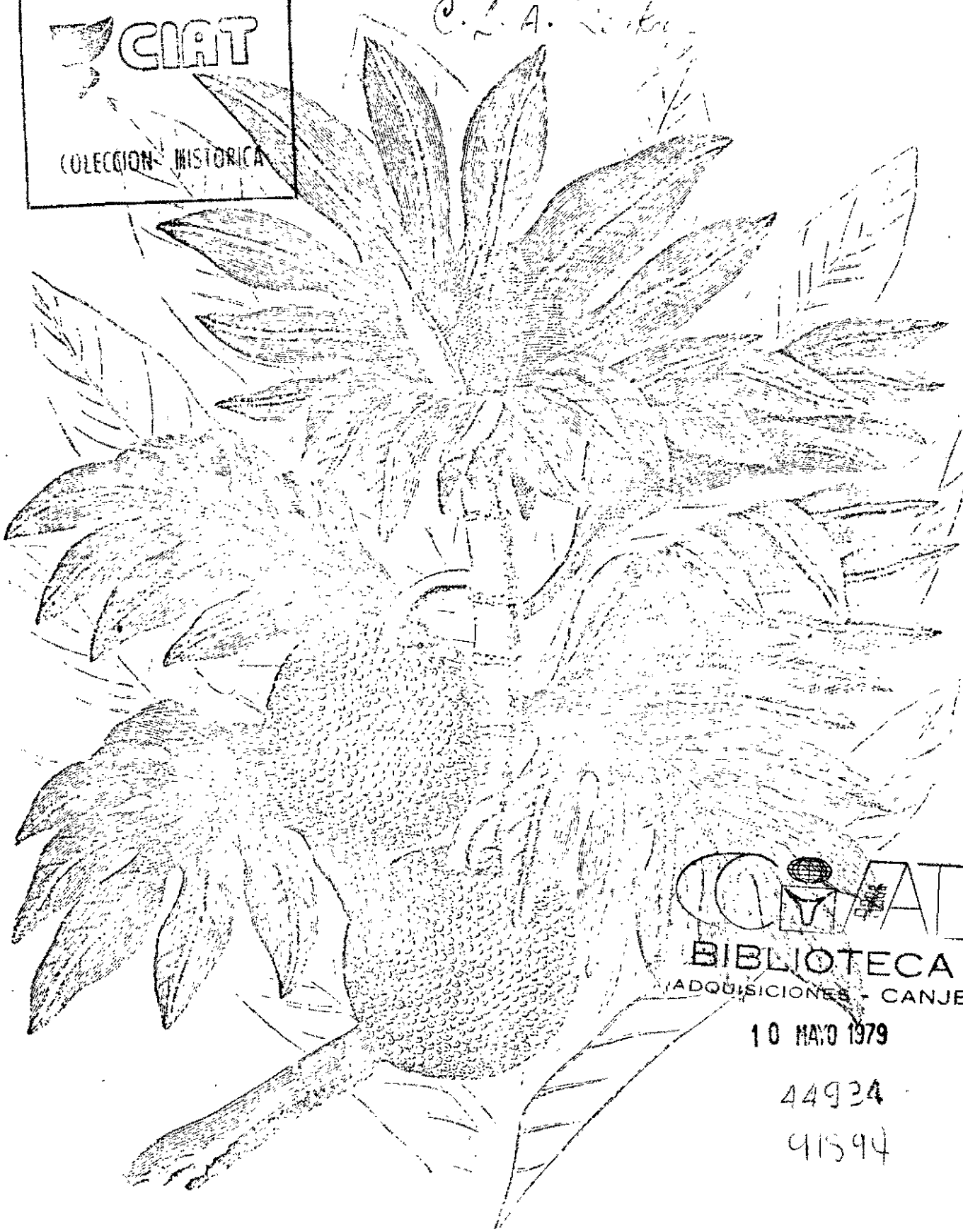
C.I.A.T./ Inter-American Development Bank

C. I. A. T.



BREADFRUIT RECONNAISSANCE STUDY IN THE CARIBBEAN REGION

RECOMMENDATIONS

It is recommended:

1. That the I.A.D.B. sponsor a mission to evaluate, collect and transfer breadfruit clones from the Pacific area to the Caribbean region by way of an intermediate quarantine station so as to ensure that diseases previously unknown in the Caribbean Region are not also transferred. This operation to be called "Operation New Providence".

2. That the Ministers of Agriculture in the Caribbean Region and CARDI be informed of the potential value of breadfruit as indicated in the present study and be requested to plan for a more detailed survey to be carried out by their staff during the crop season 1978 by means of a questionnaire applied on a sample basis. A draft questionnaire is appended to this report. It is suggested that a prize (following the long tradition of "Premiums" of the Royal Society of Arts) might be offered in each island to the returner of the questionnaire adjudged most informative.

3. That an Information Bulletin on breadfruit be published for widespread distribution in the Caribbean Region by the Bank entitled "Why waste good food? Preserving the breadfruit". Caribbean Breadfruit Bulletin No.1 IADB (draft appended.) This will be based upon the direct transfer of existing knowledge from the South Pacific region.

4. That the IADB introduces a programme called the Caribbean Operation for the Utilization of Technology (CARIOUT!) with the objective of fostering (sponsoring) through existing Organisations, such as CARDI and the Association of Caribbean Universities, specific developmental activities using existing knowledge. In particular CARIOUT should aim to seek out and support, mainly (but not exclusively) Caribbean people from various walks of life, irrespective of formal qualifications, who have knowledge and proven abilities that could be of community benefit if extended. Specifically, in the area of breadfruit development, it is proposed that funds should be made available to the following individuals after consultation with the Bank as follows:
   a) Miss Lashley - funds to set up a rural food processing industry in Tobago to prepare and market breadfruit flour, breadfruit figs and to develop recipe products to popularize the use of the breadfruit among the people of Tobago.
   b) Mr John Wezgren - to undertake graduate studies in the UWI using his present knowledge and experience as a basis for a thesis on the "Transfer of knowledge to village technology."
   c) Mr Baichoo (or to the Department of Agriculture, Horticulture Section, Timheri, for the re-equipping of an area of the existing (rundown) nursery for the development of vegetative propagation of breadfruit in Guyana.
   d) Mr Hussein for i) travel funds to visit the island of Saba to assess the supply position of breadfruit root cuttings and to transfer cuttings on a sufficient scale for large propagation trials in Montserrat. ii) to collect (purchase) seed of

breadnut and jackfruit from Trinidad and Jamaica respectively to establish a seedling nursery in Montserrat for experiments/ development of top-working propagation of breadfruit.

5. Initiate a programme (through Mr Kirby, Acting Director of Agriculture) at the St. Vincent Botanic Garden to purchase and propagate from root cuttings of superior breadfruit clones (existing on that island) from carefully identified individual trees of the Koshi, Cocoabread and Waterloo breadfruit. These nurseries in time to provide for the further supplies of clonal cuttings for trials for evaluation in several Caribbean localities in comparison with the new clones to be introduced under recommendation 1.

6. In the longer term (1978+), depending upon the outcome of inter-Ministerial discussions for which papers should be prepared during the coming year's work, IADB may wish to support a CARDI programme of development-orientated research on the breadfruit based on a well-dispersed set of coordinated operations comprising unter alia the following locations and objectives.

GUYANA

a) Breadfruit propagation and "orchard" establishment on hilly land (5-20° slopes) in selected areas situated near to possible processing centres for cassava.
b) An expanded programme of breadfruit planting in domestic plots in the coastal area.

TRINIDAD

A programme of breadfruit propagation and orchard planting on hill lands possibly as part of the Caroni River basin conservation and management project. Planting might be sited sufficiently near to the site of the proposed new Food Processing Institute so that produce could be fully utilized for the production of breadfruit flour for a composite flour programme and perhaps other products.

TOBAGO

Processing development as a village industry and extended plantation development.

JAMAICA

Development for composite flour programme (continuation of ongoing endeavour).

BARBADOS (subject to decision on whether to include in 5 year plan). Assistance in large, economic tree crop/land reclamation project in Skotland District, planned eventually to release for economic use about 1/7th of the land area of Barbados.

MONTSERRAT

The inclusion of breadfruit production and associated processing in a more general tree crops development programme for rationalised land use.

ST VINCENT
Development of composite flour programme to include breadfruit flour - a logical continuation of the project begun already at the Food Processing Laboratory. Use of the Botanic Garden facilities to undertake a much expanded programme of breadfruit clonal production. St Vincent Botanic Garden a possible site for "New Providence" programme of introductions and multiplication of new Pacific clones after completion of quarantine operation at Kew.

Possibility of related programmes to be considered for:
St Lucia, Dominica and Granada and the Grenadines.
French Islands (Martinique and Guadeloupe,
Santa Domingo.
Central American countries
Northern Colombia.
Venezuela.
Mexico.
Saba (wet hilly island associated with St Martins)

7. The role of the Universities and Agricultural Colleges in the Caribbean should be carefully considered in relation to the CARIOUT objective. It may be desirable to attempt to interest the Universities in seeking ways to attach academic merit (for the award of higher degrees) to thesis programmes reporting on the candidate's own endeavours towards overcoming the technical and economic problems of attempting to apply results of research to development situations and identifying problems arising for research solution. Such programmes would be in contrast to the tradition of developing new research data as an end in itself. Depending upon the extent to which the University Faculties feel they can follow this path, they might be considered useful recipients of CARIOUT funding.

8. The Bank may wish to consider employing a breadfruit consultant on a continuing basis to report annually on achievements with CARIOUT funds.

RECOGNIZANCE SURVEY OF THE CARIBBEAN FOR BREADFRUITS - DIARY OF VISITS

June 12 Travel London to Trinidad.

June 13 am Meet Mr Amado Gavidia, representative of IDB for Trinidad.
Visit CARBI at University of West Indies, St.Augustine campus - discussions Mr Winston Charles (agronomist) and Mr Hussein and Dr P.O. Osaji (livestock feeds).
pm Field trip to Sangre Grande area to study and collect breadfruits with Charles and Hussein. Met Mr Dial (Agricultural officer - extension) and visited three farmers.

June 14 am IDB followed by St Augustine. Discussed with Dr R. Phelps of CARDI (pathologist), Mr Borai and Dr Dennis Adams (taxonomic botany and herbarium), Professor Lawrence Wilson (Professor of Agriculture) Dr G. Iton (Head of Cocoa Research Unit), Dr Lloyd Rankine (Agricultural Economist) and Professor John Spence (Dean of the Faculty of Agriculture).
Travel to Georgetown, Guyana late pm.

June 15 am Visit CARICOM for discussions with Michael Lim Chy (Agricultural Economist), Byron Blake (Economist) and then with Mr Joseph Tyndall, Deputy Secretary General of CARICOM.
pm Visit Ministry of Agriculture, Guyana and discuss with Mr Irwin Telfer (Deputy Chief Agricultural Officer for Development).
Lunchtime discussions with Mr Stanley Lee and Mr O.T. Donald at Zoological and Botanical Gardens.
Travelled with assistant Mr Seobayan Budha to Agricultural Station at Mon Repos, Demerara Coast. Discussions with Mr C.S. Baichoo (Horticultural Officer - Crops) and Mr T. Hubbard (Senior Agricultural Officer - soils).
Field tour of farmers with breadfruit trees accompanied by Mr Budha.
evening Visit Mr Adrian Thompson (Retired Civil Servant and very well known botanist).

June 16 am Discussions with Mr James Marzoff (working on a food and nutrition survey in Guyana for George Washington University in association with President Gorgas Research Institute, Panama.)
Visited farms and the Timheri Horticultural Station with Mr Baichoo and met Mr Ivor Agarda, Head of the Station.
Travelled to Trinidad with Professor Leslie Cummings - statistician and economist with the University of Guyana.
pm Visit Ministry of Agriculture, Trinidad and Tobago for discussions with Mr E.M. Jones (Chief of Extension and Development) and Mr Braithwaite, Permanent Secretary.
evening Visit the University Experiment Station with Professor John Spence and visit at his house for dinner and to meet Mr Sam Bharat (Chief Technical Officer, Research at the Central Agricultural Research Station, Centeno) and others from the Faculty of Agriculture, including Dr Robert Quintyne (solar drying technology specialist).

June 17 am Fly to Jamaica in company with Dr R. Pierre, Director CARDI.
pm Visit Jamaican office of CARDI for discussions with Dr W.N. Prendergast. Then met Professor Colin Weir (Professor of Agriculture, Jamaica campus of UWI).
Visited Mrs Cynthia Graham (née Perkins) at the Ministry of Commerce Food Storage Unit (Joint author of paper on fresh storage of

June 18 am Work in Scientific Library and main University Library, Mona UWI.
pm Met and collected specimens with Dr George Proctor of the Jamaica Institute - botanist.
Visited Mr Alfred E. King and Mrs Thelma King (leading members of the Jamaica Agricultural Society with special interests in food preservation and utilization).
Dinner with Mr and Mrs Douglas Aitken and family (Reginald Aitken Ltd are leading importers and agents for food processing equipment).

June 19 pm Visited Dr Ken Leslie of the Caribbean Food and Nutrition Institute
Depart for Puerto Rico. Arrive Mayaguez.

June 20 am Visited Professor Francisco L. Jordan Molero, Head, Department of Horticulture, University Puerto Rico, Mayaguez campus. (Research student Eugenio Doro not present is working on breadfruit propagation).
Visited Mayaguez Institute of Tropical Agriculture of ISDA, Mr Narciso Almeyda, head of fruits and nut crops programme. Also discussed with Dr Telek (process chemist) and Dr Walter Kaiser and Dr Nadir Vakili of the grain legume section.
pm Field trip with Mr Almeyda to collect breadfruits on West coast and with Professor Jordan Molero to the field station horticultural unit to see stem-propagated breadfruit trees.
Overnight hospitality and further discussions provided by Dr Telek.

June 21 am Depart for and arrive San Juan, travel to Rio Piedras by car.
Visit Department of Horticulture, Dr Carlos Aponte - pomologist and Department of Food Technology for discussion with Professor M.A.Gonzales.
pm Travel to San Maarten.

June 22 am Collecting breadfruit material.
Visit to Mr Pierre Jones ; retired extension worker of IRAT based in Guadaloupe and was responsible for an introduction programme for breadfruit trees to San Maarten in late 1950's.
pm Further collecting and photographing of breadfruit trees. Met Mrs Adrienne Gibbs and Mrs Bonice Brooks.
Depart for Antigua. Overnight Antigua.

June 23 am Travel to Montserrat.
Visit Produce Chemists Laboratory. Mr Paul Hermson and Mr Bryan Adams.
pm Discussions with Mr Memphis Meade - Director fo Agriculture and Mr Jim Bass, Permanent Secretary, Ministry of Agriculture.

June 24 am Interview for Radio Antilles at request of Director of Agriculture.
Visits to discuss wtih Miss Lashley (Home Economics and Nutrition worker now retired but very active and working temporarily in Montserrat) and Miss Viola Horsham - Nutrition Officer, Montserrat Government.
pm Field trip with Mr Tom Farrell, A.O.Extension to collect breadfruits and see thermal springs (for possible use for processing factory.)
Met and discussed development policy with Mr Kenneth Cassels, Permanent Secretary to Chief Minister.

June 25 Discussions with Mr Memphis Meade, Director of Agriculture.
Travel to Antigua for transit stop.(Discussions at Antigua airport with F. Dowers (ex Minister of Agriculture, St Vincent and now working in CARICOM)
pm Travel to Barbados

June 26 Sunday.
pm Visit with Mr and Mrs Tuley to see breadfruits and collect in the eastern side of Barbados and visit Welshman Hall Gulley where original breadfruit introductions made to Barbados in late 18th century or early 19th century.

June 27 am Visit Caribbean Development Bank - Dr Lewis Campbell, Head of Agricultural Branch and Mr Arnold Cruikshank. (Plan to meet Mr Silva at same time miscarried). Discussions on CARDI and possible infrastructure for agricultural developments.
Visit Ministry of Agriculture. Conference chaired personally by the Minister Mr Bolden, with Permanent Secretary and all main technical personnel. (Note that a breadfruit development is being proposed as a substantial development in the coming 5-year plan). Further programme arranged by Mr Ernest Payne - Chief Agricultural Officer Extension and Development. (Other present at meeting included Mr Braithwaite - economist, Chief Agricultural Officer Smith, and Mr Barton Clarke, Agronomist, tree crops.)
Working lunch with Mr Paul Tuley, Head of Mission and Mr J. Williams, agricultural engineering advisor.
pm Meeting at YWCA with M. Georges Xandri and M. Daniel Regis both of College Agricole de Tivoli, Fort-de-France, Martinique, together with Mrs Elaine Yarde, Nutrition Officer, Minsitry of Health, Barbados, and Mr Frans Teutscher, an FAO/UNDP Associate expert helping in preparation of 5-year plan for 1978-82. Discussion on breadfruits in the French Antilles.
Departure for St Vincent.

June 28 Met by Mr Kirby, Acting Director of Agriculture. Visited St.Vincent Botanical Garden, the site of the original introductions of breadfruit to the English-speaking Caribbean. Visited Residence of Mr and Mrs Gibson who have collected best breadfruit varieties for their own use and interest.
pm Visited residence of the Frazer family (caretaker Miss Taylor) at Windsor to collect 'Waterloo' breadfruit.
To the Agricultural Processing Laboratory. Met and discussed with Mr J.J. Wegrzyn (British Graduate Volunteer) and Miss Elaine Wallace (Peace Corps).
Plane overflew St Vincent so departure delayed until next morning.
Evening discussions arranged by Mr Kirby with Mr and Mrs Slusarenko (British Graduate Volunteers) - schoolteachers of Biology and interested to find useful work in which they might contribute to development.

June 29 am Meet and discuss with Mr Eddie Griffith. Biology teacher/agriculture.
Fly to Trinidad - in company with Professor John Spence, Dean, Faculty of Agriculture, UWI with whom it was useful to have further discussions and make arrangements for final Trinidad visit.
pm Arrive Tobago.
Discussions with Mrs Eunice Elder, Home Economics specialist (about to retire) and headmistress of Moriah Government School, Moriah.

June 30 am Return to Trinidad.
Visit Department of Physics, UWI. Discussion with Dr George Sammy
Visit Library to collect some data.
Travel to Bogota.
Dinner with Dr A.K. Thompson and family.

July 1 am Visit Colombian Coffee Federation, Division for Crop Diversification in the coffee zone.
Meet Mr W.B. Willems, British advisor on crop marketing (who was previously responsible for export development of breadfruit from St Lucia and advised on exportation from Dominica, and Dr A.K. Thompson, British advisor on crop storage (who previously worked on storage of fresh breadfruit in Jamaica.
Visit to the Food Technology Department of the Instituto Investigaciones Tecnologica, Dr Teresa Salazar de Buckle, for discussion on composite flours and their work on unusual ingredients.
Evening. Depart for Cali. Arrive CIAT.

July 2-4 Writing part of report at CIAT.

July 5 Travel to Washington.

July 6 Visit InterAmerican Development Bank and present part of report and verbal account.

ACKNOWLEDGEMENTS

In preparing this report and carrying out the study tour I have been greatly assisted by many people, including all those mentioned in the diary of visits, but also to farmers: Seeprasud, Hermann Henriques, Castillon Robert, Udit Sadoo, Mrs De Freitas, Mr Froston (retired oil worker), Mr and Mrs Samuel Dublin, and Mr Herbert Small. Also to the Superintendant of Welshman's Hall Gulley, Mr Worrell and to taxi drivers Mr Edwin Bruce (Trinidad), Ethyl Clark (Montserrat), Cephas Jack (Tobago) who have provided useful information. For special thanks for great generosity with their time and help in contacting others I would especially thank Professor John Spence and Mr Denis Adams of the Unviersity of the West Indies, St. Augustine, Trinidad, Mr Irwin Telfer of the Ministry of Agriculture, Georgetown, Professor and Mrs Colin Weir and Dr Prendergast of the University of the West Indies, Mona, Jamaica; Mr Memphis Meade, Director of Agriculture Monstserrat, Mr Kirby, Acting Driector of Agricultur, St. Vincent, and Mr Ernest Payne of the Ministry of Agriculture, Barbados. without thier unstinting assistance much less information could have been aquired in the short time available.

I would like to thank the Librarian and staff, Mr D.G. Coursey and Dr John Marriott of the Tropical Products Institute, London for helpful discussions and access to information. Very special thanks are due to Dr Frances Jarrett for making available copies of her own personal notes from her literature search of 1959 as well as reprints of her publications, Miss Smith, archivist of the Royal Botanic Gardens, Kew; Miss Phyllis Edwards Information Officer and Archivist at the British Museum, Natural History, Miss Blundell and Mrs Heathcote of the Royal Society of Arts and Madame Elaine Dourron, Arhicvist at the Musee d'Histoire Naturelle, Paris.

For hospitality and useful discussion on the wider perspective I am most grateful to Mr and Mrs Paul Tuley, of the Overseas Development Division of the British Government in Barbados, to Dr and Mrs Lehel Telek in Mayaguez, Puerto Rico, to Dr and Mrs A.K. Thompson in Bogota and Mr and Mrs Adrian Thompson in Guyana.

TAXONOMY AND NOMENCLATURE

In this report I am adopting the name for the breadfruit, breadnut and close relatives of Artocarpus communis J.R. & G.Forst as amended by F.M. Jarrett (1959). Jarrett gave her reasons for preferring this name to others such as A.incisus (Thunb)L.f. or A.altilis(Parkinson) Fosberg in a lengthy and scholarly argument on pages 116-119 in Jarrett 1959.[1] She regards A.altilis as a nomen subnudum. The opposite argument is put by Fosberg (1960)[2] pages 101-103, who not only continues to use this name but regards Jarrett's arguments as providing evidence for the preferrment A.altilis over A.communis. In using A.communis in this review however I am not only accepting Jarrett's arguments and authority, but from the genetic standpoint prefer the concept that embraces the wider genetic diversity that can be considered as contributing to the germplasm base for the improvement of the cultivated crop. I thus do not wish to exclude from discussion those seeded forms with entire leaves and irregularly shaped fruits for the Mariannas Islands known there as Dug-dug (or doug-doug) which Fosberg regards as a separate species A. mariannensis Trec. whose introgression with A.altilis he then discusses. Entire leaved forms of breadfruit are not uncommon, and many highly desirable forms such as the'Rare' breadfruits of Tahiti fall outside Fosberg's categorisation of A.altilis (Fosberg loc cit pg.104). Fosberg himself comments when discussing the distribution of breadfruits that "Some of these records undoubtedly apply to A.mariannensis but unless his specimens are available it is usually impossible to tell which of the species an author had". Surely this comment alone is good reason for adopting a single valid name covering them all?

Common names at the species level

Both Barrau[3] and Jarrett (loc cit) discuss the names used for the breadfruit in the Pacific in some detail. Barrau's map is reproduced as Fig.1. Caution in using the names to draw conclusions about the early

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1. Jarrett, F.M. (1959) Studies in Artocarpus and allied genera. III. A revision of Artocarpus subgenus Artocarpus. Journal of the Arnold Arboretum 40,(2), 116-119.
2. Fosberg, F.R. (1960) Introgression in Artocarpus (Moraceae) in Micronesia. Britonia 12, 101-113.
3. Barrau,J. (1957) L'arbre a pain en Oceanie. J.d'Agric.et du Bot.Appl.4, ---------- (1959) Maquesas Journey. S.Pac.Quart.Bull.9(1),18-21. 117-123, ---------- (1962) Les plantes alimentaires de l'Oceanie, origines distri-

distribution should be exercised because, as Henry[1] pointed out, names in Tahiti were rather fluid. Meʻ or Maʻi could mean rice or food in much of SE Asia as well as meaning the breadfruit. "In ancient times breadfruit was always called 'uru (head) until long, long ago a king of Ra'iatea, named Mahoru, took that name, and it was then called maiore; but gradually the name maiore wore out and 'uru again became the common name of the fruit." Maiore also means 'almost without' in Tahiti. Bligh had also reported this habit of name changing[2]. "A chief may take any name he likes, and if it happens to be the name of a thing, or of day, or night, another is thought of for it to be called by, and he retains the name." One of the interesting name groups is that including Kuhu, Kulud etc. since in the Moluccas the cognate form Kolo is the name for the species Artocarpus blanco(Elmer)Merr.[3] which, though quite close to cultivated breadfruit, and certainly sometimes confused with it, is by both Jarrett and Fosberg excluded from synonomy with A. communis or A. altilis respectively.

Common names at the cultivar or variety level

Although not of particular interest for taxonomic botanists, the cultivar names used in any areas are of the greatest interest to economic botanists, and particularly when plants are vegetatively propagated, synonymy in names of valued clones is well worth trying to disentangle. Since Captain Bligh collected only from a small area and there is much written on the clones of Tahiti, it is especially interesting to attempt to identify the genotypes introduced to the West Indies in the 18th century with their Tahiti synonyms as well as to indicate close similarity and possibly synonymy bewteen the clones in different Pacific islands.

To Wester[4] should be given credit for the first attempt to bring together names and descriptions from the earlier and widely scattered

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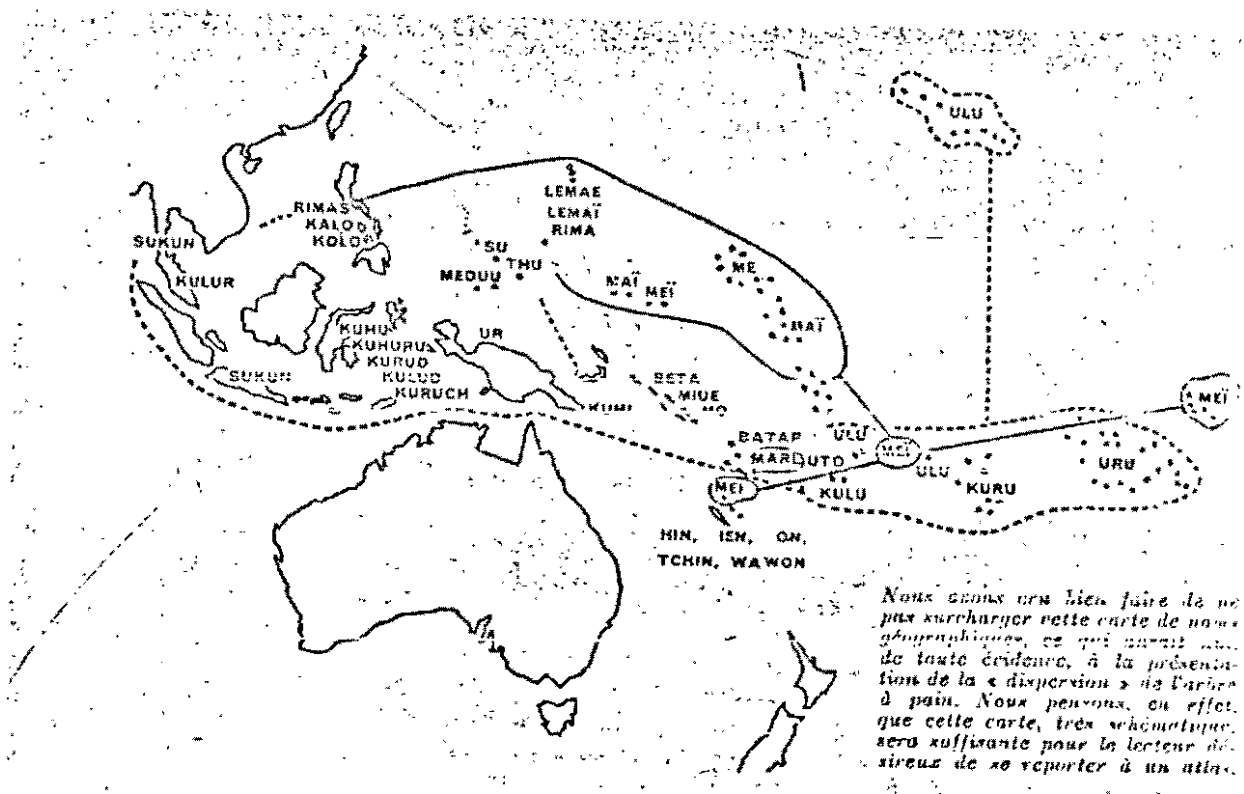
1. Henry, T. (1928) Ancient Tahiti. Bernice P. Bishop Museum. Bulletin 48. p.40.
2. Bligh, W. (1792) In: Lee, I. (1920) Captain Blighs 2nd Voyage to the South Seas. p.111.
3. Barrau, J. (1957) L'arbre a pain en Oceanie. J.d'Agric.et du Bot.Appl. 4.
4. Wester,P.J. (1928) The seedless breadfruits of the Pacific Archipelagoes. Agr.Rev. 17, 24-39.



Nous avons cru bien faire de ne pas surcharger cette carte de noms géographiques, ce qui aurait nui de toute évidence, à la présentation de la « dispersion » de l'arbre à pain. Nous pensons, en effet, que cette carte, très schématique, sera suffisante pour le lecteur désireux de se reporter à un atlas.

LES NOMS INDIGENES DE L'ARBRE A PAIN ET LEURS APPARENTAGES.

Fig 1

literature. The first collection of 20 cultivar names and descriptions is thought to have been made by the Swedish botanist Solander on Cook's Endeavour expedition, but has never been published. Wester's review covers contributions by Seemann[1], Bennett[2], Christian[3] and privately communicated notes from others, but he overlooked the important publication by Raoul[4] who listed and partially described 16 clones which in his opinion were the only ones that merited multiplication, or the list of eight varieties which Bligh described from the Bounty expedition[5]. Fortunately, most of Raoul's list can be reconciled with other lists. More recently, under the auspices of the South Pacific Commission there have been collecting expeditions through much of Micronesia, Melanesia and Polynesia, and Parham[6] lists and describes 166 named trees from Papua and New Guinea, New Hebrides, Rotuma, Tonga, Niue, Western Samoa and American Samoa. All Parham's varieties are classified under the following descending orders of classification: leaf shape; presence or absence of hairs on the mid-rib and lower leaf surface; shape and skin texture of fruit; presence or absence of seed. Twelve leaf shape classes are distinguished, four fruit shapes and five categories of skin texture. Independantly Koroiveibau[7] published descriptions of 70 trees from Fiji. Parham[8] has partially described 19 cultivars from Samoa and listed 12 other names. According to Handy and Handy[9] Dr Forest Brown was able to distinguish more than 200 different cultivars in the Maquesas Isalnds in 1921 but unfortunately Brown's full list and descriptions does not appear to be published.

Various short papers by Barrau and his associates describe a few clones of particular characteristics such as salt resistance etc. (see section on

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1. Seemann,B. (1868) Flora Vitiensis (Flora of Fiji). Sub-order Artocarpeae represented by Antiaris, Caturus, Artocarpus and Trophis.
2. Bennett, G. (1860) Wanderings of a Naturalist in Australasia.
3. Christian, F.W. (1899) The Caroline Islands.
4. Raoul, E. and Sagot, P. (1893) Manuel Practique de Cultures Tropicales et des Plantations des Pays Chauds. Challomel, Paris.
5. Bligh, W. (1792) A voyage to the South Sea. Printed Fitzpatrick, Dublin.
6. Parham,J.W. (1966) Coconut and breadfruit surveys in the South Pacific Region. South Pacific Commission Tech.Information Paper No.1.
7. Koroiveibau, D. (1966) Some Fiji breadfruit varieties. Fiji Dept. Agric.Bull. No.46.
8. Parham, B.E.V. (1972) Plants of Samoa. NZ, DSIR. Int.Ser. 85. Wellington.
9. Handy,E.S. and Handy, E.G. (1972) Native planters in Old Hawaii. Bernice Bishop Museum Bulletin No.233. 149-155.

ecology).

For present purposes an attempt is made to relate the kinds of breadfruit presently occurring in the Caribbean to corresponding names in the South Pacific area and especially in Tahiti.

ECOLOGY OF BREADFRUITS

In considering the potential adaptation of any crop plant it is most important to consider the whole ecological range of genetic variation in the species and corresponding range of adaptation in nature. In accounts in standard works on food crops the adaptation of breadfruit is misleadingly limited by a lack of appreciation both of the genetic variability and of knowledge of the conditions under which the species thrives in its native habitats. Jarrett's account[1] taken from collector's notes accompanying dry herbarium material is extremely valuable.

Of misleading accounts, MacCaughey was quoted by Popenoe[2] as saying that breadfruit requires "a warm humid climate throughout the year, copious precipitation, moist fertile soil and thorough drainage. The absence of any one of these conditions is a serious deterrent to normal growth of the plant or may wholly prevent its fruiting. It is scarecely tolerant of shade" In India Singh et al.[3] give a rather broader description of the ecology and adaptation. These authors say that the breadfruit is essentially a tropical plant requiring a warm humid climate with plenty of rainfall for best growth. In cultivation it has, according to them, to be restricted to the humid tropical regions. It can be grown from sea level to about 3000 ft. in southern India and flourishes on the West coast and on the hills of the western Ghats. Growing the tree, they say, in regions not possessing a uniformly warm and humid climate has rarely been successful. The general climatic requirements of the breadfruit are for an annual rainfall of 80-100 inches well distriubted through the year, a temperature range of 60-100°F and a relative humidity of 70-80%. In places with less rainfall than this, a more equable climate and less humidity such as is found in Coimbatore, the trees can nevertheless be grown successfully with greater attention to irrigation and other cultural details."

Soil conditions

Lateritic red loams, according to Singh et al. are most suitable for

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1. Jarrett,F.M. (1959) Studies in Artocarpus and allied genera. J.Arnold ARboretum 40, 113-368.
2. Popenoe, W. (1920) Manual of Tropical and Subtropical Fruits. Chap.15, The breadfruit and its relatives.
3. Singh, S., Krishnamurthi, S. and Katyal, S.L. (1967) Fruit culture in India. New Delhi, Indian Council of Agricultural Research.302-6.

breadfruit cultivation, but at the same time it requires a high humus content with high fertility. In contrast MacKay[1] received advice from Barrau for the planting of a garden for Truk Intermediate School indicating that the breadfruit should be planted on sandy coral soils (together with coconuts) and on loamy clay alluvium, but that lateritic hillsides which were to be re-afforested, should not be planted with breadfruits. Singh et al. say that in shallow soils the tree may grow satisfactorily, but sooner or later a decline sets in resulting in the death of the tree. This condition for example often occurs in rocky slopes where the tree has been planted. Good drainage they say is essential to maintain the tree in good condition. Stagnation of water around the roots is a factor known to increase premature fruit drop.

In contrast with these text book accounts, in Fiji it is recorded that breadfruit is most important in the diets of people of the small, dry islands such as Lau and Yassawa groups[2], and Jarrett records that the seeded forms of the breadfruit in Micronesia occur principally on the coralline limestone high islands. In New Guinea breadfruits occur wild, according to Archibald et al. "along waterways and as a marginal constituent of periodically inundated forest on the flood plain." Lam[3] described breadfruit as a locally frequent natural constituent of extensive freshwater swamps.

The breadfruit is an important item of food in the Marquesas Islands at 10°S. in the East of Polynesia, and this group of islands are much drier than most of Micronesia, with an average of only 40-60" annual rainfall and severe droughts occur rather often. The climate here is described as "of the equatorial dry type."

Cultivar adaptation to different ecological conditions

Clearly, within the genetic range of the breadfruit, there is a much greater potential for adaptation to different climatic conditions than is indicated in the standard text book accounts. Massal and Barrau[4] indicating 50 cultivars from Ponape and 30 or so from Tahiti, say that each variety tends to be specifically adapted to a particular environment. Among the many lists of names varieties described from various parts of the South

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1. MacKay,R. (1959) A garden for Truk Intermediate School. S.P.Q. Bull. 9(1), 36-8.
2. Koroiveibau, D. (1966) Some Fiji breadfruit varieties. Fiji Dept. Agric.Bull. No.46.
3. Lam Sarpontia Vol V 1945 - Quoted in Jarrett 1959 (not seen in the

Pacific, several have important ecological attributes ascribed to them. For example, the variety Mai-Tarika from the Gilbert Islands is said to be salt tolerant (Massal and Barrau, 1954). The variety Mejwaan from the Marshall Islands is also claimed to be quite resistant to brackish water (Coenen and Barrau,[1]) and Manitarvaka is drought resistant in Tahiti (Wester[2]). There are also variations in fruiting season in a single climate so that in Ponape the variety Mai-Up bears its fruits from early May until the middle of June, Lukuwal fruits later than this. On the Truk Islands the long breadfruit season begins with the variety Mai-Chun and ends with the variety Mai-Koch (Coenen and Barrau). On the Kapingamarangi atoll the local varieties bear fruit only once a year for a period of about three months from December to March while recently introduced varieties bear fruit under the same conditions two or even three times a year.

There appears to be a great difference in the height of trees, though the extent ot which this is genetically or environmentally determined needs investigation. In particular it appears from the report of the South Pacific Breadfruit Survey of the Southern Territories (Parham, 1966[3]) that there are many dwarf trees occurring in the New Hebrides with recorded heights from 10-20ft. In Hawaii there is, or used to be, a breadfruit variety, although not an edible one, known as Ula-Hua or Ula-Kapua which is described as being recumbent on rocks. "Lukunal"is a bush variety from Ponape (Christian,1899[4]).

In Tahiti one of the forty varieties described by Henry[5] is specifically recognised as a mountain variety. This is known as Aume'e'abei and has large and very rough fruits and there is another mountain variety in Ponape called En-Charak (Christian,1899).

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1. Coenen, J. and Barrau, J. (1961) The breadfruit tree in Micronesia. S.P.Q. Bull. 11, 37-9.
2. Wester, P.J. (1928) The seedless breadfruits of the Pacific Archipelagoes. Philip.Agr.Rev. 17, 24-39.
3. Parham, J.W. Coconut and breadfruit surveys in the South Pacific Region. South Pacific Commission Tech.Information Paper No.1
4. Christian, F.W. (1899) The Caroline Islands.
5. Henry,T. (1928) Ancient Tahiti. Bernice Bishop Museum Bulletin 48, 39-48.

18th CENTURY CROP PLANT MIGRATIONS

The latter half of the 18th century was a period of enormous activity in the disemination of crop plants around the tropical world.[1] The French based this activity on the Botanic Gardens at Pamplemousses in Mauritius as a convenient tropical staging post. The British had no such similar facility but after other encouragements of financial rewards failed, pioneered the really long range transport of living plants with the ill-fated Bounty expedition,followed by the successful mission of the Providence and Assistant.

For the British Empire the Royal Society for the Encouragement of Arts, Manufactures and Commerce (better known as the Royal Society of Arts) played a prominent role in fostering the setting up of tropical botanic gardens and the interchange of plants to furnish them,especially with useful species.

In 1772 the Captain General of St Vincent, Mr Valentine Morris approached Sir Joseph Banks, Director of Kew Gardens with the suggestion of trying to introduce the breadfruit to St Vincent[2], (this may perhaps have been as a result of hearing of Sonnerats collections and transhipment to Mauritius), but despite the offer of a prize in 1777 by the R.S.A. nothing materialised. The Jamaican planters also offered their own prize in 1775,with no result, following serious famines between 1780-6 in Jamaica due to a combination of hurricanes and drought and restrictions on food imports. Matthew Wallen, a member of the Jamaican Assembly suggested to Mr Hinton East, the Receiver-General and owner of a fine private botanical garden, that the King (George III) be petitioned through Sir Joseph Banks, to send an expedition to bring the breadfruit to Jamaica.[3]

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1. Bouvier, R. (1946) Les migrations vegétales. Flammarion, Paris.

2. Wood, H.T. (1913) A History of the Royal Society of Arts. John Murry. London.

3. Powell, D. (1973) The voyage of the plant nursery HMS Providence 1791-3. Bull. Inst. of Jamaica. Science Series No.15 pt. 2.

INTRODUCTIONS OF BREADFRUITS AND BREADNUTS TO THE CARIBBEAN

Both the ill fated voyage of the Bounty in which large numbers of breadfruit trees were collected but subsequently thrown into the Pacific during the Mutiny and the following voyage of the Providence to recollect in Tahiti and deliver living breadfruit trees to St Vincent and Jamaica, have been often described[1-6], but these accounts give little help in assessing the extent of the variation within breadfruits that was aquired. On the second voyage there appears to be no record of the names of the varieties collected although Bligh on the earlier voyage recognised the existance of eight different varieties in Tahiti.* It seems from the record of the log that nearly all the material for the Providence voyage must have come from the 'breadfruit walk', a carefully guarded and patrolled grove in the immediate neighbourhood of Matavai Bay where Providence was anchored except for a few plants that were fortunately able to be collected on May 26th 1792 shortly before the Providence sailed which were specially brought from Tiarraboo "which are vastly superior to any at his place; I had heard of this kind, and had such reports confirmed by the chief, that I employed two men to go for mine. Our number is now increased by seven tubs containing three to five plants, seven small pots one and two.....".[6]

The second voyage went smoothly and Bligh delivered to the Governor at St. Helena,according to instructions,a collection of plants. Here is the only direct reference in the whole of Bligh's log to the fact that he considered he had on board five different kinds of breadruits. Nowhere are they named. (Unless in Wiles' personal diary which may still be extant in Jamaica.)

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1. Bligh, W. (1793) Report to the Society on the Providence expedition. Trans. Roy.Soc.Arts 12, 305.
2. ---------- (1792) A voyage to the South Sea. Printed Fitzpatrick, Dublin.
3. Lea, Ida (1920) Captain Bligh's second voyage to the South Seas. Longman Green & Co. 290 pp.
4. Howard, R.A. (1953) Captain Bligh and the breadfruit. Scientific American (March), 88-94.
5. Powell, D. (1973) The voyage of the plant nursery HMS Providence 1791-3. Bull.Inst.of Jamaica. Science Series No.15 pt.2.
6. Allan, D.C.G. (1977) Log of the Providence. (Read in the Royal Society of Arts Library, facsimile limited ed.).

* Patteh, Eroroo, Awanna, Mi-re, Oree, Powerro, Appeere, Rowdeeah. In Bligh, 1793.

During the journey Bligh had called at Timor and there took on board both seedless and seeded breadfruit plants of Timor. James Wiles, the horticulturalist of the Providence expedition recorded (fide Powell, 1973 loc cit)[1] that "The breadfruit of Timor grows much freer and appears a hardier sort than those of Otaheite.... We procured from these four young plants of the seeded fertile variety." They also acquired four seedless Timor breadfruits of which two were left at St Vincent, 1 in Jamaica and one taken on to Kew.

Despite the widely held opinion that the Bligh introduction was the first of breadfruits to the Caribbean, it appears that this is not so, although probably only the seeded forms had been introduced earlier. The French navigator Sonnerat[2] collected breadfruits in "Luçon" (Luzon, Philippines) in 1772. Sonnerat's plants were of the seeded breadfruit and are illustrated by him in four plates (reproduced as Fig.). Sonnerat writes "J'en ai rapporté quelques plans à l'Isle de France. Il y a lieu d'espérer qu'ils y réussiront, par les soins qu'a pris M.Poivre pour les accoutumer au climat, moins chaud que celui des pays où croît naturellement l'arbre à pain." Poivre, who was a great collector and distributor of plants had already in 1755 attempted to distribute breadfruit.[3] "J'ai distribué à divers colons ces plantes de toutes espèces que j'avais apportée, entres autres des cocoyams et de Rima (breadfruit), dont le fruit sert de pain aux habitants des isles de Mariannes."

At how early a date Poivre succeeded in getting live breadfruits to the French Antilles is not certain, but Sir George Young, who as army surgeon took charge of the setting up of the St Vincent Botanical Garden (and won a Gold Medal of the Royal Society of Arts for his work), wrote to Sir Joseph Banks in 1787[4] that he had information "By which it seems beyond doubt that the Rima or breadfruit tree is arrived in the French West Indies - indeed the cargo .... much to his credit." One may be fairly confident that this material to which this account refers is derived from the Sonnerat collections in Luzon. East[5], in Jamaica also had breadfruit material, probably also of French origin before the Bligh expedition. He wrote to

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1. Powell, D. (1973) loc cit.
2. Sonnerat,N.G. (1776) Voyage à la nouvell guinée. Chap. Viii, pp. 409-18.
3. in Cordonnier, H. (1928) Voyages de Pierre Poivre 1748-57.
4. Young, Sir George (1787) m/s letter to Sir Joseph Banks, Kew.
5. East's letter quoted by Powell (1973) loc cit.

Banks in 1784 "I have two other plants that came from the Isle of Bourbon supposed by some to be the breadfruit, but I am extremely doubtful as they do not in the shape of the leaf by any means correspond to the account and drawing given by Mr Ellis*... The acquisition of the best kind of breadfruit would be of infinite importance to the West India Islands."

There has been much confusion concerning the exact cargo of plants intercepted by HMS Flora of Admiral Rodney's squadron in 1782. The prize was a cargo of plants bound from Mauritius or Reunion to Martinique and may well have included many plants from the Sonnerat collection. Tessic[1] seemed quite clear that both the jakfruit and the seeded variety of breadfruit (Chataigne de Malabar) were introduced to Jamaica during the interception of 1782, since after his account of the breadruit he then has a section on the Jakfruit which he says was introduced at the same time as the preceding species. Popenoe[2] has also suggested 1782 for the date of introduction of seeded breadfruits, but since his authority is not given he may also be relying on Tessic. Tessic indicates that by 1818 the Chataigne de Malabar was already widely distributed in the Antilles. This would be quite probable since reproduction would be by easily distributed seed.

It is certain also that the seeded breadruit was already in cultivation in the St Vincent Botanical Garden before the arrival of the Providence. Anderson, in a long account to the Royal Society of Arts in 1789 states that "Previous to the arrival of the Providence, a young plant of the Chataigne de Malabar was sent to the garden from Martinique for the true breadfruit. It grows as fast and gives fruit as soon, but rises to a larger and stronger tree (than the breadfruit)."

Thus it seems in no doubt that the seeded breadfruit was indeed sucessfully introduced to the Caribbean 11 years before the seedless clones brought by the Providence, and in that time may have become quite widely distributed. The intercepted introduction is likely to have been followed by other successful attempts and the source of these early introductions may be either from the Poivre collections of 1755 or the Sonnerat collection of 1771-2, though probably the latter. Robley[3] reported that one such

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1. Tessic, F.R. (1818) Flore des Antilles. Paris.
2. Popenoe,W. (1920) Manual of Tropical and Subtropical Fruits. Chap.15 The breadfruit and its relatives.
3. Robley,J. (1802) Letters to the Royal Society of Arts. Trans.Roy. Soc.Arts. 20, 357 and 21, 417.

introduction was made to Martinique in 1792. In addition to the Providence introductions, the French made introductions of seedless breadfruit to Martinique and Cayenne shortly afterwards of material of a variety called 'kele kele' from the Tonga Islands (island of Tangatabou) collected on the expedition of La Perouse commanded by Entrecasteaux with Labillardière as botanist and LaHaye as gardener. Plants were transhipped at Surabaya in Java and sent on to Mauritius by Rear Admiral Williamiez in the Régénérée. Details of the transhipment from Mauritius to Martinique and Cayenne have not yet been uncovered.

Tavares (fide Jarrett[1]) indicates that the seedless breadfruit was introduced from Cayenne to Brazil in 1811 but this does not exclude the possibility that the Portuguese may have made direct introductions from other sources, such as the Maldive Islands for example, from which Thunberg[2] says it was introduced to Ceylon as early as 1727 or 1728.

According to Popenoe[3] the breadfruit is now widely distributed on the coasts of Central America and Mexico, but only of any economic importance on the Atlantic coast of Costa Rica and in part of Colombia.

Standley and Steyermark[4] in the Flora of Guatamala say that the breadfruit is consumed in the banana growing regions of the Atlantic coast where people of African origin "consume the young fruits in large quantities, usually sliced and fried." Both seeded and seedless varieties are eaten.

Breadfruits are known to have been taken to Central America in the early 19th century by "black carrib" indentured labourers who went to work in the Central American sugar plantations. Standley and Steyermark say that whereas both seeded and seedless forms occur on the Atlantic coast, that on the Pacific coast all trees are of a seed form and the fruits are much used for fattening pigs. They suggest that the seeded breadfruit may have reached Central America and Mexico one or two centuries earlier than the Caribbean introductions by way of the Spanish ships which plied regularly between the west coast and the Philippines.

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1. Jarrett, Frances M. (1959) Studies in Artocarpus and allied genera. Journal Arnold Arboretum 40, 113-368.
2. Thungerg, C.P. (1779) Sitodium incisum et macrocarpon etc. Phil.Trans. Roy.Soc.Lond. 69, 462-84.
3. Popenoe, W. (1920) Manual of Tropical and Subtropical Fruits. Chap. 15, The Breadfruit and its relatives.
4. Standley, P.C. and Steyermark. (1946) The flora of Guatemala.

GENETIC VARIATION IN THE SOUTH SEA ISLAND BREADFRUITS

In view of the fact that the majority of plants taken by Captian Bligh to the West Indies were collected in Tahiti (with the exception of 4 breadfruit and 4 breadnuts from Timor) it is relevant to draw particular attention to acocunts of the variation of the breadfruit within the island of Tahiti. According to Wester[1] the Swedish botanist Solander compiled the first variety list of seedless breadfruits, enumerating 20 kinds from Tahiti.

On the Bounty voyage Captain Bligh was aware of the existance of eight different varieties which he lists without description. Bennett[2] listed 20 different kinds from Tahiti. Raoul[3] listed and partially described 16 varieties which he stated were the only ones worth multiplying, and named eight others that he was aware of but had not cultivated.

The American consul to Tahiti, Mr Howard Withey, basing his notes upon information provided by Forest B.H. Brown, sent a list of 52 kinds of breadfruits to Wester, who published these, together with information from earlier authors. That same year Henry[4] published an independent list.

The following Table collates all these various reports and suggests correspondences with the types now found in the Caribbean. (Table 1)

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1. Wester, P.J. (1928) The seedless breadfruits of the Pacific Archipelagoes. Philip.Agr.Rev. 17, 24-39.
2. Bennett, George. (1860) Wanderings of a Naturalist in Australasia.
3. Raoul,E. (1893) In Sagot, P. and Raoul, E. Manuel Practique de Cultures Tropicales et des Plantations des Pays Chauds. Challomel, Paris.
4. Henry, T. (1928) Ancient Tahiti. Bernice Bishop Museum Bulletin 48, 39-48.

TABLE 1

TAHITI BREADFRUIT VARIETIES DESCRIBED BY VARIOUS AUTHORS

Bligh[1]	Raoul[2]	Henry[3]	Wester[4]	Description
	Apuahu	Apo-oahu	Abuabu	Very high yielder (Raoul) ?= Mapua (Wester)
			Aeka	Fruit nearly globose, smooth with convex facets, flesh very loose textured. 'Stem' 2-3 cm.
			Afatu	Fruit small and round (Bennett)
		Aipuu		
			Anuanu	Mis-spelt Anuanni by Wester, Annuanu in Bennett which was Wester's source.
			Aoa	
			Apil	Fruit small and round
Apeere		Apiri or Atiati		
	Apuapua			Has very large fruit (Henry)
		Araoro		" " " " (Henry and Raoul)
	Aravei	Aravei		
			Auena	
Rowdeeah	Rare-autia		Autea (= Rowderah,Bligh) = Rautea	Fruit large, spherical, slightly tuberculate. = Banabran (cf. Ota? of Raoul, very easily cooked) Jamaica? Very large leaves, not at all sinuated. Round fruit. Rare-autia of Raoul - has entire leaves.
		Aume'e'avei	Avei	Fruit has rough surface (Wester); has very large fruit with rough sting (Henry). cf. Koshi of St. Vincent.
			Aveu	Fruit large, spherical to broadly ellipsoidal, nearly smooth, facets coarse and slightly elevated. Stem 75 mm long.
Awanna				No information.
			Balekana	Leaves pinnatisect, even surface, fruit small but of superior quality.
			Buko	Leaves pinnatisect,even surface, fruit large, short ovate and smooth. cf. common breadfruit of West Indies.
Eroroo				cf. Roro of Raoul
		Fara	(Faara in Bennett overlooked by Wester)	A fine kind with fruits in clusters of 3 or 4, found at Parara. (cf. Faara of Caroline Islands)
	Afara			Afara of Raoul, very easily cooked.
		Fafaua		Fruit large, 13 cm across, unequilateral, smooth, long stemmed. A good variety.
		Ha'ama		A mountain variety.
			Haupuhu	Fruit broadly ovoid, 9 x 13 cm smooth, facets almost flat, flesh loose textured around the core. 'Stem' 3 cm long.
	Aavana	Havana		Has fine and delicate fruit.
			Impak	Fruit large and round (Christian, 1899).
		Iriava		No description.
			Kakanokoe	" "
		Mai'aro'aro		" "
			Mai-noir	" "
Mi-re		Maore	Maire	Fruit small, 125 mm diam. spherical, nearly smooth, yellowish or brownish green, 'stem' 75 mm. long,hairy. Excellent quality, cooks quickly, tree common, very ornamental and prolific (Wester) cf. Common breadfruit of W.Indies.
			Mamaitavaka	Fruit very small, 14 cm maximum diameter. 'Stem' 4 cm. and rather hairy, core relatively large, bakes in hot ashes in 10 minutes, tastes more like a potato than other vars. Quite drought resistant.
		Manatea / Mamina		-
			Maoi	Undescribed
			Mapua	" ? = Apuahu(Raoul) or Abuabu (Wester).
			Movai	"
			Ofatia	cf. large size (Bennett 1860)
			Ohinuhinu	Undescribed
			Onape	cf. large size (Bennett 1860)
	Opiha		Opiha	Bennett 1860 (Wester lists the name only for the Maquesas.)
			Opiripiri	? = Piipiia (Bennett,Wester) and Piia(Wester)
Oree				
	Otea	Otea	Otea	?=Rautia, Autea etc. Very easily cooked (Raoul) cf.Large size (Bennett)
			Ovai	The fruit is very large and of excellent quality(Withey in Wester) cf.?Avei
	Pata	Paea	Paea	Fruit is very large, 20 cm diameter, broadly ellipsoidal, rough with pointed projections, 'stem' 10 cm long and glabrous, cooked flesh is very sticky (Withey in Wester). Has elongated and very large fruits which come in the last of the season and is not as substantial as the other kinds(Henry) cf = Waterloo of St.Vincent Out of season production (Raoul)

Bligh	Raoul	Henry	Wester	Descriptions
			Pafai	
			Paifee	
	?= Afara		Pafara	Fruits small and round fruits (Bennett) ?= Afara (cf Raoul) - very easily cooked.
			Paimach	Small fruit (Wester)
	Maire paparu		Paparu	Maire paparu - very high - very high yield (Raoul)
	Puatata		Patara	Puatata (Raoul) Fruits very large.
Patteah		Patea	Patea	Undescribed
	Petautia			Fruits very large (Raoul)
			Patuki	Fruits very large, 20 x 14 cm. nearly smooth. The facets slightly concave.
			Pehi	Undescribed.
		Peti	Peihuri	
	Pererau-ohua			
			Piia	cf.Paea?
			Piipiia	A large, otherwise undescribed fruit.
			Pimata	Undescribed, rare, said to be only a single tree.
			Pohauta	The fruit is round, smooth and of excellent quality, the 'stem' is 75 mm long and hariy.
		Ponafara		
			Poru	The fruit is large, 20 cm in diameter, globose, smooth. The stem if 75 mm long and hairy.
			Potopot	Fruit oblong, light coloured and spiny.
	Puatata			Fruits very large, (Raoul).
Powerro	Pueru	Puero	cf. Puverto	Fruits much esteemed (Raoul)
			Puaa	The fruit grows several in a clusters and is spherical and smooth 'stem' about 62 mm long and hairy, core small.
			Pufatata	Fruit large, broadly ellipsoidal, facets large and conical, 'stem' glabrous, 75 mm. long.
			Pulang	Undescribed.
		Pu'upu'u	Puupuu	The thick bark makes the best tapa (barkcloth), beautifully white fruit (Henry). cf. Puou of Caroline Islands, fruit large (5 kilos), smooth, flesh yellow.
	Ragro			Very easily cooked (Raoul)
	Rare	Rare	Rare	The fruit is large, 15 cm long, ellipsoidal, smooth with slightly elevated facets. The skin is 7.5 cm long, hairy, the core oblong. cf.excellent quality (Wester). Fruit round with bright epidermis Fruits much sought after (Raoul).
	Rare-aume			
	Rare-autia or Rare-ati			
	Rati			
		Rare		
		Rareautai		Varieties with absolutly entire leaves (Raoul)
		Raumae	Raumae	cf. Rare-aune above and cf. Aume
Rowdeeah			Rautia	cf. Rare-autia above and cf. Autea.
	Rorotoma			Fruits enormous (Raoul).
			Rokouta	The leaves are pinnatisect with a bullate surface giving the tree a diseased appearance.
	Roru			Fruits very large (Raoul).
			Rau-vara-vara	Undescribed.
			Rokouta	
	Rorotomak			Enormous fruit to 5 kg. (cf. Jokaha).
	Roru			Fruit very large (Raoul)
			Sore	Leaves are pinnatisect with an even surface. The only seeding variety is called Fiji. Known under above name as Rewa, Vaka sorune in Ovalau, Asalea in straits of Somojomo, and Maliva in Nububalaou-alia Fiji (Wester)
	Taiere	?=Taea		Very easily cooked (Raoul)
			Tagafei	Undescribed.
			Tapa	
		Tao		
			Teve	
	Titia	Tiatea	Tiakia	Undescribed.(Wester) " (Raoul)
		Toarau		cf. Toerau of Maquesas Islands.
		Tohe-hava'e		
		Tohe-ti'apau		
			Tookaha	The fruit is large, up to 5 kilos in weight, flesh of excellent quality. The largest breadfruit in the northern group, said to have biennial bearing habit.
	Tuavera			No description.
	Tuutu		Tutou	Tuutu, very high yield (Raoul)
			Vaka	Fruit large, oblong and spiney.
		Uru-huerro		Has black edible seeds.
		Uru-ma'ohi		The most common and a very good kind (Henry). cf. Waterloo of St. Vincent.

1. Bligh, W. (1793) A voyage to the South Seas. Dublin.

2. Raoul, E. (1893) In, Sagot, P. and Raoul, E. Manuel Practique de Cultures Tropicales et des Plantations des Pays Chauds. Challomel, Paris.

3. Henry, Teuira (1928) Ancient Tahiti.Bernice Bishop Museum Bulletin 48, 39-48.

4. Wester, P.J. (1928) Philipp.Agr.Rev. 17, 24-39. Westers list includes earlier lists from Bennett (1860) Wanderings of a Naturalist. Notes from

HISTORY AND VARIETIES OF BREADFRUIT IN THE WEST INDIES

To return to Captain Bligh and the events thereafter. The prize for the successful introduction of the breadfruit to the West Indies went to Captain Bligh in 1793. Whoever else may at various times have made other introductions, it is quite certain that the great majority of breadfruits now in the Caribbean originate from the Bligh introductions. One can be confident of this because of the considerable information we have on the vigorous efforts and successes in multiplication and distribution of planting material from these early introductions, and from the fact that most of the breadfruits now in the Caribbean can be related to the five types known to have been introduced which have been described by Hooker in 1828. It is known that Bligh left 331 breadfruit trees from Tahiti and two trees from Timor at the St Vincent Botanic Gardens. In the transactions of the Royal Society of Arts there is considerable correspondence from Dr Anderson reporting on the way in which the breadfruit trees flourish and much of this has been written up by Lansdowne Guilding in his History of the St. Vincent Botanic Garden[1]. It was Guilding who provided the illustrations which were published by Hooker in the Botanical Gazette in 1828 and who also provided Hooker with the information about the main features of the five varieties. The early events in Jamaica are described in the log of Providence, including the details of how many of the 348 breadfruits trees were distributed to different parts of Jamaica.

The Providence and Assistant put to sea again on January 30th 1793 from St Vincent and were brought to moorings near Port Royal in Jamaica on February 5th. On February 7th the naval Commodore,Ford and "many gentlemen from the shore" came on board to see the breadfruit trees which were then apparently "in the highest perfection". A committee meeting on February 9th discussed the destination of the breadfruit trees within Jamaica. The 348 breadfruits, including one seedless breadnut, which were landed at Jamaica and distributed as follows: 84 were landed at Henderson's wharf for the county of Middlesex (Eastern Jamaica); 75 at Greenwhich for the county of Surrey and for the garden owned by Hinton East (which subsequently became the Liguaria Botanical Garden), 105 at Port Morant for the county of Surrey and for the nursery being established at the Bath Garden; 83 to Savannah LaMar in the West of Jamaica for the County of Cornwall. The single breadnut tree from Timor went with a consignment of plants to Port Morant. The expedition's

botanist, Mr James Wiles was engaged in the capacity of gardener and remained at the Bath Gardens to take over responsibility for the nursery operations. Captain Bligh took the plants himself to Port Morant in the Providence , while Captain Portlock in the Assistant delivered the plants to Savannah LaMar. In addition to the breadfruit and breadnut trees, 10 plants of the Jackfruit or Nanka, grown from plants raised on board from seeds collected in Timor, were delivered to Port Morant for the Bath Garden. Although Bligh's list does not indicate the landing of any Timor breadfruits in Jamaica, Wiles, in a later correction to Hortus Eastensis says that of the four breadfruits from Timor, two were landed in St. Vincent, one in Jamaica and one taken on to Kew.

After some delays for naval activities in the Caribbean, occasioned by the outbreak of war with France, Captain Bligh received orders to sail for England on June 10th 1793 and he anchored at Deptford on August 7th. Among the plants which the Providence brought back for the Royal Botanic Gardens at Kew were not only the breadfruit trees from both Tahiti and Timor, but also 8 other species, including sago and coconut from Tahiti, Cherimoyas, Lemon China, nanka, Mango and others from Timor, the China orange from St Helena and the custard apple, avocado pear, cabbage tree, Akee, wild mangosteen and nazeberry from Jamaica. All in all the expedition had been a quite remarkable success and a most impressive feat of horticulture as well as of navigation.

After the successful landing of the breadfruit in Jamaica and St. Vincent the Royal Society of Arts continued to offer premiums from 1795 onwards to "the person who shall have provided in any of the islands ... the greatest number of breadfruit trees, not fewer than 100, and properly secured and fenced the same, in order to supply fruit to the inhabitants."

The trees grew and flourished in the West Indies and satisfactory reports were sent to Jamaica and St. Vincent. Wood[1] has summarised these reports as follows. "From reports made to the Society in 1795 by General Melville (St. Vincent) and by Dr. Dancer (Jamaica) in 1796, it appears that the trees grew and flourished in the islands, and a little later further information was received from St. Vincent. Dr. Alexander Anderson, the superintendent of the Botanic Gardens in that island, reported fully in 1798 on the condition of the trees there, and stated that they were well established and were producing an ample supply of the fruit. Later reports in 1802 and 1803 were equally satisfactory, and in 1807 he writes that though it is one of the most

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1. Wood. Sir H.T. (1913) A History of the Royal Society of Arts. John Murray London.

valuable productions sent to the West Indies, it is not appreciated at its proper value. He adds that it was said that the negroes did not like it, but that he did not believe this. Its want of popularity he attributes to the apathy of the planters. It may be added that in 1799 a gold medal was awarded to S.Mure for a plantation of breadfruit trees in Jamaica, and two gold medals were given in 1802 and in 1803 to the Hon.Joseph Robley, the Governor of Tobago, for his plantation of breadfruit trees in that island."

At no stage, in any of these discussions of the distribution is any mention made of different varieties of the breadfruit.

Not until 1826, in Hooker's report, is attention first drawn to the varietal variation other than in a report from Anderson in 1798 that he had at that time six varieties in the St. Vincent Botanic Garden (including the seeded variety which he had from Martinique). In the following Table 2, I list the descriptions as given by Lansdowne Guilding to Hooker and published in the Botanical Gazette with indications of the names that now correspond to these types in St. Vincent, notes on their relationship to other varieties seen in the West Indies and finally, a suggestion of possibly corresponding varieties that are known from Tahiti.

TABLE 2

Type as described by Guilding and Hooker	Corresponding name in St.Vincent, 1977	Variation on the type	Similar types in Tahiti (and/ or other S.Sea islands
Round and rough (muricated) fruit	Koshi (excellent quality)	large, white fleshed	cf.Rokouta or Avei or Ovai and Balekana of Fiji and Samoa.
		smaller with yellowing flesh	
Oval and smooth variety the second best.	"Common type" (smooth to slightly rough skin; yellow fleshed may have rougher skin)	Yellow flesh when mature. Cream " " " White " " "	cf. Buko or Maore Buco of Samoa.
Oval and rough, one of the most valuable.	Waterloo (skin v.rough) Excellent quality.	Not seen except in S. Vincent.	cf. Ouaka or Paea.
Round and smooth variety	Cocoabread.	= "Banbran" in Jamaica. Also in Mayaguez Inst. Garden but not seen elsewhere in Puerto Rico.	cf Opiha.
Timor variety:smaller and very inferior. "The Timor breadfruit has the [illegible]	Captain Bligh Tree.	Timor breadfruit in St.Catherines, Jamaica as described by Powell	Savisavi of Fiji.

During the recent survey more than 30 individual collections of breadfruits were made in the Caribbean in the form of herbarium specimens and these are now preserved for further study, and in due course will be compared with similar sheets from the putative parental clones from the South Seas, to see to what extent exact correspondences can be discovered.

Meanwhile, it is clear that the variation present is limited and that, if there is to be a substantial programme of expansion, that the introduction of a much wider range of germplasm is highly desirable. Herbarium material has also been examined from the Caribbean at the Royal Botanic Gardens, Kew, where an oval fruited variety, which appears similar to the most common type found in Trinidad, but collected from Martinique, is described as being the variety which is most commonly eaten in the fresh state.

AGRONOMY OF THE BREADFRUIT

Propagation

Seeded varieties of the breadfruit, i.e. breadnut or Chataigne are of course grown from seed. Only fresh seed is viable and it should be planted according to Theobald[1] in well drained media.

The seedless varieties or true breadfruits have of course to be propagated vegetatively. The traditional method in the South Sea Islands is to use naturally produced suckers, of which four or five in a year arise from the roots at some distance from the parent tree. The number of shoots which develop can be greatly increased by pruning the parent tree heavily according to information provided by Miss Lashley to the writer. It is also widely known that artificially exposing lateral roots and making slight injuries promotes the regeneration of suckers near the point of injury. Theobald[1] also refers to the value of repeated root pruning around the developed sucker before any attempt is made to lift and transplant this. Repeated root pruning over several months will lead to the development of a good root ball for the transplant. In the West Indies two informants (Mrs Thelma King & Mr Danville Roach) have said that it is important, when transplanting a sucker, to make sure that the plant is set up in its new position in the same directional orientation as it was when attached to the parent tree. In this way the relative light and shade received by the different leaves will be similar, and the plant will receive less shock. Although this may sound a small detail, it is quite likely to be of significance, and it would be an interesting observation to verify experimentally.

The most common way of propagating the breadfruit is by the use of root cuttings. Singh et al.[2] reported that, depending upon the conditions and season of propagation success ranging from 29-90% can be achieved. In India 90% success was obtained from root cuttings about 1" diameter and 9" long planted horizontally. Under the same conditions only 40% success is achieved if the cuttings are planted vertically. The greatest advance in the propagation of breadfruit from root cuttings was published as long ago

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1. Theobald, W.L. (1976) Ethnobotany of the breadfruit. Bull.Pacific Trop.Bot.Gdn. 6(1).
2. Singh, S., Krishnamurthi, S. and Katyal, S.L. Fruit culture in India. New Delhi, Indian Council of Agricultural Research, 1967.

as 1945 by Julien[1] in Mauritius, but the paper is little known. In Julien's method, freshly dug roots are cut into pieces 8" long of diameter from 3/10th of an inch to 1¼ inches. The fresh cuttings are dipped into 2% potassium permanganate to coagulate the latex. The treated roots are then placed in a sandbed in a horizontal position a quarter inch apart and covered with a layer of sand to ½inch deep. The germination bed is watered every morning. After 45 days all the cuttings are removed from the propagator and at this time most of them will have produced a gall-like callus and it is from these that adventitious shoots will develop. The root cuttings bearing calli are laid out again on a propagating bed with the calli facing upwards and recovered with sand to ½inch depth. The roots that have not yet produced calli can be replaced in the original propagator and looked at again a week later. As soon as suckers appear above the sand in the second stage propagator, the cutting is ready for potting out. Five classes of cutting are described by Julien.

1. Those bearing suckers but no side roots.
2. Cuttings with both suckers and side roots.
3. Cuttings that develop suckers with two separate root systems on either side of the shoot.
4. Cuttings developing the roots.
5. Cuttings which fail to develop suckers or roots.

The first three classes of cuttings can produce good plants. Cuttings of classes one and two are treated by re-dipping the cut end of the cuttings nearest to the sucker in potassium permanganate solution and then coating cut end with paraffin wax. The cuttings are planted in pots in a diagonal position with the paraffin waxed end uppermost above the level of the potting medium. Julien used a solar propagator but mist propagation would probably be equally satisfactory. A solar propagator consists of a plant frame with a sloping glass roof allowing plenty of light to reach the young plants in the bed. In a solar propagator cuttings are kept moist by spraying them by hand with water once or twice a day. The propagation bed is very well drained.

In India there has been considerable work on propagation on breadfruits

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1. Julien, J.H. (1945) Breadfruit propagation. Rev.Agr.Maurice 24, 31-33.

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by budding and grafting. Thomas[1] says that either grafting or budding to the wild Jackfruit is an easy operation. Although one might also anticipate that budding or grafting to the seeded breadfruit should be possible,there are reports in the literature suggesting that this is far from easy. (Raoul in Sagot and Raoul,1893). There are many examples of propagation of tropical bush and tree crops which have showed the value of persevering in trying to propagate difficult species. Recently a great advance has been made in Durian propagation in Thailand by top cleft-grafting young seedlings, and this is a technique which should be tried with the seeded breadnut as a stock.

There are scattered reports, and I have also had personal information from informants, on successful use of marcotting for propagating stems of the breadfruit, but this method never seems to have become popular. The rooting of shoot cuttings was pioneered by the work of Muzik[2] in Liberia. A quick-dip method, using a 1% indole butyric acid solution gave the best results though succes was also obtained by immersing the bases of the cuttings for 24 hours in 0.002% indole butyric acid solution. Three to four node cuttings of about $\frac{3}{8}$" diameter and 12-15 inches long were successfully struck after treatment in sand beds. After planting out the cuttings, the beds were mulched with banana leaves to prevent excessive evaporation. Beds were lightly shaded and the cuttings were watered daily. The success was up to 80%. There seems to have been little published follow-up from this important paper. The newest phase of development of breadfruit propagation was initiated in Puerto Rico[3] where a method has been described to produce multiple propagating material from a single stock plant by propagating all leafy stem cuttings produced successively from a shoot from a root cutting. Recently Prendergast[4], with the collaboration of an American Peace Corps volunteer, has developed this technique further and they are now able to obtain 20 young plants from a single 8" cutting. In their method the callus developed on the root cutting is excised so that the method is essentially one of micro-propagation. Details of the method have not yet been published,

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1. Thomas, C.A. (1969) You can grow breadfruit in your garden. Indian Hort. 13(4), 27.
2. Muzik,T.L. (1948) Effects of hormone on root formation in Artocarpus communis. Science 107, 225.
3. Rodriguez. (1975)
4. Prendergast,

but it holds out great promise as a new technique for rapid propagation.

Care of the transplanted nursery plants

The possible importance of transplanting to the field with the main leaves in the original orientation has already been mentioned for transplanted suckers, and the same may well apply to nursery grown plants from root cuttings or ex-plants. It would at least be a wise precaution to attempt to keep plants in their original orientation pending further experimental work. Raoul, in what is probably the most important account of the agronomy of breadfruits so far published, points out that it is essential to maintain favourable moisture conditions around a young transplant until re-growth has begun. He describes the establishment of sucker transplants of about 1½ m. height. These can be successfully established if the entire shoot is wrapped around with a bandage of plant fibre to prevent drying out until re-growth starts, and also applying plenty of mulch on the surface of the ground. (This old French method of bandaging plants after transplanting is also used with remarkable success in transplanting palms and other trees under desert conditions in the Middle East at the present time.)

Spacing

Jacques Barrau has suggested a practical spacing of 25 ft x 25 ft for breadfruits for a school garden in Truk. In India Singh et al. suggest a spacing of 40 ft between trees "which is necessary to permit trees to attain their normal growth". While it may be true that such a wide spacing will be required to allow trees to attain their normal growth, it far from clear that this would be the best system of management. It is more likely that a combination of a closer spacing and vigorous pruning, or the use of dwarfing rootstocks would be a better practice, but this needs development-orientated research work.

Intercultivation

Deep cultivation of the land in the breadfruit plantation or garden is to be avoided since the shallow growing roots would be injured. However, rather than attempting to keep the plantation clean weeded, the use of intercropping at least for a few years should be considered desirable and

has been suggested by the Indian workers. They suggest particularly the combination of breadfruit with ginger,pepper or vanilla which require shade, and for both the vining crops, the vines could be trained to climb over the early branches of the breadruit tree which will rapidly grow beyond the reach of the vines. They also recommend the growing of leguminous cover crops, and this suggestion could of course be extended to the growing of crops for the provision of nutritious forage such as Stylosanthes or, on neutro-alkaline soils, alfalfa.

Fertilizers

There has been no systematic work on the use of fertilizers of bread-fruits, but responses would be expected during the early years. Indications with almost all other tropical tree crops show the economic advantage of encouraging healthy and vigorous early growth. This is an area requiring experimental work, but the use of fertilizers should not wait for the results of research to be published. In domestic cultivation in the West Indies, the best-growing breadfruit trees are usually found near to house sites and receive considerable quantities of household refuse and sometimes night soil as well. Probably the most productive breadfruit seen by the writer during his tour of the Caribbean had a pit latrine sited near the tree. Fertilizer practice should be suggested by analogy with recommendations based on research for other crops to take account for the differences in natural soil fertility.

Pruning

There appears to have been no formal research carried out on the pruning of breadfruits, but several informants have mentioned the practice. The most obvious reason for pruning breadfruit trees is to keep the height down so that harvesting can be facilitated. Several informants commented on methods that they themselves had discovered for pruning breadfruits. One observation was that branches that have already produced a crop of fruits do not fruit again and frequently die back. Removal of these,after harvesting the fruits, below the point where the fruits were borne, during the following dry season stimulates the production of new vegetative growth from dormant buds and keeps the tree in thriving and productive conditions. This would seem to be a sensible practice, but should also be the subject of experimental work.

Harvesting

As is very well known , breadfruits are usually harvested before fruits soften, but after the development of small drops of latex on the surface of the fruits. These dry to form mealy, grey blobs. Breadfruits at this stage are described as being "fit". The breadfruits are usually harvested either by climbing up the tree or by knocking down the fruits with a stick with a hook or some other convenient implement on the end. The fruits are usually allowed to fall to the ground and many are damaged in the process. Climbing the trees can be dangerous since the wood tends to be brittle and accidents have occured quite frequently. The difficulty of harvesting trees of the size normally occurring in the Caribbean is one of the principle reasons why little attention has been given to increasing the production of breadfruits. The production of trees that are much easier to harvest, either by pruning or genetic manipulation, is a very high priority requirement. There is no reason to think it cannot be achieved by one or both means. There are well documented sources of bush or low-growing trees of breadfruits which should be regarded as potential rootstocks for the cultivation of dwarfs. (See section on variability). For this reason it is eesential to move ahead as fast as possible with the development of an effective propagating technique for the production of desirable, scion material on seedling root stocks.

Hand pollination

In India Singh et al. claim that higher production can be attained by hand pollinating breadfruits. While this may be true, it is unlikely to be a practical technique, particularly for large scale production, as so far as is known, there is no experimental evidence to support its being necessary.

General

Although there has been little formal work published on the agronomy of breadfruits, and none in the Caribbean region, I was informed (personal communication Irwin Telfer) that about 15 years ago some agronomic work was carried out in Guyana by P.O. Jackson. This might be worth following up if unpublished data is available. During my visit the only attempt to propagate the breadfruit on any substantial scale which I saw was in the nursery at Timheri in Guyana. There, about 1,000 breadfruit trees were being produced per year, and this was insufficient to meet the demand for plants.

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It was costing the Department of Agriculture in Guyana 35 cts. to buy a root cutting, and the resulting tree was being sold for over 50 cts. Losses in the propagating beds were unsatisfactorily high and Mr Baichoo is immediately beginning to use the Mauritius method of Julien. On the "black market" in Georgetown privately produced breadfruit plants are selling from $1.50 - $4.00 per plant in comparison with 50 cts being charged by the Government's nursery.

Premature fruit drop

Breadfruits that have not reached the stage of "fitness" frequently drop. These are sometimes fed to the pigs, but usually wasted. Heavy drop appears to be associated either with excessive drought during the period when the fruits are developing, but also when there is excessive soil moisture. Several separate informants reported that premature fruit drop can be at least partially controlled by hammering iron nails into the stems of breadfruit trees. This is by no means impossible and it may be that one of the causes of fruit drop is iron deficiency which could well be remedied by such a practice. Here again is a lead requiring experimental follow-up.

DISEASES AND PESTS OF BREADFRUIT

In the Caribbean

Within the Caribbean the only apparently quite serious problem is caused by Rosellinia sp. This has damaged trees in both Dominica and Trinidad. It appears to be associated with neglected trees in areas where either rank weed growth has occurred, or where trees have been mechanically damaged by cultivation operations. Mr Dial (Agricultural Officer, Extension at Sangre Grande, Trinidad) says that 60% of trees less than 2 yours old died recently when planted on old cocoa land. Rosellinia disease of breadfruit should be actively investigated as soon as possible (perhaps at the University of the West Indies, St. Augustine). It is not anticipated that a pathogen of this kind will prevent successful breadfruit production if due care is given to agronomic practices avoiding predisposing conditions, but more needs to be known of this disease.

Scale Insect infestation was very severe on the Cocoabread variety in the garden of Mr and Mrs Gibson at Montrose, St. Vincent. The tree seemed to suffer little damage from this. Nevertheless, scale infestation should be considered a potential hazard and be investigated if breadfruit production is to be stimulated. Soft scales and mealybugs were also seen on breadfruit in the Sangre Chiquito area in Trinidad. Their possible role in weakening trees and making them vulnerable to pathogens should be considered.

Ants may infest the dead or dying back shoots that appear to be a natural response to heavy fruiting. Pruning back all dead shoots regularly should be encouraged as for all trees.

Diseases in the South Pacific

A very serious disease occurs in the Pingalap Atoll (Zaiger and Zentmeyer[1]), and this has led to advice (Reddy[3]) to prohibit the import of

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1.Zaiger, D. and Zentmeyer, G.A. (1966) A new lethal disease of breadfruit in the Pacific Islands. Pl.Disease Reptr. 50(12), 892-6.
2.Zaiger, D. and Zentmeyer, G.A. (1967) Epidemic decline of breadfruit in the Pacific islands. FAO Plant Prot.Bull. 15(2), 25-9.
3.Reddy, D.B. (1969) Seventh session of Plant Protection Committee Noumea, New Caledonia, 15-23 July, 1969. Inf. Lett. FAO Pl. Prot.Comm. S.E.Asia 71,2pp.

planting material from all areas where this serious disease occurs. The etiology of the disease is still rather uncertain, but the probability is that it is a Fusarium wilt disease, possibly caused by a form of Fusarium solani, and that other fungi involved in the dying back which occurs such as Phomopsis sp. are secondary invaders. However, a Pythium sp. has been obtained from diseased roots and the disease may still prove to be primarily a root rot.

It is unfortunate that the collecting that was carried out in the 1950's and 1960's by Barrau and associates for the South Pacific Commission probably included areas where the disease occurred, and hence it is likey to have been spread, through the well-intentioned operation of distributing germplasm, to new areas in the Pacific. Great care must be taken to rpevent its spread to the Caribbean and other parts of the New World in any new introductions that may be considered desirable. To this end the use of intermediate quarantine facilities, including a generation of propagation from disease-indexed material, is proposed.

According to Zaiger and Zentmeyer[1] "Pingalap disease has affected a large number of varieties of both seeded and seedless types of breadfruit and appears to be spreading throughout the islands of the western Pacific. Until the receipt of a report of a similar malady occurring on Tarawa Atoll in the Gilbert Islands , the disease had been reported only from the United States administered islands of the Trust Territory of the Pacific Islands, Guam and American Samoa.

The epiphytotic nature of the disease can hardly be overemphasized. On the island of Guam, and at Maorik Atoll, Marshall Islands, the extent of damage is no less than catastrophic. On the former island, tens of thousands of dead trees give an appearance from the air of a forest fire having ravaged the landscape. The majority of an estimated 80,000 dead and dying trees there ere in robust health and in full bearing only 2 years ago." Between 1957 and 1966 the disease was found in Pingalap (Caroline Islands), Guam and Saipan (Mariannas), Kili (Marshalls), American Samoa, Truk (E.Carolines), Ponape (Carolines) and Tarawa (Gilbert & Ellice Islands).

A fruit disease associated with, and probably caused by Phytophthora palmivora affects breadfruit in Truk[2].

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1. loc cit.

2. [illegible] Phytophthora fruit rot of breadfruit.

THE STATUS OF THE BREADFRUIT AS AN ECONOMIC CROP PLANT IN THE CARIBBEAN

There is very little appreciation at present of the breadfruit and a paucity of meaningful statistics. However, a certain amount of factual information has been unearthed. In Table 3 following, the relative importance of the breadfruit in different Caribban islands, as revealed in Nanton's surveys during the 1950's, is presented. From this the overwhelming importance of Jamaica as a breadfruit island is apparent. However, the data provided by the Caribbean Food and Nutrition Institute for breadfruit, cassava and yams in Jamaica between the years 1958 and 1973 (Table 4), in so far as they can be relied on, indicate a very serious fall in the production of breadfruit whereas the production of yams has risen substantially over the same period. Cassava has been relatively stable. The rather abrupt changes in figures for example between 1967-8 suggest that there has been an abrupt change in the way in which the statistics have been collected rather than in production.

Much information which is very useful has been collected in the recent Food Balance Sheets of the Caribbean. Table 5 provides data for Antigua, Dominica, Grenada and the British Virgin Islands. The data for the fruits picked per tree have been added in the preparation of this report and are important because they indicate a much lower figure than has often been suggested in the published literature. This may be because the number of fruits picked is much smaller than the number produced.

Barbados is the island which at present is attaching the greatest importance to the productivity of the breadfruit, and data in Tables 6 and 7 provide relevant information from the Food and Nutrition Survey of Barbados and from the Food and Nutrition Institute Balance Sheets.

The Food and Nutrition Survey also indicated the very low cost price per 1000 calories of breadfruit in comparison with otehr indigenous starchy crops, and that it is cheaper on a calorie basis than four out of six imported dietary calorie sources.

TABLE 3

COMPARISON BETWEEN BREADFRUIT PRODUCTION IN THE ENGLISH SPEAKING CARIBBEAN ISLANDS BASED ON DATA COLLECTED 1954-1958 by W. NANTON

ISLAND	Number of trees on farms	Number of growers
Antigua with Barbuda	556	-
Barbados	24,654	-
Dominica	61,220	5,100
Grenada Island	58,640	6,280
Jamaica	2,278,400	-
Montserrat	9,520	1,016
St.Kitts Nevis with Anguilla	8,234	-
St. Lucia	168,280	8,250
St. Vincent	38,460	6,220
Trinidad and Tobago	71,629	-

Source: Food Balance Sheets for the Caribbean. [illegible]
Nutrition Institute. 1976.

TABLE 4

JAMAICA BREADFRUIT, CASSAVA AND YAM PRODUCTION 1958-73
(In 10 metric tons)
Population 1958: 1,610,000
1973: 2,002,796

YEAR	PRODUCTION	DISPOSAL			PER CAPUT SUPPLIES				
		Animal feed	Waste	Food	Amount /year kg	Amount /day grams	Energy /day calories	Protein /day grams	Fat /day grams
Breadfruit									
1958	13,161	3,265	1,814	8,081	50.2	137.7	89	1.4	0.4
1960	6,095	-	609	5,485	34.0	93.3	51	0.8	0.3
1961	6,531	-	653	5,878	35.9	98.4	54	0.8	0.3
1962	6,531	-	653	5,878	35.3	96.8	54	0.8	0.3
1963	7,076	-	707	6,368	37.6	103.2	56	0.9	0.3
1964	6,803	-	680	6,123	35.6	97.7	53	0.8	0.3
1965	6,531	-	653	5,878	33.6	92.3	50	0.8	0.3
1966	6,803	-	680	6,123	34.5	94.6	52	0.8	0.3
1967	6,531	-	653	5,878	32.6	89.3	49	0.7	0.2
1968	3,265	-	326	2,939	16.0	43.9	24	0.3	0.1
1969	3,538	-	353	3,184	17.1	46.8	25	0.4	0.1
1970	3,592	-	359	3,233	17.1	46.8	25	0.4	0.1
1971	3,723	-	372	3,350	17.3	47.6	26	0.4	0.1
1972	3,723	-	372	3,350	17.0	46.7	25	0.4	0.1
1973	3,723	-	372	3,350	16.7	45.8	25	0.4	0.1
Cassava									
1958	1,229	-	-	491	3.1	8.4	9	0.1	-
1960	997	-	99	816	5.0	13.9	15	0.1	-
1961	889	-	89	719	4.3	12.0	13	0.1	-
1962	892	-	89	722	4.3	11.9	12	0.1	-
1963	907	-	90	735	4.3	11.9	12	0.1	-
1964	878	-	87	708	4.1	11.3	12	0.1	-
1965	820	-	82	657	3.7	10.3	11	-	-
1966	1,231	-	123	1,027	5.7	15.8	17	0.1	-
1967	1,530	-	153	1,296	7.1	19.7	21	0.1	-
1968	842	-	84	707	3.8	10.5	11	-	-
1969	1,125	-	112	961	5.1	14.1	15	0.1	-
1970	2,016	-	201	1,814	9.5	26.2	28	0.2	-
1971	1,741	-	174	1,567	8.1	22.2	24	0.2	-
1972	2,125	-	212	1,912	9.7	26.6	28	0.2	-
1973	1,506	-	150	1,356	6.7	18.5	20	0.1	-
Yams									
1958	6,077	-	-	6,077	37.8	103.5	93	2.2	0.2
1960	4,954	-	396	4,558	28.3	77.5	70	1.6	0.1
1961	4,291	-	343	3,948	24.1	66.1	59	1.3	0.1
1962	4,955	-	396	4,558	27.4	75.1	67	1.5	0.1
1963	4,989	-	399	4,590	27.1	74.4	67	1.5	0.1
1964	5,479	-	438	5,040	29.3	80.4	72	1.6	0.1
1965	4,586	-	366	4,219	24.1	66.2	59	1.3	0.1
1966	6,348	-	507	5,840	32.9	90.2	81	1.8	0.1
1967	7,458	-	596	6,861	38.0	104.3	94	2.1	0.1
1968	6,630	-	530	6,100	33.3	91.2	82	1.8	0.1
								1.7	

TABLE 5

PRODUCTION DATA FOR BREADFRUITS 1961 for ANTIGUA, DOMINICA, GRANADA and the BRITISH VIRGIN ISLANDS

Trees related to size of holding, bearing and non-bearing trees, number of fruits and average numbers of fruit harvested per bearing tree.

ANTIGUA	Size Group (acres)									
	Total	0-	1-	5-	10-	25-	50-	100-	200-	500+
Holdings reporting	282	51	186	25	11	3	4	2	-	-
Total no. trees	552	51	370	68	37	5	12	9	-	-
No. non-bearing trees	213	-	169	36	-	-	5	5	-	-
No. bearing trees	339	51	201	32	37	5	9	4	-	-
No. fruit picked ('000)	70.6	0.5	66.7	0.9	2.4	-	0.1	-	-	-
Fruits picked/tree	208.3	9.8	331.8	28.1	64.8	-	11.1	-	-	-
DOMINICA										
Holdings reporting	4,386	607	2461	697	377	93	65	32	29	20
Total no. trees	39,032	2136	18783	6098	5012	1592	1183	922	1661	1645
No. non-bearing trees	2,060	19	1532	214	216	66	1	10	-	2
No. bearing trees	36,972	2117	17251	5884	4796	1526	1182	912	1551	1643
No. fruit picked ('000)	506.4	117.7	980.4	183.9	90.5	35.3	22.4	15.7	10.3	50.2
Fruits picked/tree	40.7	55.6	58.8	31.6	*	*	*	*	*	30.5
GRANADA										
Holdings reporting	7,468	2419	3766	722	361	86	34	24	46	10
Total no. trees	95,932	10444	35527	19031	8628	6363	2441	2288	6068	5142
No. non-bearing trees	17,417	1842	6609	3069	1967	1168	219	355	1057	1131
No. bearing trees	78,515	8602	28918	15962	6661	5195	2222	1933	5011	4011
No. fruit picked('000)	2829.7	375.5	926.6	448.6	382.3	115.8	82.8	51.7	232.5	173.9
Fruits picked/tree	36.0	43.6	32.0	28.1	57.4	30.0	37.2	26.7	46.4	36.0
BRITISH VIRGIN ISLANDS										
Holdings reporting	101	9	20	37	23	7	4	1	-	-
Total no. trees	185	9	25	74	52	15	9	1	-	-
No. non-bearing trees	13	-	-	7	6	-	-	-	-	-
No. bearing trees	172	9	25	67	46	15	9	1	-	-
No. fruit picked ('000)	8.9	0.6	0.6	3.7	2.7	0.7	0.4	0.2	-	-
Fruits picked/tree	51.7	66.6	24.0	55.2	58.7	46.7	44.4	2.0	-	-

TABLE 6

BARBADOS BREADFRUIT, SWEET POTATO AND YAM PRODUCTION 1966, 1969 & 1971

(In 10 metric tons)

Population 1966: 235,500
1969: 238,000
1971: 236,400

YEAR	PRODUCTION	DISPOSAL			PER CAPUT SUPPLIES				
		Animal feed	Waste	Food	Amount /year kg.	Amount /day grams	Energy /day calories	Protein /day grams	Fat /day grams
Breadfruit									
1966	285.7	-	2.8	282.9	12.0	32.9	20	0.3	0.1
1969	265.0	-	-	265.0	11.2	30.5	25	0.4	0.2
1971	97.6	-	9.7	87.9	3.7	10.2	6	0.1	-
Sweet potato									
1966	712.3	3.5	3.5	705.1	29.9	82.0	79	0.9	0.2
1969	494.7	2.4	4.9	483.9	20.3	46.1	54	0.6	0.2
1971	676.2	33.7	33.7	608.2	25.7	70.3	68	0.8	0.2
Yams									
1966	868.5	-	7.5	739.1	31.4	86.0	73	1.5	0.1
1969	1,100.3	10.0	20.0	972.8	40.9	96.0	87	2.0	0.2
1971	1,435.1	132.8	67.7	1,030.3	42.4	115.9	105	2.4	0.2

Source: Food Balance Sheets for the Caribbean. Caribbean Food and Nutrition Institute. 1976

TABLE 7

LEAST EXPENSIVE SOURCES OF PROTEIN AND CALORIES WITHIN FOOD GROUPS (1966)

(Barbados)

Foods (listed in order of ascending cost of both nutrient)	Cost (in E.C. $) per 20 gm protein	Cost (in E.C. $) per 1000 calories
Cereals and cereal products		
Wheat flour (unenriched	.05	.07
Cornmeal	.09	.10
Rolled oats	.09	.14
Rice	.12	.13
Wheat flour (enriched)	.10	.15
Whole barley	.11	.15
Roots, tubers, starchy fruits		
Breadfruit	.12	.10
Yams	.29	.34
Irish potatoes	.34	.41
Sweet potatoes	.49	.27
Bananas	.75	.39
Sugars		
Granulated sugar (crude)	Infinity	.07
Granulated sugar (white)	Infinity	.14

Source: The National Food and Nutrition Survey of Barbados. Pan American Health Organization. 1972

THE POTENTIAL PRODUCITIVTY OF BREADFRUITS

This is one of the most difficult subjects about which to speculate when at the present time there are no productive plantations or orchards of breadfruits. Sophocles 496-406 B.C. was pertinently quoted recently in a publication from the University of Arizona, Tucson[1] "One must learn by doing the thing, for,though you think you know it,you have no certainty, until you try."

Speculating about yields per unit area on the basis of yields from individual plants is notoriously dangerous. The figures given by Purseglove who suggests yields of up to 700 fruits per tree, with fruits in a weight range of 2-10 lbs would, at a spacing of 30 x 40 feet, or about 36 trees per acre, equate to a yield potential of the order of 22 tons per acre fresh weight (about 5 tons per acre dry weight). However, there is very little certainty that such large numbers of fruits per tree can be attained in practice.

During my survey, physical counts and enquiries suggested that an average number of fruits per tree might be in the range of 150-200 fruits, taking a figure of 2 lbs per fruit and a spacing of 35 trees per acre. This would suggest that 4.5 - 8 tons fresh fruit per acre might be produced. Barrau, in the South Pacific estimated average yields of 50-150 fruits per tree, or, depending on fruit size, about 150 kg. per tree as an average yield. This would be equivalent to a dry matter yield of about 3,700 lbs per acre.

In Barbados, I understand that data have been taken on a sample basis from counted trees by the FAO-UNDP planning team who have made an estimate of productivity depending on climatic differences between wet and dry areas of 6.7 - 13.4 tons per acre on a fresh weight basis.

There is surprisingly close agreement between the figures suggested by Raoul long ago, for an average of about 50 fruits per tree with the actual production figures in the statistics from the Caribbean islands at the present time, and unless there is to be a great improvement in the efficiency of harvesting, it might be wise to base computations on an expectation of only about 50 fruits per tree. If a population of 25 x 25 ft or about 70 trees per acre produce at this rate one would expect 3,500 fruits per acre, and if fruits weighed approximately 2 lbs this would be equivalent of a fresh weight yield of about 3.12 tons per acre. I suggest that this would be a reasonable

alternative to other starch producing crops.

In comparison with this figure, it is interesting to compare figures recently presented by Dr Lloyd Rankine, who has studied yields and production economics of ground provisions in the Caribbean countries with the following results from Barbados, St. Kitts and St. Vincent. (Table 8)

TABLE 8

Country	Average yield of sweet potato t/acre (fresh weight)	Average yield of yams t/acre (fresh wt)
Barbados (small farms)	4.47	4.63
(estates)	3.42	2.77
St Kitts (small farms)	1.22	0.37
(estates)	0.91	1.13
St Vincent (windward side)	1.78	1.97
(leeward side)	2.48	1.38

(data from paper in Proc.3rd Int. Root Crops Conference)

DOMESTIC USE OF BREADFRUITS IN THE CARIBBEAN

Breadfruits as human food have a curious double status. At the lower end of the economic scale, particularly among those of African origin, the breadfruit has apparently retained the image of a cheap food to be used as a rampart against starvation, for which purpose its introduction to the Caribbean was indeed intended.

Having such an image, any encouragement of its use for the poor by those better off may be construed as an attempt to provide a sub-standard food.[1] Among those more interested in either food diversity (dieticians and home economists) or those who have realised the value of a special regional cuisine as a positive virtue, the breadfruit has attained, together with akee (Blighia sapida) and saltfish, a great reputation and is considered a food to be prepared and served on special occasions as well has having a regular place in a mixed diet when in season. The majority of the population between these two groups make little use of breadfruit unless they have to. Between different islands there may well be differences in attitude towards breadfruits which in a short survey it has not been possible to explore even superficially, but Byron Blake (CARICOM)contrasted its food status in Jamaica (more esteemed) with Trinidad (used only as a side dish.)

The market in distant places such as London and New York for fresh or part-cooked breadfruits (see section) indicated that many West Indians away from home wish to use breadfruit when there must certainly be cheaper alternatives available.

In Guyana and in Trinidad with large populations of Asian origin, the breadfruit and the breadnut are both much valued and have been incorporated into diet mainly as vegetables rather than staple starch, and are curried.[2] In Guyana the population of Indian descent tend to make more use of the breadfruit while those of Portuguese and African descent are reported to

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1. Both the Minister of Agriculture for Barbados, Dr.Ken Leslie of CFNI Jamaica and Mr. Byron Blake (CARICOM) have commented particularly on the sociological problems surrounding any attempt to promote the expanded use of breadfruit as direct human food. The Minister suggests that a sociologist would have to be involved in any attempt to develop breadfruit as human food. Several others have commented along similar lines.

2. Mature breadnut seeds or immature breadnut fruits are more popular for currying than breadfruit. In Tobago currying is popular with African as

prefer the breadfruit.[1] In Guyana the Government ban about three years ago on the import of potatoes has greatly stimulated the demand for and use of breadfruit.

During the survey about 20 recipes have been collected (Appendix). Many have been published in the West Indies[2,3] and in Hawaii[4]. Recipes exist for the use of breadfruits at all stages of ripeness. As the fruit ripens and becomes sweeter and softer different methods of preparation are appropriate.

Under-ripe breadfruits can be pickled with lime, onion, salt and pepper (Barbados). "Fit" breadfruit (the stage at which latex exudes and congeals on the skin indicates "fitness") can be used to make roast breadfruits, jacketed breadfruits, stuffed breadfruits and boiled or steamed breadfruits. Steamed breadfruits can be prepared further with grated coconut to make the Grenada speciality "Oiled Down" or the Tobago speciality "Sandcoach". Pounded or steamed or boiled breadfruit is widely used to prepare a "cou-cou" (or "coo-coo") of mashed product like that prepared from other starch ingredients. Breadfruit soup is made in Guyana from ripe breadfruit pudding; sweets and fritters can be prepared from fruit too ripe for other human uses.

Both breadfruit chips (rather like potato chips) and breadfruit flour, and also candied breadfruit male inflorescences have been found, during the survey, domestically prepared but such use is probably rather unusual at present.

The storage and marketing of fresh and semi-fresh whole breadfruits

Bell and Coursey (1971) indicated the existance of a market in Europe for breadfruits.

Entrepreneurs in Jamaica and St Lucia and also in Dominica, Grenada, St. Vincent and Montserrat in the English-speaking Caribbean and in Guadaloupe in the French Antilles have recognized this export potential for breadfruits for consumption in the U.S.A. or Europe by West Indian

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1. p.c. Mr C. S. Baichoo
2. Phyllis Clarke. West Indian Cookery Nelson.
3. Anon. (1958) Favourite West Indian Recipes. Central Information and Publicity Services. Jamaican Agricultural Society.
4. Anon. (1976) Breadfruit(Ulu) - Uses and Recipes. Pacific Tropical Bot. Gdn Honolulu

nationals. It is possible that there may be also a fringe market for other communities, but there has been no detailed study, to my knowledge, of the nature and extent of the market or of likely price elasticities of demand. As a significant contribution to the economic development of the Caribbean countries the export market is of very minor significance, but because vigorous entrepreneurs require assistance and know-how to set about getting it, there has been a considerable research activity to service this enterprise including technical assistance from Britain.[1] A programme which has had assistance from two highly qualified staff from the Tropical Products Institute is continuing in Jamaica at the Food Laboratory of the Ministry of Commerce and Consumer Protection. This work is encouraged by the Jamaica's Agricultural Society through the President, Mr Fletcher, who is also locally involved with marketing aspects. In St. Lucia another British advisor, who was responsible[1] for setting up the St. Lucia Marketing Board included breadfruits, with conspicuous success, among the exports developed by air freight to Europe. During a test marketing period from January to 30th April 1973 the price of breadfruits, which were then out of season, was only 4 cents (EC) per lb in St. Lucia so that the selling price - on consignment - to Covent Garden Market in London had only, in effect, to cover the freight cost and profit (At this sort of price it might be much more useful to the St Lucia economy to use the breadfruits as animal feed). Problems arose with the freight rate which increased from 1971 to a level where the export was less attractive by air and the Board was obliged to discontinue shipments. Even in October 1972, with sale proceeds on 3200 breadfruits of £1426.33, 62% of the sale value was absorbed by airfreight, 11% by clearing and forwarding charges in London with only 1.6% being taken as profit by the Board (probably a quite uneconomic rate for the service) and 9.3% going to procedures.[2] No such accurate information has been able to be obtained for Jamaica or other islands.

Recently Geests have been shipping breadfruits from St. Lucia to Europe on Banana boats, but details were not obtained.

Breadfruits are exported fresh by air from Guadaloupe to San Maartens

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1. Dr A.K. Thompson assigned for three years on Technical Assistance for work on the storage of a number of commoditeis in the fresh state including breadfruits.
2. William B. Williams (1973) Report on the operation of the St. Lucia's Marketing Board and on matters apertaining thereto (mimeo).

and were on sale at a retail price of US$1 per fruit of about 3-4 lb in weight. Though the market is probably small, the fact that the trade exists at all is an indication that it is esteemed. There was also inter-island export from Montserrat recorded in Annual Reprots during the period 1944-50's, but this trade has dwindled. St. Lucia and Dominica are thought to export to Barbados.

TABLE 9

TABLE Exports of fresh breadfruit from Montserrat 1949-50
(no data obtained thereafter)

1944	92 bags (say 150 per bag) or say	14000 lbs
1945	31 "	4700 lbs
1947	20 "	3032 lbs
1948		60387 lbs
1949		3120 lbs
1950		6060 lbs

The research work in Jamaica[1,2,3] has shown that enclosing fresh breadfruits in polythene wrapping and chilling, but at a temperature a little above 12°C to avoid chilling injury, could permit storage during transportation to market for up to 19 days.[2,3] Subsequent work by Marriott[3] found significant changes in storage which depended for example upon the maturity of the fruits at harvest. For practical purposes, if fruits were fully mature at picking but were allowed to fall to the ground after pulling off the tree, a mean storage life of 10 days was possible, but if fruits were immature and were caught this could be increased to 15 days with the same post harvest storage at 12.5°C in polythene bags.

Entrepreneurs operating from Jamaica[4] have however found a way of preserving whole breadfruits for sea transport to New York and to Europe by part roasting the fruit then allowing them to cool completely before packing in barrels and are reported to be established in trade in this commodity.

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1. Thompson, A.K., Been, B.O. and Perkins, C. (1974) Storage of fresh breadfruit.
2. Thompson, A.K., Been, B.O. Caribbean Food Crops Society 12th Annual General Meeting, Jamaica pp. 120-124.
3. J. Marriott (in press).
4. Mr Domingo of Kingston and Mr Upwood of St. Thomas. Mr Upwood is reported to core as well as roast his breadfruits before export.

The part roasting is enough to coagulate the latex and probably to denature the endogenous oxidases. It is interesting that a similar immediate post-harvest treatment is that of the traditional way in the Reef Island in the Pacific by which breadfruit is preserved. There, after cooling, it is peeled and dried to be stored for extended period in the form of irregularly shaped biscuits or "nambo".

It would be valuable to refine this technique in terms of the times and temperatures giving the best economic combination of low fuel use against improved storage and acceptance on the market.

In the Seychelles breadfruit sliced into ½" thick slices has been dried in copra driers from 4 days at 120°F and successfully stored in airtight containers (Barrau, 1956), and in Ceylon sliced breadfruits cut into salt solution (⅛lb:1 gall) and then blanched in boiling water for 3-5 minutes have been dried on bamboo slats at 70°C. for 4-6 hours to a storable product of 8-10 months durability.

The preparation and use of breadfruit flour

An extensive interest has developed during the past decade in the preparation and use of flours for the part substitution of imported wheat for making bread in many countries whose climates are unsuited to wheat production. Dr. George Sammy, for the Caribbean region has been a pioneer in exploring the possibilities of substituting sweet potato, yam and cassava flours partially for wheat and has been influential in encouraging work in this direction by home economists as well as industrialists. However, no large scale regular use of non-wheat flours has yet, to the best of my knowledge, occurred. As an extension of my Caribbean tour I visited Dr. Teresa Salazar de Buckle at the Instituto de Investigaciones Tecnologicas in Bogota, whose organization has been heavily involved in composite flour research and has now embarked on a training and development programme for the bakery industry in Colombia.[1,2] While it is likely that wheat flour will

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1. Sammy, G. (1972) The status of composite flour research at UWI, St. Augustine, Trinidad. International conference on production and marketing of composite flour, baking and pasta products, Bogota, Colombia. Sammy, G. (1974) a model for agro-based industries in the LDC's of the Caribbean Commonwealth - Fruit and vegetable processing. Paper for Ministers of Agriculture meeting CARICOM secretariat, May 1974.
2. Work at IVT Bogota on bread and pasta use of composite flours has been in association with the Institute for Cereals, Flour and Bread, TNO, Box 15, Wageningen, Holland.

become partially substituted for bread making in the not-too-distant future the substitution of wheat in preparation of pasta products by rice flour, with a small addition of soy flour is perhaps easier and will also be developed. Pieraerts (1923)[1] quoted in Bois[2] first produced breadfruit flour and determined its chemical composition (as also of banana and cassava).

Breadfruit flour has been made in the Caribbean by a variety of methods. Details of work by Otto Jensen in Montserrat who prepared a flour meal for uses in animal feed were not available but during my survey I have collected three flour samples from Jamaica (Mrs Thelma King), Montserrat (Miss Lashley) and St Vincent (Mr J.J. Wegrzyn) respectively. It is agreed by all these workers that the use of a solution that will effectively prevent browning (presumably due to the oxidation of polyphenols) is essential. Mrs King uses lime juice as the anti-oxidant, Miss Lashley a solution of common salt and Mr Wegrzyn either 2% sodium metabisulphite or 1.5% potassium metabisulphite. Mr Wegrzyn has kept sufficiently detailed records to enable him to compute the probable economic cost of small scale flour production. In his opinion, with a cost of breadfruit at 6 cents (EC) per lb for fresh breadfruit, flour could be produced as a "factory door" price of 60 cents(EC)per lb.

The only use of breadfruit flour in bread making so far seems to have been in St Vincent where Mr J.J. Wegrzyn, who is a British Graduate Volunteer, qualified in both bakery and food technology, has studied the use of levels of substitution for wheat at 10%, 15% and 20% levels. At 10% an entirely satisfactory loaf was made and considered in no way inferior to one baked from 100% wheat flour. At 15% substitution an acceptable loaf could be made if the composite flour was treated in the same way as a wholemeal flour. At 20% substitution there was a reduction in loaf volume and quality. However, studies were made at Queen Elizabeth College, London on the nutritional value of the 25% composite flour with the remarkable and unexpected result that the food value as measured by Net Protein Utilization was substantially improved in the composite flour over that of the straight wheat flour.[3] The amino acid composition of the breadfruit flour was also determined[4] but data are not available to show the extent to which the amino

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1. Pieraerts (1923) (not read in original) A propose de l'Arbre a pain. L'Agronomie coloniale, p.172).
2. Bois, D. (1927) Les Plantes Alimentaires chez tous les Peuples et a travers les ages. Lechevalier, Paris.

3,4. See appendices to this report.

acids account for all the nitrogen content of the flour so that protein levels assessed conventionally as crude protein must still be treated with caution.

St. Vincent has ordered a small scale flour mill with the intention of producing composite flours to commercialise the results of the research carried out. Assistance may well be required in this development.

I was informed that "some years ago" there was work at the Scientific Research Council of Jamaica on breadfruit flour, but this was apparently discontinued. I was unable in the time available to track it down. However, work is currently in progress again at the Jamaican Industrial Development Corporation's Food Technology section under the direction of Mr Don Evans on the production of a range of non-cereal flours, including breadfruit, with full mechanization of the operation of peeling, cooking and mashing which are followed by drum drying. It seems to be recognized that cooking or some other way of destroying enzymes associated with browning is an indispensable part of the process. The possibility of hydrolysis of the starch to produce glucose is under consideration.

There has been interest also in using breadfruit flour as an intermediate for the production of alcohol, and quite recently Mrs Thelma King prepared a sample of several kilograms of flour in her kitchen (by her lime juice method) for sending to the U.S.A. for study for this purpose.

In Barbados there are ambitious long range plans to develop the breadfruit as industrial crop on a substantial scale. A team of FAO personnel have been assembling guesstimates of productivity, based on sample surveys and enquiry from owners of existing trees.[1] The figures have still to be subjected to scrutiny by a local assessor but it is suggested that under favourable "wet" conditions that 30,000 lbs per acre of fresh breadfruits per year might be obtained and under "dry" conditions 15,000 lbs per acre. Working on a shadow price using the cost of imported wheat flour, it is being suggested that this would allow - after taking off the costs of flour production - a production cost per acre of Barbados $2600 under wet, or $1300 per acre under dry,conditions for the raw breadfruits. I am not aware of the extent of the data to back up these figures nor have any details on Barbadian work on breadfruit flour production.

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1. The FAO team working on breadfruit for inclusion of a project for the 1978-82 five year plan is Mr Aart van Minden, Agronomist and Mr Frans Teutscher, Associate expert in Food Technology.

I discussed possible uses of breadfruit flour with Professor Gonzalez at the Food Technology Laboratory at Rio Piedras, Puerto Rico. He stresses that, in his opinion, cassava flour is a more suitable ingredient for composite use[1] than breadfruit because of the low amylose content of the breadfruit flour but that if breadfruit flour can be produced by a sufficiently cheap process - which will probably have to involve sulphiting and if possible sun drying rather than using expensive fuel, it may be useful. More work needs first to be done on possible anti-nutritional factors of such possibly cheap-to-produce products before their food use should be encouraged.

In Brazil[2] breadfruit starch was found in general to resemble that of sweet potato and cassava but the starch grains were like those of rice. It is believed it might find a use in textile manufacture.

Other uses of breadfruit as human food

In the work carried out in Trinidad by Dr Sammy it was considered that one of the most promising uses for breadfruit was in the manufacture of a breakfast food. A product was developed comprising 40% breadfruit starch together with soyabean flour and flour of other leguminous pulses. These were processed to drum dried flakes. However no manufacturers came forward or showed interest.

Breadfruit chips have been prepared and are marketed, I understand, by at least three firms in the Caribbean reigon: Sunshine Foods based in Trinidad and Barbados, Holiday Foods of Vieux Fort St Lucia and Fritos. It have not been possible to follow up these leads in the time available. Breadfruit chips have been made domestically by Mrs Thelma King in Jamaica, and I have a sample. They are rather tough - these were made without pre-cooking the thin breadfruit slices before frying, whereas Dr Sammy maintains that an acceptable substitute for a potato crisp can be produced if the chips are precooked. In Puerto Rico (Professor Jordan Molero) said the best chips

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1. Berrios, M.L. and Gonzalez (1971) Extraction, purification and amylose content of some starches. J.Agricultural Univ., P.R. 55, 263-4.
2. Ernesto Tomasquin et al. (1969) Estado de Amidos Nacionais. Revolucion Industrial, 134, 22.

can be made from nearly soft overripe breadfruit.

A student from Dominica working in Trinidad[1] undertook a study as part of a postgraduate diploma, on the canning of breadfruit. His final method consisted in slicing, blanching in steam, canning in 1.5% brine and retorting for 20 minutes at 15 lbs/sq in (250°C) for 20 minutes. Some breadfruits are known to be being canned now in Dominica and it is probable that this is an application of the Trinidad research project. Dr Sammy considers that the chief problem with the product is the uneven texture with a tendency to be mushy in the more porous part of the "fruit".[2] Breadfruits have been canned since 1973 after being processed and are exported to London and New York by Jamaize Frozen Foods Ltd.[3].

The prospects for commerical dehydration of breadfruit have been studied in California by Reeve.[4]

A very attractive candied product can be made from the male inflorescence of the breadfruit as is done in some areas of the South Pacific.[5] Mrs King produces candied breadfruit "swords" in Jamaica and a sample has been obtained. If breadfruit were to be grown as a commercial crop the collection and candying of otherwise waste male inflorescences could be a useful minor industry.

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1. Lubin, H.H. (1973) The canning of breadfruits (Artocarpus communis) in brine. Thesis undertaken as part fulfillment for the qualifications for the post graduate diploma in Food Technology, University of the West Indies.
2. The fruit of the breadfruit is in fact not a fruit at all but a syncarp.
3. A.S. Johnson, ex-Managing Director, p.c. Mr Selvin Campbell is the present Managing Director.
4. Reeve, R.M. (1974) Economic Botany 28, 82-96.
5. Massal, E. and Barrau, J. (1954) Pacific subsistence crops - breadfruit. South Pacific Commission Quarterly Bulletin 4(4), 24-6.

CHEMICAL COMPOSITION AND THE NUTRITIONAL VALUE OF THE BREADFRUIT AND BREADFRUIT PRODUCTS

There have been a surprising large number of determinations of the constitution of the breadfruit. Data from all the published records which have been located are presented in Table 10 following in which all the data are presented on a dry weight basis as well as on a wet weight basis when originally published in that form. It will be seen that, on a dry weight basis the reports of protein composition vary from 3.75% in Peters, 1956 to 7.92% in the data from INCAP. It seems probable that an average protein content of somewhere between 5.5 and 7% on a dry weight basis would be a reasonable figure to assume as a basis for other computations.

Net protein utilization (NPU) was assessed for samples of wheat flour and a composite flour containing 25% breafruit sent from St. Vincent for analysis at Queen Elizabeth College, London in 1974 with the following result.

	NPU_{op}	NPU_{st}	$NDp_{cals\%}$
100% wheat flour	35	36	4
75% wheat flour +25% breadfruit	47	59	7

"From these results, the composite flour compares very favourably with the wheat flour sent from St. Vincent. I would be more sceptical of the results except that when Derek Miller and I discussed them in July, we decided to have them rechecked, and this is the final result."

The amino acid composition (FAO, 1968) is as follows:

Amino acid	Level (mg/gN)
Isoleucine	419
Leucine	436
Lysine	363
Methionine	75
Phenylalanine	518
Threonine	425
Tryptophan	111
Valine	483
Argenine	306
Histidine	100
Alanine	244
Aspartic acid	675

TABLE 10

PUBLISHED DATA ON THE COMPOSITION OF BREADFRUITS

References		Moisture content %	Dry matter %	N %	Crude protein %	Crude fibre %	Carbo-hydrate %	Fat %	Mineral matter (ash) %	Food calories /100 gm.	Ca** mg/ 100gm.	Phos-phate mg/ 100 gm	Fe** mg/ 100gm	Vitamins
Reeve,1974 (a)		*0.86*	99.14	1.22	7.63	6.30	-	2.63	3.69					
Reeve,1974 (b)		*0.25*	99.75	1.13	7.06	6.27	-	2.71	3.92					
Reeve,1974 (c)		*0.51*	99.49	1.22	7.63	6.10	-	2.21	3.81					
Miller, 1929(d)		67.8	*32.2*	-	1.34	1.5	27.82	0.31	1.23		22	62	-	Vit.A 150u./1
	(e)		*100*		*4.16*	*4.66*	*86.39*	*0.96*	*3.82*		*68*	*190*		cooked ripe br
Purseglove 1968	(d)	75.5	*24.5*	-	1.3	1.8	20.1	0.5	0.8	-	39	-	-	
	(e)		*100*	-	*5.31*	*7.35*	*82.05*	*2.01*	*3.26*	-	*370*	-	-	
Massal & Barrau	(d)	70.0	*30.0*	-	-	-	25.0	1.6	1.7	105	33	32	1.1	Vit.A 40u.
1954	(e)		*100*		-	-	*83.33*	*0.53*	*0.40*	*350*	-	-	-	Thiamin 0.15mg Rib'n 0.03mg Niacin 0.9 Ascorbic acid
Peters 1956(whole fresh breadfruit)	(d)	80.0	*20.0*	0.01	0.75	1.2	12.5	0.5	0.75	-	30	28	-	Figures given are as in Mas & Barrau 1954
	(e)		*100*	*0.50*	*3.75*	*6.0*	*72.5*	*2.5*	*3.75*	-	*150*	*140*	-	
Peters 1956('nambo' biscuits)	(d)	8.0	*92*	0.68	4.3	4.7	72.0	2.1	4.2	-	44	13	-	
	(e)		*100*	*0.74*	*4.67*	*8.78*	*78.3*	*2.28*	*4.56*	-	*48*	*14*	-	
Thompson et al1974 (immature fruit)		*68.1 - 68.3*												
('fit' fruit)		*65.6 - 67.4*												

The higher figures of each pair are those of freshly harvested fruits and the lower after 4 days.

Thomas 1969	(d)	75.5	*24.5*		1.5	-	21.6	0.2	0.9	-	50	40	5	
	(e)		*100*		*6.12*	-	*87.7*	*0.82*	*3.67*	-	*220*	*176*	*22*	
Koppikar,1951	(d)	73.7	*26.3*	-	1.94	1.11	21.95	0.51	0.79	100	-	-	-	
			100	-	*7.38*	*4.22*	*83.46*	*1.94*	*3.0*	*333*	-	-	-	
Sholto-Douglas 1972	*(d)*				1.31	-	21.5	0.3	-	-	28	-	0.5	Vit.A 20 u. B1 0.09 mg/10 B2 0.06 mg/10 Niacin 0.8 " Vit.C 22.0 "
Wegrezyn 1977 (breadfruit flour)	(e)				2.53	-	-	1.06	-					
Thompson 1914 (Hawaiian - less ripe breadfruits)	(d)	*58.18*	41.82		1.57	1.20	27.83+	0.19	0.95	-	-	-	-	Free sugars 9
	(e)		*100*	-	*3.75*	*4.78*	*66.69*	*0.45*	*2.27*	-	-	-	-	
Thompson 1914 (Samoan ripe breadfruits)	(d)	*73.11*	26.89	-	1.57	0.97	9.21+	0.51	1.15	-	-	-	-	
	(e)		*100*		*5.84*	*3.60*	*34.25*	*1.89*	*4.27*	-	-	-	-	
INCAP/ICNND 1961	(d)	73.3	*22.7*	-	1.3	1.8	20.1	0.5	-	81	27	-	1.9	Thiam.0.1
	Refuse 32%		*100*	-	*5.72*	*7.92*	*88.54*	*2.20*	-	*356*	*118*	-	*8.5*	Ribo'n 0.06 Niacin 0.7 Vit C 29 mg/1

KEY

(a) Freeze dried material
(b) Dried in a vacuum oven at 60°C
(c) Dried at 105°C
(d) Data on a wet weight basis
(e) Data on a dry weight basis (Note: Figures presented in italics are conversions to moisture-free basis)

* Publications claim that data was on a dry weight basis but that is obviously an error.

\+ Carbohydrates excluding sugars.

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Dr Robert Luse has kindly provided the following notes on the nutritional value of breadfruits as indicated by the data now provided.

" Unfortunately, the published amino acid composition for breadfruit (FAO, 1968) is based on but a single sample, so there is no indication of genetic and environmental variation. However, accepting the limitation of the data, it is clear that breadfruit has a considerably higher content of the essential amino acid lysine than does wheat (at least twice as much as flour). This undoubtedly explains the approximate 50% increase of nutritional value of the wheat-breadfruit composite flour compared with wheat flour alone.

Breadfruit also seems higher than wheat flour in content of several other essential amino acids: isoleucine, phenylalanine, threonine and valine (and possibly tryptophan). Indeed, its ratio of essential amino acids to total amino acids is 50% higher than that in wheat flour.

In comparison with other sources of calories in the tropical diet, e.g. milled rice and sweet potato, breadfruit would also seem superior as regards to the essential amino acids listed above. It would seem, though data are fragmentary, to be a much poorer source of the sulfur amino acids. If its protein content is actually 2.2% for a flour at 12% moisture (Maurifoods Ltd. data, 1974), it proves a poor source of concentrated protein (cf. wheat flour at 11% protein, milled rice at 7%, sweet potato a t 3.8% - all 12% moisture). Thus it can be said to be a dilute source of good quality protein. It then becomes a matter of finding a processing step to concentrate this protein, though combining it with a more concentrated source of protein such as wheat, where its higher lysine content can enhance the nutritional value of the product is an excellent proposal. More should

1/ Notes kindly provided by Dr. R. Luse, CIAT, on figures obtained during the survey.

be done to determine accurately the amino acid content of breadfruit flours, so as to obtain the basis for preparing a nutritionally optimal blend of breadfruit with wheat."

BREADFRUITS FOR ANIMAL FEED

Breadfruits are fed raw to pigs in Polynesia, often over-ripe.[1] A similar use is widely practiced in the Caribbean. Whereas breadfruits in the state considered fit for human consumption may sometimes, when in glut, be cooked before feeding to pigs, this is apparently quite unnecessary and several respondants regularly used fresh but over-ripe fruits.

Since gluts of breadfruit are highly seasonal, the storage of breadfruit for stock feed by a cheap method has obvious attractions and the development of silage using breadfruit in Jamaica[2] could well be followed up if supplies ever again exceed demand for human use to a level where the sole problem is to avoid waste. It may also be socially difficult to rapidly expand the direct human use of breadfruits for sociological reasons,and the use of expanded production for animal feed as an alternative to the production of flour for incorporation into bread or pasta may be a possible alternative or parallel development. For animal use the concept of a least cost supply of calories will be overriding. In 1850 breadfruit in the Caribbean was used almost exclusively for animal feed.[3]

In the Caribbean, if breadfruit production is to be strongly stimulated there will have to be a reasonable incentive to farmers to produce, so that there is a limit to how low a price might be paid, even for naturally dropped and collected fruits (which would be expected to be worth much less than those requiring hand harvesting.) It is reasonable to think of about half the cost of wheat flour as the economic value of the raw material on a equal-calorie basis, at which production for animal feed would be attractive. As a shadow price,planners in Barbados[4] use the cost of cassava meal or chips for considering the economics of breadfruit for animal feed.

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The production of a crude breadfruit biscuit similar to that produced in the Reef Islands and known there as "Nambo"[1] might be able to be developed as a simple rural technology to convert the perishable fresh product. Nambo rather than fresh breadfruit might then be purchased and, depending upon their quality, be milled either to a flour for human consumption, or, if sub-standard, compounded into animal feed. An obvious advantage in encouraging farmers to carry out their primary (dewatering) processing is that this reduces transport costs and should also be able to be price structured so as to give a share of value added to the primary producers. Several farmers, shown the account of drying in the Reef Islands, were enthusiastic about the opportunity to avoid waste in this way.

In countries where serious consideration is being given to the use of cassava grown on a large scale on flat land for feed production, there may be an interesting possibility of growing breadfruit trees on nearby hill slopes in need of protection and too steep for arable crop mechanisation. The interaction of agriculture and forestry for rationalised food production is discussed in depth in Bene, Beall and Cote (1977)[2].

Since breadfruit produces mainly in the wet season and at that time the cassava will be more difficult to harvest than in the dry period, there might be a complementary use of capital by processing breadfruit to meal during the wetter season and cassava in the drier season. That breadfruit might utilize land not suitable for higher priced crops, or be used in mixed economic forests would give it a potential advantage over other carbohydrate sources.

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PRESENT AND POTENTIAL MEDICINAL USES OF BREADFRUIT

In the South Seas the leaves and the latex are used medicinally.[1] The leaves are pounded up with ferrous oxide and are used for curing fungal infections of the mouth (thrush) in Hawaii.[2] Theobald[3] also reports the use of pounded leaf buds with red earth and smearing the mixture inside the mouth for thrush. In Trinidad I obtained information from two independant sources[4,5] that the leaves of breadfruits are used to make an infusion for the relief of hypertension and also for the treatment of asthma[4]. The more precise account[5] indicated that a slightly yellowing leaf should be broken up and used to make an infusion with water "in much the same way as tea" and that one cup of this tea should be taken every morning for just three days.

In Hawaii the latex is also used for external skin disorders and as a chewing gum[2] and similar uses have been mentioned by several informants in the Caribbean and Guyana. I have also been told that in Trinidad the latex is used for treating sciatica. The latex is collected fresh onto a cotton pad which is then bandaged so as to be held as a pad against the spine of the sufferer. Herbst [6] provides information on uses of breadfruit for different medicinal uses in the Gilbert Islands. "The latex collected from the base of the stem is diluted with one spoonful of rainwater and used as a remedy for diarrhea. For afflications of the inner ear four or five young leaves are crushed and the extracted juices are poured into the ear, or a young leaf may be warmed and pushed into the ear canal. Five to seven young

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4. Mrs Martha Fredericks (met on an aeroplane) of Arima.
5. Mr Bristol of Point Fortin, South Trinidad.
6. Herbst,D. (1953) Bull.Pacific Trop.Bot. Gdn. 3, 2.6 Report from the Gilbert and Ellice Islands. Part II.

leaves may be eaten to counteract food poisoning. The leaf buds of te mai are chewed and spat on to a piece of cloth which is then squeezed into the eye to treat conjunctivitis".

That the latex of breadfruit should be pharmacologically active is not surprising but investigational work on the active chemicals concerned needs to be done since none has yet been reported for this species. The latex of the closely related Jackfruit has been studied and is said to contain acetylcholine, while that of the fairly closely related Moraceaeous genus Antiaris, at least of A.toxicaria, the Upas tree of Java, is a powerful arrow poison.[1,2]

The monkey breadfruit (Artocarpus lakoocha) which is reported at Kew to occur in Guyana as well as in Asia, has been used to control tapeworm infections.[3]

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