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

Farm and Forestry
Production and Marketing Profile for

Sweetpotato

(*Ipomoea batatas*)

By Scot C. Nelson and Craig Elevitch

PAR

USES AND PRODUCTS

Sweetpotato has a wide range of uses, including foods, beverages, medicines, ceremonial and household objects, fishing bait, and animal feed.

Foods. Sweetpotato is baked or steamed in jackets in ovens to eat as a carbohydrate. Cooked sweetpotatoes may be peeled, mashed, and mixed with water to form a paste. Raw, peeled sweetpotatoes may be grated and mixed with coconut milk and served as a dessert after wrapping them in leaves and baking. Young leaves growing near the apex of vines are cooked as greens, sometimes in coconut milk.

Beverages. Sweetpotato genotypes having high sugar content in the storage roots may be cooked and then treated and fermented to produce alcoholic beverages.

Medicines. Various parts of the sweetpotato plant and various genotypes may be used as treatments for health conditions or in medical applications such as asthma relief, laxative, induction of vomiting, and as a gargle. Parts of the plant may also be used as components of medicinal mixtures for application or ingestion.

Ceremonial. A nursing Hawaiian mother may wear a sweetpotato vine garland to ensure milk flow.

Households. Old leaves or vines may be used as padding under floor mats.

Fishing. Flesh of the sweetpotato storage roots of certain genotypes may be used as bait for mackerel scad fish at their offshore breeding locations.

Animal feed. Leaves and vines are maintenance food for hogs. The storage roots serve as food for final fattening.

Worldwide production

China produces about 75% of the world's sweetpotatoes. According to the Hawai'i Department of Agriculture Annual report (2007), sweetpotato ranked as the 18th most valuable agricultural commodity in the state in 2006, valued at $4.44 million for a production of 2,730 metric tons (MT) (3,000 tons) at a farm price of $1.63/kg ($0.74/lb). Hawai'i's market share of sweetpotato consumption was 76% in 2007, as 24% of sweetpotatoes (772 MT, 849 T) were imported.

BOTANICAL DESCRIPTION

Preferred scientific name

Ipomoea batatas (L.) Lam.

Family

Convolvulaceae (the morning glory family)

Top: Five different sweetpotato varieties grown in Hawai'i. These cooked roots display some of the variety in shape, size and color inherent in the genus. Middle: These market baskets in Tongatapu, Tonga show the traditional Polynesian starch staples including sweetpotato, breadfruit, and banana. Bottom: When eating sweetpotato shoots, usually only the tender young growth up to the 3rd or 4th leaf is consumed.

Common names (after PIER 2010)

The common name in English is sweetpotato or sweet potato. The term "sweet potato" is really a misnomer, because it implies they are potatoes that are sweet, when in reality they are as different from potatoes as carrots are. Recognizing this, the National Sweetpotato Collaborators Group and the National Sweetpotato Association endorsed the spelling "sweetpotato" in 1989.

In the U.S., the word "yam" is often used for orange-fleshed sweetpotatoes, which causes confusion with "true" yams, *Dioscorea* spp. Table 2 below distinguishes among sweetpotato, white potato (*Solanum tuberosum*), and yam.

Chamorro: *kamote*
Chuukese: *kómwu*, *kómwuti*, *kómwuutiy*, *omwuti*, *sachúmayimwo*, *yomwuutiy*
Fijian: *kūmala*, *kawai ni vavalangi*, *kumala*, *kumara*, *ndambithi*, *wa uvi*
Filipino: *kamote*
French: *patate douce*
German: S*üßkartoffel*, *Suesskartoffel*, *Batate*
Hawaiian: *ʻuala*, *ʻuwala*, *ʻwala*
Hindi: *mitha alu*, *sakarkand*, *shakar kanda*
I-Kiribati: *te kumara*
Indonesian: *ubi jalar*
Italian: *patata dolce*
Japanese: *satsuma imo*, さつまいも *satsuma imo*, 薩摩芋 *satsuma imo*, *ryuukyuu imo*, *kara imo*, *kan sho*
Kwaraʻae: *butete*
Korean: *ko gu ma*
Malay: *ubi keladi*, *ubi keladek*, *ketela rambat* (Java), *ubi jalar* (Indonesia)
Maori (Cook Islands): *kuʻara*, *kūara*, *kūmala*, *kūmara*, *kumara*
Marquesan: *kūmaʻa*
Mashallese: *biteto*, *juweet potato*, *piteto*
Niuean: *kumara*, *simala*, *timala*
Pitkern (also Pitcairnese): *kumara*, *oumera*, *tek*
Palauan: *emutii*
Portuguese: *batata doce*, *batata da ilha* (Brazil)
Pukapukan: *kūmala*
Rapa Nui: *kūmara*
Rarotongan: *kūmara*
Samoan: *ʻumala*
Satawalese: *kamote*, *komote*
Spanish: *batata*, *boniato*, *camote* (Latin America), *cumala huasca*, *cumal huasca*, *cumara*, *curiti*, *jarissi jabo*, *kamote* (Philippines)
Tahitian: *umara*, *ʻumara*
Tongan: *kumala*, *kumara*
Ulithian: *komoti*
Woleaian: *gamwuutiy*
Yapese: *gamuti*, *kamuut*

Brief botanical description

Seedlings are similar to morning glories with their bilobed cotyledons. When mature, a predominately prostrate, dicotyledonous sweetpotato plant has a shallow vine canopy and produces several types of roots. The edible root (the sweetpotato) is a storage root and not a tuber, which initiates at the first stem node beneath the soil to which it attaches by a thinner root. Three types of sweetpotato canopies exist: trailing (vine), bunched (bush), and intermediate. These types vary greatly in length of vines, patterns of branching, and internode length. Shapes and sizes of the leaves and length of petioles vary considerably among genotypes. Leaf shapes vary from heart-shaped to more or less deeply 5-lobed, or from broad and entire to deeply indented or lobed. Flowers are complete, the corolla generally white at margins and having pink to purple throats. Capsules bear the hard-coated seeds, but few seeds are produced, even under optimum conditions. Many genotypes do not flower readily and some genotypes are sterile.

DISTRIBUTION

The sweetpotato probably originated in South America or Central America (geographically between the mouth of the Orinoco River in Venezuela and the Yucatan peninsula of Mexico). Sweetpotato cultivation is worldwide in more than 100 counties, including Central America, South America, North America, Pacific Islands, Asia, India, Africa, Australia, the Caribbean, and the Mediterranean basin.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

Sweetpotato grows in both tropical and temperate environments. The staple type of sweetpotato (versus the dessert

Table 1. Elevation, rainfall, and temperature

Elevation range	**lower:** 0.5 m (20 in) above sea level **upper:** 600 m (2000 ft)
Mean annual rainfall	**lower:** 500–1,300 mm (20–50 in) **upper:** 900–1,300 mm (35–50 in) is optimum; it can tolerate much higher rainfall amounts in well drained soils
Rainfall pattern	It prefers uniformly distributed rainfall
Dry season duration	Sweetpotato is drought tolerant after 40 days of growth
Mean annual temperature	**lower:** 21°C (70°F) **upper:** 27°C (81°F)
Mean air temperature	greater than 25°C
Minimum temperature tolerated	0°C (32°F), as it does not tolerate frost

type) is more commonly grown in tropical climates. The staple type of sweetpotato, with white to cream-colored flesh, is comparatively rich in proteins, starch, and dry matter.

Soils

Sweetpotato grows suitably on various types of soils. The best are soils that are loose, of low clay content, well drained, and relatively free of stones. In high-rainfall areas, planting on high ridges or mounds provides necessary drainage. Best crop results occur on lands that have not been used for sweetpotato cultivation for at least several years before planting. The slightly acidic soils of some Pacific islands (pH 5.0–6.0) are very suitable for cultivation of sweetpotatoes, but they also grow well in the alkaline limestone soils Guam and Pacific atolls. In areas covered with lava, soil and decomposed organic matter may be placed in holes or pockets without mounding.

GROWTH AND DEVELOPMENT

Sweetpotatoes may be planted and grown throughout the year in the Pacific islands. However, short day length stimulates root development, whereas long day length stimulates shoot development. Hence, the best months for planting in Hawai'i (north of the equator) in terms of high yields are from March to May, while the lowest yields are realized when planting occurs from October to December. During the cultivation periods having highest air temperatures and longest day lengths, sweetpotato root harvest can occur 4 to 5 months after planting. In cooler locations or in periods and during times of shorter day length, from 5 to 6 months of plant growth are required before harvest. Harvesting sweetpotato after 6 months produces jumbo-sized roots, but earlier harvest can reduce the incidence of pest and disease problems.

AGROFORESTRY AND ENVIRONMENTAL SERVICES

Although most sweetpotatoes produced worldwide are grown in monocropping systems, the plant performs well in polycropping systems or as a component of well managed agroforestry systems. The rapidly spreading sweetpotato foliage can shade and choke out many weeds to protect the overstory companion crops in these more diverse cropping systems. However, sweetpotato is not regarded as an invasive plant.

Environmental services

If fields of sweetpotatoes are kept free of weeds for the first 4–8 weeks of growth, the vines will cover the field completely and significantly inhibit further weed development. Mature, densely planted fields may inhibit soil erosion.

PROPAGATION AND PLANTING

Crops of sweetpotato normally grow from vine tip cuttings, about 20–30 cm (8–12 in), from which all foliage is removed except two or three terminal leaves. Stem cuttings are planted from 15–30 cm (6–12 in) apart at an obtuse angle of insertion, with about ⅔ of the vine covered with soil. Row spacing is about 0.9 m (3 ft). Plants grow rapidly thereafter, quickly filling in space completely with a dense canopy of sweetpotato vines of varying height. Vine height depends on sweetpotato variety, soil type and fertility, and irrigation, but generally reach 0.3–0.9 m (2–3 ft) tall.

Table 2. Distinguishing sweetpotato, white potato, and yam.

	Sweetpotato	White potato	Yam
Scientific name	*Ipomoea batatas*	*Solanum tuberosum*	*Dioscorea* species
Plant family	Morning glory (Convolvulaceae)	Nightshade (Solanaceae)	Yam (Dioscoreaceae)
Plant group	Dicotyledon	Dicotyledon	Monocotyledon
Flower character	Monoecious	Monoecious	Dioecious
Edible parts	Storage root	Tuber	Tuber
Shape	Short, blocky, tapered ends	Variable, mainly blocky to oval	Long, cylindrical, some with "toes"
Number per plant	4–10	5–10	1–5
External texture of edible storage organ	Smooth, thin skin	Smooth to slightly rough, thin to thick skin	Rough, scaly skin
Dry matter	22–28%	Approx. 22%	20–35%
Mouth feel	Moist	Dry	Dry
Taste	Sweet	Starchy	Starchy
Vitamin A	High (orange varieties)	Very low	Very low
Propagation	Transplants/vine cuttings	Seeds, tuber pieces	Tuber pieces
Growing Season	90–150 days	80–115 days	180–360 days
Climate required	Tropical, temperate tropical	Temperate	Tropical, temperate tropical

Sweetpotato (*Ipomoea batatas*), white potato (*Solanum tuberosum*), and yam (*Dioscorea alata*) are easily distinguished in the field. Top left: White potato plants. Bottom left: Sweetpotato variety collection at Maui Nui Botanical Garden, Kahului, Hawai'i. Right: Yam leaves.

Left: Grocery store sweetpotato (upper shelf) and white potato (lower shelf). Right: Yam tubers in Tongatapu, Tonga.

Top left: A sweetpotato mound outside a family home in Yap. The sweetpotatoes are harvested as needed, rather than harvesting the whole mound at one time. Top right: Sweetpotatoes growing together with pineapple in a small field in Yap that had been most recently planted in taro. Bottom right: Sweetpotato, yam, and squash growing in a secondary forest in Yap that had been cleared for crops. Bottom left: Sweetpotato ground cover in a mixed orchard in ʻUpolu, Samoa.

Recommended outplanting techniques

Vine cuttings may be planted directly into moist soils. Irrigate a planted field regularly for the first 4–8 weeks to ensure adequate formation and growth of roots. Soils may be hilled or mounded to promote a well drained rhizosphere.

CULTIVATION

Variability and known varieties

Sweetpotato is a highly variable species, with approximately 3,000 cultivars worldwide. There are two types of sweetpotatoes: 1) moist (baking) types and 2) dry (boiling, frying) types. The dry-fleshed varieties have white to pale or purple skin types and are referred to locally in Hawaiʻi as "sweetpotato." The moist, orange-fleshed types are often referred to under the misnomer "yam." Both the dessert or starch types of sweetpotatoes may be baked, but the starch types are probably best for boiling or frying.

There are many cultivars indigenous to Hawaiʻi and the Pacific islands. In Old Hawaiʻi, for example, there were about 230 sweetpotato cultivars. By 1940, only 24 were still being grown. Therefore, over 200 cultivars are presumed lost forever.

The cultivars recommended currently for cultivation in Hawaiʻi include:

Moist (baking) types

ʻHoʻolehua Gold'—orange flesh and reddish skin
ʻKona B'—light orange flesh and red to orange skin
ʻIliua'—orange flesh

Dry (boiling, frying) types

ʻWaimānalo Red'—white flesh and red skin
ʻHoʻolehua Red'—white flesh and red skin
ʻRapoza'—purple flesh and white skin
ʻOnokeo'—white flesh and purple skin
ʻOkinawan'—purple flesh and whitish skin

Basic crop management

Traditionally, people planted sweetpotatoes in mounds created by hand. The earth was heaped up into hills where soil

was powdery and dry. Higher soil mounds were formed in wet areas where root aeration might have been limited. Several stem cuttings (or slips) were inserted into holes created by sticks within each of the irregularly spaced soil mounds. After planting, mounds were mulched with plant material. Periodically, soil in mounds was loosened using a stick and re-heaped around the base of plants. Weeds were removed and vines trained around mounds and partially covered with soil. After the storage roots began to grow, smaller storage roots were pinched off to allow the larger roots to enlarge. Partial harvesting of mounds or harvesting over a longer duration was common. Entire plants were not dug out and harvested at one time. Only the largest roots were carefully removed and the disturbed area re-covered with soil to minimize damage from rats and root rot.

Modern farmers in many areas of the Pacific still use traditional cultivation practices in commercial fields and in home gardens. Much of the work is still accomplished by manual labor. Export farmers growing on large scale farms prepare fields and soil hills with tractors and manage crops with pesticides to control weeds and diseases. Stem cuttings for new fields may still be planted by hand. Modern commercial fields in Hawai'i are dug at harvest with potato harvesting devices drawn by tractors that turn over the plants and expose the roots for collection in plastic baskets and subsequent processing.

To start a new field, disease- and pest-free stem cuttings must be obtained from healthy vines. It is important to cut only healthy appearing, aerial vines and to avoid removing and planting rooted vines with the soil attached. Hilling or mounding of soil before planting helps to ensure good soil drainage in order to avoid root rots.

Crop rotation minimizes the accumulation of harmful insect pests and plant pathogens in sweetpotato fields. Sweetpotatoes should be grown only once every 3 or 4 years in a given location.

Recommended planting density

A recommended planting density for monocrops of sweetpotato is 1.2 m (4 ft) between rows and 25–30 cm (10–12 in) between plants within rows. A spacing of 25 cm × 120 cm (10 in × 48 in) requires 32,300 cuttings/ha (13,068 cuttings/ac), whereas at a spacing of 30 cm × 120 cm (12 in × 48 in), 26,900 vine cuttings are required per hectare (10,890/ac). Space between plants can be increased in polycropping or agroforestry settings.

Growing in polycultures

Attack and damage from plant pests and diseases are reduced where crops are grown in diverse polycultures. Sweetpotatoes can act as a ground cover for other plants, as shown in accompanying photos. However, sweetpotato yields best in sunny areas and generally yields lower where grown in an understory within a polycrop or an agroforestry setting.

Left: Intercropping taro with sweetpotato is common in Hawai'i, as in this field. Right: Hugo Gange in Guam hand waters his sweetpotato field, newly planted on shallow limestone soil. Every fifth row is planted in coconuts, which will become the permanent crop.

Left: Harvesting baskets become dirty after use and should be cleaned before using them again. The dirt on the baskets contains fungal spores that can be transferred unwittingly to other sweetpotatoes, potentially contaminating them and causing infections. Right: Baskets of sweetpotatoes after washing and before boxing at a packing facility in Hawai'i.

Left: A tractor-drawn and -powered potato harvester is used to dig up sweetpotatoes at larger commercial operations. Right: A mechanized hiller pushed and directed by hand can be used to form mounds of soil within fields before planting sweetpotato vine sections.

Top: A typical sweetpotato field in Hawai'i. Middle: A harvested field of sweetpotatoes in Hawai'i. Off-grade sweetpotatoes and debris should be removed from fields and not allowed to disintegrate there. If sweetpotato debris is left in the field, populations of plant pathogens and parasitic insects will increase on the debris and negatively affect future crops. Bottom: Taro plant volunteers emerging in a sweetpotato field in Hawai'i. Although taro is a common intercrop with sweetpotato, both are susceptible to some of the same fungal plant pathogens.

PESTS AND DISEASES

Sweetpotato is susceptible to attack by a number of insect pests and plant pathogens in the Pacific islands, which can reduce marketable yields.

Some important insect pests of sweetpotato in the Pacific

Beetles: sweetpotato weevil (*Cylas formicarius*) and other weevils; sweetpotato flea beetle (*Chaetocnema confinis*), tortoise beetles (scientific names varies).

Caterpillars: sweetpotato hornworm (*Agrius cingulatas*); black cutworm (*Agrostis ipsilon*); Mexican leafroller (*Amorbia emigratella*); green garden looper (*Chrysodeixis erisoma*).

Flies: gulf wireworm (*Conoderus amplicollis*).

Leaf miners: sweetpotato leafminer (*Bedellia orchilella*).

Mites: tumid spider mite (*Tetranychus tumidus*).

Some important plant pathogens and diseases in the Pacific

Black rot (*Ceratocystis fimbriata*) (anamorph: *Chalara* sp.)

Chlorotic leaf distortion (*Fusarium lateritium*) (teleomorph: *Gibberella baccata*)

Fusarium root rot and stem canker (*Fusarium solani*)

Fusarium wilt, stem rot (*Fusarium oxysporum* f. sp. *Batatas*)

Java black rot (*Lasiodiplodia theobromae* = *Diplodia gossypina*)

Mottle necrosis (*Pythium* spp., *P. scleroteichum*, *P. ultimum*, *Phytophthora* spp.)

Rhizoctonia stem canker, sprout rot (*Rhizoctonia solani*) (teleomorph: *Thanatephorus cucumeris*)

Rhizopus soft rot (*Rhizopus* spp., *R. stolonifer*)

Some important plant-parasitic nematodes in the Pacific

Burrowing (*Radopholus similis*)

Reniform (*Rotylenchulus reniformis)*

Root-knot (*Meloidogyne* spp., *M. arenaria, M. hapla, M. incognita, M. javanica*)

Insects and diseases that can commonly reduce marketable yields in the Pacific

Insects: Sweetpotato weevils, gulf wireworm, sweetpotato flea beetle, sweetpotato vineborer.

Diseases: Fungal rots diseases (black rot, Rhizopus soft rot, Java black rot, scurf, scab); root-knot nematodes.

Left: Symptoms of sweetpotato black rot, one of the most important plant disease problems in sweetpotato production in the tropics. Middle: Chrysalis of the sweetpotato hornworm (*Agrius cingulata*), a parasite of sweetpotato that ranges in distribution from Canada to South America. The chrysalis is edible for humans. Right: Adult male sweetpotato bug (*Physomerus grossipes*) on Maui.

Top left: Fungal molds can spoil sweetpotatoes in transit. Top right: Insect tunneling injury. Bottom right: The common fungal disease known as scurf disease causes superficial brown lesions on the skin. Bottom left: Rat gnawing injury.

Pests and disease prevention

There are a number or practices that are useful for preventing and treating problem pests and diseases.

Intercropping. Various plants such as papaya, cassava, and pineapple can be planted together with sweetpotato (avoid monocropping).

Crop rotation of sweetpotato with crops that are not susceptible to attack by the main insects and pathogens that parasitize sweetpotato. Do not plant successive crops of sweetpotato in the same field; wait at least 3 years between sweetpotato crops. Crops used for rotation with sweetpotato in Hawai'i include alfalfa, beans, beets, cowpea, kai choy, lettuce, peanut, pigeon pea, sorghum, spinach, and sweet corn. Although taro is also used, it is not ideal as it can host some fungal pathogens that affect sweetpotato. Because of the somewhat allelopathic nature of sweetpotato, rotation crops should be selected carefully.

Agroforestry. Plant sweetpotato as an understory crop in a diverse agroforestry setting.

Cultivar selection and development. Select or develop cultivars that are pest-resistant and high-yielding in your environment.

Curing. Cure sweetpotatoes after harvest to reduce the incidence and severity of fungal diseases (see "Postharvest handling" below).

Sanitation. Keep the washing and packing area clean; use clean water for processing sweetpotatoes; clean up plant debris from fields after harvest.

Choice of planting location. Avoid planting in heavy or poorly drained soils.

Hilling. Plant sweetpotatoes in hills or mounds to ensure adequate drainage and aeration.

Choice of planting material. Do not plant vines with their roots attached by collecting planting material from well above the soil.

Pest scouting and identification. Look through the field weekly for estimates of pest populations; submit samples for diagnosis where necessary.

Irrigation. Cease irrigation about one month before harvest.

Harvesting. Minimize injury to sweetpotato storage roots during harvest and processing.

Shipping. When exporting sweetpotatoes, ensure they are properly cooled en route and that boxes enclosing them do not become wet.

Top: Tufts or "whiskers" of spore-bearing fungal mycelium emerge through the skin infected by Rhizopus soft rot disease. Middle: Leaf and stem scab caused by the fungus *Elsinoe batatas* is a very severe disease on some Pacific islands. The leaves curl and fail to expand normally. Bottom: Sweetpotato weevils. It is important to remove off-grade sweetpotatoes from fields after harvest to prevent weevil populations from increasing.

COMMERCIAL PRODUCTION

Postharvest handling

Harvested sweetpotato roots are selected in the field, placed in crates, and transported to a packing house or shed where they are washed. Off-grade sweetpotatoes are culled (i.e., oversized, roots damaged by weevils, pathogens or machinery, misshapen roots, etc.). When the harvest is performed during dry soil periods, handle roots carefully to minimize damage. When harvest occurs during wet soil period, allow the roots to dry naturally in a shaded area until the soil dries and then gently rub them to remove the soil.

Curing of sweetpotatoes does not normally occur in Hawai'i or the Pacific, although the practice may be common elsewhere. Roots are usually shipped soon after harvest. Curing consists of storing harvested sweetpotatoes at 29.4°C (85°F) and 90–98% relative humidity in a well ventilated room or shaded area for 4–7 days, after which they are stored at 15.6°C (60°F) with ventilation. Historically, sweetpotatoes were cured in burlap bags or in baskets or crates placed under raised houses or buildings. Curing heals wounds in the sweetpotatoes as a cork-like layer is formed beneath the skin or bruised fleshy areas. Curing sweetpotatoes has a number of benefits, including increased storage life and higher sugar content.

Sweetpotato roots will not store well if the soil is very wet just before their harvest, if roots are chilled below 10°C (50°F) for 5 days after harvest, or if the roots are not cured properly before storage.

Processing

The following processed products are possible at a community or farm level without high technology or expensive equipment.

Jam

Peel sweetpotatoes and finely dice them into lemon juice. Add sugar and desired spices. Bring the mixture to a boil and then reduce the heat and gently simmer until thick and jam like, about 30 minutes. Skim off foam that may appear on the surface as the jam cooks. Transfer the jam to sterile jars, filling each to within 3 mm (0.12 in) of the top. Screw on the lids. Store the sealed jars in a refrigerator.

Dehydration

Wash sweetpotatoes and cut them into 6 mm (0.5 in) slices. Blanch slices in a pot of boiling water for 5 minutes. Soak blanched slices in 2 liters (2.2 quarts) cold water and 120 ml (½ cup) lemon juice for about 45 minutes to keep them from oxidizing while they dry. The lemon juice also helps them retain their original color when cooked. Dry the slices until brittle. Store in heavy-duty plastic bags or an airtight container, and keep away from direct light.

Powdering

Sweetpotato powder is formed after dehydration of the sweetpotato and enzymatic dispersal of the flesh to single cells. The cell wall of the product is unbroken, so it remains its original nutrition and flavor.

Fermentation

A variety of fermented beverages can be made from sweetpotatoes, including wine, beer, and vodka.

A recipe for sweetpotato wine:

- 2.7 kg (6 lb) sweetpotatoes
- 1.1 kg (2.5 lb) granulated sugar
- 450 gm (1 lb) raisins
- 1 tsp acid blend
- ½ tsp pectic enzyme
- 3.8 liters (1 gal) water
- 1 tsp yeast nutrient
- Wine yeast

Dice peeled potatoes finely and just cover with water in a pan and boil. Cover the pan and reduce to a simmer for about 25 minutes. Place minced raisins in a primary fermentation vessel with half the sugar. Strain the potatoes over the primary. Add enough water to make one gallon. Dissolve sugar by stirring. Add acid blend, yeast nutrient and pectic enzyme. Cover with cloth and wait 12 hours. Pitch the yeast, cover, and ferment for 4–7 days, stirring twice per day. Strain material and add the remainder of the sugar and stir to dissolve. Pour into a secondary and fit with an air lock. Rack every 30 days until clear (this may require 4–5 months). Wait another 30 days, stabilize and rack again after 10 days. Sweeten to taste or bottle dry. Taste after 6 months, or longer if needed.

Chips

Bake sweetpotato slices at 230°C (450°F) and flip after about 10 minutes. Use seasoning or cooking spray or oils as desired.

Other

Other processed foods include sausage, vermicelli, crackers, cakes, ice cream and sherbet.

Product quality standards

Grading standards are employed in various locations to ensure control of sweetpotato root quality parameters. Below are the grading standards used in the mainland United States and Hawai'i.

Sweetpotatoes grown in the U.S. are graded based on their size, shape, and surface appearance. The roots are separated

Top left: Processing facility next to water pond used for storage of sweetpotato wash water. Top right: A typical sweetpotato packing-house in Hawai'i. Middle left: An automatic sweetpotato washer. Middle right: Water used to wash sweetpotatoes should be clean, not recycled, and not dirty as shown here. The tank or pond of water should be placed at an elevation that is above the sweetpotato washing machine or washing bench to avoid runoff of contaminated wash water back into the water storage tank or pond. Here, the water is dirty and contaminated with pathogens and is unsuitable for washing sweetpotatoes. Bottom left: Washed sweetpotatoes in baskets in a packing house. These will be boxed for local distribution or for further treatment (irradiation) before export to the U.S. mainland. Bottom right: Off-grade sweetpotatoes at a packing house.

into U.S. No. 1 and 2 fresh market grades, canner and jumbo processing market grades, and a cull grade.

U. S. Grading Standards (measurements for fresh market)

U.S. No. 1 Extra: Length is no less than 3 in and no more than 9 in; width is no less than 1.75 in and no more than 3.25 in; weight is not more than 18 oz per root.

U.S. No. 1: Length from 3 to 9 in; diameter is 1.75–3.5 in; weight is not more than 20 oz per root.

U.S. Commercial: Meet requirements for U.S. grade No. 1 except that an increased tolerance for defects is allowed.

U.S. No. 1 Petite: Allows for the packing and shipping of smaller size sweetpotatoes.

U.S. No. 2: Length is greater than 1.5 in and root weight is 36 oz.

Culls

Wholesale quantities are comprised of Hawaii Fancy, Hawaii No. 1 or Hawaii No. 2. Consumer packages and bulk displays are comprised of Hawaii Grade AA, Hawaii Grade A or Hawaii Grade B. The minimum export grade is Hawaii No. 1.

Product storage requirements and shelf life

Cured sweetpotato can be stored for 4–7 months at 12.8–15.6°C (55–60°F) and 85–90% relative humidity. Other processed products (i.e., canned sweetpotatoes) can be stored much longer, depending on processing and packaging. Non-cured sweetpotatoes do not store well and have a much shorter shelf life.

Recommended labeling

In Hawai'i, sweetpotato roots are packed in either 22.7 kg (50 lb) crates or 18.2 kg (40 lb) cartons. Labeling on the box should include grade, weight, pest treatment (e.g., irradiation), cultivar name or the word "sweetpotato," distributor name and contact information (telephone, address, web site, and production location [e.g., Hawai'i]) and date of packing.

Value-added product labeling includes additional or different information, such as expiration date, nutritional value, etc.

SMALL SCALE PRODUCTION

Plant 30 to 50 cm (12–20 in) vine cuttings on 20–35 cm (8–14 in) ridges or hills (height of ridge depends on soil texture). The soil for ridges should be turned about 2–3 months before planting to decompose organic matter for reduction of soil pathogens. Pluck off all leaves from the vine cuttings, except for the 3 or 4 at the tip and avoid damaging the leaf bud at the tip. Gather the cuttings in the evening after a rain shower. The cuttings may be kept bundled before planting for up to several weeks or until roots begin to emerge from them. Plant about 2 or 3 stem cuttings per mound into holes made with a digging stick. After planting, mulch the mounds with plant material. During crop growth, periodically loosen the soil around roots with a stick and re-heap soil around the base of plants. Weed as needed. The growing and lengthening vines can be trained around the ridge with some soil placed over them and pressed down at intervals to create more roots. It is not necessary to harvest the mounds completely at one time; the sweetpotatoes may be harvested

Table 3. Hawai'i Grading Standards (from Hawai'i Dept. of Agriculture Marketing and Consumer Services Division)

	Hawaii Fancy (Grade AA)	Hawaii No. 1 (Grade A)	Hawaii No. 2 (Grade B)
Basic requirements	Single variety, firm, smooth, fairly clean, well shaped	Single type, firm, fairly smooth, fairly clean, fairly well shaped	Single type, firm, not more than slightly dirty, not badly misshapen
Free from	Freezing injury, internal breakdown, black rot, wet breakdown or other decay, insects, insect hole or tunnel, rodent injury, sprouts, growth cracks	Freezing injury, internal breakdown, black rot, wet breakdown or other decay, insects, rodent injury	Freezing injury, internal breakdown, black rot, wet breakdown or other decay, insects
Free from injury caused by	Secondary rootlets, cuts, bruises, scars, scurf or other diseases, insects, mechanical or other means	Secondary rootlets, cuts, bruises, scars, scurf or other diseases, growth cracks, grass roots, wireworms, weevils or other insects, sprouts, mechanical or other means	Cuts, bruises, scars, growth cracks, grass roots, wireworms, weevils or other insects, mechanical or other means
Size requirements	Diameter 1.75–2.25 In; length 3–9 in; weight not more than 16 oz	Diameter 1.75–3.75 In; length 3–10 in; weight not more than 24 oz	Diameter not less than 1.75 In; weight not more than 32 oz
Tolerances (weight basis)	a) defects: total 10% provided not more than 5% damage and not more than 3% serious damage by weevils and not more than 1% soft rot or wet breakdown; b) off-size: total 10%, provided not more than 5% below the minimum diameter or minimum length specified	A) defects: total 10% provided not more than 5% serious damage and not more than 3% serious damage by weevils and not more than 1% soft rot or wet breakdown; b) off-size: total 10%, provided not more than 5% below the minimum diameter or minimum length specified	A) defects: total 10% provided not more than 3% serious damage by weevils and not more than 1% soft rot or wet breakdown; b) off-size: total 10%, provided not more than 5% below the minimum diameter specified

gradually over time. This process, known as "milking," removes only the largest roots first from mature plants. After harvesting some sweetpotatoes from a mound, be sure to cover the holes with soil to prevent exposure of the roots to rats and air.

Use in the Pacific

This crop is widely used by households as a food staple where it is grown in the Pacific. It is one of the best crops to prevent starvation during times when other crops could be destroyed by typhoons.

Small-scale processing

Processed sweetpotato roots and extracts from sweetpotatoes may be used to for a wide range of products. The examples below occur in Japan and China—other products are possible.

Sugar syrup products: a) sour sugar candy (caramel, candies, jam, paste, jelly); b) malt candy (caramel, medicine, paints, traditional confectioneries); c) powder sugar syrup (sake, ice cream, sausages, soy sauce, baby foods).

Processed foods: a) direct food products (powder); b) processed foods (seafood products such as Japanese kamoboko, sausage, vermicelli); c) beer; d) crackers; e) vodka; f) cakes; e) ice cream and sherbet.

Processed starch: a) dextrin (paste, tape, ink); b) soluble starch (magazine paste, tablets).

Miscellaneous: a) makeup (toothpaste, face powder, washing powder); b) model adhesives, glues (toys, charcoal, matches, umbrellas); precipitation protection (shoe polish).

More advanced processing (may not be suitable for small farms): Saccharification products (dextrose, fructose, glucose, maltose, amylose, amylose paste, sugar residues).

Animal feed: roots and shoots.

Import replacement

Because sweetpotato is such a rich source of nutrition and calories and roots have a long shelf life after curing, growing it on a family farm can completely replace retail purchases of this crop. Perhaps it could also partially replace other starch and sugar-containing crops or products that are normally imported.

YIELDS

In Hawai'i, the average yield in 2006 was 3,000 kg/ha (16,700 lb/ac). The most important commercial product is the sweetpotato storage root, although the shoots are also edible and nutritious. In addition, a wide range of other food and non-food products may be derived from sweetpotato.

Top left: A box used for shipping sweetpotatoes from Hawai'i to the U.S. mainland. Note the "yam" misnomer. Sweetpotatoes are packed into these boxes after washing and drying, and transported to an irradiation facility to kill insect pests. These export boxes have no vents or openings, and therefore during shipping some fungal disease problems can develop because relative humidity rises in the closed boxes, especially if the boxes become wet during transport. Top right: A box used for local distribution of sweetpotatoes in Hawai'i, where insect pest quarantine within the state is not an issue. The box has openings in the sides that allow high relative humidity to dissipate. Bottom: A tractor-trailer with a load of sweetpotatoes in boxes in Hawai'i to be transported from the washing and packing facility to local grocery stores and markets or the irradiation facility. It is very important to cover the load with a plastic tarp to protect the boxes from rainfall.

Top left: Mixed homegarden of sweetpotato, taro, cassava, banana, and sugarcane in Palau. Bottom left: Sweetpotato growing on the rocky margins between a tropical fruit orchard and vegetable field. Kealakekua, Hawai'i. Right: Mayumi Oda lifts vines from the soil on the edge of a sweetpotato patch to reduce additional rooting from stem nodes.

Left: Container-grown sweetpotato in Hōlualoa, Hawai'i. Right: Lava cavity that Hawaiians of Old filled with organic matter for sweetpotato cultivation. North Kona, Hawai'i.

Table 4. Composition of young sweetpotato shoots (leaf and tender tips) and roots, per 100 g of edible portion.

	Young shoots (cooked)	Roots (baked in skin)
Water	87	63.7
Calories (food energy)	41	141
Carbohydrate (g)	9.2	32.5
Fiber (g)	1.2	0.9
Protein (g)	2.6	2.1
Fat (g)	0.2	0.5
Ash (g)	1.4	1.2
Calcium (mg)	24	40
Phosphorous (mg)	60	58
Sodium (mg)	–	12
Potassium (mg)	–	300
Iron (mg)	0.6	0.7
Vitamin A (IU)	2908	8100
Thiamine (mg)	0.07	0.09
Riboflavin (mg)	0.18	0.07
Niacin (mg)	0.07	0.7
Ascorbic acid (mg)	1	22

Source: Huang 1979

MARKETS

Local markets

Fresh sweetpotatoes (or sweetpotato products) are commonly found at farmers' markets in the Pacific. Most retail grocery stores or food markets carry locally grown sweetpotatoes throughout the year, as the crop may be planted and harvested at almost any time (although some months may be better than others for planting). Restaurants also serve sweetpotatoes in a number of dishes, including baked, in soups, and in potato salads. Tourists enjoy seeing and eating the colorful cultivars with which they were previously unfamiliar.

Export market

In Hawai'i in 2006, sweetpotato was the 18th most valuable agricultural commodity, with a farm value of over $4.4 million. Most of the potatoes produced were exported to the U.S. mainland.

Specialty markets

Organic certification can give farmers access to the health food market. Other special customer preferences include locally grown (e.g., grown within 100 km [62 mi] of the market), and heritage varieties (e.g., Hawaiian varieties).

Imported organic sweetpotatoes can be found in abundance in Hawai'i health food stores, indicating that there is a market for certified organic, locally grown sweetpotatoes.

Branding possibilities

Branding possibilities exist for unique or rare cultivars of sweetpotato or for specialty products obtained by processing of sweetpotato. Site of origin (e.g., a Pacific island) and cultivation methods (e.g., organic, agroforestry) may enhance the value of brands, such as those produced in Hawai'i.

Potential for Internet sales

Internet sales of value-added, processed sweetpotato products (such as candies or powders) is possible, and probably more likely than sales of raw roots. However, bulk sales of sweetpotatoes at wholesale prices via Internet advertising may be possible.

EXAMPLE SUCCESSES

Cacho Farms, Upper Kaiwiki, Hilo, Hawai'i

Nestor Cacho Sr. began growing sweetpotato when the sugar plantations closed down about 20 years ago. His father was among the first farmers to plant sweetpotato commercially. He found that sweetpotato was an easy plant to grow with little maintenance. Nestor sells his sweetpotatoes through a major distributor and to customers on neighbor islands. The off-grade sweetpotatoes are sold at farmer's markets. Nestor harvests either manually or by machine, and washes, grades, and packs into 5-, 30-, or 40-lb boxes. Marketing is by word of mouth. The biggest challenges Nestor faces are insects and wild pigs that feed on his sweetpotatoes.

L&E Farms, Wainaku, Hilo, Hawai'i

Lily Castillo's father started growing sweetpotatoes in the 1990s after their ginger crop failed due to bacterial wilt disease. In 2000, the Castillos began farming sweetpotatoes year-round and the crop improved each year. Now, Lily produces sweetpotatoes year-round by herself, selling them in local markets and to some mainland outlets via a major

Table 5. Basic sweetpotato cultivation and processing inputs and materials for mechanized systems.

Item	Equipment, materials or labor requirement
Land clearing	Tractor
Land preparation (plowing, ridging)	Tractor and accessories
Processing of planting materials	Sweetpotato vines
Planting	Labor
Weeding	Labor
Fertilizer application	Fertilizer, tractor
Harvesting	Baskets, labor, shovels or mechanized harvesting device (e.g., tractor)
Transportation	Truck
Curing	Controlled environment
Washing	Clean water supply, pump, washing machine, packing house, electricity, power supply
Sorting	Labor
Packing	Cardboard boxes, labor, scale, pallets

distributor. She harvests manually, and washes and packs for delivery. Lily emphasizes the unique quality of her product. Her biggest challenge is finding virgin land on which to plant.

ECONOMIC ANALYSIS

In Hawai'i in 2005, 138 ha (340 ac) of sweetpotato were harvested at farms. The yield per hectare was an average of 18,870 kg (16,800 lb/ac). The average farm price was $1.33/kg ($0.606/lb). The total value of sales was $3.4 million. In 2003 the price was $0.80/kg ($0.363/lb) and in 2004 it was $1.01/kg ($0.458/lb). One's expected income may vary from year to year as farm prices fluctuate. Most value normally occurs in retail markets and in value-added products, translating into higher expected incomes in those areas of sweetpotato production.

Costs of sweetpotato cultivation and processing vary according to cultivation and processing systems. Material costs escalate in the mechanized cultivation systems that use tractors, trucks and in processing operations that use packing houses designed for cleaning and curing sweetpotatoes.

FURTHER RESEARCH

Potential for crop improvement

According to the International Potato Center (CIP), "Today, genetic diversity is under relentless attack. Areas rich in plant species are being destroyed by desertification, deforestation, erosion, competition for land for housing, highways, and recreation, and by farming itself. And uncertainty exists as to whether the needed increase in world food production can be met without these species. Maintaining this diversity is vital to global food security. Food crop scientists rely on variation in the chromosomes of primitive and wild plants to produce better-adapted and higher-yielding varieties having resistance to pests and diseases."

Given that the CIP has collected more than 6,500 samples of sweetpotato, there is opportunity to improve cultivars within this genetically diverse genus.

Improving potential for family or community farming

Education about the importance of using crop rotations for sweetpotato cultivation would probably improve yields in Hawai'i. This would involve equipping farmers with crops and technologies to replace sweetpotatoes in non-growing years. Improved education about better field sanitation following sweetpotato harvests would reduce pest outbreaks, such as sweetpotato weevils and root rotting fungi.

Locally grown sweetpotatoes on display in cardboard boxes at a Hawai'i grocery store in 2008. The retail price was $2.18/kg ($0.99/lb).

Genetic resources where collections exist

International Potato Center (CIP), Lima, Peru: http://www.cipotato.org/sweetpotato/

The World Vegetable Center (AVRDC): http://www.avrdc.org/

REFERENCES CITED AND FURTHER READING

Bison, L.E., and Maretski, A.N. 1982. Sweet potato. Hawai'i Cooperative Extension Service, Commodity Fact Sheet SP-1(A). University of Hawai'i at Mānoa, Hawai'i Institute of Tropical Agriculture and Human Resources.

Clark, C.A., and Moyer, J.W. (eds.). 1988. Compendium of sweet potato diseases. APS Press, American Phytopathological Society.

Clark, C.A., C.W. Averre, P.D. Dukes, J.W. Moyer, G.L. Philley, J.B. Ristaino and C. Stevens. 1993. Diseases of Sweetpotato (*Ipomoea batatas* (L.) Lam.) American Phytopathological Society. http://www.apsnet.org/online/common/names/swtpotat.asp [accessed March 17, 2010]

Hawaii Department of Agriculture, Marketing and Consumer Services Division, Commodities Branch. 1986. Standards for Hawaii-grown sweet potatoes. http://hawaii.gov/hdoa/qad/comm/AR-41-57.pdf [accessed March 17, 2010]

Huang, W.-Y. 1979. Comparative food values of sweet potatoes in Hawaii. Departmental Paper 42. University of Hawai'i, College of Tropical Agriculture and Human Resources, Hawai'i Agricultural Experiment Station.

Migvar, L. 1968. How to grow taros, yams, cassava, and sweet potatoes. Agricultural Extension Bulletin No. 7. Trust Territory of the Pacific Islands.

Nakamoto, S.T., Wanitprapha, K., Iwaoka, W., and Huang. A. 1994. Research Extension Series 150. Cassava, ginger, sweet potato and taro trade statistics. University of Hawai'i, College of Tropical Agriculture and Human Resources.

Nelson, S.C. 2008. Java black rot of Okinawan sweetpotatoes. PD-55. University of Hawai'i at Mānoa, College of Tropical Agriculture and Human Resources, Cooperative Extension Service. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-55.pdf [accessed March 17, 2010]

Takeda, K.Y. 1981. Sweet potato production.Commodity Fact Sheet SP-3(A). Hawaii Institute of Tropical Agriculture and Human Resources, Hawaii Cooperative Extension Service.

Traynor, M. 2005. Sweet potato production guide for the top end.Information Booklet IB1. Department of Primary Industry, Fisheries, and Mines. Crops, Forestry and Horticulture Division. Northern Territory Government, Darwin, NT, Australia.

United States Department of Agriculture. 2005. United States Standards for Grades of Sweetpotatoes. USDA Agriculture Marketing Service, Fruit and Vegetable Division, Fresh Products Branch. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050330 [accessed March 17, 2010]

United States Department of Agriculture. 1997. United States Standards for Grades of Sweetpotatoes for Canning or Freezing. USDA Agriculture Marketing Service, Fruit and Vegetable Division, Fresh Products Branch. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050444 [accessed March 17, 2010]

United States Forest Service, Pacific Island Ecosystems at Risk (PIER). http://www.hear.org/pier/ [accessed March 17, 2010].

United States Department of Natural Resources, NRCS. 2010. Sweetpotato plant profile. The PLANTS Database National Plant Data Center, Baton Rouge, LA. http://plants.usda.gov/java/profile?symbol=IPBA2 [accessed March 17, 2010]

Valenzuela, H., Fukuda, S., and Arakaki, A. Undated. Sweet potato production guidelines for Hawaii. University of Hawai'i at Mānoa, College of Tropical Agriculture and Human Resources. http://www.extento.hawaii.edu/Kbase/reports/sweetpot_prod.htm [accessed March 17, 2010]

Villareal, R.L., and Griggs, T.D. 1982. Sweet potato—proceedings of the first international symposium. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan, China.

Vinning, G. 2003. Select markets for taro, sweet potato and yam. RIRDC Publication no 03/052. Rural Industries Research and Development Corporation. http://hbs.bishopmuseum.org/fiji/pdf/vinning2003.pdf [accessed March 17, 2010]

Internet

The United States Sweetpotato Council: http://sweetpotatousa.org/

Purdue University, Hort. 410 (sweetpotato) links: http://www.hort.purdue.edu/rhodcv/hort410/sweetp/sweetp.htm

Sorting *Ipomoea aquatica* & *I. batatas* names http://www.plantnames.unimelb.edu.au/Sorting/Ipomoea.html#batatas

What is the difference between a sweet potato and a yam? http://plantanswers.tamu.edu/vegetables/sweetpotato.html

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

Farm and Forestry Production and Marketing Profile for Sweetpotato (*Ipomoea batatas*)

Authors : Scot C. Nelson, PhD, University of Hawai'i at Mānoa, Cooperative Extension Service, 3050 Maile Way, Gilmore 402, Honolulu, HI 96822; Tel: 808-956-2000; Email: snelson@hawaii.edu; Web: http://www.ctahr.hawaii.edu.
Craig Elevitch, Permanent Agriculture Resources, PO Box 428, Holualoa, Hawaii 96725; Tel: 808-324-4427; Fax: 808-324-4129; Email: par@agroforestry.net; Web: http://www.agroforestry.net.

Recommended citation: Nelson, S.C., and C.R. Elevitch. 2011 (revised). Farm and Forestry Production and Marketing Profile for Sweetpotato (*Ipomoea batatas*). In: Elevitch, C.R. (ed.). Specialty Crops for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holualoa, Hawai'i. http://agroforestry.net/scps

Version history: March 2010, February 2011

Series editor: Craig R. Elevitch

Publisher: Permanent Agriculture Resources (PAR), PO Box 428, Hōlualoa, Hawai'i 96725, USA; Tel: 808-324-4427; Fax: 808-324-4129; Email: par@agroforestry.net; Web: http://www.agroforestry.net. This institution is an equal opportunity provider.

Acknowledgments: The authors thank Kamaui Aiona, Heidi Johansen, Mari Marutani, and Lisa Raymond for valuable comments during the writing of this profile.

Sponsors: Publication was made possible by generous support of the United States Department of Agriculture Western Region Sustainable Agriculture Research and Education (USDA-WSARE) Program. This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, and Agricultural Experiment Station, Utah State University, under Cooperative Agreement 2007-47001-03798.