

Sapodilla and Related Fruits

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To get mL CO₂ kg⁻¹ h⁻¹, divide the mg kg⁻¹ 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 mg kg⁻¹ h⁻¹ by 220 to get BTU per ton per day or by 61 to get kcal tonne⁻¹ day⁻¹.

Black Sapote

Scientific Name and Introduction

Black sapote (*Diospyros dignya*) resembles a large, round, green tomato. It weighs 200 to 250 g, is 5 to 12 cm in diameter, and has a thin skin. The green color changes to brown or black when ripe. During ripening, pulp becomes soft and black.

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 to 5 °C (34 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 of some fruit is likely 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 with a green surface and yellow, mealy flesh. 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. To measure SSC, it is necessary to disrupt pulp by mechanical means and dilute with water. Otherwise 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 is very dry when ripe (Lizana 1980). Intense respiratory activity and sugar accumulation occur during ripening (Lizana et al. 1986).

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 having a peachlike flavor. The fruit is a drupe about the shape and size of an orange, with a russet surface covered with small spots. It is round with a thick, brown, leathery skin containing one large single seed surrounded by a thin layer of flesh. The tough rind is about 4 mm thick. The flesh, or endocarp, is yellow, about 2 to 5 mm thick, and 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 (81 °F) is as much as 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 (81 °F) is 28 to 40 mg (14 to 20 μL) $\text{CO}_2 \text{ kg}^{-1} \text{h}^{-1}$ (Akamine and Goo 1978).

Sapodilla

Scientific Name and Introduction

Sapodilla (*Manilkara achras* [Mill] Fosb., syn *Achras sapota*, L.) is the fruit of the chicle tree and is 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 contains one or several shiny black seeds. It weighs about 70 to 300 g and has a dull brown color, thin skin, and yellowish, light brown, or red pulp. Sapodilla fruit are prized for a 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).

Fruits shed brown scaly external material and become smooth when reaching physiological maturity (Lakshminarayana 1980). Fruit ready for harvest do not show green tissue or latex when scratched with a fingernail. Fully mature fruit have brown skin and 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 stylar 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 (54 to 61 °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—less than 10 h at 4 °C (39 °F)—before storage at 20 °C (68 °F) extends 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 27 °C (80 °F) and 15 days at 10 °C (50 °F) without any effect on ascorbate content (Salunkhe and Desai 1984).

Modified Atmosphere (MA) 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 days to 18 days in 5% CO₂, 21 days in 10% CO₂, and to 29 days in 20% CO₂. However, fruit held in 20% CO₂ failed to ripen, and this level of CO₂ is deleterious.

'Kalpatti' fruit treated with 6% Waxol, with 250 or 500 µL L⁻¹ Bavistin, or with 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 (54 °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. Storage of fruit at 6 to 10 °C (43 to 50 °F) causes irreversible damage and results in poor flavor (Broughton and Wong 1979, Salunkhe and Desai 1984). Chilling injury 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 content (Shanmugavelu et al. 1971, Das and Mahapatra 1977, Ingle et al. 1982). Removing ethylene delays ripening (Chundawat 1991).

Respiration Rates

Sapodilla is a climacteric fruit (Lakshminaryana and Subramanyam 1966, Broughton and Wong 1979) but does not reach the climacteric while on the tree (Lakshminaryana and Subramanyam 1966). The respiration rate at 24 to 28 °C (75 to 82 °F) was 16 mg (9 µl) CO₂ kg⁻¹ h⁻¹ (Lakshminaryana and Subramanyam 1966). Preharvest 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 accelerates it (Lakshminaryana 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).

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 (*Ceratitis capitata*, Wied.) and Mexican (*Anastrepha ludens*, Loew.) species.

Sapote

Scientific Name and Introduction

The sapote (zapote, mamey, mamey colorado, mamey sapote, chico-mamey, marmalade-fruit, marmalade-plum, or 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 and salmon pink, orange, and red or reddish-brown in color. The pulp has a rich, sweet, almondlike flavor; low fiber content; and creamy texture. 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 squashlike flavor.

Horticultural Maturity Indices and Harvesting

Fruit are harvested when the flesh begins to turn red and are mature when the newly exposed layer has turned from green to pinkish-brown, orange, or red. Immature fruit fail to soften, and their pulp will turn dark-brown and inedible. Harvesting must be done carefully to avoid mechanical damage. The fruit should be twisted 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 flat fiberboard boxes using sleeves or excelsior (McGregor 1987).

Optimum Storage Conditions

Storage life is 2 to 6 weeks at 13 to 18 °C (55 to 64 °F) with 85 to 90% RH.

Ethylene Production and Sensitivity

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

Physiological Disorders

Fruit are chilling sensitive. Symptoms include brown spots on the skin, poor color development, and off flavor.

Star Apple

Scientific Name and Introduction

The star apple (caimito, sweetsop, or anon) (*Chrysophyllum cainito* L.) is an apple-sized fruit, commonly round but sometimes ovate, heart-shaped, or conical. It has a smooth, waxy skin. The fruit appears as a star when cross-sectioned. Fruit have a soft flesh and are 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 often split open, especially during the rainy season.

Packaging

Fruit are tray-packed in fiberboard boxes of 4.5 kg (10 lb) capacity (McGregor 1987).

Precooling

Precooling should be done by hydrocooling or forced-air cooling.

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 to 43 °F) with 90% RH for about 3 weeks.

Chilling Sensitivity

This fruit is slightly sensitive to chilling injury.

Ethylene Production and sensitivity

Ethylene production at 20 °C (68 °F) is 10 to 100 mL 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 nonclimacteric 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 1,600 to 4,400 BTU ton⁻¹ day⁻¹, 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.

White Sapote

Scientific Name and Introduction

White sapote, or zapote blanco, (*Casimiroa edulis* Hlave & Lex) is also known as matasano in Spanish, meaning “killing healthy person” because of 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 oblate, and 5 to 10 cm in diameter. The fruit is round, oval, or ovoid. The skin is very thin and the flesh is cream-colored to yellowish, soft, and very sweet, with 1 to 5 large, hard, ovoid seeds. Green-skinned varieties have white flesh, and yellow-skinned varieties have yellow flesh. The skin is thin and smooth and the flesh has a custardlike 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 6 to 9 mo after bloom. Fruit color at maturity ranges from apple-green to orange-yellow, depending on the 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 bitter.

Optimum Storage Conditions

Storage life is 2 to 3 weeks at 19 to 21°C (66 to 70 °F) and 85 to 90% RH.

Postharvest Pathology

White sapote is resistant to phytophthora and to armillaria, but some cultivars can be attacked by fruit flies.

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