

Sapodilla and Related Fruits

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Note regarding following respiration data for Sapodilla and related fruit:

To get $\text{mL kg}^{-1} \text{h}^{-1}$, divide the $\text{mg kg}^{-1} \text{h}^{-1}$ rate by 2.0 at 0°C (32°F), 1.9 at 10°C (50°F), and 1.8 at 20°C (68°F). To calculate heat production, multiply $\text{mg kg}^{-1} \text{h}^{-1}$ by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

Sapodilla

Scientific Name and Introduction: The sapodillas (*Manilkara achras* (Mill) Fosb., syn *Achras sapota*, L.) are fruit of the chicle tree, and also known as sapota, chiku, ciku, dilly, nasberry, sapodilla plum, chico zapote, zapote, chico, néspero and sapota plum. The fruit is a fleshy berry, ellipsoidal, conical or oval, and contain one or several shiny black seeds. It weighs about 70 to 300 g, has a dull brown color and thin skin and yellowish, light brown or red pulp. Sapodilla fruit are prized for pleasant aroma and sweet taste. Fruit growth follows a sigmoid pattern (Lakshminarayana and Subramanyam, 1966). Fruit are very susceptible to mechanical injury.

Horticultural Maturity Indices: The erratic flowering habit of sapodilla and the presence of fruit at all stages of development on the tree make it difficult to determine optimum harvest time (Lakshminarayana, 1980). Fruit harvested later than optimum time usually soften very rapidly and become very difficult to handle. Fruit harvested earlier than physiological maturity may not soften, are usually low in sweetness and high in astringency when ripe, with a rather unappealing alcoholic aftertaste, and form pockets of coagulated latex that lower quality. Unripe fruit are highly astringent and contain large amounts of leucoanthocyanidins. The sucrose content and pulp-to-peel ratio increase during maturation (Pathak and Bhat, 1953). The fruit shed off brown scaly external material and become smooth when reaching physiological maturity (Lakshminaryana 1980). Fruit ready for harvest will not show a green tissue or latex when scratched with a fingernail. Fully mature fruit will have a brown skin, and fruit will separate easily from the stem without leaking latex. Extent of scurfiness is also a good indicator of maturity (Kute and Shete, 1995). A fruit with a smooth surface, shining potato color and rounded styler end is considered mature (Kute and Shete, 1995).

Grades, Sizes and Packaging: Fruit are commonly cell packed in fiberboard or wood flats with 25 to 49 fruit (4.5 kg; 10 lb) per flat (McGregor, 1987).

Optimum Storage Conditions: Postharvest life is 2 to 3 weeks at 12 to 16°C (53.6 to 60.8°F) with 85 to 90% RH. Storage-life is about 13 days at 25°C (77°F), 15 days at 20°C (68°F), and 22 days at 15°C (59°F) (Broughton and Wong, 1979). Short-term holding of fruit for less than 10 h at 4°C (39.2°F) before storage at 20°C (68°F) extended storage-life up to 24 days with satisfactory quality (Broughton and Wong, 1979). Exposure of fruit to gamma irradiation at 0.1 KGy extended storage-life by 3 to 5 days at 26.7°C (80°F) and 15 days at 10°C (50°F) without any effect on ascorbate content (Salunkhe and Desai, 1984).

Modified and Controlled Atmosphere (CA) Considerations: Storage-life of sapodilla is extended by use of MA and removal of ethylene (Broughton and Wong, 1979; Yahia, 1998). Storage-life at room temperature increased from 13 to 18 days with 5% CO_2 , 21 days with 10% CO_2 , and to 29 days with 20%

CO₂. However, fruit held in 20% CO₂ failed to ripen, and this level of CO₂ (20%) is deleterious.

'Kalpatti' fruit treated with 6% Waxol or 250 or 500 ppm Bavistin, or hot water at 50 °C (122 °F) for 10 min, and wrapped in 150 gauge polyethylene film with 1% ventilation, ripened later than the controls, but fungal rot was high (Bojappa and Reddy, 1990). Fruit treated with 6% wax emulsion and packed in 200-gauge polyethylene covers containing ethylene and CO₂ absorbents had a shelf-life of 45 days at 12 °C (53.6 °F), 10 days more than controls (Chundawat, 1991).

'Jantuang' fruit were successfully stored using MAP for 4 weeks at 10 °C (50 °F) and 3 weeks at 15 °C (59 °F), a week longer than fruit without MAP (Mohamed et al., 1996).

Chilling Sensitivity: Sapodilla fruit are highly susceptible to chilling injury (CI). Storage of fruit at 6 to 10 °C (50 °F) causes irreversible damage and results in poor flavor (Broughton and Wong, 1979; Salunkhe and Desai, 1984). CI also occurred in fruit stored for 21 days at 10 °C (50 °F). However, fruit waxed with a fatty acid sucrose ester kept for 40 days at 10 °C (50 °F).

Ethylene Production and Sensitivity: Ethylene production is 2.8, 3.7 and 6.1 μL kg⁻¹ h⁻¹ at 15, 20 and 25 °C (59, 68 and 77 °F), respectively (Broughton and Wong, 1979). Treatment of sapodilla fruit with etherel at 1 to 3 mL L⁻¹ accelerated ripening, and reduced pectin content, phenolic content, SSC, sugar content and Vitamin C (Shanmugavelu et al., 1971; Das and Mahapatra, 1977; Ingle et al., 1982). Removal of ethylene delays ripening (Chundawat, 1991).

Respiration Rates: Sapodilla is a climacteric fruit (Broughton and Wong, 1979, Lakshminaryana and Subramanyam, 1966), but does not reach the climacteric while on the tree (Lakshminaryana and Subramanyam, 1966). The respiration rate at 24 to 28 °C (75.2 to 82.4 °F) was 16 mg (9 μl) CO₂ kg⁻¹ h⁻¹ (Lakshminaryana and Subramanyam, 1966). Pre-harvest sprays of isopropyl n-phenylcarbamate (IPC) at 100 μL L⁻¹ retard respiration, while maleic hydrazide at 0.5 to 1.0 mL L⁻¹ accelerate it (Lakshminarayana and Subramanyam, 1966).

Postharvest Pathology: Diseases and pests are rare. *Phytophthora palmivora* and species of *Pestalotiopsis* and *Phomopsis* can cause fruit rot (Snowdon, 1990). Some species of bacteria are associated with fruit latex (Pathak and Bhat, 1952).

Pests: Insects that infest sapodilla fruit include *Nephopteryx engraphella* Rag., fruit flies and an unidentified borer (Kute and Shete, 1995). The most troublesome fruit flies are the Mediterranean fruit fly (*Ceratitidis capitata*, Wied.) and Mexican fruit fly (*Anastrepha ludens*, Loew.).

Sapote

Scientific Name and Introduction: The sapote, zapote, mamey, mamey colorado, mamey sapote, chico-mamey, marmalade-fruit, marmalade-plum, grosse sapote (*Pouteria sapota* Jacq., H.E. Moore & Stearn, syn. *Colocarpum sapota* (Jacq., Merr., *Calocarpum mammosum*, Pierre., *Achras mammosa* L., *Lucuma mammosa*, Gaertn., *Vitellaria mammosa*, Radlk., and *Achradelpha mammosa*, Cook) is ovoid to ellipsoid in shape, 7 to 15 cm long and 10 to 15 cm in diameter. The skin is thick and woody with a russet-brown and somewhat scurfy surface. The pulp of mature fruit is soft and smooth to finely granular in texture, salmon pink, orange, and red or reddish-brown in color. The pulp has a sweet, almond-like flavor and low fiber content, creamy texture and rich flavor. Fruit weigh 0.3 to 3 kg and contain a large elliptical seed that has a shiny, hard, dark-brown surface with a light-brown hilum on the ventral side.

Quality Characteristics and Criteria: Inferior or improperly ripened mamey sapotes will develop a pronounced squash-like flavor.

Horticultural Maturity Indices and Harvesting: Fruit are harvested when the flesh begins to turn red, and mature when the newly exposed layer is turned from green to pinkish-brown, orange, or red. Immature fruit will fail to soften, and their pulp will turn dark-brown and inedible. Harvesting must be done carefully to avoid mechanical damage. Twist the fruit until it breaks from the stem. Poles with knives at the end are also used to harvest fruit. Fruit should not be allowed to fall on the ground.

Grades, Sizes and Packaging: Fruit are packed in 3 kg capacity fiberboard, flat boxes using sleeves or excelsior (McGregor, 1987).

Optimum Storage Conditions: Storage-life is 2 to 6 weeks at 13 to 18 °C (55.4 to 64.4 °F) with 85 to 90% RH.

Ethylene Production and Sensitivity: The fruit is climacteric and is one of the most prolific producers of ethylene at $> 100 \mu\text{L kg}^{-1} \text{h}^{-1}$ at 20 °C (68 °F) (Kader, 1992).

Physiological Disorders: Fruit are chilling sensitive. Symptoms include brown spots on the skin, poor color development, and development of off-flavor.

Star Apple

Scientific Name and Introduction: The star apple, caimito, sweetsop, or anon (*Chrysophyllum cainito* L.) is apple-size fruit, commonly round, sometimes ovate, heart-shaped or conical, with a smooth and waxy skin. They appear as a star when cross-sectioned. Fruit have a soft flesh, yellowish green in color, with a mild sweet flavor. The pulp is white or creamy white, with numerous embedded small, shiny, dark brown seeds.

Harvesting: Fruit should be matured on the tree, but picked before fully ripe. Fruit picked immature will be astringent and contain a sticky white latex. Fruit left to ripen on the tree are often split open, especially during the rainy season.

Packaging: Fruit are tray-packed in fiberboard boxes of 4.5 kg capacity (Mcgregor, 1987).

Pre-cooling: Pre-cooling should be done by hydro-cooling or forced-air.

Optimum Storage Conditions: Star apple intended for cold storage are picked at the half-ripe stage, cured in a well-ventilated room for 2 days and held at 3 to 6 °C (37.4 to 42.8 °F) with 90% RH for about 3 weeks.

Chilling Sensitivity: Fruit are slightly sensitive to chilling injury.

Ethylene Production and sensitivity: Ethylene production at 20 °C (68 °F) is 10 to 100 nL kg⁻¹ h⁻¹. The fruit does not respond much to treatment with ethylene (Pratt and Mendoza, 1980).

Respiration Rates: The star apple is a non-climacteric fruit. The respiration rate at 20 °C (68 °F) is 25 to 50 mg (13 to 25 μL) CO₂ kg⁻¹ h⁻¹. Heat evolution is 1600 to 4400 BTU per ton per day, equivalent to a respiration rate of 7 to 20 mg CO₂ kg⁻¹ day⁻¹ at 3 to 6 °C (37.4 to 42.8 °F) (Pratt and Mendoza, 1980).

Postharvest Pathology: The most important pests include the annona seed borer and the ambrosia beetle. The annona seed borer lays eggs in the seeds of very young fruits; insects develop in the seeds and emerge

as adults when the fruit matures.

Mamey Apple

Scientific Name and Introduction: Mamey apple, also known as mamey and zapote (*Mammea americana*), is a fruit of about 300 to 500 g with a peach-like flavor, round with a thick brown leathery skin containing one large single seed surrounded by a thin layer of yellow flesh. The fruit is a drupe about the shape and size of an orange, with a russet surface covered with small spots. The rind is tough, about 4-mm thick, and the flesh is yellow. The endocarp is yellow, about 2- to 5-mm thick and is fused with the testa.

Chilling Sensitivity: Chilling injury symptoms include failure to ripen, accelerated softening, development of brown spots in pulp, and development of off-flavors and aromas.

Ethylene Production: Ethylene production at 27 °C (80.6 °F) is up to 400 $\mu\text{L kg}^{-1} \text{h}^{-1}$, among the highest of all fruits (Akamine and Goo, 1978).

Respiration Rates: Mamey apple is a climacteric fruit. The respiration rate at 27 °C (80.6 °F) is 28 to 40 mg (14 to 20 $\mu\text{L CO}_2 \text{ kg}^{-1} \text{h}^{-1}$) (Akamine and Goo, 1978).

White Sapote

Scientific Name and Introduction: White sapote or zapote blanco (*Casimiroa edulis* Ilave & Lex) is also known as matasano in Spanish meaning “killing healthy person” due to the presence of the glucoside casimiroside, mainly in seeds but also in bark and leaves. This compound has sedative effects, induces sleep, and can also calm rheumatic pains. The fruit is dull-green to greenish-yellow, subglobose to obovate, and 5 to 10 cm in diameter. The skin is very thin and the flesh is cream colored to yellowish, soft and very sweet, with 1 to 5 large, hard, avoid seeds. The fruit is round, oval or ovoid in shape. Green-skinned varieties have white flesh and yellow-skinned varieties have yellow flesh. The skin is thin and smooth and the flesh has a custard-like texture and sweet flavor.

Quality Characteristics and criteria: Quality fruit are yellow to yellowish green and 60 to 120 mm in diameter (McGregor, 1987).

Horticultural Maturity Indices: White sapote fruit ripen after 6 to 9 mo from bloom. Fruit color at maturity ranges from apple-green to orange-yellow, depending on cultivar. Overripe fruit are commonly pungent with an unpleasant flavor. Fruit taste best when tree-ripened, but should be picked before ripening. Fruit should be handled very carefully during harvesting because they are easily bruised, turning the skin black and the flesh beneath it bitter.

Optimum Storage Conditions: Storage-life is 2 to 3 weeks at 19 to 21°C (66.2 to 69.8 °F) with 85 to 90% RH.

Postharvest Pathology: White sapote is resistant to Phytophthora and to Armillaria, but some cultivars can be attacked by fruit flies.

Black Sapote

Scientific Name and Introduction: Black sapote (*Diospyros dignya*) resembles a large, round green tomato, is 200 to 250 g, 5- to 12-cm in diameter with a thin skin, green color changing to brown or black when ripe. During ripening, pulp becomes soft and black in color.

Optimum Storage Conditions and Chilling Sensitivity: Black sapote is chilling sensitive. Fruit held at 15, 20 or 25 °C (59, 68, or 77 °F) for up to 7, 10, or 15 days, and then transferred to 25 °C (77 °F), ripened normally (Miller et al., 1997). Fruit held at 10 °C (50 °F) for 7 days and then transferred to 25 °C (77 °F) also ripened normally. However, some fruit held at 10 °C (50 °F) for 10 or 15 days showed abnormal ripening, and most fruit stored at 1 or 5 °C (33.8 to 41 °F) did not ripen normally or failed to ripen regardless of storage duration. Black sapote will tolerate irradiation at 0.15 kGy, but abnormal ripening will likely occur with some fruit when treated at 0.3 kGy (Miller et al., 1997).

Lucuma

Scientific Name and Introduction: The lucuma, lucumo, lucmo, lucma, rucma, or mamon (*Lucuma obovata*, HBK) is round or ovate, green on the surface, with yellow flesh and mealy texture. Fruit are about 7 cm long. The lucuma is a climacteric fruit. It has a low water content (64 to 72%) and higher amounts of riboflavin, niacin, and ascorbate than apples or bananas (Wenkam and Miller, 1965; Lopez, 1984).

Horticultural Maturity Indices: The maturity index commonly used is a change of peel color from green to yellow. However, variability exists in peel and pulp color ranging from green to yellowish-green peel, and light-yellow to orange-yellow pulp (Lizana, 1980). SSC can be used as a harvest index, but fruit have a dense and dry pulp. Therefore, to measure SSC, it is necessary to disrupt pulp by mechanical means and dilute with water. If pre-mechanical disruption of cells is not undertaken, apparent SSC content will appear lower than the true value (Lizana et al., 1986).

A classification of five stages of maturity was developed according to peel and pulp color, texture, SSC and respiration (Lizana, 1980). The classes in relation to peel and pulp color are:

Class	Peel color	Pulp color
1	light-yellow	light-yellow
2	light-green	creamy-yellow
3	yellow-green	yellow
4	green-yellow	dark-yellow
5	green-yellow	orange-yellow

Fruit ripened on the tree usually become soft and very fragile (Lizana, 1980). The pulp of the fruit is very dry when ripe (Lizana, 1980). Intense respiratory activity and sugar accumulation occur during ripening (Lizana et al., 1986).

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