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Breadfruit Fermentation in Micronesia¹

JENNIFER ATCHLEY² AND PAUL ALAN COX³

*Throughout Oceania, pit fermentation of starchy crops was used as means of ensuring a predictable food supply despite the vagaries of drought, cyclonic storms, and warfare. During a 6-mo period, fermentation techniques for breadfruit (*Artocarpus altilis*) were studied in Micronesia in the islands comprising Majuro, Guam, Belau, Yap, and Ponape. Fermentation techniques were found to vary throughout Micronesia but as a whole to differ significantly from techniques used in Polynesia. We believe the benefits of such food preservation technologies to be significant in facilitating colonization of temporally marginal island environments.*

Breadfruit *Artocarpus altilis* (Parkinson) Fosb. is probably native to Polynesia where it is of ancient cultivation (Purseglove, 1968), although Linton (1926) considered it to be introduced to the Pacific islands by prehistoric settlers from Malaysia. Breadfruit may, however, be of hybrid origin with *Artocarpus mariannensis* Trec., a Micronesian endemic, as a putative ancestor (Coenan and Barrau, 1961). *Artocarpus altilis* has been collected on most of the inhabited islands of Micronesia; *Artocarpus mariannensis* has been collected from Alamagan, Guam, Palau, Sonsorol, Ulithi, Eauripik, Woleai, Faraulap, Ifalik, Lamotrek, Satawal, Truk, Nama, Kapingamarangi, Eniwetok, Rongelap, Utirik, Ujae, Lae, Ailuk, Likiep, Arno, Jaluit, Ebon, and Tarawa (Fosberg et al., 1979). The hybrid *Artocarpus altilis* × *mariannensis* has been collected in Guam, Palau, Sonsorol, Woleai, Truk, Satawan, Eniwetok, Bikini, Jemo, Wotho, Arno, and Tarawa (Fosberg et al., 1979). The related jackfruit cultivar, *Artocarpus heterophyllus* Lam., has been reported from Guam, Palau, Yap, Ponape, Nauru, and Tabiteuea.

In both prehistoric and modern times breadfruit has served as a major starch staple throughout Micronesia, despite its periodic unavailability due to its distinctive fruiting phenology. The fruit is generally produced between May and August, with a lesser season in January (Massal and Barrau, 1954). Over 30 cultivars that vary in phenology are known in Micronesia. Thus in Ponape, ripe fruit can be obtained throughout the year. In islands and atolls without such a variety of cultivars, the period of availability of breadfruit as a staple food can be extended by pit fermentation. These fermentation techniques were once widespread throughout Oceania (Barrau, 1961; Cox, 1980, 1981; Murai et al., 1958; O'Connell, 1972; Soucie, 1971; Yen, 1973) and were an important cultural adaptation to the constant threat of drought, cyclonic storms, and warfare everpresent in Oceania, particularly in the western Pacific (Cox, 1981; Freeman 1951).

The present study was designed to compare methods of breadfruit fermentation in practice within Micronesia to each other and to methods extant in Polynesia. It is anticipated that a similar survey of Melanesian technologies will be completed at a later date. During a 6-mo period in 1983–1984, interviews and observations of fermentation techniques were conducted in Majuro, Ponape, Belau, Yap, and

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Guam. In addition, the results of a 1982 survey of megalithic structures in Ponape for evidence of prehistoric fermentation pits are also here reported.

MAJURO

Early recordings of breadfruit fermentation in Majuro by sailors and missionaries provide rough sketches of production techniques then extant. For example, missionary Louisa Maritta Bailey Whitney in 1871 settled on Ebon, the southernmost island of the Ralik chain of the Marshall Islands. She grew quite fond of breadfruit and *kwonjin*, or fresh unpeeled breadfruit roasted on the coals. Of it she wrote in her journal:

The time of rest for the breadfruit trees has come, and we are told that from this until Jan. we must expect to be without Kwonjin. This is the time when the natives resort to "biro" or buried breadfruit. I like the taste of it well enough but always wonder whose hands have been in it. (Whitney, 1871, p. 20)

The method of preparation appears to remain unchanged. Ripe seedless breadfruit is harvested using forked sticks to snap the peduncle, causing the fruit to fall. Men and women then scrape the skins off the ripe breadfruit with sharpened cowrie shells. An example of such a scraper is in the Alele Museum in Majuro. The fibrous core is removed and discarded before the fruit is cut into small pieces and put into a burlap bag. In ancient times coconut-leaf baskets were used for this purpose. The bag is then tied with twine braided from fibers from the coconut mesocarp and submerged in seawater in the lagoon for 2 h. During this period the bags are beaten with sticks or trodden upon to soften the breadfruit sections. After the breadfruit reaches the desired soft consistency, the bag is removed from the lagoon and brought to shore, where it is beaten with sticks to remove excess water. The bags are placed on banana leaves and allowed to drain for several days. Possibly some fermentation occurs during this stage, as the breadfruit becomes considerably softer. The product is stored in wooden boxes, which are lined with fresh banana leaves, or when available, plastic. The box is relined with fresh leaves once a week. After fermentation for a month in the wooden box, the fermented breadfruit or *bwiru* is ready to eat.

In this condition, the *bwiru* can be stored indefinitely as long as the leaves lining the box are changed. The surety of preservation of *bwiru* was recognized by early missionaries as a method that they could adapt for their own cultural needs: previously prepared *bwiru* could be substituted for fresh breadfruit on the Sabbath. Laura Whitney wrote:

I have adopted Mrs. Snow's [an older missionary from Ebon] plan of preparing for the Sabbath and I like it because it gives us a whole Sabbath instead of a day divided between cooking and going to meeting. It is this, to cook enough *kwonjin* and whatever else we need and have no fire made on the Sabbath. (Whitney, 1871, p. 16)

The custom of using *bwiru* as a sabbath food, apparently instigated by the early Christian missionaries, persists to this day. Our informant Annako, originally from Ebon but now resident on Majuro, usually prepares *bwiru* on Saturday afternoon for consumption on Sunday. Frequently her relatives on Ebon prepare *bwiru*, and send it to Annako after wrapping it in plastic bags and coconut frond baskets. Each basket weighs approximately 15 kg. These bags are stored in a

wooden box near her house (Fig. 1a). Infrequently the contents of the box are sorted, maggots removed, and the remaining bwiru repackaged in a new plastic bag (Fig. 1b). The bwiru photographed was approximately 1 mo old, and had a pungent smell similar to strong cheese or saurkraut. At this stage the bwiru is yellowish in color and has a dough-like texture. The stored bwiru is prepared for consumption by rinsing it inside a cloth sack (Fig. 1c). The sack is repeatedly wrung out (Fig. 1d) and re-rinsed until the yellowish color in the fluid coming from the sack disappears. Rinsing apparently is not necessary as Annako remarked with some disgust that the inhabitants of the neighboring Arno atoll do not rinse their bwiru. Once cleaned and rinsed, the bwiru is then kneaded (Fig. 1e). A special board made from the wood of a tree species, uncollected by us but called *chebbi* by the natives, was used in the past, but now any clean board is used. Small balls, about 20 cm in diameter are kneaded for approximately 15 min. During the kneading, a curry-colored substance called *bwil* causes a sticky build-up on the heel of the hand and is removed periodically with a knife.

After kneading, small doughballs approximately 8 cm in diameter are boiled in an infusion of coconut milk (extracted from grated coconut) in water for approximately 2 h. After cooking, the bwiru tastes bland and starchy in contrast to its strong odor.

A nearly identical method of preparation and use is found among the inhabitants of Wotho and Mejit, which are nearly 300 km distant from Majuro (Doug Green, pers. comm.). In Wotho, 50-gal oil drums are used to store the bwiru instead of wooden boxes. However, on both islands green leaves are used to line the barrels or boxes. After removal from the boxes, the bwiru has coconut milk added to it. The dough is then wrapped in leaves and cooked in earthen ovens, in a manner similar to the preparation of *masi* in Samoa (Cox, 1980, 1981).

YAP

Throughout the islands of Yap, fermented breadfruit or *mar* as it is called in the Woleain language, is a staple. Processing methods and usage of *mar* in remote islands such as Asor, Woleai, and Ifalik remain relatively unchanged from ancient times since these islands have not yet been significantly affected by Western culture.

A. Asor

On this small island in the Ulithi atoll, *mar* is made by every family. We estimate the current population to number between 50 and 75 people. *Mar* pits are maintained behind the homes of two of our informants, Sarah Tathog Iaylor, and her mother, Maria Resog. Both of their *mar* pits are supplied with breadfruit from trees owned by Maria at the edge of the village. Maria's *mar* pit was dug by her brother and is approximately 1.3 m in diameter and 1 m deep. The pit is lined with fallen, dried breadfruit leaves. The leaves are arranged in 3 layers with the laminae overlapping (Fig. 2a).

At the end of the breadfruit season (August), 700 breadfruit or *mai* were picked by Sarah and her aunt. The ripe fruit are peeled with knives, and the fibrous core is removed and discarded. The breadfruit are cut into cubic sections about of 2 cm on a side. These chunks are placed into tightly woven, coconut-leaf baskets



Fig. 1. a. *Bwiru* box in Majuro. b. Removal of *bwiru* from box. c. Rinsing *bwiru* in water. d. Wringing excess water from *bwiru*. e. Kneading *bwiru* on board.

and laced up with cord. The baskets are taken to the lagoon and tied to coral heads to soak overnight. The following day the substance is taken out of the baskets and placed on banana leaves. Banana leaves are then placed on top of the pile, which is left to drain and ferment for 4 days.

At this point, the substance, called mar is ready to eat and is said by Sarah to resemble in all respects preserved mar from pits. Pit preservation of mar is performed by placing it in a pit lined with breadfruit leaves. Breadfruit leaves are placed on top of the mar. Coconut-leaf thatching is then placed on top of the pit, and a further addition of corrugated aluminum siding is placed on top of the thatching (Fig. 2b), which is weighted down with limestone boulders.

The leaf lining of the pit is changed by uncovering the pit and removing the mar (Fig. 2d). When Maria's pit was uncovered, the top layers of breadfruit leaves were infested with insects. A small amount of rotted mar, which occasionally occurs near the pit covering, was removed and discarded. The color of the mar was yellowish and the texture very much like *bwiru* in Majuro—moist, crumbly, and dough-like. A mild but distinctly fermented smell was detected, and the mar, when first uncovered, was warm to the touch. The mar was removed and placed on banana leaves while the breadfruit leaves lining the pit were changed. After changing the lining the mar was repacked back inside of the pit and the pit resealed.

In the Ulithi atoll, a portion of mar must be first given to the island chief before any individual or family eats its mar. This offering is cooked after mixing it with coconut and sugar by frying, baking, or boiling. The finished product is taken to the men's house where men of the community eat it with the chief. After this, the mar may be eaten by the families as they wish.



Fig. 2. a. Method of overlapping breadfruit leaf laminae for pit linings on Ulithi atoll. b. Aluminum and rock covering of *mar* pit. c. A *mar* pit. d. Removal of the top layer of *mar* pit. e. Preserved *mar* from pit. f. Replacement of leaf lining in *mar* pit.

B. Woleai

On the Woleai atoll, the *mar* pit of our informant Justinamai Thugo was investigated. It is 3.1 m in diameter and is located in front of her house. It is somewhat in a state of disrepair, with debris being mixed in with the top level of leaves and thatching. Her *mar* was made from ripe unseeded breadfruit, after first peeling them and sectioning them with a knife. The breadfruit sections were placed in large metal pots and covered with leaves to keep out rats and flies. The breadfruit was allowed to ferment in the pots for 2 wk and placed into a pit lined with banana leaves after first covering the leaves with a sheet of plastic. The *mar* was covered with more banana leaves and coconut leaf thatching.

C. *Ifalik*

To the east of Woleai atoll lies Ifalik. The high chief Pakalamar described their process of breadfruit fermentation, which is very similar to the Ulithan method. He first climbs a breadfruit (*mai*) tree and tosses down some ripe breadfruit. Pakalamar explained that this is a man's job because women throughout the Yap outer islands wear only a cloth *lavalava* wrapped around their waists. If a man were to see her inner thighs, a taboo area, the woman would be brought to shame.

Pakalamar's wife then peels the breadfruit. Both seeded and unseeded varieties are used, so she carefully removes any seeds she finds; these are saved and later eaten after frying. The breadfruit are chopped into small pieces that are placed into burlap bags. The bags are taken to the ocean where they are tied to coral heads with coconut husk cord and left overnight. On the following day, the mar is taken out of the bags and placed in coconut-leaf baskets. The baskets are covered with banana leaves and left to drain and ferment for 5 days.

Pakalamar's fermentation pit, about 1 m in diameter and 1 m deep, is lined with fresh banana leaves and dried breadfruit leaves. This pit has been reused for several years. After the mar has been placed in the pit, dried breadfruit leaves and fresh banana leaves are placed on top. Coconut-leaf thatching is placed as the uppermost layer.

Pakalamar filled his pit during the height of the breadfruit season in August. It was opened in October after there was no more fresh breadfruit available. By December his mar pit was empty. However, a neighbor's mar pit was still full, and so was used to provide mar for the Christmas feast. The mar was prepared by first mixing it with sugar and grated coconut, called *showl*. As this mixture was heated over a fire, its consistency became much thinner. This batter-like substance was poured onto taro leaves, which were folded and tied with the pinnae from coconut leaves. The packets were baked for 3–4 h in an *um* or stone oven. After baking the mar was orange in color and resembled a pudding in consistency. It had a sweet, pleasant taste.

Our informants reported a form of breadfruit preservation called *kajaring*, which is no longer practiced in Ifalik. Breadfruits were wrapped with dried breadfruit leaves and allowed to ferment for several weeks while still hanging on the tree. Pakalamar reported the taste of mar to be made in this fashion to be much more powerful than the taste of regular mar.

BELAU

The islands of Kayangel, Babelthaup, and Koror were studied, but we can find no evidence of fermentation technologies ever having been used there. The inhabitants of Babelthaup indicate no need for food preservation technologies as they feel they have enough fresh food. The 2 islands of Babelthaup and Koror have over 160 mi² of land area, much of which is arable.

In Peleliu, a method similar to *bwiru* is used. Breadfruit is fermented in seawater, and stored in baskets on top of stone platforms. This type of preservation is called by them *telib* and is practiced exclusively by the Peleliuans (MacKenzie, 1964). The practice, though, appears to be dying out. On Peleliu, informants reported

that the inhabitants of Tobi Island, approximately 500 km south of Koror, ferment breadfruit in pits. However, we were unable to visit Tobi to confirm this report.

The attitudes of the inhabitants of Belau towards fermented breadfruit are associated with their traditional disdain for the inhabitants of Truk. Fermented breadfruit is a Trukese staple that is eaten throughout the year (Murai et al., 1958). Peter Aldabai from Babelthaup said "We have no need for fermented breadfruit in Belau. We have papayas and plenty of coconuts, and always fish or turtle. We have no need for the awful stuff. Only the Trukese eat it." Older people refer to fermented breadfruit as "smelly Trukese food." Frank Perron, Director of the Micronesian Maritime Demonstration Center, noted that few typhoons hit Belau, and thus there is no need for food reserves.

GUAM

We can find no extant practice of breadfruit preservation on Guam and have been unable to find any evidence that such technologies were ever used by the Chomorro people or other inhabitants of the northern Marianna islands. None of the people interviewed were familiar with any practice for breadfruit preservation.

PONAPE

At least 30 varieties of breadfruit are cultivated on the mountainous island of Ponape (Soucie, 1971). Breadfruit is a staple on this island. In Ponape there are 15 large traditional political divisions, somewhat similar to districts or counties. Each political division appears to have its own variation of standard breadfruit fermentation techniques; during interviews, 7 different methods of preparing fermented breadfruit were recorded.

In Awok village ripe breadfruit is available year-round. Men climb the trees to pick ripe breadfruit, which are peeled by men and women with cowrie-shell scrapers. After the core is removed, the breadfruit is chopped into slices resembling shoestring french fries. A pit is dug and lined with fresh banana leaves. A second lining of *Canna indica* leaves is next placed in the pit. The breadfruit slices are placed into the pit, which is covered with a lining of *C. indica* leaves and then a lining of banana leaves. The pit is covered with rocks. Our informant Sebastian Amor digs a ditch around his pit to facilitate drainage. The mar is allowed to ferment for 3 mo. When the pit is first opened, the mar is removed and the leaf lining is changed. Subsequently the lining is changed every 2 mo.

Before the mar can be cooked, a small portion must first be given to the Nanmwarki, titleholders in the complex Ponapean social system (P. Lawrence, pers. comm.). The mar is cooked by mixing it with pieces of coconut and baking it in loaves called *dolmangas*. These baked loaves must be presented to the village chief or cabinet members at some point afterward. Once such tributes have been made, the person who has prepared the mar may eat what remains in the pit.

Ponapeans who live near the ocean preserve their breadfruit in the saltwater lagoons. The fermented breadfruit product, called *mahr sed*, tastes somewhat different from mar prepared by Ponapeans who live inland. Ponapeans, who enjoy fermented breadfruit, eat it several times a month, usually on weekends.

In the Metalanimw municipality, Spensir James reported that the preparation

of mar is considered to be a man's job. The skins of ripe breadfruit are removed with cowrie-shell scrapers. The core is removed, and the entire breadfruit is thrown into the fermentation pit. The pits are lined with dried banana or breadfruit leaves. A lining of fresh *Canna indica* leaves is next placed in the pit. Similar layers of leaves are placed over the breadfruit and the pit sealed. Whenever the pit is opened to remove mar, the leaf lining is changed. Drainage ditches are also usually dug around the periphery of the pit. The village chief decides when mar should be given to the Nanmwarki, or titleholders (Hughes, 1969). When such a decision is made, every family with a mar pit bakes a mar loaf approximately 6 cm by 2 cm by 3 cm. Men chosen by the village chief take these loaves, called *keinmahr*, to the Nanmwarki. The loaves are usually accompanied by a fish offering. After this offering has been made, the villagers are free to eat their mar whenever they choose.

In the municipality of Kitti, Pencile Lawrence, a native scholar and student of breadfruit cultivation practices, reported that mar production was much more widespread in Ponape prior to the Japanese occupation. In Kitti only seedless varieties of breadfruit are used to make mar. Men, women and children climb the breadfruit trees or harvest the ripe fruit with a long pole. The breadfruit are peeled with cowrie-shell scrapers and cored. The breadfruit is cut into quarters and placed in pits lined with dried banana leaves and an inner lining of fresh banana leaves. The breadfruit is next covered with 2 similar layers and several large rocks are placed on top. A drainage ditch is dug around the pit. During the course of the year, the leaf lining of the pit is changed several times. After the mar has fermented for 2 wk, it is ready to use. However, as in other Ponapean municipalities, an offering must first be given to the Nanmwarki. This is prepared by mixing the mar with grated coconut and baking a loaf in a stone oven. This loaf, called *songmar*, is given directly to the Nanmwarki by the family making it. Some families rinse the mar prior to baking it.

An unusual method of mar manufacture, similar to the *kajaring* method of Ifalik atoll in Yap, is called *marenlong* (literally: "mar from the air") in Ponape. Green leaves are wrapped around ripe breadfruit on the tree and tied with coconut-fiber cord. The breadfruit ferment while on the tree. Mar prepared in this fashion could be eaten only by the Nanmwarki. It was considered to be a point of prestige to produce in this fashion the finest *marenlong* for the Nanmwarki. Dahlquist (1972) notes that in ancient Ponape the possession of fermentation pits served as an index of prestige. The pits were kept concealed until occasions such as feasts, when they were publically displayed.

DISCUSSION

Breadfruit preservation in Micronesia shows some striking differences and similarities to related technologies in Polynesia. In both areas, significant societal control of preserved food supplies is apparent. In Ta'u Island of the Manu'a group in Samoa, the first offerings of fermented breadfruit traditionally go to the chiefs (Cox, 1980). This is nearly identical to the practice in Ponape and is similar to that of Ulithi atoll inhabitants or the offerings of Ponapeans to the Nanmwarki. Presumably the ability to place societal control over private food supplies would, particularly during a famine, increase the efficiency of food rationing and reduce

the probability of societal collapse during a famine. Noticeably absent from Micronesia, however, are the large communal *masi* pits such as were built in the Society Islands or Tonga (Cox, 1980) and supplied and maintained by the entire village. Of the Marquesans, Handy (1923) wrote:

The first or preliminary crop of breadfruit . . . belonged entirely to the chief, and served to fill his private breadfruit paste pits from which his household, guests, assistants, and workers were fed, and the great tribal reserve pits back in the valley, which were filled in good times as a provision against their famines. The second harvest was used to fill the private family pits. (p. 183)

The only structures we know of in Micronesia that could possibly qualify as communal storage pits occur in the ruins of Nan Madol on the island of Ponape. Inside the major walled complex are located 4 stone-lined pits that could possibly have served as fermentation pits. The central pit, surrounded by 2 separate 7 m high walls, was square, measuring approximately 3.3 m on each side. Today it is approximately 2 m deep. It is covered with several monolithic pieces of basalt. In the outer court, protected only by the outer wall, are 2 rectangular pits of similar design, each measuring 3.3 by 5 m. These are also covered with large pieces of basalt. Although large, these are well within the size range of known stone-lined fermentation pits in Polynesia. In the Marquesas, Kruzenshtern (1811) described a fermentation pit from the Atu Ona valley that was 8 m deep. Linton (1923, as quoted in Handy, 1923) described a fermentation pit 6 m in diameter and 10 m deep.

It is unclear if the Micronesian methods were developed independently of the Polynesian methods. Certainly the Yap word *mar* could be a cognate of *masi* (the Polynesian name for fermented breadfruit) and the Yap word for breadfruit—*mei*—is nearly identical to the Tongan and Tahitian words. Possible contact points for such cultural diffusion include the Polynesian outlier island of Kapingamarangi, where the seeded varieties of breadfruit trees are reportedly similar to *Artocarpus mariannensis* (Coenan and Barrau 1961). Nevertheless, there are significant distinctions between the Polynesian and Micronesian techniques. Immersion of the breadfruit for an extended period in seawater is not done in Polynesia. Above-ground fermentation in baskets is also unknown in Polynesia. However, in Kapingamarangi, the preparation of *tipak*, or breadfruit preserved in sheet form, combines features of both Micronesian and Polynesian techniques (Coenan and Barrau, 1961). The initial fermentation is conducted above ground for 1 or 2 days, but the fruits are then baked in an underground oven, pounded into a paste and dried in the sun. After rolling into cylindrical shapes, the resultant sheets are wrapped in *Pandanus* leaves and stored.

In both Micronesia and Polynesia, however, fermented breadfruit allowed survival in the face of famine from storm, drought, warfare, or other catastrophies which were surprisingly frequent in Oceania (Cox, 1980). In this sense these fermentation technologies represent a significant cultural adaptation to otherwise potentially lethal environments (Kirch, 1979) and may have been of considerable importance in the colonization of new islands (Shattenburg, 1976).

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