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THE SOURSOP, OR GUANABANA (ANNONA MURICATA LINN.)

JULIA F. MORTON[1]

The genus *Annona*, of the family Annonaceae, includes 60 or more species, mostly of tropical American origin. The four best-known as bearers of edible fruit are the true custard apple, or bullock's heart (*A. reticulata* Linn.), the sugar apple, or sweetsop (*A. squamosa* Linn.), the cherimoya (*A. cherimola* Mill.), and the soursop (*A. muricata* Linn.). The first is the most variable in quality and least-prized and its status is that of a dooryard fruit sometimes sold on local markets. The second is popular as a home fruit in the Caribbean area and the East Indies and is the favorite *Annona* of India where it is called *sitaphal* or "custard apple" and is given its greatest attention as a fresh fruit crop. The third is the most celebrated for its flavor but succeeds only in climates comparable to its native Andean region. A hybrid between the sugar apple and the cherimoya (an atemoya) is the so-called "custard apple" grown commercially and marketed as a fresh fruit in Queensland, Australia. The fourth species, the subject of this paper, is the most tropical, the largest-fruited, and the only one lending itself well to preserving and processing.

The soursop is known in Spanish-speaking countries as guanábana, or guanaba, and elsewhere by various names including sorsaka, zuurzak, corossol and graviola. Oviedo, in 1526, described it as abundant in the West Indies and in northern South America. It is today found, both wild and cultivated, from sea level to an altitude of 3,500 ft. (72) throughout the West Indies and from southern Mexico to Brazil. It was one of the first fruit trees carried from America to the Old World Tropics (43) where it has become widely distributed from southeastern China to Australia and the warm lowlands of eastern and western Africa. The tree has been raised successfully but has never fruited in Palestine (47). It became well established at an early date in the Pacific islands.

In Florida, it has been grown to a limited extent for possibly 90 years. Sturtevant noted that it was not included by Atwood among Florida fruits in 1867 but was listed by the American Pomological Society in 1879 (70). In the southern part of the state, it succeeds in protected locations despite temporary defoliation and interruption of fruiting by occasional cold spells in winter. It fruited at the home of Capt. John Fogarty in Manatee before the freeze of 1886 (55). It has survived but failed to thrive at the Plantation Field Laboratory, Ft. Lauderdale, having suffered repeated cold injury (13). Young trees in exposed places are killed by only a few degrees of frost. The soursop is safe in the open at Key West and is fairly common there in home gardens.

DESCRIPTION

The tree is low-branching and bushy but slender because of its upturned limbs (15), and reaches a maximum of 25 or 30 ft. in height. Young branchlets are rusty-hairy. The leaves, normally evergreen, are alternate, smooth, glossy, dark-green on the upper surface, lighter beneath; oblong, elliptic or narrow-obovate, pointed at both ends, 2½ to 8 in. long and 1 to 2½ in. wide; and highly aromatic when crushed. The flowers, which are borne singly, may emerge anywhere on the trunk, branches or twigs (68, 82). They are short-stalked, 1½ to 2 in. long, plump, and triangular-conical, the three fleshy, slightly spreading, outer petals yellow-green, the three close-set inner petals pale-yellow.

Soursops are more or less oval or heart-shaped, sometimes irregular, lopsided or curved due to improper carpel development or insect injury. They range in size from 4 to 12 in. (15, 35, 68) long and up to 6 in. in width, and may weigh as much as 10 (8, 11) or 15 lbs. (10). The fruit is compound and covered with a re-

[1]Director, Morton Collectanea, University of Miami, Coral Gables.

ticulated, leathery-appearing but tender, inedible, bitter skin from which protrude few or many stubby, or more elongated and curved, soft, pliable "spines." The tips break off easily when the fruit is fully ripe. The skin of the immature fruit is usually dark-green, becoming slightly yellowish-green (82) before the fruit is soft to the touch. The inner surface of the skin is granular and separates easily from the mass of snow-white, fibrous, juicy segments—much like flakes of raw fish—surrounding the central, soft-pithy core. In aroma, the fruit is somewhat pineapple-like, but its musky, subacid to acid flavor is unique. Most of the closely-packed segments are seedless. In each fertile segment there is a single oval, smooth, hard, black seed, ½ to ¾ in. long; and a large fruit may contain from a few dozen to 200 or more seeds.

Varieties

In Puerto Rico, the wide range of forms and types of seedling soursops are roughly divided into three general classifications: sweet, subacid and acid; then subdivided as round, heart-shaped, oblong or angular; and finally classed according to flesh consistency which varies from soft and juicy to firm and comparatively dry. The University of Puerto Rico's Agricultural Experiment Station at one time catalogued 14 different types of soursops in an area between Aibonito and Coamo (62). In El Salvador, two types of soursops are distinguished: *guanaba azucarón* (sweet), eaten raw and used for drinks; and *guanaba ácida* (very sour), used only for drinks (67). In the Dominican Republic the *guanábana dulce* (sweet soursop) is most

Fig. 1.—This soursop tree at Palm Lodge Tropical Grove, Homestead, is multiple-stemmed from having been cut back after severe cold injury. It is not unusual for fruit to be borne low on the trunk. —Photo by Kendal and Julia Morton

sought after (19). The term "sweet" is used in a relative sense to indicate low acidity. Dr. Frank Venning informs me that a medium-sized, yellow-green soursop called *guanábana sin fibre* (fiberless) has been vegetatively propagated at the Agricultural Experiment Station at Santiago de las Vegas, Cuba. The foliage of this superior clone is distinctly bluish-green (72). In 1920, Dr. Wilson Popenoe sent to the United States Department of Agriculture, from Costa Rica, budwood of a soursop he named "Bennett" in honor of G. S. Bennett, Agricultural Superintendent of the Costa Rican Division of the United Fruit Company. He described the fruit as large and handsome (which is evident in his photograph accompanying the introduction record No. 51050) and he declared the tree to be the most productive he had seen (5).

Propagation and Culture

The soursop is usually grown from seeds. They should be sown in flats or gallon cans (48) and kept moist and shaded and will *germinate* in 30 days or less (68). However, the tree can be easily propagated by cuttings and by shield-budding (68). It has been successfully inarched and grafted on *A. reticulata* (42) and also grafted on *A. montana* Macfad., the mountain soursop (72), and *A. glabra* Linn., the pond apple (39), though the latter has had a dwarfing effect in some trials (41). Grafts on *A. squamosa* and *A. cherimola* do not live for long, despite the fact that the soursop is a satisfactory rootstock for *A. squamosa* in Ceylon and India (63). Soursop seedlings are generally the best stock for propagation of good varieties of the soursop (41).

In ordinary practice, seedlings, when 1 ft. or more in height (48), are set out in the field at the beginning of the rainy season (24) and spaced 12 to 15 ft. apart (62, 79) though 25 ft. each way has been suggested (50). Pennock specifies 8 x 8 ft. spacing for small gardens in Puerto Rico (48). The tree grows rapidly and begins to bear in 3 to 5 years. In Queensland,

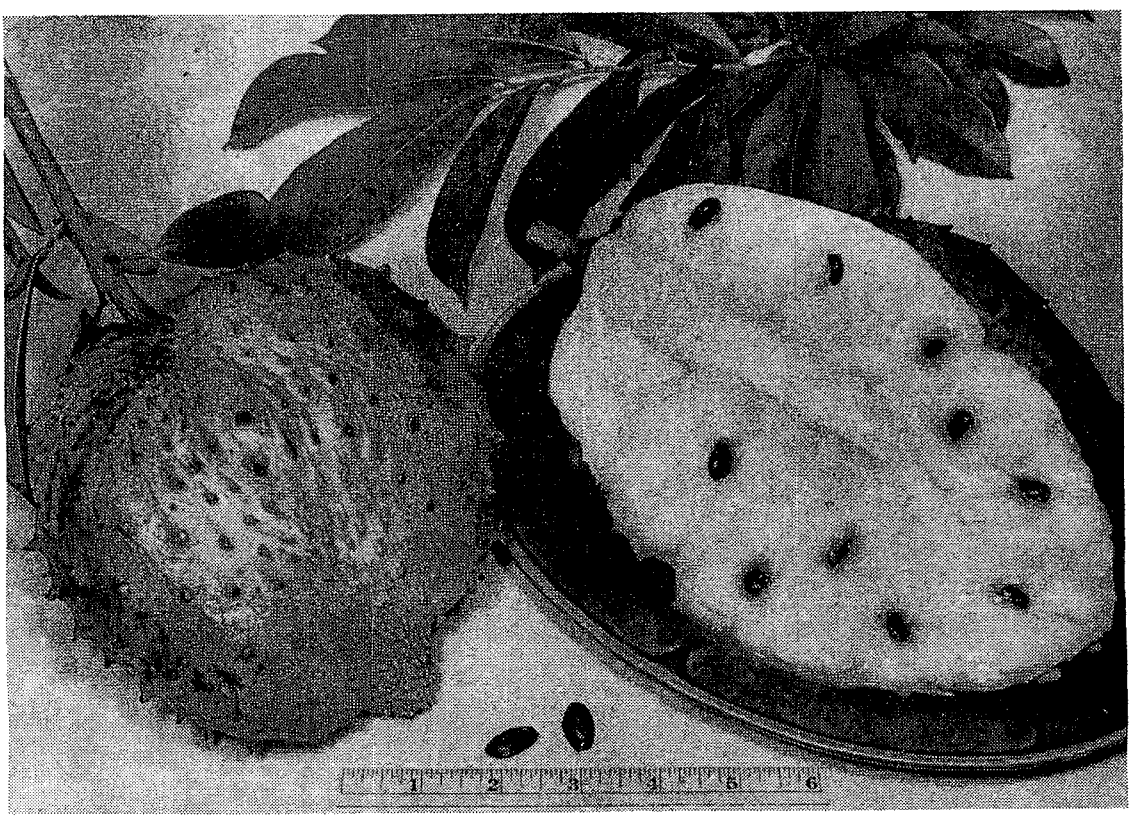

Fig. 2.—The soursop is variable in size and form and is a compound fruit, its white flesh being composed of flat, fibrous segments or "flakes" much like pieces of raw fish. —Photo by Kendal and Julia Morton

Fig. 3.—Dr. Wm. C. Cowgill holding typically large soursops at Buga, Cauca valley, Colombia.
—Photo by Frank D. Venning

well-watered trees have attained 15 to 18 ft. in 6 to 7 years (68). Best growth is achieved on deep, rich, well-drained soil, but the tree can be and commonly is grown in acid and sandy soil, and in the porous, oolitic limestone of South Florida and the Bahama Islands. Mulching is recommended to avoid dehydration of the shallow, fibrous root system during dry, hot weather (69). If in too dry a situation, the tree will cast off all of its old leaves before new ones appear (68). In Puerto Rico, it is said to prefer an altitude between 800 and 1,000 ft., semi-dry soil, with moderate humidity, plenty of sun and shelter from strong winds (62). A fertilizer mixture containing 10% phosphoric acid, 10% potash and 3% nitrogen has been advocated in Cuba and Queensland (68).

Yield

The soursop, unfortunately, is a shy bearer, the usual crop being 12 to 20 (63, 68) or 24 (26) fruits per tree. In Puerto Rico, production of 2½ to 4 tons of fruit per acre is considered a good yield from well-cared-for trees (62). Generous fertilization has been found to increase the crop (53). Hand-pollination may encourage fruit-set inasmuch as normally the pollen is shed before the stigma is receptive (32). There are often a number of small, malformed fruits resulting from imperfect pollination.

Diseases and Pests

It has been observed in El Salvador that soursop trees in very humid areas often grow well but bear only a few fruits, usually of poor quality, which are apt to rot at the tip. Most of their flowers and young fruits fall because of anthracnose caused by *Colletotrichum gloeosporioides* Penz. In dooryard plantings this can be controlled by the application of fungicides (2). Pennock stresses that trees for cultivation near San Juan, Puerto Rico, should be seedlings of trees from similarly humid areas which have greater resistance to anthracnose than seedlings

Fig. 4.—Yellowish immature fruits of the guanábana sin fibre (fiberless soursop) on tree near Havana, Cuba. —Photo by Frank D. Venning

from dry zones (48). The same fungus causes damping-off of seedlings and die-back of twigs and branches (44). In the East Indies, soursop trees are sometimes afflicted with the root-fungi, *Fomes lamaoensis* Murr. and *Diplodia* sp. and by pink disease due to *Corticum salmonicolor* Berk. et Br. (46).

Queenland's principal soursop pest is the mealy bug which may occur in masses on the fruits (68). The mealy bug is a common pest also in Florida, where the tree is often infested with scale insects; sometimes by a lace-wing bug; and the fruit is subject to fruit fly attack (41). Red spiders are a problem in dry climates (50). In Surinam, bagging of soursops is necessary to protect them from the moth, *Cerconota anonella* Sepp., which lays its eggs in the very young fruit causing stunting and malformation, and the wasp, *Bephrata maculicollis* Cam., the larvae of which live in the seeds and emerge from the fully-grown ripe fruit, leaving it perforated and highly perishable (71). These insects as well as the Caribbean fruit fly (*Anastrepha suspensa* Loew) and a lesser pest, *Thecla ortygnus* Cramer, which attacks the flowers, seriously limit the cultivation of the soursop in Trinidad. The last-named insect is a common handicap in Venezuela. The sphinx caterpillar (*Cocytius antaeus antaeus* Drury) may be found feeding on soursop leaves in Puerto Rico (36).

Season and Harvesting

The soursop tends to flower and fruit more or less continuously, but in every growing area there is a principal season of ripening. In Puerto Rico, this is from March to June or September (62); in Queensland it begins in April (68); in southern India, Mexico and Florida it extends from June to September (42, 35, 41); in the Bahamas, it continues through October (40).

The fruit is picked when full grown and still firm but slightly yellow-green. If allowed to soften on the tree, it will fall and crush. It is easily bruised and punctured and must be handled with care. Firm fruits are held a few days at room temperature. When eating-ripe, they are soft enough to yield to the slight pressure of one's thumb. Having reached this stage, the fruit can be held 2 or 3 days longer in a refrigerator. The skin will blacken and become unsightly while the flesh is still unspoiled and usable. In Venezuela, the chief handicap in commercial processing is that the fruits stored on racks in a cool shed must be gone over every day to select those that are ripe and ready for juice-extraction.

Food Uses

Soursops of least acid flavor and least fibrous consistency are cut in sections and the flesh eaten with a spoon. The seeded pulp may be torn or cut into bits and added to fruit cups or salads, or chilled and served as dessert with sugar and a little milk or cream. Most widespread throughout the Tropics is the making of refreshing soursop drinks (called *champola* in Brazil; *carato* in Puerto Rico). For this purpose the seeded pulp may be pressed in a colander or sieve or squeezed in cheesecloth to extract the rich, creamy juice, which is then beaten with milk or water and sweetened. Or the seeded pulp may be blended with an equal amount of boiling water and then strained and sweetened. If an electric blendor is to be used, one must first be careful to remove all the seeds, since they are somewhat toxic and none should be accidentally ground up in the juice. Dr. Ramon V. Valmayor, University of the Philippines, College, Laguna, has told me that in Los Baños soursop drinks are popular but the normal "milk" color is not. The people usually add pink or green food coloring to make the drinks more attractive. The strained pulp is said to be a delicacy mixed with wine or brandy (46) and seasoned with nutmeg (1). Soursop juice, thickened with a little gelatin, makes an agreeable dessert (68). In the Dominican Republic, a soursop custard is enjoyed and a confection is made by cooking soursop pulp in sugar sirup with cinnamon and lemon peel (19). Soursop ice cream is commonly frozen in refrigerator ice-cube trays in warm countries. In the Bahamas it is simply made by mashing the pulp in water, letting it stand, then straining to remove fibrous material and seeds. The liquid is then blended with sweetened condensed milk, poured into the trays and stirred several times while freezing (27). A richer product is made by the usual method of preparing an ice cream mix and adding strained soursop pulp just before freezing. Several recipes for soursop sherbet and mousse are presented by Miller *et al.* in Hawaii (38). The pulp is used, too, for making tarts and jelly (54, 58), sirup and nectar. Seeded soursop pulp has been successfully frozen in sirup at

the College of Agriculture, Mayaguez, P.R. Dr. Valmayor says that the strained, frozen pulp, in plastic bags holding 1 or 2 lbs., is sold in Philippine supermarkets. The juice is used in bottled carbonated beverages in Guatemala (67), and a fermented, cider-like drink is sometimes made in the West Indies (12). Immature soursops have been cooked as vegetables (33) or used in soup in Java (46). I have boiled the half-grown fruit whole, without peeling. In an hour the fruit is tender, its flesh off-white and mealy, with the aroma and flavor of roasted ears of green corn (maize).

Status and Increasing Demand

In regions where sweet fruits are preferred, as in South India and Guam, the soursop has not enjoyed great popularity. However, in the East Indies it has been acclaimed one of the best local fruits (11). In Honolulu, the fruit is occasionally sold but the demand exceeds the supply (38). It is one of the most abundant fruits in the Dominican Republic and one of the most popular in Cuba, Puerto Rico, the Bahamas and Colombia.

In 1887, Cuban soursops were selling in Key West, Fla., at 10 to 50 cents apiece (55). In 1920, Wilson Popenoe wrote that "In the large cities of tropical America, there is a good demand for the fruits at all times of the year, a demand which is not adequately met at present." The island of Grenada produces particularly large and perfect soursops and regularly delivers them by boat to the market of Port-of-Spain because of the shortage in Trinidad (10).

For years, seeded soursop pulp has been canned in Mexico and served in Mexican restaurants in New York and other northern cities. The sirup has been bottled under the GOYA brand by the Puerto Rico Food Products Corporation for local use and export. In 1942 further exploitation was anticipated in Puerto Rico and there are today a few commercial soursop plantations near the south coast of that island (60). In 1957, local soursops purchased by Puerto Rican processors for various purposes amounted to $3,757.00, and 6,121 gals. of guaná-

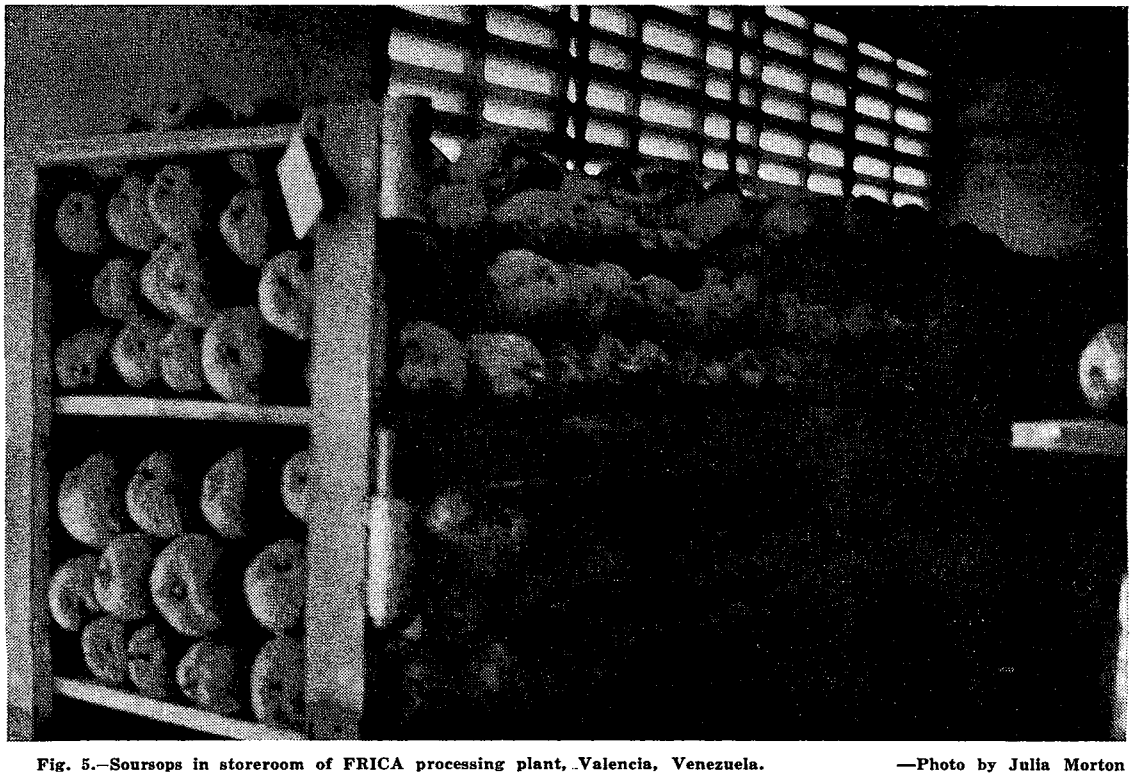

Fig. 5.—Soursops in storeroom of FRICA processing plant, Valencia, Venezuela. **—Photo by Julia Morton**

bana nectar and 562 gals. of sirup were preserved (56).

In 1951, Prof. Clery Salazar, who was encouraging the development of soursop products at the College of Agriculture at Mayaguez, told me that they would like to adopt an English name more appealing than the word "soursop," and not as likely as guanábana to be mispronounced.

Soursops produced in small plots (none over 5 acres) throughout Venezuela (34a) supply the processing plants of FRICA (in Valencia) where the quick-frozen concentrate is packed in 6 oz. cans, and YUKERY where soursop nectar is canned for domestic sale and export. The strained pulp has also been preserved under the OXCART brand in Costa Rica.

Some Key West restaurants have always served soursop ice cream and now the influx of residents from Cuba and Puerto Rico into the South Florida area has created a strong demand for it. The canned pulp is imported from Central America and Puerto Rico and used in making ice cream and sherbet at the McArthur Dairy plant in Ft. Lauderdale and elsewhere.

In Colombia, where the soursop is generally large, well-formed and of high quality (72), this is one of the 14 tropical fruits recommended by the Instituto Latinoamericano de Mercadeo Agricola for large-scale planting and marketing (4). At the First International Congress of Agricultural and Food Industries of the Tropical and Subtropical Zones, held in December of 1964, scientists from the Research Laboratories of Nestlé Products in Vevey, Switzerland, presented an evaluation of lesser-known tropical fruits and cited the soursop, the guava and passion fruit as the three most promising for the European market, because of their distinctive aromatic qualities and their suitability for processing in the form of preserved pulp, nectar and jelly (81).

Fruit Composition

The United States Department of Agriculture Handbook No. 8, *Composition of Foods*, tabulates the following "Nutrients in the edible portion of 1 pound" of raw soursop (exclusive of skin and seeds which constitute 32% of the fruit as purchased): Food energy, 200 calories; protein, 3.1 g.; fat, .9 g.; total carbohydrate, 50.3; calcium, 43 mg.; phosphorus, 83 mg.; iron, 1.9 mg.; sodium, 43 mg.; potassium, 817 mg.; vitamin A value, 20 I.U.; thiamine, .22 mg.; riboflavin, .14 mg.; niacin, 2.6 mg.; ascorbic acid, 60 mg. (75).

Analyses are presented also by H. Lopez *et al.*, in *Tabla Provisional de la Composicion Nutritiva de los Alimentos Cubanos* (1956) and this source cites amino acids content per 100 g. of edible portion as: tryptophane, 11 mg.; methionine, 7 mg.; lysine, 60 mg. (34).

In Brazil the free amino acid content was found to be 0.055 g. N/100 g. Proline and y-aminobutyric acid predominated among the 11 free acids detected. (73)

The nonvolatile acids and flavor of the soursop were studied at the University of Puerto Rico Agricultural Experiment Station in 1940 and it was concluded that "the organic acids of the guanábana or soursop consist of a mixture of malic and citric acids in approximately the proportion 2:1. A trace of isocitric acid was also found. The flavor of guanábana is evidently due, at least mainly, to a mixture of amyl caproate with geranyl caproate, and possibly other caproates." (3)

Constituents of Seeds and Other Parts of the Tree

The presence of the alkaloids *anonaine* and *anoniine* has been reported in this species (78). The alkaloids *muricine*, $C_{19}H_{21}O_4N$ (possibly des-N-methylisocorydine or des-N-methylcorydine and *muricinine*, $C_{18}H_{19}O_4$ (possibly des-N-methylcorytuberine) are found in the bark; an unknown alkaloid in the leaves and seeds (76, 78). The bark is high in hydrocyanic acid. Only small amounts are found in the roots and leaves and a trace in the fruit (54). Summaries of various chemical investigations are presented by Quisumbing (54), Watt and Breyer-Brandwijk (76) and other compilers.

Folk Medicine

In *Materia Medica* of British Guiana, we are told to break soursop leaves in water, "squeeze a couple of limes therein, get a drunken man and rub his head well with the leaves and water and give him a little of the water to drink and he gets as sober as a judge in no time" (1). This sobering or tranquilizing formula may not have been widely tested, but soursop leaves are regarded throughout the West Indies as having sedative or soporific properties. In the Netherlands Antilles the leaves are put

Fig. 6.—Soursop foliage and flower and a 6 oz. can of quick-frozen concentrate. —Photo by Julia Morton

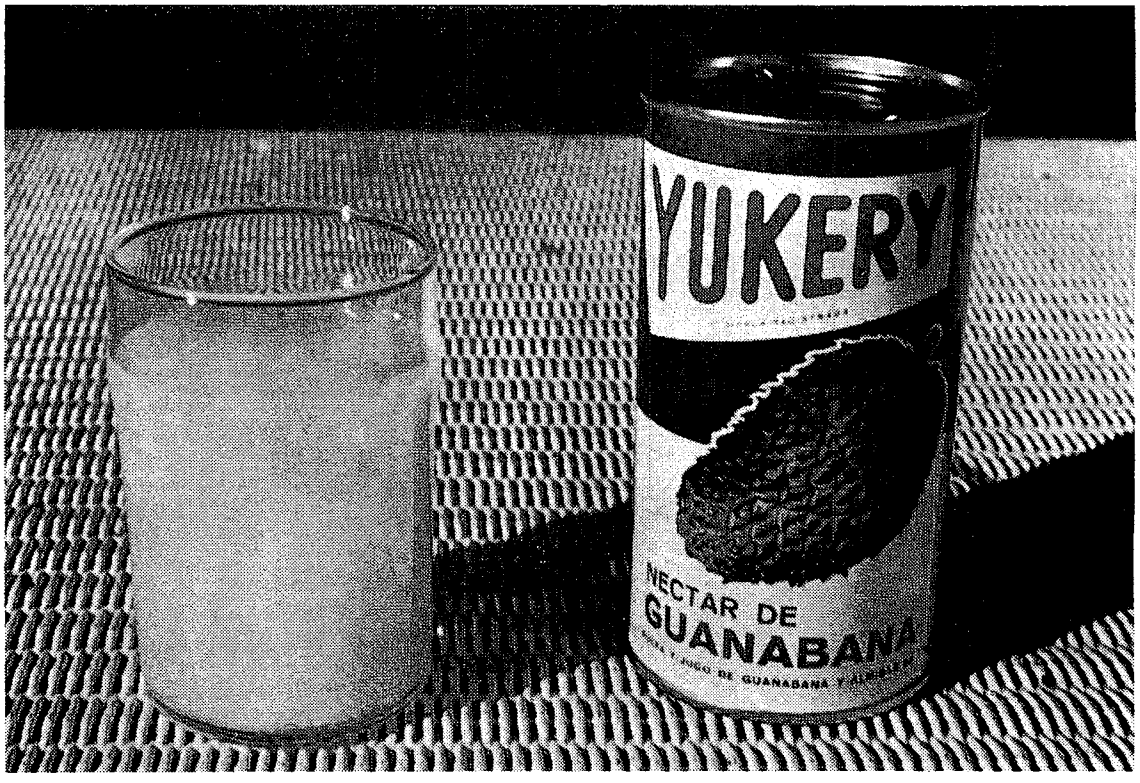

Fig. 7.—YUKERY brand soursop nectar canned in Venezuela has the distinctive flavor of the fresh juice.
—Photo by Julia Morton

into one's pillowslip or strewn on the bed to promote a good night's sleep. An infusion of the leaves is commonly taken internally for the same purpose. It is often drunk in the evening as a pleasant "tea." In Africa, it is given to children with fever and they are also bathed lightly with it (18). A decoction of the young shoots or leaves is regarded in the West Indies as a remedy for gall bladder trouble, as well as coughs, catarrh, diarrhea, dysentery and indigestion; is said to "cool the blood," and, being antispasmodic, to stop vomiting and aid delivery in childbirth (57, 76). The decoction is also employed in wet compresses on inflamations and swollen feet. The chewed leaves, mixed with saliva, are applied to incisions after surgery, causing proudflesh to disappear without leaving a scar. Mashed leaves are used as a poultice to alleviate eczema and other skin afflictions and rheumatism and the sap of young leaves is put on skin eruptions (12).

Soursop fruit juice is said to be diuretic and a remedy for haematuria and urethritis. Taken when fasting, it is believed to relieve liver ailments and leprosy. The roots of the tree are employed as a vermifuge, and the root bark to counteract ptomaine poisoning (57, 76). A tincture of the powdered seeds and bay rum is a strong emetic. Pulverized immature fruits, which are very astringent, are decocted as a dysentery remedy. To draw out chiggers and speed healing, the flesh of an acid soursop is applied as a poultice unchanged for three days (57). Soursop flowers are believed to alleviate catarrh (76).

Insecticidal and Other Uses

Soursop seeds, roots and bark have been used as fish poison (76). When pulverized the seeds are effective against head lice (57), southern army worms and pea aphids, and petroleum ether and chlorophorm extracts are toxic to black carpet beetle larvae (31). The leaf decoction kills head lice (67). In Gambia the leaves are said to exterminate bedbugs (18). The bark

of the tree has been employed in tanning (29). The bark fiber is strong but, since fruiting trees are not expendable, is resorted to only in necessity (12). In the Virgin Islands, the fruit is placed as a bait in fish traps (67).

Soursop wood is pale, aromatic, soft, lightweight and not durable. It has been used for ox yokes because it does not cause hair loss on the neck (67). In Colombia, it is deemed to be suitable for pipestems and barrelstaves (49).

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THE MANGO INFLORESCENCE

THOMAS T. STURROCK[1]

The mango fruit has been the subject of much interest by growers, scientists, and laymen for many centuries. In contrast very little has been written about the blossoms which are necessary before these highly desirable fruit can be produced. A discussion is presented here concerning these blossoms and some of their irregularities.

Descriptions of the inflorescence are found in the literature (6, 10, 11, 12, 13). In general the inflorescence is a terminal shaped panicle with a main rachis and side branches from it often arising in an irregular manner. Cymes are produced on these side branches. The cyme is a determinate inflorescence with the apex bud blooming first and subsequent buds arising laterally. These lateral buds may give rise to secondary cymes of their own with their apex buds blooming next and the laterals to these arising later.

This complex structure in the mango produces an inflorescence with a few hundred to several thousand individual blossoms and requires up to a month for the final blossoms to open (1, 2, 12). This time for opening gives opportunity for many environmental factors to effect the eventual fate of these blossoms.

The individual blossoms are of two types either perfect or staminate. The perfect blossoms are easily distinguished from the staminate by the presence of a globular ovary with a lateral style (Fig. 1) which is absent in the staminate type (Fig. 2). Both types of blossoms generally have one functional stamen and several sterile staminoids.

Counts made by Cobin and Harkness (2) reveal a spread between varieties as to the percentage of perfect blossoms from 3.0 to 3.5 for the Edward variety to 29.7 for the Kent variety. More detailed work by these workers

[1]Florida Atlantic University, Boca Raton.