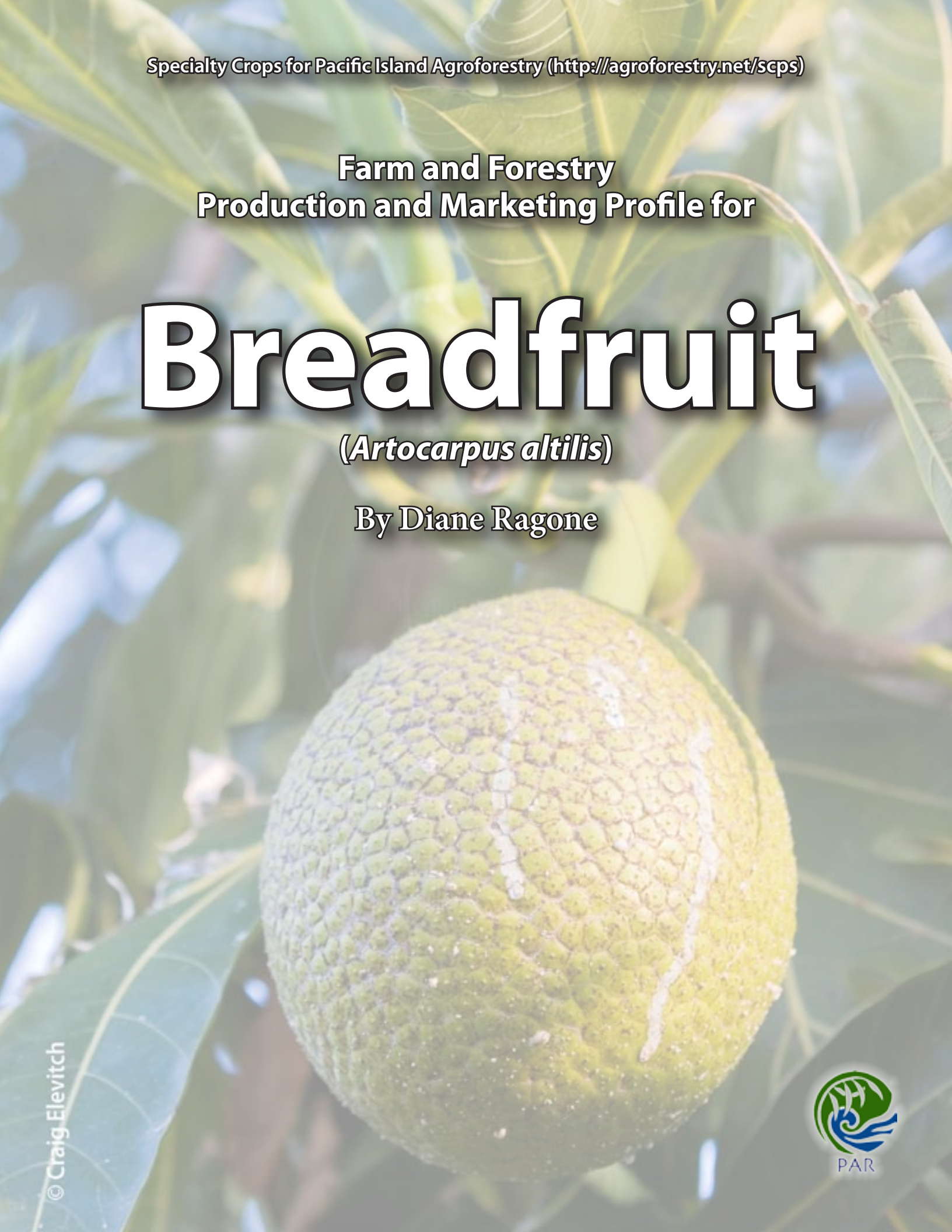
Specialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps)

Farm and Forestry
Production and Marketing Profile for

Breadfruit

(*Artocarpus altilis*)

By Diane Ragone



PAR

USES AND PRODUCTS

Breadfruit produces abundant, nutritious fruit (i.e., high in carbohydrates and a good source of fiber, vitamins, and minerals) that is typically cooked and consumed as a starchy staple when firm and mature. Ripe fruit can be eaten raw or cooked, processed into chips and other snacks, dried into flour or starch, and minimally processed or frozen. Breadfruit flour can be partially substituted for wheat flour in many bread, pastry, and snack products. Seeds, cooked in the fruit and eaten throughout the Pacific islands—but rarely in Polynesia—are high in protein, relatively low in fat and a good source of vitamins and minerals. Breadnut seeds tend to be larger and sweeter than breadfruit seeds and can be roasted or boiled. In Ghana, breadfruit and breadnut seeds have been made into nutritious baby food. In the Philippines, immature fruit is sliced, cooked, and eaten as a vegetable.

Breadfruit is a cultural icon in the Pacific. All parts are used medicinally, especially the latex, leaf tips, and inner bark. The wood is lightweight, flexible, and may resist termites. It is used for buildings and small canoes. The attractive wood is easily carved into statues, bowls, and other objects. Older, less productive trees are utilized as firewood throughout the region. The inner bark is used to make bark cloth (tapa, siapo), but this formerly widespread custom is now only practiced in the Marquesas. Large, flexible leaves are used to wrap foods for cooking in earth ovens. The sticky white latex is used as a chewing gum and adhesive and was formerly widely used to caulk canoes and as birdlime (to catch birds). Dried male flowers can be burned to repel mosquitoes and other flying insects.

ENVIRONMENTAL PREFERENCES

Climate

Breadfruit is adaptable to many ecological conditions. The latitudinal limits are approximately 17°N and 17°S, but maritime climates extend that range to the Tropics of Cancer and Capricorn.

Soils

Breadfruit prefers deep, fertile, well drained soils, although some varieties are adapted to the shallow sandy soils of coral atolls. It prefers light and medium, freely draining soils with pH 6.1–7.4 and tolerates saline and coralline atoll soils.

NAMES

Preferred scientific name

Artocarpus altilis (Parkinson) Fosberg

Family

Moraceae (mulberry family)

Many village roads in Samoa are lined with breadfruit trees growing in home gardens.

Elevation, rainfall, and temperature

Elevation range	0–1,500 m (0–5,100 ft); best below 600–650 m (2,000–2,160 ft).
Mean annual rainfall	1,500–3,000 mm (60–120 in), but trees can yield regularly on Pacific atolls that receive 1,000 mm (40 in).
Rainfall pattern	It prefers climates with bimodal rainfall.
Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)	3–6 months (specific months vary depending on variety).
Mean annual temperature	15–40°C (59–104°F); best at 21–32°C (70–90°F).
Mean maximum temperature of hottest month	32–38°C (90–100°F).
Mean minimum temperature of coldest month	16–18°C (61–64°F).
Minimum temperature tolerated	5–10°C (41–50°F). At low temperatures, it may drop leaves and shoots, not yield fruit, and die back.

Common names

Pacific islands

beta (Vanuatu)
bia, bulo, nimbalu (Solomon Islands)
breadfruit (English)
kapiak (Papua New Guinea)
kuru (Cook Islands)
meduu (Palau)
mei, mai (Federated States of Micronesia [FSM], Kiribati, Marshalls, Marquesas, Tonga, Tuvalu)
mos (Kosrae)
ʻ*ulu* (Hawaiʻi, Samoa, Rotuma, Tuvalu)
ʻ*uru* (Society Islands)
uto, buco (Fiji)

Other regions

árbol a pan (Spanish)
brotfruchtbaum (German)
fruta pão (Portuguese)
khanun-sampalor, sa-ke (Thai)
khnaôr sâmloo, sakéé (Khmer)
kulur, kuror, sukun (Indonesia)
l'arbre à pan (French)
laba pen, vèritab (Haiti, Creole)
mshelisheli (Swahili)
rata del (Sri Lanka)
rimas (Philippines)
sake (Vietnamese)

BOTANICAL DESCRIPTION

Breadfruit is an attractive evergreen tree, typically 12–15 m (40–50 ft) tall with a 0.3–1 m (1–3.2 ft) diameter trunk, often with buttress roots. Milky white latex is present in all parts of the tree. Male and female flowers occur on the same tree. Male inflorescence is an elongated club-shape, up to 5 cm (2 in) in diameter and 45 cm (18 in) long, comprised of thousands of tiny flowers attached to a central spongy core. The tree is deciduous. Female inflorescence is more rounded and consists of 1,500–2,000 reduced flowers attached to a spongy core. Flowers fuse together and develop into the skin and fleshy, edible portion of the fruit. Large glossy dark-green leaves are alternate, ranging from almost entire to deeply dissected, with up to six pairs of lobes and a large apical tip. Fruit are usually round, oval, or oblong, weighing 0.25–5 kg (0.5–11 lb). Skin is greenish-yellow, patterned with hexagonal markings, and has a smooth, bumpy, spiny, or spiky surface. Flesh is creamy white or pale yellow and contains none to many seeds, depending on the variety. Seeds are brown, typically shiny, rounded or obovoid, irregularly compressed, 0.5–2 cm (0.2–0.8 in) thick, and embedded in the pulp. Seeds germinate immediately and cannot be dried or stored.

Female (horizontal) and male (vertical) inflorescences.

Breadfruit comes in many shapes, sizes, colors, and textures.

DISTRIBUTION

The wild, seeded, ancestor of breadfruit, *Artocarpus camansi* Blanco, or breadnut, is native to New Guinea, and possibly the Moluccas (Indonesia) and the Philippines. Breadfruit, both seeded and seedless forms, does not naturally occur in the Pacific islands. This species was first domesticated in the western Pacific and spread by humans throughout the region beginning 3,000 years ago. Breadfruit is found throughout the tropics and cultivated on most Pacific islands. In the late 1700s, several seedless Polynesian breadfruit varieties and breadnut from New Guinea were introduced to the Caribbean. These were subsequently distributed throughout the Caribbean to Central and South America, Africa, India, Southeast Asia, Madagascar, the Maldives, the Seychelles, Indonesia, Sri Lanka, northern Australia, and south Florida. In recent years, some breadnut trees have been planted in French Polynesia, New Caledonia, Palau, Pohnpei, and Hawai'i, mainly by Philippine immigrants.

GROWTH AND DEVELOPMENT

Breadfruit is fast growing in favorable conditions, growing in height 0.5–1.5 m (1.7–4.8 ft) per year and trunk diameter of 0.5–1 m (1.7–3.3 ft) in the first 10–12 years. Small branches often die back at the tip after fruiting, but new shoots and branches continue to develop throughout the life of the tree. Breadfruit bears seasonally, with most varieties producing one or two crops per year. The main crop typically occurs during the hot, rainy, summer months, followed by a smaller crop 3–4 months later. Vegetatively propagated trees start fruiting in 3–6 years. Grafted trees can begin bearing in 2–3 years. Trees grown from seed begin to flower and produce fruit in 6–10 years, or sooner.

PROPAGATION

Breadfruit is clonally propagated using root shoots or root cuttings. Vegetative propagation is required for seedless varieties and preferred for seeded varieties. Seeds are rarely used because seedlings are not true-to-type. New branches and shoots can be air-layered (marcotting). Seedless varieties can be grafted onto seeded rootstock using various techniques such as approach grafting or cleft grafting. Under good conditions, grafted trees can begin bearing in 2 years. Breadnut is always grown from seed.

Steps for root shoots and root cuttings

- Place root shoots and cuttings in a propagating bed, flats, or individual pots.
- Space 10–15 cm (4–6 in) in a row and 15–20 cm (6–8 in) between rows in beds or flats.
- Use well drained potting media or clean, washed silica sand with coir dust or sawdust (2:1 ratio). Do not use beach sand because it is too saline. Coral and shell sand are too alkaline.
- Place cuttings either horizontally (lightly covered with media) or at a 45° angle with the upper ¼ exposed.
- Keep cuttings protected from wind and shaded (up to 60% shade). Mist or water as needed depending on ambient humidity. It is critical to keep the media moist, so the cuttings do not dry out. However, the cuttings can rot if the media is too wet.
- The expected rate of successful rooting is 30–85%.
- Shoots begin to develop from adventitious buds after 3–4 weeks.
- When shoots are 20–25 cm (8–10 in) tall with roots—usually in 4–6 months—carefully transplant the cuttings into 4–8 liter (1–2 gallon) pots, using a well drained media. Fertilize sparingly.
- Keep plants in partial shade and weed free.
- Grow to a size of 0.6–1.6 m (2–5 ft) in 6–9 months and then field plant.

Outplanting techniques

- When plants are to be field planted in full sun, gradually move to full sun conditions in the nursery for about 2 months to harden them to site growing conditions.
- Keep plants moist and do not expose to strong wind.
- Reduce the size of the lower leaves by ½–⅔ to reduce transpiration. Do not remove or damage the growing point where new leaves develop.
- Protect from wind and excessive heat during transport.
- Dig a hole the same depth and twice as wide as the container. Add a small amount of mulch or slow-release balanced N-P-K fertilizer to the bottom of the hole and cover with soil.
- Carefully remove the tree from the container to prevent damage to the root system; place the tree in the hole; add soil no higher than the level of the plant in the pot; mulch and water well.
- Success rates close to 100% can be expected.

Plant at the onset of the rainy season; if the weather is dry, irrigate for the first 1–3 months of establishment. It is important to practice deep irrigation to encourage a deep root system. Mulching young plants is beneficial to keep soil moist, supply nutrients, and control weeds around the root system. Do not use herbicides around the base of the tree since they can damage the surface roots or young trunk. Protect young trees from pigs, cattle, goats, and horses that may eat the bark and tender shoots.

Breadfruit propagated by root cuttings and root suckers in nursery.

CULTIVATION

Breadfruit is genetically diverse, especially the seeded forms in the western Pacific and hybrids (with *Artocarpus mariannensis*) in Micronesia. Numerous Polynesian triploid varieties are genetically identical but morphologically distinct and tend not to thrive under atoll conditions, while both seeded and seedless hybrid varieties are better adapted to atoll conditions.

Breadfruit is traditionally grown in integrated mixed agroforestry systems. It is best to keep trees mulched and to use a non-climbing leguminous ground cover in orchards. Use compost or provide a complete fertilizer at the beginning and end of the fruiting season to maintain the health and vigor of trees, especially those that are 10 or more years old. Remove dead or damaged branches after the fruiting season.

In Fiji, commercial orchards of 10–20 trees are considered ideal for small farmers (NWC 2005). Trees benefit from good composting and mulch, although no systematic work has been done on fertilizer application. Large mature trees are often topped in the Pacific and elsewhere to induce new shoot growth, but this can often be detrimental to the tree as wounds do not heal well. Limit pruning on mature trees to the removal of dead, damaged, or dangerous branches. Young trees, especially those grown for commercial production, can be carefully pruned every year or so to encourage a good structure and branching habit. Keeping them low makes it easier to reach and harvest fruit.

Growing breadfruit as an integral part of a polyculture and has numerous advantages: total productivity, maximizing the use of available land, plant interactions, sustainability, etc. The main disadvantage is pest and disease control in orchards used for commercial production of fresh fruit for export markets (see following sections).

Known varieties

Numerous named varieties in the Pacific islands are perpetuated by vegetative propagation. Some varieties, such as 'Ma'afala', 'Maopo', 'Puou', and 'Meinpadahk', are widely distributed. Others are localized to specific islands.

'Ma'afala' is widespread in the Pacific and is also found in Australia, southern Florida, and possibly the Caribbean region. The small leaves are moderately dissected with 3–5 pairs of lobes. The tree reaches up to 10 m (33 ft) tall with a spreading canopy.

'Maopo' in Samoa and Tonga (known as 'Hamoa' in the Society Islands, 'Mei aukape' in the Marquesas, 'Uto lolo' in Fiji, 'Morava' in the Cook Islands, and 'Sra fon' in Kosrae) is widespread in the Pacific and was introduced to the Caribbean by Captain Bligh. Leaves are almost entire with shallow lobes at the tip. Vigorous rootstock is good for grafting. It reaches heights of 15 m (50 ft) or taller.

'Puou', a common and popular variety throughout the Pacific region, is also found in Australia, southern Florida and possibly the Caribbean. The large leaves are dull and shallowly dissected with 4–6 pairs of lobes. Fruit is round, oval, or heart-shaped with a long, stout stalk up to 10 cm (4 in) and a distinctive raised "neck." Tree is generally smaller (up to 10 m [33 ft] tall) with a dense, spreading canopy and produces many root suckers.

'Meinpadahk' (also known as 'Butatak' or 'Betaaktak') a seedless hybrid variety, is important throughout the FSM, Marshall Islands, and Kiribati, and well adapted to atoll conditions. Trees are tall, reaching heights of 12–15 m (40–48 ft), with a dense spreading canopy. The small, shiny, moderately dissected leaves have 3–5 pairs of lobes, some with only 1–2 pairs.

Fruit characteristics of some widely distributed varieties

Variety	Shape and flesh	Fruit size	Fruit weight
'Ma'afala'	Small oval fruit with white flesh, seedless, occasionally with 1–2 seeds	12–16 cm × 10–13 cm (4.7–6.3 in × 3.9–5.1 in)	0.6–1.1 kg (1.3–2.4 lb), average 0.8 kg (1.8 lb)
'Maopo'	Oval to broad ovoid fruit with pale white or creamy flesh, seedless	16–22 cm × 16–18 cm (6.3–8.7 in × 6.3–7.1 in)	2–3.1 kg (4.4–6.8 lb), average 2.5 kg (5.5 lb)
'Puou'	Creamy-pale yellow flesh, seedless, occasionally with 1–2 seeds	15–22 cm × 14–19 cm (5.9–8.7 in × 5.5–7.5 in)	1.2–2.5 kg (2.6–5.5 lb), average 1.9 kg (4.2 lb)
'Meinpadahk'	Fruit is oval to asymmetrical, light yellow-green, and seedless	12–16 cm × 12–15 cm (4.8–6.3 in × 4.7–5.9 in)	0.8–1.3 kg (1.8–2.9 lb), average 1.1 kg (2.4 lb)

‘Meinpadahk’

‘Puou’

‘Maopo’

‘Maʻafala’

PESTS AND DISEASES

Breadfruit is a hardy tree and relatively free of diseases and pests. Mealybugs can be a serious problem and Kiribati experienced fruit loss and tree decline as a result. In Australia, fruit spotting bugs (*Amblypelta* spp.) have caused some commercial fruit to be downgraded through shape distortion and hard spots. The glassy-winged sharpshooter (*Homalodisca coagulata*), a destructive leafhopper, reached Tahiti and other islands in French Polynesia in 1999, becoming a serious agricultural pest. It has been controlled by the introduction of a parasitic wasp in 2005. This leafhopper reached Hawai'i in 2004 and the Cook Islands in 2007. *Cercospora* leaf spot is seen on many trees. *Phellinus noxius*, a root rot, and fruit rots caused by *Phytophthora*, *Rhizopus*, and *Colletotrichum* (anthracnose) can cause substantial fruit loss. If affected fruit are not removed, the rot can spread up the stalk and into the stem, killing the branch tip. Fruit flies infest ripe fruit on the tree and ground. Tree decline and dieback is problematic throughout the Pacific and Caribbean Islands, especially on atolls. Since no pathological cause has been identified, they are considered to be the result of storm damage, drought, aging of the trees, or salinity.

Proper care (e.g., removing diseased fruit, removing dead and dying branches, and mulching) is essential to maintaining the health and vigor of trees. Incidence of fruit rot and fruit flies can be reduced by not allowing fruit to ripen on the tree or fall to the ground, and by picking infected fruit (which should be composted away from the trees or fed to animals such as pigs). Good sanitation, especially fruit fly control, is essential to maintaining the level of fruit quality required by export markets. Natures Way Cooperative Fiji (NWC 2005) details pests and diseases and their control for export. This involves bait spraying, which is a mandatory requirement to export fresh fruit to New Zealand. Since it involves the careful application of malathion, fruit cannot be marketed as organic. For local use and processing, other methods to reduce fruit rot and fruit fly problems should be used.

DISADVANTAGES

The main drawbacks of breadfruit as a crop are:

- Fruit are perishable with limited shelf life.
- Seasonal production, especially if only a few varieties are grown.
- Challenging harvest and postharvest handling.
- Limited availability of planting material for good quality varieties.
- Limited research and extension on agronomy, yields, pruning, and orchard management.
- Limited support for research and development and marketing of products.
- Lack of awareness about breadfruit.

INVASIVE POTENTIAL

Breadfruit has no potential for invasiveness. Most varieties are seedless and can only be propagated vegetatively, requiring humans to distribute and spread them. Clonal offspring spread a limited distance from the original tree via root shoots. Seeded varieties are not readily spread since seeds are relatively large and lose viability quickly.

AGROFORESTRY

Breadfruit trees provide shade, mulch, and a beneficial microclimate. They are generally included in home gardens or mixed agroforestry systems with other useful plants. Widely spaced trees (12 m × 12 m [40 ft × 40 ft] is recommended for commercial production) in an orchard can be interplanted with small fruit trees and a leguminous cover crop. Short-term fruit crops (e.g., pineapple, banana, and papaya) or field and vegetable crops (e.g., taro, tomato, and eggplant) can also be grown between young breadfruit trees. A leguminous cover crop should replace these intercrops when they begin to interfere with orchard operations. Some interplanting systems include:

- In the Federated States of Micronesia (Pohnpei), breadfruit is typically grown with yam (*Dioscorea* spp.). Yam vines climb trellises of beach hibiscus (*Hibiscus tiliaceus*) or bamboo and grow into the canopy of the tree during its non-fruiting period and are dormant while the breadfruit is harvested. This allows breadfruit to be picked without damaging the yam vines.
- In American Samoa, breadfruit is grown with taro, cassava, bananas, citrus, and cacao.
- In Palau, breadfruit is grown with betel nut, cassava, taro, citrus, and ornamentals.

ENVIRONMENTAL SERVICES

Breadfruit is often grown on steep hillsides, especially on the high islands of Micronesia, where it is the canopy species in traditional agroforestry systems. It can be interplanted with a wide range of crops and plants (e.g., yam, banana, medicinal plants, aroids, gingers, noni, kava, coffee, cacao, black pepper, etc.).

Breadfruit trees grow well on hillsides, protecting watersheds, providing erosion control, and windbreaks. The canopy provides beneficial shade for plants and people and the large leaves create mulch. It is used as a trellis tree for yam. The fruit is an important food source for flying foxes, native doves, and other birds in the Pacific islands. Honeybees

Left: Coffee orchard interplanted with breadfruit, coconut, and other food plants in Hōlualoa, Hawai'i. Center: Yam (*Dioscorea* spp.) trained up bamboo poles into a breadfruit tree canopy in Pohnpei. Right: Harvesting breadfruit in American Samoa with a long picking pole made of beach hibiscus.

benefit by collecting pollen from the male inflorescence and droplets of latex that ooze from the fruit surface.

COMMERCIAL PRODUCTION

Harvest

Breadfruit is generally picked and consumed when mature but not yet ripe. Careful harvest and postharvest handling is essential for maintaining fruit quality. Fruit that fall to the ground tend to bruise and soften sooner than those which are picked from the tree and gently handled. Common tools for harvesting fruit are a long picking pole with a forked end to clasp the stem or a woven or mesh bag to catch the fruit. Tripod orchard ladders are very practical, as the tripod design allows them to be safely used on uneven or rough terrain.. Made of aluminum they are lightweight, sturdy, and durable. Commercial ladders range in height from 1.5 m to 4.9 m (5–16 ft), depending on the manufacturer.

Left: Harvested breadfruit ready for postharvest storage prior to export from Samoa. Right: In regions where people are less familiar with breadfruit, labeling that educates consumers about taste and preparation is a good sales tool.

Postharvest handling and processing

Fruit quickly ripens in just 1–3 days after harvest. Shelf life can be extended by careful harvesting and pre-cooling fruit with chipped ice in the field and during transport. Covering fruit with water can also delay ripening for a few days.

Natures Way Cooperative Fiji (NWC 2005) has produced a detailed manual for growing and marketing fresh breadfruit for export. New Zealand requires that imported fruit go through a high temperature forced air quarantine treatment to kill fruit fly eggs and larvae. The fruit is then inspected, packed, and held at 15°C (40°F) for shipment; at which temperature fruit can remain firm for 10 days (Stice et al. 2007).

Value-added processing

Breadfruit's seasonal nature makes profitable processing difficult. Food processing operations must operate extremely efficiently because competition keeps profit margins low. Idle time during process-

ing is highly unprofitable because fixed costs accrue and production of finished products for sale diminish. This is the driving force for mass production (Beyer 2007). Seasonal supply difficulties can be mitigated by: 1) bulk preservation (i.e., drying/freezing raw material at the height of the season); 2) dovetailing breadfruit processing with other products with different seasonal glut; and, 3) planting varieties with sequential seasons.

Development of products for local use to replace imported foodstuffs or products that are shipped via sea freight is the most cost effective and beneficial to local economies. The simplest, most cost- and energy-efficient means of processing breadfruit is to slice or shred raw fruit, dry the pieces using a solar dryer/dehydrator (electric dryers are more energy intensive), and grind into a rough meal or flour. A traditional method of drying involves roasting whole fruit in a fire, cutting it into small pieces, and drying over a hot fire. These pieces (called *namba* in the Solomon Islands) have a pleasant, smoky flavor. Breadfruit flour can be used as a partial substitute for imported wheat flour in breads, cakes, and pastries, and is suitable for export. Ground meal can be used as a component of animal feed.

The traditional Pacific breadfruit preservation method of fermenting fruit in a leaf-lined pit, or more recently, in plastic or metal containers, deserves attention. Ripe fruit can be dried in thin sheets as a delicious "fruit leather" or mixed with other locally grown products to create fruit bars. Chips and other snack foods fried in coconut or other oil, can be sold locally. For export, these snacks require greater investment in energy, equipment, packaging materials, and preservatives to maintain freshness and quality.

Minimally processed pulp has the appearance, texture, and taste of fresh breadfruit. Minimal processing involves placing slices or cubes of fruit in plastic bags, vacuum sealing, then immersing in boiling water so the heat penetrates through the bags and the surface of the pulp reaches at least

Left: Organic breadfruit chips produced in Samoa. Top right: Breadfruit chips have a unique appearance and good taste and texture. Bottom right: Breadfruit dried in a solar dehydrator: thin slices (larger pieces) and shredded pieces, ready to be ground into flour or meal.

Breadfruit fermentation pit in Chuuk, FSM. 1987.

80°C (176°F) for 15 seconds (Beyer 2005). The pouches are immediately cooled using cold water to prevent overcooking. This is repeated 24 hours later and again on the third day. This technique results in pack sterility.

Where refrigeration/freezer facilities are economically feasible, and enough product is available to process, peeled mature and ripe fruit can be frozen. Frozen fruit can be thawed, cooked, and mixed into dough that makes excellent extruded products. Frozen breadfruit "French fries" could replace imported fries made from potatoes.

Recommended labeling

Useful information includes country of origin, locality, breadfruit variety (if known), list of ingredients, net weight, nutritional composition (if known), and producer's name and contact information. An attractive label and packaging draws the consumer's attention to the product and helps with marketing. If certified organic by an independent, internationally recognized organization, the certifying organization's name and logo should appear on the label. Exporters should research and comply with the requirements of the importing country.

SMALL SCALE PRODUCTION

Breadfruit is an important staple crop in the Pacific region and makes substantive contributions to local food security. Traditional Pacific diets were mainly based on starchy staple crops and marine resources. Numerous health problems are associated with replacing the island diet of local foods with imported white rice and flour, refined foods, sweets, and fried foods. Breadfruit is an excellent dietary staple and compares favorably with taro, plantain, cassava, and sweetpotato, all commonly eaten in the Pacific. Breadfruit is a nutritious, high-energy food with moderate glycemic index, rich in fiber, and a good source of vitamins B_1, B_2, and C, potassium, magnesium, and calcium, with small amounts of thiamin, riboflavin, niacin, and iron. Some cultivars contain small amounts of folic acid. Ripe fruit, especially yellow-fleshed varieties, can be a good source of provitamin-A carotenoids.

When possible, plant more than one variety to extend availability of fruit over a longer period. Keep trees low for easier harvesting. Since full fruiting potential from new trees takes 3–4 years, intercrop with pineapples, papaya, banana or other faster yielding crops to achieve quicker returns, while the breadfruit reaches a productive age.

In rural areas, and where subsistence agriculture is still a way of life, breadfruit is prepared and eaten regularly during the season. In Pohnpei, Kosrae, the Marshall Islands, and the Marquesas, some families still preserve fruit by fermentation. Excess or ripe fruit, peels, and cores are fed to pigs in many areas. Unfortunately, breadfruit production has declined in many areas over the past 10–20 years with increased reliance on imported staples such as rice.

Breadnut and breadfruit seeds are a good source of protein, potassium, calcium, phosphorus, and niacin, similar in flavor and texture to chestnuts. Seeds can be boiled, roasted, or ground into meal or flour. Breadnut seeds are generally sweeter and tastier than breadfruit seeds.

Growing breadfruit on a family farm or homestead allows the grower access to a readily available, nutritious source of carbohydrates. Breadfruit can supplement or replace imported crops such as rice or potatoes. Dried and ground into flour, it can partially replace imported wheat flour in many baked products and snack foods. Dried, ground meal can also partially substitute for imported poultry and pig feed. Breadfruit cultivation does not depend on expensive petroleum-based fertilizers.

YIELDS

Yields vary depending upon variety, age, tree health, and growing conditions, ranging from less than 100 to more

Nutrient composition of breadfruit (per 100 g [approx. ½ cup])

Nutrient	Mature, raw[1]	Mature, raw[2]	Mature, steamed[3]	Mature, boiled[1]	Mature, baked[2]	Ripe, raw[4]	Ripe, boiled[4]
Energy (kcal)	107	68–112	107–138	75	112–115	-	-
Protein (g)	1.5	0.8–1.4	0.6–1.3	1.3	0.6–1.3	-	-
Carbohydrate (g)	23.6	17.5–29.2	25–33	14.4	29.9–30.2	-	-
Fat (g)	0.4	0.3	0.1–0.2	0.9	0.2	-	-
Fiber (g)	2.5	0.8–0.9	2.1–7.4	2.5	0.9	-	-
Water (g)	72	67.6–79.4	65–73	81	66.5–67.2	-	-
Calcium (mg)	25	19.8–36	10–30	13	23.2–26.4	-	-
Iron (mg)	1	0.33–0.46	0.4–1.1	0.2	0.36–0.52	-	-
Magnesium (mg)	24	26.4–41.1	20–30	23	23.1–46.2	-	-
Phosphorus (mg)	-	26–29.7	18–41	-	26.4–32.1	-	-
Potassium (mg)	480	224–354	283–437	350	283–339	-	-
Sodium (mg)	1	4.2–10.4	13–70	1	4.9–6.6	-	-
Zinc (mg)	0.1	0.07–0.1	0.07–0.13	0.1	0.07–0.17	-	-
Copper (mg)	-	0.06–0.1	0.04–0.15	-	0.04–0.10	-	-
Manganese (mg)	-	0.04–0.07	0.04–0.08	-	0.03–0.07	-	-
Boron (mg)	-	0.50–0.54	0.09–0.19	-	0.51–0.72	-	-
Vitamin C (mg)	20	18.2–23.3	2–12	22	14.1–15.4	-	-
B_1 Thiamin (mg)	0.1	0.25–0.31	0.09–0.15	0.08	0.19–0.22	-	-
B_2 Riboflavin (mg)	0.06	0.09–0.11	0.02–0.05	0.05	0.07–0.10	-	-
B_3 Niacin (mg)	1.2	1.6–1.8	0.75–1.4	0.7	1.6–1.9	-	-
Folic acid (µg)	-	-	0.67–1.0	-	-	-	-
ß-carotene (µg)	24	-	8–20	30	-	48–140	1–868
alpha-carotene (µg)	-	-	-	-	-	<10–14	<5–142
ß-cryptoxanthin (µg)	-	-	8–11	-	-	1	<10
lycopene (µg)	-	-	13–26	-	-	-	-
lutein (µg)	-	-	41–120	-	-	204–590	35–750
zeanthin (µg)	-	-	-	-	-	60	<10–70

Sources: 1. Dignan et al. 2004 (no data on varieties); 2. Meilleur et al. 2004 (1 variety, 2 locations); 3. Ragone and Cavaletto 2006 (20 varieties); 4. Englberger et al. 2007 (14 varieties boiled, 2 raw)

Left: Breadnut seeds (bottom row) tend to be larger and a lighter brown color than breadfruit seeds. Ruler scale is in centimeters. Right: Breadfruit poi (breadfruit specially pounded with a small amount of water) is a traditional processed product of Hawai'i.

Nutrient composition of breadfruit/breadnut seeds (100 g, 10–12 seeds)

Nutrient	Raw[1]	Boiled[1]	Boiled[2]	Roasted[1]	Roasted[2]
Water (g)	56.3	59.3	59	49.7	50
Energy (kcal)	191	168	155	207	191
Protein (g)	7.4	5.3	5.3	6.2	6.2
Carbohydrate (g)	29.2	32	27.3	40.1	34.1
Fat (g)	5.6	2.3	2.3	2.7	2.7
Fiber (g)	5.2	4.8	3	6	3.7
Calcium (mg)	36	61	69	86	86
Iron (mg)	3.7	0.6	0.7	0.9	0.9
Magnesium (mg)	54	50	50	62	62
Phosphorus (mg)	175	124	-	175	-
Potassium (mg)	941	875	875	1082	1080
Sodium (mg)	25	23	23	28	28
Zinc (mg)	0.9	0.83	0.8	1.03	1.0
Copper (mg)	1.15	1.07	-	1.32	-
Manganese (mg)	0.14	0.13	-	0.16	-
Vitamin C (mg)	6.6	6.1	6.1	7.6	7.6
B1 Thiamin (mg)	0.48	0.29	0.34	0.41	0.41
B2 Riboflavin (mg)	0.30	0.17	0.19	0.24	0.24
B3 Niacin (mg)	0.44	5.3	6	7.4	7.4

Sources: 1. USDA 2007; 2. Dignan et al. 2004

than 600 fruit per tree with average yields of 150–250 fruit or 160–500 kg (350–1100 lb) per year. Approximately 5.5 MT/ha (2.4 T/ac) were produced in a traditional mixed agroforestry system on Pohnpei. Farmers in Tanzania reported yields of up to 900 fruit/tree, with an average of 400 fruit/tree (Maerere and Mgembe 2007). Approximately 75% of the fruit is edible (pulp). The skin is also edible and nutritious, although considered less palatable, and, along with the pulp, can be ground into flour, especially for animal feed.

When growing breadfruit for fresh fruit export markets, trees should be planted about 12 m (40 ft) apart (NWC 2005) to help with orchard management and to reduce pest and disease problems. Closer spacing is possible in an orchard if trees are regularly pruned and shaped to maintain a low profile.

COMMERCIAL PRODUCTION

Breadfruit is mainly produced for local use and commercial production figures are difficult to obtain for most countries.

Agricultural censuses conducted by the U.S. Department of Agriculture (www.agcensus.usda.gov) provide detailed information on the number of farms that grow breadfruit, number of trees, amount harvested, age of farmers, and value of the breadfruit crop for American Samoa, Guam, Commonwealth of the Northern Mariana Islands (CNMI), and the U.S. Virgin Islands. Production figures are not available for Hawai'i or Puerto Rico.

American Samoa was the largest producer by far, with more than 5,000 farms growing breadfruit, mostly for family consumption. In 2003 the age of breadfruit farmers was: 34 years or younger (472 farmers), 35–54 years (2,869 farmers), 55–64 years (1,382 farmers), and 65 years or older (1,090 farmers).

American Samoa production 1990–2003

	2003	1999	1990
Number of farms	5,813	5,900	827
Number of trees	150,778	142,245	83,409
Quantity harvested for sale (lbs)	703,375	761,786	101,418
Quantity harvested for consumption (lbs)	4,102,985	6,007,567	890,317
Value of sales ($)	388,725	331,063	27,222
Value of consumption ($)	2,267,543	2,643,330	(NA)

Source: USDA 2003 and 1999 Agricultural Census (www.agcensus.usda.gov).

In the Commonwealth of the Northern Mariana Islands, ten of the farms were on Saipan and four were on Rota. The age of farmers ranged from younger than 44 years (2 farmers), 45–54 years (8 farmers), 55–65 years (2 farmers) and 65 years or older (2 farmers).

Commonwealth of the Northern Mariana Islands production

	2002	1998	1990
Number of farms	14	9	33
Number of non-bearing trees	96	33	NA
Number of bearing trees	169	37	NA
Quantity harvested (lbs)	3,690	2,584	15,010

Source: USDA 2002 and 1998 Agricultural Census (www.agcensus.usda.gov).

In 2002, two of the farmers growing breadfruit on Guam were 55–64 years, and three were 65 or older. The value of the crop was not reported.

Guam production

	2002	1998	1993
Number of farms	5	26	12
Number of non-bearing trees	33	9	58
Number of bearing trees	107	81	109
Quantity harvested (lbs)	2,430	3,890	3,720

Source: USDA 2002 and 1998 Agricultural Census (www.agcensus.usda.gov).

The U.S. Virgin islands saw almost a 50% decline in the number of farms growing breadfruit from 1997 to 2002. In 2002, the age of breadfruit farmers was 44 years or younger

(4 farmers), 45–54 years (8 farmers), 55–64 years (11 farmers), and 65 years or older (14 farmers).

U.S. Virgin Islands production

	2002	1997–1998	1993
Number of farms	37	70	44
Number of non-bearing trees	106	171	148
Number of bearing trees	144	540	201
Quantity harvested (lbs)	5,875	18,299	5,535

Source: USDA 2002 and 1998 Agricultural Census (www.agcensus.usda.gov).

The agriculture census for the U.S. Virgin Islands provides production data for the islands of Saint Croix, and Saint John and Saint Thomas combined.

Saint Croix and Saint John & Saint Thomas production

	Saint Croix		Saint John & Saint Thomas	
	2002	1997	2002	1997
Number of farms	28	54	9	16
Number of non-bearing trees	76	134	30	37
Number of bearing trees	75	97	69	443
Quantity harvested (lbs)	3,505	3,759	2,370	14,540

Source: USDA 2002 and 1998 Agricultural Census (www.agcensus.usda.gov).

Number of farms and annual income from breadfruit sales in 2002 for American Samoa, Commonwealth of the Northern Mariana Islands (CNMI), and U.S. Virgin islands ranged from less than $100 to more than $10,000 per year.

Sales in American Samoa, CNMI, and U.S. Virgin islands

Income	American Samoa (2003)	CNMI (2002)	U.S. Virgin Islands (2002)
<$100	3,896	-	-
$100–499	337	-	-
$500–1,199	410	-	11
$1,200–2,499	315	3	13
$2,500–4,999	253	3	4
$5,000–7,499	169	2	3
$7,500–9,999	74	-	2
≥$10,000	359	6	4

Source: USDA 2003 (American Samoa) and 2002 (CNMI and U.S. Virgin Islands) Agricultural Census (www.agcensus.usda.gov).

For Hawai'i, fruit are generally available July–December (Hawai'i Dept. of Agriculture, no date). The U.S. Department of Agriculture National Agricultural Statistics Service Hawai'i Field Office (USDA NASS, no date) reported that island growers sold an estimated 2.3 million pounds of tropical specialty fruit in 2007 (Associated Press, August 14, 2008). Some of the tropical specialty fruits included in the survey were lychee, mango, starfruit, and breadfruit. However, specific production figures for breadfruit were not documented as production is not high enough to warrant this treatment.

The latest comprehensive agricultural census for Fiji in 1991 reported there were 183,000 bearing trees in the country (NWC 2005). That figure is probably much lower today due to hurricane damage and other tree losses. The 1999 agricultural census for Samoa estimated 89,000 trees in 13,009 holdings (McGregor 2002). The 2005 agricultural census for Samoa showed that 34 holdings grew breadfruit for export, 469 for sale and consumption, and 14,680 for home consumption (Tuivavalagi and Samuelu 2007). In Kiribati, 7,588 households had at least one breadfruit tree. A survey of 65 farms showed that 52,000 fruit were produced, ranging from 271–1,071 fruit per farm. Tarawa, where the demand was highest, had the lowest production, with average yeilds of 150 fruit (Kairo 2007).

Australian farmers, mainly in coastal north Queensland and around Darwin, produce 20 MT (22 T) year valued at AU$60,000 for the Australian fresh market (Goebel 2007). There are three commercial orchards with 60, 100, and 150 trees each, and about 30 smaller plantings totaling 100 trees.

In 2004, 571,340 fruit were produced and 166,826 kg traded in the Maldives, where breadfruit is an important subsistence crop. On the main market of Malé Atoll, 76,453 kg (168,200 lb) valued at Rf959,965 at Rf12.56/kg (approx. US$1.00/kg) were sold. During the year, 8,659 trees were planted (MFAMR 2004). Many breadfruit trees were destroyed in the December 2004 tsunami.

The Caribbean region is also a major producer of breadfruit. There were estimated to be more than 2 million trees in Jamaica in the 1950s. By the 1980s, about 46,000 remained and Hurricane Gilbert in 1988 may have killed or damaged 50% of those (Webster 2006). Due to the growing demand for breadfruit as fresh fruit or for processing, there have been national efforts to plant more breadfruit trees. As of April 2001, the Rural Agricultural Development Authority helped plant 18 ha of breadfruit, exceeding their target of 15 ha (37 ac) (RADA 2001). The Jamaican Ministry of Agriculture's Agriculture Development Strategy 2005–2008 (2005) targeted planting 70 ha (172 ac) of breadfruit trees in Year 1, 50 ha (124 ac) in Year 2, and 30 ha (74 ac) in Year 3. Total planting figures are unavailable, however, approximately 209 small plots totaling 2.6 ha (6.4 ac) have been planted of the 'Macca' or 'Prickly' variety (Webster 2006).

Baskets of breadfruit for sale at Fugalei Market, Apia, Samoa, where fruit are available year-round.

Area in cultivation for example Pacific islands

Country	Year	No. Trees	Holdings	Area (ha)
Cook Islands	2000	2,223		3
Guam	1987	1,006	156	-
Niue	1989	3,656		-
Northern Mariana Islands	1990	475	33	-
Palau	1989	192	-	-
Samoa	1989	-	-	1,062
Samoa	1999	-	13,009	-

Source: FAO Statistics Division World Census of Agriculture (www.fao.org)

Area in cultivation for example Caribbean islands

Country	Year	No. Trees	Holdings
Barbados	1989	1,713	-
St. Lucia	1986	-	6,438
St. Lucia	1996	70,010	-
Trinidad & Tobago	2004	27,694	-

Source: FAO Statistics Division World Census of Agriculture (www.fao.org)

MARKETS

Market data are hard to come by for most countries in the Pacific region. Fresh, cooked, and prepared fruit are generally available through markets, roadside stands, and other small vendors. Processed products, mainly chips, are sold at the same venues and by retailers. Breadfruit-based dishes are occasionally available at restaurants serving local foods. Samoa sells 100–300 MT (110–330 T) of fresh fruit annually, with 60–130 MT (66–143 T) sold in the Fugalei Market in Apia (McGregor 2002).

The current main export market is fresh fruit shipped by air freight. On a very small scale, traditional products are shipped internally, such as *namba* (from the Temotu Province to Guadalcanal in the Solomon Islands) and a preserved fruit paste (from Kapingamarangi to Pohnpei Island, FSM). Whole roasted fruit are occasionally air freighted from Tahiti and Hawai'i to Pacific islands, New Zealand, and the mainland United States. Commercial exports of fresh fruit in the Pacific region commenced in 2001 with shipments from Samoa and Fiji to New Zealand. New Zealand currently imports fresh fruit of 'Maopo', 'Ma'afala', and 'Puou' from Samoa and 'Uto dina' and 'Balekana' from Fiji. If supply and fruit quality constraints can be met, it is estimated that New Zealand markets could readily consume 4 MT (4.4 T) per week of fresh breadfruit with a market potential of 500–1,500 MT (550–1,650 T) per year (Stice et al. 2007).

Samoa exported 74 MT (81 T) in 2004–2006 (Tuivavalagi and Samuelu 2007). Annual exports from Fiji were 2 MT (2.2 T) in 2001, increasing to 12 MT (13 T) in 2005 (Stice et al. 2007). Up to 9 MT (10 T) per month of frozen breadfruit pieces were exported from Fiji (Beyer 2007). In 2007, 1–2 MT (1.1–2.2 T) per day were needed by a commercial processor to fill the demand for canned breadfruit shipped to Australia, New Zealand, and Canada (Fiji Times 2007). Fresh and cooked breadfruit imports to Australia from the Pacific are currently prohibited, although commercially produced peeled, seeded, and frozen pulp is permitted (Goebel 2007). The U.S. Department of Agriculture (Federal Register 2008) allowed the shipment of irradiated breadfruit to the U.S. mainland, opening the door for fresh fruit exports from Hawai'i.

In Hawai'i, fresh breadfruit is generally available in ethnic grocery stores and at local farmers markets. A few restaurants and individuals are processing breadfruit and/or preparing and serving breadfruit on a small scale. For example, one local entrepreneur on the Hawai'i Island makes breadfruit chips as well as a manju-type confection and pies using ripe breadfruit. A few island chefs feature or use breadfruit at their restaurants.

There is an increasing demand for fresh breadfruit in Hawai'i by Hawaiians and others interested in a traditional island diet for health reasons. Breadfruit can serve as a replacement for wheat-based food products, which are associated with food allergies. A large potential market for fresh breadfruit and breadfruit products also exists in the communities of Pacific islanders who reside in Hawai'i and on the U.S. mainland. In addition, markets can be created in the food service industry where new cuisines have developed in recent years, incorporating Asian/Pacific influences into themes such as Hawai'i regional cuisine.

Native Hawaiian and Other Pacific Islander Populations (NHPI) for the United States and the State of Hawai'i in 2000

	Total U.S.[1]	Hawaii[2]

Total Population	281,421,906	1,211,537	
	NHPI alone[3]	NHPI alone[3]	NHPI alone or in combination[4]
Native Hawaiians	145,809	80,137	239,655
Samoan	96,756	16,166	28,184
Tongan	29,940	3,993	5,988
Other Polynesian	6,314	588	3,019
Micronesian	77,422	9,818	16,843
Melanesian	10,287	240	503
Other Pacific islander, not specified	41,867	872	5,059

Sources: 1. The Native Hawaiian and Other Pacific islander Population: 2000. U.S. Department of Commerce. U.S. Census Bureau. December 2001. 2. The State of Hawai'i Data Book 2000. Hawai'i Department of Business, Economic Development and Tourism. 3. Respondents who reported their race as one or more of the six detailed groups, but no other race. 4. Respondents who reported they were a Pacific islander and another race, e.g., Caucasian, Asian.

Several Caribbean countries (Jamaica, St. Lucia, Dominica, St. Vincent, and the Dominican Republic) ship fresh fruit to the U.S., Canada, and Europe. Exports declined from 2,023 MT (2225 T) in 1998 to 1,203 MT (1,320 T) in 2005, even though demand remained high (Roberts-Nkrumah 2007). Jamaica is the largest exporter in the region, exporting 3,437 MT (3,780 T) during 2000–2004 (517–776 MT [570–850 T] per year) with a total value of approximately US$3 million (RADA 2003–2006). Mauritius exports breadfruit to Europe on a small scale of 0.4 MT (0.44 T) in 1996, 20 MT (22 T) in 1997 and 1.9 MT (2.1 T) in 2000 (MAFTNR 2003).

Specialty markets

There are several promising specialty markets, including

- organic and natural foods
- bird, bee, and flying fox friendly (conservation twist)
- watershed protection
- sustainable agriculture, and
- potential carbon credits.

The historical importance of breadfruit and name recognition in many countries (based on its connection to *Mutiny on the Bounty*) could play a key factor in marketing. Specialty varieties identified by region could also be helpful in catering to expatriate markets.

ECONOMIC ANALYSIS

A financial model for a breadfruit orchard of 20 trees was developed for Fiji (NWC 2005). It assumes that a household, using entirely its own labor, operates the orchard. The trees are planted at 12 m × 12 m (40 ft × 40 ft) spacing, requiring an area of approximately 0.3 ha (0.75 ac). Wide spacing minimizes fungal disease problems and allows for crops to be grown between the trees. Some production is realized in the second year, with full production achieved in 4 years.

Yield estimates are regarded as conservative and no fertilizer is applied, although subsequent research may show that applying fertilizer is economically worthwhile. A farm gate price of FJ$0.50/fruit (FJ$0.45/kg) is assumed. This is the price currently paid for breadfruit picked from scattered trees. The quality of fruit from the orchard can be expected to be superior with a lower rate of rejection at the exporter's pack house than for fruit collected in unmanaged agroforests.

Yields and returns for a breadfruit orchard of 20 trees in Fiji

Year	2	3	4–16
Marketable yield			
Number of fruit/tree	15	75	150
kg of fruit	16.5	82.5	165
Total marketable production (kg)	330	1,650	3,300
Sales @FJ$0.45/kg	FJ$148	FJ$742	FJ$1,485

Source: NWC 2005

Over a 16-year period, the average annual labor input of the household is 37 days. Estimated average annual gross margin from the 20 trees is FJ$1,200 (or FJ$60/tree). Estimated return to household labor is about FJ$33/person per day. In 2007, the per capita income in Fiji was US$3,300 (World Bank 2009), equivalent to US$12.69/day based on a 5 day work week. Additional income from interplanting other crops during the first 3 years can be expected.

Profits are high because of the relatively low labor requirement for breadfruit production. Estimated financial returns are sensitive to yield. If marketable yield could be increased 50% by using better varieties and/or improved management, average gross margins would increase to FJ$1,671/farm, FJ$84/tree, and FJ$38/person per day.

In Jamaica, production costs and revenue projections for establishing a 1 ha (2.5 ac) orchard (Webster 2006) were based on 125 trees/ha (50 trees/ac), with first economic bearing 3 years after planting, two bearing seasons per year, and marketable yield at 60% total annual yield: 5,000 fruit at Year 3 and 16,625 fruit at peak production (7 years). Average base price per fruit was JM$15.00 (US$0.25) with annual inflation rate of 10%.

Estimated returns for 1-ha breadfruit orchard in Jamaica

Year	Annual return JM$	Annual return US$
0 (establishment)	-52,500	-875
1	-21,800	-363
2	-23,980	-400

3	18,622	310
7	331,829	5,530
10	541,992	9,033

Expected income per tree

The average price for fresh breadfruit at the Fugalei Market, the main produce market in Samoa, was ST$0.97/kg in 2005 and ST$0.99/kg in 2006, ranging from ST$0.55–1.76/kg (Tuivavalagi and Samuelu 2007). Data from the Central Bank of Samoa Fugalei Market Survey Report reported prices of ST$0.55–3.96/kg during 2007. Higher prices were obtained when supplies were low. In Fiji, producers received FJ$0.45–1.00/kg. In Kiribati, individual fruit sold for US$1.50–2.30 in 2005–2006 (Kairo 2007). In American Samoa in 2003 the market value of breadfruit was US$3.98/kg (USDA 2003)

No figures are available for processed or value-added products. However, Beyer (2005) provides a formula for estimating production cost during the early stages of development of processed/value-added products: to estimate the cost of raw materials, labor and services, add the cost of raw materials, multiply by 3 and add 10%. This estimated cost of production can then be used in the following formula to calculate an approximate wholesale price that must be competitive with similar products in order to be profitable.

> cost of production + cost of distribution (transport) + profit = minimum wholesale price needed for profitability

If the price the market is willing to pay is too small, there will be a loss on the part of the producer, and the product is not economically feasible.

Some examples of this formula applied to the economic feasibility of possible local products in Pohnpei (Beyer 2005) include:

Frozen breadfruit pieces

Expenses	**US$**
breadfruit	0.30/lb
plastic pouch	0.03 per unit sold
Total raw materials	0.33/lb
Processing (×3 + 10%)	1.10/lb

Assuming a 20% mark-up by retailers, the minimum retail amount that would need to be charged at retail (in addition to transportation and the producer's profit margin) is US$1.32/lb.

It is estimated that this product will be consumed as the carbohydrate portion of a main meal. Even at this price, a frozen breadfruit product is unlikely to compete with rice or ramen noodles. However, this product might compete favorably with other carbohydrate products such as imported potatoes, frozen French fries (US$6.45 per 500 g bag), and pizza crusts.

Extruded breadfruit snacks

Expenses	US$
breadfruit	0.30/lb
oil (est.)	0.01 per 4 oz packet
salt	0.01 per 4 oz packet
Total cost of ingredients	0.32/lb

Per 4 oz package costs	US$
raw materials	0.08
plastic pouch	0.03
Total cost of raw materials	0.11
Total production cost (x 3 + 10%)	0.36

Assuming a 20% mark-up by retailers, the minimum retail amount that would need to be charged for extruded breadfruit snacks at retail (in addition to transportation and the producer's profit margin) is US$0.44/4-oz packet.

Breadfruit snacks are likely consumed at barbeques and other social events. The major competition is likely to be commercial extruded crispy snacks processed from various starches, with a retail price of around US$1.65/4-oz pack. Based on the estimated price of US$0.44/4-oz pack plus transportation cost and profit, it is expected extruded breadfruit snacks will compete favorably against similar imported snacks based on corn and rice.

FURTHER STUDY

Participants at the "First International Symposium on Breadfruit Research & Development" (Taylor and Ragone 2007) made the following recommendations for breadfruit production, product development, and marketing:

- Develop a variety of convenient products with extended shelf life to replace imported less-healthy staple and snack foods, targeting all age groups.
- Choose innovative approaches for improving marketing—health, cultural, food security, environmental, and fair trade.
- Consider traditional methodology, such as fermentation, for product development, rather than concentrating all efforts on modern methodology.
- Develop good production practices specific to each geographic area and different varieties of breadfruit; incorporate planting of different varieties to increase production and year-round availability.
- Embark on commercial production by planting breadfruit orchards and experimenting with production techniques (e.g., pruning, harvesting, etc.).

- Identify desired products and production practices designed specifically to meet the demand for "a product." Develop guidelines for production practices for specific products to be disseminated in a suitable form.
- Produce a comprehensive production manual for export as well as simple leaflets for growing breadfruit in a homegarden.

GENETIC RESOURCES

The National Tropical Botanical Garden (NTBG) in Hana, Hawai'i, maintains an extensive germplasm collection with 200 accessions and 120 varieties. The Breadfruit Institute at NTBG, Hawai'i (breadfruit.org) has partnered with a horticultural company to propagate selected breadfruit varieties on a large scale. Methods are now in place to grow and ship healthy, vigorous young breadfruit plants that will mature quickly and easily into productive trees.

Breadfruit collection at National Tropical Botanical Garden, Hana, Maui, Hawai'i.

The USDA Clonal Germplasm Repository in Waiakea, Hawai'i, maintains 30 breadfruit accessions.

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Specialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps)

Farm and Forestry Production and Marketing profile for Breadfruit (*Artocarpus altilis*)

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