

SAPOTE, SAPODILLA AND STAR APPLE

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Summary

Red (or mamey) sapote, sapodilla, and star apple are common fruits in tropical America and in some other tropical and subtropical areas of the world. Generally, mamey sapote, sometimes referred to as red sapote, is economically more important than sapodilla and star apple, with a notable exception in India, where sapodilla is the most important of these three fruits. There is an unsatisfied and increasing demand for this fruit group, both in internal and international markets; and producing countries in Central America,

the northern tier of South America, the Caribbean islands and several countries in tropical Asia are striving to supply those needs.

Mamey sapote, sapodilla, and star apple are not difficult to grow and so far do not have devastating pests and diseases, though that may change once large orchards become more abundant in traditional and new growing countries. On the other hand, the trees of these three crops are well suited for agroforestry systems, in which they are already used to provide shade to coffee, cacao, and mangosteen. Such intercropped systems reduce the agricultural pressure on the environment and to a large extent preserve the biodiversity of the production locations. While there are general guidelines for the production of these crops, much research is needed to develop more efficient production systems for monoculture and inter-cropped mamey sapote, sapodilla and star apple, and to prolong the post-harvest life of these fruits while preserving their eating quality and keeping up with the demands of traditional and emerging markets.

1. Introduction

Fruits in general are important sources of antioxidants, vitamins and minerals, and usually have industrial and medicinal applications. Mamey sapote, sapodilla and star apple are common and appreciated fruits in most areas of tropical America and to some extent in parts of tropical Asia, but are less common in other parts of the world. The market for fresh fruits, frozen pulp, and oils from these crops has been expanding and, in consequence, the areas under production and/or their productivity is expected to expand as well.

2. Mamey sapote

In most producing countries, mamey sapote is the most important fruit in the Sapotaceae family. This species has been important for centuries in Mexico, Central America and the Greater Antilles. The fruit is a good source of antioxidants, vitamin A and potassium. It is highly regarded and sought after by Mexicans, Central Americans, Cubans and Dominicans, among others. Increasing demand for domestic and export markets since the 1970s has spearheaded interests in a more organized production, improved crop husbandry and post-harvest technology, mainly in order to increase the supply of this unique fruit. Mamey sapote is sometimes also called “red sapote”. The former is the Cuban common name, which has been expanded to the southern US and from there to other places by means of Florida researchers and growers. Mamey sapote is the English version of the Mexican common name *sapote colorado* (literally mamey sapote). ‘Mamey’ is actually a taino word used for a different fruit (*Mammea americana*) and was adopted into the Dominican dialect of the of the Spanish language as synonym of “orange in coloration”. The Cubans seem to be using it in a similar fashion, to depict a red-orange sapote.

2.1. History and Economic Importance

The center of origin of the mamey sapote is the lowlands of tropical America, mainly Mexico and Central America. The tree is a natural component of the Central American and southern Mexican tropical forests. The word "sapote" or “zapote” appears to come

from the generic noun in the Aztec language "tzapotl", meaning round, soft, and sweet fruit with large seeds, and the word "atzapotl cuahuatl" is used to name the mamey sapote in the Nahuatl language of the pre-Columbian Mexicans.

The mamey sapote was utilized and grown by pre-Columbian civilizations in Mexico and Central America for many centuries, for its fruit and to use the seed oil for hair care, and the wood to build furniture and houses. From Mexico and Central America in general it spread to other wet tropical parts of the western hemisphere. There are records from the early years of the conquest of Mexico and Central America by the Spanish in the 16th century, which mention that Spanish soldiers used to eat mamey sapote when they ran out of usual foodstuffs. In 1529, the Spanish conquerors of Nicaragua documented the possibility of extracting good quality oil from mamey sapote seeds as a substitute for the olive oil to which they were accustomed to consuming in Spain.

The Spanish took the tree to The Philippines in the early 16th century, and from there it spread to other tropical areas of Asia, Oceania, and Africa, in particular to Vietnam. Mamey sapote was recorded in Colombia and Ecuador in the 1700s. It has probably been present in the Florida Keys and southern mainland Florida (USA) for several centuries, though it was only officially introduced in Florida in the 1880s.

Nowadays, most of mamey sapote is consumed as fresh fruit in domestic markets. Production of economic importance occurs in Mexico, USA (southern Florida), Cuba, Dominican Republic, Central America, Venezuela, and to a lesser extent in Trinidad-Tobago, Guadalupe, Haiti, Puerto Rico, Brazil, Colombia, and Ecuador. It was introduced in the Canary Islands in the 1990s, and its adaptation to that location indicates it could be grown commercially in Africa as well. There has been an increasing interest in this fruit in Australia, Spain, and Israel, and Vietnam.

2.2. Taxonomy

The mamey sapote (*Pouteria sapota*) is a tree in the Sapotaceae family, which contains approximately 55 genera and some 800 species. In different countries it is also known as *Calocarpum sapota*, *Calocarpum mammosum*, *Lucuma mammosa*, *Achradelpha mammosa*, *Vitellaria mammosa*, and *Sideroxylon sapote*). Other common names of the mamey sapote are marmalade fruit, marmalade plum, sapota mammee, mammee apple, mamey sapote, mamee sapote, and mamee zapote. It is called *chico-mamei*, or *chico-mamey* in Malaysia and The Philippines. In French it is called *sapotier jaune d'oeuf*, *grand sapotillier*, *sapote à crème* and *grosse sapote*.

Names in Spanish vary from one country to another, and include *zapote colorado* in Costa Rica, *zapote mamey* in Mexico, *zapote grande* in El Salvador, *zapote de carne* in Colombia, *mamey*, *mamey sapote* and *mamey colorado* in Cuba (not to be confused with a different fruit called mamey or mamey of Santo Domingo, *Mammea americana*), *zapote* in the Dominican Republic, *guaicume* in Nicaragua, *mamey de la tierra* in Panama, and *mamey sapote* in Puerto Rico (Swenson and Anderberg, 2005).

Other fruit trees of economic importance in the Sapotaceae family are the star apple (*Chrysophyllum cainito*), the abiu (*Pouteria cainito*), the canistel (*P. campechiana*), the

lucmo (*P. lucuma*), the naseberry or sapodilla (*Manilkara achras*), the green sapote (*P. viridis*), and the Australian plum (*Sideroxylon australe*) (Pennington, 1990; Swenson and Anderberg, 2005).

2.3. Plant Description

The mamey sapote is a large and erect tree, frequently reaching 18 m in subtropical regions, sometimes to 30 or 40 m in tropical regions, with a short or tall trunk that may reach 1 meter in diameter. The crown is large, with relatively few branches with a horizontal or drooping habit, spreading or compact depending on the variety (Fig. 1).



Figure 1. Mamey sapote tree.

Flowers – The mamey sapote flowers appear in groups of 6 to 12 in the leaf axils near the tips of the branches, and are abundant, bell-shaped, whitish, small, and have both male and female parts. The trees may flower throughout the year, but usually most commercial varieties produce most of their fruits within a few months of the year, which depends on the variety, mostly between May and September in the northern hemisphere. Although solitary trees may produce fruits, the flowers are generally cross-pollinated, and the rate of cross-pollination is as high as 100% in trees in the wild, and as much as 70% in trees in monoculture in intensively managed orchards (Azurdia, 2006).

Fruits – The fruit is a berry with a thick, leathery, hard, brown, scurfy peel. It may be round, ovoid, or elliptic, which in most varieties is 7 to 25 cm long, and ranges in weight from 225 to 2700 g. The flower calyx is retained at the fruit base. In mature fruits, the pulp comprises about 70 to 80% of the fruit. The pulp has a low fiber content and is sweet and soft, with a color varying from pinkish, or orange to reddish (Fig. 2).



Figure 2. Mamey sapote fruit.

Component	Unit	Approximate amount
Water	Grams	62.0
Food energy	Kilocalories	134.0
Carbohydrates	Grams	34.0
Protein	Grams	1.0
Dietary fiber	Grams	2.2
Fat	Grams	0.6
Potassium	Milligrams	344.0
Magnesium	Milligrams	30.0
Calcium	Milligrams	74.6
Phosphorus	Milligrams	28.00
Sodium	Milligrams	10.0
Iron	Milligrams	1.6
Ascorbic acid	Milligrams	20.0
Vitamin A	International units	410.0

Table 1. Concentration of selected nutrients in 100 grams of fresh pulp of mamey sapote.

(Sources: USDA Agricultural Research Service, 2005; USDA Nutrient Database for Standard Reference, Release 18; Nutrient Data Laboratory Home Page, <http://www.nal.usda.gov/fnic/foodcomp>; and Morton, J. *Fruits of Warm Climates*; <http://www.hort.purdue.edu/newcrop/morton/index.html>).

The pulp is considered as a good source of vitamin A and potassium (Table 1), and contains the amino acids tryptophan (19 mg per 100 g), methionine (12 mg per 100 g) and lysine (90 mg per 100 g). Fruits reach harvesting maturity 10 to 24 months after flowering, depending on the cultivar and environmental conditions. Generally, the fruits in the lower part of the branch have a lower abortion rate than those closer to the apex of the branch.

The fruits of most varieties contain 1 to 4 large, hard, glossy, brown or black, pointed seeds. Usually one seed weighs between 15 and 60 g. The kernel is bitter, smelling of almond, and oily. In over mature fruits, the seeds may sprout inside the fruit.

Leaves - The leaves are simple with petioles 2 to 5 cm long, a large blade (about 10 to 30 cm long and 4 to 10 cm wide), oblanceolate and pointed at both ends, and clustered around the ends of the branches. Young leaves have hairy, light green or brownish undersides, with upper sides light green or pink; mature leaves are not hairy, and turn dark green. The leaves may fall in late winter or in spring, prior to the new foliar flush. The plant contains the characteristic latex of the Sapotaceae.

2.4. Breeding and Varieties

In mamey sapotes grown from non-grafted seedling, there is a wide genetic variation for fruit size, shape, pulp color and general quality, as well as tree size and shape. Most of that variation is said to be yet unexplored, but collections of superior trees are kept in Mexico (National System for Plant Germplasm of Mexico and the Conkal Technological Institute of Yucatan), Central America, the Caribbean and South America. Such variation has allowed for a selection of exceptional trees multiplied as clones, varieties or cultivars, mainly in Central America, Mexico, the Caribbean islands, Venezuela, and Florida (USA) (Campbell *et al.*, 2006; Cituk, 2009).

The common method of production in Mexico is still in small orchards, or the harvest is even from wild trees. Local people simply distinguish the (highly variable) fruit quality among natural or planted trees. Grafting is generally employed in small plantations. The fruits of *Pouteria sapota* and *Manilkara sapota* are sold in street markets as well as in super markets. Besides, there are collections of superior trees with selected propagation material, mainly focusing on export markets.

In Central America and Mexico, some of the varieties grown are ‘Magaña I’, ‘Magaña II’ ‘Rivera’, ‘Cáceres’, ‘Valiente’, ‘Velado’, ‘Tazumal’, ‘Datil’, and ‘Cuban 1’. In the Dominican Republic, the two leading varieties are ‘Key West’ and ‘Magaña’, and other imported varieties have been tried, but did not well adapt to the environment or the market needs of the local fruit industry. In Puerto Rico, tested varieties include ‘Magaña’, ‘Mayapan’, ‘Pantin’, ‘Tazumal’, ‘Pace’, and ‘Copan’, and superior trees with dark-red pulp have been selected from the western area of the island.

In Florida (USA), the varieties ‘Pantin’ and ‘Magaña’ made up nearly 98% of all the commercial trees in 2008. ‘Pantin’ or ‘Key West’ is a variety from Florida, with tall trees of medium yield, harvest in July-August, and ovoid fruits 400 to 1100 g with pink-reddish and fibreless pulp. ‘Magaña’ is a variety from El Salvador, with small trees that

grow slowly but may produce fruit one year after planting. ‘Magaña’ has large elliptic fruits (740 to 2400 g) of pink pulp with excellent eating quality, that take about one year to mature and usually harvests in April-May in Florida (Balerdi *et al.*, 2008).

Selection and breeding of mamey sapote varieties should focus on trees that are precocious, produce high yields, medium size or large fruits of homogenous shape, superior pulp quality, small number of seeds, low tendency to seeds germinating inside the fruit, harvesting season in months when there is little output with current varieties, compact tree habit, higher tolerance to pests and diseases, and good keeping in storage and transit.

2.5. Ecology and Growing Conditions

Ideal locations for commercial mamey sapote production have good soil drainage, high temperatures, high relative humidity, and high solar light intensity. The crop grows well in tropical regions at altitudes up to 600 m; it is rarely found at locations above 1000 meters altitude, as in this environment the tree grows small and slowly, fruits take much longer to mature and fruit quality is lower.

The mamey sapote tree grows and produces well in a warm temperature, preferably above 27° C. Young trees suffer cold temperatures more than adult trees; the latter survive with minor damage at -2° C for several hours.

The tree grows best with an annual and well distributed rainfall of about 1500 to 2000 mm. It does not support long droughts, which result in leaves falling, growth retardation, and reduced fruit yield. Relative air humidity should by preference be above 70% for good growth.

The species prefers constantly high access to water, without being flooded. The trees really speed up growth when planted near streams or water bodies. Interestingly, the nàhuatl common name “atzapotl cuahuatl” means literally “water sapote fruit tree”).

This crop has a wide range of adaptation to soils, including clayey, calcareous or sandy soils, with high or low natural fertility, and good drainage. Soils with less than 2 meters of permeable soil or with a high water table are not recommended for long-lasting orchards. Roots subjected to low oxygen conditions become weak and susceptible to soil-borne pathogens. Usually, the mamey sapote grows and yields best in deep clayey or loamy soils with good internal drainage and pH values of 5.5 to 6.5.

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Biographical Sketches

Bryan R. Brunner studied plant science at Rutgers University, New Jersey (1985), and completed a master's degree in tropical agriculture in the Department of Agronomy and Soils at the University of Puerto Rico, Mayagüez (1989). He holds a Ph.D. in plant breeding and genetics from Michigan State University (1992). He taught graduate plant breeding and was Head of the Horticulture Department at the University of Puerto Rico, Mayagüez (1999-2003).

Dr. Brunner currently works as a horticultural researcher at the Agricultural Experiment Station of the University of Puerto Rico in Lajas. His research interests include germplasm management of tropical and subtropical fruits, and organic agriculture. He has advised numerous graduate and undergraduate student research projects, and authored or co-authored more than 50 scientific publications and three books in the areas of tropical fruits, ornamentals and organic agriculture.

J. Pablo Morales-Payan is currently professor and the University of Puerto Rico, Mayagüez. He obtained a M.Sc. in Horticulture in Rutgers University (1989) and a Ph.D. in Horticultural Sciences (weed science and plant pathology) at the University of Florida-Gainesville (1999). His current research and

teaching is focused on the use of exogenous substances for physiological regulation; on practices for sustainable/organic production systems for horticultural crops with emphasis in weeds and pests; and on disease ecology and management. He has led many research projects and has served as thesis chairman of numerous graduate and undergraduate plant science students in several academic institutions in the Dominican Republic and in Puerto Rico.

Dr. Morales has been National Director of the Agricultural Research Department of the Dominican Republic, Chair of the Agronomy Department at UNPHU, President of the Dominican Society of Agriculture and Forestry Researchers (SODIAF), and President of the Caribbean Division of the American Phytopathological Society. He also served as Research Director of the Dominican Team with the Network for Vegetable Research and Development of Central America, Panama, and the Dominican Republic (REDCAHOR). In 2007 he received the 'Eugenio de Jesus Marciano' award, the highest distinction bestowed by SODIAF, for his contributions to research and education in agricultural sciences.