

Star apple (*Chrysophyllum cainito* L.)

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Abstract: Star apple is a non climacteric fruit, with high antioxidant capacity and high nutritional and health potential. However, this fruit is only commercially produced on a very limited scale in a few regions. Extensive research is still needed on diverse aspects of postharvest physiology, biochemistry and technology. This chapter discusses the currently available information on the postharvest handling of this fruit.

Key words: *Chrysophyllum cainito*, star apple, postharvest, nutrition, health, quality, processing, storage.

19.1 Introduction

Although star apple (*Chrysophyllum cainito* L.) fruit are very tasty, their commercial importance is lower than that of other fruits from the same family (Sapotaceae). Mainly consumed fresh, star apple fruit has a great potential in international markets due to its flavor and appearance which make it very suitable for inclusion in salads as an exotic fruit. The fruit has been found to contain antioxidants in a recent study which increases opinion of its nutritional value.

19.1.1 Origin, botany, morphology and structure

From the Sapotaceae family, the star apple (*Chrysophyllum cainito* L.), also called caimito, goldenleaf tree, sweetsop, or anon, is believed to be native to Central America, although others consider that it may be indigenous to the West Indies. It is well distributed at low and medium altitudes from the south of Mexico to northern Argentina and Peru. In the United States, it grows well only in the warmest locations in southern Florida. The star apple is an evergreen tree that grows up to 15 m with a short trunk of diameter 60 cm. The crown is dense, broad and the bark exudates white gummy latex. Star apple tree is propagated through

seeds but this can also be done through grafting (Alvarez *et al.*, 2004). The leaves are elliptic to oblong and are glossy above and coated with silky hair beneath that is golden in color. The flowers are clustered in the leaf axils and range from a green-yellow color to purple and white.

Star apple is an apple size fruit (see Plate XLII in the colour section between pages 238 and 239), commonly round, sometimes ovate, heart-shaped or conical, with a smooth and waxy skin. A star shape appears in its cross section. The fruit is characterized by its soft flesh that is yellowish green in color, with a mild sweet flavor. The pulp is white or creamy white, with numerous small, shiny, dark brown seeds embedded in it (Morton, 1987; Orwa *et al.*, 2009).

19.1.2 Worldwide importance

Star apple is commercially grown in Australia and Mexico (Morton, 1987). It is of minor commercial importance in the United States as compared to other Sapotaceae fruits despite its tasty flavor: only six acres, approximately, of commercially grown and harvested star apple exist in Florida. The price for a dozen star apple fruits was between one and a half and three dollars during production peak and fifteen dollars outside this period (Alia-Tejagal *et al.*, 2005).

19.1.3 Culinary uses

The fruit can be eaten fresh or chilled to improve the flavor. It is cut in half and the flesh is spooned out, discarding the seed cells and core. The skin is not edible and should be discarded. In the same way, special care must be taken to not let the skin latex come in contact with the flesh. In Jamaica, the frozen flesh is mixed with other frozen fruit and served as a salad. Fresh pulp can be mixed with sour orange juice or prepared into preserves. In other areas, a decoction can be prepared from the flesh, while others prepare an emulsion from the seed kernels.

The nutritional value of star apple fruit is presented in Table 19.1. The flesh of star apple is very sweet with glucose being the main sugar (Heredia *et al.*, 1998). The seeds have been reported to contain 1.2% of the bitter, cyanogenic glycoside, lucumin (Morton, 1987). Several polyphenolic compounds with antioxidant activity have recently been characterized in star apple fruit. For instance Luo *et al.* (2002) identified catechin, epicatechin, gallic acid, epigallocatechin, quercetin, quercetrin, isoquercitrin, myricitrin and gallic acid in the fruit. The following phenolic compounds were identified by Fujuki *et al.* (2010): chlorogenic, syringic, ferulic, benzoic, *p*-coumaric, vanilic, caffeic, gallic, and protocatechuic acids. This might support the finding that extracts of star apple showed high antioxidant capacity (Luo *et al.*, 2002; Einbond *et al.*, 2004). Epicatechin was found as the main polyphenol present in the fruit while quercetin had the highest antioxidant activity (Luo *et al.*, 2002). In addition, cyanidin-3-O- β -glucopyranoside, an anthocyanin with antioxidant properties was identified in the fruit (Einbond *et al.*, 2004).

Table 19.1 Nutrient value of star apple fruit (100 g of fruit)

Constituent	Approximate value
Water content	78.4–85.7 %
Calories	67.2
Protein	0.72–2.33 g
Carbohydrates	14.65 g
Total sugars	8.45–10.39 g
Fiber	0.55–3.30 g
Ash	0.35–0.72 g
Calcium	7.4–17.3 mg
Phosphorus	15.9–22.0 mg
Iron	0.30–0.68 mg
Carotene	0.004–0.039 mg
Thiamin	0.018–0.08 mg
Riboflavin	0.013–0.04 mg
Niacin	0.935–1.340 mg
Ascorbic acid	3.0–15.2 mg
Tryptophan	4 mg
Methionine	2 mg
Lysine	22 mg
Total volatiles	0.154 mg
Total phenols	217.0–387.1 mg

Source: Morton (1987); Pino *et al.* (2002); Alvarez *et al.* (2006), Parker *et al.* (2010).

Differences may exist between cultivated and wild trees of star apple regarding acidity, pH, total soluble phenols, and sugar concentration. Total soluble phenols content has been reported in the range of 217.0 to 387.1 mg 100 g⁻¹, depending on whether the fruit is from wild or cultivated trees, respectively (Parker *et al.*, 2010).

Analysis of volatile components of star apple have revealed 104 compounds, from which (E)-2-hexenal, 1-hexanol, limonene, linalool, α -copaene and hexadecanoic acid were found to be the major constituents. Altogether, these compounds contribute to the pleasant flavor of the star apple fruit (Pino *et al.*, 2002).

Ripe fruit of star apple are eaten to alleviate inflammation of the respiratory tract, and used as a treatment for diabetes and to ease angina. Unripe fruit are consumed to cure intestinal problems but if taken in excess can cause constipation. Decoctions of the leaves are used as a treatment for cancer and as a pectoral (Morton, 1987; Orwa *et al.*, 2009). Seeds are taken as a powder and in other areas as a tonic and stimulant, to stop diarrhea, bleeding or gonorrhoea. The latex is used as a vermifuge (Morton, 1987). An aqueous decoction of star apple leaves are used to treat diabetes. In a recent study with rabbits, this aqueous decoction was found to have hypoglycemic activity when used at doses greater than 10 g L⁻¹ although toxic effects were present at a dose of 30 g L⁻¹. These effects were attributed to the alkaloids, sterols and triterpens found in the plant (Koffi *et al.*,

2009). Another study showed that extracts of star apple leaves were able to inhibit *E. coli in vitro* (Medina *et al.*, 2001).

19.2 Fruit development and postharvest physiology

19.2.1 Fruit growth, development and maturation

Growth of star apple fruit follows a sigmoidal system (Santamaria Herreria, 2004). Fruit must mature on the tree before they can be harvested and maturation takes about 180 days (Pino *et al.*, 2002). Total soluble solids content in ripe fruit can reach up to 11.7°Brix with an average value of 10.1°Brix and ranges of pH in ripe fruit are from 5.42 to 6.18. At maturity, 60% of the fruit weight corresponds to the skin, 37% to the pulp and 3% to the seeds. The majority of the fruit found in Morelos, a central state in Mexico, present dark purple skin color, although green fruit may also be found. Thus, great variation exists in color parameters of star apple fruit (Table 19.2), although apparently dark purple colored fruit are preferred, at least in this area of Mexico (Alvarez *et al.*, 2006).

Table 19.2 Color parameters in ripe fruits of star apple

Color parameter	Mean value ± Standard deviation
Lightness	29.2 ± 8.8
Hue	56.1 ± 30.7
Chroma	8.6 ± 7.0

Source: Alvarez *et al.* (2006).

19.2.2 Respiration, ethylene production and ripening

The star apple is a non-climacteric fruit (Yahia, 2004) and respiration rate at 20°C is about 25–50 mg CO₂ kg⁻¹ hr⁻¹. Heat evolution of the fruit is 1600 to 4400 BTU ton⁻¹ day⁻¹ equivalent to a respiration rate of 7–20 mg CO₂ kg⁻¹ day⁻¹ at 3–6°C. Ethylene production at 20°C is 10–100 nL kg⁻¹ hr⁻¹ (Pratt and Mendoza, 1980).

19.3 Maturity and quality components and indices

Because not all fruit on a tree mature at the same time, it is difficult to establish a maturity index. Fruit harvested before they are fully ripe will have a poor, gummy, texture and an astringent taste in addition to presenting sticky latex which makes the fruit inedible (OFI-CATIE, 2010). Fruit can be picked when the base of the fruit is still green for easier transporting and to reduce physical damage (Sagarpa, 2010). Fully mature fruit present dull skin and are soft to the touch (Morton, 1987). In addition, a pale to dark purple color of the skin is seen in mature fruits.

19.4 Preharvest factors affecting fruit quality

Conditions during fruit growth will affect the composition of the fruit. For instance, differences have been found in total sugars, acidity, pH, and soluble phenols, between wild and cultivated trees of star apples. Higher sugar concentration, less acidity and lower phenolic content was found in fruits of cultivated trees of star apple when compared to wild trees (Parker *et al.*, 2010). This could be due to the effects on domestication and selection of the cultivated trees.

19.5 Postharvest handling factors affecting quality

19.5.1 Temperature management

Star apple fruits can be maintained at 3–6 °C for a few weeks (OFI-CATIE, 2010).

19.5.2 Physical damage

Since the fruit needs to ripen on the tree, sometimes mature fruit fall to the ground and are then picked up, which commonly causes mechanical damage.

19.5.3 Water loss

The fruit is very susceptible to water loss. Therefore the use of high relative humidity (90%) can help reduce water loss during storage and shipping of star apple (OFI-CATIE, 2010).

19.6 Physiological disorders

The fruit is slightly sensitive to chilling injury.

19.7 Pathological disorders

Pestalotia and *Diplodia*, which cause stem-end decay, are an important problem in the Philippines. Other important disorders attacking the leaves include *Phomopsis* sp., *Phyllosticta* sp., and *Cephaleuros virescens* (Morton, 1987).

19.8 Insect pests and their control

Sometimes, larvae of small insects such as the anona seed borer infect young fruit and emerge when the fruit ripens. Other insects include the twig borer, carpenter moth, mealy bugs, scales and fruit flies. *Dacus dorsalis*, a fruit fly, constitutes a serious problem since it makes the fruit inedible. Ripe fruit on the tree may be eaten by birds, bats or squirrels (Morton, 1987; Orwa *et al.*, 2009).

19.9 Postharvest handling practices

19.9.1 Harvest operations

Fruit are usually harvested from late winter to early spring. An adult tree may produce up to 60 kg of fruit. Star apple fruit are hand-picked by cutting the stem (Morton, 1987).

19.9.2 Packinghouse practices

The fruit is tray packed in fiberboard boxes of 4.5 kg capacity (McGregor, 1987). Precooling can be done by hydrocooling or forced-air cooling.

19.9.3 Control of ripening and senescence

The fruit does not seem to respond appreciably to treatment with ethylene, propylene or ethephon at 1000 ppm (Pratt and Mendoza, 1980).

19.9.4 Recommended storage and shipping conditions

In order to maintain a good quality, fruit must be kept at 3–6 °C and 90% RH. Under these conditions fruit present a shelf life of three weeks (Morton, 1987; Yahia, 2004), and can benefit further from an adequate modified atmosphere system (Yahia, 1998).

19.10 Processing

Star apple fruit are mainly consumed as fresh, however, sometimes the pulp can be preserved in jellies. The seed kernels may be used to prepare a drink to imitate milk of almonds, nougats and other confectionary products. Frozen pulp of star apple may be used to make ice cream and sherbets (Morton, 1987).

19.11 Conclusions

Star apple is a non climacteric fruit and is considered exotic. It has a very pleasant flavor and nice appearance because of its star shape when cut in half. Elaboration of processed products from star apple fruit is limited and the fruit is mainly consumed as fresh. Although a tropical fruit, star apple fruit are somewhat resistant to chilling injury and therefore low temperatures can be used to extend their postharvest life. Ethylene application has not shown significant effects. Several polyphenolic compounds with antioxidant activities have been found in the fruit which increase the nutritional value.

19.12 References

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