidants and nutrients from the fruit and spices. Incorporating sapota into the diet not only adds diversity but also makes use of its nutritional and ethnomedicinal qualities, making it a nutritious addition to everyday meals.

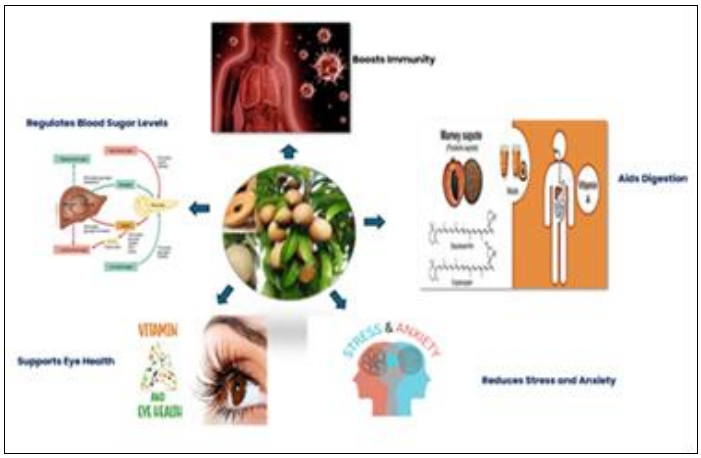

Fig 5: Health Benefits of Sapota

Interrelationships Among Research Findings

1. **Phytochemicals and pharmacology:** Sapota's antioxidant, antimicrobial, and anti- inflammatory properties are clearly linked to its flavonoids, tannins, and phenolics.
2. **Ripening and processing:** In order to minimize postharvest losses, value-added products are necessary due to its quick ripening and softening.
3. **Ethnomedicine and scientific evidence:** Research showing antimicrobial and antipyretic effects supports traditional uses for fever, cough, and digestive problems.
4. **Nutrition and industry:** Its use in beverages, confections, and functional foods is supported by its high sugar content, aroma, and nutrient composition.

Adverse Effects of Sapota

1. **Seed Toxins:** According to the document, sapota seeds contain toxins, particularly hydrocyanic acid, which can be dangerous if consumed without being properly removed. As a result, care should be taken to avoid eating the seeds raw, and moderation is suggested to avoid gastrointestinal distress from consuming too much fiber.
2. **Blood Sugar concerns:** Although sapota is a powerful blood pressure-lowering food, its high sugar content (~25 Brix) can cause a spike in blood glucose levels if consumed in excess. It is recommended that diabetic patients watch how much sapota fruit they eat in order to avoid hyperglycemia and other metabolic problems.
3. **Gastrointestinal issues:** Due to its high fibre content it can cause gastrointestinal issues such as flatulence, abdominal discomfort if consumed in excess. (Jaiswal, 2018).

Room for Improvements

1. **Cultivation and Breeding Improvements:** According to the document, sapota is growing in popularity due to its year-round harvesting and high yields. It doesn't, however, adequately describe how researchers are attempting to enhance the plant itself. For instance, little is known about attempts to choose or cross-breed different types to make them larger, tastier, more resilient to pests and diseases, or longer-lasting. Although more than 35 sapota varieties are commercially grown in India, little is known about whether current breeding initiatives are intended to enhance these varieties for increased productivity or better quality. Moreover, there isn't much discussion of sustainable farming methods. Increasing productivity may require the use of water- efficient irrigation systems, organic farming, integrated pest management (IPM), and soil health management. Moreover, there isn't much discussion of sustainable farming methods. In order to increase productivity and environmental sustainability Integrated pest management (IPM), organic farming, and water-efficient irrigation systems may be crucial., and soil health management. Additionally, cultivars with improved nutritional profiles or higher NPK (nitrogen, phosphorus, and potassium) content may be developed; however, this will require agronomic and genetic research that is not covered in detail in the document.
2. **Enhancemental and Socioeconomic Aspects Improvement:** The ecological effects of large-scale sapota cultivation, such as changes in land use or the consequences of growing the same crop repeatedly in the same location, are not discussed in great detail in the paper from an environmental perspective. Future studies have a great chance to examine more environmentally friendly agricultural methods. These studies could guarantee that sapota cultivation promotes sustainable community development and doesn't negatively impact the environment or jeopardize farmers' livelihoods. According to the report, India is a significant producer of sapota, with vast quantities grown and exported, supporting the livelihoods of many farmers, especially in states like Karnataka, Gujarat, and Andhra Pradesh. However, it doesn't go into great detail about how this crop impacts farmers' daily lives, such as their income, difficulties they encounter, or changes in market prices. Additionally, because sapota is a perishable fruit, it doesn't address topics like how to minimize post-harvest losses or how farmers could enhance the value of their produce to increase its profitability.

Research Gaps, Contradictions, and Limitations: [36-37]

1. Methodological inconsistencies and fragmentation:

Full potential realization is limited by the fragmented nature of current research on Sapota phytochemistry, pharmacology, and processing, which uses inconsistent methodologies and infrequent cultivar or molecular comparisons.

2. Gaps in Breeding and Cultivation:

There is little information available on breeding for better nutrition, yield, quality, and pest resistance; IPM, organic farming, and drip irrigation are examples of sustainable farming methods that are not thoroughly covered.

3. Environmental and Socioeconomic Aspects:

Inadequate attention to market dynamics, postharvest loss reduction, farmer impacts, and environmental effects like sustainable monoculture and changes in land use.

4. Prospects for Upcoming Studies By filling in these gaps through interdisciplinary research, Sapota utilization can be improved through improved cultivars, sustainable farming, and value-added products while maintaining eco-economic viability.

Conclusion

Manilkara zapota has a wide range of nutritional, medicinal, and industrial potential, as this review highlights. Its rich array of bioactive compounds provides cardioprotective, anti-inflammatory, antioxidant, and antimicrobial qualities. Its significance as a hardy tropical fruit with health-promoting properties is further highlighted by its ethnomedical applications and cosmetic advantages. However, excessive consumption of the high fibre content can cause gastrointestinal distress, and careful processing is necessary to ensure safety due to the seed toxins. Because of the fruit's short postharvest shelf life, creative processing and preservation methods are needed to minimize losses and increase value.

Future studies should concentrate on creating better cultivars with increased size, flavour, resistance to pests and diseases, and nutritional value through selective breeding and

biotechnological methods. To reduce environmental effects and guarantee long-term productivity, Water-efficient irrigation, organic cultivation, and integrated pest control are examples of sustainable farming practices. Investigating cutting-edge postharvest technologies can also decrease waste and increase shelf life.

Future prospects for sapota in the pharmaceutical, cosmetic, and nutraceutical sectors appear bright. Novel therapeutic formulations addressing metabolic disorders, skin aging, and chronic diseases may result from ongoing research into its bioactive compounds. It is projected that the creation of standardized herbal medicines, value-added processed goods, and functional foods from sapota will expand markets and provide financial advantages to farmers. Ultimately, optimizing sapota's health advantages, sustainability, and economic feasibility in the future will depend heavily on ongoing scientific research and technological advancement.

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Consent for publication: Not applicable

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