Black sapote (*Diospyros digyna* Jacq.)

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**Abstract:** Black sapote (*Diospyros digyna* Jacq.) is a climacteric fruit, popular in Mexico, that is consumed fresh as well as in other processed forms. The fruit is greatly valued for its excellent organoleptic characteristics, but unfortunately not enough information is available on its postharvest physiology and handling. Therefore guidance on optimum conditions for handling is not available and needs to be developed. The fruit is very sensitive to chilling injury, and its very soft texture when ripe makes its handling and shipping somewhat difficult.

**Key words:** *Diospyros digyna*, black sapote, postharvest, ripening, nutrition, processing.

11.1 Introduction

Although is sometimes believed that black sapote (*Diospyros digyna*) belongs to the Sapotaceae family because of its common name, it actually comes from a different family, the Ebenaceae. It is a climacteric fruit (Yahia, 2004) and is widely accepted in regional markets due to its organoleptic characteristics. It has excellent potential for commercialization as an exotic fruit, yet in spite of this, information on its postharvest biology and physiology necessary to establish optimum storage and transport conditions is limited.

11.1.1 Origin, botany, morphology and structure

Black sapote is native to the coasts of Mexico and Central America, where it is usually found as a cultivated crop. It is also known in Spanish as *sapote, sapote negro, matasano de mico, sapote de mico, or ebano*, while in Hawaii people know it as black persimmon. The black sapote tree is an evergreen that reaches a height of up to 25 m. Fruit are bright green and shiny when young (Plate XIXa: see colour section between pages 244 and 245), nearly round with a diameter of 5 to
12.5 cm and present a pronounced four-lobed, undulate calyx. When ripe, the fruit's skin becomes olive-green and then muddy-green (Plate XIXb: see colour section between pages 244 and 245). The pulp is glossy, brown to very dark brown or black, with a jelly-like consistency and sweet and mild flavor. Although the fruits are mostly seedless, sometimes up to 10 to 14 seeds can be found (Morton, 1987).

11.1.2 Worldwide importance
Black sapotes are found in tropical and subtropical areas of Mexico with the states of Tabasco, Guerrero, Chiapas and Puebla being the main areas of production. In 2001, production of black sapote in Mexico reached more than 700 tons with a total value of 1.35 million pesos (SAGARPA, 2001).

11.1.3 Culinary uses, nutritional value and health benefits
Black sapote pulp can be eaten fresh, served as a dessert accompanied with milk, made into ice cream, or mixed with orange juice, liquor, or wine and served as a dessert. It is also made into liquor in Central America. Some of the medicinal benefits attributed to black sapote include the decoction made with the leaves, which is used as an astringent and febrifuge. Other preparations from black sapote are used to treat skin rash and leprosy (Morton, 1987). The nutritional composition of black sapote is presented in Table 11.1.

It contains mainly carbohydrates and minerals and is an important source of ascorbic acid, calcium and phosphorus (Miller et al., 1997). Although Morton (1987) reported an ascorbic acid concentration of 191.7 mg 100g⁻¹, recent analysis

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Approximate value</th>
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<tbody>
<tr>
<td>Water content</td>
<td>79.46–83.1%</td>
</tr>
<tr>
<td>Protein</td>
<td>0.62–0.69 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>12.85–15.11 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.01 g</td>
</tr>
<tr>
<td>Ash</td>
<td>0.37–0.6 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>22.0 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>23.0 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.36 mg</td>
</tr>
<tr>
<td>Total carotenoids</td>
<td>399.4 µg</td>
</tr>
<tr>
<td>β-carotene</td>
<td>64.7 µg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.03 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.20 mg</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>24 mg</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>2064 µg</td>
</tr>
<tr>
<td>Total soluble phenols</td>
<td>247 mg</td>
</tr>
</tbody>
</table>

Fig. 11.1 Antioxidant capacity of hydrophilic and lipophilic extracts of black sapote measured by DPPH and FRAP assays. Source: Yahia et al., 2010.

by HPLC reported 24.1 mg per 100 g fruit (Corral-Aguayo et al., 2008). Vitamin E content in black sapote (2,064 µg 100 g⁻¹ fw) is higher than that of other tropical fruits such as strawberries and mango, and was found to be mainly in the form of α-tocopherol (Corral-Aguayo et al., 2008). The content of total phenols in black sapote has been reported as 247 mg equivalents of gallic acid per 100 g fresh weight (Corral-Aguayo et al., 2008). HPLC-DAD-Mass Spectrometry (HPLC-MS) analyses revealed major phenolics are sinapic acid, myricetin, ferulic acid, and catechin (110.7, 85.0, 81.9, and 79.941 mg 100 g⁻¹ dw, respectively) (Yahia et al., 2010).

The antioxidant capacity (AOC) of black sapote hydrophilic (HPE) and lipophilic (LPE) extracts has been evaluated using the DPPH (2,2'-diphenyl-1-picrylhydrazyl) and FRAP (ferric ion reducing antioxidant power) assays. AOC of the HPE was much higher than that of the LPE using the two assays (HPE: 302.734, LPE: 2.180 mg AAE 100 g⁻¹ fw by DPPH; and HPE: 501.478 mg ascorbic acid equivalents (AAE) 100 g⁻¹ fw, while AOC was not detected in the LPE by FRAP) (Fig. 11.1) (Corral-Aguayo et al., 2008; Yahia et al., 2010).

11.2 Fruit development and postharvest physiology

11.2.1 Fruit growth, development and maturation
Fruit takes about four months from anthesis to maturity. The firmness of black sapotes decreases during ripening with a more pronounced decrease three days
after harvest, which corresponds to an elevation of ethylene synthesis (Arellano-Gómez et al., 2005). After the same period of time, total phenolics presented a reduction of more than 80%, while the activity of polyphenol oxidase increased significantly. Total carotenoids were lower at the end of ripening as well as ascorbic acid, which presented a reduction of about 62%. This decrease in ascorbic acid and the increase in polyphenol oxidase activity could explain the darkening of the pulp during ripening (Arellano-Gómez et al., 2005).

11.2.2 Respiration, ethylene production and ripening
Black sapotes are climacteric fruits (Yahia, 2004). The maximum production of CO₂ was reported by Arellano-Gomez et al. (2005) on day six after harvest (about 367.3 mL kg⁻¹ h⁻¹), and that of ethylene is reached on day five (480 μL kg⁻¹ h⁻¹). Due to this respiratory behavior, this fruit is considered to be highly perishable. The total soluble solids content in fully mature fruit is in the range of 17.9 to 21.5°Brix, while their water content is 77.5% (Corral-Aguayo et al., 2008).

11.3 Maturity and quality components and indices
The unripe fruit of the black sapote has a golden yellow colored pulp [skin? – see comment] that turns brown-black when ripe (Ledesma and Campbell, 2001). The external and internal color of fully ripe black sapote fruit has been characterized and is presented in Table 11.2.

The color parameteres of black sapote pulp correspond to a dark brown color (Corral-Aguayo et al., 2008). Fruits should be harvested when fully mature but still unripe, or when they present a bright green color. When harvested at this stage, they become ripe in about ten days if kept at room temperature. Fruits harvested later, when they are olive-green, will ripen in two to six days. Fully ripe black sapotes (Plate XX: see colour section between pages 244 and 245) are very soft and they can be kept in the cold for only a very few days, but their handling becomes difficult due to their excessive softness (Morton, 1987; Yahia, 2004).

| Table 11.2 Color characteristics of fully ripe fruit of black sapote |
|-----------------|-----------------|-----------------|
| Parameter       | Skin            | Pulp            |
| L               | 41.2            | 22.6            |
| a               | 4.5             | 16.5            |
| b               | 6.2             | 2.9             |
| Chroma          | 7.8             | 16.8            |
| Hue             | 53.1            | 10.2            |

Source: Adapted from Corral-Aguayo et al. (2008).
11.4 Postharvest handling factors affecting quality

11.4.1 Temperature management
Black sapote fruit held at 15, 20 or 25°C for up to seven, ten, or 15 days and then transferred to 25°C ripened normally (Yahia, 2004). The same was observed when the fruit were kept at 10°C for seven days and then transferred to 25°C. However, some fruit held at 10°C for ten or 15 days had abnormal ripening, and most fruit stored at 1 or 5°C did not ripen normally or failed to ripen regardless of the storage duration (Miller et al., 1997; Yahia, 2004).

11.4.2 Physical damage
Fully ripe fruits of black sapote are extremely soft (Plate XIXb: see colour section between pages 244 and 245), and therefore very prone to physical damage.

11.5 Physiological disorders
Black sapote is chilling sensitive (Yahia, 2004). Some of the fruit held at 10°C for ten or 15 days showed abnormal ripening, and most fruit stored at 1 or 5°C did not ripen normally or failed to ripen regardless of storage duration (Yahia, 2004).

11.6 Pathological disorders
Janick and Paull (2008) indicated that black sapote is not commonly affected seriously by diseases.

11.7 Insect pests and their control
Although no important pests are reported in black sapote, it is a fruit fly host (Janick and Paull, 2008).

11.8 Postharvest handling practices

11.8.1 Harvest operations
The harvest season of black sapote in Mexico is from August to January. A cutting pole with a cloth bag attached is used to harvest the fruits when they are mature green or olive green (Morton, 1987).

11.8.2 Control of ripening and senescence
Black sapote will tolerate irradiation at 0.15 kGy, but abnormal ripening will likely occur in fruit treated at 0.3 kGy (Miller et al., 1997; Yahia, 2004).
11.8.3 Recommended storage and shipping conditions

Storage of black sapote fruits at 13 to 15°C and 85 to 90 percent RH will extend their shelf life for up to two to three weeks (McGregor, 1989; Yahia, 2004). Modified and controlled atmospheres are not practiced, but they could help (especially modified atmosphere packaging) in extending the storage and shipping life (Yahia, 1998; 2008).

11.9 Processing

Black sapote is mainly eaten fresh, but also processed into several products. The fruit is peeled and the pulp is placed in bottles or frozen, and also used to make ice cream (SDR, 2010). The fresh pulp of black sapote is used to prepare puddings, cakes and mousse.

11.10 Conclusions

Black sapote presents a climacteric behavior and its postharvest handling is difficult, especially due to the lack of adequate information. This fruit has potential for commercialization as exotic fruit due to its excellent organoleptic properties and multiple uses, especially processed. However, very limited information exists on their postharvest biochemistry, physiology and handling and thus it is difficult to establish the optimum conditions for storage and transport to extend their shelf life. The fruit needs to be harvested and transported while still unripe because once it reaches full ripeness, it becomes soft and handling becomes unsuitable. It is consumed fresh and made into preserves and several other processed products, which gives an added value and would facilitate its commercialization.

11.11 References


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