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Twelve Fruits

With Potential Value-Added and Culinary Uses

Ken Love, Richard Bowen, and Kent Fleming

University of Hawai'i at Mānoa • College of Tropical Agriculture and Human Resources

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Preface

This publication is based on activities of the "12 Trees Project," a three-year agricultural demonstration program funded by Western Sustainable Agriculture Research and Education (Western SARE), a competitive grants program of the USDA Cooperative State Research, Education, and Extension Service. The grant, titled Development of a Sustainable Polyculture Production and Marketing System for Exotic Tropical Fruits, was awarded to Dr. Richard Bowen of the Department of Natural Resources and Environmental Management, College of Tropical Agriculture and Human Resources (CTAHR), University of Hawai'i at Mānoa. Dr. Kent Fleming, a CTAHR Department of Tropical Plant and Soil Sciences extension economist based in Kealakekua, was the project co-director and prepared the cost-of-production information. Ken Love (Love Family Farms, Captain Cook, Hawai'i) was employed by the Research Corporation of the University of Hawai'i to implement the project; he gathered most of the information presented in this publication, and took the photographs.

The goals of the project were to increase profitable agricultural diversification and contribute to developing a consistently high-quality, year-round supply of fruits for local markets.

Fifty-four Hawai'i chefs, fruit buyers, and growers were invited to select the kinds of fruits they would like to see for sale in local markets, based on their desire to utilize the fruits in culinary applications. In selecting the final 12 fruits, consideration was given to seasonality and harvest times so that availability of harvested fruit and on-farm labor needs were spread over the year.

Fruit trees were planted and brought into production in a demonstration orchard at the Kona Pacific Farmers Cooperative on Nāpō'opo'o Road in South Kona. Members of the cooperative as well as members of the Hawaii Tropical Fruit Growers / West Hawai'i and other interested growers were encouraged to plant the selected trees. The site was certified as USDA organic by the Hawaii Organic Farmers Association. During the course of the three-year project, fruits from this orchard, as well as additional fruits purchased from area farmers, were donated to the University of Hawai'i Center–West Hawai'i culinary arts program, where instructors and student chefs developed recipes, some of which are included here, while others are posted on the Internet at www.hawaiifruit.net/index-recipes.html.

Acknowledgments

Mahalo to Dick Kuehner, who designed the layout of the 12 Trees Project orchard, and Fred Boech, who provided irrigation design and installation. The Kona Master Gardeners, the Kona Pacific Farmers Cooperative board of directors and members, and the Kona Outdoor Circle provided invaluable volunteer assistance at the site. Mahalo to Chef Paul Heerlein and students at the UH Center–West Hawai'i culinary arts program. Finally, Bryan Brunner, Dale Evans, Robert Paull, and Francis Zee made helpful contributions to this publication.

The authors and publisher intend that the information in this publication is reliable, but they do not assume responsibility for consequences of using the information provided.

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Cherimoya

Scientific name: *Annona cherimola*
Family: Annonaceae
Origin: South America

Cherimoya, considered to be one of the most delicious South American fruits, is thought to have originated in Peru and Ecuador and has become naturalized throughout the tropical highlands and subtropical areas of South America. The spreading, low-branched trees can grow to 30 feet tall but usually are kept shorter for ease of harvest. The leaves of different cultivars and seedling trees vary a lot in shape and can be from 3 to 10 inches long and 2 to 5 inches wide. The fruit also is found in a wide variety of shapes and sizes with varying degrees of U-shaped, smooth indentations or bumpy protuberances.

Cherimoyas generally ripen 5–7 months after pollination. Ripe fruit can be from 1 to 12 inches in diameter. The fruit contains numerous black or brown seeds, which are easily separated from the pulp. Usually eaten fresh out of hand, cherimoya is also used to flavor flan, sorbet, and ice cream. The tree is believed to have come to Hawai‘i in the 1790s, although fruiting trees were first recorded in 1825. By 1920 the tree had become naturalized in Kona and Ka‘ū on the Big Island.

Cultivars

Of the many cultivars of the fruit, a few popular types are ‘Bays’, ‘Whaley’, ‘Deliciosa’, ‘Chaffey’, ‘Booth’, and ‘McPherson’. In Spain, ‘Pinchua’ and ‘Baste’ are important. In South America, popular cultivars include ‘Lisa’, ‘Impresa’, ‘Umbonada’, ‘Papilonado’, ‘Tuberculada’ and ‘Chevez’. Varieties differ in smoothness of skin, number and size of protrusions, amount of seeds, and extent of depressions in the skin. Trees producing seedless fruit are sometimes reported. Seedlessness of fruit can be induced by repeated applications of gibberellic acid.

Environment

The subtropical cherimoya prefers higher elevations, to 5000 feet, but will bear fruit as low as 800 feet. At lower elevations, however, trees seem to be less productive and the fruit is more susceptible to insect damage. Seedling trees have been planted at lower elevations in Kona in hopes that a suitable selection can be found. Generally, atemoya (A. *squamosa* x *A. cherimola*) is recommended for low elevations. Cherimoya prefers rich, loamy, well drained soil with uniform moisture. The tree is drought tolerant and does not tolerate standing water. Orchard trees are generally spaced 20–25 feet apart but can be closer if intensive pruning is practiced. Seedling and grafted plants will bear fruit in 2–4 years given proper nutrition.

Horticulture

Shaping the young trees is important to fruit production. Limbs need to be able to support the heavy fruits, which can weigh more than 2 pounds. Usually two or three lower limbs that angle upward at about 60 degrees from the trunk are saved. The pruning style adopted in many production areas is called the open goblet. Prune during the rest period when leaves begin to fall shortly after harvest is completed. Tip rapidly growing shoots to encourage flowering.

Apply a balanced fertilizer, such as 6-6-6, quarterly. In the 12 Trees Project, under conditions of above-average initial soil fertility, one-year-old trees received ½ pound yearly; two-year-old trees received 1 pound yearly. Where soil fertility is not above average, these amounts can be doubled. An additional pound per year of growth until 5 pounds is reached is recommended. In producing

Cherimoya flower

Annona seed wasp damage

orchards, various N-P-K formulations are used, depending on the soil nutrient status. UH-CTAHR's Agricultural Diagnostic Service Center can analyze soil and offer recommendation for soil amendments; this fee-based service is available through Cooperative Extension Service offices statewide. Cherimoya usually requires extra potassium for good production, up to 10 pounds per year for mature trees. Leaf yellowing can be an indication of the soil being too wet or too dry, or it can be caused by rapid temperature changes, nutrient deficiencies, or soil pH below 5.5 or above 6.5.

Pollination

Cherimoya usually does not ordinarily yield heavily in Hawai'i. Its flowers contain both male and female organs, but they mature at different times. In major cherimoya growing areas in New Zealand and California, hand-pollination or a pollination gun is used to ensure good fruit set and result in fruits that are more uniform in size. Pollination needs to be done when the female flowers are receptive, over a 6–8 hour period. Pollen is collected in the afternoon from partially opened flowers and transferred by brush to the stigmas of female-stage flowers, either just after collection or the following morning (with pollen refrigerated overnight). This process is usually repeated for 4 or 5 days during peak flowering.

Observations in South Kona revealed that when the often-flowering soursop (*Annona muricata*) is planted among cherimoya trees, the cherimoya produces more fruit than in locations where soursop is not planted, possibly because more pollinators are attracted to the area.

Propagation

In Hawai'i, cherimoya cultivars are often grafted onto seedling rootstocks of cherimoya or another annonaceous fruit such as soursop (*A. muricata*), pond apple (*A. glabra*), or custard apple (*A. reticulata)*. The sugar apple (*A. squamosa*) is used as a rootstock in other locations where the cherimoya is grown, but it has not adapted well to Hawai'i. Airlayers and cuttings are not very successful ways to propagate the tree. Seeds can remain viable for up to two years. Soursop rootstock is commonly used in the Kona district, often with one soursop vertical remaining so that the tree will be more attractive to insect pollinators (and also produce both types of fruit).

Pests and diseases

The annona seed wasp (*Bephratelloides cubensis*), first reported in Hawai'i in 1986, has caused extensive damage to both commercial and backyard growers on O'ahu and the Big Island. The insect tunnels through the fruit after devouring the seed as larvae. The emergence holes on the developing and ripening fruit cause rapid decay and easy access for ants and other insects attracted to the fruit. Infested fruit needs to be removed from the orchard to reduce breeding grounds and prevent re-infestation. Using protective wrapping (fruit bags) after fruit set will also prevent damage from the insect.

Cherimoya is also susceptible to anthracnose (*Colletotrichum gloeosporioides*), which appears as dark spots that can produce pink spores. Black canker (*Phomopsis anonacearum*), which appears as hard or cracked purple spots on the surface, is also a problem. *Botryodiplodia*

rot (*Botryodiplodia theobroma*) causes the flesh to become brown and corky. These diseases can be minimized with good field sanitation practices and approved fungicides.

Harvesting and yield

Yields vary greatly depending on pollination practices. Five-year-old trees that have not been artificially pollinated can produce 25 or more fruits per season. Thirty-year-old trees in Italy have produced up to 300 fruits. Hand pollination tests in New Zealand produced up to 100 fruits per tree.

Timing of harvest is crucial, and care must be taken with harvested fruit. If picked too early, the fruit will not ripen properly and will become mealy. Overripe fruit can split, resulting in rapid decay.

Packaging, pricing, and marketing

Harvested fruit for wholesale markets are generally sized and packaged in single layers to prevent bruising. Ripe fruit should be kept at 32–41°F. Stores selling unripe cherimoya often put them in chilled sections of the produce department, which will prevent the fruit from ripening. Unripe fruit should not be chilled and should kept at 68–73°F. It can be stored at 50–55°F with 90–95% relative humidity for two to three weeks. In Hawai'i, cherimoya is sold by weight; 2005 wholesale prices ranged from $1.50 to $2.50 per pound, while retail farmer's market prices were as high as $5.95 per pound. In some retail locations, individual fruits are placed inside foam netting to prevent bruising.

Possible toxins

The seeds of cherimoya contain several alkaloids (anonaine, liriodenine, and lanuginosine) that should be considered poisonous. In some places the seeds are crushed and used as insecticide.

Recipe: Cherimoya mousse

Christina Pettersen

Curd:
- 6 T butter
- 4 T sugar
- 3 egg yolks
- ½ cup cherimoya puree

Combine all ingredients in a double boiler and cook until thick enough to coat the back of a spoon. Strain through a sieve and cool.

- 1 cup heavy whipping cream
- 1 env. gelatin

Whip heavy cream to soft peaks, reserving 2 T for gelatin.

Mix gelatin with 2 T water to soften. Let sit for 3 minutes. Melt gelatin in a pan and stir in reserved cream.

Beat curd until light. Drizzle melted gelatin into whipped cream and continue to beat to firm peaks.

Stir ⅓ of whipped cream into cherimoya curd. Fold in remaining whipped cream. Chill until served. Garnish with candied figs.

Nutritional value per 100 g of edible portion*

Water	68–79.39 g
Energy	74–110 kcal
Protein	1.54–1.65 g
Total lipid (fat)	0.13–0.62 g
Ash	0.64–0.67g
Carbohydrate, by difference	17.70–28.8 g
Fiber, total dietary	2.3 g
Sucrose	1.30 g
Minerals	
Calcium, Ca	8–9 mg
Iron, Fe	0.25–0.30 mg
Magnesium, Mg	16 mg
Phosphorus, P	24–26 mg
Potassium, K	269 mg
Sodium, Na	4 mg
Zinc, Zn	0.18 mg
Copper, Cu	0.073 mg
Manganese, Mn	0.083 mg
Vitamins	
Vitamin C	11.5–12.2 mg
Thiamin	0.091–0.112 mg
Riboflavin	0.112–0.119 mg
Niacin	0.574–1.02 mg
Pantothenic acid (B_5)	0.237 mg
Vitamin B_6	0.212 mg
Folate, total	18 mcg

*Values compiled from various sources

Fig

Scientific name: *Ficus carica* L.
Family: Moraceae
Origin: Western Asia and the Mediterranean

Steeped in the history and ritual of ancient cultures, the fig has endured the test of time as one of the most universally enjoyed fruits. Fig remnants were found in archeological excavations dating back to 5000 BC. Cultivation of the fruit was reported first in ancient Rome, where 29 different types of fig were grown. Believed to be indigenous to Asia Minor, the fig spread beyond the Mediterranean region before recorded history. It reached as far north as England in the early 1500s, when it was already reported as being cultivated in China. Hiram Bingham first reported the fig in Hawai‘i in 1825.

Members of the Moraceae family, figs are cousins to the *Artocarpus* species breadfruit and jackfruit.

Cultivars

There are about 1000 cultivars of fig, which are usually distinguished by their size, color of the fruit, and shape of the leaves. The National Clonal Germplasm Repository in Davis, California, has 140 fig accessions in its collection. In Hawai‘i the most common types found are ‘Brown Turkey’ and ‘White Kadota’; some ‘Black Mission’ figs are found at lower elevations.

Environment

Figs of various types can be cultivated from sea level to over 5000 feet, so the crop has potential to be grown in most of Hawai‘i’s microclimates. The plant is tolerant of most soils with good drainage. It tolerates drought and some soil salinity but not highly acidic soil.

Horticulture

The fig tree has numerous spreading branches and contains a significant amount of latex, which is an irritant and may cause skin rash. In Hawai‘i the tree grows rapidly and can achieve heights of 30 feet or more. The fruit of older trees is seldom harvested due to the height of the branches. These trees can be cut back to within a few feet above the soil.

In many regions where figs are grown the trees are pruned severely after harvest. In Hawai‘i, branches can be cut back to the first node, and new growth will appear within a month after pruning. Pruning should be done after each harvest. The tree can be pruned as an espalier or kept very low to the ground. In Hawai‘i’s lower elevations, with irrigation, fruit forms continuously throughout the year, and pruning should be frequent, with the trees shaped to facilitate harvesting. Although not necessary, irrigation at lower elevations will increase production: a ½-gallon/hour emitter for 10 minutes a day in the early morning ensured constant production at a site at 430 feet elevation. At elevations above 900 feet, the tree usually produces one or two crops per year. At mid-elevations, 600–900 feet, it will produce two or more crops per year, while at lower elevations production is continuous.

Pests and diseases

In Hawai‘i the most common problem is bird damage. Mylar tape, Christmas tinsel, and other reflective materials such as aluminum pie pans or used CDs are all effective in reducing damage. Protective fruit wrapping as the fig develops is also effective, but increased heat inside the wrappings can cause the fruit to ripen prematurely. Wrapping growing figs in newspaper was a common practice in Hawai‘i during the early 1900s. Figs are a fruit fly host, with ‘Brown Turkey’ being less

susceptible than 'White Kadota'. Following the Hawai'i Area-Wide Fruit Fly Pest Management Program recommendations is advisable. The mango flower beetle (*Protaetia fusca*) may also feed on ripe figs. Plant disease pathogens that affect fig in Hawai'i are *Alternaria tenuis,* which appears as brown to black spots on the fruit, and *Aspergillus* sp. (black mold) and *Fusarium* sp. (soft rot), which occur especially as postharvest problems.

Food uses and nutrition

Figs are high in fiber, which is good for lowering blood pressure and controlling cholesterol. Being high in fiber, they also give a feeling of fullness and are good for diets. Figs are a good source of potassium and vitamin B_6.

'Brown Turkey'

Nutritional value per 100 g of edible portion*

	Fresh	Dried
Calories	51–80	274
Moisture	77.5–86.8 g	23.0 g
Protein	0.69–1.3 g	4.3 g
Fat	0.14–0.30 g	1.3 g
Carbohydrates	12.96–20.3 g	69.1 g
Fiber	0.89–2.2 g	5.6 g
Ash	0.41– 0.85 g	2.3 g
Calcium	28–78.2 mg	126 mg
Phosphorus	21–32.9 mg	77 mg
Iron	0.6–4.09 mg	3.0 mg
Sodium	2.0–3 mg	34 mg
Potassium	188–194 mg	640 mg
Magnesium	16 mg	
Carotene	0.013–0.195 mg	—
Vitamin A	20–270 I.U.	80 I.U.
Thiamine	0.034–0.06 mg	0.10 mg
Riboflavin	0.039–0.079 mg	0.10 mg
Niacin	0.32–0.412 mg	0.7 mg
Ascorbic acid	2–17.6 mg	0 mg
Citric acid	0.10–0.44 mg	
Vitamin B_6	0.11–0.18 mg	

*Values compiled from various sources

Recipe: Fig and feta gau gee and wontons

Ken Love

Ingredients:
6 ripe 'Brown Turkey' figs
4 oz crumbled feta cheese
1 T finely chopped garlic
Fresh ground pepper
1 package wonton wrappers

Wash and cut off stem end of figs. Put figs, cheese, and garlic into food processor or blender and pulse slowly. Texture should be slightly lumpy and not liquid. Season with a pinch of fresh ground pepper.

Spread about 1 teaspoon of the mixture onto a wonton and fold to desired shape. Dampen edges of the wonton so it sticks together. Deep-fry wontons until golden brown. Makes about 50 pieces. You can also add finely chopped fresh spinach and cooked rice or orzo pasta to the mixture if desired. You can also steam the wontons or form them into shumai.

Serve with sweet and sour dipping sauce or spicy chili sauce.

Grumichama

Scientific name: *Eugenia brasiliensis* Lam.
Synonyms: *Eugenia dombeyi* (Spreng.) Skeels, *Myrtus dombeyi* Spreng., *Stenocalyx brasiliensis* O. Berg
Family: Myrtaceae; Origin: Southeastern Brazil

Grumichama, also called Brazil cherry and Spanish cherry, is an attractive tree growing up to 45 feet tall with thick, waxy, oblong, deep green, 3–4-inch leaves. The tree can be pruned as a shrub and kept at 6-foot heights to facilitate harvesting. In Hawai‘i it produces fruit from 300 to 2000 feet elevation. Mature flowering trees are reminiscent of Japanese cherry trees, producing thousands of white four-petaled flowers, each with about 100 white stamens and yellow anthers. The long-stemmed fruit is ½–1 inch in diameter and turns from green to red to dark purple and black as it ripens. One variety produces a yellow fruit. The fruit's thin, fragile skin holds juicy white to red pulp and one to three small gray seeds. The aromatic flavor is like a sweet, subacid cherry with a hint of jaboticaba.

A member of the Myrtaceae family, grumichama is related to guava, jaboticaba, mountain apple, and other members of the genus *Eugenia*, which includes more than 30 species with edible fruits. The tree was first reported in Hawai‘i in 1821 in Don Francisco de Paula Marin's journal. Grumichama may have arrived here as early as 1791.

Cultivars

There are no cultivars reported, but a number of differences have been observed in seedling trees in Kona and Puerto Rico. Three types have been distinguished based on differences in the firmness of the pulp, the number of sepals, and the color of the fruit and pulp. There are no discernible differences in flavor.

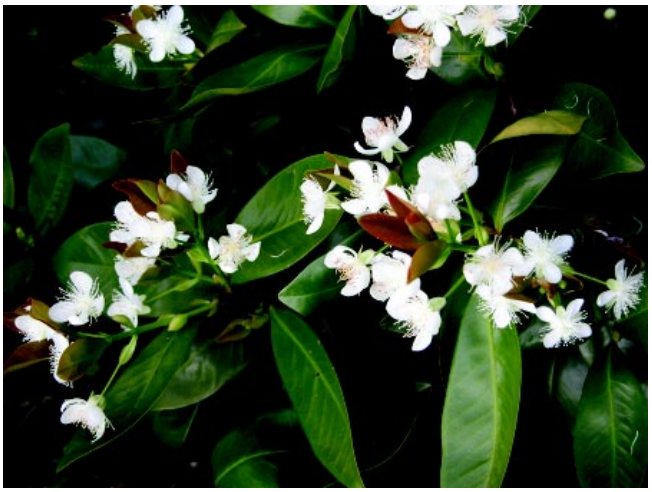
Environment

Grumichama is a subtropical plant that grows best in partial shade but will produce fruit in full sun. Fruit production is best when annual rainfall is above 70 inches; supplemental irrigation can be used where rainfall is lower. The tree prefers deep soils but will survive shallow sandy soils when given enough moisture. Fruit production generally begins in the fourth year from seedling trees that are about 4 feet tall. The trees will grow about 1 foot per year but can be kept pruned as a hedge and still produce abundant fruit. Given enough moisture, trees at elevations from 250 to 900 feet tend to produce more fruit than those at higher elevations, although leaf growth appears to be about the same. Other than that, seasonal changes and Hawai‘i's microclimates have little effect on the tree as long as it has sufficient moisture. Numerous seedlings are often found under abandoned trees. The tree is well known for the speed at which the flowers develop into fruit. Depending on the elevation and rainfall, flowering occurs in May–July, with fruit being ready to harvest 3–4 weeks after flowering.

Horticulture

Although there is some commercial cultivation in Brazil, grumichama is still regarded more as a backyard tree when left to grow tall. Cultivated trees can be maintained at heights of 10 feet or less to facilitate harvesting. Trees can be planted at 15–20 foot spacing or grown at closer spacing in hedgerows, which although attractive tend to produce less fruit than trees spaced at 15 feet.

Apply ¼ pound of organic 6-6-6 fertilizer four times per year until the third year of growth, then switch to ¼ pound of 8-8-8 and increase the amount commensurate with growth. Fertilizer should be applied around the drip line. Twice-yearly applications of compost or mulch will help growth. Micronutrients should be applied as needed. Care should be taken not to over-fertilize, which sup-



Grumichama flowers

presses flowering. The tree is tolerant of a wide range of soils that are well drained. Sufficient water is essential, especially during flowering and fruit development. One-year-old trees in a dry location at 350 feet elevation, which received 10 minutes of daily irrigation with a ½-gallon/hour emitter, showed more growth than trees without irrigation. As with most *Eugenia* species, grumichama requires a little pruning for keeping the desired height or shaping and removing dead wood. Weed control is crucial during the first few years of growth. Mulching with organic materials or black polyethylene sheets reduces weed growth. Young, shallow-rooted trees require protection from strong winds.

Pests and diseases

There are no serious disease problems with grumichama when proper cultural practices are employed. It is considered a host for fruit flies. Following the guidelines established by the Hawai‘i Area-Wide Fruit Fly Pest Management Program (HAW-FLYPM) greatly reduces the number of infestations. Birds remain the largest problem for growers of the fruit. Some Brazilian growers use netting to keep birds from the tree. Mylar tape, Christmas tinsel, and used CDs hung from the tree can help minimize bird damage. For many culinary applications where the fruit will be processed or cooked, it can be harvested when red, before birds are attracted to the sugars that develop in the dark purple, fully ripe fruit.

Propagation

Generally grown from seed, grumichama can be grafted or cloned by air-layer and cuttings. Seeds remain viable for up to 6 weeks.

Harvesting and yield

The harvest season is short, with fruits ripening over a 2-week period from May to July, depending on elevation. The thin-skinned grumichama fruit is delicate, and care needs to be taken when harvesting and packaging fresh fruits for commercial sales. Placing fruits in 1-pint containers in no more than a double layer prevents damage and maintains attractiveness. Keeping the stem on the fruit is difficult but helps to prevent desiccation. The fruit is marketable for 10–12 days after harvest. Mature, 10-foot-tall trees can yield more than 50 pounds of useable fruit. Mature trees kept pruned at 6 feet should yield about 30 pounds of fruit. Approximately 6 pounds of fruit can be processed into 8 cups of puree.

Postharvest quality

The fruits should be refrigerated as soon as possible after harvest. Samples harvested, packaged, and chilled within an hour maintain appearance and quality for 12 days. Samples left in open air for 5 hours before refrigeration (at 36°F) maintained quality for only 5 days. Fruits should be utilized as soon as possible after harvest. Processed puree can be frozen for future use, although some loss of flavor has been reported.

Packaging, pricing, and marketing

For grocery and restaurant distribution, plastic containers with single and double layers of fruit were tested with no discernable differences. Given the sensitivity of the fruit and skin, larger packages are not recommended, as the weight of multiple layers of fruit will damage the skin and cause indentations that make the fruit less desirable when used in displays. As many chefs and pro-

duce buyers in Hawai‘i are not familiar with grumichama, it is advisable to offer samples as well as information on the fruit. Fruit availability is generally for only 2 weeks of the year, and advance notice given to buyers will help in generating sales. Having a good working relationship with chefs and wholesale buyers will ensure that the fruit does not go to waste. Culled and excess fruits can be processed in a certified kitchen for future use. Many island chefs prefer to work with frozen puree.

Fresh fruit in plastic blister packs sold for $7.00 per pound to hotel and restaurant chefs. Wholesale buyers and grocery store buyers paid $4.50 to $5.50 a pound. Processed puree in 8-cup packages sold for $50.00. An 8-cup package can yield approximately 24 4-oz jars of jelly with a wholesale value of about $100.00.

Food uses and nutrition

Grumichama is generally eaten fresh. Chefs have used it in buffet lines and as an edible decoration on plates. The taste has been described as a cross between black cherry and jaboticaba with a hint of Concord grape. Grumichama jelly and syrup can be found at some of Hawai‘i’s farmers’ markets. In the Caribbean, a reduction made from the juice of the fruit is used to accompany fish dishes. It can also be used as base for hot sauces.

Whole pitted fruits can be used in pies, cakes, and fruit salads. Processed puree is used in jam and jelly or in sauces. The pulp is juicy with a dry “grape like” skin.

Average degrees Brix

18 (10 samples from three trees at three elevations)

Fruit flavor *(scale: 0 to 5)*

Sweet to sour, 1.5
Bitterness, 0.5; with skin, 2
Astringency, 0.5; with skin, 2.25

Nutritional value per 100 g of edible portion*

Moisture	84 g
Protein	0.3 g
Fiber	0.6 g
Ash	0.43 g
Calcium	39.5 mg
Phosphorus	13.6 mg
Iron	0.45 mg
Carotene	0.039 mg
Thiamine	0.044 mg
Riboflavin	0.031 mg
Niacin	0.336 mg
Ascorbic acid	18.8 mg
Carbohydrate	13.4 g
Fat	0.3 g
Vitamin A	67 IU

*Values compiled from various sources

Grumichama “clam-shell” fruit pack for retail sale

Grumichama tart with lilikoi sauce

Kumquat

Scientific name: *Fortunella* species
Family: Rutaceae
Origin: Southern China

Kumquat (cumquat) means golden (kum) good fortune (quat) in Cantonese Chinese. A potted kumquat tree with fruit is the ornament of choice during the Chinese New Year celebration in Southeast Asia, a tradition similar to the display of Christmas trees. The fruits are used in many Asian ceremonies and as offerings on the home altar. Kumquat is called jinju in Mandarin Chinese and kinkan in Japanese. It was described in Chinese literature as early as 118 BC and was first mentioned in European literature in the early 1600s. Chinese immigrants probably brought kumquat to Hawai‘i, perhaps as early as 1825.

Types

There are a number of kumquat species, including meiwa (*Fortunella crassifolia*), and nagami (*F. margarita*), the two most common species grown in Hawai‘i. “Hong Kong wild” (*F. hindsii*), marumi (*F. japonica*), *F. obovata*, and *F. polyandra* are other species found from Southeast Asia to Japan.

Environment

Considered a subtropical tree, the kumquat can be grown from low elevations up to 5000 feet. Newly planted trees at low elevations benefit from shading until well established. Kumquat is slow-growing and will enter periods of winter dormancy. It rarely grows taller than 15 feet.

Horticulture

Kumquat is sensitive to drought and flooding but tolerant of a wide range of temperatures. It is often grown as a decorative hedge in Japan, planted as close as 3 feet apart. In orchard plantings in California the trees are spaced 5–12 feet apart. Fertilizer applications every four months with 6-6-6 organic or all-purpose citrus fertilizer will keep the tree healthy and producing. Irrigation is helpful during periods of extended drought.

Pests and diseases

Kumquat is a fruit fly host, so following the recommendations of the Hawai‘i Area-Wide Fruit Fly Pest Management Program (HAW-FLYPM) is highly advisable. *Phyllocnistis citrella*, the citrus leafminer, can be a problem, and a range of insecticides, including oil-based products, are labeled for use against such leaf pests. If the product label allows, application should be repeated every 2 weeks when the plant flushes. *Phytophthora citrophthora*, a fruit rot, and *Lasiodiplodia theobromae*, a fruit and stem rot, also can affect the plant. Initial symptoms are yellowing and browning of leaves on some branches. These branches as well as any dead wood should be pruned and disposed of.

Propagation

Kumquat is rarely grown from seed, as seedling roots do not grow well. Commercial orchards in China use shield budding on trifoliate orange rootstock, although rangpur lime and grapefruit rootstocks are also acceptable. Air-layers and other forms of grafting are also possible. Lemon and sweet orange are not used as rootstock, as they grow too vigorously for the slow-growing kumquat.

Ripe nagami kumquats

Meiwa

Harvesting and yield

Fruits are harvested when fully ripe and orange. Fruits should be free of defects and inspected carefully for damage from fruit flies. In Hawai‘i, meiwa kumquat is sometimes confused with calamansie (*Citrus microcarpa*), which bears a small, round, orange-colored lime. The meiwa fruit has a much thinner skin and much sweeter taste than the lime. Meiwa also does not fruit as heavily as calamansie, which often produces large clusters of limes. China is the largest producer of kumquats, with more than 18,000 tons harvested yearly.

Postharvest quality

When stored at 36–39°F, kumquats keep well for 1–2 months in commercial produce storage refrigerators, or about 2–3 weeks in a home refrigerator. Juice and whole or sliced fruits can be frozen for future use. At room temperature the fruit will last only a few days. The thin-skinned fruit should be packaged in blister packs no more than 3 inches deep to prevent compression damage.

Packaging, pricing, and marketing

Kumquats sold in Asia and Hawai‘i are either sold loose, with or without leaves, or packaged in small blister packs. Packaged fruits should be free of defects and inspected for possible fruit fly damage. Kumquats should be fully ripe and orange when packaged. If sold with leaves attached, the leaves should be free of insect damage. In Hawai‘i, kumquats are more commonly found in farmers’ markets but are occasionally sold in supermarkets around the New Year holiday. Prices in Hawai‘i range from $2.50 to $7.00 per pound for both wholesale and retail. Chefs often request the best quality fruit for their culinary creations.

Nagami

Food uses and nutrition

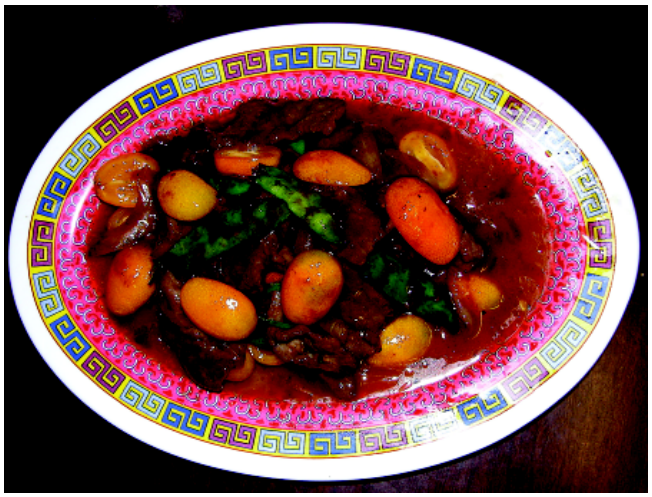
Kumquats are a good balanced source of vitamins and antioxidants. Cryptoxanthin, zeaxanthin, and lutein are essential for eye and vision care. Kumquats are eaten fresh or made into jams, jellies, and pickles; candied; and used in a wide variety of recipes.

Nutritional value per 100 g of edible portion*

Water	80.85 g
Energy	71 kcal
Energy	296 kj
Protein	1.88 g
Total lipid (fat)	0.86 g
Ash	0.52 g
Carbohydrate, by difference	15.90 g
Fiber, total dietary	6.5 g
Sugars, total	9.36 g
Minerals	
Calcium, Ca	62 mg
Iron, Fe	0.86 mg
Magnesium, Mg	20 mg
Phosphorus, P	19 mg
Potassium, K	186 mg
Sodium, Na	10 mg
Zinc, Zn	0.17 mg
Copper, Cu	0.095 mg
Manganese, Mn	0.135 mg
Vitamins	
Vitamin C, total ascorbic acid	43.9 mg
Thiamin	0.037 mg
Riboflavin	0.090 mg
Niacin	0.429 mg
Pantothenic acid	0.208 mg
Vitamin B6	0.036 mg
Folate, total	17 mcg
Folate, food	17 mcg
Folate, DFE	17 mcg
Vitamin A	290 IU
Vitamin A, RAE	15 mcg
Vitamin E (alpha-tocopherol)	0.15 mg
Carotene, alpha	155 mcg
Cryptoxanthin, beta	193 mcg
Lutein + zeaxanthin	129 mcg

*Values compiled from various sources

Kumquat sorbet



Kumquat Mongolian beef as served in a restaurant in Captain Cook, Hawai'i

Recipe: Kumquat, ginger, and Chinese 5-spice marmalade

Chef Paul Heerlein

8 cups thinly sliced kumquats
½ cup tangerine juice
6 oz pectin
5½ cups sugar
3 T finely minced fresh ginger
1 tsp (heaping) Chinese 5-spice

In a saucepan, combine the kumquat and tangerine juice and bring to a boil. Slowly add the pectin while whisking, and then bring to a second boil. Add sugar while whisking and bring to boil again. Turn off the heat, stir in the ginger and 5-spice, and bottle immediately. Boil the filled jars for twenty minutes.

Loquat

Scientific name: *Eriobotrya japonica*
Family: Rosaceae
Origin: China

Loquat is among the first fruits cultivated in Asia and is steeped in ancient Chinese mythology. For centuries only the Chinese royalty was allowed to eat the fruit, as it was thought that loquat fruit falling into the rivers gave the koi, or carp, the strength and desire to swim against current and up waterfalls and be turned into mythical dragons. The fruit was introduced from China to Japan as early as 700 AD. In 914 the first Chinese medical textbook was translated to Japanese and mentioned how to use loquat to obtain clear lungs. Japanese law books in the early 900s stated the proper way to present loquat as an offering to the Shinto gods. In Hawai‘i, loquat is sometimes called pipa (Chinese) or biwa (Japanese).

Loquat is one of the most popular fruits in the world. It was grown in Europe in the early 1700s. Spain, China, and Japan are the world's largest commercial producers. Loquat is also very popular in the Middle East, India, South America, and South Africa.

The fruit may have been introduced to Hawai‘i as early as 1787 with Chinese visitors. In 1831, Dr. F.J.F. Meyen wrote of hearing about a Chinese settlement on Maui prior to Captain Cooks' arrival. Loquat was found in the yards of many of Hawai‘i's first Asian immigrants.

Cultivars

There are over 900 loquat cultivars, and work on the crop is conducted in many growing areas around the world. In Hawai‘i, common varieties are 'Tanaka', 'Gold Nugget', 'Mammoth', 'Advance', and 'Wolf'. Varieties introduced in the 1990s from Japan include 'Obusa', 'Fusahikari', and 'Mizuho'. Many older, wild loquat trees in Hawai‘i are thought to be seedlings and produce small, inferior fruit. These trees can be top-worked and grafted with newer varieties. A seedless variety, 'Kibou', was developed in 2003 in Chiba, Japan, but it has not yet been released to growers.

Environment

A subtropical tree, the loquat is well adapted to Hawai‘i's wide range of climates. It prefers upper elevations from 1000 to 5000 feet but is often found grown at lower elevations as an ornamental. Loquat leaves are sometimes used as fodder or made into tea. The fruit is susceptible to sunburn at lower elevations. The tree tolerates most soils with good drainage. Salt spray can cause leaf drop.

Horticulture

Loquat grows rapidly and needs frequent pruning to keep it managed and facilitate harvesting. The tree has a shallow root system and may require irrigation at lower elevations. Trees at the 12 Trees Project site, at 430 feet elevation, were given 15 minutes of water daily with a ½-gallon/hour emitter. The tree is a heavy feeder and requirements for fertilizer vary greatly depending on location. Generally, in Hawai‘i, ½ pound of 6-6-6 fertilizer applied four times per year to mature trees will ensure good fruit growth. Loquat can be pruned as an espalier or kept low to the ground. Multiple branches on new growth are removed, leaving only the top and bottom branches.

In Asia, various techniques are used to produce large fruit with high quality. As flowers develop, they should be thinned to three bottom stalks (racemes). Depending on the variety, only three to five fruits are left on each panicle. The fruit should be covered to protect it from

Loquat inflorescences are trimmed to have fewer flowers; after the fruits develop, they are thinned to three or four per inflorescence and then bagged.

fruit flies and to slow coloration. Double bags used in Japan reduce the light reaching the fruit for 80% of fruit development. When that is reached, the outer bag is removed, leaving the inner bag, which permits 60% of the light to reach the fruit. Most loquats turn from green to yellow to light orange when ripe.

In general, loquat flowers and fruits in Hawai‘i earlier than other growing locations, from late November through April, with peak production in January and February.

Pests and diseases

Loquat is a fruit fly host. In addition to the protective wrapping, following the Hawai‘i Area-Wide Fruit Fly Pest Management Program recommendations is highly advisable. The tree is also susceptible to nematodes. Good sanitation should be practiced. Green scale (*Coccus viridis*) can also affect the plants. Loquat can be affected by fire blight (*Erwinia amylovora*), and damaged wood should be removed and disposed of.

Propagation

Loquat does not produce true to seed but is easily grafted. Older trees can be top-worked to change the variety. Scions for grafting should be from 2-year-old wood taken 3–4 months before the tree usually produces fruit. Air-layering also works well with loquat.

Harvesting and yield

Loquat is very fragile and should be packaged in the field while harvesting. The fruit should be picked when orange colored. Fruit stems should be cut close to the fruit and not pulled off. Trees can produce from 100 to 300 pounds of fruit per season. A mature ‘Gold Nugget’ loquat tree in South Kona at 1800 feet elevation, covering a 20 x 25 foot area at a height of 12 feet, produced 300 pounds of marketable fruit.

Bruised and sunburned fruit can be used in value-added products such as jam.

Postharvest quality

Loquat can be kept in cold storage for 2 months with little damage. In grocery stores it should be kept in chilled areas of the produce section to ensure quality.

Packaging, pricing, and marketing

Loquat is packaged differently for hotel and restaurant markets than it is for grocery or sales at farmers’ markets. The fruits should be packaged so that they do not touch other fruits, which can cause bruising and discoloration. Fruit size can vary greatly, and same-sized fruit should be packaged together. Current wholesale prices in Hawai‘i depend on fruit size and can range from $2.00 per pound to $3.50 a pound or more. Retail prices in Japan for top-quality fruit can be as high as U.S. $50 for 12 fruits. Loquat is a popular fruit with hotel chefs, who wish to feature it both as fresh and in various recipes. Loquat can used in many value-added products. The fruit is the main ingredient in over 1000 food products in Japan and is often the featured topic on TV cooking shows.

Food uses and nutrition

Loquat is a good source of vitamin A; just a few fruits can provide up to half the recommended daily allowance. Vitamin A is important to visual and dental health. For thousands of years, the Chinese used extract from loquat leaves as an important ingredient for lung ailments.

Bagging loquat fruits is a common practice throughout Asia; these trees are in South Kona.

Bruised or sunburned fruits are still useful in many recipes.

Branches can be tied down to keep trees low.

Nutritional value per 100 g of edible portion*

Moisture	87 g
Calories	47–168
Protein	0.43–1.4 g
Fat	0.64–0.7 g
Carbohydrates	11–43.3 g
Fiber	0.83–1.7g
Ash	0.48 g
Calcium	9–70 mg
Iron	0.14–1.4 mg
Phosphorus	11–126 mg
Potassium	185–1216 mg
Vitamin A	1122–2340 I.U.
Ascorbic acid	0–3 mg

**Values compiled from various sources. Ranges vary greatly due to degree of ripeness of fruits tested.

A "wild" type of loquat

Recipe: Poha loquat salsa

Vince Mott and Ann Rothstein

3 lb poha, cut in half
1 lb loquat, peeled and seeded
3 small mangoes, diced
¼ cup red onion, minced
1 red bell pepper, minced
3 Anaheim chilies, roasted and diced
1 Kona Rangpur lime, juiced
3 slices fresh ginger
Zest of 1 tangerine
2 cups sake
6 cups water
1 T lilikoi puree
1 T olive oil
1 pinch salt
Optional: ¼ cup cilantro

Cook peeled loquats in simple syrup (1 cup water and 1 cup sugar), then cut and dice. Save syrup to flavor salsa, if desired. Mix loquat with other cut fruit and other ingredients. Add additional lime juice to taste.

Mysore Raspberry

Scientific name: *Rubus niveus* Thumb. Synonym: *Rubus albescens* Roxb.
Family: Rosaceae
Origin: India, Burma

Mysore raspberry, also called snowpeaks, Ceylon raspberry, and hill raspberry, is a large shrub sometimes growing to over 15 feet tall. Its 2–4 inch leaves are dark green on top and white or light green on the underside. Its long, white cane, rachis, petiole, and midrib all have sharp, curved spines or thorns. The five-petaled, pink to red-purple flowers occur in axillary and terminal clusters. The fruit turns from red to purple and black when ripe. Clusters can contain more than a dozen fruits. Among over 200 species of edible *Rubus* found worldwide, this is one of the few that will grow at low elevations in the tropics.

The plant spreads when the tips of its long canes bend down to the ground and root. Seed germination is slow and very irregular. In 15 years at a South Kona farm and 10 years at a Honalo farm, the plant has not been found outside of the area where it is cultivated. Commercial cultivation has been reported in Florida, India, and Puerto Rico as well as in Hawai‘i.

In Hawai‘i there are two endemic *Rubus* species and several that are naturalized. The Hawaiian Ecosystems at Risk project reports that *Rubus niveus* was introduced in 1965. It is classed as a noxious weed by the Hawai‘i Department of Agriculture. Kaua‘i, O‘ahu, Moloka‘i, and Lāna‘i are free or relatively free of the plant, and state law prohibits importation of *Rubus niveus* plants or propagative materials to those islands (fruits for consumption are allowed).

Cultivars

There are no selected cultivars. No variation has been reported in new plants made from tip cuttings.

Environment

The Mysore raspberry enjoys an extensive climatic range. It is found as high as 10,000 feet elevation in its native area and as low as 300 feet elevation in the tropics. The shrub will grow in a wide range of adequately drained soils, in full sun or semi-shaded areas. Plants will produce fruit within the first year of planting.

Horticulture

Where cultivated in Hawai‘i, young tip-rooted plants are usually placed 3–6 feet apart in rows where a trellis and wire is used to keep the canes upright and facilitate harvesting. Rows are spaced 7–9 feet apart. Commercial raspberries in U.S. mainland locations average 1200 plants to the acre with trellises. Frequent pruning is done to keep the canes from growing to excessive lengths and from touching the soil, where they will root and spread. Harvested branches are removed, as are old canes. This ensures fresh growth and production the following year.

Although the plant will produce fruit year-round, in Hawai‘i the bulk is harvested from February to June. Irrigation is essential in dry areas. Quarterly fertilizer application with 6-6-6 and bi-monthly mulching ensures steady growth and production. Apply 1–2 oz of fertilizer per plant quarterly during the first year, followed by 4–6 oz in subsequent years. Due to the spreading nature of the plant, frequent pruning is advised. If left unchecked, the planted area will more than double within a year, making harvesting difficult and time-consuming. Because of the sharp, curved thorns, it is advisable to use leather gloves when training the plants to the trellises, pruning, and harvesting. The difficulty of work-

The red berries are half-ripe, the black ones are ripe.

The plant's thorns are a major drawback to its commercial use.

ing with this plant is reason to give serious consideration to whether or not it should be planted.

Pests and diseases

Southern green stink bug (*Nezara viridula*), red-banded thrips (*Selenothrips rubrocinctus*), and broad mite (*Polyphagotarsonemus latus*) and other mites damage young leaves and are occasionally found on the undersides of leaves, usually those low to the ground. Aphids spread raspberry leaf curl, a virus. Regular applications of organic soaps or organic pesticides on non-fruiting canes will control most of the pests. Damage to the fruit by insects and birds has been reported. No fruit fly infestation has been reported.

Propagation

Seed germination is slow and irregular. Plants can be propagated from stem cuttings, but the preferred method is tip-rooting. Pots with peat moss and soil are placed around a mature shrub, and the tips of its canes are buried in the medium. The potted plants are ready for field planting in 4–5 weeks, after new growth appears and the parent cane is cut.

Harvesting and yield

Berries picked for market should be three-fourths purple-black. Fully ripe, purple berries have a shorter shelf life but can be harvested for immediate culinary use or frozen for future use. Harvest should be daily during peak periods or in excessively hot or wet weather and at least twice weekly during other times. Berries are picked and placed directly in the marketing container (a vented clamshell), generally on top of an absorbent pad or piece of napkin lining the bottom of the container. Putting no more than two layers of berries in a container will prevent damaged fruit. To maximize shelf life, berries should be cooled no more than 30 minutes after picking. Damaged or culled berries can be placed directly into freezer bags and frozen for culinary use. In Florida, plants that received afternoon shade had a higher yield than those in full sun. At the 12 Trees Project site, eight plants were trellised in an area 4 feet by 30 feet. In South Kona, a single plant produced 4000 fruits weighing 14.5 pounds in a 1-year period.

Postharvest quality

Berries should be chilled immediately after harvest. Loss of marketable fruit can be as high as 30 percent in some raspberry growing areas due to poor handling during the harvest and improper postharvest care. Raspberries should be stored at 31–32°F with relative humidity of 90%. Improper chilling or display in retail outlets can cause gray mold (*Botrytis cinerea* Pers).

Packaging, pricing, and marketing

The Mysore raspberry was in great demand by hotel chefs on the Big Island in 2005, even with the ready availability of raspberries from the U.S. mainland. Chefs have expressed a desire for locally produced fresh berries for use as both a decorative topping on desserts and for producing sauces or glazes. Packaging a single layer of fruits can be time-consuming but will ensure product stability for decorative purposes. Culled fruits can be placed directly into freezer bags and frozen for future sale. As the time from harvest to chill is crucial for the longevity of the berry, it is advisable to have a cooler in the field so that each filled 2-oz clamshell container can be kept cool and out of direct sunlight. Fresh and frozen berries were sold directly to hotel and restaurant chefs for $7.00 per pound. An 8-cup package of berries will yield approximately 24 4-oz jars of jam with a wholesale value of $108.00.

Plastic "clam-shell" pack; the napkin absorbs moisture.

Food uses and nutrition

High in manganese, 1 cup of berries supplies more than 60% of the recommended daily allowance. Manganese helps the body with calcium absorption and aids in the prevention of osteoporosis. The berry is also a good source of dietary fiber.

Average degrees Brix

14 (6 samples from 6 shrubs at 250 foot and 1300 foot elevations)

Nutritional value per 100 g of edible portion*

Energy	28 kcal
Moisture	90 g
Protein	1.3 g
Carbohydrates	4.4 g
Fat	0.6 g
Fiber	3.7 g
Beta carotene	6 g
Retinol equivalent	2 g
Vitamin E	1.40 mg
Thiamin	0.03 mg
Riboflavin	0.05 mg
Niacin	0.50 mg
Vitamin B_6	0.10 mg
Folacin	26 g
Vitamin C	27 mg
Fat	
Saturated	0.1 g
Unsaturated	0.1 g
Polyunsaturated	0.4 g
Cholesterol	0 mg

*Values compiled from various sources

Recipes

Raspberry butter

Jokrishner Arrellano and Chef Paul Heerlein

2 lb soft butter
10 oz Mysore raspberry puree
1 T sugar or honey to taste
1 cup tree tomato (tamarillo) sauce

Mix together. Pipe into rosettes and freeze on a steel pan. Pieces can stored in freezer bags for future use.

Mysore raspberries terrine

Chef Paul Heerlein

1½ lb white chocolate, chopped
2 qt cream
2 qt Mysore raspberries

Boil 1 qt cream. Pour over chocolate and whisk until smooth. Pour remaining quart of cold cream over. Wisk in. Refrigerate one day ahead. Fold raspberries into chocolate mousse. Pour into terrine mold and freeze for one day. Slice. Serve with a Mysore raspberry sauce.

Poha (Cape Gooseberry)

Scientific name: *Physalia peruviana L.*
Family: Solanaceae
Origin: Peru

Cape gooseberry, called poha in Hawai‘i, was distributed by early explorers and first reported in England in 1774. A commercial crop in many countries, the poha is often used in Hawaiian Regional Cuisine. First noted on the Big Island in 1825, the fruit is common in the wild and cultivated for home and commercial use around the state.

The plant is a low-growing shrub with velvety leaves and yellow, bell-shaped flowers. Mature fruit is round and orange skinned with many edible seeds. It is juicy and sweet with a distinctive flavor.

Cultivars

Poha is also known as golden berry in many English-speaking countries. In Australia, it is marketed under the cultivar names ‘Golden Nugget’ and ‘New Sugar Giant’. Growers in New Zealand often take cuttings from plants that produce the sweetest fruit for propagation.

Environment

Poha is commonly found at upper elevations on mountain slopes from 1000 to 4000 feet and is reported to occur as high as 8000 feet. Plants at lower elevations usually produce smaller fruit. Because it is non-native in Hawai‘i and birds distribute its seeds, poha is regarded as an invasive species, although its threat to native species and ecosystems is not well characterized.

The plant’s shallow root system is best adapted to soils with good drainage. The plant is among the first to take root in newly cleared lands and does well in relatively poor soils. Fertile soils favor vegetative growth over fruit production. Poha becomes dormant during extended periods of drought unless irrigated. Harvesting is facilitated when plants are spaced 4–6 feet apart in rows and, optimally, trellised or staked. Planting in raised beds has helped ease the labor of harvesting.

Horticulture

Poha tolerates a wide variety of soils with pH between 5.0 and 6.5. Because of its shallow root system, similar to that of tomato, mulch and organic soil amendments help retain water and nutrients. Plants at the 12 Trees Project were given ¼ cup of 6-6-6 organic fertilizer every 4 months, placed around the drip line. Fruit ripening can take several months, and harvest generally occurs 60–100 days after flowering. Poha should be severely pruned after harvest, and plants should be replaced after 3–4 years when fruit size and yield diminish.

Pests and diseases

The broad mite, *Polyphagotarsonemus latus*, feeds by puncturing the stem and sucking the sap from the wound. This will stunt growth, discolor leaves, and deform young foliage. The solanaceous treehopper (*Antianthe expansa*), thrips, and various beetles can also affect the plant. Sooty mold (*Asteridiella acervata*), root-knot nematode (*Meloidogyne* sp.), and bacterial wilt (*Pseudomonas solanacearum*) are among the pathogens that can affect poha. In general, good field sanitation, appropriate horticultural practices, and an integrated pest management program can prevent crop damage.

Propagation

Poha is usually started from seed but can be started from stem cuttings 6–8 inches long. A rooting hormone will help induce rooting. Young seedlings are susceptible to

Papery fruit sacks (and a praying mantis)

high temperatures, and it is advisable to plant them in the late afternoon or during cloudy weather. Seedlings should be kept moist and shaded.

Harvesting and yield

Poha is harvested every few days, when the husks are dry and turn to a straw color. It is often picked in the afternoon, when there is little moisture. Many growers shake the bush so that the dry husks fall and are easily picked up from the ground. Plastic sheets are sometimes placed under the plants to catch the fallen fruit.

Plants at lower elevations (300–700 feet) under irrigation produce small fruit in large quantities, sometimes more than 1000 fruits per plant. Higher elevations (700–3000 feet) without irrigation produce an average of 300 large fruits per shrub. Averages in South America are 3000 pounds of fruit per acre. Laborers harvest 10–12 pounds of in-husk fruit per hour.

Postharvest quality

Poha will last up to several months dry and in-husk. Large commercial producers store them in-husk at 33°F. They will keep more than a year when husked and frozen. The husks are kept on when shipping the fruit, and it should be stored dry.

Packaging, pricing, and marketing

In Hawai‘i, poha fruit is often sold husked in local groceries and farmers’ markets. In Japan, the fruit, grown

Poha flower

Harvesting poha at the 12-Trees Project orchard

in South America, is sold in-husk in small blister packs. In Hawai‘i, poha can wholesale to restaurants for as much as $3.50 in-husk and $7.00 husked, but it is often found cheaper in grocery stores. Jam manufacturers and restaurants throughout Hawai‘i continuously seek fresh and fresh-frozen husked poha.

Food uses and nutrition

Poha is often eaten fresh and made into jelly and jam or canned whole for culinary purposes. In Europe, the fresh fruit is dipped into chocolate or used to decorate cakes. It is also used in sauces.

Poha is a source of phosphorus, which helps the body process vitamins and aids in the conversion of food to energy. The primary benefit of phosphorus is the building of bones and teeth, when balanced with calcium and magnesium. Poha also contains a cross-section of bioflavonoids (vitamin P), which help with anti-inflammation and act as natural blood thinners.

Husked poha fruits

Nutritional value per 100 g of edible portion*

Moisture	78.9 g
Protein	0.054 g
Fat	0.16 g
Fiber	4.9 g
Ash	1.01 g
Calcium	8.0 mg
Phosphorus	55.3 mg
Iron	1.23 mg
Carotene	1.613 mg
Thiamine	0.101 mg
Riboflavin	0.032 mg
Niacin	1.73 mg
Ascorbic acid	43.0 mg

*Values compiled from various sources.

Recipe: **Poha apple vinaigrette**

Chef Sandy Barr

2 green apples
1 cup poha
½ tsp sage
1½ tsp tarragon
1 tsp salt
1 tsp chopped garlic
3 T sugar
½ cup white wine vinegar
¾ cup vegetable oil

Peel, seed, and quarter apples. Microwave for 5 minutes.

Place all ingredients except poha and oil in a food processor. Puree well and then, with processor running, slowly add the oil. Add berries last, and process until they are just broken. Yield: 3 cups.

See also the recipe for poha-loquat salsa, p. 20.

Pomegranate

Scientific name: *Punica granatum* L.
Family: Punicaceae
Origin: Iran, Afghanistan, India

One of the earliest cultivated fruits, mentioned in ancient Egyptian mythology, the pomegranate is steeped in history and tradition. Early travelers carried the fruit throughout the Middle East and Northern Africa. The fruit became the symbol of the lands of Armenia. Eating pomegranate was said to "purge the system of envy and hatred." Recent worldwide popularity of the fruit and its juice is due to the health benefits from antioxidants in the fruit.

Spanish settlers first reported pomegranate in California in 1769. The fruit is commonly referred to as grenade or granada or by the Persian names dulim or dulima. In Japanese the fruit is called zakuro, and it is sometimes sold under that name in Hawai'i. Dr. F.J.F. Meyen first observed it in Hawai'i in 1825, and Hiram Bingham reported it for sale in a Honolulu market in 1831.

Cultivars

There are hundreds of known pomegranate varieties. The USDA germplasm repository in Davis, California, has 189 accessions from many parts of the world. Pomegranates can be divided into four groups based on skin color: dark red, yellow-green, black-violet, and white. Plants do not come true from seed, and therefore seedling trees in Hawai'i are highly variable in quality. Compared to cultivated varieties, seedling trees often have larger seeds that make up over half of the fruit's weight. In India, the seeds are used for culinary purposes, and some varieties reflect this by having 70 percent of the fruit weight being seeds. A cultivar from California named 'Wonderful' is found in Hawai'i. 'Grenada', a patented variety that matures a month earlier than 'Wonderful', is also found here.

Environment

Pomegranate trees tolerate a wide range of soils and are very tolerant of drought. Irrigation is used to guarantee fruit production, as trees will not flower in extended periods of drought.

Trees are spaced 15–20 feet apart in commercial orchards. Generally, 20-foot spacing is used in large orchards to facilitate weeding and field maintenance. Wide spacing and planting in full sun allows enough light to reach the fruit to ensure coloration.

Horticulture

Pomegranate requires an active pruning regime for the first 3 years in the field. After planting, the low side shoots should be cut off to leave one or more trunks. The tree is a vigorous grower, with many root shoots and suckers that should be removed, as they generally do not bear fruit, and they grow rapidly at the expense of fruiting wood. Fruit forms only at the tips of new growth. Branches should be shortened to encourage new shoots, and the tree should be kept low to facilitate harvesting. Fertilizer is generally applied in fall or winter, with ½ pound of nitrogen followed by ¼ pound of 6-6-6 organic fertilizer in spring for young trees. The trees reach full production in 5–6 years. Some producing trees in the Middle East are reported to be 200 years old.

Pests and diseases

Pomegranate can suffer foliar damage from whitefly (*Aleurodicus* sp.), thrips (*Selenothrips* sp.), mealybugs (*Pseudococcus* sp.), and scale (*Ceroplastes* sp.).

Wet fruit rot (*Phomopsis* sp.) can occur at the base of the fruit. Removing and disposing of affected fruit is

Pomegranate flower

The red flesh covering the seeds is the edible portion.

advisable to prevent spread of the fungus. Fruit rot from *Botrytis cinerea* can occur after harvest from improper storage.

The hard shell of the fruit prevents damage from a number of insects, but the base of the fruit, the calyx, and the stamen cluster can be home to ants, roaches, and other pests. Some growers will cut the stamen cluster off half-way through the growing cycle to prevent infestation. In Asia, it is common to use protective wrapping or fruit bags on pomegranate once the fruit is set. This helps to prevent damage from pests and diseases. It also helps produce even fruit coloration.

Propagation

Pomegranates are commercially propagated from hardwood cuttings 10–20 inches long, treated with a rooting hormone used to ensure development. Air-layers are also possible. Seeds germinate easily but often produce unreliable results. Grafting is seldom successful.

Harvesting and yield

Fruit ripens 6–7 months after flowering but will crack if left too long on the tree. Generally, fruits are harvested once they turn color and before yellowing appears at the base.

The fruit does not continue to ripen once harvested, and timing can be critical in commercial orchards. Growers in Israel and California tap the fruit, listening for a metallic sound that tells them it is time to harvest. Strong stems make it necessary for the fruit to be cut from the tree and not pulled off by hand. Mature, healthy trees can produce 100–200 fruits. Kona trees at 400 feet elevation produce three to five fruits per week throughout the year when irrigated. An older tree at 1800 feet elevation in South Kona produced more than 200 fruits from July through December.

Postharvest quality

The pomegranate has a long storage life, more than 7 months when held at 32–41°F and 80–85% relative humidity. The fruit is susceptible to chilling injury and browning if stored below freezing.

Packaging, pricing, and marketing

In production areas in California, the fruit is packed in boxes by size with the calyx or stamen end up, often in molded plastic trays to prevent bruising. In Hawai‘i, the fruit is often sold at autumn farmers’ markets in boxes. It is also sold to hotel chefs, who prefer fresh, locally grown pomegranates to treated imports. Wholesale prices run from $2.00 to $2.50 per pound. Fruits sold at farmers’ markets on the Big Island sell for $0.50 to $2.00 each, based on size.

Food uses and nutrition

Pomegranate juice can help prevent hardening (arteriosclerosis) of the carotid arteries. The seeds, which are used as a spice in India, are high in fiber. The fruit is high in antioxidants including phenolic compounds and anthocyanins.

Immature fruits

Recipe: Pomegranate syrup on pineapple banana sorbet

Kalani Adams

24 cups sugar
6 split Hawai'i vanilla beans
6 pineapples
12 ripe bananas
6 T pomegranate syrup
4 cups water

Peel, core, and trim pineapple. Peel bananas.

In medium saucepan, dissolve sugar in 4 cups of water over moderately high heat. Add vanilla bean and let mixture infuse until cool. Pass though chinois to remove any solids.

Puree pineapple and banana in a food processor. Add sugar mixture and process just until mixed. Stir in pomegranate syrup. Pour mixture into ice cream maker and freeze until firm. Drizzle additional pomegranate syrup before serving.

Makes 48 servings.

Nutritional value per 100 g of edible portion*

Calories	63–78
Moisture	72.6–86.4 g
Protein	0.05–1.6 g
Fat	0.9 g
Carbohydrates	15.4–19.6 g
Fiber	3.4–5.0 g
Ash	0.36–0.73 g
Calcium	3–12 mg
Phosphorus	8–37 mg
Iron	0.3–1.2 mg
Sodium	3 mg
Potassium	259 mg
Carotene	None to trace
Thiamine	0.003 mg
Riboflavin	0.012–0.03 mg
Niacin	0.180–0.3 mg
Ascorbic acid	4–4.2 mg
Citric acid	0.46–3.6 mg
Boric acid	0.005 mg

*Values compiled from various sources

Rangpur ("Kona") Lime

Scientific name: *Citrus* x *limonia* Osbeck
Family: Rutaceae
Origin: Northwest India

Often called a "mandarin lime" or "local lemon" in Hawai'i, this lime is a naturally occurring hybrid between lemon and mandarin orange (tangerine). It is a medium-sized citrus tree often confused with tangerine or other citrus on first glance. The fruit is polyembryonic and thus usually reproduces true to seed. A popular rootstock in many citrus-growing areas, the tree evolved in Hawai'i as an ornamental, often when the grafted scion died off.

The spreading and drooping branches have dull green foliage with an occasional purple tint on new growth. The tree can reach a height of 20 feet. The number and size of its thorns varies from tree to tree, with some being almost thornless. The fruit rind is orange to reddish orange with minutely pitted, moderately loose skin having oil glands and a lime-like aroma. Highly acidic and very juicy, the fruit has eight to ten segments with numerous seeds and is slightly hollow in the center. Reportedly introduced to Hawai'i in the 1880s, the fruit has acclimated to Hawai'i's volcanic, well drained soils. Used for culinary purposes since the early 1920s, the trees have been maintained for their fruit rather than their use as a rootstock. The juice from the fruit has also been used for cleaning dishes and glass. India exports Rangpur lime marmalade to England, but no other commercial production is known outside of Hawai'i. However, the fruit has found a growing following on the Big Island and arguably deserves to be called "Kona lime." Further selection work to determine specific cultivars for Hawai'i is recommended.

Cultivars

There are few reported cultivars of Rangpur lime, as most trees are produced from seed. Occasional differences occur in the color and texture of the rind, number of seeds, and amount and size of thorns. Two other mandarin limes are often categorized with Rangpur: the kusaie lime, a yellow-colored, highly acidic form of the Rangpur; and the Otaheite Rangpur, an acidless form of the fruit. The 'Citrolima' cultivar has large leaves and vigorous growth and is often used in Brazil as a rootstock for Valencia oranges.

Environment

The Rangpur lime, as with most citrus, grows best in well drained soil. In the Kona district the tree is found from sea level to 3000 feet elevation. It is tolerant of colder areas and should do well at much higher elevations given sufficient rainfall and nutrition. Spacing is consistent with other citrus, usually planted 15–20 feet apart (about 100 trees per acre). Seedlings will produce fruit in 4–6 years, reaching full production in 7–10 years. The trees can be grown and will fruit in pots. When rootbound in large tubs, they become dwarfed. The tree is more tolerant of salt and high pH than many citruses. It is resistant to a number of diseases, making it the rootstock of choice in large citrus-producing areas in Brazil. The tree requires irrigation in periods of extended drought but will not tolerate being waterlogged.

Horticulture

Young trees are pruned to establish structure and shape, which facilitates harvesting and increases yields of mature trees. Annual pruning to maintain a desired height of

6–8 feet and to thin new growth and remove deadwood is advisable. Increased yield can be obtained by pruning to open the tree interior to light and air circulation. Flowering and fruiting occurs on second-year growth.

Pests and diseases

A common problem for most citrus in Hawai‘i is the citrus leaf miner, *Phyllocnistis citrella* Stainton. Damage to new growth and developing fruit can be extensive, with the insect tunneling just under the surface of the leaves or skin of the fruit. Control of the leafminer by a parasitic wasp found in Hawai‘i, *Ageniaspis citricola* Logvinovskaya, helps minimize damage. Spiders, flower bug (*Orius insidiosus*), ladybugs, fire ants, and the lacewing (*Chrysoperla rufilabris*) also help to keep the leaf miner in check. Petroleum sprays help to inhibit egg-laying but need to be repeated every two weeks when the plant flushes.

Foot rot and root rot from *Phytophthora* species can be a problem with Rangpur lime. Good soil drainage is important to prevent rot from occurring. Over-watering and wetting of the trunk will promote the spread of this pathogen.

Citrus black fly, *Aleurocanthus woglumi* Ashby, damage citrus trees by sucking the sap, removing water and nutrients. They excrete small droplets of honeydew, on which the sooty mold fungus grows. Sooty mold causes a reduction in photosynthesis that leads to a general decline in plant health and reduced fruiting. Parasitic wasps were released in 2000, and they have helped to control this pest. Neem oil and other sprays help limit infestation. Once a tree is infected, it is important to make sure it has enough water and additional fertilizer to replenish lost nutrients.

Fruit flies are not a major problem for the Rangpur lime, although it is generally advisable to follow the recommendations of the Hawai‘i Area-Wide Fruit Fly Pest Management Program (HAW-FLYPM).

Citrus tristeza virus is not a major problem for the Rangpur lime, as it has some natural resistance. Other resistant rootstocks such the mandarins ‘Heen Naran’ or ‘Cleopatra’ can be used for this lime or other citrus.

Propagation

The Rangpur lime tree is generally propagated by seed but can also be grafted. Trees with few thorns or those that are especially prolific producers can be grafted onto a Rangpur or other citrus rootstock such the rough skinned lemon, *Citrus jambhiri*, ‘Heen Naran’, or trifoliate orange, *Poncirus trifoliata* Raf. Rangpur lime can co-exist with other citrus on the same rootstock. On a single tree in South Kona, Rangpur lime, Meyer lemon, and tangelo have been grafted and all produce fruit.

Kona Rangpur lime tree at the Kona Pacific Farmers Co-op

Harvesting and yield

The fruit is harvested when orange. A mature, 7-foot, well pruned tree can produce 100 fruits or more per season and yield an average of 50 pounds of fruit. Older trees that have not been pruned can yield 300–400 fruits, but harvesting is difficult and time-consuming due the excessive height and numerous thorns.

Postharvest quality

As with most citrus, Rangpur limes can be stored at 36–39°F for up to 5 months. A wax coating will lengthen the time they can be stored, often up to 10 months. Frozen juice can be stored for future use.

Packaging, pricing, and marketing

Fresh fruit sold to markets in South Kona are boxed in 10-pound packages and wholesaled for 50 cents per pound. The markets found that consumers often confused the fruit with tangerines regardless of signage that promoted the unusual locally grown fruit. Packaging of five fruits in a vented plastic bag was then used. Hotels and restaurants order the fruit by weight, sometimes as much as 50 pounds at a time. Individual fruit, with an average weight of 7 ounces, are sold at farm stands for 50 cents each. In order to interest other hotel and restaurant chefs in the fruit, samples were sent to 10 Big Island chefs who had not previously ordered the fruit from wholesalers. Sample recipes created by students at the UH Center–West Hawai‘i culinary arts program, as well as nutritional information, was sent with the fruit. Seven of the 10 chefs continued to order the fruit after receiving the first samples.

Nutritional value per 100 g of edible portion*

Moisture	88.7–90.86 g
Energy	24–25 kcal
Protein	0.053–0.112 g
Fat	0.01–0.17 g
Fiber	0.1–0.5 g
Carbohydrate	8.33–10 g
Ash	0.25–0.40 g
Calcium	4.5–33.3 mg
Phosphorus	9–21 mg
Potassium	82 mg
Sodium	4 mg
Iron	0.11–0.33 mg
Vitamin A	0.003–0.040 mg
Thiamine	0.019–0.068 mg
Riboflavin	0.011–0.034 mg
Niacin	0.14–0.25 mg
Ascorbic Acid	25.10–48.7 mg

*Values compiled from various sources

Kona Rangpur lime cheescake

Kona Rangpur lime creme brulee

Kona Rangpur lime papaya pie

Food uses and nutrition

All citrus fruits contain healthy amounts of vitamin C, which helps to manufacture the collagen that helps the body heal cuts and wounds. The zest from limes and other citrus also contains compounds that can block cancerous cell changes. Limonene in the zest can increase the levels of liver enzymes that fight cancer-causing chemicals.

Recipes

Kona Rangpur lime papaya cheesecake
Teri Wisdom

6 egg yolks
1½ cups sugar
2 Rangpur Kona limes, juice and zest
1 teaspoon vanilla
¼ cup water
2 teaspoons unflavored gelatin
2 cups whipping cream
8 ounces cream cheese, softened
½ teaspoon salt

Procedure
Mix egg yolks, sugar, lime juice, and lime zest in double boiler to 165°F; remove from heat.

Place mixture in a bowl and beat until it thickens and starts to cool, 4–8 minutes. Set aside.

Combine water and gelatin. Let stand to hydrolyze. Heat heavy cream to a simmer and add gelatin. Stir to dissolve gelatin for one minute. Remove from heat and set aside.

Whip cream cheese and salt till light and fluffy. Scrape bowl to ensure all cream cheese is whipped.

Fold in cooled whipped cream mixture, and then fold in egg mixture. Spoon into cups and freeze overnight or until set.

For the lilikoi sauce and papaya garnish:
Mix 1 cup lilikoi puree with 1 cup sugar and 2 T lime juice in sauté pan; heat to simmer, reducing until it becomes a thin sauce. Cool.

Peel, seed, and slice papayas thinly for garnish.

To serve, loosen cups of frozen or set dessert in warm water briefly, plate upside down, garnish with papaya slices, and drizzle with lilikoi sauce. Yield: 6 servings

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Kona Rangpur lime hummus
Chef Paul Heerlein

2 cans chickpeas (garbanzo beans), drained
1 head roasted garlic
1 clove chopped garlic
Water
Olive oil
Kona Rangpur lime juice
Curry powder
Salt

Puree chickpeas and garlic to desired consistency, add remaining ingredients to taste.

Kona Rangpur lime hollandaise sauce
Vince Mott

2 lb clarified butter, warm but not too hot to the touch
12 egg yolks
2 oz cold water
3 oz Kona Rangpur lime juice
Cayenne to taste
Salt to taste

Place yolks and cold water in a stainless steel bowl and beat well. Beat in a few drops of the juice. Hold the bowl over a hot water bath and continue to beat until yolks are thickened. Draw a figure 8 in the mix to test thickness.

Remove bowl from heat. Using a ladle, slowly and gradually beat in the warm butter. Use approximately 2–2½ oz per egg yolk. Add the butter drop by drop at first then ladle by ladle. Continually beat during this process. If the sauce becomes to thick to beat before all the butter is added, beat in a little more Kona Rangpur lime juice.

When all the butter has been added, beat in the remaining lime juice. If necessary, thin sauce with a few drops of warm water.

Hold in bain marie in a warm-water bath; will hold for about 1½ hours. Yield: 1 quart.

Surinam Cherry

Scientific name: *Eugenia uniflora* L. Synonym: *Eugenia michelii* Lam.
Family: Myrtaceae
Origin: Surinam to Southern Brazil

Surinam cherry, also called pitanga, Brazil cherry, and (in Hawai‘i) pumpkin cherry, is a large shrub that can reach heights in excess of 25 feet. It is often referred to as a tree. The evergreen, ovate to lanceolate leaves are slightly bronze colored when young and about 2 inches long by ½–¾ inches wide. One to four fragrant white flowers are found together in a leaf axil, each ⅜ inch diameter with an average of 50 stamens. The fruit is thin skinned with seven or eight ribs, 1½ inches in diameter, and has one to three seeds. The fruit is green when young, turning to orange and then bright red or dark purple-black. The sweet, juicy flesh is considered refreshing by some and an acquired taste by others, due to its resinous flavor.

A member of the Myrtaceae family, the plant is related to guava, jaboticaba, mountain apple, and other members of the genus *Eugenia*, which includes more than 30 edible species.

Chefs chose Surinam cherry as part of the 12 Trees Project because of its versatility for culinary uses, attractive color, and unusual flavor. Introduction of the fruit into Hawai‘i is believed to have been prior to 1911.

Cultivars

Two distinct variations are found in Surinam cherry, a common red-colored fruit and a less resinous dark-purple-to-black, often sweeter fruit. An Israeli cultivar named ‘Gitit’ is untested in Hawai‘i, as are plants from a Brazilian breeding program that identified three promising cultivars in 1996. A Florida cultivar named ‘Zill’ and other “black” Surinam cherry seedlings are scheduled to begin variety trials at the Kona Experiment station in 2007.

Environment

Surinam cherry is a tropical plant that can also be grown in subtropical regions. It can be grown at sea level, although it is intolerant of salt in the soil, and it has been found at elevations up to 5000 feet. The plant has a long taproot and can survive periods of drought. It produces fruit in full sun or partial shade. The plant thrives in most soils but produces more fruit in deep loamy soil.

Some seedlings will produce fruit in 2–3 years, while others will produce in 5–6 years. Fruit matures within 3 weeks after flowering. In many parts of Hawai‘i, fruiting occurs year-round when rainfall is abundant.

Horticulture

Cultivation of Surinam cherry occurs in many countries. Often planted in rows spaced 6–10 feet apart, the shrubs are also planted as hedgerows as close as 3 feet apart. The plant responds favorably to ½-pound quarterly applications of organic 6-6-6 and to irrigation in dry areas. Regular mulching is advisable. Ten minutes of daily irrigation with a ½-gallon/hour emitter helps the plant create larger and somewhat sweeter fruit. In countries where Surinam cherry is grown, no pruning is done until after the first year the shrub has heavily fruited. Pruning dead wood and shaping or lowering the tree to facilitate harvesting is advisable, usually after the sixth or seventh year of growth. This highly adaptable plant also serves as an ornamental and will flourish in locations where other fruit crops are difficult to establish.

Pests and diseases

Surinam cherry is a fruit fly host. Following the recommendations of the Hawai‘i Area-Wide Fruit Fly Pest

Surinam cherry flowers

In any given fruiting period, fruits ripen over several weeks.

Management Program (HAW-FLYPM) is highly advisable. Scale insects and caterpillars are also attracted to the tree. Twig dieback and root rot, caused by *Rhizoctonia solani*, often occur in Hawai'i. Other reported problems include leaf spot caused by *Cercospora eugeniae*, *Helminthosporium* sp., and *Phyllostica eugeniae*; thread blight from infection by *Corticium stevensii*; and anthracnose from *Colletotrichum gloeosporioides*. The use of insecticidal soap or neem oil sprays, and proper care of the tree, help to combat these diseases.

Propagation

Although usually grown from seed, grafting of plants that bear superior fruit occurs in countries where the fruit is commercially cultivated (e.g., Brazil and India). Successful air-layering is also reported. Numerous seedlings are often found under existing trees, and the small ones can be easily transplanted. Seeds are viable for about a month and germinate in 3–4 weeks.

Harvesting and yield

Surinam cherry sold as fresh fruit is generally harvested when fully ripe, when the fruit contains more sugar and less resin. Care must be taken not to damage the thin skin. When the color is orange or orange-red, the fruit is edible and somewhat firmer and less susceptible to damage, but it has a more resinous flavor. Fruit harvested for processing can be picked as soon as it becomes orange. Chefs and jelly manufacturing companies have expressed a desire for fruit at this stage. Ripe fruit should be packaged in the field in the vented clamshell container in which it will be sold. It should be chilled as soon as possible after harvest. Firmer fruit is also easier to pit than softer, fully ripe fruit. Yields of trees observed in Hawai'i have varied from 6 pounds from a 4-year-old tree to 24 pounds from a 20-foot, untrimmed tree in the wild. In India the fruit is harvested once or twice daily, with yields ranging from 6 to 8 pounds per plant per year. Israel reports one untrimmed tree producing 2700 fruit in one year, with a total weight of 24 pounds. The average yield from a Brazilian test plot was 15.4 pounds per tree per year.

Postharvest quality

As with most members of the *Eugenia* genus, the faster the fruit can move from field to refrigeration, the longer its shelf life. Freshly picked Surinam cherry chilled within an hour of harvest maintained its integrity in the produce section of a South Kona supermarket for 14 days.

Packaging, pricing, and marketing

The demand for Surinam cherry increased dramatically during the course of the 12 Trees Project due, in part, to the awareness created by the project with area chefs who had been unfamiliar with this common, locally grown fruit, and also because of the outstanding recipes developed by the community college culinary arts program. In addition to demand from chefs, Hawai'i jelly manufacturers have also requested large quantities of the fruit. In both cases, fresh fruit or frozen puree would be acceptable. Fresh fruit packaged for the consumer should be in vented clamshell containers with no more than a double layer of fruit. Packed fruit should be even-colored and inspected carefully for defects and possible infestation. Fruit that leaks juice should be discarded or kept for processing. Fruit harvested for sale to processors should be washed. Seeds and stems should be removed prior to processing into puree with a commercial juicer. Puree for sale to chefs and manufacturers should be processed in a commercial kitchen as required by the state Department of Health. In some cases chefs will prefer to purchase fruit that has been cooked and strained but not pureed. During the first two years of the 12 Trees

The black-fruited Surinam cherry is called "Kawahara" in Kona; the red fruit is the more typical color.

Nutritional value per 100 g of edible portion*

Calories	43–51 g
Moisture	85.4–90.70 g
Protein	0.84–1.01 g
Fat	0.4–0.88 g
Carbohydrates	7.93–12.5 g
Fiber	0.34–0.6g
Ash	0.34–0.5 g
Calcium	9 mg
Phosphorus	11 mg
Iron	0.2 mg
Carotene (vitamin A)	1,200–2,000 I.U.
Thiamine	0.03 mg
Riboflavin	0.04 mg
Niacin	0.03 mg
Ascorbic acid	20–30 mg

*Values compiled from various sources

Project the retail price of Surinam cherry jumped from $2.00 per pound in 2003 to $3.50 per pound in 2005. Wholesale prices to groceries and wholesalers jumped from $1.50 to $2.50 per pound in the same period.

Food uses and nutrition

A good source of vitamin A, vitamin C, iron, and iodine, and an antidiarrhoeic, Surinam cherry also has substantial amounts of the antioxidants lycopene, beta-cryptoxanthin, gamma-carotene, and rubixanthin. The seeds are reported to be toxic to some people and should be avoided.

Average degrees Brix

13 (five samples each from two trees with red fruit);
15 (5 samples from one tree with black fruit)

Recipes

Surinam cherry curry sauce
Chef Paul Heerlein

4 cups Surinam cherry puree
Thai yellow curry paste to taste
Raw honey to taste
½ cup sake
2 cloves crushed garlic
1 large knob of ginger, sliced
Butter to taste

Surinam cherry ice cubes
Vince Mott

1½ cups Surinam cherry puree
1 cup water
2 oz sweet light molasses
2 oz sugar

Mix together, pour ½–1 oz into small cups or ice cube trays, and freeze.

Place cherry cubes in glasses of Kona Rangpur lime punch just before serving. Mint leaf garnish is optional.

Tree Tomato (Tamarillo)

Scientific name: *Cyphomandra betacea* (Cav.) Sendt.
Family: Solanaceae
Origin: Peruvian Andes and Bolivia

The tree tomato is a shallow-rooted tree that can reach a height of 20 feet. The wood is brittle and the trees are short-lived, usually lasting from 12 to 15 years. The almost heart-shaped leaves can reach a foot or more in length and a width of up to 5 inches. The fragrant flowers, up to ½-inch in diameter, can be pink, light blue, or white and are usually borne near the tips of the branches. The red, yellow, orange, or purple fruit is long-stemmed, 3 inches long by 1½ inches wide, and generally ovoid with somewhat pointed ends. The seeds are thin, flat, and hard. The tree is related to poha, tomatillo, and lulo. The name tamarillo was devised in 1967 in New Zealand for marketing purposes.

Poha (*Physalis peruviana*) was observed growing in Hawai‘i by the naturalist Andrew Bloxum in 1825. Sharing a geographic point of origin with tree tomato, there is some speculation that it might have been introduced to Hawai‘i around the same time, both fruits having been referred to as “lost crops of the Incas,” who cultivated the trees prior to Columbus finding the New World.

Cultivars

The tree tomato does not grow true from seed, resulting in wide variation in fruit color and size. In New Zealand, ‘Red Beau’ (1991) and ‘Kaitaia Yellow’ (1981) are popular cultivars. Selections found in California and Florida include ‘Rothamer’, ‘Oratia Red’, ‘Inca Gold’, and ‘Ecuadorian Orange’. Breeding programs in Brazil have also produced local selections.

Environment

The tree tomato is a subtropical plant that is usually found at from 1000 to 10,000 feet elevation in its native environment. In Hawai‘i it is found at 200–4000 feet elevation. Trees at lower elevations tend to produce more but smaller fruits. The plants grow best in a lightly compacted soil with good drainage. The roots will not tolerate standing water, which may kill the tree in a matter of days. Protection from wind is essential for these shallow-rooted trees. Brittle branches are also susceptible to winds, especially when laden with fruit. Trees will produce fruit after 18 months, but it is considered advisable to sacrifice the first year’s crop to strengthen the root system and develop the plant. Trees in New Zealand’s large commercial plantings are short-lived, lasting only 4–6 years. In Hawai‘i, trees will produce for up to 15 years with proper care and nutrition. On average, a cluster of 20 flowers will produce only four or five fruits. Flowers will abort if not pollinated. It takes approximately 25 weeks from fruit set to maturity.

Horticulture

New Zealand’s commercial harvest of tamarillo averaged 1500 metric tons in 2004 with 100 tons being exported and 100 being processed. The remainder was sold as fresh fruit.

Seedlings are field-planted when they are 2–5 inches tall and are spaced 6–10 feet apart. In windy areas, they are often planted closer together. The first year’s flowers are often removed. Bone meal is commonly used when planting in New Zealand. Trees are cut back severely each year to a height of 3–4 feet to encourage branching. In Hawai‘i, a quarterly application of ½ pound of organic 6-6-6 fertilizer is recommended. In the fifth year of growth, additional application (2–3 pounds) of mixed phosphate, nitrate of soda, and sulfate of potash

is recommended. Annual pruning should be done to remove branches that have previously fruited. Judicious pruning can also help to extend the fruiting season and facilitate harvesting. Irrigation is needed only in periods of drought. Mulching will alleviate tree stress under drought conditions. The tree grows best in organically rich, light soils.

Pests and diseases

The tree tomato is susceptible to a number of problems, which can be controlled with proper care. Fruit flies will attempt to lay eggs in the fruit. The tough skin offers protection, but this makes the fruit unattractive for marketing as fresh fruit. Use of strategies recommended by the Hawai‘i Area-Wide Fruit Fly Pest Management Program (HAW-FLYPM) can be very effective in preventing damage to fruit. The most common problem, powdery mildew (*Oidium* sp.), can be addressed with applications of commercial insecticidal soaps and neem oil sprays. Root-knot nematodes (*Meloidogyne* sp.), root rot, crown rot (*Phytophthora* sp.), and wilt from *Pseudomonas solanacearum* also affect the plant. Good cultural practices should help to stave off these problems.

Propagation

Tree tomatoes can be propagated by cuttings of 1–2-year-old growth and by seed. Tissue culture is practiced in New Zealand. Seeds tend to produce taller trees, better suited to protected areas, while trees from cuttings tend to be shorter and bushier, making them better for windy areas.

Harvesting and yield

Fruit should be picked with the stem on or cut with a small piece of stem left intact. The tough skin lets pickers place the fruit into bags or directly into boxes. The fruit ripens over a 6–8-week period in Hawai‘i, generally from September through May, depending on location and elevation.

Cultivated fields in New Zealand can produce more than 6 tons of fruit per acre. In Hawai‘i, a single tree can produce more than 60 pounds of fruit annually.

Postharvest quality

Tree tomatoes can be stored for up to 9 weeks if kept between 37.4 and 40°F with 90–95% relative humidity. The fruit suffers from chilling injury if kept below 37.4°F. Decay occurs if the fruit is stored above 40°F. Peeled fruit can be processed and frozen. It can also be placed into jars with sugar syrup to preserve it for future use; follow the USDA guidelines for preserving.

Tree tomato flowers

Packaging, pricing, and marketing

In New Zealand the fruit is packed in egg-type cartons after being graded to size. Small, medium, and large fruits are sold direct to wholesalers, stores, and processors.

In Hawai‘i, imported fruits sold individually retailed for as much as $10.99 per pound. Locally grown fruits sold to groceries in the Kona district are packed three or four per plastic container and have wholesaled for $5.00 per pound. Big Island hotel and restaurant chefs have purchased 10–20 pounds of fruit, packed in boxes, at a time.

Food uses and nutrition

Tree tomatoes are highly versatile for culinary use. They can be used as a substitute for tomatoes, cut fresh in salads, served sweetened in desserts, or added to spicy sauces. Chutney made with the fruit is highly valued in New Zealand and often found served in place of tomato ketchup. West Hawai‘i chefs have developed a number of recipes, curries, and chutneys using the fruit.

Average degrees Brix

8–10 (California data)

Nutritional value per 100 g of edible portion*

Moisture	82.7–87.8
Protein	1.5 g
Carbohydrates	10.3 g
Fat (ether extract)	0.06–1.28 g
Fiber	1.4–4.2 g
Ash	0.61–0.84 g
Calcium	3.9–11.3 mg
Phosphorus (with seeds)	52.5–65.5 mg
(without seeds)	13.1 mg
Iron	0.66–0.94 mg
Carotene	0.371–0.653 mg
(calculated as vitamin A)	540 I.U.
Thiamine	0.038–0.137 mg
Riboflavin	0.035–0.048 mg
Niacin (with seeds)	1.10–1.38 mg
(without seeds)	1.011 mg
Ascorbic acid	23.3–33.9 mg

*Values compiled from various sources

Banana-stuffed guava French toast with tree tomato sauce

Recipes

Tree tomato rice

Teri Wisdom

Serving size: 6 to 8

2 cups sweet rice, washed and drained
2 cups white rice, washed and drained
8 cups water
3 T vegetable oil
3 cloves of garlic, crushed
2 lb chicken, cut into bite-size pieces
1 medium onion, diced
3 chopped tree tomatoes
1 cup chicken broth
2 medium green bell peppers, sliced into thin strips
1 T annatto seeds soaked in 1 cup water for 30 minutes
1 T raisins
1 tsp salt
½ tsp pepper
3 hardboiled eggs

Procedure
Cook rice.

Heat oil in large pot, sauté garlic until light brown. Add chicken, and brown.

Add onions and tree tomatoes; cook until onions are soft.

Add the chicken broth, cover, and simmer for 8–10 minutes or until the chicken is tender.

Remove seeds from water and stir in vegetables for the orange color. Be sure to not add the seeds.

Add the cooked rice, raisins, salt, and pepper, and mix well.

Cook 10 minutes more, stirring occasionally to prevent burning.

Tree tomato sauce

Chef Paul Heerlein

6 oz ginger
4 cups white wine
36 oz passion orange juice
1 orange zest
3 quarts pineapple juice
2 tsp brown cloves
1 T allspice
22 lb tree tomato

Procedure
In a saucepan, add white wine and ginger and reduce by half.

Add all remaining items except tree tomato and reduce half-way.

Add tree tomato and reduce to desired consistency.

Tropical Apricot

Scientific name: *Dovyalis hebecarpa* x *D. abyssinica*
Family: Flacourtiaceae
Origin: Florida

Tropical apricot is a naturally occurring hybrid from Florida, developed in 1953 from a cross between kitembilla (*Dovyalis hebecarpa*) and Abyssinian gooseberry (*Dovyalis abyssinica*).

The plant has many of the attributes of both parents. It is also known as dovyah's hybrid or just dovyalis. The name ketcot was proposed in 1960 but was not widely adopted, as the fruit never achieved the popularity that was expected. The name tropical apricot, which has been used to describe the fruit's color and taste, is how the plant is commonly referred to in the pan-tropical areas where it grows. The dovyalis should not be confused with mamey (*Mammea americana* L.), another fruit called tropical apricot or South American apricot.

Tropical apricot is a large shrub growing to more than 25 feet tall with a width that matches its height. Its long branches are covered with 2–4-inch, deep green leaves and often with thorns. The branches bend downward, increasing the width of the plant, and are covered with numerous male, female, and perfect flowers. The fruit is thin-skinned, ¾ inch to almost 2 inches in diameter, turning from green to pale yellow-orange to red when fully ripe. Yellow-orange fruits are harvestable and will continue to ripen to red. The soft yellow-orange flesh is usually sour, with a distinctive apricot-like flavor. Some larger fruits contain one to five seeds, although most fruits are seedless.

Tropical apricot is a recent introduction to Hawai'i, although its parent, the kitembilla, (*Dovyalis hebecarpa*), was brought to the islands in the early 1920s and was used as a boundary plant to keep cattle out of sugarcane fields. Use of kitembilla fruit, often mixed with papaya or mango, was popular for jam and jelly.

Cultivars

Plants are usually identified as sour and less sour, thorny or nearly thornless. The thorns can be as long as 4–5 inches on mature trees. Seedling shrubs are highly variable in thorniness, degree of sourness of the fruit, and rate of growth. A cultivar, 'Prodigal', is available in Florida and may be available in local nurseries.

Environment

The tropical apricot is adapted to a wide range of soils and elevations from 300 to 2500 feet, and it has been known to survive frost in northern Florida. In deep soils with proper nutrition, the plants can grow more than 3 feet per year in height and width. Seedlings tested in South Kona showed significantly more growth in deeper soil (32 inches of soil) than those planted in rocky areas (13 inches of soil). Mature trees will produce some fruit year-round, with peak production in the spring rainy season and a second moderately heavy crop in the fall. Spacing of 15 feet is recommended for producing trees and 3–5 feet for hedgerows.

Horticulture

Plants should be given a complete fertilizer, such as organic 6-6-6, quarterly. Additional minor elements should be applied yearly or twice yearly if the soil pH is above 6.7. Heavy mulching during the dry season will help maintain the plants' health and appearance.

Tropical apricot requires heavy pruning, especially if maintained as a barrier hedge.

Remove branches with excessive thorns, dieback, or lateral growth to facilitate harvesting. Thirty minutes of pruning per month was sufficient for a 20-year old tree

in South Kona. Mature plants do not require as much rainfall or irrigation once established. Ten minutes of daily irrigation using a ¼-gallon/hour emitter will increase production during off-seasons. The plant will fruit in full sun or partial shade. Most of the fruits form on outer branches.

Pests and diseases

No diseases have been reported in the literature or observed on producing trees in South Kona. The fruit is susceptible to fruit fly infestation. Following the Hawai'i Area-Wide Fruit Fly Pest Management Program (HAWFLYPM) is highly advisable, as is following good sanitation practices, such as removing fallen and infected fruits. Birds occasionally enjoy the ripe fruits but are not a major problem.

Propagation

This plant is easily propagated from cuttings or from air-layers, which will fruit in the first or second year after planting. Seedlings are often found under mature trees. Seedlings generally produce fruit in 3–4 years, but they tend to have more thorns than plants propagated from cuttings or air-layers. Grafting the tropical apricot to a kitembilla rootstock has been practiced in South Florida's commercial nurseries.

Harvesting and yield

The tropical apricot is a heavy producer. A 15-foot tall shrub can produce more than 100 pounds of fruit per year. When harvesting for fresh sales, it is advisable to place fruits directly in the vented container in which it will be sold. Care should be taken to make sure the stem end of the fruit is intact and the fruit is free of fruit fly infestation, which usually appears as a soft spot. When harvested for processing, the fruit should be processed as soon as possible after harvest, as it attracts fruit flies and continues to decay.

Postharvest quality

Once tropical apricot is harvested it should be kept chilled to prevent decay. Tests at a South Kona grocery showed the fruit held its appearance for 20 days on store shelves before signs of mold or desiccation were visible.

Packaging, pricing, and marketing

Tropical apricot can be packaged in ½-pint or 1-pint vented plastic containers for sale as fresh fruit in grocery stores and farm stands. As most produce buyers are not familiar with the fruit, smaller containers are advisable until the fruit gains a following at the market.

Immature fruit

Although the fruit has a thin skin, it holds well on store shelves. Signs in stores promoting the fruit should reflect its unique apricot-sour taste. Fresh fruits sold to hotel chefs and restaurants can be packaged in larger containers, up to 5 pounds, but fruits should not be packed in more than four or five layers in order to protect the skin. Frozen puree can be packaged in 8-cup, or smaller, freezer bags.

In 2005–06, fresh tropical apricot sold to Big Island chefs for $3.50 a pound and was wholesaled to groceries at $2.50 a pound. Frozen puree was sold for $40.00 per 8-cups.

Food uses and nutrition

The fruit was a favorite of Big Island chefs and student chefs working with the 12 Trees Project. It is easily frozen for future use, either as a whole fruit or as processed puree. Chefs have created jelly, juice, salad dressing, dipping sauce, hot sauce, BBQ sauce, pickles, chutney, soup, wine, and brandy with this highly versatile fruit. The fruit is said to have great potential for development of value-added products. As fresh fruit, those who prefer a unique, sour taste enjoy it.

The fruit can be processed into a puree using a home or commercial juicer. Some chefs will process the fruit up to three times in a juicer. Different consistencies of puree are achieved when the fruit is passed though the juicer followed by the waste from the first pass.

Most jelly made with tropical fruit is based on a 1 to 1 ratio of fruit to sugar; however, with the sour tropical apricot, 60–70% sugar is usually required to make the taste more palatable. The USDA guidelines for producing jelly should be followed.

Average degrees Brix

8–12 (five samples from each of two tropical apricot plants)

Mature fruit

Nutritional value

per 100 g of edible portion of kitembilla*

Moisture	81.9–86.36 g
Protein	0.174–1.5 g
Fat	0.13–1.02 g
Carbohydrate	11.42 g
Crude fiber	1.3–1.9 g
Ash	0.56–0.63 g
Calcium	8–13.3 mg
Phosphorus	12–26.8 mg
Iron	0.45–1.41 mg
Carotene	0.125–0.356 mg
Thiamine	0.012–0.017 mg
Riboflavin	0.033–0.051 mg
Niacin	0.261–0.316 mg
Ascorbic acid	64.5–117 mg

*No nutritive studies on the tropical apricot are available. The values are compiled from various sources for the kitembilla parent of tropical apricot.

Recipes

Tropical apricot red curry coconut sauce

Keola Tom

1 large can coconut milk
24 oz chicken or vegetable stock
3 cups tropical apricot juice
4½ oz fish sauce (Patis or other brand)
6 oz red curry paste
(start with 3 oz, then adjust to taste)
3 cups sugar
Grated ginger to taste
Grated garlic to taste
Tamarind to taste
2½ T paprika

Combine the first six ingredients and stir until sugar dissolves. Add the rest of the ingredients and bring to a boil. Simmer 5–10 minutes, stirring occasionally. More paprika can be added for color and to keep curry from becoming too spicy. Yield: 5 quarts. Serve with wok-fired shrimp and scallops.

Tropical apricot dipping sauce for spring rolls

Vince Mott

2 cups tropical apricot juice
50 ml (3 tablespoon + 1 teaspoon) peanut oil
2 dried chilies
3 scallions, white part with about 1 inch of green left on, finely sliced
1 large knob ginger, finely diced
2 cloves garlic
15 ml (1 T) Chinese shaohsing wine
15 ml (1T) rice wine vinegar
2 T sea salt
2 T fine sugar

Mix ingredients well.

Cost of Production

For each species grown in the 12 Trees Project, one or more plants were monitored to obtain an estimate of the economic viability of its production. The following data were collected:

- average marketable yield per plant per year
- average market price per pound
- gross revenue per plant per year
- growing costs (fertilizer, irrigation, pruning, and weed and pest control)
- harvesting costs (picking, packing, and delivery to market)
- annual operating cost (the total of growing and harvesting costs, sometimes referred to as "total variable cost")
- gross margin (gross revenue minus operating cost).

All labor to grow and harvest the plants was assumed to be paid at an hourly wage rate of $16.00, including withholding, FICA, and benefits.

The gross margin is the amount of money available to pay all the ownership costs associated with the enterprise. Ownership costs, sometimes referred to as "fixed costs," include the value of the land used (rent or rent equivalent or mortgage and property taxes), the value of the capital investment (such as the plant establishment cost, buildings, and vehicles), the value of the management, and the value of any unpaid labor (all paid labor is already included in the gross margin). Ownership costs, unlike operating costs, vary substantially from farm to farm and depend largely on how the farming operation is financed and on economies of scale. Each grower will have to calculate the total farm ownership cost and then allocate an appropriate portion of this cost to each crop enterprise on the farm. Then the crop's profitability can be determined by subtracting its share of the total ownership cost from the gross margin for the crop.

The yield and cost estimates summarized below are based on experience at the 12 Trees Project site and, in some cases, other locations. Yields and costs result from the growing conditions for the plants at the various locations and the management conditions, which we tried to make optimal. Different results may be obtained with other locations and management conditions.

The average market price used is based on actual sales in 2005 and 2006. There is no guarantee that this price will be obtained in the future, especially if production increases significantly. The estimated costs and returns are simply a starting point for growers to make their own estimates.

Plant	Number of plants monitored	Per-plant annual marketable yield (lb)	Average market price ($ / lb)	Gross revenue ($)	Total growing cost ($)	Total harvesting cost ($)	Total variable cost ($)	Gross margin ($)
Cherimoya	3	30	3.50	525.00	79.15	238.35	286.65	238.35
Fig	1	788	3.30	2,598.75	58.81	535.20	594.01	2,004.74
Grumichama	1	61.8	7.00	432.25	17.13	107.60	124.73	307.52
Kumquat	1	40	5.25	210.00	20.42	85.10	105.52	104.48
Loquat	1	190	3.75	712.50	148.87	157.90	307.88	405.73
Mysore raspberry	1	11.6	7.00	81.20	48.37	80.61	128.98	–47.78
Poha	3	2.8	7.00	58.80	42.63	45.41	88.04	–29.24
Pomegranate	1	40	5.25	210.00	20.42	85.10	105.52	104.48
Rangpur lime	2	83	0.60	99.75	80.26	23.06	103.32	–3.57
Surinam cherry	1	12	3.75	45.00	19.45	29.50	48.95	–3.95
Tree tomato	1	54	5.00	270.00	30.57	57.70	88.27	181.73
Tropical apricot	1	85	2.53	214.63	22.51	64.64	87.15	127.47

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Appendix: Some Observations on the Twelve Fruits

by Ken Love

What follows is a collection of somewhat random thoughts about the fruits chosen for the 12 Trees Project. These thoughts include horticultural and personal observations, notes on marketing, and a few opinions on their potential—or lack thereof—in culinary circles. I've also included suggestions for alternatives to the 12 fruits, alternatives that I believe have greater potential for enjoyment and profitability than the original choices.

Although the project has ended, the UH Center–West Hawai'i culinary arts program has continued directing students to use the 12 Trees Project fruits as part of their curriculum. Students who graduated after the first year of the project have continued to use the fruits upon starting their professional careers. After exposure to the 12 chosen fruits, they have developed an increased interest in many other unusual fruits grown in the Kona district.

At the beginning of the project, I didn't agree with many of the choices that the 54 Big Island chefs made, and more than three years later, I tend to feel the same way, although I have altered my opinions on a few of the fruits based on both horticultural and marketing experiences.

Cherimoya

Cherimoya is certainly a delicious fruit, and I'm quite sure it has value as a commercial crop—with some aggressive marketing. The tree does not thrive at lower elevations, where it seldom bears fruit. Trees at the project site did flower, but even with hand pollination, if they fruited at all, the fruit was small, hard, and often suffered damage from borers. Older trees that had fruited at 1800 feet elevation on my farm in 'Opihihale, South Kona, have never fruited since being moved to the project site at 430 feet elevation. Three-plus years after transplanting, they had good growth with copious foliage and flowers, but they had never set fruit, even with hand pollination.

At the beginning of the project, I would have said that cherimoya is the best tasting of the annona family. Today, I would vote for rollinia. I suspect once we have enough production and chefs get a taste of rollinia fruit, it might move cherimoya to the back seat. Atemoya, although it has had fairly consistent production on a few commercial farms in the state, never really delights people the way cherimoya or rollinia does. The advantage of atemoya is that it will produce well at most elevations. It is a cross between cherimoya (*Annona cherimola*) and sugar apple (*A. squamosa*). The sugar apple, which is also called sweetsop, is very popular in Florida and the Caribbean. It is seldom found in Hawai'i. Although there are a few producing trees, the number of fruits on a tree is far less than on a cherimoya tree of the same size or age. Visiting and local Filipinos, who are always on the quest for "atis," one of the favorite fruits of the Philippines, often ask for sugar apple at farmers markets. Sometime in the future, it would be beneficial for someone to plant a wide range of the sugar apple cultivars in hopes of finding one that will be more accepting of Hawai'i's microclimates. As for me, I'll stick with rollinia (*Rollinia mucosa* and *Rollinia deliciosa*), which has a number of advantages over the other annonas. It does well at most elevations: I've seen it at from 300 feet to 2400 feet. With irrigation or enough rain, it produces more fruit and more consistently than cherimoya. The fruit tastes like a caramel and lightly lemon-flavored cherimoya. The only fault it seems to have is that the fruits vary in size from very small to very large. There seems to be little consistency in fruit size, although this is the same with most annonas. Still, the smaller fruit has the same texture and taste as the very large fruit, which is something I don't find with cherimoya, which can be overly sweet and gritty in some sizes and smooth as custard in others. Rollinia fruit, although not yet tested by chefs or most fruit growers, can be used in any dishes in which chefs currently use cherimoya or atemoya. Crème brulee and ice cream or sorbet would have an extra complexity from rollinia that could be highly desirable.

The profitability of all of the annona fruits can be considerable if a grower develops good relationships with chefs and stores. We've had no problems selling any number of annonas both wholesale and at retail farmers' markets. In my experience of marketing fruit in Hawai'i, I've only seen rollinia sold at two grocery stores and perhaps a half dozen times at farmers' markets. I've never seen chefs experiment with it. Frankly, I tend to eat or sell the ones I grow rather than send samples to chefs. I do plant the seeds and plan to increase my production—as well as consumption! Savvy growers will plant rollinia instead of cherimoya and plan to market it aggressively.

Fig

One of my earliest childhood memories was enjoying a wheel of dried figs from Greece. I was amazed by the taste and texture of something that to my five-year-old mind was also to be played with. It wasn't until I was much older that I understand the difference between fresh and dried figs, and I still enjoy working with both. The USDA germplasam depository in Davis, California, has 139 types of figs in their collection, only a handful of which are growing in Hawai'i. This presents us with many opportunities for growers, chefs, and those who develop value-added products. Some of the figs taste very different than others. Figs were by far the most profitable of the 12 Trees Project fruits, sometimes as much as 10 times the value of Kona coffee growing in the same amount of space, and with much less labor. The fig tree at the project started as a foot-long cutting from my 'Brown Turkey' tree in South Kona. Within a year it produced its first fruit. Within seven years it produced over 4000 fruits in a year, in part due to aggressive pruning and shaping. Because fig trees produce fruit only on new growth, it is always advisable to prune to keep the tree short and let it grow outward rather than upward. If you turn your back on it for more than a month, you'll wind up with 25-foot shoots that head straight up. The trees lend themselves to espalier as well as being weighted down or tied to stakes, which is the common method in Japan.

Figs lend themselves to a virtually unlimited number of culinary delights and value-added products. A quick study at any international food show, such as Food Ex in Tokyo each March, will reveal hundreds of fig products from Portugal, Turkey, Greece, Japan, Iran, and Iraq. A small, dried, whole fig from Iran is popular in Japan for use in baked breads and other confections. A few products I've produced with seconds and culls include fig macadamia nut spread and dried fig pieces in locally produced honey. These sell out quickly at farmers' markets in Kona.

There is always the question of what would happen when there are hundreds of acres producing the amount of figs that our test tree produced. The 4000-plus figs were sold to four restaurants, with an average 3-month waiting list. There were two times during the year when we had an excess of figs, some of which were sold to other restaurants. We had requests from Big Island chefs who wanted to add figs to their menus and also from restaurants on other islands. I'm convinced that we have a way to go before the market would be saturated, at which time the need to focus on value-added products would become apparent.

Many growers who have figs wonder how they could better rid themselves of birds, which often peck at the ripe figs. We found that silver or gold Mylar tape, Christmas garland or tinsel, pie plates, aluminum foil, or any reflective material hung in the tree served as an effective deterrent for up to 3 months, after which time the birds came back. When we added to or moved the reflective material, the birds disappeared again. We found this necessary, on average, every 3 months. Old CD disks hung from string on the trees were very effective. In the future I hope to conduct tests using ultrasound deterrents. If I had an extra acre now, I would screen the whole place in and plant figs.

Grumichama

Grumichama is one of the most delightful fruits I've run across. It's more labor intensive to harvest and package than some of the others, but it has great potential. With a taste that reminds people of black cherry and Concord grape or jaboticaba, it is usually enjoyed fresh off the tree. One of the problems is in fighting the birds, which also love the fruit. Fortunately, older trees are very prolific, and there is usually enough to go around. Using Mylar tape and metallic reflective materials is effective, but not as much so as with figs.

The fruit is largely untested by the majority of chefs around the state. The few whom we have been able to supply with samples are anxious to get more, both to use as fresh fruit on buffet lines and in dessert confections. The shelf life is rather short, and postharvest care is essential with grumichama if it is going to be marketed as a fresh fruit. The most desirable form of presentation at a grocery store in Kona and for delivery to chefs was single-layer clamshell packs containing fruits with the stem on.

Picking the fruit with the stem on is somewhat cumbersome but helps to increase the shelf life of the fruit. If I'm picking the fruit with the intention of processing it into a puree, I tend not to keep the stems on. Frozen puree can last more than a year. Removing the one to three seeds needs to be done by hand, as none of the processors or juicers were effective; the soft seed would be damaged, and the puree would contain too much grit and seed material. This could be strained out, but that was more time consuming than removing the seeds by hand. We would sit down to watch a DVD for 2 hours and process enough fruit to produce 10 cups of puree.

We produced jelly, syrup, and various sauces with the grumichama, all of which tested well and sold out at farmers markets. I'm looking forward to working with this fruit and experimenting with ice cream and fudge recipes.

Kumquat

Kumquat seems to be a largely misunderstood fruit with new chefs on the Big Island. I believe this is due to the common confusion between kumquat and calamonsie, or calamondin. The calamonsie is a lime that is often grown by the state's Filipino farmers. It is round and about the same quarter-size diameter as the 'Meiwa' kumquat. Chefs are more familiar with the 'Nagami', an elongated kumquat commonly grown in California. Whereas the skin and pulp of the calamonsie is very sour, kumquats have a much sweeter skin and taste. Over 100,000 kumquat recipes are listed on Internet, so the fruit is obviously well known in most areas. Many of these recipes are considered classics. I feel this fruit was chosen by chefs because of these classic recipes as well as the culinary versatility of the fruit. When I had extra fruit I would bring it to the local Chinese restaurant, where they would use it with a variety of dishes. We also processed the fruit and made marmalade or jelly and bottled whole fruit in a light syrup to preserve it. In Japan it is commonly used to flavor the distilled alcohol shochu or processed into a brandy-like liquor. In Taiwan it is dried and candied. Highly versatile, the kumquat has a bright future for chefs in Hawai'i.

Loquat

One of my favorite fruits, loquat has a history as interesting and complex as its flavor. Having spent at least a month out of each year for almost 10 years studying this fruit in Japan, I'm convinced that its potential in the US as a fresh fruit or for culinary use and in value-added products is virtually unlimited. At the Biwa (Japanese for loquat) Club in Southern Chiba, Japan, about 4 hours from Tokyo, there are more than 2000 items for sale made with loquat fruit or reflecting the image of loquat. Many streets in Tokyo have loquat trees planted as part of the landscaping, some of these from the late 1940s.

Arguably one of the most popular fruits in the world, there is a name for loquat in many languages except English, although the fruit is sometimes called "Japanese medlar." The fruit is mentioned in Chinese and Japanese historical documents dating back 5000 years. Europeans' first exposure to the fruit was in the late 1600s. Spain is currently the top producing country. There is continuing research on this crop throughout the Mediterranean region as well as all over Asia.

It is thought that early Chinese immigrants first brought the fruit to Hawai'i, perhaps even before Captain Cook's time. The fruit and trees were described by early visitors to Maui. Many of Hawai'i's residents who have limited knowledge of the fruit do not find it that exciting, often complaining that it is very small and sour with large seeds. This happens because most of he trees are seedlings, which have become invasive in parts of the state. These trees can be thinned, top-worked, and grafted with newer varieties developed in Japan. To get fruit that that is really a taste treat and desired by chefs, a fair amount of labor is required. Once you've tried a "perfect" loquat, there is no turning back! Ideally, the fruit should be orange colored, very sweet, and approach tennis-ball size, weighing more than 3 ounces. In Japan, fruit sold in the spring is sized, with a dozen of the largest going for as much as $50.00! Hawai'i can produce loquat at different times of the year than any of the other locations where it's grown. We could produce the fruit for New Year celebrations, which in past years the Japanese Loquat Cooperative has expressed an interest in.

In Hawai'i the fruit must be grown inside bags to protect it from fruit flies, birds, and sunburn. Bagging is done after both the flowers and fruit have been thinned, which helps in producing larger size fruit. Trees at higher elevations produce larger fruit, but it will produce in lower areas. If we had enough production of loquat in November and December, I feel that opening the Japanese market would not be a problem. Getting the support of the Japanese would not be as much of a problem provided we follow their growing guidelines and stick to the varieties of loquat they like. Getting the quarantine agencies to approve it could be a setback.

The thousands of loquat products in Japan, Taiwan, China, Spain, Algeria, Israel, and other producing countries have never been mimicked here. Such value-added products are another option for growers in Hawai'i.

Mysore raspberry

Without a doubt, mysore raspberry is the most controversial fruit on the list. It was the number-one choice of the 54 chefs, although it could have been any locally grown raspberry. It is on the noxious weed list for all islands except the Big Island, meaning that it is illegal to plant it outside of the Big Island, where it is also on lists of undesirable, invasive plants. I would not recommend growing it, but not for the reason of potential invasiveness. I feel the plant is highly misunderstood and should be separated from other *Rubus* plants. It does not send up shoots from the roots like thimbleberry or other raspberries. Birds seldom spread it, and the seeds are hard to germinate. Over more than 15 years in South Kona, I could only get a second plant by rooting the tips of the long canes. The main problem with this plant is its fishhook-type thorns, which can make it extremely painful to harvest. It's a lot of work for little or no profit.

The fruit tastes very good, chefs like it, and it is nice to have a fresh raspberry growing in a tropical location, but this plant is a pain to work with. I would hope that in the future a thornless strain could be developed.

Poha

Poha is a delightful fruit that is also a lot of work. I might not have chosen were it not for its history as part of Hawai'i Regional Cuisine. Poha is always in demand by chefs and has not achieved its rightful place among the state's more popular fruit. This due to the nature of the plant and the time it takes to harvest and husk enough to make it worthwhile. I do think that a dedicated poha farmer could find other growing systems that would facilitate ease of harvest and cut into the labor-intensiveness of preparing the fruit for sale. What surprised me during the course of the project were the time trials for harvesting and husking the fruit. Even at $7.00 a pound, poha was not profitable; it routinely sells for $2.50 to $3.50 in local markets. I buy it all and can easily resell it at $7.00. Because of the cost of production, with $12.00 per hour labor and benefits, the cost to produce the $7.00 worth of poha was more than $9.00. It's very time-consuming. We tried a number of different growing systems: trellises, raised beds, fences, and a volunteer plant. There was no discernable difference in the amount of time to harvest and husk fruit from any of these systems, although the experience does give me a number of ideas to try in the future to save harvesting time.

Chefs enjoy working with the fruit and have created a number of dishes. The fruit could be considered an "identifier" in much Hawai'i Regional Cuisine. While larger jelly makers on O'ahu and Kaua'i will call when looking for 3000 to 5000 pounds, I have a tough time getting 50 pounds for a Big Island restaurant. Poha is considered invasive, being readily spread by birds, but despite it being naturalized, there is just not enough of the fruit to go around. Then again, if the price paid was in keeping with the time involved, maybe there would be.

Pomegranate

When the 12 Trees Project started, I would often say that I would have never chosen pomegranate for this project! Don't get me wrong, I love them, but there are so many coming in from California and so many products from a number of other producing regions that we have kind of a glut of pomegranate thanks to all the publicity and network-marketed items that are now in the marketplace. Still, the chefs wanted locally grown fruit. Since it was a known fruit for many chefs, and they had experience working with it, they wanted it fresh. What I learned since the start of the project is that the USDA Germplasam Repository in Davis, California, has 189 types of pomegranate in their collection. This opens many possibilities for growers here who wish to work with the plant. The fruit sells well at farmers markets, with most people saying they just eat it fresh. A few people mentioned that they make juice from it. One of the advantages in growing it here is that the plant does well in dry, lower elevations. The famous botanist David Fairchild first sent plants to the US in the late 1800s from the desert around Baghdad.

If I was going to plant pomegranate now, I would look into many of the more unusual varieties available through the USDA Germplasam Repository and plant known varieties rather than air-layers made from seedlings here.

Rangpur ("Kona") lime

My first exposure to what I now call the Kona lime happened many years ago, while standing in front of the then Kona Farmers Co-op office. The inviting-looking orange fruit seemed like a tangerine, peeled like one, and even had the little white strings often found under the rind. I tease people who try it now by saying that it is what made my hair fall out. The plant was originally brought here as a rootstock for sweet citrus, but the grafts died off and people often forgot about the trees with the "sour orange." Some chefs found the fruit in the 1980s and started using it for confections and in lime pies. A slice of Kona lime is often found in ice tea or drinks at Kona's older restaurants. Student chefs in the culinary program involved with the project found it useful as a base in sauces, for juices, and in desserts. Many of our newer farmers have not realized that they have this lime and just think of it as a sour orange. Once they find out that it is a lime, it seems to open a world of possibilities both for recipes and marketing of the fresh fruit.

The only drawback with the fruit are the numerous long and very sharp thorns on the trees. Some trees have few or no thorns, and they should be the ones that are propagated. Seedling trees often produce fruit within a few years, but the thorns can make harvesting difficult and sometimes painful. The marmalade we make from this fruit is some of the best I've had anywhere.

Surinam cherry

The acquired taste needed for this fruit makes it a hard sell at many of the farmers' markets, but those who love it swear by it. A test underway at UH-CTAHR's Kainaliu Research Station will help to identify select black varieties of the usually red fruit. The black Surinam cherries are sweeter and less resinous than the common red

types. The plant is on state invasive species lists, but in terms of market demand, I can't get enough of it. As with poha, the large jelly manufacturers are looking for 3000 to 5000 pounds at a time. Without a processing facility, it's impossible to gather enough fruit to fulfill their needs. Chefs and student chefs have been very creative with the Surinam cherry. The red curry base made with its juice is very good. Fruit flies and birds are a major deterrent to harvesting fruit in the wild. Some researchers feel this fruit has great potential as a cash crop for Hawai'i. I tend to agree, but it can be labor-intensive, as the fruit is fragile and requires special care in postharvest handling.

Tree tomato / tamarillo

Another fruit with great potential, the tree tomato is rapidly becoming a favorite of many chefs. Their fondness for tamarillo comes from the fruit's adaptability to be used both in savory and meat sauces as well as sweetened for dessert sauces. When I first started producing the fruit, I simply peeled it and cut it into salads, finding the taste much better than common tomatoes. Now I make sauces and reductions for use with scallops, vegetables, or in other dishes. Simple jams and ketchup made from the fruit are delicious. There is some confusion with the use of both names. New Zealand named the fruit tamarillo, which has caught on in many locations, as they are large producers and fruit from that country is often found at Hawai'i stores as well as in U.S. mainland markets. The fruit has been grown here for many years and is known as tree tomato. If we increase production and local sales, it might be good to devise a Hawaiian name in order to better promote and market the fruit and recipes developed at resort hotels using it. Although not nearly as profitable as figs in the 12 Trees Project, the fruit has great potential, both economically and for the chefs to be creative and develop a competitive edge.

Tropical apricot

As one of the first growers of this fruit in Hawai'i, I've always had a fondness for it in sauces and as a juice. Considered sour by most, I found it refreshing and extremely versatile for use in sauces and jellies. I still enjoy the fruit, but after working with the "father" of this natural occurring hybrid, kitembilla, (also called Ceylon gooseberry), I find that I've developed a fondness for that as well, perhaps even more than for tropical apricot. I feel the *Dovyalis* group of fruits, which includes a number of cultivars, has great potential. Generally sour tasting and with nasty thorns, these plants tend to hybridize when different seedlings are planted in proximity. Trees of both tropical apricot and kitembilla at the project site produced fruits with characteristics different from the parent trees. I feel that with a significant amount of selection work, sweeter, thornless types would evolve, making it much more desirable to produce and use as a fresh fruit. Even lacking this development, chefs very much desire tropical apricot, and we have no problem selling all that we can produce. This seldom leaves us enough for making jam. Chefs at the resorts enjoy working with this highly versatile fruit for sauces and gels. They often request it for culinary events. I feel that this fruit, as well as kitembilla, should also be given local names.

Recommendation

What I feel is needed most in Kona is a cooperative fruit processing facility that would include a community kitchen, or, alternatively, a private company that purchases fruit and produces frozen purees and products made from 100% locally grown fruit. Currently, many of the resort hotels buy frozen guava, lilikoi, and mango puree from the Montreal office of a French company! Hotel chefs here often request frozen fruit puree, which we cannot produce in quantity at local facilities and with the limited labor available. We also receive a number of requests each month from U.S. mainland chefs. I would urge county and state government in conjunction with the university to make this happen.

Summary

In addition to those of the 12 Trees Project, many other fruits deserve equal attention. Over the course of this project I have had many discussions with growers and chefs about the hundreds of fruits and thousands of varieties that could be grown. The difference among varieties is something that is just beginning to be understood by the chefs here. With 200 types of avocado, 200 types of mango, and more than 50 types of banana, there are many avenues for chefs to exercise creativity. There is not sufficient quantity of many of these fruit types to promote them across the board, but growers who have the unusual varieties can market them in a limited way as a high-value crop. With some of the rare Hawaiian bananas, we've found that being able to give chefs and grocery stores the fruit history in the form of a sign they can post for their guests and customers greatly helps to increase the value. In short, once growers are educated as to what they have, they in turn can educate their customers, who in turn pass the information on to their customers. We've seen the value of some rare bananas increase 300% in the past 2 years.

Other fruit that I hope we can work with in the near future include jaboticaba, rollinia, acerola, and white sapote. Developing value-added products from bilimbi, small starfruit, and soursop would also benefit a number of area growers. Jackfruit and breadfruit are others that deserve special attention from researchers.

Much needs to be done to dispel many myths regarding local fruit. Growers often perpetuate these myths, but it is also done by the stores that often resist selling some types of fruit like pummelo and breadfruit. Many of the buyers who have been in the produce business for 30 or more years still operate on 30-year-old demographics. To them, every home already has a breadfruit tree or pummelo tree. It took some time to convince one of the local markets to sell "ugly" local lemons (jambhiri), but once they decided to take a chance they found that the lemons sell very well. I'm sure this would be true of many other fruits if they were given shelf space in the already-squeezed produce section.

With the ever-increasing number of new farmers, often people moving to the Kona district who have little or no experience in tropical agriculture, an opportunity exists in the form of new interest in the more unusual crops grown, in terms of their use and marketing. For example, strawberry guava, which is considered highly invasive and can easily be found in the wild, sells well when packaged and put into the market at $2.50 a pound. An informal query of some of the buyers revealed that they have the plant on their land but did not know what it was or that it was edible. This was also true for Surinam cherry and a few other fruits tested. I also found that many of the new farmers had little knowledge of the differences between types of fruit with similar appearance, such as passion fruit and guava. Some new farmers were wary of fruit trees that grow in unusual ways, such as jaboticaba and wi apple. All of this experience tells me there is a need for continuing education regarding tropical fruits. Information and extension assistance on horticulture, postharvest handling, marketing, and developing value-added products will contribute to the overall rural economic development and sustainability of small farms across the state. When agricultural tourism is added to the equation, a grower soon finds that new priorities tend to change the basis of profitability. A number of new farmers in South Kona now plant newly cleared land with agtourism in mind rather than production crops. This greater diversity will lead to greater profits and sustainability.