White sapote (*Casimiroa edulis* Llave & Lex)

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**Abstract:** White sapote is a climacteric fruit and only slightly susceptible to chilling injury. The fruit is commercially produced and consumed in few countries. Limited information is available on its postharvest physiology and handling, and therefore research is needed on several physiological, biochemical, pathological, and entomological aspects related to this fruit. This chapter discusses some of the information available on the handling of the fruit.

**Key words:** *Casimiroa edulis*, white sapote, postharvest, quality, nutrition, health, processing, insects.

24.1 Introduction

Contrary to what is sometimes believed, white sapotes are not related to the Sapotaceae family, but actually belong to the Rutaceae family. Although white sapotes are not very popular among consumers they still have great potential for commercialization as an exotic fruit. In addition, the white sapote tree has great adaptability to arid regions which represents a sustainable option in these areas where other species do not grow. However, information on their postharvest biology and technology to establish optimum storage and transport conditions is still very limited.

24.1.1 Origin, botany, morphology and structure

White sapote (*Casimiroa edulis* Llave & Lex), also known as Mexican-apple, casimiroa, zapote blanco, chapote, matasano, cacchique, ceaxmisttea, cochitzapoti, is native to Mexico and Central America. It can be found in central and southern Mexico as a cultivated and wild species and is also grown in Guatemala, El...
Salvador and Costa Rica. Commercially, it is grown in New Zealand and on a small scale in South Africa. It is an evergreen tree that can grow up to 5–20 meters depending on the cultivar and type of soil. It has a dense crown, with glossy and bright green leaves. White sapote flowers are small and green to yellow which make them very attractive to insects like bees or ants. Fruit of white sapote vary from 2 to 15 cm in length with an apple-green color when young to orange-yellow color at maturity. Fruit (see Plate XLIII(A–C) in the colour section between pages 238 and 239) are oval, symmetrical or irregularly shaped with a thin and smooth skin that may be bitter. Its external appearance sometimes resembles that of an apple. Flesh color depends on the variety. Fruit with green skin present white flesh, while fruit with yellow-colored skin present flesh of the same color. The flesh is sweet and presents a gritty texture. Its flavor is similar to that of peach or banana and it may be bitter sometimes. If the fruit is left to become overripe, the flesh becomes pungent and an unpleasant flavor develops (Morton, 1987).

24.1.2 Worldwide importance
White sapote adapts to subtropical weather, growing not only in Mexico and the United States, but also in temperate areas of New Zealand, Australia, and Israel. The fruit has recently been introduced in Japan, where it is little known as a fresh crop (Yamamoto et al., 2007). White sapote is also cultivated in Egypt for its fruit (Romero et al., 1983). Interest in commercialization of fresh white sapote in the United States and other countries has increased in recent years, as has interest in its medicinal properties (Campbell and Vallis, 1994).

24.1.3 Culinary uses, nutritional value and health benefits
Fruit of white sapote are usually eaten alone or mixed in fruit salads, and can be served with cream and sugar. The pulp can be added to ice cream, milkshakes or made into jam.

The nutritional value of white sapote is presented in Table 24.1. White sapote fruit are rich in β-carotene and ascorbic acid. Reducing sugars contribute to 66.2% of the total sugars in pulp which presents about 14.7°Brix (Osama Samaha, 2002). Antioxidant capacity of white sapote leaf-extracts has been evaluated using the ABTS+ (2,2′-azinobis(3-ethylbenzothiazolone-6-sulfonic acid) free radical assay). Ethanol extracts presented the highest values of antioxidant capacity followed by the ethyl acetate extracts (842 and 712 μM Trolox equivalents g⁻¹ dry weight, respectively). Phenolic compounds isolated from leaves extracts included quercetin and its 3-O-rutinoside, 6-hydroxy 5-methoxyflavone, and 5-methosyflavone 6-O-β-D-glucoside (Awaad et al., 2006).

It is generally believed that white sapote seeds are toxic to humans if eaten raw. Indeed, its common name ‘matasano’ in Spanish means ‘killing healthy person’. In Mexico and some other countries it is claimed that white sapote fruit helps to relieve pain caused by arthritis and rheumatism. Actually, the meaning of the Nahuatl name for white sapote is ‘sleepy sapote’ or ‘sleep-producing sapote’.
Table 24.1 Nutrient value of white sapote (100 g of fruit)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Approximate value</th>
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<tbody>
<tr>
<td>Water content</td>
<td>78.3%</td>
</tr>
<tr>
<td>Protein</td>
<td>0.143 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.03 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>0.9 g</td>
</tr>
<tr>
<td>Ash</td>
<td>0.48 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>9.9 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20.4 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.33 mg</td>
</tr>
<tr>
<td>Carotene</td>
<td>5.98 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.042 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.043 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.472 mg</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>37.75 mg</td>
</tr>
</tbody>
</table>


There have been reports about the sedative properties of seed, bark and leaf extracts in Mexico where they have been used for a long time for these purposes. All these effects are thought to be due to the presence of the glucoside casimirosine, mainly in seeds but also in the bark and leaves.

The blood-pressure lowering properties of white sapote have been confirmed in some studies (Petit-Play et al., 1982) and extracts of the leaves, bark and seeds are used for this purpose. In Mexico, a decoction from the leaves and seeds is used to treat anxiety, insomnia and hypertension (Vidrio and Magos, 1991; Hernandez, 1993; Garzon-de la Mora, 1999). Compounds with cardiovascular activity were identified as histamine derivatives like N,N-dimethylhistamine (Magos et al., 1999).

One study performed in mice showed that extracts prepared from white sapote leaves possessed sedative properties along with anxiolytic and anti-depressant activities when given at 6.25, 12.5, and 50 mg kg⁻¹ (Mora et al., 2005). Leaves of Caimiroa edulis showed anxiolytic effects in rats, causing side effect reactions like reduced mobility (Molina-Hernández et al., 2004). In rats, aqueous extracts of white sapote seed have been shown to present vaso-relaxing activity which was found to be endothelium-dependent (Magos et al., 1995; Muccillo Baisch et al., 2004). Some other compounds such as coumarins, flavonoids and limonoids, among others, have been found in white sapote (Dreyer and Bertelli, 1976; Murphy et al., 1968; Rizvi et al., 1984; Sondheimer et al., 1959). Some of these compounds are known to present diuretic or anti-inflammatory properties (Morton, 1987).

A polymethoxylated flavone called zapotin has been isolated from white sapote which induced cellular differentiation, cell death and cell cycle arrest in HL-60 promyelocytic cells (Mata-Greenwood et al., 2001). Zapotin has also shown chemopreventive activity by inhibiting cell growth of the colon cancer cell lines HT-29, SW480, and SW620. In addition, it caused cell cycle arrest as well as an increase in cell apoptosis which may suggest that this compound could be used as a therapeutic agent in colon carcinogenesis (Murillo et al., 2007). Extracts of
White sapote seeds also showed anti-mutagenic action and inhibited induced preneoplastic lesions in a mouse model (Ito et al., 1998). Isolation of phytochemical compounds in these extracts showed four furcoumarins: phellopterin, isopimpinellin, \((R, S)\)-5-methoxy-8-\{6,7-dihydroxy-3,7-dimethyl-2-octenyl\}osy]psoralen, and \((R, S)\)-8-\{6,7-dihydroxy-3,7-dimethyl-2-octenyl\}oxy]psoralen; four alkaloids: casimiroin, 4-methoxy-1-methyl-2(1H)-quinolinone, 5-hydroxy-1-methyl-2-phenyl-4-quinolone, and \(\gamma\)-fagarine; and two flavonoids: zapotin and 5,6,2'-trimethoxyflavone (Ito et al., 1998). Lastly, leaf and stem extracts of white sapote showed fungicidal actions against \(\textit{Rhizopus stolonifer}\) of ciruela fruit (\textit{Spondias purpurea} L.) during storage (Bautista-Banos et al., 2000).

### 24.2 Fruit development and postharvest physiology

#### 24.2.1 Fruit growth, development and maturation

The growth of white sapote fruit follows a single sigmoidal pattern (Yonemoto et al., 2006) and maturity is reached 6–9 months after blooming.

#### 24.2.2 Respiration, ethylene production and ripening

White sapote is a climacteric fruit (Yahia, 2004). Fruit kept at 21°C and 82% RH had a respiratory peak after 4–5 days (199 mL CO\(_2\) kg\(^{-1}\) h\(^{-1}\), 651 \(\mu\)L C\(_2\)H\(_4\) kg\(^{-1}\) h\(^{-1}\)) (Lozano et al., 2006). Respiration rate is reduced when fruit is stored at 1°C and no ethylene production is observed during these conditions (Yonemoto et al., 2002). Total sugar content of harvested fruit kept at 21°C and 82% relative humidity (RH) did not change during ripening but the level of reducing sugars increased from 6.1 to 7.8%. The ratio °Brix/acidity increased during ripening (from 28.4 to 34.1%) as a consequence of the increased reducing sugars content and decreased acidity (Lozano et al., 2006).

#### 24.3 Maturation and quality components and indices

White sapote fruit should be harvested before ripening (Morton, 1987). The days after pollination could be used as a maturity index: for white sapote cultivar ‘Cuccio’, it takes 212 days after pollination to reach maturity. Another maturity index could be percent dry matter, since this parameter is strongly correlated with total soluble solids. A more convenient and non-destructive maturity index is skin color measured by a colorimeter. In that case, \(a^*\) value is measured on the sun-exposed side while \(b^*\) is evaluated on the shaded side. Seed color could also be measured to determine maturity (Yonemoto et al., 2006).

Skin color and size are used as quality parameters and according to McGregor (1987), good quality fruit are yellow to yellowish-green and are 60–120 mm in diameter. According to Morton (1987), skin color of fully ripe white sapote fruit is usually apple-green to orange-yellow. White sapote fruit (see Plate XLIII(A–C).
in the colour section) are easily bruised if not handled correctly which produces bitterness of the flesh. Overripe fruit are pungent and have an unpleasant flavor (Morton, 1987).

A value of 18% dry matter at maturity of cv. ‘Cuccio’ is reported. In another study, mature fruit were reported to present a pH of about 5.1, 0.34% acidity, total soluble solids content of about 19.9% and about 14.7°Brix (Osama Samaha, 2002). Volatile compounds responsible for the aroma of white sapote fruits were identified during fruit ripening. They corresponded to 4 esters, 6 alcohols, 1 ketones, 4 aldehydes, and 3 terpenes. The sweet and fruity aroma was found to be originated from ethyl butanoate (El-Mageed, 2007). Some other aromatic compounds with properties to attract fruit flies have been identified in white sapote: myrcene, styrene, 1,2,4-trimethylbenzene, 1,8-cineole, linalool, and β-trans-ocimene (Gonzalez et al., 2006).

24.4 Preharvest factors affecting fruit quality
Temperatures below 3°C will damage young fruit, affecting the quality of ripe white sapotes (Yonemoto et al., 2004).

24.5 Postharvest handling factors affecting quality

24.5.1 Temperature management
Studies on white sapote cv. ‘Yellow’ showed that the respiration peak is reached at day four from harvest and when fruit are held at 35°C, and at day 6 at 15, 20, 25, and 30°C. When stored at 10°C a respiration peak was not evident. Respiration rate was slowed down at 1°C and there was no ethylene production. Temperatures higher than 30°C induced skin browning, which was not observed at 10–25°C. Fruit surface softening was observed at 5°C. Fruit stored at 1°C for 10 to 63 days ripened normally after transfer to 25°C. However, chilling injury was observed in fruit stored for 63 days at 1°C (Yonemoto et al., 2002).

24.5.2 Physical damage
Special care must be taken not to harvest the fruit by pulling it manually since the stem will be severed completely producing fruit bruising and decay later on. Young fruits bruise very easily, developing flesh bitterness, and therefore they must be handled with care (Morton, 1987). Fruit that has been physically damaged will develop browning of the skin and pulp bitterness (Yahia, 2004).

24.6 Physiological disorders

24.6.1 Chilling injury
No production of white sapote is seen when ambient temperatures fall below –2.5°C and as already mentioned, young fruit are severely damaged at 3°C.
However, when mature white sapote fruit were exposed for five hours at $-2^\circ C$ for five days, no damage was observed. Thus, the recommended temperature for cultivation is higher than $-2^\circ C$ (Yonemoto et al., 2004). As mentioned above, chilling injury was observed in fruits stored at $1^\circ C$ for 63 days (Yonemoto et al., 2002).

24.6.2 Other physiological disorders
Quarantine treatments have been tested on white sapote in order to kill *Anastrepha suspense*. Immersion of fruit in water at $43.3^\circ C$ for 90 or 120 minutes or at $46^\circ C$ for 60 or 90 minutes produced pitting and decay and ripening was abnormal. The level of decay also increased and ripening was affected when white sapote fruit was treated with methyl bromide at 20 to 40 g m$^3$. In addition this produced a reddish hue on the fruit (Hallman, 1993).

24.7 Pathological disorders
Fruit of white sapote present resistance to Phytophthora and Armillaria (Morton, 1987). White sapote is a host of *Puccinia thaliae* (Sivanesan, 1970). Although not affected by it, white sapote tree is a carrier of psorosis virus disease (El-Tomi et al., 1963).

24.8 Insect pests and their control
Few pests affect white sapote fruit, however, the fruit are highly infested by *Anastrepha ludens* (Aluja et al., 1987). Some volatile compounds in white sapote have been found to attract *A. ludens* to baited traps (Gonzalez et al., 2006). Although not a target of the African citrus psylla, *Trioza erytreae*, white sapote has been reported as a host for this pest (Fernandes and Franquinho Aguiar, 2001).

24.9 Postharvest handling practices
24.9.1 Harvest operations
The white sapote season starts in late May until August in the Bahamas while in Mexico it goes from June to October (Morton, 1987). In Florida, fruit matures in November or December (Schroeder, 1954). Fruit are harvested by cutting the stem and leaving a small part of the peduncle, which falls once the fruit is fully ripe. When fruit are harvested just before full ripeness, they become soft soon after. Because of that, it is recommended to harvest white sapotes some weeks before ripeness so fruit can develop complete flavor (Morton, 1987).
24.9.2 Packinghouse practices
Some common practices during white sapote packing include grading according to size and wrapping to delay ripening. Fruit are usually packed in wooden boxes with some type of cushioning material to avoid physical damage during holding and shipping (Morton, 1987).

24.9.3 Recommended storage and shipping conditions
Maintaining white sapote fruit at 19–21 °C and 85–90% RH prolongs their shelf life for up to 2–3 weeks (McGregor, 1987). The fruit might benefit from an adequate modified atmosphere system (Yahia, 1998).

24.10 Processing
White sapote fruit can be used to make different products such as juice, jam, tart, biscuit, and sherbet (Osama Samaha, 2002).

24.11 Conclusions
White sapote is a climacteric fruit with potential for commercialization due to its organoleptic properties and the fact that it is considered an exotic fruit. However, limited information on the postharvest biochemistry, physiology and technology is available and thus it is difficult to establish the optimum conditions that would preserve quality during extended storage and shipping. White sapote fruit, although mainly consumed fresh, could be used to produce added-value products such as preserves and other products.

24.12 References


