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An Overview of Breadfruit (*Artocarpus altilis*) in the Caribbean

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Abstract

Breadfruit (*Artocarpus altilis*) was introduced to the Caribbean in 1793 to enhance the food supply. This paper presents a brief account of the introduction and discusses the changing status of the crop as a carbohydrate food source in terms of consumption levels, major methods of utilisation, production systems and markets. The constraints to commercialisation of the crop, and past and present research activities undertaken to address these limitations, are also discussed. Research activities include germplasm collection, conservation, description and evaluation, macro- and micro-propagation, crop phenology, pruning, disease control, post-harvest physiology and technology, product development, nutritional composition, and medicinal and insecticidal properties. Research on breadnut (*A. camansi*), a close relative, is outlined. Breadfruit has significant potential to contribute to food needs in the region. Development of the agricultural sector and breadfruit conservation and commercialization are linked. Closer collaboration among producers, processors, marketers, the rural population, government agencies and research and training institutions is a necessary framework for achieving these objectives.

INTRODUCTION

In the multi-lingual Caribbean, the common names breadfruit, *Artocarpus altilis* (Parkinson) Fosberg, is referred to as "cow," "panbwa," "pain bois," "frutapan," and "fruta de pan." This paper treats primarily with the English-speaking Caribbean except where otherwise specified, therefore, the name breadfruit will be used. The food import bill for this region was USD 1.5 billion in 2001 suggesting that food security through increased production of local food should be an important goal. Breadfruit also has the potential to contribute to sustainable agricultural development because of its multiple food and non-food uses which should improve its economic viability. As a tree crop, its production is environmentally friendly: its cultivation and harvesting do not disturb the soil; the litter encourages nutrient recycling and the canopy protects against soil erosion. It is also a low-maintenance, perennial crop that does not require annual replanting. Despite the tremendous potential that these characteristics confer, breadfruit remains very much under-utilised in the Caribbean. This paper discusses factors influencing its under-utilisation, efforts that are being made to promote the crop, and briefly proposes a framework for its development.

INTRODUCTION OF BREADFRUIT TO THE CARIBBEAN

Breadfruit was successfully introduced into the Caribbean in 1793 by Captain William Bligh. This introduction was in response to requests to King George III by British sugar cane planters and merchants to acquire the plant which Captain Cook had encountered in the South Pacific and had described as being similar to bread in flavour, texture and use (Powell, 1977). During this period, Caribbean agriculture-based economies were dominated by sugar cane and food requirements of the local populations were met primarily by imports such as wheat flour and salted meats and fish. Significant

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decimation of African labour, particularly from 1775 due to disease and food shortages caused by natural disasters and the trade embargo imposed on food imports from the United States during the War of Independence, prompted the requests. Breadfruit's introduction represented the first official, deliberate attempt at food security in the Caribbean. Apart from its organoleptic characteristics, this species was regarded as an ideal choice because it was less susceptible to hurricanes than plantains, reputedly bore fruit for nine months of the year and, very importantly, required little maintenance. A total of 682 plants survived the six-month journey from Tahiti and Timor and were delivered to St. Vincent and Jamaica. From these two territories, especially St. Vincent, the plant was distributed throughout the Caribbean.

THE STATUS OF BREADFRUIT IN THE CARIBBEAN

Consumption

The Africans, who were expected to be the major beneficiaries of this new food source, rejected the fruit, preferring the more familiar yams and plantains, so it was fed to pigs, thereby contributing indirectly to the local food supply. During the post-Emancipation period, it became an important carbohydrate source and until the mid-twentieth century, it was a staple, particularly for the rural population in some territories. In Jamaica, the estimated annual per capita consumption was 50.2 kg in 1958 which declined to 16.7 kg by 1973; in Barbados, the annual per capita consumption was only 3.7 kg in 1971 compared with 12 kg in 1966 (Leakey, 1977). These figures can be compared with the estimated annual per capita yam consumption in Jamaica in 1973 (58.6 kg) and in Barbados in 1971 (42.4 kg). Estimated total consumption in Jamaica between 1995 and 1999 was 16,400 t (Wickham, 2001), compared with 33,500 t in 1973.

Traditionally, breadfruit consumption was stigmatized due to its association with slavery, food shortages and poverty. As economic conditions improved and lifestyles changed, wheat flour, white potatoes and rice consumption increased, while consumption of local root crops and breadfruit declined. Although factors such as higher prices, perishability and inconvenient preparation methods also weighed against both root crops and breadfruit, the decline in root crop consumption was less marked than in breadfruit. Leakey's (1977) estimates suggest that declining breadfruit consumption was also related to declining production levels.

Negative perceptions of breadfruit are not ubiquitous, since the crop is highly appreciated in St. Vincent and Jamaica. In St. Vincent, it is part of the national dish along with jackfish, and in Jamaica, it is commonly eaten with the favorite dish, ackee and saltfish. A recent Trinidad survey suggests the strong stigma against breadfruit has declined and that high consumption at meals is not related to household income (Roberts-Nkrumah and Badrie, 2005). Breadfruit has been identified among 25 local "super-foods" which are nutrient-rich (Magnus, 2005). It is believed that health education and increasing appreciation of local culture are major factors contributing to the attitude change, especially among the middle class. Often, during season the fruit is found on many restaurants' daily menus and its place in the local cuisine and culinary potential are featured at annual breadfruit festivals and food fairs throughout the region. The French and Dutch islands appear to appreciate it, while the Spanish-speaking territories still regard it as food for the very poor.

Utilisation

In the Caribbean, breadfruit is utilised at all meals primarily as a carbohydrate source, its bland flavour complemented by meat- or fish-based dishes, especially salted fish and salted pork. Major forms of preparation include roasting, boiling, frying of roasted or boiled slices and baking. Boiled flesh is used widely, often as a substitute for white potato in salads, pies and casseroles. In Trinidad and Grenada, the most popular form of preparation is a one-pot dish called "Oil-Down" (Roberts-Nkrumah and Badrie,

2005). Fruits are used to prepare a milk-based drink or punch, with or without alcohol, and wines. Male inflorescences are made into a candy.

Flour is a traditional preservation method in rural areas and is used in porridges or substituted for wheat flour. Fried chips are prepared at home as a snack food and manufactured seasonally by a few cottage industries. Three large chip processors in Barbados, Trinidad and Jamaica have stopped production due to increasing labour costs in Trinidad and unknown factors in the other territories. "Mafongo" is a fried and crushed breadfruit chip that is consumed in Puerto Rico.

Yellowing leaves are used for hypertension control. Burnt male inflorescences are a mosquito repellent. The wood is used as an inexpensive construction lumber.

Production

Large numbers of trees occur in natural groves in abandoned areas, gullies or "ghauts." On farms, they are grown mostly with other tree crops, bananas and short-term crops. They are also planted on field borders, as shade trees or as windbreaks. Pure-stand cultivation is new and very small scale. A 15 ha commercial orchard, established in Jamaica during the 1990s, was abandoned over the last 3 years as its owner company reduced its diversification activities. A few smaller orchards were recently established.

Breadfruit's genetic diversity is limited in the region. Bligh recorded that he had collected six types (Powell, 1977). Some countries recognize only one type, but in most of the others, including Puerto Rico, 'Yellow' or 'Yellow Heart' and 'White' or 'White Heart' cultivars are recognized based on their flesh colour. In St. Vincent and Jamaica, diversity is greater with at least 24 and six cultivar names, respectively, predominantly 'Yellow' and 'White', with other less-known cultivars.

Official production figures are not available for most territories. The general view is that production decreased significantly due to decline in tree populations, resulting from tree removal (for urban expansion and short-term cash crops) and, except by farmers who sell the fruit, non-replacement of trees dying from old age, disease or environmental stresses.

Planting material is sold by government and private nurseries and farmers. At government nurseries, annual production ranges from one to several hundred plants. Most nurseries produce only the 'Yellow' cultivar because of farmers' preferences.

Markets and Trade

Breadfruit is marketed locally, regionally and internationally. The domestic market is the largest market for most territories except those that are major producers with small local markets (e.g., St. Lucia). Fruits are sold fresh but in response to the demand for more convenience, small quantities of minimally processed and prepared forms such as whole roasted fruits and peeled, vacuum-packed, chilled or frozen slices are now available.

Fresh fruits are exported regionally to those territories where production is relatively low, largely due to their prevailing drier climate. Immigrants from territories with higher production also create a demand. Most breadfruit exported from Dominica goes to the Leeward Islands, which also import fruit from St. Lucia. The extra-regional export market for fresh breadfruit has existed for several decades, namely from Jamaica to England. Since the 1980s, with the agricultural diversification thrust, several other Caribbean territories became exporters to England, Canada and the United States where there are large Caribbean immigrant populations. The major exporters are St. Lucia and Jamaica. Trinidad and Guyana also export breadnut or "chataigne" (*A. camansi* Blanco). During the 1990s, extra-regional exports peaked in 1998 at 2023 t but fell to 1203 t by 2005 (Table 1). Declining exports were due to the closure of the marketing company that supported the export of non-traditional crops, financial losses and natural disasters, such as the hurricanes of 2004, which severely damaged trees and resulted in reduced supplies.

CONSTRAINTS TO COMMERCIALISATION AND RESEARCH ACTIVITIES

In the Caribbean, there is a history of research on breadfruit to address several constraints to production, shelf-life and product development that have frustrated the interest in greater exploitation of the commercial potential of this crop. Most of the research has been undertaken at the University of the West Indies (UWI) campuses in Barbados, Jamaica or Trinidad, and to a lesser extent at other research institutions in the region. The most important constraints, and the past and current research activities undertaken to address them, are summarized below. Details on research in the Caribbean on production, post-harvest and product development are presented in other papers at this symposium.

Production Constraints

1. Seasonality. Breadfruit has two annual production periods. The major season is June-September with a smaller crop in December-February. Some breadfruit can be found year-round in locations with favourable environmental conditions. Prices fluctuate significantly with season.

2. Tree Height. Mature trees can be over 20 m tall and bear over 300 fruits/yr, but more than 50% is lost because fruits in the upper canopy are inaccessible for harvesting.

3. Limited Germplasm. Available germplasm is limited, causing little difference in seasonality and tree height. Where greater diversity exists, there is no conservation and evaluation.

4. Lack of Planting Material. Constraints to commercial orchard establishment are inadequate quantities of planting material, an inefficient 12-month-long propagation process, and non-uniformity of material size.

5. Lack of Information on Suitable Orchard Establishment and Management Practices. There is no available information on appropriate agronomic practices such as plant spacing and arrangements, tree training and height control, or nutrition and water management to guide commercial production. Considerable fruit drop occurs from early fruit growth almost to maturity.

6. Disease. Fruit rot—causing large dark brown, sunken areas on the skin—makes fruit unmarketable. This disease is referred to as "bee sting" and believed to be associated with insect damage. Another important disease in some territories is a tree dieback or decline that reduces the fruit number and size, causes branch dieback and can kill mature trees within a year from the first observation of symptoms.

Production-related Research Activities

1. Germplasm Description, Collection and Evaluation. In 1990, description of the existing breadfruit germplasm in Jamaica, St. Vincent and Trinidad began (Roberts-Nkrumah, 1997) and a field collection was established at the UWI in Trinidad for more detailed description and evaluation. Table 2 shows the breadfruit cultivars that have been identified in the region. In 1990, the UWI, on behalf of the Jamaica Agricultural Development Foundation, introduced 30 accessions from the breadfruit collection at the National Tropical Botanical Garden in Hawaii, USA. Planting material was sent to Jamaica to establish collections in different locations there. Presently, the only accessions in Jamaica are at the Mona Campus. An evaluation of 25 surviving accessions from Hawaii was undertaken at the St. Augustine Campus in Trinidad (Roberts-Nkrumah, 1998). Vouchered herbarium specimens were prepared and preliminary characterization work using morphological descriptors and molecular markers has been done. All accessions are being evaluated for horticultural characteristics such as tree growth, seasonality, disease susceptibility and yield. This evaluation needs to be extended to other locations.

2. Plant Propagation. In Puerto Rico, research was done to improve planting material uniformity by taking cuttings from the adventitious shoots (Rivera-Lopez and Rodriguez, 1975). Studies in Trinidad focused on improving the efficiency of using root cuttings to obtain more plants. Research on breadfruit micropropagation has demonstrated that this is

a viable approach for mass producing uniform planting material (Rouse-Miller and Duncan, 2000). However, plants produced by this method still have to be field evaluated.

3. Orchard Management. Investigations on the pattern of fruit set on breadfruit canopies have indicated the importance of tree spacing, arrangement, height and canopy architecture on harvestable yield and profitability of pure stand plantings (Roberts-Nkrumah, 2004). Some preliminary studies on pruning mature trees have been undertaken in St. Lucia and Jamaica and research on spacing and pruning are in progress in Jamaica and in Trinidad.

In Trinidad, studies on the comparative phenology of breadfruit cultivars was undertaken and continues along with studies on nutrient uptake. Efficacy of growth regulators on vegetative and reproductive growth has been examined. Proper cultivar selection, improved water and nutrition management, pruning and where appropriate, the use of growth regulators, may also be useful components of strategies to address the problem of seasonality.

4. Disease Control. Studies were conducted in Jamaica on the breadfruit tree decline disease by Coates-Beckford and Pereira (1992, 1997). High nematode populations, *Fusarium* spp. and *Pseudomonas* spp. were associated with affected trees and soil solarization was recommended as a control measure. Further investigations may be needed in other territories where the disease has been attributed to water-logging.

Post-harvest Constraints

Breadfruit is harvested in the green-mature stage to facilitate preferred forms of preparation. A major problem is that fruits ripen in 2-3 d and are rarely utilised in this form. Traditionally, harvested fruits were stored in water to extend shelf-life. Polius (1981) estimated that post-harvest losses were up to 50% in St. Lucia, and attributable to improper harvesting methods and inadequate post-harvest management, particularly temperature management. These losses and those represented by fallen fruit contribute to substantial waste of this crop.

Post-harvest Related Research Activities

Studies in Jamaica on the effects of cultivar, harvest method, storage temperature and packing (Thompson et al., 1974; Marriott et al., 1979) highlighted the potential for shelf-life extension by low-temperature storage and the risk of chilling injury. Subsequent work in Trinidad explored temperature, storage in water, shrink-wrapping, coatings, packaging and controlled atmosphere storage (Maharaj and Sankat, 2004). Research on shelf-life extension for minimally processed food was undertaken. In Trinidad, Passam et al. (1981) reported on blanched and frozen breadfruit slices and Samsoondar and Sankat (1998) examined the effect of storage temperature and packaging on the physical, chemical and sensory characteristics of minimally processed breadfruit. Physiological studies include fruit growth and maturity indices in Barbados (Worrell et al., 1998) and preliminary investigations to compare cultivars in Trinidad and enzyme systems involved in breadfruit ripening (Williams and Golden, 2002).

Product Development Constraints

The major constraint to product development is that raw material supplies are seasonal, limited and relatively expensive due to the demand for fresh fruit. The bulky nature of the fruits and their short shelf life also make storage options expensive. Other constraints that can negatively affect product quality include variable stages of fruit maturity at harvest, cultivar differences, difficulties in hand preparation (e.g., peeling and knife-drag due to latex content) and inner tissue sponginess of mature fruit. The requirement for hand preparation makes breadfruit processing uneconomical where labour costs are high.

Product Development-related Research Activities

Among research and development (R&D) activities in the Caribbean, breadfruit flour has been investigated most widely. Research in Jamaica, St. Vincent, Montserrat and Trinidad focused on preventing flour browning by applying antioxidants (Leakey, 1977) and the development of composite flours. Varying proportions of breadfruit flour to wheat flour were evaluated for their suitability for baked products, and comparisons were made with composite flours of other starchy foods. Work was done on the use of breadfruit flour for extruded product manufacture (Baccus-Taylor and Comissiong, 1996). Nochera and Caldwell (1992) evaluated the effect of adding various protein sources on the nutrient composition and the sensory characteristics of baked products made from composite flour using Puerto Rican breadfruit. Bates et al. (1991) established the acceptability of chips made from Puerto Rican breadfruit. In Trinidad, research was conducted on flavoured chips to improve consumer appeal and Roberts et al. (2007) evaluated different cultivars for suitability for chip production. Work has also been done on extruded products, canned breadfruit slices (Baccus-Taylor and Comissiong, 1996) and on a milk-based, pasteurized breadfruit drink (Graham et al., 1997).

Other Areas of Research

1. Consumer Preferences. Perceptions of breadfruit as being less desirable than other starchy foods is a constraint that still affects consumption in some parts of the Caribbean, especially among the youth. In order to satisfy consumer needs and encourage increased consumption, a survey was recently conducted on consumer attitudes about breadfruit and preferences for cultivars and cooking methods in Trinidad (Roberts-Nkrumah and Badrie, 2005). This information provides useful guidelines for evaluating cultivar sensory characteristics and suitability for different methods of preparation and processing.

2. Nutrition and Health. To educate Caribbean people about the link between the diet and health, the Caribbean Food and Nutrition Institute conducted studies on the nutrient composition of local foods and published information to encourage consumption of breadfruit, among other foods, for the management of diabetes mellitus. Nutritional composition of common breadfruit-based meals (e.g., ackee and saltfish and roasted breadfruit (Samuda et al., 1998) and "oil-down" (Badrie et al., 2005) was analysed to provide more useful information on nutrient intake from breadfruit consumption. Investigations showed that breadfruit can be recommended for consumption by diabetic persons based on its lower glycaemic index than that of cereals (Ramdath et al., 2004).

3. Insecticidal and Medicinal Properties. In Jamaica, studies by Young et al. (1993) on the efficacy of breadfruit leaf extracts in lowering blood pressure in rats seem to validate the use of the breadfruit leaf in traditional medicine for hypertension control. Williams (1993) reported that extracts from the plant may be effective for tick control on livestock. Other studies indicated potential usefulness of extracts as bait for sweet potato weevil control and as an anthelmintic (treatment against roundworm).

4. The Breadnut or "Chataigne." In the Caribbean, this species, generally viewed as a seeded breadfruit, is the probable ancestor of breadfruit (Zerega et al., 2004). Although introduced into the region before breadfruit, trees are seen in only a few countries, mostly Trinidad and Guyana where cooked immature fruit and mature seeds are appreciated, especially by people of East Indian descent. Fruits are exported, mainly to Canada. Breadnut has received very little research attention. Areas that have been addressed include nutrient composition of the seed (Negron de Bravo et al., 1983) in Puerto Rico, and micropropagation (Rouse-Miller, 1993), fruit and seed yields (Bennett and Nozzolillo, 1987; Roberts-Nkrumah, 2005), and seed canning (Matthews et al., 1997) in Trinidad.

THE FUTURE OF BREADFRUIT IN THE CARIBBEAN

Breadfruit faced two major obstacles to its recognition as an important contributor to food supply. Firstly, it is a late-comer relative to other tropical starchy crops and imported cereals. Secondly, the crop thrives without maintenance leading to the persisting view that it is of low value because it requires no inputs. This easily accounts for the general failure to replace trees and the scarcity of some cultivars which may require more care than 'Yellow' and 'White'.

Nevertheless, expectations about the potential importance of breadfruit in the region are optimistic. The preceding discussion indicates that consumer attitudes are changing and the history and breadth of research on breadfruit in the Caribbean suggest that there is confidence in the potential of this crop. The governments of St. Vincent and Jamaica have now included breadfruit among those crops to be given emphasis in agricultural development programmes. This development needs support in these countries and encouragement in others, and perhaps the time has never been more favourable than to do so now.

Demonstration of breadfruit's economic potential is critical to securing acknowledgement of the value of this crop to food security and agricultural development and interest in germplasm conservation. Towards this end, it is important to support commercial activities (production, marketing, exporting and processing) to achieve greater economic viability. Greater domestic consumption also needs to be encouraged, especially among youth. Past and current research provides valuable information for improvement of these and other relevant areas to accelerate sustainable breadfruit commercialisation. However, the information needs to be shared at the industry level through outreach and training activities. The research has to be expanded, but lack of funding has seriously limited studies in several key areas identified above. Another key aspect of improved breadfruit production and utilisation is that the participation of the rural population must be deliberately sought, but not within the context of breadfruit as a food crop for poverty alleviation since this will only perpetuate negative attitudes. Rural people can contribute much to the knowledge of production systems, pests and diseases, food and non-food uses, germplasm conservation, and should be active participants and beneficiaries in any efforts to develop a breadfruit industry.

Creation of closer links between the government, private sector and research institutions is a critical requirement within the Caribbean. The UWI should play a major role in initiating these linkages, because this task will be best performed using a regional approach to address broad, common issues. Within this framework of collaboration, there should be wider participation in setting research priorities for breadfruit, more outreach and information-sharing and more tangible support for, and coordination of, national and regional research efforts for better use of limited resources.

Literature Cited

Baccus-Taylor, G.H.S. and Comissiong, E.A. 1996. Processing of breadfruit. In: S. Forde (ed.). Marketability of Caribbean minor fruits. Proc. CARDI/CTA Workshop on Marketability of Caribbean Minor Fruits, Port of Spain, Trinidad and Tobago, 19-24 October 1996. St Augustine, Trinidad and Tobago, p.164-170.

Badrie, N., Balfour, S., Ottley, K. and Chang-Yen, I. 2005. Nutrient composition of a commonly consumed West Indian meal of breadfruit (*Artocarpus altilis* Fosberg) oil down. J. Nutrition in Recipe and Menu Dev. 3:19-35.

Bates, R.P., Graham, H.D., Matthews, R.F. and Clos, L.R. 1991. Breadfruit chips: stability and acceptability. J. Food Sci. 56:1608-1610.

Bennett, F.D. and Nozzolillo, C. 1987. How many seeds in a seeded breadfruit, *Artocarpus altilis* (Moracae). Econ. Bot. 41:370-374.

Caribbean Food and Nutrition Institute. 1995. Food composition tables for use in the English-speaking Caribbean, 2nd Ed. CFNI, Jamaica.

Coates-Beckford, P.L. and Pereira, M.J. 1992. Survey of root-inhabiting microorganisms of declining and nondeclining breadfruit (*Artocarpus altilis*) in Jamaica. Nematropica 22:55-63.

Coates-Beckford, P.L. and Pereira, M.J. 1997. Soil solarization for the control of a slow decline of breadfruit (*Artocarpus altilis*) trees. Plant Path. Bull. No. 1. Dept. of Life Sciences, Univ. of the West Indies, Mona Campus.

Graham, O., Wickham, L.D., Badrie, N. and Mohammed, M. 1998. Physicochemical, microbiological and organoleptic evaluation of a pasteurized breadfruit drink. Proc. 9th Seminar on Agricultural Res. and Development, NIHERST, Trinidad and Tobago, p.21-28.

Leakey, C.L.A. 1977. Breadfruit reconnaissance study in the Caribbean region. CIAT/Inter-American Dev. Bank, Cali, Colombia.

Magnus, H. 2005. The top 25 superfoods. Cajanus 30:3-13.

Maharaj, R. and Sankat, C.K. 2004. Effect of shrink-wrapping and controlled atmosphere storage on the postharvest browning and quality of breadfruit. ASEAN Food J. 13:29-40.

Marriott, J., Perkins, C. and Been, B.O. 1979. Some factors affecting the storage of fresh breadfruit. Scientia Hort. 10:177-181.

Matthews, R., Commissiong, E., Baccus-Taylor, G. and Badrie, N. 2001. Effect of peeling methods on breadnut (*Artocarpus altilis*) seeds and acceptability of canned breadnut seeds in brine. J. Food Sci. Technol. 38:402-404.

Negron de Bravo, E., Graham, H. and Padoran, M. 1983. Composition of breadnut (seeded breadfruit). Caribbean J. Sci. 19(3-4):27-32.

Nochera, C. and Cadwell, M. 1992. Nutritional evaluation of breadfruit-containing composite flour products. J. Food Sci. 57:1420-1422, 1451.

Passam, H.D., Maharaj, D.S. and Passam, S. 1981. A note on freezing as a method of storage of breadfruit slices (*Artocarpus altilis*). Trop. Sci. 23:67-74.

Polius, J. 1981. Post harvest losses in St. Lucia. In: Report of post harvest losses consultative meeting. Caribbean, Food Production and Rural Dev. Div., London, Commonwealth Secretariat. 2:95-106.

Powell, D. 1977. The voyage of the plant nursery, HMS Providence, 1791-1793. Econ. Bot. 31:387-431.

Ramdath, D.D., Isaac, R.L.C., Teelucksingh, S. and Wolever, T.M.S. 2004. Glycaemic index of selected staples commonly eaten in the Caribbean and the effects of boiling v.crushing. British J. Nutrition 91:971-977.

Rivera-Lopez, C. and Rodriguez, S.J. 1975. A method to obtain relatively uniform breadfruittrees from a stockplant. J. Agri. Univ. Puerto Rico 59:77 -78.

Roberts, K., Badrie, N. and Roberts-Nkrumah, L.B. 2007. Colour and sensory characteristics of fried chips from three breadfruit (*Artocarpus altilis*) cultivars. Acta Hort . 757:225-231.

Roberts-Nkrumah, L. B. 1997. Towards a description of the breadfruit germplasm in St. Vincent. Fruits 52:27-35.

Roberts-Nkrumah, L. B. 1998. A preliminary evaluation of the imported breadfruit germplasm collection at the University of the West Indies, Trinidad. Proc. 34th Caribbean Food Crops Soc. Meeting, p.29-34.

Roberts-Nkrumah, L. 2004. Management implications of the distribution of fruit set on breadfruit trees. Acta Hort. 632:201-207.

Roberts-Nkrumah, L. 2005. Fruit and seed yields in chataigne (*Artocarpus camansi* Blanco) in Trinidad and Tobago. Fruits 60:387-393.

Roberts-Nkrumah, L. B. and Badrie, N. 2005. Breadfruit consumption, cooking methods and cultivar preference among consumers in Trinidad, West Indies. Food Quality and Preference 16:267-274.

Rouse-Miller, J. A. 1993. Studies on *Artocarpus altilis* with emphasis on in vitro propagation. MPhil. Thesis. Dept. Plant Science, Faculty of Natural Sciences, St. Augustine. (Unpubl.).

Rouse-Miller, J. and Duncan, E.J. 2000. In vitro propagation of *Artocarpus altilis* (Park.) Fosberg (breadfruit) from mature plant material. In Vitro Plant Cellular and Developmental Biol. 36:115-117.

Samsundar, J. and Sankat, C.K. 1998. Storage of minimally processed breadfruit. Proc. Interamerican Soc. for Trop. Hort. 42:133-139.

Samuda, P.M., Bushway, A.A., Beecher, G.R., Cook, R.A. Work, R., Cook, C.M. and Bushway, R.J. 1998. Nutrient content of five commonly consumed Jamaican foods. J. Food Consumption and Analysis 11:262-275.

Thompson, A.K., Been, B.O. and Perkins, C. 1974. Storage of breadfruit. Trop. Agri. 51:407- 415.

Wickham, L. D. 2001. Small-scale processing of starchy staples in CARICOM countries. Food and Agriculture Organization, Rome.

Williams, L.A.D. 1993. Adverse effects of extracts of *Artocarpus altilis* Park. and *Azadirachta indica* (A. Juss) on the reproductive physiology of adult female tick, *Boophilus microplus* (Canest.). J. Invertebrate Reproduction and Dev. 23:159-164.

Williams, O.J. and Golden, K.D. 2002. Purification and characterization of ACC oxidase from *Artocarpus altilis*. Plant Physiol. Biochem. 40:273-279.

Worrell, D.B., Carrington, S.C.M. and Huber, D.J. 1998. Growth, maturation and ripening of breadfruit, *Artocarpus altilis* (Park.) Fosb. Scientia Hort. 76:17-28.

Young, R.E., Williams, L.A.D, Gardner, M.T. and Fletcher, C.K. 1993. An extract of the leaves of the breadfruit, *Artocarpus altilis* (Parkinson) Fosberg exerts a negative inotropic effect on rat myocardium. Phytotherapy Res. 7:190-193.

Zerega, N.J.C., Ragone, D. and Motley, T.J. 2004. Complex origins of the breadfruit: implications for human migrations in Oceania. Amer. J. Bot. 91:760-766.

Tables

Table 1. Extra-regional breadfruit exports from the English-speaking Caribbean from 1998 to 2005.

Year	Quantity exported (t)
1998	2023
1999	1757
2000	1461
2001	1328
2002	1752
2003	1441
2004	1393
2005	1203