



Hawaiian Breadfruit

Ethnobotany, Nutrition,
and Human Ecology

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3050 Maile Way, Honolulu, HI 96822

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www.ctahr.hawaii.edu

Printed by (to be filled in by streamline creative)

ISBN 1-929325-17-7

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Hawaiian Breadfruit

Ethnobotany, Nutrition, and Human Ecology

The breadfruit tree, known throughout the Hawaiian archipelago as *‘ulu*, occupied an important multi-dimensional niche in ancient Hawaiian culture. This majestic, spreading tree figured prominently in Hawaiian spiritual life, was employed in a range of material applications, and served as a ready source of food and medicine. Breadfruit trees were common features of the landscape around villages and work sites and were also cultivated in large, well tended groves, both before and for some time after the arrival of Captain Cook in 1778. Today *‘ulu* is, on the whole, relatively uncommon as a food in Hawai‘i. Although its wood is still sometimes used for carving, its practical uses today are substantially fewer than in earlier times. Nevertheless, breadfruit trees are still found throughout Hawai‘i, particularly in rural locations and in the remnants of ancient plantations.



Breadfruit trees were common features of the landscape around villages and work sites and were also cultivated in large, well tended groves, both before and for some time after the arrival of Captain Cook in 1778.

In the following pages we summarize some of the available ethnographic and ethnohistorical information about the Hawaiian breadfruit tree, situate its occurrence in Hawai‘i, evaluate its importance in ancient Hawaiian economy and human ecology, and add a modern nutritional assessment of the fruit. Our purpose is to address questions of its significance in ancient Hawai‘i, especially as a crop for food and animal feed, and to stimulate renewed interest in *‘ulu* as a culturally appropriate component of Hawaiian landscapes and as a healthful and easily produced food. The trees that once shaded many Hawaiian homes and work sites could do so again throughout the islands, providing nutritious, inexpensive, and easily prepared food for many months of the year.

Botany

Edible species of the paleotropical (Old World Tropical) genus *Artocarpus*, a member of the mulberry family (Moraceae), are believed to have originated in Indo-Malaysia, western Melanesia, and the Philippines,^(11, 12, 56, 111) although some authors believe their presence in the Philippines may have resulted from a more recent introduction.^(103, 120) According to French ethnobotanist Jacques Barrau, three of the perhaps 50 species of breadfruit were domesticated, with “the crop [then having] been fairly profoundly modified in cultivation.”^(13, p. 201) Many-seeded and seedless cultivated varieties (cultivars) are known. Seeded varieties are diploid ($2n = 56$), while seedless ones are triploid ($2n = 84$).⁽¹⁰²⁾

The breadfruit, known to botanists as *Artocarpus altilis* (Parkinson) Fosb., is a large, sterile tree with monoecious flowers and edible fruits; the Hawaiian type is most likely of hybrid origin. The species was first described to the Western world in the accounts of the Spanish explorer Mendaña, following his visit to the Marquesas Islands in 1595.⁽⁴⁹⁾ Breadfruit is distributed throughout Oceania, and in Polynesia it is absent only on Easter Island and in New Zealand and the Chatham Islands. Its seedlessness is believed to have originated in Polynesia,^(101, 111) with the number of cultivars increasing noticeably as one moves from the western to the eastern Polynesian archipelagoes. The infraspecific diversity of breadfruit varieties in Polynesia is especially marked in the Marquesas and the Society Islands (presently French Polynesia), where scores of clones—perhaps even hundreds⁽⁸⁶⁾—were once cultivated.^(46, 102) In Hawai‘i, only one prehistoric seedless variety is known.^(51, 107)

The trunk of the breadfruit tree can attain a diameter of 2 feet (60 cm) or more. It is often straight in its lower portion, usually branching at 10–15 feet (3–5 m) above ground level. Its lower branches spread horizontally before curving upward and usually are much longer than the upper branches. As a result, its



In ancient times in Hawai‘i, breadfruit trees would have dominated every other type of cultivated vegetation in most areas used for habitation and agriculture.

horizontal branches may break under even moderate winds. The mature tree forms a dome-shaped canopy reaching a height of 35–50 feet (10–15 m) and is capable of providing considerable shade. In ancient times in Hawai‘i, breadfruit trees would have dominated every other type of cultivated vegetation in most areas used for habitation and agriculture.

The wood of the tree is yellow and turns dark brown when exposed to air. It is relatively soft and light but elastic, with an open, coarse grain, and is said by some authors to be termite resistant,^(75, p. 39) although others claim otherwise.⁽⁷⁴⁾ The young bark is clear green, turning gray with age. The salmon-red inner bark is milky and fibrous. Mature leaves are leathery, dark green on their upper surface with paler green undersides, 12–36 inches (30–100 cm) long, sometimes deeply incised, and attached to the branches by short, thick petioles.



The fruits are bright green when young, turn brown when partially ripe, and then turn a rich yellowish-brown when thoroughly ripe.

The tree generally begins to bear its oval or spheroid fruits at 5–7 years of age. In Hawai‘i, the fruit enlarges to a diameter of 3–8 inches (8–20 cm), is seedless, and individuals weigh up to around 10 pounds (4 kg). Observers in Polynesia have put the range of fruit weight at between 1 and 5 pounds (0.5–2 kg). Others have variously stated that fruits weigh anywhere from 1 to 5 kg, or between 2 and 11 pounds. When one of us weighed 10 “typical” fruits from each of two trees in West Hawai‘i, one located at around 600 m elevation and the other at about 300 m, the fruits averaged just over 3 pounds. Some of the variation in fruit weight reported in the literature may be attributable to the age of the tree, because as the tree ages, the fruits get smaller.⁽⁹⁶⁾

Each fruit is composed of between 1500 and 2000 flowers fused into an organ technically called a syncarp. The fruits are bright green when young, turn brown when partially ripe, and then turn a rich yellowish-brown when thoroughly ripe. The pulp (fruit flesh) is white in young fruit but becomes creamy yellow in mature fruit; the pulp surrounds a tough core that, like the skin, is removed before consumption. Throughout Oceania, breadfruit trees are estimated to produce from 50 to 150 fruits per year,⁽¹¹⁾ although yields of up to 700 fruits per year have been noted.⁽¹⁰¹⁾

Agroecology

Breadfruit locations in Hawai‘i

Breadfruit trees are found where they were planted by man, or within root-spreading distance of those trees. Under favorable conditions, ‘ulu freely self-propagates from root shoots, and such “starts” will coexist with and eventually replace the parent trees. Unless removed, damaged, or out-competed by other vegetation, breadfruit trees can self-propagate indefinitely. Many breadfruit trees can still be found today on all the main islands between 1000 and 2000 feet (300–600 m) elevation in both windward and leeward settings. But a survey of breadfruit trees presently existing in Hawai‘i would not provide a reliable picture of the extent of ‘ulu in the islands in ancient times; for that, we have pieced together a patchwork of information drawn from various literature sources.

When Europeans arrived in Hawai‘i, breadfruit trees were observed growing either individually or in groups of a few together near habitations,⁽⁷⁵⁾ or in extensive orchard-like plantations either near or sometimes at some distance from inhabited areas.^(32, 82) Upon entering the agricultural zone above Kealahou Bay on Hawai‘i in December 1778, the HMS *Discovery* surgeon David Samwell noted only a few houses within the plantations there.^(14, p. 1166) Similar approaches to breadfruit cultivation (scattered versus intensely planted) have been noted in Samoa.⁽¹⁰²⁾ Both planting strategies were described many times in Hawai‘i during the 19th century.^(3, 19, 38, 123) On Hawai‘i, in particular, the two ways of growing breadfruit have been linked to windward versus leeward geographical and cultural variables. For example, according to archeologist T. Stell Newman, in the windward regions of the island of Hawai‘i the

“...settlement pattern is characterized by scattered fields or gardens with scattered small villages or family habitations...generally less intensive cultivation of available land...[while on the leeward side are found]...massive field systems in contradistinction to the scattered fields of the windward type. The West Kohala system, for example, measures about two by thirteen miles while the Kona system measures about three by eighteen miles...”^(90, p. 6)



A survey of breadfruit trees presently existing in Hawaii would not provide a reliable picture of the extent of ‘ulu in the islands in ancient times.

It was these West Hawai‘i (leeward) field systems and their associated breadfruit plantations that fascinated early visitors to Hawai‘i in the late 1700s and early 1800s. In 1793, for example, surgeon-naturalist Archibald Menzies of the HMS *Discovery*

“...entered [the Kona] breadfruit plantations, the trees of which were a good distance apart, so as to give room to their boughs to spread out vigorously on all sides....” ^(82, p.74)

Again, in 1794, Menzies and company

“...commenced [their] march [uphill from Kealakekua Bay] with a slow pace, exposed to the scorching heat of the meridian sun, over a dreary barren track of a gradual ascent, consisting of little else than rugged porous lava and volcanic dregs, for about three miles, when [they] entered the bread fruit plantations whose spreading trees with beautiful foliage were scattered about that distance from the shore along the side of the mountain as far as [they] could see on both sides.”

The West Hawai‘i field systems and their associated breadfruit plantations fascinated early visitors to Hawai‘i.

Charles Wilkes, leader of the American Exploring Expedition in 1840, located this same breadfruit plantation 2 miles (3.2 km) back from the Kona coastline, where “...in a belt half a mile wide, the breadfruit is met with in abundance...” ^(123, p. 95) This zone was referred to “in the native land claim records of the mid-nineteenth century as the *kalu‘ulu* or *maloko‘ulu*.” ^(69, p. 186) Our review of land claims from three West Hawai‘i *ahupua‘a* (Holualoa, Keauhou, and Ke‘ei) indicated extensive reference to *kaluulu* and *‘ulu*, with all evidence pointing to these words as the terms applied to the breadfruit zone within what is now called the Kona Field System (discussed in detail on pp. 43–46).

Summarized in Appendix Tables A-1 to A-4 (see pp. 51–54) are historical observations or accounts of breadfruit on the main Hawaiian islands of Hawai‘i (Table A-1); Kaua‘i and Ni‘ihau (Table A-2); Maui, Lāna‘i, and Moloka‘i (Table A-3); and O‘ahu (Table A-4). Each table includes citations of literature that refer to what might be either “scattered sites,” “plantation sites,” or “legendary sites.” We relied mostly on documented descriptions of 18th- and 19th-century Euro-American visitors and on other miscellaneous reports, many of which include brief ethnohistorical

statements, some of which provided insights into traditional Hawaiian agriculture. Our distinction of the planting patterns described, between individual trees (“scattered sites”) and many trees in groves (“plantation sites”), is fairly well justified in some cases. However, the citations often lacked detailed information, and in many instances we used considerable license in our classification. Thus the information presented in the tables is only suggestive of what actually may have existed.

Under “scattered sites” we group what appear to be examples of one or a few trees, possibly representing cases of breadfruit trees grown in proximity to house lots or work sites. These references might indicate trees planted and managed by individual households who were the direct beneficiaries of the trees and their products. Such trees would provide readily available fruits and other useful items, as well as shade and play areas for children.

Under “plantations” we group those references that appear to indicate multiple, adjacent trees unlikely to have been self-propagated from a single parent tree. Much more so than in the case of individual trees, these trees appear to have been planted, managed, and their fruits consumed through the organizational mechanisms of a complex political economy. While in some cases we employ considerable subjectivity in concluding that a concentration of trees is being described, writers sometimes simplified our task by employing terms such as “groves,” “plantations,” or “orchards.”^(10, 33, 82)

Under “legendary sites” are found references to breadfruit locations in published accounts or summaries of Hawaiian myths and legends. Many of these sites were also recorded in the ethno-historical literature, highlighting the intersection of Hawaiian mythology with physical reality and, on some occasions, the empirical basis of traditional oral history.

Each site is presented as cited in abbreviated form (e.g., “innumerable plantations”) along with actual or approximate dates of observation (e.g., “in 1779” or “early 1800s”), and the bibliographic reference.

Growing conditions

The widespread distribution of breadfruit in old Hawai‘i, as evident from the literature cited in the Appendix tables, testifies to the presence of highly suitable growing conditions in a range of ecological zones on the main islands. As we have seen,



Breadfruit arboriculture was by no means restricted to windward settings in Hawai‘i, or to lowland areas.

breadfruit arboriculture was by no means restricted to windward versus leeward settings in Hawai'i or to such lowland areas as are described, for example, as the principal breadfruit zones of the Society Islands. In February 1793, Menzies compared the upland breadfruit groves of West Hawai'i with the lowland plantings of Tahiti:

“Higher up along the verge of the woods...we...entered their breadfruit plantations...here the size of the trees, the luxuriancy of their crop and foliage, sufficiently show that they thrive equally well on an elevated situation...which was not the case in the crowded groves of Tahiti, where we found them always planted in the plains along the sea side....” (82, p. 74–76)

Likewise, in August 1819, French botanist Charles Gaudichaud of the ship *Uranie* observed breadfruit growing at higher elevations (above 1000 ft [300 m]) in or near Hawaiian villages where “...all necessary conditions for vegetation: excellent soil and a super-abundance of warmth and humidity...” were found. He further observed “...habitations bordering the virgin forests...shaded by...*artocarpus* [breadfruit]...and near them...all the useful vegetables previously observed along the border of the sea...irrigated by thousands of little streams....”^{79(113, p. 8–9)} Prehistorian Peter Bellwood similarly describes breadfruit trees thriving at elevations well above sea level on Hawai'i:

“At Lapakahi, [Kohala District of Hawai'i]...from about 1400 [A.D.]...ethnohistorical accounts indicate the cultivation of...breadfruit...in sheltered spots...found on higher inland slopes where rainfall was sufficient for cultivation.” (18, p. 107)

Whether found near sea level or at higher elevations, Hawaiian breadfruit groves appear to have been situated in areas with deeper, well drained soils, adequate moisture supplied by rainfall or groundwater, and direct sunlight during most of the day. Intolerance of saline soils ensures that most varieties do better when grown some distance from zones having ocean spray or groundwater salinity.⁽¹⁰⁸⁾ It is not surprising, then, that in a Pacific-wide context a positive correlation was found between breadfruit

presence and an adequate water regime,⁽⁹³⁾ for if subjected to insufficient moisture, the fruits will fall before reaching maturity.^(30, 96) This may be due, in part, to shallow root systems that gather the plants' water requirements mostly from the surface soil.⁽⁷⁴⁾ Scientific descriptions of optimal breadfruit growing conditions highlight these same criteria: adequate water regime, good soil and drainage, freedom from shade, and year-round warmth and humidity.^(75, 96, 101) Nevertheless, some breadfruit trees are observed to grow in conditions of salinity or drought elsewhere in Oceania, and it is possible that varieties had been selected for such tolerances.^(24, 86)

Soils

We have mentioned that Gaudichaud found breadfruit soils at higher elevations in Hawai'i to be "excellent," and the Reverend William Ellis noted that the soil in breadfruit groves "...was entirely covered with a rich mold, formed by decaying vegetation and the decomposed lava."^(33, p. 27–28) A somewhat more technical understanding of the relationship between soil types and breadfruit is obtained by comparing the locations of plantation sites in the Appendix tables with soil maps constructed for the Hawaiian Islands by the U.S. Soil Conservation Service.⁽¹¹⁷⁾ This agency used a 10-order soil classification system, and four of the orders are found to cover over half of the state. These soil orders—Histosols, Inceptisols, Oxisols, and Mollisols—dominate the areas where the breadfruit concentrations noted in our tables were found in Hawai'i.

Histosols and Inceptisols cover about 40 percent of the state and are largely confined to the island of Hawai'i. These two orders represent the substrate for all of the breadfruit locations cited for that island. Histosols occur on geologically young, forested lands and are characterized by a relatively thin layer (2–8 inches [5–20 cm]) of organic material over lava rock. Inceptisols develop mostly from the layers of volcanic ash that cover much of Hawai'i and East Maui.⁽⁸⁾ The third order, Oxisols, constitutes the substrate of all cited breadfruit locations on Kaua'i and, on Maui, the locations in Keka'a and the central valley. Oxisols dominate relatively flat lands at lower elevations on the geologically older islands and possess "...exceptional resistance to physical deterioration under intensive mechanized agriculture...."^(8, p. 47) They supported the state's formerly extensive pineapple and

Optimal breadfruit growing conditions include an adequate water regime, good soil and drainage, freedom from shade, and year-round warmth and humidity.



On the island of Hawai‘i, breadfruit plantations flourished on once-forested lava substrates with relatively thin layers of organic material and volcanic ash.

sugarcane plantations, of which those currently in the central valley of Maui are a remnant. The fourth soil order, Mollisols, represents the substrate of the breadfruit locations on O‘ahu and in the Lahaina region of Maui. Mollisols are “...well-drained, relatively young soils that develop on coral, lava, or alluvium. They occur in moderately dry areas of the islands and are generally rich in plant nutrients.”^(8, p. 47)

While these descriptions are based on soil surveys conducted in the mid-20th century, they generally agree with the cursory observations of soils made by early Euro-American visitors to Hawai‘i. On the island of Hawai‘i, breadfruit plantations flourished on once-forested lava substrates with relatively thin layers of organic material and volcanic ash. Elsewhere, they thrived on geologically older and deeper soils rich in plant nutrients and highly resistant to deterioration.

Phenology

As we have seen, breadfruit was cultivated at various elevations in prehistoric Hawai‘i, from sea level to the lower border of the native forest, which we estimate to have been located, depending on the extent of clearing, at up to about 2600 ft (800 m) above sea level.^(3, p. 143)

We have found only a few statements about moisture regimes associated with Hawaiian breadfruit plantations. For example, archeologist Patrick Kirch found that in West Hawai‘i “...[breadfruit] arboricultural intensification (e.g. in field systems) was limited to Kona because the lower rainfall at [the] Lalamilo and Kohala [field systems to the north] was below the ecological tolerance of the tree.”^(69, p. 189)

Water availability for a representative sample of breadfruit plantations can be estimated from rainfall statistics published by the State of Hawai‘i.⁽⁴¹⁾ These provide median annual rainfall data for a 67-year period (1916–1983) from rain gauge measurements throughout Hawai‘i. For our purposes, estimated median annual rainfall data were obtained from sites situated in or near known breadfruit-growing locations on the four main islands (taken from the Appendix tables). Elevations and average minimum and maximum temperatures for the rain gauge sites were also obtained. This information is summarized in Table 1.

Despite variations in data on rainfall, elevation, and temperature found at known breadfruit sites within and among islands,

Table 1. Summary of rainfall, elevation, and annual temperature ranges and medians at Hawaiian breadfruit plantation sites.

	Rainfall		Elevation		Temperature	
	range	median	range	median	range	median
Hawai'i	40–145 inches	59 inches	30–1500 ft	1050 ft	60–82°F	72°F
	1000–3700 mm	1500 mm	9–475 m	320 m	16–28°C	22°C
Kaua'i	47–67 inches	51 inches	85–230 ft	184 ft	66–80°F	73°F
	1200–1700 mm	1300 mm	26–70 m	56 m	19–27°C	23°C
Maui	14–35 inches	28 inches	10–400 ft	236 ft	65–86°F	73°F
	350–890 mm	700 mm	3–122 m	72 m	18–30°C	23°C
O'ahu	45–60 inches	52 inches	20–200 ft	177 ft	69–82°F	75°F
	1150–1500 mm	1325 mm	6–61 m	54 m	21–28°C	24°C

medians of the data from island to island correspond with the breadfruit plant's basic requirements, as outlined above, with the exception of the Maui plantation sites. There, the groves, especially around Lahaina, receive substantially less rainfall than those on the other islands, well below the 60–100 inches (1524–2540 mm) of annual rainfall determined to produce optimum breadfruit growth.⁽¹⁰¹⁾ In comparison, Puna plantation sites are characterized by a median annual rainfall of 145 inches (3683 mm). Nonetheless, breadfruit thrived in the Lahaina region, apparently because of the many streams traversing the Lahaina plain, the area's well known high water table,⁽¹²⁴⁾ and the Mollisol substrate, which ensured adequate drainage. The availability of groundwater near Lahaina has been noted:

“Southward along the coast from the ali'i settlement were a number of areas where dispersed populations grew taro, sweetpotato, breadfruit and coconut on slopes below and in the sides of valleys which had streams with constant flow.” ^(46, p. 492)

The Kona Field System was an enormous upland zone of very productive agricultural land organized from early times.

With the exception of West Hawai'i, where breadfruit groves were found up to perhaps 2000–2600 ft (600–800 m) above sea level,⁽⁶⁹⁾ most concentrated breadfruit arboriculture in Hawai'i was confined to below 650 ft (200 m) (see Table 1). West Hawai'i's tableland topography between 1000 and 2000 ft (300–600 m) elevation and its summer orographic rainfall pattern are unique in the archipelago⁽⁴⁰⁾ and most likely contributed to the transformation of the native mesic forest there into an enormous upland zone of very productive agricultural land which was organized from early times into what is now called the Kona Field System.^(3, 65, 70)

The temperature data for plantation sites show no unexpected discrepancies, with the median annual temperatures of all locations, summarized in Table 1, falling within the optimum range of 70–90°F (21–32°C).⁽¹⁰¹⁾ Maui has the warmest locations, which were also the lowest and driest. Sites on Hawai'i were the highest and coolest, and also the wettest.

Of the climatic and physical elements, it can be argued that adequate rainfall and a relatively flat, open topography with good drainage at an elevation below 600 m were the most important criteria for the installation of breadfruit plantations in Hawai'i, where variability in temperature is small within general lowland

(below 2000 ft [600 m]) elevational gradients, and where microclimatic differences are largely attributable to precipitation gradients.⁽⁴¹⁾ In general, adequate rainfall, or in some cases groundwater supply, combined with fertile, well drained lowland soils or upland tableland soils and tropical temperatures to provide Hawaiian planters with many desirable locations to grow breadfruit. The number and, in several notable instances, the extent and density of the plantations within the archipelago testify to the degree to which Hawaiians recognized and exploited these conditions.

Historical Aspects of Hawaiian Breadfruit

Hawaiian oral history, archaeology, ethnography, ethnohistory, and studies of breadfruit horticulture permit us to reconstruct aspects of breadfruit's history and human ecological significance in ancient and early post-Cook Hawai'i (after 1778). For example, a review of the evidence allows the conclusion that the plant could only have come to Hawai'i through human agency. Given that the

Hawaiian breadfruit is sterile, and that mature trees were found in the islands by the first Euro-American visitors, no other explanation is possible. But where did the plant come from?

The traditional presence of the specific Hawaiian cultivated variety of breadfruit has been documented in several other Polynesian archipelagos.⁽¹⁰²⁾ In Samoa, for example, the Hawaiian cultivar is called *ulu e'a*. There, as in the Cook Islands, the Marquesas, and the Society Islands, where it is variously known as *ulu maoi*, *maohi*, *maori*, or *maore* (all of which are Polynesian variants of the Hawaiian term *maoli*, meaning native, indigenous, genuine, or real⁽⁹⁸⁾), it is one of scores of breadfruit cultivars grown. On the Polynesian outlier of Anuta, it is called *maore*. According to breadfruit expert Diane Ragone, in each of these islands the Hawaiian type is "recognized as one of the oldest [breadfruit]



The specifics of time and place of breadfruit's actual implantation in Hawai'i are unknown.

Once in Hawai‘i, breadfruit was said to have been planted either at Pu‘uloa in Kohala on Hawai‘i or at Pu‘uloa or Kualoa on O‘ahu.

cultivars.”^(103, p. 206) Horticulturist G. P. Wilder describes this variety (*maohi*) in Tahiti as “...the commonest of all the breadfruit [varieties]...[with a]...flavor very agreeable.”^(122, p. 44) Similarly, Tahitian scholar Teuira Henry calls the ‘*uru-ma‘ohi* of Tahiti “the most common and a very good kind.”^(50, p. 41) Ragnone concluded that “its widespread distribution and antiquity suggest that this may be one of the earliest, if not the original, seedless triploid cultivar.”^(102, p. 120)

‘*Ulu* was one of the many edible plants transported to Hawai‘i on the Polynesian colonizing voyages, perhaps via a transport technology similar to that described for open-ocean movement of breadfruit in the Caroline Islands, where

“the rooted cultivars were wrapped in well rotted coconut husk fiber...the whole thing...wrapped in dried leaves...then a coconut basket is woven around the entire sucker.”^(108, p. 44)

However, it is unknown if breadfruit’s introduction to Hawai‘i was early or late, or if it resulted from a single colonization event or occurred several times over a long period. Sustained prehistoric Eastern Polynesian intercourse with Hawai‘i has yet to be convincingly demonstrated,⁽³¹⁾ and the specifics of time and place of breadfruit’s actual implantation in Hawai‘i are unknown. Legendary evidence suggests several spots where breadfruit may have been introduced.

Traditional oral history

Hawaiian mythology scholar Martha Beckwith noted that legends take rational or mythical (non-rational) turns regarding the origin of breadfruit.^(17, p. 97) The rational legendary explanations point to breadfruit as being physically transported to Hawai‘i, possibly from Samoa or Tahiti. In one such version, the voyage was made by Kaha‘i, with Hawaiian breadfruit appearing to come either from Upolo in Tahiti or the Samoan group.^(44, 112) Once in Hawai‘i, breadfruit was said to have been first planted either at Pu‘uloa in Kohala on Hawai‘i,⁽¹⁷⁾ at Pu‘uloa on O‘ahu,^(37, 44, 64) or at Kualoa on O‘ahu.^(22, 29, 89)

Taking forms intermediate between rational and mythical accounts, other legends tell of fishermen from Pu‘uloa who were blown off course to the “traveling island of plenty” of the gods

Kāne and Kanaloa, from whence they brought breadfruit back to Hawai‘i.^(16, p. 16) The goddess Haumea, hearing of this, visited the trees and then scattered breadfruit throughout the islands.⁽³⁷⁾

In mythical legendary explanations, breadfruit trees originated from human body parts, from dead people, or from divine intervention.⁽¹⁷⁾ One of these legends describes a man from Ka‘awaloa in Kona on Hawai‘i who told his children that a breadfruit tree would grow at the door of their house after his death. His hair and hands would be the roots, his legs the branches, and his testicles the fruit. Gods from Waipi‘o on Hawai‘i, not knowing this, cooked and ate the fruit, but when told that the fruits were from a dead man’s testes, they vomited from Kona to Waipi‘o, spreading breadfruit throughout the western and northern parts of the island.^(17, 37) Another account relates that the god Kū bid farewell to his earthly wife during a famine and disappeared into the ground. From there a breadfruit tree grew, providing fruit for his wife and child.⁽¹⁷⁾ Another narrative tells of a man named Ulu who died of hunger. His family buried his body near a spring. During the night, a breadfruit tree grew from the spot, producing fruits that provided for them.^(17, 37) In another variant, Abraham Fornander related an account of the creation of the first man that implicates breadfruit:

“After Kumu Honua was created and placed upon his land, Kane conferred with him and his wife and established laws for them, and the law was called ‘laau’ (tree). The words of Kane are not fully reported in the legend; but it was afterwards thought that the tree was the breadfruit-tree (‘ulu) and that it grew at Honokohau, in North Kona, Hawaii; that it sprung from Kane...and that its fruits have been bitter or sour from that day to this.” ^(37, p. 268)

Hawaiian beliefs, sayings, and legends about breadfruit

According to Hawaiian scholars Mary Kawena Pukui⁽⁴⁴⁾ and Martha Beckwith,⁽¹⁷⁾ Hawaiians recognized male and female forms of breadfruit, as they did in many other plants. These sexual concepts do not correspond to those recognized in scientific botany. The sexual distinction in breadfruit involves the recognition of “normal,” erect plants as male versus stunted or



Upright breadfruit trees were viewed as kinolau of Kū... “bushlike” or so-called female plants are closely associated with “the mysterious form-changing goddess Haumea...,” mother of Kū and patron of childbirth.

“bushlike” plants as female.^(17, 118) Examples of female breadfruit plants were found on Ni‘ihau. Their so-called “stunted” nature there may result from their reported cultivation in cavities and sinkholes⁽¹²¹⁾ and this, when combined with their being little fresh water on that island, may possibly have resulted in the impression that the trees hugged the ground.⁽⁹⁷⁾

Upright breadfruit trees were viewed as *kinolau*, or instances of the “myriad bodies” of Kū,⁽⁴⁶⁾ one of the four major Hawaiian gods. Certainly, this belief accounts in part for the association between Kū and breadfruit in traditional origin accounts. The “bushlike” or so-called female breadfruit plants were closely associated with “the mysterious form-changing goddess Haumea...,” mother of Kū and patron of childbirth.^(16, 54, 64, 118) In several Hawaiian legends Haumea took breadfruit form,⁽¹⁷⁾ and in at least one instance it is said that Haumea “entered a breadfruit tree in her supernatural form.”⁽⁵⁴⁾ Breadfruit was also sacred to Kāne,⁽¹⁸⁾ the Hawaiian deity responsible for introducing cultivated plants. Narratives exist in which an altar decoration or offering to Laka (goddess of *hula*) was made from breadfruit⁽²⁹⁾ and in which its role in the annual *makahiki* festival is described.⁽⁷⁷⁾

Breadfruit also figures in many accounts of transition between life and death⁽⁸⁹⁾ and in those depicting the moment at which a departed soul becomes either a respected ancestral spirit (*aumakua*) or a perpetually drifting and unaffiliated one—these latter concepts perhaps drawing somewhat from Christian beliefs of the afterlife.^(37, 62, 66) Funeral wreaths are sometimes made from breadfruit leaves.⁽⁸⁹⁾

Given its important place in Hawaiian cosmology and its elaborate and eclectic material role (discussed below), it is not surprising that breadfruit was a common component in Hawaiian proverbs, riddles, aphorisms, and adages involving aspects of traditional Hawaiian life and expressions of cultural values. There are several excellent compendia of these sayings.^(46, 58, 97)

Breadfruit introduction, early arboriculture, and plantations

Differences in oral histories related to breadfruit prevent well founded conclusions about the provenance of the Hawaiian breadfruit, especially since the lone Hawaiian cultivar was traditionally present in several Polynesian island groups, including the Marquesas and the Society archipelagos, both of which are

candidates as points of departure for the Polynesian colonizers of Hawai‘i. It bears noting that the “rational” legendary accounts support the scientific explanation that the plant reached Hawai‘i through human agency, possibly to be grown first on O‘ahu or Hawai‘i.

Regardless of the provenance and the date of introduction of breadfruit, the elaboration of Hawaiian sayings, origin accounts, and legends involving the tree reflects a longstanding association, both metaphorical and material, between breadfruit and Hawaiians. This point seems to be confirmed by the cultural association between ‘ulu fruit and the uniquely Hawaiian ‘ulu *maika* bowling stones, the innovation of which is dated to what is called the “mid-Developmental Period,” A.D. 600–1100, by archaeologist Patrick Kirch.⁽⁷⁰⁾ He believes that the *maika* bowling game was invented then, and because ‘ulu is linked to the game conceptually,⁽⁷⁷⁾ it suggests the possibility that breadfruit was present in Hawai‘i before 1100 A.D. Other archaeologists including Melinda Allen support the hypothesis of a later introduction based on a reading of oral history and physical evidence, and in consideration of “the relatively minor importance of breadfruit in Hawaiian economy...”^(3, p. 147) which, she claims, is consistent with a later introduction.

Polynesian colonizers of Hawai‘i probably first planted breadfruit cuttings near their habitations. Elsewhere in Polynesia, people have planted breadfruit trees near their homes for each newborn, both metaphorically and sometimes in reality, in order to ensure the child a life-long food supply.^(30, 45) However, by at least the late 18th century, individual plantings of breadfruit near habitations had been complemented in Hawai‘i by massive plantations, some of which covered many square kilometers, and these plantations were, in all likelihood, managed by complex political hierarchies.

The information compiled in the Appendix tables provides some sense of where breadfruit was traditionally grown in Hawai‘i. But what made these observations of breadfruit trees so worthy of recording? Certainly, several 18th- and 19th-century Euro-American visitors and settlers were impressed by the extent and the organization of the breadfruit groves,^(19, 33, 82) the best example of which is the Kona Field System. Many early ethnohistorical accounts are so strongly worded that some later writers have referred to this plantation as a veritable forest of breadfruit.^(46, 65, 106, 109)

The size and maturity of the breadfruit trees in the groves noted by late 18th and early 19th century observers, and their association with the sophisticated understory horticulture characteristic of the Kona Field System,⁽⁸²⁾ indicate that large-scale breadfruit arboriculture and clonal crop polyculture involving taro, sweetpotato, banana, sugarcane, and other domesticated crops were flourishing in Hawai‘i well before the arrival of non-Polynesians. Indeed, many of the groves are referenced in Hawaiian legends, confirming the antiquity and the importance of breadfruit at these sites long before they were recorded by Euro-Americans.^(17, 37, 99, 105)

There is also evidence that some plantations may have been developed after European contact. In 1779, for example, David Samwell noted that Lāna‘i was generally barren, and he was told by the “Indians” that no plantains or breadfruit were grown on the island.^(14, p. 1220) However, over a century later, breadfruit groves were found on the east coast of Lāna‘i, opposite Maui.⁽³⁴⁾ This apparent change may be related to transformations in the use of space similar to those described at Anahulu, O‘ahu.⁽⁷¹⁾ There, a process of agricultural intensification that included the creation of breadfruit groves occurred following a massive historical Hawaiian population movement that was motivated by the political and military ambitions of Kamehameha I in the early 19th century.

Breadfruit and political implications

In contrast to the scattered plantings of breadfruit trees near house sites, intensive breadfruit arboriculture had important political underpinnings in Hawai‘i. Breadfruit groves constituted a resource management option that was functionally similar to intensive wetland taro cultivation and to large-scale pisciculture, all of which were driven in large measure by political-militaristic competition, chiefly glorification, and the associated requirement of feeding large human populations upon which the chiefly power bases resided.⁽⁶⁹⁾ In noting that the major breadfruit groves generally cut across boundaries of *ahupua‘a*, the traditional political-economic unit, many observers believe that this agricultural pattern was an outgrowth of some form of central planning and organized implementation.^(3, 28, 65, 69) A similar pattern has been noted in the Marquesas Islands, where “individuals owned trees in the vicinity of their houses and chiefs owned

plantations....”^(44, p. 182) Given the extent and the apparent productivity of the Kona Field System (discussed further on pp. 43–46), and that of the other West Hawai‘i field systems in Kohala and Waimea,⁽⁷⁰⁾ it is no surprise that a West Hawai‘i chiefly line eventually achieved military supremacy and paramount status within the Hawaiian archipelago.⁽⁶⁹⁾

Recent times

By the late 1800s and early 1900s, many of the heavily planted breadfruit groves had been seriously fragmented or destroyed,^(44, 48) mostly as a result of depopulation, land-use changes,⁽⁷⁶⁾ and associated forces of cultural decline that led to shifts in food availability and dietary preferences. By 1926, University of Hawai‘i horticulturist Willis Pope wrote that “...there are no breadfruit orchards anywhere....”^(96, p. 10) Nevertheless, isolated trees near homes or work sites can still be found throughout Hawai‘i, and remnants of the Kona Field System plantation are visible from the air.

The Ethnobotany of Breadfruit in Hawai‘i

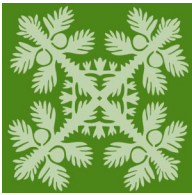
The breadfruit tree was of great practical value to Hawaiians. In everyday life, the wood and sap were used in construction; the bark, root, and milky sap were employed in medicine; and the bark, wood, sap, and leaves had many common household applications. The sap and fruit were used in bird-capturing and fishing activities. The wood was commonly carved to produce domestic and ritual goods, sporting gear, and game pieces. The fruit was prepared in a variety of ways for human and animal consumption. As a foodstuff, it was a regular item in ceremonial offerings, tribute, trade, and taxation. Whether it was used as a raw material or as a final product, Hawaiians employed nearly every part of the breadfruit tree.⁽⁴⁴⁾ Today the breadfruit design is popular in Hawaiian quilts and other art forms, including tattoo. The material aspects of Hawaiian breadfruit ethnobotany are summarized in the following sections.



Material culture

Construction

The wood of the breadfruit tree was commonly used by ancient Hawaiians in building and to a lesser degree in canoe construction. Door frames^(6, 63, 77) and house timbers⁽⁷⁵⁾ were made from breadfruit wood, as were the seats, decking, and paddles of canoes.^(52, 74) Damaged canoes were repaired with this light wood. Sometimes entire hulls were constructed from ‘ulu logs, but it is generally thought that these were much less common than canoes built of *koa* (*Acacia koa*), the preferred wood,^(52, 77) and use of breadfruit wood may actually have been confined mostly to small inshore craft and training canoes for children. Older trees that had ceased to produce well were probably the ones most often taken for these uses.⁽¹⁰³⁾



Today the breadfruit design is popular in Hawaiian quilts and other art forms, including tattoo.

The milky sap of the tree was employed as glue and caulking in canoes, buildings, and musical instruments.^(21, 52, 75) In Samoa, the Hawaiian breadfruit called *ulu e‘a* was believed to produce the best sap for these purposes.⁽¹⁰³⁾

Domestic applications

Objects made from parts of the breadfruit tree were common in the Hawaiian domestic economy. The inner bark of young breadfruit branches was used to make *kapa* (tapa, or bark cloth) for clothing and other household applications.^(14, 46, 77) Hawaiian historian Samuel Kamakau claimed that “...the first tapas made from plants were made from *pō‘ulu* (the tender shoots of the breadfruit tree)...” and that “...later, *wauke* [*Broussonetia papyrifera*] was obtained,”^(63, p. 109) but it is generally felt that breadfruit tapa was not as soft or durable as tapa made from *wauke* (paper mulberry), the preferred natural resource.^(46, 81) The male ‘ulu flower is said to produce a yellowish dye.^(20, 21)

The easily worked but fairly durable wood of the breadfruit tree was also employed to construct smaller household or ceremonial objects such as bowls,⁽⁵⁷⁾ poi boards, drums, and implements used in sports and other physical activities. Five of the 49 *pahu* in the Bishop Museum drum collection were judged to have been carved from breadfruit.⁽⁶⁰⁾ Like several of the lighter Hawaiian woods, breadfruit was used to make surfboards.^(29, 73) In the late 1800s, the English traveler Isabella Bird observed “surf-bathing” and described the “wave sliding boards” as “... a tough plank shaped like a coffin lid, about two feet broad, and from six to nine

feet long, well oiled and cared for...made of the erythrina [*wiliwili*], or the breadfruit tree.”^(19, p. 69) Breadfruit wood was also used to construct sleds for racing down hillsides.⁽³⁷⁾ As with canoe repairs, breadfruit wood was used to patch many smaller wooden objects.⁽²¹⁾

The emory-textured leaf served as a fine “sandpaper” for finishing all sorts of woodwork and objects used in body decoration such as *kukui* nut (*Aleurites molucanna lei*).⁽⁵²⁾ As with canoes and their parts, bowls made from Hawaiian hardwoods like *koa* and *kou* (*Cordia subcordata*) were progressively smoothed with natural abrasives, first with coral or pumice and eventually with breadfruit leaves.^(29, 57, 77) The leaf sheathes served as extra-fine sandpaper for delicate work.

Breadfruit was closely associated with the Hawaiian game of ‘*ulu maika*, which was described as a favorite of Kamehameha I.⁽³⁷⁾ Players hurled or bowled a bi-convex stone disc called ‘*ulu* along a course where accuracy and distance were objectives and betting was common. Half-grown breadfruits may have been originally used in this game,⁽⁷⁷⁾ much as they were found to have been used in Samoa,⁽²¹⁾ thus lending the name of the plant to the spherical stone used later.

The breadfruit tree itself served in other important ways that have not been well recognized in studies of Hawaiian human ecology. One poorly appreciated “application” was the shade from the tropical sun provided by breadfruit foliage. This shade was a desirable attribute of the tree in inhabited areas and was often remarked upon by early visitors.^(5, 33) During a visit to Waimanu Valley, O‘ahu, in 1873, Isabella Bird saw “...some very pretty grass houses, under the shade of the most magnificent breadfruit trees....”^(19, p. 139) Similarly, at Pa‘ula on Hawai‘i, Handy and Handy noted that

“...there were also breadfruit trees, sweet-potato plantations, and many kukui and kou trees. People from the beaches liked to rest in the shade of those trees, cooking breadfruit, roasting kukui nuts, and preparing pandanus leaves for mat making.”^(46, p. 603)

Within heavily cultivated areas of dryland taro, sweetpotato, or other annually cropped plants where most if not all natural overstory vegetation had been removed, intense midday sun can become not only uncomfortable for humans but can reduce

Like several of the lighter Hawaiian woods, breadfruit was used to make surfboards.

agricultural production. Hawaiians were known to have made fires on exceptionally dry, hot days to produce smoke, thereby attempting to protect their crops from the sun's burning rays.^(63, p. 25) Early Euro-American observers saw sweetpotato and paper mulberry^(82, p. 75) growing within breadfruit groves, sometimes along with mountain apple (*Syzygium malaccense*)^(33, p. 32) and banana.^(14, p. 521) The tree does not appear to have been limited to the *kalu-'ulu* (breadfruit) zone when grown in the Kona Field System, having also been planted to some extent in the *'āpa'a* zone, where taro and sweetpotato horticulture dominated.⁽⁷⁶⁾ It is probable that one feature of breadfruit's presence within these zones of intense cropping activity was to supply a measure of shade to the other cultivated plants grown there, as well as to the people tending them.



Breadfruit shade was a desirable attribute of the tree in inhabited areas and was often remarked upon by early visitors.

Other under-appreciated uses of breadfruit in domestic life were its role as firewood and in play. Its wood was sometimes used as fuel,⁽³⁷⁾ and there are several 19th century accounts of Hawaiian children singing or chanting from perches in breadfruit trees high above the ground.^(54, p. 29)

Medicine

Hawaiians used the bark, buds, fruit, and roots of the breadfruit tree medicinally, but the milky sap appears to be the part of the tree most frequently employed in medicinal preparations.

Hawaiians used the roots of the breadfruit tree as a purgative.^(75, 107) A remedy for “impure blood” was said to involve breadfruit bark pounded with flowers or bark from six plants and then cooked in coconut milk.⁽⁵⁹⁾ The bark was employed as a bandage or cast to set bone fractures,⁽⁴³⁾ and a treatment for thrush involving breadfruit leaf buds has been described.⁽⁴⁶⁾

Breadfruit sap was applied externally to combat skin eruptions.⁽⁴⁷⁾ These were considered by several observers to have been one of the most common afflictions of early Hawaiians and possibly were linked to overconsumption of salt.⁽⁹²⁾ Sap was mixed with *lama* (*Diospyros* species) wood ashes for ulcers and sores around the mouth.⁽⁵⁹⁾ Other combinations involving breadfruit sap were prepared with *kukui* (*Aleurites molucanna*) and, in post-Cook times, papaya (*Carica papaya*) and tobacco ashes to hasten the healing of deep cuts, wounds, sores, and unspecified “skin diseases.”⁽⁵⁹⁾ Breadfruit sap served to fill and “repair” damaged teeth, and mixed into a paste with fern fronds, it was applied to fever blisters until scabs formed.⁽⁷⁹⁾

The fruits were common ingredients in a multitude of “medical treatments” involving other plants.^(43, 59) It is claimed that breadfruit leaves “had special powers” to treat various disorders when placed under sleeping mats.^(43, p. 24) The phytochemical bases for many of these medicinal applications were summarized by Ragone,^(104, p. 37) thereby demonstrating the efficacy of breadfruit-derived treatments in many traditional therapeutical uses.

Procurement of protein, fat, and other animal products

The fruit of ‘ulu was an important fodder for domestic pigs^(29, 96) and dogs⁽¹¹⁵⁾ in Hawai‘i, as it was elsewhere in Oceania,⁽¹⁰²⁾ and it is still commonly fed to pigs. Both animals were produced in large numbers by Hawaiians as articles of food, tribute, and trade.^(22, 33, 115) Pigs were especially important in ritual⁽⁶⁹⁾ and, after Cook’s arrival, were highly prized by visiting ships seeking non-perishable provisions.^(14, 33, 115) Dogs were consumed in traditional ritual and aristocratic feasting as well as in everyday life,^(16, 21) sometimes in large numbers,^(32, p. 247) and it is probable that dog consumption among Hawaiians increased in the post-Cook period as the foreigners’ demand for pigs drew down those stocks.^(115, p. 8)

The intensive production of breadfruit and other plant foods apparently allowed a steady supply of pigs and dogs for consumption, gift-giving, tribute, and taxation in ancient times and in the early post-Cook period in Hawai‘i. After the arrival of explorers, whalers, and merchants, the wide availability of breadfruit permitted Hawaiians to offer it to honored guests and to exchange it for desired trade items. Cook’s ships and those that immediately followed them were well supplied, through gift-giving and trade, with pigs and plant foods that commonly included breadfruit.^(14, pp. 1081, 1151, 1188, 1219, 1221) Exchange was not new to Hawaiians; like other agricultural products, breadfruit was already commonly traded within traditional Hawaiian society among fishermen and farmers, the latter exchanging agricultural products for marine resources.^(63, 123)

Specialized uses

Like other Polynesians, Hawaiians once caught and variously



Breadfruit leaves “had special powers” to treat various disorders when placed under sleeping mats.

Intensive production of breadfruit and other plant foods apparently allowed a steady supply of pigs and dogs for consumption, gift-giving, tribute, and taxation.

used many species of endemic forest birds and hole-nesting pelagic birds. One of the principal capture techniques involved smearing sap of breadfruit and other plants onto long poles and then placing these sticky traps where forest birds congregated in trees or directly into the nesting holes of pelagic birds.^(14, 37, 77) Boiling the sap may have been part of the glue preparation process.⁽⁵⁾ Feathers from captured forest birds were used to make chiefly capes and other regalia, and the birds commonly were consumed afterwards.^(77, p. 37) The use of wild birds as food after their capture was a common practice throughout Polynesia.^(46, 63, 66, 80)

The ripe fruits of 'ulu placed in baskets were used by Hawaiian fishermen to entice fish, especially *kala* (*Naso* species), into fishtraps.⁽⁶³⁾ As chum, breadfruit was also employed to fatten fish and to attract a broad range of species into areas where baited hooks and nets had been placed.⁽⁶⁷⁾

Uses of breadfruit as animal fodder, as an item of exchange for fish, as a bird lime, and as a fish bait can be viewed collectively as mechanisms by which a raw agricultural product was transformed into or used to procure less abundant and highly valued protein, fat, and other animal products during ancient and early historical times. Successful breadfruit arboriculture and related success in animal husbandry contributed to higher living standards among the common people and enhanced prestige among the chiefs, for, as Hawaiian scholar David Malo put it, pigs and dogs “were sources of wealth...and in great demand...”^(77, p. 78)

Role in the human diet

During repeated visits to the main islands in 1778 and 1779, Cook's ships always found “breadfruit [to be] in great plenty.”^(14, p. 1221) Approximately 50 years later, during the first half of the 19th century, Malo again recorded that “the *ulu* or breadfruit is very much used as a food by the natives.”^(77, p. 43) By the 1920s, however, heavy breadfruit consumption had become a thing of the past, with the 1921 Hawaii Agricultural Experiment Station annual report stating “the fruit of [breadfruit] was once extensively used for food by the Hawaiians.”^(48, p. 21)

These and other accounts of breadfruit's important food role, the apparent ease with which it was obtained by early visitors, and its common use as pig and dog fodder and fish food and bait all seem to combine to indicate that breadfruit occupied a very significant economic position during the late Hawaiian pre-Cook

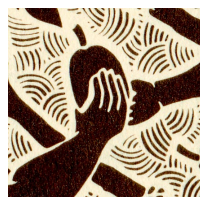
and early post-Cook periods. Nevertheless, at least one of the early European experiences with breadfruit in Hawai‘i was less than satisfactory. In the 1804 Russian expedition to Hawai‘i, Yuri Lisianski found the breadfruit quality to be poor^(10, p. 34) and also indicated difficulty in obtaining the fruits. On the surface, this account seems to contradict other evidence suggesting that Hawaiian breadfruit was abundant and of high quality. Nevertheless, this apparent incongruity may perhaps be explained by considering known features of Hawaiian breadfruit maturation and physical requirements.

Hawaiian breadfruit trees mostly produce from mid-summer to late fall, doing best in well watered, deeper soils with good drainage at some distance from saline conditions. The two sites at which the Russians describe breadfruit in Hawai‘i, near Hikiau Heiau in Kealakekua Bay and at Ka‘awaloa just north of there, and the timing of their visits in early to mid-June, would seem to ensure under normal conditions that the Russian experience with Hawaiian breadfruit would be one of the poorest of any of the early European visitors. Indeed, when considering the timing of the visits at the start of the fruiting season, that rainfall at Ka‘awaloa and Kealakekua Bay is one of the lowest in Hawai‘i,⁽⁸⁾ and that the light soils (at Ka‘awaloa) and the proximity to the ocean (at both sites) would be similarly unfavorable to breadfruit culture, we may understand why “Lisianski and his men were not impressed by the...breadfruit trees...[that] were [there] in poor condition.”^(10, p. 139) It is also worth considering the possible effects of drought that year, as serious rainfall deficiency occurs somewhere in Hawai‘i every 21 years, on average.^(46, 69)

With the exception of a second less-well documented critical remark,^(83, p. 4) the other early descriptions of Hawaiian breadfruit that we surveyed portray it as an important component of the traditional diet, as a plant readily supplied to visitors when available, and as a common fodder for domesticated animals.^{(7, 19,}

33, 38, 72, 82, 100, 113)

Despite the preponderance of evidence demonstrating a very substantial role for breadfruit in the traditional Hawaiian economy and diet, none of the evidence we reviewed places the crop in a paramount position as the human staple, as it was, for example, in the Marquesas Islands. Describing Hawaiian foods of the early 1820s, William Ellis stated that



Early descriptions of Hawaiian breadfruit portray it as an important component of the traditional diet, as a plant readily supplied to visitors when available, and as a common fodder for domesticated animals...

“The natives subsist principally on the roots of the arum esculentum, which they call taro, on the convolvulus batatas, or sweetpotato, called by them uara, and uhi, or yam. The principal indigenous fruits are the uru, or breadfruit; the niu, or cocoa-nut; the maia, or plantain; the ohia, a species of eugenia; and the strawberry and raspberry.”^(33, p. 25)

Ellis’ placement of breadfruit in a non-staple though important subsistence position in the Hawaiian food hierarchy is particularly useful because it was made by a person who had in the early 19th century visited other Polynesian archipelagos where breadfruit production and consumption predominated in the agricultural systems.

Later writers are less subtle than Ellis in their assessments of the breadfruit’s alimentary status in traditional Hawai‘i. Explorer and eclectic natural historian Joseph Rock, for example, claimed that “...in Hawaii the breadfruit has not played a very important part in the household..., as it did...in the South Seas.”^(107, p. 117) Others, like botanist Elbert Little and forester Roger Skolmen, stated rather unequivocally that it “was not an important food... probably because the Hawaiians had not introduced good varieties,”^(74, p. 98) even though, as we mentioned earlier, the Hawaiian cultivar is consistently viewed elsewhere as a superior variety. The botanist Degener says that “...as an article of food, the breadfruit was not of much importance in Hawaii.”^(29, p. 129; see also 51, 83, 95)

...but by the 1920s, heavy breadfruit consumption had become a thing of the past.

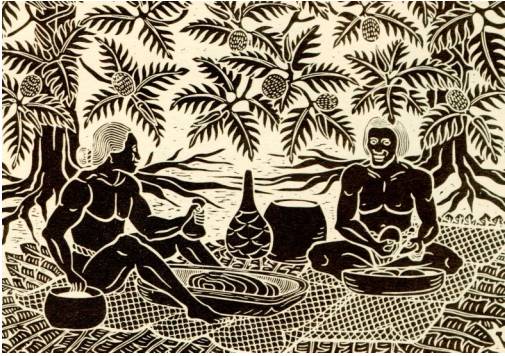
Fortunately, these negative appraisals of breadfruit in Hawai‘i by 20th century writers having little or no first-hand experience with traditional Hawaiian lifeways have been balanced by more nuanced modern descriptions that we feel are more in line with the comments of earlier Hawaiian and Euro-American observers. While well known Bishop Museum ethnographers E.S. Craighill Handy and Elizabeth Green Handy generally placed breadfruit in a secondary alimentary position in Hawai‘i, they nevertheless recognized regional variation in production and consumption: “...except in Puna, Hawai‘i, breadfruit was wholly secondary to taro and sweetpotato as a staple.”^(46, p. 151) On Lāna‘i, archeologist Kenneth Emory noted that “...the sweet potato was the staple, although taro, yams, and breadfruit were important supplementary items of diet.”^(34, p. 520)

Explanations proposed to account for the secondary agricultural and alimentary importance of breadfruit in Hawai‘i, when compared to other Polynesian archipelagoes where breadfruit was the staple, have ranged from cultural preferences to physical environmental differences. Most authors promote this second explanation^(1, p. 20; 46, p. 73) claiming, for example, that the Marquesans, Samoans, and Tahitians produced an agroecological response favoring breadfruit over taro because of topographic and climatic factors that made large-scale irrigated taro agriculture more difficult there when compared to Hawaiian conditions. Despite such ecological-geographical assertions, Handy also saw cultural factors at work, noting that “...Hawaiians consider [breadfruit] inferior in taste and in nutritional value and...because it produces much gas....”^(44, p. 189; 83) Indeed, as we will see further on, preference for taro in Hawai‘i was probably at least in part culturally determined, for breadfruit is nutritionally equivalent to taro, and when considering vitamin and mineral content, it may even be somewhat superior to taro in overall food value.

Preparation of breadfruit as food

The fruits were picked by hand or knocked off the tree using long wooden poles (*lou*), to be caught in a net or by a person waiting below.^(21, 44) Breadfruit can be prepared and consumed in a number of ways. Baking in earth ovens (*imu*) or broiling over hot coals and preparation as *poi ‘ulu* were common. Roasted breadfruit is mentioned as a principal dietary element of certain traditional specialists such as *kūkini* (runners). While in training, it is claimed that *kūkini* were denied *poi* and heavy foods, being permitted fowl and vegetables, and especially roasted taro, sweetpotato, and breadfruit.⁽⁷⁷⁾ It is generally believed that breadfruit was not *kapu* (forbidden) to women.^(2, p. 36)

Breadfruit was also prepared as a yellowish *poi* in Hawai‘i, much in the same way that taro *poi* was prepared,⁽⁹⁵⁾ with the degree of fermentation corresponding to individual taste. Some people preferred breadfruit *poi* because it was said to be “sweeter” than taro *poi*, while others preferred taro and breadfruit *poi* mixtures.⁽⁷⁷⁾ Whether eaten directly after baking, or transformed into *poi*, fairly small quantities were most likely prepared and consumed within a few days. The fruit was also transformed into *piele ‘ulu* (or *piepiele ‘ulu*), a pudding of coconut milk and breadfruit cooked in earth ovens, or into *pepeie‘e*, a hardened



Breadfruit is nutritionally equivalent to taro, and when considering vitamin and mineral content, it may even be somewhat superior to taro in overall food value.

during World War II in many of the more remote and less well provisioned areas of Hawai‘i. The latex from a scored trunk or branch was traditionally chewed by children^(46, p. 154) and, after the introduction of sugar and mint and other aromatic plants, these were added to the latex as flavor enhancers. Today, many nontraditional edible breadfruit products are being developed, ranging from chips to flour to freeze-dried derivatives.^(104, p. 27)

While many people in Hawai‘i with access to breadfruit trees still enjoy eating breadfruit, some reject the taste.^(48, p. 21) The following account of breadfruit as food by one Hawaiian (W. S. Lokai) in the early 20th century exemplifies the less-than-unanimous appreciation of the fruit:

“Breadfruit was of three kinds. 1. The rat-eaten breadfruit; the reason it was so called was on account of the holes made by rats. 2. The wind-stricken fruit; it was so called because of its exposure to the wind at all times. 3. The soggy fruit; so called because the inside or pulp was water-soaked, lumpy and tough when eaten.” ^(37, p. 678)

Food preservation

Long-term preservation of breadfruit through an anaerobic fermentation process involving intense acidification was practiced on many of the Pacific archipelagoes where the tree was grown.^(9, 27, 95, 108) This practice is generally viewed as a cultural response to lean times resulting from chronic drought or disruption of agricultural production by warfare.⁽²⁷⁾ Despite the fact that breadfruit spoils quickly once harvested,⁽¹⁰³⁾ and ensilage of the fruits in large subterranean pits was a major cultural feature of the Marquesas

version of the latter involving much the same preparation but with more coconut milk added. Once dried, it could be consumed over several months.^(22, 46, 73) Hawaiian historian David Malo^(77, p. 21, 43) considered *poi ‘ulu* and *pepeie‘e* to be “delicious.”

More recently, people have taken to boiling breadfruit or frying it in butter. As a modern foodstuff, breadfruit’s importance jumped

and Samoa, Hawaiians do not appear to have practiced this preservation technology. The earliest Euro-American visitors to Hawai‘i do not mention breadfruit preservation of any sort, nor is the practice of fermentation in pits supported to any extent by the archaeological record. Nonetheless, one early 19th century observation suggestive of pit ensilage was made during the visit by the Kruzenstern-Lisianski expedition to O‘ahu in 1804 by Fedor Shemelin, who found breadfruit to have been placed in a hole “for two months when not quite ripe.”^(10, p. 139) However, evidence suggests that this may have been a fairly recent innovation at the time it was recorded, for Cook and King claim to have shown Hawaiians how to preserve breadfruit in this manner in 1778.^(103, p. 211) Small pits possibly used for food storage were also described by archeologist Roger Green at Makaha on O‘ahu, but he concluded “it is unlikely that [they] were used for [breadfruit] preservation.”^(42, p. 70)

Food Value of Hawaiian Breadfruit

In the following section we present a nutritional assessment of Hawaiian breadfruit. First, we summarize (Table 2) a series of nutritional analyses reported from 1917 through 1976. These provide a background and comparative base for results obtained during the course of our study.

The sampling design for the analyses presented in Tables 3–6 (pp. 32–35) was adopted to assess overall nutritional quality of the Hawaiian breadfruit cultivar as well as quantitative differences in food value between breadfruits from geographically and climatologically distinct areas within the state of Hawai‘i. Two distinct sites were sampled, one in a leeward upland area of the island of Hawai‘i, and the other in a windward coastal location. Both sites are known to have produced abundant breadfruit in ancient times. Fruits chosen appeared ripe but not so overripe as to make handling difficult. Each fruit was beginning to ooze gum and was mottled but still firm, although not brick-hard to the touch. Fruits from the windward location were gathered from breadfruit trees within Hilo city limits (~50 ft [15 m] elevation). Fruits from the leeward site were collected from trees in the Keauhou area of Kona (600–700 ft [180–210 m] elevation).



Table 2. Older nutritional data on Hawaiian ‘ulu.

Reference	1	2	3	4	5
Preparation	–	Baked	Baked	Boiled ^{a/} _b	–
Calorie count	–	–	–	119 / 134	–
Carbohydrate	25%	27.82%	–	29.3 / 31.7 g	“high”
Fat	–	0.31%	–	0.3 / 0.3 g	–
Protein	–	1.34%	–	1.3 / 1.4 g	–
Fiber	4%	1.50%	–	–	–
Calcium	–	0.022%	–	21 / 24 mg	“fair”
Phosphorus	–	0.062%	–	59 / 67 mg	“fair-good”
Iron	–	–	–	0.4 / 0.4 mg	“poor”
Vitamin A	–	“fair”	“poor”	0 / 26 IU	“poor”
Vitamin C	–	“poor”	“fair”	10 / 10 mg	“fair”
Thiamin	–	–	“fair”	122 / 109 mg	–
Riboflavin	–	–	–	58 / 56 mg	–
Niacin	–	–	–	0.7 / 1.3 mg	–
Ash	–	1.23%	–	–	–
Water	25–30%	67.80%	–	–	–

– information not provided

References and sample information

1. MacCaughy (ref. 75, p. 43), citing *Hawaiian Planters Monthly* 13:315 (1894); unspecified amount of breadfruit.
2. Miller (ref. 83, p. 5), unspecified amount of Hawaiian ‘ulu mixed with an unspecified Samoan variety.
3. Miller and Bazore (ref. 84, p. 19), qualitative summary re: Hawaiian ‘ulu.
4. Miller and Branthoover (ref. 85, p. 5). ^a100 g “green, mature, cooked” breadfruit; ^b100 g “ripe, cooked” breadfruit.
5. Na Lima Kokua (ref. 87, p. 3), qualitative summary re: Hawaiian ‘ulu.

At each location, two fruits were gathered from each of three trees. The fruits were harvested in early December, 1991, and prepared within two days of harvest. We tested four samples from each location (eight samples total): raw fruit, baked fruit, *poi* made from the baked fruit, and fermented *poi'ulu*. Details of the experimental methods are given on page 31.

Each prepared sample was analyzed in triplicate for water, protein, fat, available carbohydrate (starch and sugar), dietary fiber, ash, 10 minerals, and 6 vitamins. Values presented in Tables 3–5 show the means of the three analyses for each of the four breadfruit preparation methods: raw, baked, *poi*, and fermented *poi*. Energy content of Hawaiian breadfruit was calculated from the protein, fat, and carbohydrate contents using standard formulas that account for the average digestibility of fruits.⁽¹¹⁹⁾

The enzymatic/gravimetric method can quantify dietary fiber by separating it from other carbohydrates such as starch. Consequently, in starch-rich foods like breadfruit, the enzymatic/gravimetric method generally yields lower but more accurate dietary fiber results. Our dietary fiber analyses resulted in significantly lower values for breadfruit than those published in USDA Nutrient Database SR-17⁽¹¹⁶⁾ for an unspecified breadfruit cultivar (see Table 3).

Data for soluble and insoluble fiber composition also are presented in Table 6. To our knowledge, these are the only values currently available for these fractions of dietary fiber in breadfruit, and we recently published them in the *Journal of Food Composition and Analysis*.⁽⁵³⁾

Mineral content is presented in Table 4. Values for water-soluble vitamins (vitamin C, thiamin, riboflavin, and niacin) and two fat-soluble vitamins, (A and E) are presented in Table 5.

Comparison of data from the Hilo and Kona breadfruits reveals some differences between the two locations. The Kona raw breadfruit samples had higher water content, possibly due to differences in the climate or soil but more likely due to the Kona breadfruit sample being slightly less ripe than the Hilo sample, as suggested by the Kona sample's lower starch/sugar content (total available carbohydrate) (Table 3). Comparison of results for baked and *poi* samples showed very similar water and carbohydrate contents for both the Hilo and Kona fruits, possibly indicating greater uniformity in ripeness.

Ash and individual mineral values were generally higher in

Methods of breadfruit sample preparation and analysis

Raw fruit samples: one of the two fruits from each of the three trees at each location was selected by flipping a coin. These fruits were sliced in half, the cores and skins were removed, and the pulp was cut into 1-inch cubes. Equal numbers of cubes from each of the three fruits were mashed together in a bowl. One cup of this mashed fruit was placed in a triple-layered freezer bag, labeled, and frozen.

Cooked samples: the six fruits remaining after sampling the raw fruit, three from each location, were baked uncovered and whole in a standard oven at 250°F (121°C) for six hours, roughly simulating the traditional Hawaiian slow-cooking process in an underground oven (*imu*). After being cooled to room temperature, each fruit was cut in half, and the core was removed. The cooked pulp was cut into 1-inch (3-cm) cubes. Equal numbers of cubes from each of the three cooked fruit samples were mashed together in a bowl.

Crushed mixtures from each of the three baked fruit samples were divided into three portions, one each for the baked fruit sample, the *poi* sample, and the fermented *poi* sample. The two portions for the baked samples were then bagged, labeled, and frozen.

Poi was made by adding equal amounts of commercial bottled water to the baked, mashed fruit pulp and pounding it to pudding consistency. The fresh *poi'ulu* was then frozen. The remaining freshly prepared *poi'ulu* samples were put in bowls, covered with cheesecloth, left to ferment at room temperature for 36 hours, and then frozen.

Chemical analyses were done at the College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa. Total dietary fiber was measured by the enzymatic/gravimetric method that was recently adopted as the standard method for dietary fiber analysis by the Association of Official Analytical Chemists (AOAC). Mineral content was analyzed by inductively coupled plasma (ICP). Water-soluble vitamins (vitamin C, thiamin, riboflavin, and niacin) were analyzed by high pressure liquid chromatography (HPLC). Two fat-soluble vitamins, vitamin A and vitamin E, were measured by standard AOAC methods.

Table 3. Breadfruit nutrient composition (per 100-g sample) and comparative values from various sources.

Sample	Water (g)	Energy (kcal)	Protein (g)	Fat (g)	Starch and sugar (g)	Dietary fiber (g)
Raw breadfruit						
Hilo	67.6	112	1.4	0.3	29.2	0.9
Kona	79.4	68	0.8	0.3	17.5	0.8
Mean	73.5	90	1.1	0.3	23.4	0.9
Baked breadfruit						
Hilo	66.5	115	1.3	0.2	30.2	0.9
Kona	67.2	112	0.6	0.2	29.9	0.9
Mean	66.9	113	0.9	0.2	30.1	0.9
Breadfruit poi						
Hilo	86.9	45	0.5	0.1	11.8	0.4
Kona	83.2	57	0.3	0.1	15.4	0.4
Mean	85.1	51	0.4	0.1	13.6	0.4
Fermented breadfruit poi						
Hilo	87.1	45	0.5	0.1	11.7	0.3
Kona	81.6	64	0.3	0.1	17.1	0.3
Mean	84.4	54	0.4	0.1	14.4	0.3
Raw breadfruit*	70.7	103	1.1	0.2	22.2	4.9
Taro, cooked*	63.8	142	0.5	0.1	34.6	5.1

*USDA Nutrient Database for Standard Reference, Release 17, 2004.

Table 4. Breadfruit nutrient composition (per 100-g sample) and comparative values from various sources.

Sample	Ash (g)	Ca (mg)	P (mg)	Mg (mg)	Na (mg)	K (mg)	Fe (mg)	Zn (mg)	Cu (mg)	Mn (mg)	B (mg)
Raw breadfruit											
Hilo	0.72	19.8	29.7	26.4	4.2	224	0.33	0.07	0.10	0.07	0.50
Kona	1.16	36.0	26.0	41.1	10.4	354	0.46	0.10	0.06	0.04	0.54
Mean	0.94	27.9	27.9	33.8	7.3	289	0.40	0.09	0.08	0.06	0.52
Baked breadfruit											
Hilo	0.85	26.4	32.1	23.1	4.9	283	0.52	0.17	0.10	0.07	0.51
Kona	1.15	23.2	26.4	46.2	6.6	339	0.36	0.07	0.04	0.03	0.72
Mean	1.00	24.8	29.3	34.7	5.8	311	0.44	0.12	0.07	0.05	0.62
Breadfruit poi											
Hilo	0.30	12.6	11.7	10.4	1.4	83	0.26	0.12	0.05	0.03	0.21
Kona	0.58	8.5	13.6	23.8	3.3	172	0.33	0.16	0.02	0.02	0.44
Mean	0.44	10.6	12.7	17.1	2.4	128	0.30	0.14	0.04	0.03	0.33
Fermented breadfruit poi											
Hilo	0.32	11.7	13.0	10.3	1.4	88	0.20	0.07	0.05	0.03	0.22
Kona	0.56	9.2	14.4	23.9	3.5	175	0.34	0.04	0.02	0.02	0.39
Mean	0.44	10.5	13.7	17.1	2.5	132	0.27	0.06	0.04	0.03	0.31
Raw breadfruit*	0.93	17.0	30.0	25.0	2.0	490	0.54	0.12	0.08	0.06	
Taro, cooked*	0.97	18.0	76.0	30.3	15.0	484	0.72	0.27	0.20		

*USDA Nutrient Database for Standard Reference, Release 17, 2004.

Table 5. Breadfruit nutrient composition (per 100-g sample) and comparative values from various sources.

Sample	Vit A RE (mg)	Vit C (mg)	Thiamine B1 (mg)	Riboflavin B2 (mg)	Niacin B3 (mg)	Vit E aTE (mg)	Vit B6 (mg)	Folacin (µg)	Vit B12 (µg)	Pantothenate (mg)
Raw breadfruit										
Hilo	-	18.2	0.31	0.09	1.6	-	0			
Kona	-	23.3	0.25	0.11	1.8	-	0			
Mean	-	20.8	0.28	0.10	1.7	-	0			
Baked breadfruit										
Hilo	-	15.4	0.19	0.07	1.6	-	0			
Kona	-	14.1	0.22	0.10	1.9	-	0			
Mean	-	14.8	0.21	0.09	1.8	-	0			
Breadfruit poi										
Hilo	-	5.7	0.07	0.03	0.6	-	0			
Kona	-	7.2	0.09	0.03	0.9	-	0			
Mean	-	6.5	0.08	0.03	0.8	-	0			
Fermented poi										
Hilo	-	6.3	0.07	0.01	0.8	-	0			
Kona	-	6.8	0.06	-	1.2	-	0			
Mean	-	6.6	0.07	0.01	1.0	-	0			
Raw breadfruit*	4	29.0	0.11	0.03	0.9	0.1	0.1	14	0	0.46
Taro, cooked*	0	5.0	0.11	0.03	0.51	0.44	0.33	19	0	0.34

RE: Retinol Equivalents; aTE: alpha Tocopherol Equivalents. A dash (-) indicates that only a trace of the nutrient was found; because these very small amounts are at the limits of analytical reliability and are not of nutritional significance, no value is reported. A blank space indicates that no analysis was conducted. *USDA Nutrient Database for Standard Reference, Release 17, 2004.

Table 6. Breadfruit nutrient composition (per 100-g sample): soluble and insoluble dietary fiber contents of Hawai'i-grown breadfruit and taro.

Sample	Dietary fiber (g)		Soluble / insoluble	Total fiber (g)
	Soluble	Insoluble		
Raw breadfruit				
Hilo	0.12	0.74	0.16	0.86
Kona	0.18	0.66	0.27	0.84
Mean	0.15	0.70	0.21	0.85
Raw taro				
'Lehua'	1.3	2.30	0.57	3.6
'Bun long'	0.8	3.00	0.27	3.8
Dasheen	2.36	2.05	1.15	4.41
Mean	1.49	2.45	0.66	3.94
Breadfruit poi				
Hilo	0.05	0.32	0.16	0.37
Kona	0.06	0.37	0.16	0.43
Mean	0.06	0.35	0.16	0.40
Average fresh taro poi	1.18	1.93	0.61	3.11

Dietary fiber values for taro are from analyses done in the laboratory of Alvin Huang, University of Hawai'i.

the Kona raw breadfruit sample than in the Hilo sample. Total ash was also higher in the Kona baked sample. Two minerals for which breadfruit is a good source, magnesium and potassium, are both significantly higher in the Kona raw and baked samples. It is possible that soil mineral content, growing conditions, fruit ripeness, or some other variable influenced some of the differences observed between the two locations. Additional sampling would be necessary to draw conclusions about the significance of the locational differences in nutrient composition, but the present data serve to suggest the potential variability that might be expected.

For comparison, the breadfruit nutrient data from USDA Nutrient Database SR-17⁽¹¹⁶⁾ are presented in Tables 3–5. This standard reference is the most common nutrient database used by nutritionists and in modern nutrient analysis software. Like most sources of nutrient data, this reference does not specify the variety of breadfruit analyzed or the provenance of the samples analyzed. Some earlier sources of nutrient data that specified “Hawaiian” breadfruit (Table 2) were limited in scope, probably relying on older and less precise analytical techniques. It is rarely clear which breadfruit variety was tested; in some cases it may not have been the Hawaiian cultivated variety at all.⁽⁸³⁾

With some minor differences, our nutrient values for raw breadfruit are similar to those published in USDA SR-17⁽¹¹⁶⁾. This can be seen by comparing the means of nutrient content values for the Hilo and Kona raw breadfruit samples with the USDA breadfruit values (Tables 3–5). Using the mean of the nutrient values for the two locations provides the most current nutrient values representative of raw Hawaiian breadfruit as commonly selected for cooking in the firm-ripe state.

Our analysis also included the trace elements manganese and boron, which only recently have been demonstrated to be important in human nutrition. Breadfruit provides a liberal amount of boron relative to the current intake recommendation of about 1 mg/day,⁽⁹⁰⁾ but it is not a good source of manganese given the recommendation for about 2 mg/day.⁽⁵⁵⁾

The slow, low-temperature baking of Hawaiian breadfruit results in substantial loss of vitamin C and thiamin. Vitamin C is reduced by about 30 percent and thiamin by 25 percent. The addition of water in preparing breadfruit *poi* reduces the concentration of nutrients by about half due to simple dilution. Fermentation at ambient temperatures for 36 hours had little effect

Assuming that taro was the preferred Hawaiian staple, breadfruit would have been consumed secondarily on a daily basis and either commonly or periodically in place of taro when the taro supply was limited or breadfruit was abundant.

on the nutrient content of the breadfruit *poi* except for depleting riboflavin.

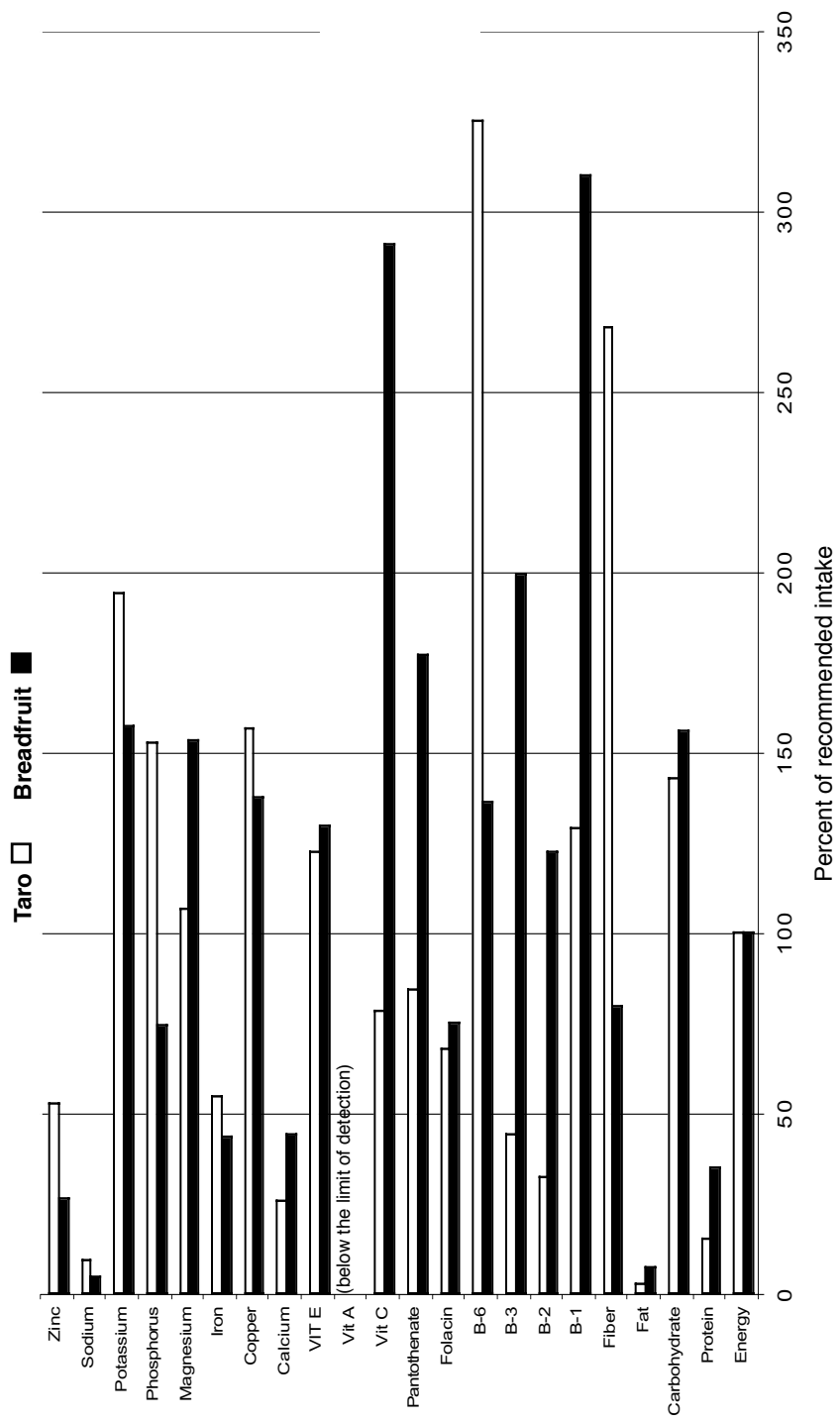
Assuming, as we have, that taro was the preferred Hawaiian staple, breadfruit would have been consumed secondarily on a daily basis and either commonly or periodically in place of taro when the taro supply was limited or breadfruit was abundant. Nutritionally, breadfruit is a very adequate substitute for taro.⁽⁵³⁾ Carbohydrate is the primary source of food energy in both foods, with protein being low and fat very low. Comparison of raw or baked breadfruit with taro in similar states illustrates substantial similarity of the macronutrient composition of these two Hawaiian foods (Table 3). Breadfruit is a fair to good source of dietary fiber. However, taro contains four to five times as much total dietary fiber as breadfruit, and taro also contains a higher proportion of soluble fiber (Table 6). Although nutrition science is only beginning to understand the importance of these two types of dietary fiber, it has been demonstrated that a higher intake of soluble dietary fiber may lower blood cholesterol levels.⁽⁴⁾

One way to evaluate the nutrient contribution of any food is to see what nutrient requirements would be met if a person ate nothing but that food to meet energy needs. Figure 1 illustrates this for a woman eating 2000 calories of baked Hawaiian breadfruit daily (and cooked taro, for comparison). This hypothetical consumption of breadfruit as a staple would contribute significant amounts of several minerals and vitamins to the diet, especially magnesium, potassium, thiamin, niacin, vitamin C, and fair amounts of riboflavin. Other nutrients are present in substantially lower quantities. Most of the B vitamins are higher in breadfruit than in taro, although vitamin B-6 is an exception. Vitamin C is much higher in breadfruit, while mineral levels are nearly equivalent in the two foods. Our analysis detected only trace amounts of vitamin A, while others have reported small amounts.⁽⁴⁰⁾ Our sampling procedures did not include the breadfruit skin, and any significant amount of vitamin A may be located there.

Looking at Figure 1, one might conclude that breadfruit is nutritionally superior to taro. Depending on the nutrients of most concern, this could be considered true if the fruit of breadfruit and the corm of taro alone are compared. However, our comparison does not include the taro leaf, which also was frequently consumed. Taro leaf is a very good source of vitamin



Figure 1. Nutrient density comparisons between breadfruit and taro. (See text for explanation.)



Comparison of breadfruit with taro shows that both staples have their nutritional strengths and weaknesses. One substitutes well for the other, and both contribute important nutrients when they serve as major sources of energy in a total dietary pattern.

A and folacin and a good source of vitamin C. The comparison of breadfruit with taro in Figure 1 shows that both staples have their nutritional strengths and weaknesses. One substitutes well for the other, and both contribute important nutrients when they serve as major sources of energy in a total dietary pattern. For instance, in considering the dietary habits of contemporary Hawaiian and other Polynesian peoples, some researchers⁽¹¹⁾ have concluded that breadfruit is nutritionally superior to the common staples rice and potato. Although the nutritional superiority of breadfruit relative to white rice is supportable, the comparison with brown rice or potato is debatable. As is the case for breadfruit and taro, these other starchy staple foods each have their nutritional strengths and weaknesses, with each filling a similar niche in an overall dietary pattern.

Overall nutritional contribution to Hawaiians

The nutrition data show that breadfruit could easily have served as the major staple in the Hawaiian dietary pattern. Nutritionally, it substitutes well for taro. Nevertheless, it seems that taro was the usual staple in the Hawaiian diet, although it also appears that considerable variation in both taro and breadfruit production and consumption existed within the archipelago; the physical and possibly cultural variables affecting this variation are poorly understood. One could guess that the substantial production of breadfruit in upland Kona was related to a need there for foods higher in protein or fat, perhaps due to the reduced availability of fish at elevations some distance from the sea. Although breadfruit is low in protein and fat, its production in Kona and other upland sites contributed to raising pigs and dogs for consumption and to obtaining fish through exchange with coastal inhabitants, thereby converting the vegetal resource into other needed nutrients. Breadfruit was thus transformed into animals that could be utilized in upland settings to satisfy normal dietary protein and fat requirements. It could also be “banked” there in the form of animals that could be consumed when taro, breadfruit, and other vegetable sources were in short supply.

Seasonality, Reproduction, and Yield

Given the differences noted in the historical record and the variability in assessments both of the agricultural abundance of breadfruit and its dietary importance in Hawai‘i, ranging from limited cultivation and marginal importance in the diet to widely cultivated and substantial in the diet, we investigated features of Hawaiian breadfruit seasonality, reproduction, and yield to see what this information could add to our knowledge of breadfruit’s importance in ancient Hawai‘i.

Seasonality

In comparing the single Hawaiian breadfruit variety to the many cultivars found elsewhere in Polynesia and throughout the South Pacific, many writers have attributed a relatively short fruiting season to the Hawaiian breadfruit: May–June through August.^{(51,}

^{75, 89, 107)} However, much evidence contradicts this claim. For example, despite generally similar conclusions on seasonality, botanist Vaughn MacCaughy also recognized “...some variation... at different elevations and on the different islands,”^(75, p. 42) as did botanist Marie Neal in noting that “a small crop is borne in winter.”^(89, p. 303) Furthermore, University of Hawai‘i nutritionist Carey Miller was able to obtain “...breadfruit from the first of September until the last of December...” with it becoming “difficult to obtain...during January and February.”^(83, p. 5) In contrast, tropical fruit specialist Julia Morton stated, “Breadfruits are most abundant in Hawaiian markets off and on from July to February.”^(86, p. 56)

Similarly, Captain James Cook was able to obtain “plenty of... breadfruit...” on January 19, 1778, upon arrival at Kaua‘i,^(14, p. 1081) and he again obtained “a large quantity of breadfruit...” on December 2 and 3, 1778, from Moloka‘i and Hawai‘i, as he did from windward Hawai‘i on December 21.^(14, p. 1152, 1154) Following his death on February 14, 1779, breadfruit was offered by Hawaiians as a “peace offering” on at least two occasions at Kealakekua Bay, on February 19 and 20,^(14, p. 1214) and it was presented to Cook’s ships for trade between Maui and Lāna‘i on February 24.^(14, p. 1219) Given that the fruits do not keep for more

Breadfruit was transformed into animals that could satisfy normal dietary protein and fat requirements, and it thus could be “banked” and consumed when other vegetable sources were in short supply.

than a few days after being gathered,^(103, p. 207) breadfruit thus appears to have been readily available in most of the archipelago well into the winter months, at least at that time. University of Hawai‘i horticulturist Willis Pope also described a longer fruiting season that is more consistent with the descriptions found in Samwell’s journal, the tree producing for “...about eight months of each year.”^(96, p. 10)

While our study of breadfruit has not investigated seasonality through direct observation, it is likely that differences in availability are attributable at least in part to year-to-year fluctuations in production and to locality-dependant factors, as ethnographers E. S. Craighill and Elizabeth Green Handy concluded when they stated that they “...were told that in Puna in a good year, breadfruit may be eaten for eight months of the year, beginning with May. Elsewhere five months is the usual period, from May to September.”^(46, p. 152)



“...in Puna in a good year, breadfruit may be eaten for eight months of the year, beginning with May.”

Moreover, few of the statements we found on seasonality draw a clear distinction between peak-season and low-season availability, a common phenomenon in many parts of Hawai‘i where breadfruit is grown. Our observations on Hawai‘i indicate that Hawaiian breadfruit is available for more than just the summer months. The fruits harvested for the nutritional analyses we did were taken from trees in East and West Hawai‘i in early December 1991. The three mature trees found at the Amy B. H. Greenwell Ethnobotanical Garden in Captain Cook on Hawai‘i (1500 ft [450 m] elevation) usually fruit copiously for about six months each year (July–August through November–December), but fruits could often be found as well during a second, smaller fruiting period in the winter.

We should also recognize that the Hawaiian chiefs on the larger islands would have been able to draw upon breadfruit trees growing over a range of elevations from sea level to perhaps 2000–2600 ft (600–800 m), with fruits from trees at the higher sites ripening later. If we consider the elevation-related differences in flowering and maturation and peak- and low-season production, an 8-month to even 10-month period of breadfruit availability might easily be possible, and especially so for the political and ceremonial needs that could not in all likelihood have been met if fruits were drawn from a single locality. The situation in Tahiti was comparable.^(36, p. 188; 50, p. 40)

Reproduction and longevity

As elsewhere in Polynesia,^(44, 101) in Hawai‘i breadfruit trees are propagated from root cuttings or root shoots,⁽⁴⁶⁾ sometimes after “wounding” surface roots to stimulate shoot production. According to Handy, breadfruit is referred to in Hawaiian as ‘*ai kāmeha‘i*, or “food (*ai*) that reproduces itself ‘by the will of the gods,’ that is, by sprouting.”^(44, p. 187)

Referring collectively to the many breadfruit varieties grown throughout southeastern Polynesia and Micronesia, French ethnobotanist Jacques Barrau noted that transplanted root cuttings will reach fruit-bearing age in about five or six years.^(11, p. 120) Although the trees are capable of several hundred years longevity,⁽¹⁰¹⁾ it is more often stated that they remain at peak fruiting capacity for between 35 and 60 years under good conditions.^(2, 94, 96)

Yield

Highly variable statements have been made about breadfruit yields in Hawai‘i. On the one hand, Stewart “found yields [to be] very partial...at any season” during 1823–25,^(83, p. 4) much as the Russian Shemelin had found in 1804. On the other hand, Captain Cook, having observed breadfruit production elsewhere in Polynesia, was impressed by breadfruit productivity in Hawai‘i, for “when he visited Kauai [he] noticed that breadfruit thrives here, not in such abundance, but produces double the quantity of fruit they do on the plains of Otaheite.”^(46, p. 153) David Samwell similarly noted that Hawai‘i, Maui, and Kaua‘i produced “the breadfruit in great plenty,” and he was told that O‘ahu also “produces plenty of breadfruit.”^(14, p. 1221)

To assist resolution of the yield issue, we have attempted to estimate breadfruit yields in ancient Hawai‘i. While we could not determine the exact extent of area planted to breadfruit, the density and uniformity of the plantings, nor the average yearly production per tree at some representative point in Hawaiian history, the preliminary calculations that we present below suggest that breadfruit production in traditional Hawai‘i must have been very sizable indeed.

Although there are many ethnohistorical records of traditional Hawaiian land management and resource use prior to 1850, at a time when Hawaiian agriculture was still flourishing,⁽⁷⁶⁾ most lack the detail needed to make explicit calculations. However, two eyewitness accounts from this period have been critical to our



Breadfruit is referred to in Hawaiian as ‘ai kāmeha‘i, or “food (ai) that reproduces itself ‘by the will of the gods,’ that is, by sprouting.”

estimates. In the first, Archibald Menzies, surgeon-naturalist during Captain Vancouver’s visit to Kealakekua Bay in 1794, describes breadfruit trees growing in the Kona Field System behind the bay:

“We commenced our march with a slow pace...for about three miles, when we entered the bread fruit plantations whose spreading trees with beautiful foliage were scattered about that distance from the shore along the side of the mountain as far as we could see on both sides.” (82, p. 74)

Some 50 years later, during the 1840–41 visit of the United States Exploring Expedition, Charles Wilkes described the same groves:

“Two miles back from the coast...in a belt a half a mile wide, the breadfruit is met with in abundance, and above this the taro is cultivated with success.” (123, p. 95)

These two accounts have permitted us to estimate the size and the yield of the breadfruit zone within the Kona Field System and, by extrapolation, to generate a rough estimate of breadfruit production in traditional Hawai‘i. But first, for context, we summarize what is known about the configuration of the Kona Field System.

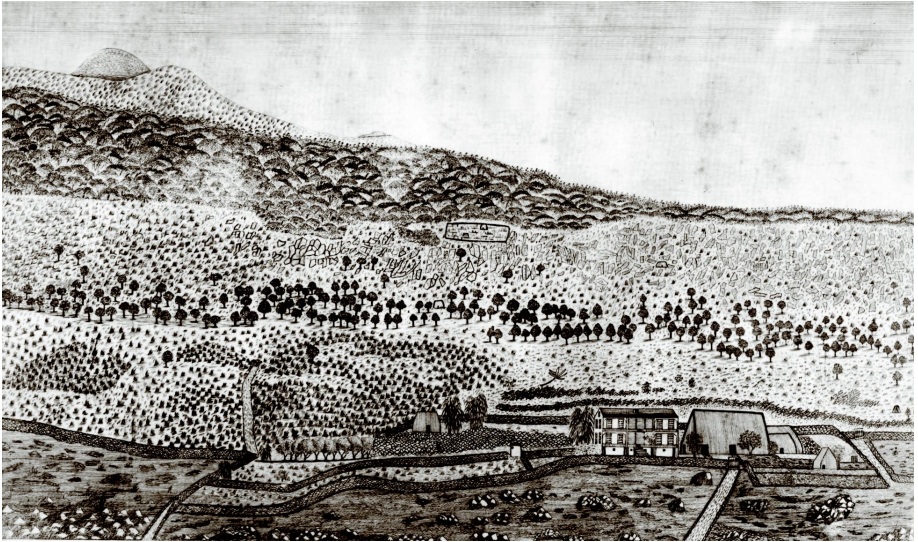
The core of the Kona Field System extended makai to mauka for perhaps five miles behind Kealakekua Bay.

The core of the Kona Field System extended *makai* (from the sea) to *mauka* (toward the mountain) for perhaps 5 miles behind Kealakekua Bay, between Honaunau to the south and what is now Kailua-Kona to the north, a distance of about 18 miles. While Ross Cordy^(25, p. 258) claims that by the end of the 18th century the system “extended from above Keāhole Point south to the border with Ka‘ū district,” a distance of approximately 43 miles, we are unsure of breadfruit planting densities at these northern and southern extremities, and we use the more widely accepted 18 mile extension to calculate our breadfruit yields. For our purposes, the system was thus approximately 3 miles (4.8 km) wide by 18 miles (29 km) long,⁽⁶⁵⁾ totaling about 34,500 acres or 140 km². Viewing it from *makai* to *mauka* (that is, looking uphill), it was composed of a *kula* or “coastal plain” zone, a *kalu-‘ulu* or breadfruit zone, an *‘āpa‘a* zone, and an *‘ama‘u* or tree fern

(*Sadleria*) zone. The *kula* zone, mostly dry and rocky, consisted of scattered plantings of sweetpotato and paper mulberry, the *kalu-‘ulu* was dominated by breadfruit trees and complimented with understory plantings, the *‘āpa‘a* zone was densely planted to dryland taro, sweetpotato, and sugarcane, and the *‘ama‘u* zone was planted intermittently to banana and other crops. Based on these descriptions and more recent statements,⁽³⁾ it is evident that the breadfruit belt occupied only a part of the Kona Field System.

Consider now Menzies’ statement that breadfruit plantations within the Kona Field System “were scattered...along the side of the mountain as far as we could see on both sides,”^(82, p. 74) and Wilkes’ claim that breadfruit formed “a belt half a mile wide” above Kealakekua Bay.^(123, p. 95) If we accept that Menzies’ observation was made from approximately a midpoint in the Kona Field System’s north–south extension in 1794, we can estimate the size of the *kalu-‘ulu* to be about ½ mile (0.8 km) wide by 18 miles (29 km) long, totaling about 5750 acres (23 km²), or about one-sixth of the area of the whole system. We can now link this estimate of the size of the Kona Field System’s *kalu-‘ulu* zone with information on numbers of trees planted per surface area, on fruit yield per tree, and on fruit weight.

We begin with Pope’s statement that “...a conservative estimate. . . indicates that an acre will yield about 12 tons of fruit [per year in Hawai‘i]...” and that trees were typically spaced about 40 feet (12.2 m) apart, resulting in a plantation of about 25 trees per acre.^(96, p. 10; 49, p. 68) Using Pope’s acreage yield estimates, the *kalu-‘ulu* zone of the Kona Field System would have produced approximately 69,000 tons of breadfruit per year. However, if we focus rather on Pope’s planting density figure per acre of 25 trees and multiply this number by conservative estimates of single-tree yields made by Barrau and others (see p. 3) of between 50 and 150 (average 100) fruits per mature tree per year, and then by fruit weight variously estimated at between 1 and 10 pounds (average 5 lb/fruit), we conclude that the Kona Field System’s breadfruit zone may have been planted to around 144,000 trees, producing about 6.25 tons per acre or around 36,000 tons of fruit per year. We could also use Ragone’s lower estimate of between 1 and 5 pounds per fruit (average 2.5 lb/fruit), or our 1991 figure of 3.2 lb average fruit weight, to conclude that about 18,000 or 23,000 tons respectively would have been produced each year in the breadfruit zone of the Kona Field System.



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We conclude that the Kona Field System's breadfruit zone may have been planted to around 144,000 trees, producing about 6.25 tons per acre or around 36,000 tons of fruit per year.

Even though other breadfruit groves existed in Hawai'i, such as in Puna and Hilo on Hawai'i and Lahaina on Maui, and perhaps also to some extent in the other West Hawai'i field systems of Kohala and Lālānilo-Waimea, and individual holdings were numerous and widely scattered throughout the archipelago (see the Appendix, pp. 57–60), we did not attempt to calculate the extent of these combined sites, as their dimensions are largely unknown. Nevertheless, in order to establish a rough estimate for archipelago-wide breadfruit production, it seemed right to multiply our estimate of the *kalu-'ulu* annual breadfruit yield by some factor commensurate with the combined production of breadfruit trees located in the other plantations, in the *'āpa'a* zone of the Kona Field System and presumably at its northern and southern extremities as described by Cordy, and in the many individual holdings throughout the archipelago. For example, if we multiply the 36,000 ton mid-range estimate of annual *kalu-'ulu* breadfruit yield by 2, we achieve a conservative archipelago-wide production estimate of 72,000 tons; if we multiply by 3, we reach 108,000 tons. Whichever may be more accurate, we felt it was fair to conclude that breadfruit production in Hawai'i in a “normal” year in the late 18th century may well have reached between 50,000 and 100,000 tons, of which more than 83 percent would have been usable as food.^(96, p. 17)

Some people may feel that our planting density and uniformity and weight assumptions for the breadfruit zone of the Kona Field System are unrealistic, and there is evidence to support this.⁽³⁾ Given that any number of topographic or phenologic impediments to planting breadfruit uniformly within the *kalu-‘ulu* zone would mean fewer trees per acre than the figure of 25 that we used, we might assume accordingly that yields would have been lower than our optimal figures indicate, whichever average fruit weight was employed in our calculations. Issues such as drought, volcanic activity, and other natural phenomena that would periodically reduce yield have also been raised,⁽³⁾ as has the issue of warfare in West Hawai‘i, where breadfruit trees would have been periodically damaged or destroyed,^(76, p. 25) a situation that is better known and documented in Central Polynesia.

All of these factors—fruit weight, seasonal fluctuations, warfare, and climatic and edaphic differences among and within islands—would need to be assessed more thoroughly in order to achieve a comprehensive assessment of breadfruit yield in ancient Hawai‘i. Nevertheless, and despite the likelihood of geographic and other irregularities that could lead to fluctuations in planting density and annual yield, whichever of our estimates of *kalu-‘ulu* plantation extent, planting density, or fruit weight we choose to link with Langsdorff’s statement based on Marquesan breadfruit consumption that “...one or two...trees are sufficient to support a man the whole year round,”^(46, p. 187) which equates to 12.5–25 people per acre planted to breadfruit, or with Sturtevant’s assessment that 1 acre (planted to 27 trees) is “sufficient for the support of from ten to twelve people during the eight months of fruit-bearing,”^(49, p. 68) our analysis still shows that total breadfruit yields were massive in ancient Hawai‘i, possibly capable of feeding from 75,000 to several hundred thousand people annually. This conclusion is consistent with other evidence that points to the ready availability of breadfruit for food, gift, and trade in early post-Cook Hawai‘i during all but a few months of the year, and to the production of surpluses that permitted breadfruit to be used regularly as animal fodder.

Observers of Hawaiian demography believe that the prehistoric population of Hawai‘i was either peaking or slightly declining in the late 1700s,^(70, 109, 112) at about the time that Euro-American visitors were first viewing breadfruit and the other



Our analysis shows that total breadfruit yields were massive in ancient Hawai‘i.

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Hawaiian crops. It is thus not surprising that “at the time of the coming of the first European explorers the breadfruit was plentiful around the native settlements and villages on all the islands; more plentiful than it had been at any subsequent period.”^(75, p. 37) On a related issue, we found no evidence to contradict the statement by Handy and Handy that “...Hawai‘i probably produced most, Kaua‘i came second, Maui third, and O‘ahu fourth.”^(46, p. 448) According to Kirch, the events and processes leading to this flourishing situation can be dated to around 1200 A.D., when “...rapid development of large, densely settled populations...and the expansion and intensification of both irrigation and dryland field systems. . .”^(70, p. 233) have been recognized in the archaeological record. Our summaries of breadfruit tree sites, uses, densities, and productivity strongly suggest that breadfruit played a major part in this evolution, contrary to the recent conclusions of some scholars.^(3, p. 147; 25, p. 37)

Conclusions

After reviewing the biological aspects and the agro-ecological features of breadfruit arboriculture in traditional Hawai‘i, we described breadfruit’s position in Hawaiian mythology and material culture, demonstrating that breadfruit was substantially implicated in a wide range of Hawaiian oral traditions and everyday activities. Its large-scale cultivation in groves had significant political overtones. We also provided suggestive evidence that the shade provided by breadfruit trees, the fish and other animal products obtained through exchange with its fruits, and the fodder provided by its fruits in animal husbandry and in pisciculture were three significant aspects of traditional Hawaiian political economy that have been largely overlooked in assessments of breadfruit’s importance in Hawai‘i. Breadfruit was also a commonly consumed food item, and we showed that its food value matched or exceeded that of taro within a comprehensive Hawaiian dietary pattern.

Our estimates of breadfruit yields point to the likelihood that breadfruit was grown on a massive scale in Hawai‘i during the traditional period for food, being capable alone of sustaining between 75,000 to several hundred thousand people annually.

Nevertheless, its human alimentary contribution by island or district appears to have varied substantially and to have been both direct and indirect, in part due to poorly understood physical and possibly cultural variables. It is worth noting that breadfruit plantations were unevenly distributed throughout the archipelago (Appendix tables), as were Hawaiian populations,⁽²⁶⁾ but the relationship between concentrations of breadfruit arboriculture and human population densities remains unstudied. It would be a useful exercise to establish the correspondence between these two variables while also taking into account other aspects of traditional Hawaiian economy, such as important locations of wetland and dryland taro cultivation and pisciculture.

We also saw that breadfruit plantation density and extent varied between windward and leeward settings, at least on the larger islands, and that plantation locations on all the main islands appeared to be near major villages and village clusters. Hilo, Kona, and Puna on Hawai‘i, Wailua on Kaua‘i, Lahaina on Maui, and Waimānalo on O‘ahu were heavily populated in the late pre-Cook period, at the time that intensive breadfruit arboriculture was practiced nearby. It is an unlikely coincidence that the largest of the Hawaiian field systems, the Kona Field System, was located in the district described by William Ellis in 1822 “as the most populous of the six great divisions of Hawaii [island].”^(33, p. 186) Presumably, the groves observed by early Euro-American visitors had been originally planted to provision the people who had settled in these areas, along with their domesticated animals. It was possibly between 1600 and 1800 A.D., the period when the most intensive development of the field systems occurred, that both human populations and breadfruit plantations within these areas began to develop substantially through mutually interacting pressures: human numbers in response to the growing availability of breadfruit and other resources, and breadfruit groves in response to the increasing need for more food and fodder, both occurring through a process mediated by competition among chiefs.

All the evidence we reviewed, whether for our ethnobotanical treatment or for our nutritional and yield analyses, underscores the inaccuracy of consigning breadfruit to a minor role in traditional Hawaiian human ecology. This beautiful, productive tree has an ongoing role to play in the Hawaiian lifestyle, and we hope our work contributes to an expansion of its presence in Hawaiian landscapes.



All the evidence we reviewed, whether for our ethnobotanical treatment or for our nutritional and yield analyses, underscores the inaccuracy of consigning breadfruit to a minor role in traditional Hawaiian human ecology.

Acknowledgments

Kealakekua Ranch Ltd. generously provided grants to the Amy B.H. Greenwell Ethnobotanical Garden, Bishop Museum, to undertake the research for and drafting of this study, and to the College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa, to assist in its publication.

The drawing on page 45, by Persis Thurston, was provided by the Hawaiian Mission Children's Society Library. The 'ulu quilt pattern image reproduced on page 1 and elsewhere was provided by the Kona Historical Society. Dietrich Varez kindly allowed us to use his block-cut images, reproduced on pages 12, 27, and elsewhere.

Many other institutions and people provided valuable support. We would like to thank the Bishop Museum Library; the UH Center, West Hawai'i Library; and the Kona Historical Society for helping us obtain bibliographic references and difficult-to-find documents. We would also like to thank Pat Bacon, Jean Greenwell, Terry Hunt, Kana'e Keawe, Alexandre Meilleur, Peter Van Dyke, and especially late Sherwood Greenwell for collaboration and support.

Appendix

Historical Citations of Breadfruit Occurrence on the Main Islands of the Hawaiian Archipelago

Details on the tables are given on pp. 5–6

Table 1. Hawai‘i.

Scattered sites

Coconut Island, Hilo, “the breadfruit...trees,” in 1843 (23)
Hāmākua Coast, “in sheltered valleys,” no date (46, p. 153)
“[trees]...in upper Huehue,” no date (61, p. 186)
Ka‘awaloa, “a few struggling trees,” in 1804 (10, p. 39)
Kapoho, “border of the lake,” in 1823 (46, p. 541)
Kohala, “to a less extent in gulches,” no date (44, p. 190)
Lapakahi, “breadfruit in sheltered spots,” from 1400 (18, p. 107)
Pā‘ūla, “breadfruit trees,” prehistoric (46, p. 604)
Waimanu Valley, “houses under trees,” in 1873 (46, p. 536)

Plantations

Hāmākua, “groves of useful trees,” in early 1800s (28, p. 24)
Hilo, “large numbers,” no date (51, p. 408)
Hilo, “adorned with clumps of...breadfruit trees...orchards of breadfruit,”
in 1825 (5, p. 96, 165)
South Hilo/Waiākea, “groves in every direction,” in 1825 (46, p. 539)
Hōnaunau, “considerable groves,” in 1823 (33, p. 163–64)
Ka‘awaloa mauka, “plantations between lava walls,” in 1779 (14, p.
1166)
Kealakekua, “innumerable plantations,” in 1783 (46, p. 525)
Kona, “two miles back from the coast...breadfruit in abundance,” in
1840 (123, p. 95)
Kona, “extensively planted,” in early 1800s (46, p. 284)
Kona, “breadfruit plantations,” in 1793 and 1794 (82, p. 74–76)
Kona, “large numbers,” no date (51, p. 408)
Kona Field System, “breadfruit forest,” in late 1700s (109, p. 3–10)
Kona Field System, “permanent zone,” in early 1800s (69, p. 189)
South Kona, “intensive cultivation,” prehistoric (46, p. 525)
Nāpō‘opo‘o mauka, “plantations,” in 1779 (10, p. 137)
Puna, “extensively planted,” in early 1800s (47, p. 284)
Puna, “the district most famous for its breadfruit,” no date (44, p. 190)
Waipi‘o Valley, “fertile region,” in 1873 (19, p. 91)

Legendary sites

- Hilo, “the breadfruit of Piihonua” (37, p. 278)
South Hilo/Waiākea, “a...tree laden with fruit” (99, p. 219-220)
North Kona, “breadfruit from the uplands of Hu‘ehu‘e” (99, p. 52–53)
Puna, “lowlands of Ko‘oko‘olau,” and “the low hanging breadfruit trees of Kalapana...the breadfruit trees of Malama” (37, p. 248, 256)
Uluka‘a, “a mythical land...with breadfruit” (105, p. 19–31)
Waipi‘o Valley, “a breadfruit grove...beside the falls of Hi‘ilawe” (17, p. 36)

Table 2. Kaua‘i and Ni‘ihau.

Kaua‘i

Scattered sites

- Ha‘ikū ahupua‘a, “old trees [in] kuleana,” prehistoric (46, p. 427)
Moloa‘a, “a few old trees,” in 1935 (46, p. 422)
Nāwiliwili River, “a few old trees,” in 1935 (44, p. 67)
Pā‘ā ahupua‘a, “planted in the gulches,” prehistoric (46, p. 427)
Waimea Village, “few trees,” in 1778 (46, p. 409)

Plantations

- Anahola, “many breadfruit trees...according to Keahi Luahine,” prehistoric (44, p. 189)
Kapa‘a/Wailua, “cultivated in quantity,” prehistoric (46, p. 269)
Upper Wailua, “extensively planted,” prehistoric (46, p. 284)
Wailua River, “abundance of trees,” prehistoric (46, p. 425)
Waimea to Wailua, “extensive plantings noted...by early voyagers” (44, p. 189)
Waipake Stream, “a number of old...trees,” in 1935 (46, p. 422)

Ni‘ihau

Scattered sites

- Ni‘ihau, “in large cracks and cavities...moist sinkholes” no date (121, p. 24, 80)

Table 3. Maui, Lānaʻi, and Molokaʻi.

Maui

Scattered sites

Lahaina, “cottage smoke among the branches,” in 1823 (33, p. 76–77)

South Lahaina, “grew in valleys,” prehistoric (46, p. 492)

East Maui, “old breadfruit trees,” no date (Hāmākua, Koʻolau, Honomanū, Wailua nui, Nahiku, Hāna, Wailua, Kīpahulu, Kukuiʻula... 46, p. 153)

Plantations

Central Valley, “much breadfruit,” prehistoric (Olowalu, Waikapū, Wailuku, Waiheʻe, Waiehu...46, p. 153)

Kekaʻa, “a famous grove,” prehistoric (46, p. 491)

Lahaina, “groups of trees...down close to the sea,” in 1825 (5, p. 103)

Lahaina, “the trees of Kauheana,” prehistoric (46, p. 494)

Lahaina, [contained] “fine trees forty years ago as any I have seen in Samoa or Fiji,” around 1840s, (44, p. 190)

Near Lahaina, “double rows of breadfruit,” in 1819 (46, p. 493)

Lele (Lahaina), “the breadfruit grove of Lele, from one end to the other of Lahaina,” 1812 (54, p. 106, 109)

S. shores of W. Maui, “second only to Puna,” no date (44, p. 190)

Legendary sites

Lahaina, “southwest of Lahaina Fort...the breadfruit trees of Kauheana,” (37, p. 542)

Lānaʻi

Plantations

East coast opposite Maui, “breadfruit groves,” late 1800s (34, p. 48)

Lānaʻi, “much breadfruit...planted,” no date (44, p. 190)

Molokaʻi

“No trees seen” in 1779 by Samwell (14, p. 1220)

Scattered sites

Southeast end, “tree was cultivated,” no date (46, p. 153)

Plantations

Hālawa Valley, “grove on south side of valley,” 1990s (39)

Table 4. O‘ahu.

Scattered sites

- Anahulu Valley, “associated with habitation,” prehistoric (68, p. 7)
Honolulu, “breadfruit...seen among the cultivated grounds,” in 1825
(5, p. 122)
Kōloa Stream, “trees at...old homesites,” in 1953 (46, p. 461)
Kualoa, “the first trees to Hawai‘i,” prehistoric (89, p. 302–304)
Moanalua River, “bank of a salt lake,” in 1815 (46, p. 474)
Pearl River, “houses shaded by foliage,” in 1831 (100, p. 63)
Waimea Valley, “house sites,” late 1800s (46, p. 464)

Plantations

- Coast of Wai‘anae Mountains, no date (44, p. 190)
Kahana Valley, “trees in the valley,” prehistoric (46, p. 445)
Southerly side, “breadfruit was planted,” no date (Wailupe, Waikīkī,
Kalihi, ‘Ewa...46, p. 153)
Waimānalo District, “was filled with trees,” in 1847 (46, p. 459)
Windward coast inland, “in sheltered places,” no date (Waialua, Waimea,
Kahuku, Lā‘ie, Punalu‘u, Kahana, Kāne‘ohe, Kailua, Waimānalo...
(46, p. 153)

Legendary sites

- Moanalua Gardens, “a breadfruit tree from which the ghosts of the dead
leaped into the underworld” (89, p. 303).

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