

Commercialization of Mangosteen in the United States: Domestic Cultivation, Imports and Marketing

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Abstract

This review covers the history of efforts to cultivate mangosteen (*Garcinia mangostana* L.) in the United States and other countries in the Western Hemisphere, and to market mangosteen in the United States. Mangosteen is highly reputed for its juicy, delicate flesh and sweet-tart flavor, but commercial cultivation and marketing in the United States started just recently. Native to Indonesia and Malaysia, mangosteen trees require a fully tropical climate and cannot be grown commercially in the contiguous United States. For more than a century, attempts have been made to cultivate mangosteen for the United States market; in the 1990s, small plantings were established in Hawaii and Puerto Rico (30 and 5 hectares, respectively), some of which are beginning to bear fruit. Because fresh mangosteens can harbor quarantine pests, the USDA's Animal and Plant Health Inspection Service (APHIS) until recently prohibited their importation from the main producing countries in Southeast Asia, or from Hawaii, to the U.S. mainland. In June 2007 APHIS published a final rule allowing the importation of fresh mangosteen irradiated at a minimum dose of 400 Gy from Thailand, which leads the world in production. Imported Thai mangosteen appears to tolerate this dose well. Shipments of fresh mangosteen from Puerto Rico, which do not require irradiation, started on a small scale in August 2007. Hawaiian growers have marketed chiefly to local hotels, restaurants and cruise ships, but in 2008 APHIS published a final rule allowing export to the mainland of mangosteen irradiated at a minimum dose of 150 Gy. Interest in the purported health benefits of mangosteen has boosted public awareness and consumption of mangosteen products in recent years.

Mangosteen (*Garcinia mangostana* L.), a member of the Clusiaceae (Guttiferae) family, has long been extravagantly praised as the "queen of fruits" and "the finest fruit in the world" (8, 12, 13, 28). The fruit is a smooth, globose berry about 4-7 cm in diameter, with a thick pericarp, purple when ripe, and a persistent calyx on the stem end. The edible portion is a white aril composed of four to eight segments, one or two of which are larger and contain seeds (1, 25, 35, 37, 41). The flesh is tender and juicy, with a delicate sweet-tart flavor, whose most important aroma components have been identified as hexyl acetate and cis-hex-3-enyl acetate (22). It is consumed fresh and also in processed forms, as canned fruit, juice and preserves.

Mangosteen is native to Southeast Asia (Indonesia and Malaysia), and is adapted to humid tropical lowlands. The tree ranges from 6 to 25 m tall, and has a straight trunk, symmetrical branching, and thick, leathery, dark green leaves. It grows best on acid to

neutral soil, with shade for the first two to four years; a short dry period helps to stimulate flowering. Under ideal conditions trees produce a first crop at five to seven years, but when growth is slowed by lower temperatures, the juvenile period can last 10 to 15 years or more. The tree can be killed by temperatures below 3-5°C (11, 35).

Mangosteen cultivation is economically significant in Southeast Asia, and Thailand is the world's largest producer and exporter of fresh and processed fruit. Cultivation, generally on a small scale, has spread to many other tropical countries, including southern India, Sri Lanka, Madagascar, Ivory Coast, Australia (Northern Territory and north Queensland), Brazil, Central America and the islands of the Caribbean. Limited current information is available about plantings and production. Harvest seasons vary considerably, both among growing areas and among years (25; Table 1).

For at least several decades, fresh man-

Table 1. World production of mangosteen. A dot (.) indicates that no information is available.

Location	Area planted (ha)	Production (MT)	Year of statistic	Availability
<u>Major commercial producers (> 1000 ha)</u>				
Thailand	63,200	175, 274	2008 ^z	Apr.-Sept.; some at other times
Indonesia	9,354	79, 073	2003 ^y	Jul.-Aug., Nov.-Feb.
Malaysia	7,632	.	1998	Jun.-Aug., Nov.-Jan.
Vietnam	4,900	4,500	2005	May-Sept. ^x
Philippines	1,354	4,692	2004	Jul.-Nov. ^y
<u>Minor producers</u>				
Brazil (Para and Bahia)	350	300	2007 ^w	Jan.-May, Aug.-Sept.
Australia	100	100	2003 ^y	Feb.-Apr., Sept.-Oct. ^y
Mexico	> 20	.	2008 ^u	.
Honduras (Lancetilla)
Costa Rica (Guapiles)	> 300 trees ⁱ	.	.	.
Guatemala	.	.	.	Jul.-Nov.
Belize	.	.	.	Feb.-May
<u>USA producers</u>				
Hawaii	30	.	2009 ^s	Sept.-Dec.
Puerto Rico	5	0.5	2009 ^r	Jul.-Aug.
Florida	< 0.1	20 fruits	2009	May-Jul.

^z A. Runcharoenpompachee and R. Chandarasrivongs, Royal Thai Embassy, Office of Agricultural Affairs, Washington, D.C., pers. Comm., Mar. 2009. From Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Thailand

^y Osman, M. bin and A.R. Milan. 2006. Fruits for the future 9: mangosteen

^x <http://www.auhoaquavietsnam.vn> <<Accessed 21 Jun. 2008>>

^w Do Sacramento, C.K. et al. 2007. Cultivo do mangosão No Brasil (Growing mangosteen in Brazil), Rev. Bras. Frutic. 29:195-203.

^v Rural industries research and development corporation exotic crop review workshop, 2003; <http://www.rircd.gov.au/reports/NPP/03-103.pdf> <<Accessed 21 Jun. 2008>>

^u F. Villaseño, R. Campbell, pers. comm., Jul. 2008

ⁱ R.C. Johnson, pers. comm., Jun. 2006

^s J. Johnson, pers. comm., Mar. 2009

^r I. Crown, pers. comm., Mar. 2009

gosteens have been exported, mostly from Southeast Asia, to ethnic and luxury markets in Europe, Canada and Japan. Because fresh mangosteens have been regarded as fruit fly hosts, however, the United States Department of Agriculture (USDA) for many years prohibited their being brought from the main countries that grow them in Southeast Asia, or from Hawaii. Mangosteens were smuggled from Canada (which does not prohibit importation of the fruit because tropical pests cannot survive there) and sold in United States Chinatowns, often relabeled to make it appear they came from a legitimate source (23; Fig. 1).

Contrary to its reputation as a forbidden fruit, the mangosteen could for many years be imported legally to the United States from 19 Caribbean and Central American countries, as well as from Puerto Rico (5). Until recently, however, there was very little commercial cultivation in those areas. For example, mangosteen is admissible from the Caribbean nation of Dominica, but the island has only small, scattered plantings, and no practical way of exporting the fruits (Noel Ramos, pers. comm., Jun. 2003). The only nation in the Western Hemisphere with substantial plantings, Brazil, now grows 350 hectares (34), but



Fig. 1. Smuggled mangosteens in New York, 1996.

its fresh mangosteen is not admissible to the United States (5; Table 2).

History

The mangosteen's reputation for exquisite flavor spurred many attempts, over more than a century, to grow the fruit in Central America, the Caribbean islands, and tropical regions of the United States, and to import it to the United States, but these efforts mostly did not prove successful. In 1878 an article in *The New York Times* called mangosteen "that most celebrated fruit of the East," with "a taste which nobody can describe any more than he can tell how a canary sings or a violet smells" (6). Another article in 1904 lamented that the mangosteen is "so delicate ... that shipment is impossible" (7). Mangosteen cannot be transported long distances by ship, "not even with the aid of refrigeration or when coated with wax," wrote a traveler to Java in 1935 (33).

The renowned plant explorer David Fairchild, who first encountered the fruit in

Java in 1895, wrote in 1907, "The mangosteen should head the list of new fruit possibilities for the western tropics. ... When once known, Americans would pay fancy prices for it" (14). For many years, he was the fruit's foremost promoter, helping to introduce it to southern Florida, Puerto Rico, Hawaii, Honduras and Panama (12, 13).

The superintendent of the University of Florida's Agricultural Experiment Station at Fort Meyers reported in 1894 that "The Mangosteen, probably the finest fruit known, has been planted but not with encouraging success" (38). Two mangosteen trees were planted at the Porto Rico Agricultural Experiment Station in 1903, but did not bear fruit until 1920 (32). By 1911 many mangosteen trees had been brought to Hawaii, but most died, and only two fruiting trees were reported (40).

Table 2. Jurisdictions from which mangosteen may legally be imported to the United States mainland.

Antigua and Barbuda
Bahamas
Barbados
Belize
Cayman Islands
Dominica
Dominican Republic
Grenada
Guadeloupe
Haiti
Hawaii (irradiated fruit)
Jamaica
Martinique
Mexico
Montserrat
Puerto Rico
Saint Barthol�my
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and The Grenadines
Thailand (irradiated fruit)
Trinidad and Tobago

Source: Fresh Fruits and Vegetables Import Manual, USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine: http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/fv.pdf <<Accessed 13 Mar. 2009>>

Efforts to grow mangosteen in tropical America continued between the world wars. The New York Times wrote in 1925: "Experiments in tropical America have reached the stage where the regular delivery of mangosteen will be possible in about 10 years. ... The experiments were carried out at Porto Rico, Jamaica and Trinidad." (8) But this wishful thinking never led to substantial plantings and commercial shipments, largely because growers were discouraged by the tree's very long juvenile period. Already in 1940, C.L. Horn reported on his experiments to stimulate growth in juvenile mangosteen trees, which were "notoriously difficult to grow" (16). A book observed in 1945 that the mangosteen "is so rare in the American tropics that the places where it is grown can practically be counted on the fingers of one's hands" (36).

The largest and most famous mangosteen planting in the western hemisphere was established in 1925 by Wilson Popenoe for the United Fruit Company's Lancetilla Experiment Station at Tela, Honduras, partly from seeds obtained by his mentor, David Fairchild, in Penang, Malaya (13, 29, 30, 31). If properly shaded when young, the trees bore fruit after eight years, and the orchard numbered 700 trees in 1941 (30). On at least one occasion about this time, the USDA forbade importation of mangosteen from Lancetilla to the United States, on the grounds that it was a fruit fly host. There were 1,000 trees in 1956, when Mr. Popenoe noted that the fruits were "perfectly grand," but added: "We can not see much of a commercial future for mangosteens. [They are] irregular bearers, and the fruit [is] rather difficult to handle commercially" (31). His nephew, John Popenoe, director of Fairchild Tropical Garden in Miami, concurred in 1967 that mangosteen at Lancetilla "is unlikely to be grown for any but local markets" (27).

Lincoln A. Martin, a geophysicist with Shell Oil, became fascinated with mangosteen when he lived in Java during the Second World War, and afterwards learned of the Lancetilla

orchard from a relative who was an officer of the United Fruit Company. In 1970 he obtained an import permit from the USDA, on condition that the fruit be fumigated to kill fruit flies, and flew considerable quantities from Honduras via Florida to California. The fruit, sold mostly in Southern California, "made quite a splash" recalled Frieda Caplan, the distributor; but the required fumigation shortened the fruit's shelf life, and led to the cessation of imports after three years, Mr. Martin said (9, 18). Now 97 years old, he remains interested in mangosteen, and organized a California Rare Fruit Growers chapter meeting on the subject in September 2009 at his home in Porterville, Calif., where, fittingly, David Fairchild II, grandson of the great fruit explorer, gave a presentation (pers. obs., Sept. 2009).

U.S. Cultivation Today

The largest mangosteen plantings in the United States are in Hawaii, where there are approximately 30 ha, of which 10 ha are bearing (J. Johnson, Hawaii Tropical Fruit Growers Association, pers. comm., Mar. 2009). The harvest season varies from September to December, depending on location, elevation, and weather conditions in individual years. Many of the plantings were started about 1990 by owners seeking alternative tropical crops, such as longan, rambutan and mangosteen, for land which had previously been planted in sugarcane, which had become uneconomic to farm, due to high labor costs. In addition, some mangosteen orchards were put in or bought by affluent and/or retired owners who considered exotic fruit farming in Hawaii to be part of an attractive lifestyle (17).

Early growers have faced significant challenges. Although to many Americans Hawaii is archetypically tropical, it's close to the Tropic of Cancer, the northern limit of the tropical zone; and although mangosteen is often considered a tropical crop, it might more accurately be described as ultra-tropical, faring best where temperatures rarely fall below 20°C. Some pioneer mangosteen

growers chose unsuitable sites at elevations of 300 m or more, exacerbating this problem, with the result that growth was slow, and trees took more than 10 years to bear fruit. In many cases there was turnover in ownership during this long juvenile period, and some new owners reassessed the commercial viability of mangosteen cultivation (17).

Sales of Hawaiian mangosteen so far have mostly been local, to natural foods stores, restaurants, hotels and farmers markets. The wholesale price has ranged from \$10 to \$14 per kg (J. Johnson, pers. comm., Mar. 2009). In May 2008, APHIS approved mangosteen for export to the mainland if irradiated at a minimum dose of 150 Gy, if the fruit is treated with a postharvest dip of warm soapy water and brushing, or if it originates from an orchard previously treated with a broad-spectrum insecticide; if these conditions do not apply, a minimum dose of 400 Gy is required (4). (While some public health advocates claim the irradiation of fruit may create chemicals harmful to human health, both the Food and Drug Administration and the World Health Organization have deemed it safe.) Dose mapping took place in autumn 2008 at the state's only produce irradiation facility, CW Hawaii Pride, in Keeaau, which charges USD \$0.55/kg to irradiate the fruit; but no commercial shipments were sent to the mainland during that season (Eric Weinert, CW Hawaii Pride, pers. comm., Mar. 2009). Much to the chagrin of Hawaiian growers, the USDA approved shipments of Thai irradiated mangosteen to the United States mainland a year before authorizing Hawaiian shipments (see below). At this time it is unclear whether Hawaiian shipments to the mainland will prove economically competitive with lower-priced Thai imports, or whether growers will find it more profitable to market their fruit locally (J. Johnson, pers. comm., Mar. 2009).

Puerto Rico offers a fully tropical climate, acceptable costs for land and labor, an active fruit production industry, proximity to markets, and privileged phytosanitary status, since USDA regulations allow mangosteens

to be imported to the United States mainland without irradiation or fumigation (3). Horticulturists long ago recognized the island's potential for mangosteen cultivation, and a test planting of about 40 trees was established in the early 1940s at the USDA's Tropical Agriculture Research Station (TARS) in Mayagüez (R. Goenaga, pers. comm., Jul. 2006). Currently the trees are about 15 m tall and bear copiously, but they are in a part of the station that is rather remote and overgrown, and are rarely harvested except by local youths (21).

The island's commercial growers mostly have ignored the potential for mangosteen cultivation, with the exception of Ian Crown of Panoramic Fruit Company (www.panoramic-fruit.com), a Connecticut-based investor with a B.S. in agriculture from Cornell University. In 1994, beguiled by the romance of old coffee mansions in the jungle, he looked to invest in a Puerto Rican farm. While researching crops to provide shade for coffee trees, he became excited by the promise of exotic fruit farming, and bought a 38 ha livestock ranch in the foothills east of Mayagüez, which he planted with mangosteen, rambutan, longan, pulasan, and other Asian fruits. After many travails, including fires and hurricanes, he now has more than 1,000 mangosteen trees scattered around the property, which would fill 5 ha if planted together (18). The harvest season ranges from July to September. In August 2007, Mr. Crown started shipping mangosteen to two specialty produce distributors, Baldor in New York and Melissa's in Los Angeles. Because of scarcity and intense interest from buyers, these first shipments sold for up to USD \$100/kg (about \$10 per fruit) at retail (20). In addition to being relatively close to East Coast markets, Mr. Crown can ship his mangosteens with the attractive sepals intact, as long as insects are flushed out by soapy water and blasts of air; by contrast APHIS requires Thai and Hawaiian shippers to remove the sepals from their fruit (2, 3, 4). Mr. Crown reports that his 2009 harvest amounted to about 500 kg, and that future yields will increase considerably (pers.

comm., Dec. 2009; Fig. 2 and Fig. 3).

Exotic fruit buffs in his area, including Bryan R. Brunner of Montoso Gardens (www.montosogardens.com) and Sadhu of Govardhan Gardens (peaceloveandunity.com/govardhangarden), grow several dozen mangosteen trees, but no one else in Puerto Rico has a commercial orchard. Undoubtedly growers would be more interested in mangosteen if the juvenile period were shorter. With this in mind Dr. Ricardo J. Goenaga, the TARS research leader, recently conducted a study of the effects of growth regulators on mangosteen trees. He found that although grafting was successful on different rootstocks and species, growth was not rapid, and there was



Fig. 2. Ian Crown picking mangosteens.



Fig. 3. Mangosteen fruit cut open to show the edible white aril.

some evidence of rootstock incompatibility. “The growth regulators we used were not effective in promoting growth in mangosteen,” he concluded (15; pers. comm., Jul. 2006).

Mangosteen cultivation in Florida is marginal in even the warmest parts of the state, and will never be commercially viable, but merits mention here because it has tantalized so many would-be growers (10). Wilson Popenoe wrote in 1941: “Ever since Doctor Fairchild began telling us about mangosteens back in the early nineteen hundreds, I suspect the secret ambition of every horticulturist in southern Florida has been to grow this fruit. Many have tried it. I played with it myself, ... but the discouragements were so numerous and so definite that I decided we were too far north” (30).

The most serious obstacle to mangosteen cultivation in Florida is that occasional cold snaps, in which the temperature falls near or below freezing, kill the trees. Mangosteens might survive in the more moderate climate right along the southern coast, but the trees require acid to neutral soil, and do not live long in the calcareous soils prevalent in these locations. Additionally, salt carried from the sea on high winter winds causes leaf tip burn (39).

But William F. Whitman, a wealthy tropical fruit collector and co-founder of the Rare Fruit Council International, famously managed to coax mangosteen trees to fruit in his yard in Bal Harbor, 600 m from the Atlantic Ocean. Starting in the 1960s, he dug large holes and refilled them with acid soil in which he planted his mangosteen trees, which he also protected with windbreaks (39). His success and advice encouraged at least one other home grower to fruit the finicky mangosteen (N. Ramos, pers. comm., Jun. 2006). In addition, he donated money to Fairchild Tropical Botanic Garden (as it is now called) for the William F. Whitman Tropical Fruit Pavilion, which was started in 2003. In this greenhouse environment three mangosteen trees, which had been started some years before, have fruited since 2006 (R. Campbell, pers. comm., May 2006, Jun. 2008).

Thai Imports

All the mangosteen plantings in the Western Hemisphere are a tiny portion of those to be found in their homeland in Southeast Asia. Thailand, the world's largest producer, had 63,200 ha of mangosteens and harvested 207,300 MT in 2008 (A. Rungcharoenpornpachee and R. Chandarasrivongs, Thai Embassy, Washington D.C., pers. comm., Mar. 2009).

It was thus a major event for United States mangosteen growers and consumers when APHIS published a final rule in June 2007 allowing the importation from Thailand of fresh mangosteen, as well as pineapples, rambutans, lychees and longans. In order to kill or sterilize insect pests, the fruit needs to be irradiated at a minimum dose of 400 Gy (2, 19). The first commercial shipments, starting in early 2008, raised the question, how well would the delicate mangosteen tolerate this dose? Postharvest quality of irradiated fruit varies greatly, depending on the species, the variety, and the dose, but so far, based on several samples bought at California markets, mangosteen seems to tolerate the treatment well. Fruit from Hawaii Supermarket in San

Gabriel, Calif., in May 2008 had dark rinds, soft enough to open by hand, and pristine white flesh, without off-flavors (21). One minor cosmetic drawback is that the sepals are removed to avoid giving refuge to insects.

The first Thai imports in early 2008 sold for as much as USD \$6 apiece at high-end stores, but within a few months mangosteen became available at Asian ethnic stores in California for as little as \$13/kg. The peak season for Thai fruit, when prices are lowest, is April to September, but some fruit may be available year-round (21). Over the course of the season in 2008, Thailand exported about 430 MT of mangosteen to the United States. The wholesale price ranged from \$75 to \$120 for a 7-kg box, the standard container (A. Rungcharoenpornpachee and R. Chandarasrivongs, pers. comm., Mar. 2009).

Nutraceutical Boom

Fresh mangosteen may just be starting to arrive on the United States mainland, and in small quantities, but since 2002, nutritional supplement purveyors have aggressively marketed high-priced mangosteen juice blends for their purported medical benefits, fueling an improbable boom. Southeast Asians have long used mangosteen rind as a traditional remedy for various ailments, and laboratory studies indicate that chemicals in the rind called xanthones show promise in combating bacteria, fungi, inflammation, free radicals and cancer (24, 26). Thus far there have been only very few tests on animals, and just one published human clinical trial (24), so there is little evidence showing that mangosteen extracts are effective in humans, who metabolize xanthones differently from mice or other animals (21). The first human clinical trial was published in 2009 (35a). Meanwhile, many vendors make unsubstantiated claims, based largely on anecdotal evidence (Fig. 4).

Many purveyors sell through multilevel marketing, a sometimes controversial business model in which distributors earn commissions from new recruits. Mangosteen elixirs, made



Fig. 4. Sample of mangosteen products for sale as nutritional supplements.

with purées of the whole fruit, are pricey, ranging from \$17 to \$40 for about 750 ml, especially since they primarily contain other fruit juices and have little mangosteen flavor. Nevertheless, seizing on the recent vogue for exotic “fruitaceuticals” like noni, goji, and açai, mangosteen beverage sellers have flourished, selling not only through independent distributors, but also through health food stores and groceries (18, 21). Piggybacking on this popularity, medium-priced single-serve mangosteen juice blends, marketed primarily as beverages, but with an aura of health, started to be marketed at supermarkets in 2008; and lower-priced Thai brands of mangosteen juice, intended for consumption as a conventional beverage, also recently started showing up in Asian stores in the United States. The marketing of mangosteen for its reputed health-giving properties has the potential to boost the demand for fresh mangosteen, both domestically grown and imported, by raising the fruit’s profile and intriguing consumers.

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CALL FOR WILDER SILVER MEDAL NOMINATIONS

The Wilder Committee of the American Pomological Society (APS) invites nominations for the 2010 Wilder Silver Medal Award. All active members of APS are eligible to submit nominations. The award was established in 1873 in honor of Marshall P. Wilder, the founder and first president of APS. The award consists of a beautifully engraved medal which is presented to the recipient at the annual meeting of APS, held during the American Society for Horticultural Science annual meeting.

The Wilder Medal is presented to individuals or organizations that have rendered outstanding service to horticulture in the area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious fruit cultivars. Individuals associated with either commercial concerns or professional organizations will be considered if their introductions are truly superior and have been widely planted. Significant contributions to the science and practice of pomology other than through fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or noteworthy publications in any of the above subjects. Information about the award, past recipients, etc. can be found on the APS web site at <http://americanpomological.org/wilder1.html>.

To obtain nomination guidelines, please contact committee chairperson:

Dr. Douglas Archbold, Department of Horticulture, University of Kentucky

Phone: 859-257-3352; fax: 859-257-2589; e-mail: darchbol@uky.edu

Nominations must be submitted by May 1, 2010.