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Mamey sapote (*Pouteria sapota* Jacq. H. E. Moore & Stearn)

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**Abstract:** Mamey sapote is a climacteric fruit popular in some countries such as Mexico. In addition to being consumed fresh, it is also processed and consumed in different forms, such as in ice creams. This chapter describes the information available on the postharvest physiology, handling and processing of the fruit.

**Key words:** *Pouteria sapota*, Mamey sapote, postharvest, nutrition, processing.

21.1 Introduction

Mamey sapote fruit (*Pouteria sapota* Jacq. H. E. Moore and Stearn) has received little attention in international markets. This is in spite of its high potential for commercialization in regions where it is considered an exotic fruit, and the high levels of carotenoids in its pulp, which make it attractive, nutritionally speaking. The trees of *P. sapota*, native to Mexico and Central America, are found in the wild and are sometimes cultivated for the fruit. However, the fruit’s climacteric behaviour makes it highly perishable and thus postharvest handling activities need to be targeted at maintaining its quality while extending its shelf life (Yahia, 2004).

21.1.1 Origin, botany, morphology and structure

Radlk., and Achradelpha mammosa, Cook. It is native to the south of Mexico (as far south as the Yucatan Peninsula), Guatemala, Belize, the north of Honduras and the Atlantic coast of Nicaragua (Azurdia, 2006).

*Pouteria sapota* is an evergreen tree that can grow up to 12.2 m and in more tropical areas can reach more than 18.3 m. It has a thick trunk and narrow or spreading crown and presents white latex. The leaves grow in clusters at the tip of the branches and are pointed at both ends with a length up to 30 cm and 10 cm wide. *Pouteria sapota* fruits are ovoid to ellipsoid and are pointed at the apex. They are from 7.5 to 22.8 cm long and weigh from 0.227 to 2.3 kg. Fruits have a somewhat scurfy, dark brown, thick, woody skin. The flesh is soft and sweet with a smooth and creamy to somewhat finely granular texture with a salmon-pink, orange to deep red color. Fruits can have from one to four large, hard, oily, polished, spindle shaped, pointed kernels presenting a glossy brown appearance, a whitish hilum on the ventral side and a bitter-almond aroma (Standley and Williams, 1967; Pennington and Sarukhan, 1968; Pennington, 1990; Morton, 1987; Orwa et al., 2009).

21.1.2 Worldwide importance

Areas of greatest production correspond to those where the largest number of trees are found and are those where the mamey sapote is native. In these areas, most trees are found in domestic gardens, as part of the natural flora, or in combination with other crops. Commercial fields of *Pouteria sapota* are not very common but some can be found in Mexico (Puebla, Veracruz, Oaxaca, Chiapas, Tabasco, Yucatan and Quintana Roo). In 1991, 2649 ha of commercial plantations of mamey sapote were reported in Mexico, mainly in Yucatan, Veracruz and Puebla. Guatemala is another important area of mamey sapote production, with levels reaching 50,000 tons in 1997 and exports to the US reaching 549 tons in 1999. The mamey sapote has been introduced to areas like Colombia, Venezuela, the Philippines, Cuba, Dominican Republic, Puerto Rico, Malaysia, Hawaii, Florida and Puerto Rico. Countries like Ecuador, Paraguay, Honduras and Costa Rica also produce mamey, although to a lesser extent (Azurdia, 2006).

21.1.3 Culinary uses, nutritional value and health benefits

Mamey sapote fruit are mainly used for their flesh whose nutrient content is shown in Table 21.1. Fruit can be eaten fresh by cutting them in half and removing the seed; the flesh can then be spooned from the half-shell. (See Plates XXXVI and XXXVII in the colour section between pages 274 and 275.) Ice cream, jam, conserves, milkshakes and pastes can be made with the mamey sapote flesh.

Mamey sapote trees are rarely used for their wood except when the fruit quality is poor. The wood is relatively durable, strong and easy to work with and can be used for cabinet work, furniture, carts, shelving and house frames (Orwa et al., 2009).

The mamey seed contains 40–60% of an oil with vaseline consistency which is considered to have a great potential in the elaboration of soap, pharmaceutical and…
Table 21.1 Nutrient value of mamey sapote fruit (per 100 g of fruit)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Approximate value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content</td>
<td>63.8%</td>
</tr>
<tr>
<td>Calories</td>
<td>126.0</td>
</tr>
<tr>
<td>Protein</td>
<td>3.1 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.1 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>31.8 g</td>
</tr>
<tr>
<td>Fibre</td>
<td>1.2 g</td>
</tr>
<tr>
<td>Ash</td>
<td>1.2 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>121 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>30 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.8 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>70 IU</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.01 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.05 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>1.9 mg</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>40 mg</td>
</tr>
</tbody>
</table>

Source: Wu and Flores (1961)

Cosmetic products. The oil is actually edible when freshly extracted (Aguilar, 1966). Among other medicinal properties attributed to the mamey sapote fruit are the oil contained in the kernel, which has been used as a skin ointment and as a remedy for hair loss. Some people use this oil as a palliative in eye and ear problems. In Mexico, the kernel coat is ground and taken to help with coronary, kidney and rheumatism problems (Azurdia, 2006; Orwa et al., 2009). It can also be mixed with parched corn, or cornmeal, sugar and cinnamon to make a beverage called ‘pozol’ (Morton, 1987). The white latex has also been used as an antifungal for the skin or to remove warts.

Some toxic effects associated with the mamey sapote are related to the kernel which contains an elevated HCN content giving it stupefying properties. The leaves have also been reported to be poisonous; however, people in Costa Rica use them to make tea that is taken to treat arteriosclerosis and hypertension (Orwa et al., 2009). The white latex that exudates from the mamey tree is irritant to the eyes and caustic to the skin, and care must be taken to avoid coming into contact with it (Morton, 1987).

21.2 Postharvest physiology

Mamey sapote is a climacteric fruit (Yahia, 2004). Mature fruit do not ripen on the tree; they only ripen when they have been detached. The fruit has high rates of respiration and degradation (Casas-Alancaster, 1977; Diaz-Perez et al., 2000). It
reaches a climacteric peak four days after harvest when it is kept at 25°C. Production of CO$_2$ ranges from 20–50 mg kg$^{-1}$ h$^{-1}$ before the climacteric peak and increases to about 110 mg kg$^{-1}$ h$^{-1}$ at the climacteric peak (Diaz-Perez et al., 2000).

The flesh of mature mamey sapote fruit presents a yellow or pale colour that changes to orange or red in fully ripe fruits (Diaz-Perez et al., 2000). The orange-red colour in ripe mamey sapote is due to the high concentration of carotenoids (130 mg kg$^{-1}$) (Casas-Alancaster, 1977), β-carotene being the most abundant (94% of the total carotenoids) (Morales-Vazquez, 1983). Browning of the flesh increases with ripeness and this is associated with the high concentration of phenolic compounds found in ripe fruit (0.3% of total phenolics). Soluble solids content (SSC) is increased during ripening. Mature fruit presented about 12% SSC while fully ripe fruit had 30–35%. SSC increases during ripening due, at least in part, to the degradation of starch into sugars. Starch content decreases from 14 to 5% with an associated increase in total sugars from 6 to 16%. Firmness of the mamey sapote fruit decreases with ripeness. Mature fruit presented a firmness value of 120 N (Newton) in mature fruit compared to 50 N in ripe fruit and almost 0 in overripe fruit (Casas-Alancaster, 1977). Acidity appears to be constant during ripening of mamey sapote fruit (Diaz-Perez et al., 2000). Fruits of mamey sapote stored at 20°C and 50–60% relative humidity (RH) for 12 days showed a decrease in total phenolic content while the activity of polyphenol oxidase (PPO) increased. The decrease in phenolics was reflected in a reduction in the astringency. During ripening the activity of other enzymes such as peroxidase (POD), catalase (CAT), and superoxide dismutase (SOD) were increased. The content of soluble protein also increased during ripening (Alia-Tejacal et al., 2005).

21.3 Maturity and quality components and indices

It is hard to say when the mamey sapote fruit are ready to be harvested. The fruit is usually harvested when the flesh begins to develop a red colour. The fruit matures when the newly exposed layer turns from green to pinkish-brown, orange, or red (Yahia, 2004). Fruit harvested when immature will fail to soft end and their pulp will turn dark brown, and become inedible. According to Morton (1987), mamey sapote fruits that have ripened irregularly will develop a strong squash flavour.

21.4 Postharvest handling factors affecting quality

21.4.1 Temperature management

The number of days required for mature fruit to ripen depends on the storage temperature. Fruit harvested at the commercial stage and maintained at 27, 25, or 20°C reached ripeness after 4, 5, or 6 days, respectively. However, overripe fruit kept at more than 20°C developed off-odours and fungal growth (Diaz-Perez et al., 2000).
Fruit kept at 10 or 15°C ripened irregularly and did not soften evenly. In addition, the flesh in these fruits adhered to the kernel. Firmness in these fruits had a high level of variation, with values of 20–50 N in some areas of the fruit, but of more than 100 N in adjacent areas. The longer the fruit were held at this temperature, the more severe the damage, which was probably due to chilling injury (Diaz-Perez et al., 2000).

Temperature also affects the SSC in mamey sapote fruit. Fruit kept at higher temperatures (27°C) had a higher SSC than those stored at 20°C (Diaz-Perez et al., 2000). This increase is due in part to starch breakdown into sugars (Casas-Alancaster, 1977).

21.4.2 Water loss
Mamey sapote fruit stored for 6 days at 25°C lost 10.8% of their initial weight; however, their overall appearance was not affected, as few changes in the skin were detectable by eye (Diaz-Perez et al., 2000).

21.5 Physiological disorders

21.5.1 Chilling injury
Mamey sapote fruit are chilling sensitive (Yahia, 2004). Typical symptoms of chilling injury include flesh browning, uneven ripening and softening, flesh adherence to the kernel, off-odours and flavours, and flesh lignification (Yahia, 2004). However, visual signs of chilling injury are hard to identify on the skin of mamey sapote fruits (Alia-Tejacal et al., 2007). In mamey fruit stored at 2°C, the activity of the enzyme phenylalanine ammonia-lyase (PAL) was lower than that in fruit kept at 10°C. No significant changes were observed in the activity of POD but a constant reduction in PPO was observed in fruit stored at 2, 10 or 20°C (Perez-Tello et al., 2009). Alia-Tejacal et al. (2005) also reported that antioxidant enzymes were negatively affected by storage temperatures lower than 10°C associated with chilling injury. Activities of PPO, CAT, and SOD decreased after storage at 5 and 10°C. In addition, the concentration of sugars is affected by exposure of mamey sapote fruit to low temperatures. Sucrose content decreased while fructose increased in fruit kept at 2°C as a result of chilling stress (Perez-Tello et al., 2009). Storage at 5°C also delayed the decrease in total phenolic content (Alia-Tejacal et al., 2005).

21.6 Pathological disorders
According to Morton (1987), anthracnose on the leaves and fruit stalks in rainy seasons is caused by the fungus Colletotrichum gloeosporioides. Infected fruit falls prematurely. Attack by the fungus Phyllosticta sapotae causing leafspot can occur in Cuba and the Bahamas but seldom in Puerto Rico. Black leaf spot (Phyllachora sp.) and root rot (Pythium sp.) may also occur in Florida. Other
fungi including *Rhizoctonia* sp. and *Pythium splendens* may attack the root causing a detrimental effect on the tree vigour (Orwa et al., 2009). After harvest, some fungi may attack the fruit, specifically *Pestalotia* and *Botryodiploidia*. However, the incidence of these fungi decreases as the fruit ripens. A reduction from 20% to 65% during ripening has been reported (Bautista et al., 2002).

### 21.7 Insect pests and their control

Mamey sapote is very sensitive to infestation with fruit flies, especially with *Anastrepha serpentine* (Yahia, 2004; Yahia and Ariza, 2003; Ariza-Flores et al., 2009). However, no quarantine treatment is used in Mexico for this fruit, and therefore the fruit’s entry to many national and international markets is restricted. Yahia and Ariza (2003) and Ariza-Flores et al. (2009) exposed fruit of mamey sapote to different hot air treatments at 40, 43, 45, 46 or 50°C for 120, 150 or 180 minutes, and these were then stored at 10°C or 25°C for up to 15 days. Larvae and eggs mortality was achieved at 43°C for 120 minutes. This heat treatment did not cause fruit injury, while keeping at a minimum the loss of firmness, fruit mass, and colour. Other attempts have been made to establish a hot water treatment for mamey sapote (Granados and Utrera, 1996; Diaz-Perez et al., 2001); however, more research is necessary to find the best conditions that not only eliminate fruit flies but also allow an acceptable shelf-life.

Other insects that occasionally attack the mamey sapote include the Cuban May beetle (*Phyllophaga bruneri*), the sugarcane rootstalk borer (*Diaprepes abbreviatus*), white peach scale (*Psuedaulacaspis pentagona*), Philephedra scale (*Philephedra sp.*) and green scale (*Coccus viridis*) (Orwa et al., 2009).

### 21.8 Postharvest handling practices

#### 21.8.1 Harvest operations

Harvest season depends on the climatic conditions and cultivar of mamey sapote. *For instance, there are two harvest seasons in the Dominican Republic (summer and winter)* while in Puerto Rico the harvest season starts in September and ends in early November (Azurdia, 2006).

Harvesting should be done carefully to avoid mechanical damage. The fruit is twisted until it breaks from its stem. Poles with knives at the end are also used to collect the fruit. The fruit should not be left to fall on the ground.

#### 21.8.2 Packinghouse practices

Some growers clean the skin of the fruits with a brush to remove possible dirt. The peduncle is also cut to improve appearance. The fruit is packed in 3 kg capacity fibreboard flat boxes, using sleeves or excelsior to prevent physical damage (McGregor, 1987).
21.8.3 Control of ripening and senescence

Storage of mamey sapote in perforated polyethylene at 25°C and external 40–45% RH reduced weight loss by 50% while slowing down changes in SSC and colour development as compared to control fruit (Villanueva-Arce et al., 1999). Use of Peakfresh and Kleen Pack films and storage at 20.5°C ± 2.0°C and 29.4% RH was reported to reduce weight loss by about 8% and delayed ripening for 3 days, keeping fruit quality (Ramos et al., 2005). Good fruit quality and no incidence of physiological disorders was achieved after storing mamey sapote for 3 weeks at 15°C and a continuous flow of 5.1 kPa CO₂ and 5.6 kPa O₂ and balance N₂ (Manzano, 2001). Storage atmosphere containing 10 kPa CO₂ and 5 kPa O₂ in a static system caused a reduction in ethylene production, thus delaying ripening, even after transferring the fruit to room temperature (Martinez-Morales et al., 2004, 2005). Treatment with carnauba wax and 1-methyl cyclo propane (1-MCP) was evaluated in mamey sapote fruit, and was reported to maintain good quality. Furthermore, 1-MCP had a stronger effect on extending fruit shelf-life than waxing (Ergun et al., 2005).

Ethylene applications (176 ppm) for 24 h to mamey sapote fruit at 20°C and 25°C accelerated ripening by 1.4 days (Table 21.2). The respiration peak occurred one day earlier at 25°C than at 20°C. The quality of the fruit was improved regarding total sugars content. Other parameters such as firmness, colour, phenolics and weight loss were not affected by ethylene treatment (Martinez Morales et al., 2003).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ethylene (ppm)</th>
<th>Temperature (°C)</th>
<th>Days until ripeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>20</td>
<td>5.2</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>20</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>176</td>
<td>20</td>
<td>3.8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>25</td>
<td>4.2</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>25</td>
<td>4.2</td>
</tr>
<tr>
<td>6</td>
<td>176</td>
<td>25</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Source: Martinez Morales et al. (2003)

21.8.4 Recommended storage and shipping conditions

Transit and storage life is extended for up to 2 to 6 weeks when fruit are kept at 13–18°C and 85–90% RH (Yahia, 2004; Azurdia, 2006).

21.9 Processing

Freezing of the flesh is probably one of the processing techniques with good potential for mamey sapote (Azurdia, 2006). Fruit are stored in the processing plant until ripe. Ripe fruits are washed manually using either chlorinated water or detergent followed by a second wash with chlorinated water. Then, fruit are cut on
stainless steel tables and flesh is extracted manually, discarding the kernel and skin. Total yield ranges from 25 to 50% of the total fruit weight. Flesh is then ground and packed in plastic bags containing 392 g that are sterilized by heating at 85°C for 15 min, followed by another 15 min at 5°C and finally 2 hours at −15°C. Bags are placed in carton containers of 5–10 kg and stored in cold rooms at −15°C for 2–3 weeks before being marketed. Frozen fruit are also prepared by first washing the fruits using chlorinated water (200 ppm) for 30 min. Packing of the fruits is done on stainless steel tables, placing fruits in plastic bags that are stored in carton boxes. Each box contains approximately 40–45 fruits and is stored in a cold room.

Flour of mamey sapote is prepared by washing and extracting the fruit using the same procedure as for frozen flesh production. However, in this case, the pulp is cut in 5 × 5 mm and placed on drying sheets. Dehydration is obtained with temperatures of 70°C for 12–40 hours until a relative humidity of 7–10% is reached. The dried pulp is then ground and packed in 45 kg bags. The yield for this process is 1 kg of flour for every 13.3 kg of pulp. The flour is mainly used for baking.

Dehydrated flesh is processed in the same way as the one outlined for flour production, except that the quality requirement of the fruit used is not as high as in the flour process. Final humidity content of the dehydrated flesh is about 16%.

Mamey sapote candy can be made by grinding the flesh and then mixing it with sugar and heating until a paste is formed. After cooling, blocks are formed, cut and wrapped for selling. Shelf-life of these products is short (15 days) and therefore their potential for exportation is limited. Frozen lollipops are made by mixing the mamey sapote flesh with sugar and water in a 3:2:2 ratio and then blending and freezing. Mamey yogurt is made with the frozen flesh by adding it to a yogurt base (Azurdia, 2006).

21.10 Conclusions

Mamey sapote is a highly perishable climacteric fruit with postharvest losses reaching up to 25% in some areas like Guatemala. Although mamey sapote fruit are mainly consumed for their flesh, different products can be elaborated from the oil contained in the seed. Storage temperature is an important factor in mamey handling since this fruit is sensitive to chilling injury. Processing of mamey sapote pulp into different products has great potential, especially considering that these products would be easier to transport to different markets. Frozen whole fruit or mamey flesh are some of the best options for exporting mamey sapote without worrying about postharvest deterioration and quarantine restrictions. Controlled/modified atmospheres constitute a possible option for extending mamey shelf-life.

21.11 References

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