Forest products, livelihoods and conservation

Case Studies of Non-timber Forest Product Systems

VOLUME 3 - LATIN AMERICA

Editors
Miguel N. Alexiades and Patricia Shanley

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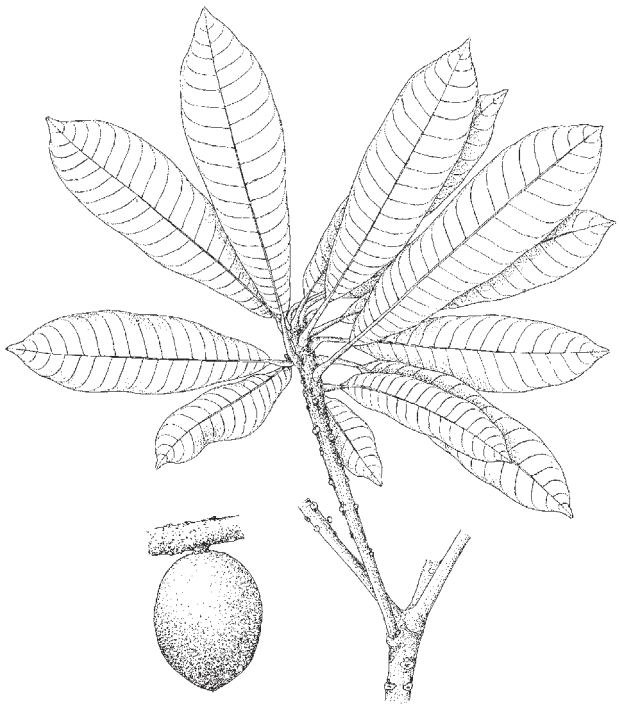
Chapter 3

Mamey Zapote [*Pouteria sapota* (Jacq.) H.E. Moore & Stearn], A Mexican Forest Fruit of High Commercial Value

Yolanda Nava-Cruz and Martín Ricker[1]



(Pouteria sapota)

Common name	Product part used	Dominant form of management	Degree of transformation	Commercial scale	Geographic distribution
Mamey, Zapote mamey	Fruit	Wild	Low	National	Wide

ABSTRACT

Pouteria sapota (Jacq.) H.E. Moore & Stearn (Sapotaceae), commonly known as 'sapote mamey' or simply as 'mamey', is native to tropical Meso-America, ranging from southern Mexico to Nicaragua. Its fruits are harvested from adult trees, growing in humid rain forest, family gardens, forest fragments, or occasional remnant trees in pasture or fallow land. Fruits are sold throughout central and southern Mexico, including the supermarkets of Mexico City. This species is also grown in Guatemala, South America, Cuba, USA (Florida), the Philippines, and Indonesia. Currently, the Mexican fruits are not exported. In this chapter, we analyse mamey production in an area of 50 km^2, with about 1850 people living in two communities situated in the Municipality of San Andrés Tuxtla (919 km^2) on the eastern coast of Mexico. We estimate that this 50 km^2 area produces about 25 tons of commercial mamey per year, about 0.6% of the 4024 tons produced in the entire country. Our study highlights (1) the under-utilization of this native forest species within the municipality of San Andrés Tuxtla, and (2) the possibility of producing high-quality fruits within a semi-natural forest system.

INTRODUCTION

Pouteria sapota (Jacq.) H.E. Moore & Stearn (Sapotaceae) is a rain forest tree with fruits the size of avocados. Its common name 'sapote mamey' is probably derived from the indigenous Nahuatl language (*çapotl /tzapotl* = 'fruit with bone'; *mama* = 'hands', probably an allusion to the spirally arranged leaves) (Siméon 2002). The pulp has a characteristic salmon red colour, known as 'mamey colour', and is highly valued for its typically sweet flavour. The fruit also contains high levels of proteins and amino acids, including aspartic and glutamic acids (Hall *et al.* 1980). The pulp is eaten directly from the fruit.

In Mexico, the mamey has been exploited and consumed for centuries. Its ancient use is indicated by the existence of many different indigenous names: Pennington & Sarukhán (1998), for example, list 20 names in 11 indigenous languages of Mexico. In the pre-Columbian accounts of New Spain, mamey was described as a fruit tree, from whose seeds oil was extracted to make the hair shiny, and to polish *jícaras* (gourds used to store liquids) and wood (Hernández 1943, Acuña 1984).

Today, people in Mexico and other countries use mamey to prepare drinks and desserts such as jellies, ice cream, and cakes. Seeds are used by the cosmetics industry to extract oils (Takeda *et al.* 1997). As mentioned above, it is still used locally in Mexico to make hair shinier. In Trinidad and Tobago, seed extract is used to control ectoparasites in dogs (Cheryl *et al.* 2000). The wood is used in construction (Pennington 1990), although in commercial terms, the species in Los Tuxtlas is classified as a 'common tropical wood', and so its price, unlike precious woods, is low.

The *Pouteria* genus contains other species with edible fruits, also valued for their taste and locally or regionally commercialized. Examples in the Amazon include *P. caimito* (Ruíz & Pavon) Radlk., *P. macrocarpa* (Huber) Baehni, *P. macrophylla* (Lam.) Eyma, *P. pariry* (Ducke) Baehni, *P. speciosa*

(Ducke) Baehni, and *P. ucuqui* Pires & Schultes (Pennington 1990, Cavalcante 1996).

An analysis of the *P. sapota* production system is of interest because this species represents a tree from primary rain forest, with edible fruits that are sold as a luxury product (that is, they are relatively expensive) in the supermarkets of Mexico City. Mexico has an estimated annual trade of more than 4000 tons (INEGI 1999), which corresponds to an annual total value of US$2,892,000 to the consumer in Mexico City.[2] Based on our estimates at Los Tuxtlas, this involves about 1,600 small producers, each with an annual average production of 2.4 tons.

In this chapter, we review the literature on *P. sapota*, and report research, from over 10 years on this species in the Los Tuxtlas region, where a research station of the Universidad Nacional Autónoma de Mexico (UNAM) is situated. We also include data from interviews conducted in the year 2000 with two mamey traders (*mameyeros*), who collected fruits from an area of 50 km^2 in the region. Furthermore, we interviewed authorities of the Municipality of San Andrés Tuxtla. We must point out that the mamey trade in this region is small and informal. No organizations exist, nor are statistical data available. Moreover, the few people involved are not always receptive to being interviewed.

Characteristics of the study site

Our study focused on an area of about 50 km^2, belonging to the Municipality of San Andrés Tuxtla, of 919 km^2 in the region of Los Tuxtlas, in the state of Veracruz (Figure 1). Los Tuxtlas is a volcanic region, extending over about 80 km by 40 km, with an altitude ranging between 0 and 1680 meters above sea level. Temperatures and annual rainfall average 24°C and 4000 mm, respectively. The soil is an Andosol and the climate is humid, with a dry season from March to May, and a rainy season from November to February (Álvarez del Castillo 1997, Martínez Del Pozzo 1997, Soto & Gama 1997).

The low altitude vegetation has been described as 'evergreen high forest' ("selva alta perennifolia" in Miranda & Hernández 1963), 'evergreen tropical forest' (Rzedowski 1986), 'tropical moist forest' (Holdridge 1967), and 'tropical rain forest' (Richards *et al*. 1996). Deforestation in the region has been severe, with most of the forest having been converted to grazing land. Eighty-four percent of the original forest cover, in an area of 850 km^2, was lost between 1967 and 1976 (Dirzo & García 1992). A list of currently or potentially commercially valuable non-medicinal plants in UNAM's 644-hectare reserve is provided in Ibarra-Manríquez *et al*. (1997). An inventory of the medicinal plants in the reserve was carried out by Mendoza-Márquez (2000).

Characteristics of the study and methodology

Our data is derived from the testimonies of two mamey collectors (*mameyeros*), operating in the municipality of San Andrés Tuxtla: Donato Quino from Xoteapan, a town of 1703 people (INEGI 2000), and Gregorio

Figure 1. Area targeted by the study on the mamey trade in southern Mexico

Sources: ESRI (Environmental Systems Research Institute, Inc.). Data and maps. 2002. Map prepared by Alejandro Flamenco (Institute of Ecology, Universidad Nacional Autónoma de México [UNAM]) with data from the Institute of Geography (UNAM), the Geographic and Statistics Information Laboratory at El Colegio de la Frontera Sur (ECOSUR), and the Instituto Nacional de Estadística, Geografía e Informática (INEGI).

González from Colonia Lázaro Cárdenas, a town of 145 people. We chose to work with these two people because they operate in two different areas of the municipality and because interviews indicated that they were the most active and best informed of the local mamey collectors. Unlike the other *mameyeros* interviewed, during the harvest season both these *mameyeros* dedicate themselves exclusively to harvesting, collecting, and selling these fruits in the local market. Donato Quino collects fruits mostly from trees in family gardens, whereas Gregorio González collects primarily from trees in areas of remnant primary and secondary forests, as well as remaining trees in grazing lands.

Donato Quino's area of influence includes the communities of Cerro Amarillo de Arriba, Cerro Amarillo de Abajo, Colonia Buena Vista, El Polvorín, La Ceiba, and margins of the city of San Andrés Tuxtla. Gregorio González operates in the environs of the communities of Colonia Lázaro Cárdenas, La Perla, Laguna Escondida, Ruíz Cortinez, and near Balzapote. The area of collection of the *mameyeros* comprises about 25 km^2 each (Figure 1).

THE PRODUCTION-TO-CONSUMPTION SYSTEM

Biology of the species

Pouteria sapota[3] is a tree that can grow to 40 m, with a trunk diameter measuring up to 1.5 m at breast height, although more typically trees reach 20 m with a 0.5-m diameter (Azurdia & Ortiz, in press). The trunk is straight and may be buttressed. The wood has a pinkish-to-greyish coffee colour, and is hard and heavy, with a specific gravity of 0.83 (Barajas-Morales *et al.* 1997).

The simple leaves are spirally arranged and the solitary flowers, greenish-cream in colour, cluster in the leaf axillae. The fruits, reddish brown with a rough texture, measure up to 20 cm long, are ovoid, and hang from new branches. The mesocarp is sweet, fleshy, orange to red, and with small quantities of latex when immature. The fruit usually contains one, occasionally two, and rarely three seeds, which can be as long as 10 cm (Pennington & Sarukhán 1998).

In the Los Tuxtlas region, flowering begins in July. Fruits take more than a year to develop. Hence, in any one harvest, which takes place between May and July, small fruits already exist that will reach maturity in the following harvest (Davenport & O'Neal 2000, Ricker 2000, 2001). Some individual trees do not follow the general pattern, with some fruiting shortly before or after the usual harvest time, stretching the harvest time from April to September. The reproductive period of a mamey trees normally begins after 10 to 20 years, depending on individual growth rate. Life expectancy is at least 100 and possibly over 200 years.

The species is introduced in Florida, where growers- unlike in Mexico- distinguish between different varieties (Morton 1987, Balerdi 1991, Campbell *et al.* 1998). Ibarra-Manríquez (1985) reports that the flowers are monoclinous, that is, they possess masculine and feminine organs. In contrast, Pennington (1990) reports that the flowers are unisexual (i.e., dioecious plant) or bisexual.

Photo 1. A mamey collector or *mameyero* transports harvested fruits to San Andrés Tuxtla, using a dirt road (photo: M. Ricker)

In Los Tuxtlas, male and female trees of *P. sapota* are not distinguished.

No studies have been published on pollinators for *P. sapota*, although flowers in the *Pouteria* genus are reported to be pollinated by bees or other insects (Pennington 1990, Ortiz & Cabello 1991, Knight *et al.* 1993). Possible predators and dispersors of fruits and seeds include the rodent agouti or *tepezcuintle* (*Agouti paca nelsoni*) and other larger mammals such as the kinkajou or *martucha* (*Potos flavus prehensilis*) (Martínez-Gallardo & Sánchez-Cordero 1997, Brewer & Rejmanek 1999).

A study of two populations of *P. sapota* in Guatemala showed that, typical of a preferentially allogamous species, genetic diversity is greater within, rather than between, populations . The authors of the study found that both young and mature plants show higher heterozygosity[1] than expected, suggesting the presence of a selection pressure for this state (Azurdia *et al.* 1999). This highlights the need to conserve the greatest possible genetic diversity, as well as selecting and cultivating the best commercial varieties.

Distribution and ecology

P. sapota is naturalized in many regions, making its original distribution uncertain. It is probably native to Meso-America, with a distribution ranging from southern Mexico to Guatemala, Belize, and northern Honduras, and spreading into the Atlantic forest of Nicaragua. In Costa Rica and Panama, it is naturally replaced by *P. viridis* (Pittier) Cronquist ("green sapote") and *P. fossicola* Cronquist, which also possess valued edible fruits (Pennington 1990). In Mexico, natural populations grow in the States of Oaxaca, Puebla,

Figure 2. Collections of herbarium examples of mamey (*Pouteria sapota*) in Mexico

The map was based on a revised version from the Herbario Nacional MEXU (Institute of Biology of the Universidad Nacional Autónoma de México [UNAM], Mexico City). Data were compiled by Lydia Ramírez Martínez (Institute of Biology, UNAM). The map was prepared by Gabriela Guerrero (Institute of Ecology, UNAM).

Guerrero, Veracruz, and San Luis Potosí (Figure 2). In addition, *P. sapota* is found in gardens in practically all the southern states of Mexico (Pohlan *et al.* 2000, González 2001).

Internationally, *P. sapota* is cultivated from Florida (USA) to Brazil and in the Caribbean (Cuba), between altitudes of 0 and 600 masl (Campbell & Lara 1982, Morton 1987, Hoyos 1989, Campbell 1994, Granados & Campbell 1994, Azurdia *et al.* 1995, Cruz & Deras 2000, Jaimez & Franco 2000). The species has also been introduced to the Philippines and later to Indonesia, Malaysia, and Vietnam (Oyen 1991), as well as India (Singh *et al.* 1997). According to Oyen (1991), the tree can survive light frosts. Low temperatures and dryness cause leaves to change colour to yellow and red, and eventually fall. We have observed the slow growth of a potted eight-year old mamey seedling in Mexico City (2400 masl), where in December temperatures to almost 0°C. In Los Tuxtlas, *P. sapota* is naturally found in evergreen high forest, over volcanic soil. In Guatemala and Belize, the species inhabits sub-perennial forest growing in calcareous soils (Pennington 1990). Morton (1987) suggests that *P. sapota* tolerates a range of soils but grows best in heavy, clay soils.

Peña-Ramírez (2002) found that seedlings are very sensitive to acidity and salinity, with a pH of less than 5.5 and salinity (conductivity) greater than 0.7 mS/cm will cause seedling death. Applying fertilizer in the field can increase mortality by increasing salinity around the roots, thus drying the seedlings by retaining water in the soil (Li *et al.* 2000, Martínez-Bravo 2001). In natural forest, the species is scarce, with 0.25 to 1 adult trees per hectare, and a reproduction rate of 7.8 new individuals per year and hectare (Miguel Martínez-Ramos 2002, personal communication).

Management and cultivation

In the study area, *P. sapota* fruits are primarily harvested in extraction systems, from trees in gardens, fragments of primary forest, and remaining trees in grazing lands. In addition, people also plant and graft trees in their gardens. The preference for cultivation probably helps reduce the the risk of over-harvesting wild populations (Peters 1996), even though it may entail a loss in genetic diversity. Home gardens with mamey trees have on the average 1 to 3 productive trees, whereas in primary forest fragments, secondary forests, and grazing lands, trees average less than 1 per hectare.

Fruit maturation in the tree is asynchronic, meaning that the same tree can be harvested again after some weeks (Heredia *et al.* 1998). To bring together a harvest of 1 ton of fruit and take it to the local market, a *mameyero* must harvest between 3 and 5 trees, covering an average distance of about 30 km.

The production system for mamey in Los Tuxtlas differs from that of other localities. For example, in the Sierra Norte de Puebla, in addition to collecting mamey in home gardens, pastures and forest, it is also grown in association with coffee, by farmers who are organized in cooperatives. In this region, each family has between 1 and 75 trees- with an average of 9; a higher number than in the Municipality of San Andrés Tuxtla. Furthermore, farmers also sell their mamey harvests in the States of Hidalgo, Tlaxcala, Puebla, and Mexico, as well as in Mexico City itself (Miguel-Ángel Martínez-Alfaro 2001, personal communication).

The species can be cultivated in the shade, in groves, or in the sun, in grasslands. When cultivated, a distance of 8 to 12 m between each tree is recommended (Morton 1987, Oyen 1991). As part of a forest enrichment planting experiment in the Los Tuxtlas forest, Ricker *et al*. (2000) planted seedlings under different degrees of canopy opening, and found the optimal opening to be 60% for seedlings in their first two years. This level of canopy cover ensures that seedlings are protected from drought by the surrounding vegetation. During the first years of cultivation, cleaning and thinning are recommended to prevent competition with other plants (Meyer & Motohashi 1989).

Ricker *et al*. (1999a) projected the survival curve for *P. sapota* in Los Tuxtlas, estimating a 56% survival rate after 20 years, though mortality rates vary according to the type of management. We deduced from our field observations that *P. sapota* grows better and is more productive when planted close to bodies of water. In some cases furrows are used to ensure

Photo 2. Fruits of mamey (*Pouteria sapota*) for sale in San Andrés Tuxtla, Mexico (photo: M. Ricker)

the soil remains moist. Initial seedling growth also depends on seed size, as larger seeds contain more nutrients (Ricker *et al.* 2000).

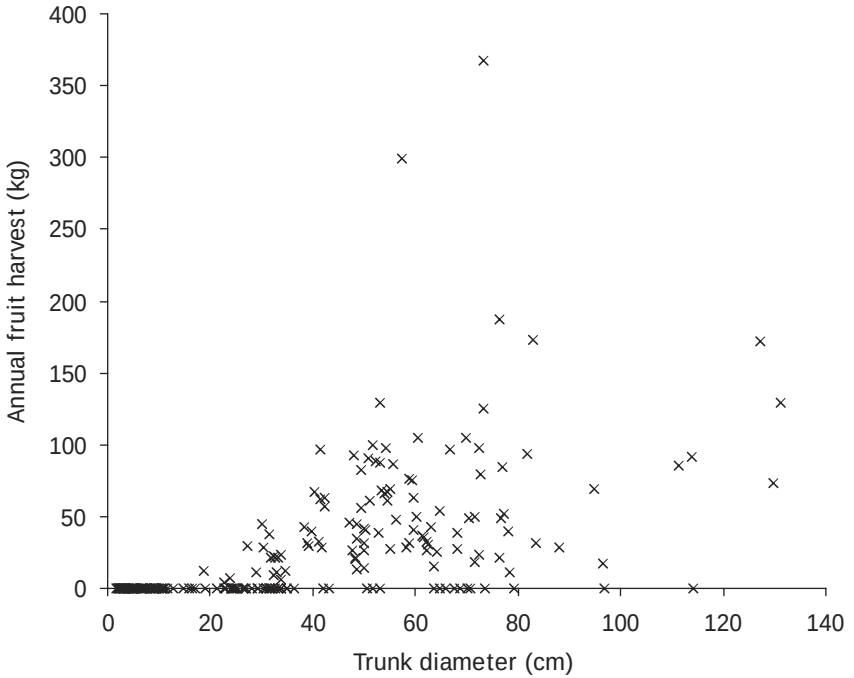
Diseases and pests do not pose a major problem for *P. sapota*. The main pest is probably the fruit fly *Anastrepha* spp. (Diptera: Tephritidae), whose larvae develop in the fruit pulp, discouraging potential customers (Knight *et al.* 1985, Hernández & Pérez 1993, Gould & Hallman 2001). Other pests are mentioned by McMillan (1990), Oyen (1991), Pérez-Morales *et al*. (1997), and Vázquez *et al*. (1999). To control the genetic quality of fruits in plantations, grafting is commonly practised, using branches from trees of known quality (Kulwal *et al.* 1985, Buisson 1986).

Production levels

The annual trade of mamey in Mexico is estimated at 4024 tons (INEGI 1999). The average annual production over the last 5 years in the Municipality of San Andrés Tuxtla is estimated at 24 to 25 tons (SNIIM 2002), or 0.6% of the national reported commercial production. These figures are rough estimates only, given that most of the trade is informal.

In a three-year study, Ricker (1998) estimated that the annual fruit production of 100 trees with a median trunk diameter of 43 cm averaged 43.6 kg, 29.3 kg, and 28.2 kg per tree, for 1995, 1996 and 1997, respectively. However, the variation between years and between trees even though of the same size is large (Figure 3). Possible factors contributing to this variation may include, for example, differences in weather conditions and the presence of pollinators between sites and years, variation in the availability of nutrients between trees, and inter annual periods of rest in fruit production of individual trees.

Figure 3. Annual harvest of the arboreal fruit mamey (*Pouteria sapota*) in relation to trunk diameter.



Wide fluctuations in production between trees and between years were found among 79 trees harvested over 3 years (1995, 1996, and 1997). The trees were located in an area of about 225 hectares (1.5 × 1.5 km) surrounding the 'Los Tuxtlas' Tropical Biology Station. A tree with a 130-cm diameter was estimated as being 189 years old (Ricker *et al*. 1999b, Ricker 2000).

In a study measuring 182 fruits from 6 *P. sapota* trees in Los Tuxtlas, Ricker (1998) found the average fruit weight to vary from 273 g in the trees with the smallest fruits to 527 g in trees with the largest fruits. These figures correspond to those reported in three sites in Guatemala (Leiva *et al.* 2002). Azurdia & Ortiz (in press) report a range of fruit weight between 85 and 1434 g, also in Guatemala. According to Morton (1987), the fruits of cultivated *P. sapota* trees in Florida weigh 0.2 to 2.3 kg- very much above the average observed in wild and semi-wild trees of Los Tuxtlas. It should be pointed out, however, that in terms of their marketing, maximum-sized fruits are often not desirable. In Mexico, for example, consumers tend to prefer medium-sized fruits because there is always a risk that a fruit may be past its peak quality, or not particularly palatable. Buying a larger, and more expensive fruit, is therefore riskier than buying a smaller fruit. This in turn is related to the fruit's perishable nature: fruits have a shelf life of 10 days and are best when consumed after three days. An estimate of mamey production levels in the 50-km^2 study area (5.4% of the municipality's 919 km^2) can be made

on the basis that one third of the study area has forests with mamey trees occuring at a density of 0.5 trees per hectare. Since each tree produces on average 30 kg of mamey per year (Ricker *et al.* 1999b, Ricker 2000), then the area produces on average about 24.75 tons of mamey per year. In other words, 5.4% of the municipality's area can potentially produce and sell a larger quantity than is currently reported for the entire area. This in turn suggests that there are no precise figures on the volumes of harvested mameys or the numbers of active *mameyeros* in the municipality. Accordingly, we cannot specify trends in extraction activities or current trade of mamey fruits in the area, although demand appears to have remained relatively stable over the last 10 years.

The socio-economic context of the *mameyeros*

The natural vegetation of Los Tuxtlas once included broad extensions of high evergreen forest. The known human settlements occupying the region 500 to 1500 years ago belonged to the Olmeca culture, famous for its large stone figures of human heads (Medel 1963, Bernal 1968). Pre- and post-conquest groups, the descendants of whom are restricted to localities such as Xoteapan and Santa Rosa Loma Larga in southern Tuxtleca region, are Popolucas and Mexicas (Andrle 1964).

Most people in the region's rural towns—Catemaco, San Andrés Tuxtla, and Santiago Tuxtla—trade in agriculture and livestock (INEGI 2000). The following information on the municipality of San Andrés Tuxtla comes from INEGI (2000): The municipal capital is the city of San Andrés Tuxtla, with about 50,000 inhabitants. As a whole, the municipality includes 150 villages, covering an area of 919 km^2, with a total population of 142,000, and an average of 4.6 people per family.The minimum wage in the region is US$4 per 8-hour working day. The average annual household income in the municipality is $1560, which is below the national annual average of $1782. Most land (67%) is communally owned in *ejidales*, with the remaining land being privately owned (32.3%), or federal (0.7%). The value of non-urban land, with or without forest (with a prohibition to fell) and not at the beach, fluctuates between $650 and $2200 per hectare. Land rental costs range between $30 and $100 per hectare and year.

The main economic activity in the region is extensive livestock production, mostly for beef, and to a lesser extent for dairy products. In recent decades, a series of commercial monocrops have been introduced, the most important being tobacco, for both national and international markets. Other important cash crops are coffee and sugar cane. In addition, rural communities, continue practising subsistence agriculture, growing maize and beans (Barrera-Bassols *et al.* 1993).

The household economy of mamey producers

Mamey production in Los Tuxtlas is low compared to other fruit crops, such as orange, mango, or papaya. Mamey provides an additional source of income- between 20% and 30% of the annual family income- to both tree owners and

fruit collectors in the region, partly because fruit production lasts only about 4 months. *Mameyeros* complement their household economy with the harvest of other fruits, such as orange, mango, and papaya. They also harvest a fruit related to *P. sapota*, the "marmalade tree" or *chicozapote* (*Manilkara zapota* (L.) van Royen, Sapotaceae). In addition, they occasionally sell their labour as masons or day labourers, or barter with their neighbours to obtain other products. Overall, only about 60% of the *mameyero* household economy is in cash, and linked to the market economy.

Women are minimally involved in harvesting mamey, perhaps because of the strenuous physical demands of climbing trees, and cutting and transporting the fruits. The children of *mameyeros* also do not seem to participate in fruit harvesting. Thus, in most cases only the father carries out the work, assisted by day labourers who are paid wages according to the time, type of work, or tasks assigned. According to our interviews, *mameyeros* have to perform the following tasks:

1. Locate productive trees with an adequate number of harvestable fruits, often covering 10 to 20 km between sites;
2. Negotiate the price with the trees' owners;
3. Climb the trees, and cut and collect the fruits in such a way that they are not damaged by falling and striking the ground;
4. Collect the fruits into sacks for transport to the closest roads, travelling between 2 and 5 km, either on foot or using draught animals, such ashorses, mules, or donkeys; and,
5. Leave the fruit to mature in the house to subsequently transport them to either the local market or to the intermediary, usually travelling1 to 3 hours in a pick-up truck.

Processing mamey

The fruits are always cut when they are immature. In the wild, they also fall from the tree while still immature, and ripen on the ground. When they are collected, they take several days to mature in a warm environment. Once mature and smooth, they maintain their quality for consumption only for a few days.

In the Los Tuxtlas region, mamey is not processed commercially, except by a few people who prepare, in small quantities, ice-cream or iced popsicles (*paletas de hielo*) from the pulp. Natives of the area also pound the seed to extract oil, which is used to add shine to their hair.

Some commercial processing occurs at a national level, such as the use of the seed oil in cosmetics, and the sporadic sale of mamey-flavoured yoghurt, cakes, and jellies in supermarkets. The scale of production, processing, and marketing of mamey fruits and seeds in other countries such as Guatemala (Azurdia & Ortiz, in press) illustrates the high commercial potential of this species.

Commercialization and marketing

The two *mameyeros* interviewed sell their harvest to local and foreign

merchants. The most common trade path is from the owners of the tree to the mamey collectors, who then sell the fruits to merchants in the marketplace in Catemaco, San Andrés Tuxtla, and Santiago Tuxtla, the main market towns

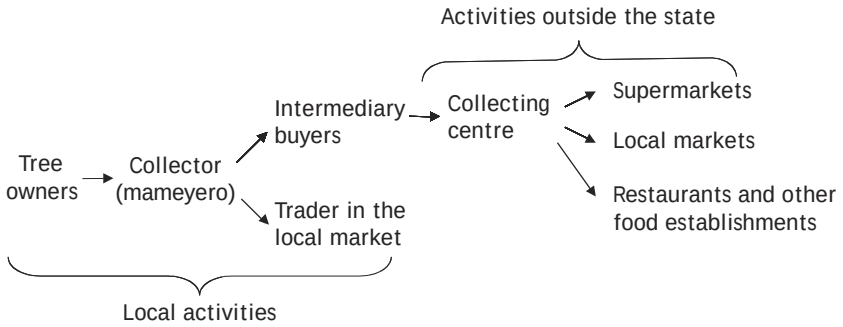
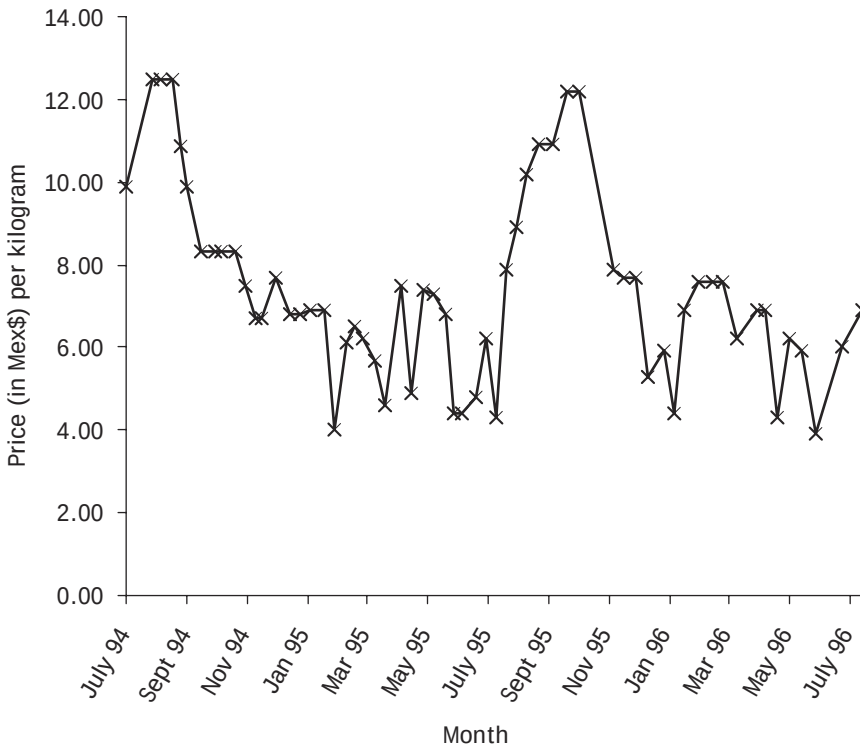


Figure 4. Price trends per kilogram of mamey sapote fruits (*Pouteria sapota*) in a supermarket in Mexico City



Data received from the supermarket 'Gigante', corner of Calle Eugenia and Calle Gabriel-Mancera, Mexico City. This supermarket sells mamey throughout the year, although the fruit comes from different states of Mexico and even from Guatemala, depending on the season. The exchange rate rose between 1994 and 1999 from about 4 Mexican pesos per U.S. dollar to 10 pesos to the dollar.

in each of three neighbouring municipalities. These merchants sell the fruits directly to the final consumer.

A second trade pathway involves wholesale intermediaries, who usually take the produce to the *Central de Abastos*, the main food wholesale market in Mexico City. From here, the mamey is distributed to large supermarkets, restaurants and local merchants, and sometimes directly to the final consumer. The following diagram shows the two marketing chains.

Figure 4 shows the supply of mamey over a two-year period in a supermarket of Mexico City. Clearly, it is not a sporadic product, as fruits harvested from different parts of Mexico with different harvest seasons are sold year-round. Its high price, compared to fruits such as strawberries and grapes, also suggests it is not considered an 'inferior' product. In contrast, the prices in Los Tuxlas are considerably lower, and the fruit is only available during the harvesting season.

Political and institutional aspects

To date, there have been no policies or programs encouraging the production of mamey or the organization of its collectors. For some decades now, local and regional policies have been directed to promote livestock and, in the case of the area surrounding the city of San Andrés Tuxtla, tobacco. No governmental institution has considered promoting mamey production as part of its rural development plans. The lack of incentives, programs to promote cultivation, and the lack of a legal framework that adjusts to the needs of mamey commercialization have all served as constraints to the development of mamey productionin the region. The lack of an organization of producers has limited the opportunities of designing a comprehensive strategy that serves to improve cultivation of the species and establish the distribution channels to allow them to capture a greater part of the product's final price.

CONCLUSIONS

Ricker *et al*. (1999b) and Ricker (2000) emphasize that forest enrichment in Los Tuxtlas with *P. sapota* seedlings would generate commercial gains of enough significance as to compete with livestock-raising, a land use which currently prevails in the area. The study concludes that forest enrichment with mamey can provide an economically viable alternative to livestock production or other forest-destroying forms of land use. The forest fragments that remain, currently threatened by the expansion of livestock-raising, are suitable sites for such enrichment plantings. This would also provide an incentive to land owners to protect what remains of the original forest.The mamey production system in Los Tuxlas region would also benefit from programs that strengthen the levels of available infrastructure and technical know-how. Programs are needed to help establish high-quality cultivation systems based on genotype selection and management regimes that favour growth rates. For example, mamey trees seem to grow faster when being close to water bodies. It is also necessary to improve the level of organization among producers, improving marketing skills and increasing the efficiency of mamey distribution and

trade. This in turn requires increasing production, improving distribution, lowering costs, and decreasing the number of intermediaries involved in the trade chain. One option for increasing the final value of mamey is promoting a higher degree of transformation, which in turn requires of investment, training and an entrepreneurial economic and political environment. Finally, activities directed at commercialization should be complemented by a program to conserve the rich natural diversity of this species in the Sierra de Los Tuxlas.

NOTES

1. Estación de Biología Tropical "Los Tuxlas", Universidad Nacional Autónoma de México, Apartado Postal 94, San Andrés Tuxtla, Veracruz 95701, Mexico. Phone: +52-2001255404 or 5408, e-mails: ynava@ate.oikos.unam.mx; mricker@ibiologia.unam.mx

2. Value estimated from the average in Figure 4.

3. Some synonyms for *Pouteria sapota* are *Achradelpha mammosa* (L.) O.F. Cook, *Calocarpum mammosum* (L.) Pierre, *C. sapota* (Jacq.) Merr., *Lucuma mammosa* (L.) C. F. Gaertner, *P. mammosa* (L.) Cronquist, and *Vitellaria mammosa* (L.) Radlk. (Pennington 1990). Common Spanish names are "zapote mamey", "zapote", "quaicuma", "mamey colorado", and "mamey". In other languages, common names include "grand sapotlillier" and "grosse sapote" (French), "mamey" (English), and "sapoti" (Portuguese) (Pennington 1990, Balerdi & Shaw 1998).

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