EXTENSION PUBLICATIONS

UNIVERSITY of HAWAI'I at MĀNOA
COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESILIENCE

Making Mā: Fermented Breadfruit

At a Glance: Breadfruit is a dietary staple for many Pacific Islanders. A traditional way to preserve breadfruit and extend its useful life is fermentation. This publication discusses breadfruit fermentation in the contexts of cultural tradition, food science, value-added agriculture, and home-based food processing. A step-by-step guide and illustrated appendix feature instructions for fermenting breadfruit at home.

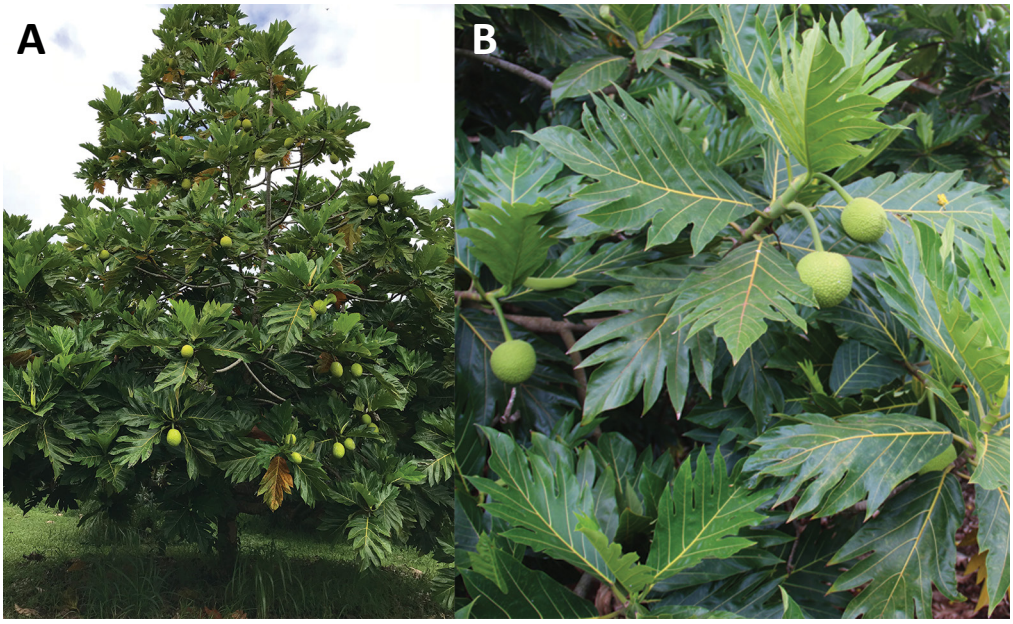

Figure 1. Cultivated by many Pacific Island communities as a staple food crop, breadfruit is a woody tree (A) with distinctive foliage (B). Photos: Noa Lincoln

Introduction

Breadfruit (*Artocarpus altilis*, Figure 1), known as ʻulu in Hawaiʻi, is a long-lived tropical tree in the fig family (Moraceae) that is a vital staple in the diets of many Pacific Island communities. The tree produces an abundance of starchy fruit that, in fresh form, have a relatively short shelf life—about two to five days at room temperature and two weeks in refrigerated conditions. While fruit can often be found year-round, the trees are seasonal, with most of the annual production taking place during four to six months. Fruit must be processed and preserved to extend its use throughout the year. Traditionally, fermentation stands out as the most important method for preserving breadfruit. This practice allows breadfruit to be stored for months, or even years, providing food security, especially during times of scarcity or seasonal fluctuations.

This publication introduces readers to breadfruit fermentation, describes practices and traditions of the Pacific, briefly explains the science of breadfruit

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fermentation, highlights opportunities for sustainable production of fermented breadfruit products in Hawai'i, and provides step-by-step illustrated instructions for fermenting breadfruit at home. Additional publications on breadfruit fermentation are listed in the References section below to help readers explore the subject in greater depth.

Brief Overview of Breadfruit Fermentation

The fermentation process allows breadfruit to be stored for long periods of time, up to years; transforms its flavor profile, adding a tangy/sour taste; changes its nutritional properties; and improves its digestibility. The final product has a dough-like texture that can be easily shaped, and when cooked, takes on a soft and chewy texture like mochi. In many Pacific Island communities, fermented breadfruit is more than just a preserved food—it is also considered a delicacy, often enjoyed during festivals and important social gatherings. It was prepared as food for long voyages between islands. Its long-standing role in both sustenance and cultural expression demonstrates the intertwined nature of food, tradition, and resilience in the Pacific Islands.

Figure 2. A pit used for traditional fermentation of breadfruit, Marquesas Islands. Photo: Noa Lincoln

Fermented breadfruit is known by many names throughout the Pacific, including ma or mā (e.g., Tuamotus, Marquesas, Caroline Islands), māsi or māsī (e.g., Samoa, Tonga, Futuna), māhi or māhia (e.g., Tahiti, Cook Islands), and mahr or māhr (e.g., Chuuk, Pohnpei). Mā holds a central place in local food traditions throughout the Oceania cultures. Mā is traditionally prepared by burying breadfruit in lined pits (Figure 2). Without exposure to oxygen, naturally occurring lactic acid bacteria lower the pH and preserve the food.

Across the Pacific, fermented breadfruit is valued for its cultural and practical significance. Its preparation is often a communal tradition that not only preserves food but also strengthens social bonds and facilitates the passing of knowledge to younger generations. In many cases, the fermentation pits themselves are sacred, treated with respect, and passed down through generations. Ceremonies surrounding the consumption of fermented breadfruit often coincide with important agricultural, religious, or communal milestones, symbolizing renewal, prosperity, and unity.

Traditional Preparation

Breadfruit is typically harvested when it is fully matured but still firm. Harvesting involves climbing the breadfruit tree or using long picking poles to harvest the fruits. Timing is important, because riper fruit with higher sugar content makes a better product. Fruit may be temporarily stored after picking to ripen further to the most desirable stage before processing.

After harvesting, breadfruit must be peeled, and the fibrous core, seeds, seed casings, and any rot must be removed. Traditional peelers were often made from cowry shells, mature hard coconut shells, or bamboo knives. In some, but not all, locations the peeled and cored breadfruit may be soaked in salt water or fresh water from several hours up to two days. The method of preparing breadfruit for fermentation varies by region and tradition, but typically involves breaking down the fruit through mashing, sectioning, or occasionally grating. Mashing turns the fruit into a pulp, sectioning cuts it into smaller chunks, and grating—though less common—shreds it into finer pieces.

Pits of varying sizes were dug in areas with good drainage, or else a stone platform was built up with a large depression built into the structure. The base and sides of the pit are thickly lined with one type of large leaves, such as banana, ti leaf, or, less commonly, breadfruit. The prepared breadfruit is placed in the pit, and tamped down in layers to minimize air pockets that

could lead to spoilage. After the fruit is settled in the pit, it is covered with additional layers of leaves. The pit may be sealed with soil to keep air out and protect the fruit. A weight such as a large stone may be placed on top to help compact the product during fermentation and minimize air pockets.

The fermentation may be left in the pits for one month up to several years, depending on the need. In some locations the pit is left undisturbed throughout the process, while in others the product is regularly unearthed and the leaf liners refreshed with new leaves. When the product is to be consumed, the pit is opened and the product is inspected for quality. The fermented breadfruit is then removed and prepared for eating. First it is washed with clean water to remove any debris and reduce sourness; different eaters may prefer more or less sourness. The mass is then drained in baskets or actively wrung through cloth to remove excess moisture. After draining, the product is further mixed through pounding or mashing, grinding or grating, or, most commonly, heavy kneading by hand.

At this point, the fermented breadfruit is ready for cooking. While there are many recipes, the most universal is to mix the fermented breadfruit with coconut milk, wrap the mixture in ti leaf, and steam, bake, or roast it. Another common use is to mix it with fresh ʻulu or kalo (taro, *Colocasia esculenta*) poi.

Food Science of Breadfruit Fermentation

Breadfruit fermentation in pits is a natural process that happens without oxygen, called anaerobic fermentation. In this low-oxygen environment, helpful microorganisms, primarily lactic acid bacteria (LAB), grow and carry out the fermentation. Enzymes from the LAB break down sugars in the breadfruit, mainly glucose, fructose, and sucrose. This process produces lactic acid that lowers the pH in the pit (that is, makes the breadfruit more acidic) and gives the fermented breadfruit its sour taste. A typical pH for fermented breadfruit is between 3.5 and 4.0, which helps keep the product safe and shelf-stable by preventing harmful microbes from growing. LAB can also produce small amounts of other acids, such as acetic and butyric acid, depending on the conditions. These add to the sour, tangy, and sometimes slightly pungent flavor of the final product.

LAB are naturally found on breadfruit and in the environment. They thrive in oxygen-poor conditions like those in fermentation pits. Some common types include *Lactobacillus*, *Leuconostoc*, and *Pediococcus*. These bacteria are especially good at turning sugars into lactic acid, but small amounts of wild yeasts, like *Saccharomyces*, and other bacteria may also be involved. Yeasts can also help break down sugars, producing small amounts of alcohol and carbon dioxide in the process. Fermentation not only changes the flavor and texture of breadfruit—making it soft and doughy—but also makes it more digestible. The process changes the nutritional profile, improves digestibility by breaking down resistant starches, and increases beneficial bacteria, or probiotics, which may support gut health.

Fermented Breadfruit as a Value-Added Product

The traditional fermentation of breadfruit offers promising opportunities for small-scale farmers growing 'ulu to reduce postharvest losses and create value-added products. In Hawai‘i, where a renewal of breadfruit agroforestry systems is occurring, fermentation extends shelf life from days to months, enabling home-scale preservation without refrigeration.

Fermented breadfruit can align with existing cultural foodways, offering a complementary counterpart to poi. Like kalo, breadfruit is a revered staple with ancestral significance. While poi holds a central, irreplaceable place in Hawaiian food culture, fermented breadfruit does not aim to compete—it resonates alongside. The same communities who value poi are likely to appreciate and support fermented breadfruit as part of a broader movement to revitalize Indigenous food traditions and strengthen food sovereignty.

For farmers, fermentation creates an accessible pathway into value-added enterprise. The resulting product can be transformed into steamed breads, dumplings, and other simple preparations that require minimal processing and can appeal to local markets. When integrated into agroforestry systems, breadfruit benefits from ecological synergies. Companion crops such as coconuts, banana, ti, and sugarcane provide materials useful in fermentation and food preparation, while also enhancing system resilience and biodiversity.

To support adoption, Cooperative Extension outreach should focus on workshops that showcase practical fermentation techniques, food safety, and community-based marketing. By building on traditional knowledge

and contemporary needs, fermented breadfruit offers a path for farmers to diversify income while reinforcing cultural identity and regional food security.

Step-by-Step Guide to Making Home-Fermented Breadfruit

1. Harvest and Preparation of Breadfruit

Breadfruit should be picked fully mature or ripe (Figure 3). Prior to preparing the mā, ideally most, or at least some of the fruit should be ripe and soft to the touch, but not completely squishy. If fruits are picked mature or full-size green, then they should be left to ripen in a cool area out of the sun. All fully matured fruits can be used, but the ripe fruits speed up the fermentation process.

To prepare the breadfruit you should have (1) a clean working area, (2) a sharp, clean knife or heavy-duty peeler, (3) clean water, and (4) a clean, sealable, food-safe container. Common modern-day food-grade containers include 5-gallon buckets, coolers, or large Ziploc® bags.

Breadfruit should be peeled and cored (Figure 4A). Any rot or discoloration should be removed and discarded, and all seeds and pseudo-seeds removed. The remaining flesh should be rinsed in clean water, squeezed dry, and added to the container (Figure 4B,C,D). Mature (still

Figure 3. Breadfruit of different maturity, showing (from left to right) full-size green, mature, half-ripe, and fully ripe. The two center fruits are the most ideal for making fermented breadfruit. Photo: Noa Lincoln

Figure 4. Preparing breadfruit for fermentation. (A) Peeling and coring the ripe breadfruit. (B) Rinsing and removing any impurities and seeds. (C) Squeezing dry. (D) Adding and compressing into a clean, airtight, food-grade container. Photos: Noa Lincoln

Figure 5. Breadfruit processed for fermentation using (A) all mature breadfruit, (B) a mix of mature and ripe breadfruit, or (C) all ripe breadfruit. Photos: Noa Lincoln

hard) breadfruit can be peeled with a peeler or knife and quartered; the core can then be cut from each quarter with a knife. For riper breadfruit, the skin can be cut off, and the core can be easily pulled out by the stem. Mature breadfruit should be sliced or grated into small pieces, while ripe breadfruit is soft and can be crushed or mashed by hand (Figure 5). If using a mix of ripe and mature breadfruit, place a layer of soft ripe breadfruit at the bottom, middle, and top of the container, sandwiching the firm, mature breadfruit between the riper layers.

2. Fermentation and Maintenance of Breadfruit

Once prepared, the container should be sealed in an airtight manner. If there is a large airspace in the container, a plastic sheet can be placed on the top of the material to minimize air contact (Figure 6).

At the start of fermentation, much of the breadfruit breaks down, causing it to shrink and release water. This will happen more with mature breadfruit compared to ripe breadfruit. One to two weeks after initial setup, the ferment should be (1) drained by pouring out excess water, which will have settled to the bottom of the container, (2) hand-mixed thoroughly and recompressed to remove all airspaces, and (3) added to, if desired, by refilling the container with additional breadfruit. To drain the water at the bottom, plunge your arm or a long utensil into the mash to create a hole, then pour the liquid from

Figure 6. Plastic wrap can be used to help seal the surface of the fermenting breadfruit product to reduce the airspace of the container. Photo: Noa Lincoln

Figure 7. Breadfruit fermentation over time. (A) One to two weeks after fermentation is established, the breadfruit still retains its texture, produces a lot of moisture that needs to be drained, and may have some white growth. (B) Four to eight weeks after establishment, some texture is still present and some moisture may still be generated, but the breadfruit has begun to be smooth and paste-like. (C) Eight to 16 weeks after establishment, the product is smooth and should have stopped producing moisture. Photos: Noa Lincoln

Figure 8. When the breadfruit product is fully fermented, it should be somewhat dry and may achieve a fine white 'skin' like an aged cheese. Photo: Noa Lincoln

the container. At this initial stage, there may be some white fungal growth, which is normal, however, black or excessive pink growth should be considered contaminated due to unclean preparation conditions.

The above steps should be repeated every one to two weeks until the product no longer shrinks or releases water (Figure 7). If ripe breadfruit was used, draining and mixing may need to occur only once, but if mature breadfruit was used, the ferment may need to be drained and mixed three or four times. When fermentation is complete, the breadfruit will have a pungent odor like an aged cheese, and can be maintained for long periods of time (Figure 8).

3. Usage and Cooking

Once the product is fermented, it can be used immediately or stored for long periods of time. Batches can last for many months without maintenance. Long-term (multi-year) storage is possible, but the product should be "fed" by mixing in additional ripe breadfruit from time to time, typically when removing some of the product for eating. The fermented product is sour, and is washed to reduce or eliminate the sour flavor. The degree of washing depends on how much of the sourness one wishes to retain, as some eaters enjoy the strong flavor.

To wash the product, a strong, fine mesh pillow case is most often used, and can be dedicated to this purpose. A cloth strainer, such as cheesecloth, may be used but the

Figure 9. Preparing the fermented breadfruit for use in cooking. (A) The product is rinsed to remove some or all of the sour flavor. (B, C) After squeezing out the rinse water, the product should look like a dry dough. (D) The dry dough should be worked to ensure an even consistency. Photos: Jermy Uowolo (A), Noa Lincoln (B,C,D)

mesh must be fine enough so that the product does not squeeze through the holes. Place the desired amount of fermented breadfruit into the strainer and repeatedly add water, hand-stir and massage the breadfruit, and squeeze out the water (Figure 9A). Pay attention to the wastewater coming from the strainer, which will start off as yellow and milky and get progressively clearer. When the water coming from the strainer is clear, the breadfruit is fully washed and will be the least sour.

After rinsing, squeeze as much water as possible from the breadfruit through the strainer. At this stage the breadfruit should feel like a very dry dough (Figure 9B,C). Place the dough in a clean container and strongly massage and rub the breadfruit to ensure an even texture (Figure 9D). Following this step, the product is ready for any culinary use.

In a simple, traditional recipe commonly prepared using fermented breadfruit, the fermented dough is mixed with coconut cream and sugar until the desired consistency and sweetness are obtained. The sweetness can be tested by tasting the product, and the consistency can be tested by forming the dough into balls, which should be smooth, not sticky, and hold their form (Figure 10). This preparation may be wrapped in ti leaf and steamed (Figure 11A), or formed into balls and boiled in coconut milk (Figure 11B). In both cases, the dough should be cooked until the consistency of mochi is achieved (Figure 11C,D).

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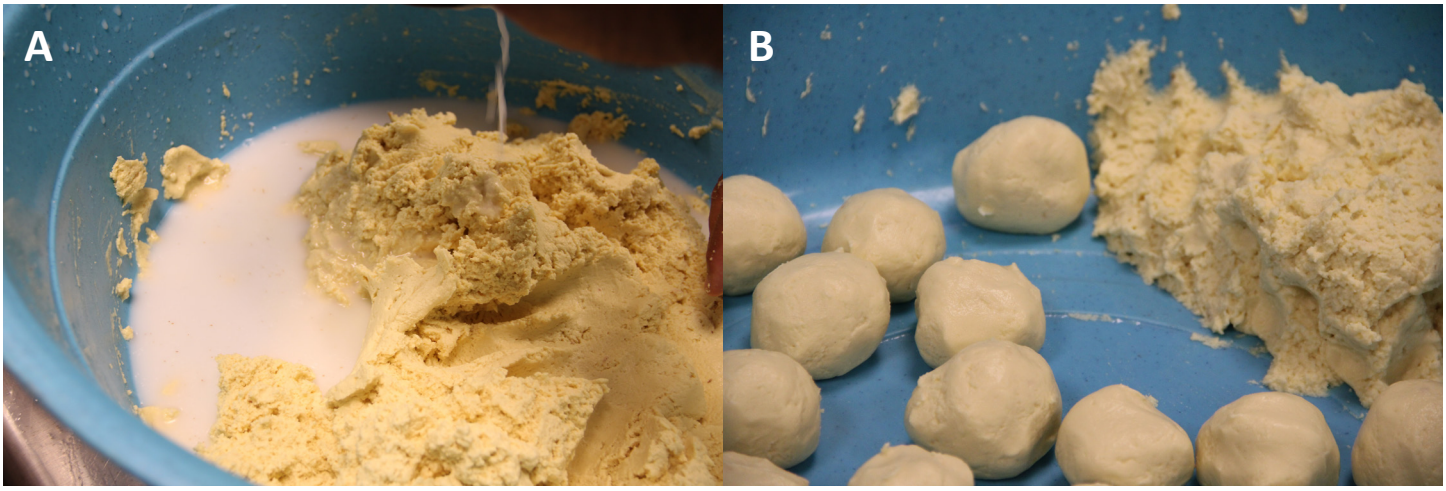

Figure 10. Preparing fermented breadfruit for traditional use includes mixing in sugar and coconut cream (A). Once the breadfruit dough is mixed to the desired sweetness, the consistency should be close to that of a bread dough (B). Photos: Noa Lincoln

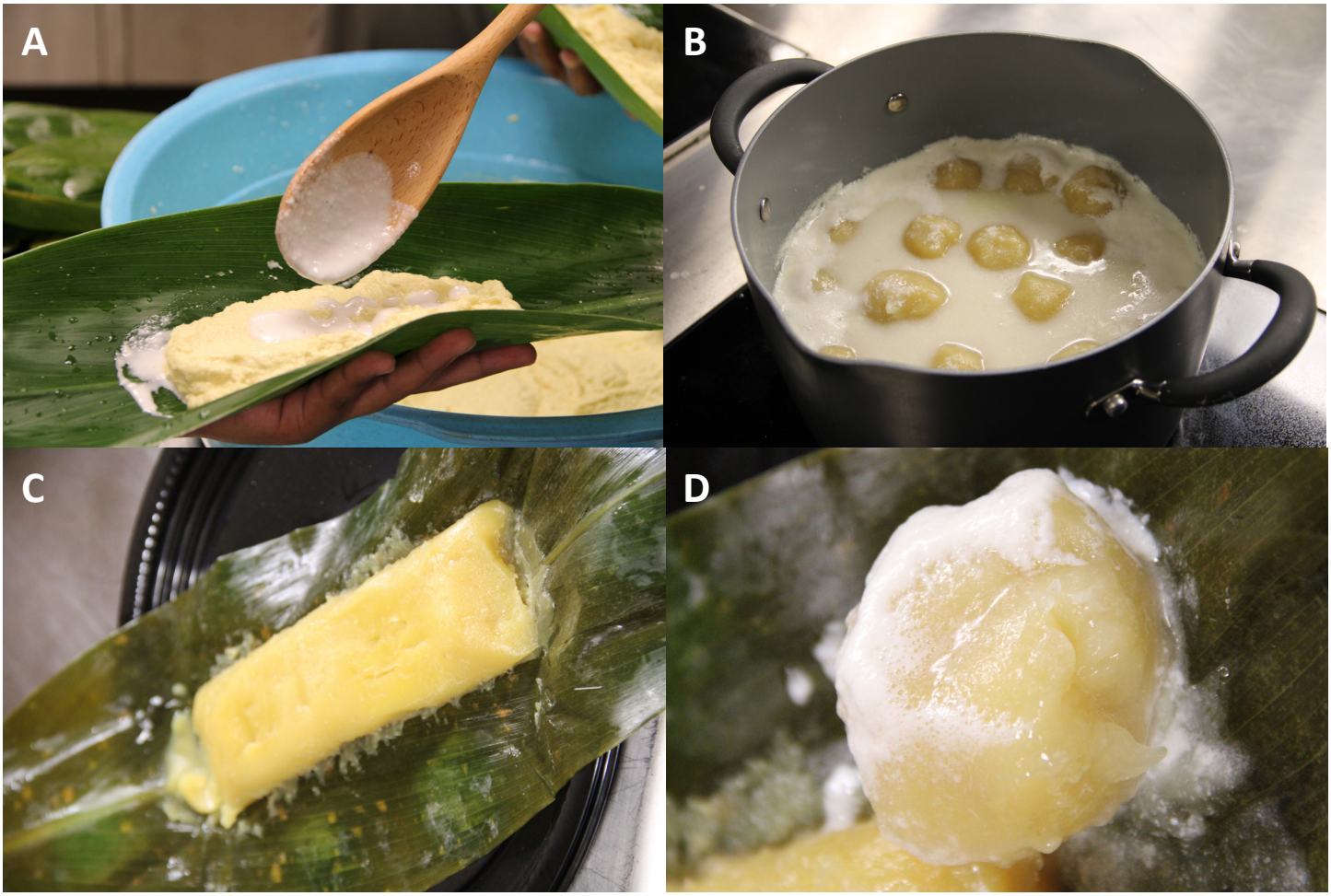

Figure 11. Once the dough is prepared, it can (A) be wrapped in ti leaf and steamed or (B) boiled in coconut milk. The final cooked product should be firm and have the consistency of mochi (C,D). Photos: Noa Lincoln

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Summary of Steps for Making Home-Fermented Breadfruit

Procedure	Description	Photos
1. Harvest	Harvest fully mature or ripe breadfruit.	
2. Initial Preparation	• Peel breadfruit and remove core using peeler or knife. • Remove any rot and all seeds. • For fully matured fruit, quarter and slice or grate into smaller pieces. • Rinse in clean water and squeeze dry. • Add to a clean and airtight food container, compress, and seal.	
3. Fermentation Process	After 1–2 weeks of initial setup, the ferment should be: • Drained by pouring out the excess water settled at the bottom of container; • Hand-mixed thoroughly and recompressed to remove airspaces; • Added to, if desired, using more peeled, cored, cut/ shredded breadfruit to refill container. Repeat these steps until the product stabilizes, that is, reaches a point of no change; the final product can be stored at this stage for longer periods.	 White fungal growth (as in picture) may occur, which is normal. Excessive black growth (not shown) should be considered contamination.

Procedure	Description	Photos
4. Timeline to Final Product	• *1–2 weeks after initial preparation:* Breadfruit still retains its texture, produces moisture that needs to be drained, and may have some white fungal growth. • *4–8 weeks into fermentation:* Some breadfruit texture is still present, and some moisture may still be generated, but the product has begun to develop a smooth and paste-like texture. • *8–16 weeks into fermentation:* The product is smooth and should have stopped producing moisture.	 Use plastic wrap to seal the surface of the fermenting product to reduce airspaces. Fully fermented product should be dry and may achieve a fine white 'skin' like aged cheese.
5. Preparation for Cooking	• Rinse the product to remove some or all of the sour flavor using a mesh pillowcase or cheesecloth as a filter. • Squeeze as much water out as possible through a strainer to form a very dry dough. • Place dough in a clean container. Strongly massage and rub the fermented breadfruit to ensure an even texture. • The dough is now ready for cooking.