Breadfruit Research in the Caribbean: Pre-Introduction to 1979

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Abstract

The introduction of breadfruit (*Artocarpus altilis* (Parkinson) Fosberg) from the South Pacific to the British West Indies more than 200 years ago, was a well-documented enterprise. The successful introduction and the subsequent plant distribution within the region received considerable support and guidance from the Royal Society of Arts and the from the West India Committee. The former institution has played a leading role in the advancement of science since the mid-18th century when the primary interest of both institutions was in trade for the economic advancement of the British empire. Through their involvement in the introduction, the venture benefitted from research, especially in botany and horticulture, which was remarkable because breadfruit was intended to serve as a food crop primarily for the enslaved African labour on the sugarcane plantations instead of as an economic crop for trade. Since its introduction, breadfruit has been grown and consumed throughout former and existing European colonies and research activities have been conducted in the English, Spanish and French-speaking Caribbean. This paper describes research investigations on breadfruit from 1768, towards its introduction and during its eventual development as a food crop in the region; across language groups, from 1768 up to 1979. The research conducted from 1980 onwards will be presented in a subsequent paper.

Keywords: Botanic gardens, propagation, consumption, production, processing, food security

Introduction

Among the wide range of plants that have been added to the Caribbean flora, the introduction of breadfruit (*Artocarpus altilis*) in 1793, by the British, has been one of the best documented and publicised. At the time of its introduction, the West Indies (used interchangeably with the Caribbean) was ruled by several European nations, who fiercely competed not only for possession of islands in the region but also to be the first to acquire and introduce economically important plants to their colonies. Sugarcane was already the crop plant that dominated the landscape and the economy; in addition, new economic crops were introduced to increase trade and income. Interestingly, in spite of the publicity, breadfruit was not introduced as a crop to be traded for economic benefit. Furthermore, even before its introduction to the region, it attracted research attention as the documented observations of explorers, natural historians, botanists, artists and gardeners that were preparatory to and eventually facilitated the success of the venture. Therefore, the history of Caribbean-related breadfruit research predates its introduction.

Research on breadfruit is documented in two papers, with the objective of tracing the history of Caribbean-related and Caribbean-based research on the plant and its food and non-food uses within the context of its status as an introduced crop. The key factors that stimulated the investigations during different

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eras are highlighted and the contribution of these research activities to the advancement of the crop is evaluated. Research on breadnut (*Artocarpus camansi*), a close relative of the breadfruit, is also included because of its introduction during the quest for the breadfruit and its subsequent importance in some parts of the region. This first paper covers research on breadfruit for the first 211 years, from 1768, when Joseph Banks first began his contribution, directly and indirectly, to western knowledge about it and subsequently influenced its introduction to the Caribbean (Leakey and Roberts-Nkrumah 2016). The second paper from 1980 to the present day is presented in a subsequent paper.

A

B

Plate 1: Breadfruit (Artocarpus altilis) (A), and its progenitor, breadnut or chataigne (A. camansi) (B)
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Introduction to breadfruit

Nomenclature

Breadfruit consists of a complex of three Artocarpus species and their hybrids within the Moraceae family, (*Artocarpus altilis* (Parkinson) Fosberg), the most well-known and the species that bears the common name, breadfruit, *A. camansi* Blanco, the breadnut or chataigne, its putative ancestor and *A. mariannensis* Trécul, the dugdug, the least common (Ragone 1997; Zerega et al. 2004) (Plate 1). *A. altilis* x *A. mariannensis* hybrids are also called breadfruit. In this paper, breadfruit is used to refer to *A. altilis*.

Origin and distribution

The place of origin has not been identified and locations in an area ranging from southeast Asia to New Guinea and the Pacific have been proposed (Zerega et al. 2004). Based on DNA fingerprinting, the most common recent view is that *A. altilis* was developed by vegetative propagation and selection from *A. camansi*, a seeded diploid (2n = 2x = 54), which is native to New Guinea. Some of the early breadfruit (*A. altilis*) types hybridised with *A. mariannensis*, also a seeded diploid, which occurs primarily in Micronesia in the North Pacific.

Through introgression with *A. mariannensis* and *A. altilis* a wide range of hybrids developed. Therefore, most breadfruit genetic diversity exists in the Pacific with cultivars of different ploidy and varying levels of seediness. *A. altilis* cultivars derived from breadnut are triploid (2n = 3x = 84) and occur mainly in Melanesia in the west and Polynesia in the east, whereas *A. altilis* x *A. mariannesis* hybrids, consisting of fertile and sterile diploids and triploids are found mainly in Micronesia (Zerega et al. 2004, 2005). Breadfruit, mainly seedless, triploid *A. altilis*, has now been distributed to approximately 90 generally tropical countries, between latitudes 20^0N and 20^0S. Breadnut has also been distributed within the tropics but to fewer countries.

Botany

Breadfruit trees are perennials that exhibit continuous monotropic growth, with annual growth rates up to 1.5 m and they can achieve heights of 20 - 25 m in good growing conditions. Lateral branches arise in groups on the upright trunk and further branching on these laterals can produce a dense canopy. Tree shape is generally pyramidal, but some cultivars have dome-shaped or spreading canopies (Koroiveibau 1983; Roberts-Nkrumah 1997, 1998; Ragone and Wiseman 2007) (Plate 2). Typically, the leaves are large, green and glossy and in mature trees, the margins are lobed, however, tree age and cultivar influence leaf size and shape. The shallow and extensive root system is adventitious because seedless cultivars are propagated vegetatively. Latex is present in all plant organs. Breadnut trees exhibit similar growth habit but are more sparsely branched and have a deeper, tap root system because they are grown from seed.

Breadfruit is monoecious and both male and female inflorescences arise from the leaf axil. Pollen production is copious only in seeded cultivars but in seedless types, pollen is less important because the fruits are parthenocarpic (Hasan and Razak 1992). The female inflorescence consists of hundreds of flowers that develop into fruitlets which fuse to form a single large fruit or syncarp (Sharma 1965; Jarrett 1977). This results in a network of polygons on the fruit surface with the remnants of the flower at the apex of each polygon. The skin texture is determined mainly by the elevation of the polygons which varies depending on cultivar and stage of fruit maturity (Koroiveibau 1983). Fruits mature from 14 - 20 weeks after appearance of the inflorescences and vary in shape and size (Latchoumia et al. 2014; Roberts-Nkrumah 2018; Worrell et al. 1998). In mature fruits, skin colour is variable, usually light green to

Plate 2: A typical breadfruit tree form
(© L. B. Roberts-Nkrumah)

brownish green and flesh colour ranges from light cream to deep yellow (Englberger and Lorens 2007); both skin colour and flesh colour are also maturity and cultivar dependent. The reproductive features of breadnut are generally similar to those of breadfruit, except that much pollen is produced, the polygons on the skin surface are raised to form spikes that persist as the fruit matures, the flesh texture of the fruits is less firm because the fruitlets are less fused and seeds are present (Jarrett 1977; Roberts-Nkrumah 2018).

Environmental requirements

Both breadfruit and breadnut grow best under tropical, lowland conditions at temperatures between $21^0 - 32^0$C. Breadfruit thrives where rainfall is well-distributed and annual receipt is at least 1500 mm. Light is critical for early bearing and high yields. Sheltered locations are preferable because persistent wind can stunt growth and hurricanes and cyclones seriously damage the trees. Both species perform well on a wide range of soil types, but prefer deep, well-drained and moisture retentive soils (Roberts-Nkrumah 2015).

Status as a food crop

Breadfruit has been an important food crop in the Pacific where it has been grown for almost three millennia. Within the last 15 years, breadfruit has been increasingly promoted as a crop that can contribute significantly to hunger alleviation with efforts being made to augment its production and consumption internationally through planting material distribution to many countries, in some of which it had not been known previously. The potential of breadfruit as a significant food crop is attributed to its high productivity of nutritious fruits. Recorded yields range from 6.67 t/ha in agroforestry systems (Fownes and Raynor 1993) to potentially 50 t/ha in pure stand at 100 trees/ha depending on cultivar (Roberts-Nkrumah 1998). Carbohydrates comprise the major nutrient in the fruits that also contain appreciable quantities of potassium, phosphorus, magnesium, calcium, Vitamin C and the B vitamins, which can contribute significantly to daily recommended intakes (Bawa and Webb 2016). Additionally, the trees are easy to cultivate, compatible with many crops in mixed crop and agroforestry systems (Fownes and Raynor 1993; Roberts-Nkrumah 2007) and provide ecosystem services such as increased soil organic matter, biodiversity and carbon sequestration (Langston and Lincoln 2018; Livingston 2023). It has been suggested that breadfruit may contribute to climate-resilience in agroforestry systems in tropical countries between latitudes 20^0N and 20^0S (Yang et al. 2022).

In recognition of its significant potential as a food crop and that its production, consumption and biodiversity were declining in the Pacific, in 2001, the Global Biodiversity Trust identified breadfruit as a crop to be conserved for food and nutrition security and its conservation became law in 2004 (Moore 2004). Several germplasm collections have been established to conserve the biodiversity of the crop and to support expanded production and utilisation (Daley et al. in press). These conservation efforts are also important for other species within the breadfruit complex, especially, for the breadnut, the putative ancestor of the breadfruit, which has not been promoted as a crop for food and nutrition security but also produces very nutritious fruits and offers similar agronomic and ecosystem benefits as breadfruit.

Outside of the Pacific, breadfruit has the greatest significance in the Caribbean which is the first region to which it was distributed and where some of the earliest commercial activities and research on the crop were undertaken. Public and private sector institutions within the region, extra-regional institutions that have collaborated with Caribbean stakeholders, as well as, community groups and individuals have contributed to

these research efforts. However, this paper is based on published work and grey literature that document valuable work in the region.

The introduction of breadfruit to the Caribbean: The role of research

British, French and Spanish explorers introduced breadfruit and breadnut from the Pacific to their colonies in the Caribbean towards the end of the 18th century (McCook 2011). The colonial powers desired to acquire the breadfruit because previous European explorers had described the fruits as suitable for consumption and easy to prepare, and the trees as highly productive and easy to cultivate (Leakey and Roberts-Nkrumah 2016). Joseph Banks, a natural historian and member of the Society for the Encouragement of Arts, Manufactures and Commerce (later the Royal Society of Arts, RSA), who became a person of great influence, visited the South Pacific with the British explorer, Captain James Cook, on his voyage of 1768 – 1771. His detailed description of breadfruit and its benefits included minimal labour required for harvesting, almost year-round availability of fruit, preparation and preservation methods to extend availability and its ability to provide food for generations (Leakey and Roberts-Nkrumah 2016).

Within the British West Indies, the sugarcane planters supported the idea of introducing breadfruit, beginning in 1772 with Lieutenant Governor Morris Valentine, governor of the Windward Islands, who requested Banks's assistance. Planters in Jamaica also joined the petition for the breadfruit, claiming dire need for a local food source for their enslaved African labour force. They attributed the high death rate of the labour force to the severely disrupted imported food supply because of the British trade embargo against the American colonies during the War of American Independence, from 1775- 1783, and to a series of natural disasters that had destroyed the provision grounds of the enslaved workers (Sheridan 1976). Banks took the petition to King George lll, who, in 1787, approved an expedition to Tahiti to obtain the breadfruit for delivery to the West Indies. Captain William Bligh, who had also sailed with Cook on a later voyage to the Pacific and had seen breadfruit in Tahiti, was appointed to lead this expedition. After his first attempt in 1789 failed because the crew of the Bounty mutinied and threw the plants overboard, he returned to Tahiti and successfully introduced the plants to St Vincent on 23 January 1793, and to Jamaica on 5 February 1793 (Powell 1977; Sheridan 1989). Altogether, 677 breadfruit plants from Tahiti and four plants (two breadfruit and two breadnut) from Timor, reached the Caribbean on this voyage (Bligh 1976).

The most commonly cited reason for the introduction of breadfruit to the region is that as an abundant, cheap, locally-grown food it would avert local food crises (Powell 1977). However, the planters had always preferred importing food to extract maximum labour because the profitability of large-scale, monoculture sugarcane operations was heavily dependent on free labour. Consequently, the trade embargo had a serious negative impact on the sugar industry in British West Indian colonies. In this political and economic context, the characteristics of breadfruit highlighted by Banks and explorers strongly recommended its introduction to solve the prevailing food crises by replacing both imported food and locally produced food that required attention by the labour force (Sheridan 1976, 1989).

Engagement of botany and horticulture in the introduction of breadfruit

The successful introduction of breadfruit to the Caribbean and its distribution within the region was not without scientific and research input due to the direct and indirect influence of the RSA. This society, comprising natural historians, scientists and traders, promoted expansion of knowledge through the sciences (Leakey 2014). The following five

examples highlight the contributions of the art and science of botany and horticulture.

Firstly, through his RSA associates Banks, himself a trained botanist, learned about the breadfruit and met Daniel Solander, a student of Linnaeus, the famous taxonomist, and Sydney Parkinson, an artist. Both men accompanied Banks on the voyage to Tahiti (Leakey and Roberts-Nkrumah 2016). Parkinson's drawing and description of the breadfruit helped to identify it when prizes were being offered for its introduction and to distinguish it from the breadnut that was mistakenly sent to Jamaica as breadfruit since 1782 after the British raided a French ship in the Caribbean. A planter who had received the plants advised Banks that the leaf shape did not match the description and drawing of the breadfruit and he requested introduction of the best type of breadfruit to the West Indies (Leakey 2014; Leakey and Roberts-Nkrumah 2016). Breadnut or chataigne had arrived in St Vincent between 1779 and 1783 when the island was under French rule. Alexander Anderson, the superintendent at the botanic garden in St Vincent from 1785, indicated its presence there (Roberts-Nkrumah 2018). Parkinson is included as an authority in the scientific name of breadfruit because his was the first published and verifiable information on this species. He named it *Sitodium altile* - the species name indicating its usefulness- and also supported his description with a drawing, thereby demonstrating the importance of botanical drawings in species identification (Plate 3). After several subsequent changes of the scientific name, one of which, *Artocarpus communis*, included the breadnut as a seeded breadfruit, taxonomists presently recognise them as two different species and have assigned breadfruit the scientific

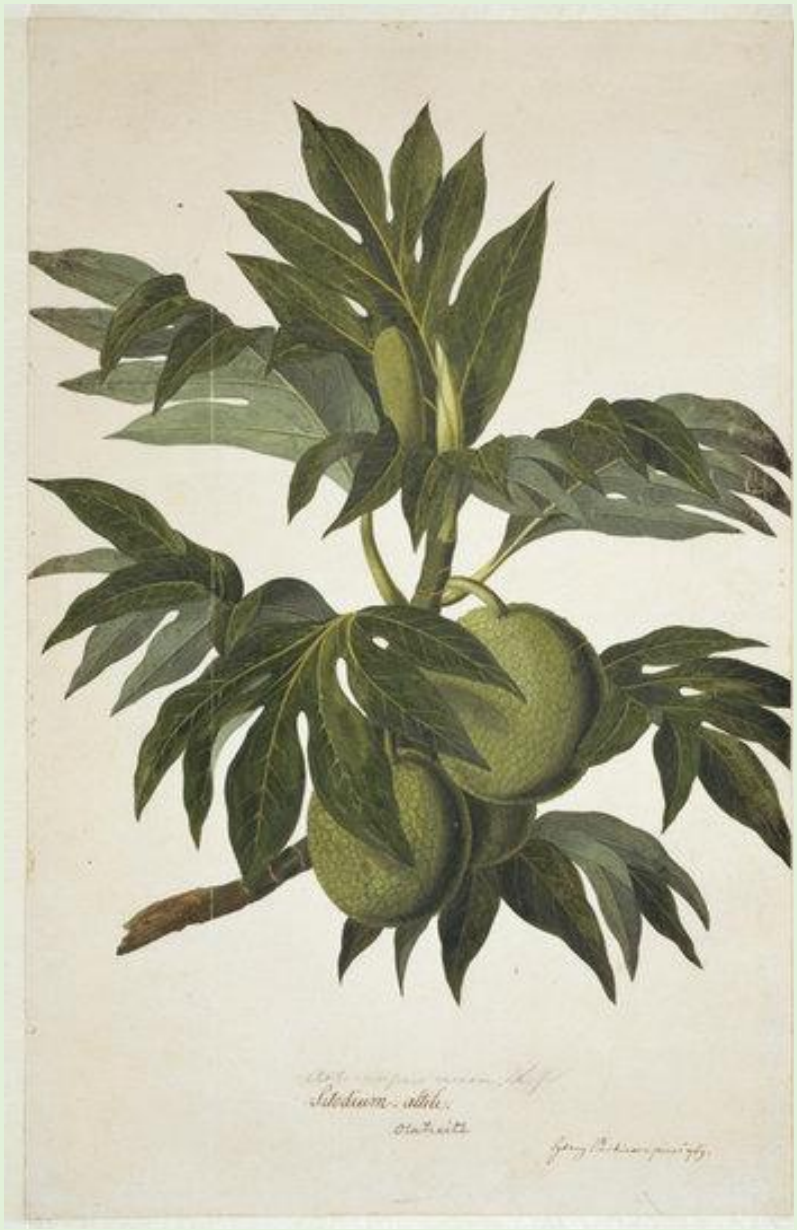


Plate 3: Watercolour of breadfruit by Sydney Parkinson
Source: Natural History Museum images (https://nhmimages.com/asset/12087/)

name, *Artocarpus altilis* (Parkinson) Fosberg (Jarrett 1959; Fosberg 1960; Fielding 2022).

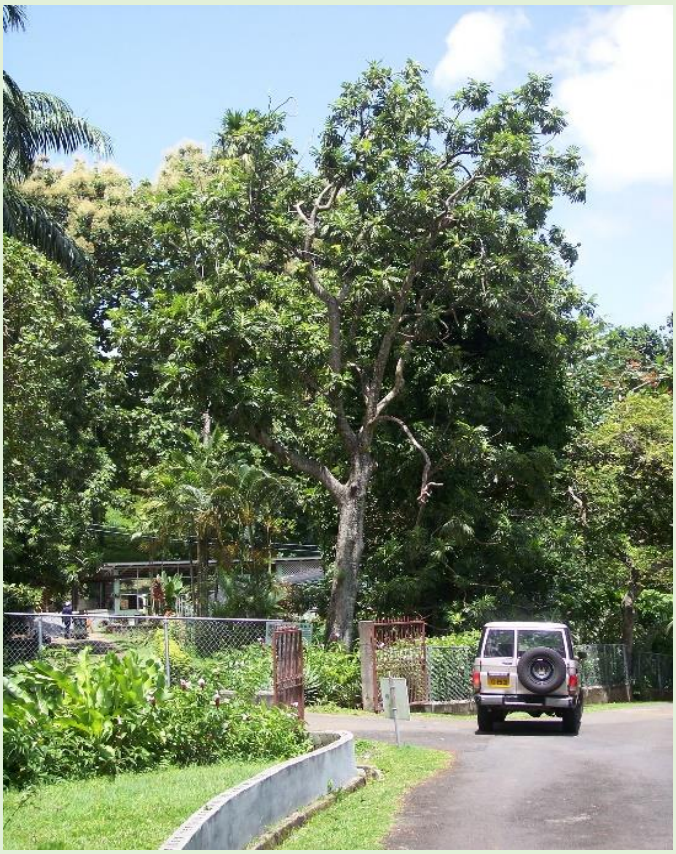
Secondly, the diaries of explorers, voyaging natural historians and gardeners and other travellers were sometimes published and were rich sources of botanical and horticultural information on exotic plants for which scientific societies sometimes used to offer prizes for the introduction of new plants. One of Banks associates at the RSA was John Ellis, a trader and natural historian who strongly supported the idea of introducing breadfruit to the West Indies. As the agent for Dominica, Ellis was also a member of the London Society of West India Planters and Merchants (predecessor of the West India Committee), which offered a very attractive premium of £100 to anyone who brought a plant of the "true Breadfruit tree in a thriving vegetation, properly certified to be the very best sort of that fruit" (W.G.F. 1922, p225). To promote this venture, in 1775, Ellis produced a manual with a detailed description of the plant and guidelines for maintaining the plants during transport from the Pacific based on the previous accounts of the plant. These guidelines included the required environmental conditions for light, relative humidity, protection from sea spray and low temperatures, soil moisture management, with designs for suitable boxes that would provide these environmental conditions. He distributed the publication to the Admiralty and the drawings to sea captains in support of the prizes offered by the society and planters for the introduction of breadfruit (Leakey and Roberts-Nkrumah 2016). The suggested boxes were not used, but the extensive modifications made to convert spaces on the ships to nurseries providing suitable environmental conditions would have considered these guidelines which proved useful for the eventually successful voyage (Roberts-Nkrumah et al. 2016). The importance of investigating suitable environments for successful introduction was recognised by a member of RSA in 1777 who suggested the offer of a prize for transporting enough plants to experiment with their establishment in multiple locations. The RSA agreed and as further inducement by 1789, offered a gold medal for the delivery of at least six live plants of one or both species (seeded or seedless types) from the South Pacific to any of the West Indian islands (Bligh 1976).

Thirdly, a network of botanic gardens was established throughout the British empire to implement the government's policy to advance the empire through economic botany. The role of these gardens was to cultivate, study and improve indigenous and introduced plants with known or potential economic value for distribution to the Royal Botanic Gardens at Kew in England, the network's centre, and to the empire's farmers (Drayton 2000; Pemberton 2006; Brooks 1922). At the time of Valentine's request, Banks was a member of the RSA and also in charge of the Kew Gardens (Leakey and Roberts-Nkrumah 2016). One supporting argument that Valentine used was the presence of a botanic garden in St Vincent that had been established by his predecessor, General Robert Melville, in 1765 with the assistance of Dr George Young, the Principal Medical Officer and the first curator of the garden (Leakey and Roberts-Nkrumah 2016; Brooks 1922). The St Vincent Botanic Garden, the first of its kind in the Western Hemisphere, was the first agricultural research facility in the British West Indies where botanic gardens established later served a similar function. The botanic garden established at Bath in St Thomas, Jamaica in 1776 was also an indicator of that island's readiness to receive breadfruit plants. Therefore, when the breadfruit plants arrived in 1793 they were first delivered to the botanic gardens in St Vincent and Jamaica for care, observation, multiplication and distribution throughout those islands and others in the British Caribbean as indicated by the reports on their progress by the curators, Alexander Anderson in St Vincent, and

James Wiles and David Breen in Jamaica, to Banks (Leakey and Roberts-Nkrumah 2016) (Plate 4).

Fourthly, suitable vegetative propagation methods had to be mastered to facilitate the introduction and distribution of the seedless breadfruit. Bligh's gardeners had little success with the adventitious shoots they used as stem cuttings, therefore, they also took on board as planting material, root cuttings from which these shoots arose. Bligh finally discovered that the Tahitian method of removing rooted adventitious shoots with a ball of soil during wet weather to reduce transplanting shock was the most successful option (Roberts-Nkrumah et al. 2016). Most likely this method was used at the botanic gardens to multiply breadfruit plants for distribution. Thus the entire propagation and establishment process provided research opportunities that ensured the success of the breadfruit introduction enterprise.

Fifthly, Anderson at the St Vincent botanic garden experimented with different methods of preparation, including boiling, toasted slices and pudding. These efforts were to encourage consumption of breadfruit which he recommended as a high quality food (Leakey 2014).



A

B

Plate 4: A sucker of an original breadfruit tree at the St Vincent Botanic Garden (A); close-up of the fruit and leaves (B)
(© L. B. Roberts-Nkrumah)

Research from the 19th century to 1959

The 19th to the mid-20th century was marked by major, though slow, social, economic and political change. Change entailed moving from sugarcane dominated economies and enslaved labour, to African Emancipation, growth of a peasantry and the demise of sugarcane, to new export crops and the imminent end of colonial government in most of the British West Indies.

Breadfruit trees thrived very well in the region and lived up to the expectations of productivity and almost year-round bearing (Plate 5). However, some 50 years after its introduction, the emancipated Africans rejected it and it failed to become their major food source as planned (Howard 1953; Parry 1955; Sheridan 1989). Instead, they fed the fruits to pigs (Howard 1953), which contributed indirectly to local food supply, but the use as 'hog food', engendered a stigma towards breadfruit consumption as the crop was associated with slavery, poverty and food shortage (Roberts-Nkrumah 2007). However, after Emancipation extremely low wages and poor working conditions persisted, and the peasantry began to accept breadfruit as a readily available carbohydrate food, and it eventually became a staple (Powell 1977). Estimated annual per capita availability for consumption in Jamaica was 50.2 kg in 1958 (Leakey 1977).

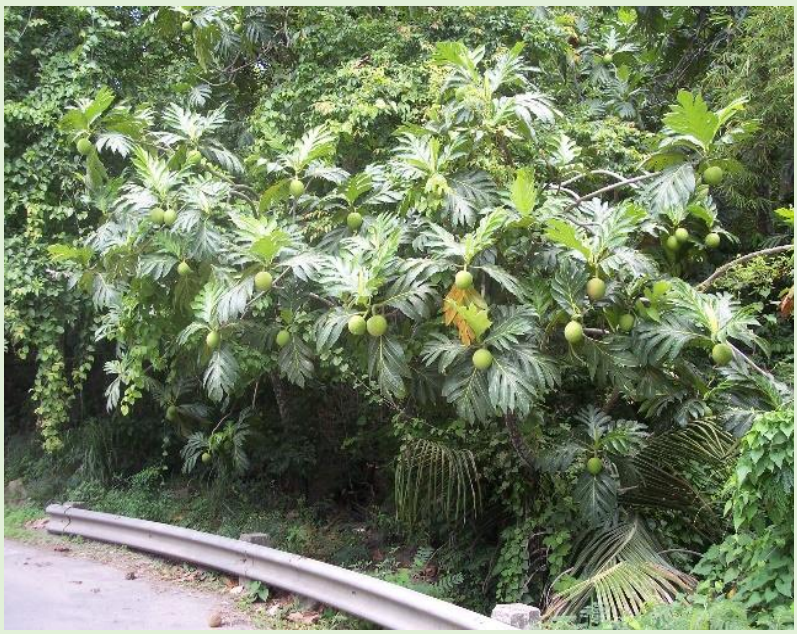


Plate 5: Breadfruit tree in bearing in a gully in Montserrat
(© L. B. Roberts-Nkrumah)

Food preparation

Research on breadfruit continued in the kitchens of the peasants. The major stimulus was its abundance, especially at those times of the year when the staples they produced were in short supply and they lacked cash to purchase imported flour and corn meal. Their culinary experiments, transformed this strange fruit into acceptable forms for consumption (Guilding 1825) that are now considered traditional Caribbean dishes. Breadfruit was roasted in the ashes of wood fires, boiled or steamed and consumed with salted fish or pork to offset its blandness (Roberts-Nkrumah 2007). A recipe book that also provided tips for preparing breadfruit was published in 1893 (Higman 2008). Home economists were actively involved in recipe development in support of campaigns to produce and consume local food to mitigate the effects of food crises precipitated by World War 2. For example, wartime breadfruit recipes were published in a Barbadian newspaper in 1942 and in a recipe book by the Jamaica Agricultural Society in 1957 (Barnes 1993).

Processing and utilisation

A breadfruit meal had been developed since 1860 in Jamaica and was used to prepare porridge (Higman 2008). Shortage of imported staples during World War 1 prompted the Department of Agriculture in Trinidad to undertake investigations that aimed to refine flour production techniques and to determine the appropriate ratio of breadfruit flour to wheat flour for bread acceptable to consumers (Freeman 1917; Williams 1917).

Production

During the post-Emancipation period, food shortages occurred frequently. Some efforts were made to increase the breadfruit

tree population to augment local food production but reports of plant propagation research to facilitate increased planting are sketchy. It is known that the Department of Agriculture in St Lucia developed successful propagation techniques by root cuttings (Brooks 1922). In the Dominican Republic, a nursery produced 5,000 plants between 1925 and 1926, although with identification of the plants as *Artocarpus incisa* seedlings, the planting material might have been breadfruit, breadnut or both. (Ciferri 1927). At the Government Experiment Station in the Bahamas, propagation by air layering and stem cuttings were tried under mist (Russel 1954), while in Guyana, treatment of stem cuttings with wax and hormones without using a propagating bin was considered an improvement over the use of root cutting (G.C.S. 1949).

Root rot and fruit rot were identified as important diseases that could adversely affect production efforts. Nowell (1923) attributed root rot that resulted in tree dieback in cocoa and other tree crops to *Rosellinia* spp. and noted that breadfruit was one of the most susceptible species (Plate 6). The two recommended options for prevention and control of the disease in breadfruit were careful management by removing dead branches and avoiding injury to the roots to preserve the trees as long as possible; and removal of infected trees with all roots.

Fruit rot was widespread and caused significant damage to breadfruit in Guyana (Stockdale 1913) (Plate 7). *Gloeosporium mangiferae* was confirmed as causative agent (Bancroft 1918). The appearance of the disease was described and recommendations for controlling the disease were removal and burial of diseased fruits in holes with lime and spraying 4% Bordeaux solution on young fruit of infected trees (Stockdale 1913).

Plate 6. Tree decline on breadfruit in St Kitts (© L. B. Roberts-Nkrumah)

Plate 7. Fruit rot in breadfruit in Guyana
(© L. B. Roberts-Nkrumah)

The death of 50% of plants at the nursery in the Dominican Republic referred to above was attributed to *Phytophthora faberi* (Ciferri 1927).

The documented breadfruit research activities during most of this period were conducted under colonial influence still focused on empire-building, with support from the West India Committee and the RSA.

The Imperial Department of Agriculture for the West Indies (IDA) was established in Barbados for research on crops other than sugarcane, and agricultural problems to encourage plantation managers and farmers to adopt science-based approaches for improved operations (Brereton 2011). The Departments of Agriculture in different colonies were located at the botanic gardens and worked closely with the IDA which was staffed by several scientists such as Nowell and Stockdale both of whom later worked at these departments on diseases affecting breadfruit, a minor crop with significant food value (Stockdale 1913; Nowell 1923). Nowell's account of crop diseases in the West Indies was prepared at the request of Sir Francis Watts, commissioner of the IDA and was published by the West India Committee. Watts strongly supported the proposal for the establishment of a college of tropical agriculture and presented his case to the RSA for such an institution to fill the shortage of men trained in research on tropical agriculture for agricultural departments throughout the expanding British empire in the tropics. He became the first principal of the West Indian Agricultural College (WIAC) when it was founded in 1922 in Trinidad and Tobago and the IDA's staff, library and equipment were transferred to it. The WIAC later became the Imperial College of Tropical Agriculture (ICTA) from which the Faculty of Agriculture of the University College of the West Indies, St Augustine Campus emerged in 1960 (Brereton 2011). This is now the Faculty of Food and Agriculture, The University of the West Indies (UWI); one of the buildings in this faculty is the Sir Frank Stockdale Building.

Research from 1960 to 1979

Significant migration from the Caribbean, which began in the 1940s and continued into the 1960s, created an overseas market among the diaspora for ethnic foods. Breadfruit was among those locally produced crops that were in demand and its commercial importance grew with exports mainly to the United Kingdom at first and later to North America. During this period, breadfruit research activity on processing and postharvest management was geared to address short shelf life which was a major constraint, especially to export.

Processing

Studies at government agencies on breadfruit processing continued post World War 2 and although the government established a processing unit for research and development in Jamaica, most commercial processing there and in Trinidad and Tobago was not linked to local agriculture (Sammy 1972). It was the research by private processing companies that first led to commercial production of processed breadfruit products and in 1960, breadfruit was first exported from Jamaica to the UK as canned slices and as chips. At UWI St Augustine campus, the newly founded Food Technology Unit in the Faculty of Engineering, gave research emphasis to product development from locally produced crops to address the increasing food import bill. Studies were conducted to improve methods for canning breadfruit in brine (Lubin 1973) and breadfruit flour substitution for wheat flour was evaluated for acceptability for making bread (Sammy 1974). Additionally, acceptable, protein-enriched with either peanut or soybean, drum-dried or cabinet-dried breadfruit breakfast foods were developed (Newton 1975). However, no studies were conducted on the amino acid profile or nutritional value of the protein-enriched products. Furthermore, a mechanism was needed to apply the findings to commercial operations (Sammy 1975).

Studies on breadfruit flour were ongoing at the cottage level in several countries in the region and at Government institutions in St Vincent and the Grenadines, Jamaica and Barbados (Leakey 1977). The main areas of investigation were

the levels of wheat flour substitution by breadfruit flour for an acceptable bread and the prevention of oxidative browning due to enzymatic activity.

Studies at the University of California with Puerto Rican breadfruit, showed that both tunnel-drying and freeze-drying extended storage life beyond 6 months and that after reconstitution in hot water, the flavour and texture of the product was similar to that of freshly cooked fruit (Reeve 1974). In the absence of information relevant to processing on the fruit, the investigations included fruit morphology, relative composition of rind, core and pulp in fresh and dried fruit, histology, starch distribution within the fruit and proximate composition of the dried fruit. Observations were made on challenges in preparing the fruit. The information obtained was applied to understand the challenges encountered during fruit preparation, the effect of different cooking methods on pulp texture and provided recommendations for preparation and suitable products. Although, the study was prompted by a request from American Samoa to the United States Department of Agriculture, the findings were of much interest to the English-speaking Caribbean, because of the use of breadfruit from Puerto Rico.

Post harvest management

The availability of processing technologies did not significantly reduce seasonal gluts or satisfy the demand for breadfruit in the UK. Extension of shelf life was a research priority primarily because the export market was based mainly on fresh fruit and a high percentage of loss due to ripening was experienced during the first shipments from Jamaica to the UK. The Food Storage Division of the Ministry of Commerce and Consumer Protection in Jamaica conducted the first investigations on the effects of cultivar, harvesting method, storage temperature and packaging on shelf life. The findings were that storage in polyethylene bags or water at temperatures as low as 12^0C extended shelf life but that temperatures lower than 12^0C caused chilling injury. Together with the results from further research with the Tropical Products Institute in England, these findings were used to improve postharvest management and the quality of shipped fruit (Thompson et al. 1974; Marriot et al. 1979).

Propagation

In Puerto Rico, a significant improvement in the efficiency of breadfruit propagation was achieved by the use of stem cuttings from adventitious shoots arising on root cuttings as planting material, instead of using one root cutting to produce a single plant. However, the actual number of rooted stem cuttings produced per root cutting was not reported. The efficacy of auxins and the effect of season of collection on rooting of lateral branches and root cuttings were also investigated (Rivera Lopez and Rodriguez 1969; Toro Toro 1979).

Reconnaissance Study

In 1977, a two-week reconnaissance of breadfruit, funded by the Inter-American Development Bank (IAB), was undertaken in Trinidad and Tobago, Guyana, Jamaica, Montserrat, Barbados, St Vincent, Puerto Rico and St Martin. Apart from a comprehensive review of existing scientific literature on breadfruit, the report from this study included findings on the current status, knowledge and potential of breadfruit and breadnut for future development in the Caribbean (Leakey 1977). On-going research on nutrient composition, composite flour, starch amylose content, propagation from callus and stem cuttings, the cost of breadfruit as a source of protein and energy, as well as statistics on production and per capita availability for several countries were recorded. Recommendations were made for the development of the crop by the introduction of additional germplasm to expand the germplasm base to address

existing constraints and the continuation of research and development activities, with the suggestion that the IAB should consider funding these activities.

This report was significant because it highlighted the status of breadfruit as an underutilised and neglected species that required government support for developmental activities at the community and institutional levels for the crop to achieve its potential to contribute to food and nutrition security and revenue generation. A more detailed survey of breadfruit in the region, a bulletin for knowledge sharing, orchard establishment and additional research to develop the required knowledge base to solve technical and economic problems was also proposed. Some key areas identified for research on a multi-locational basis included germplasm evaluation, propagation and composite flour. Therefore, this study contributed to an expanded view of the future breadfruit research needs in the Caribbean and suggested a coordinated regional approach (Leakey 1977).

Conclusion

Undoubtedly, the two voyages of Captain Bligh to the South Pacific between 1789 and 1791 accomplished important objectives associated with expansion of the British empire, including the acquisition of new plant species of known or potential economic importance. These objectives, however, did not overshadow the objective to obtain the breadfruit plant which, with minimum care, was expected to contribute to the profitability of the sugar industry in the Caribbean by providing a bountiful food supply to stem the starvation and loss of the free labour force due to food shortages. Backed by the RSA and the West India Committee of planter and traders, some of the best minds and competent hands engaged in research, especially in botany and horticulture to support the successful introduction and subsequent distribution of the plant throughout the Caribbean. Breadfruit did not become the main staple even after the crop was accepted as a food item for human consumption, apparently because of preference for the more familiar local staples. It gained a reputation as a crop that could be relied on during food crises because of its high productivity. However, this advantage did not stimulate consistent research to develop it as a food crop with attractive, convenient and affordable products for year-round availability and increased local consumption; instead the research was more export-oriented. For almost 200 years after its famous introduction to the region, the research at government and agricultural institutions was inadequate and insufficiently integrated and coordinated for the development of this food crop, reflecting its status as an underutilised and neglected crop in spite of its demonstrated potential to contribute to food and nutrition security.

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