PD-AAZ-311

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UNITED STATES OF AMERICA
AGENCY FOR INTERNATIONAL DEVELOPMENT
REGIONAL DEVELOPMENT OFFICE/CARIBBEAN

P. O. BOX 302
BRIDGETOWN
BARBADOS

April 17, 1989

Dr. Keith D. Hunte
Principal of the Cave Hill Campus
University of the West Indies
P.O. Box 64
Bridgetown
BARBADOS

SUBJECT: Grant No: 534-0936-G-00-9117
Post-Harvest Physiology of Some
Under-Exploited Tropical Fruit

Dear Dr. Hunte:

Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, the Agency for International Development (hereinafter referred to as "A.I.D." or "Grantor") hereby grants to The University of the West Indies (UWI) (hereby referred to as the "Grantee"), the sum of $100,080 to characterize the ripening process in two tropical fruits, Annona muricata (soursop) and Artocarpus altilis (breadfruit) and to develop the post-harvest technology required for their further commercial exploitation, as described in the Schedule of this grant and the Attachment II, entitled "Program Description."

This grant is effective June 1, 1989, and shall apply to commitments made by the Grantee in furtherance of program objectives during the period beginning with the effective date and ending December 31, 1992.

This grant is made to the Grantee, on condition that the funds will be administered in accordance with the terms and conditions as set forth in Attachment I, entitled "Schedule"; Attachment II, entitled "Program Description;" and Attachment III, entitled "Standard Provisions," which have been agreed to by your organization.

Please sign the original and two (2) copies of this grant to acknowledge your receipt, and return the original and one (1) copy to the Regional Development Office/Caribbean.

Sincerely,

Stanley D. Heishman

Stanley D. Heishman
Regional Contracting Officer

Attachments:
I. Schedule
II. Program Description
III. Standard Provisions

ACKNOWLEDGED: THE UNIVERSITY OF THE WEST INDIES (UWI)

By: Keith D. Hunte

Title: Principal - UWI Cavehill

Date: 1989-05-13

Fiscal Data

Appropriation No:	72-1191021.6
Budget Plan Code:	DDSA-89-29534-KG11
Allowance:	946-51-534-00-19-91
Project No:	936-5542.19
Total Estimated Amount:	$100,080
Total Obligated Amount:	$100,080
Funding Sources:	AID/W

SCHEDULE

A. Purpose of Grant

The purpose of this Grant is to provide support for The University of the West Indies' proposal, "Post-harvest Physiology of Some Under-exploited Tropical Fruit" as described in Attachment Two to this Grant entitled "Program Description." The principal investigator is Dr. C.M. Sean Carrington, Lecturer, Department of Biology, UWI. The principal collaborators are Dr. D.J Huber, Department of Vegetable Crops, University of Florida, and Dr. Steve New, Caribbean Trading Company.

B. Period of Grant

The effective date of this Grant is June 1, 1989. The expiration date of this Grant is December 31, 1992.

C. Amount of Grant and Payment

1. AID hereby obligates the amount of $100,080 for the purposes of this Grant. This is the maximum obligation of funds for the specific research objectives supported under this Grant.

2. Payment shall be made in U.S. dollars to the Grantee, by the RDO/C Controller, in accordance with procedures set forth in Implementation Letter No. 1 under this Grant.

3. Grantee agrees to submit documentation required by RDO/C to support expenditures made with Grant funds.

4. Pursuant to Optional Standard Provision 16, the provisional overhead rate for reimbursement of indirect costs is 10%, and the final overhead rate to be negotiated will not exceed 10%.

D. Financial Plan

The following is the Budget for the Grant. All expenditures under this Grant are expected to be made during years one to three of the Grant period; the final seven months of the Grant period shall be used for finalizing research results and no expenditures are expected or planned for this portion of the Grant period. Revisions to this Budget shall be made in accordance with Standard Provision of this Grant, entitled "Revision of Grant Budget". The Grantee shall not exceed the total obligated amount of $100,080. Following are the approved cost elements amounts.

GRANT BUDGET

		US$ 6/89 to 5/90	US$ 6/90 to 5/91	US$ 6/91 to 5/92	US$ Total
1.	Personnel	8,574	9,432	10,376	28,382
2.	Equipment	32,500	- 0 -	- 0 -	32,500
3.	Supplies	3,400	5,000	7,200	15,600
4.	Training	5,000	- 0 -	- 0 -	5,000
5.	Travel	- 0 -	4,500	5,000	9,500
6.	Overhead Costs	4,947	1,893	2,258	9,098
		54,421	20,825	24,834	100,080

E. Reporting and Evaluation

1. Progress Reports

Interim progress reports are required every six months, except the last six month period, which will be pre-empted by a final report. Progress reports are due within thirty days following each six month period. The first report should contain any revisions in key dates projected for the research schedule.

2. Final Report

The principal investigator should submit a final report no later than the completion date of the grant, December 31, 1992. This report should be sufficiently detailed to substantiate findings and to permit scientific evaluation of research.

3. Interim progress reports: the principal investigator shall forward one copy of each interim progress report to the following addresses:

a) Mr. Howard F. Batson
RDO/C Project Officer
United States Agency for International Development
P. O. Box 302
Bridgetown, Barbados

b) Harvey Hortik
Technical Backstop Office
AID/ST/AGR, Room 420-C
SA-18
Department of State
Washington, D.C. 20520
U. S. A.

c) AID/SCI, Room 320
SA-18
Department of State
Washington, D.C. 20520
U. S. A.

d) AID Reference Center,
PPC/CDIE/DI, Room 105
SA-18
Department of State
Washington, D.C. 20520
U. S. A.

4. Final report: the principal investigator should submit three copies of the final report to AID/SCI, one copy to the AID Reference Center, one copy to the Technical Backstop Office and one to the RDO/C Project Officer

F. Special Provisions

1. Standard Provisions applicable to this grant are the Mandatory Standard Provisions for Non-U.S., Non-Governmental Grantees. The following optional Standard Provisions for Non-U.S., Non -Governmental Grantees, are not applicable to this grant; 2, 7, 9, 11, 12, 14, 15, 17, 19, 20, 21.

2. International Travel between Barbados and the U.S. is hereby approved subject to the limitations of Standard Provision 3 "Air Travel and Transportation".

G. Overhead Rate

See Article C.4 of this Attachment.

H. Title to Property

Title to all property financed under this grant shall vest in the grantee subject to the conditions specified in Standard Provision No. 18, "Title To and Use of Property".

I. Authorized Geographic Code

The authorized geographic code for procurement of goods and services under this grant is Code 935, "Special Free World", as stipulated in optional Standard Provision 6, "Ineligible and Restricted Goods and Services".

PROGRAM DESCRIPTION

A. Purpose of Grant

The overall objective is to characterize the ripening process in two lesser-known, but commercially promising, tropical fruit (*Annona muricata*, soursop and *Artocarpus altilis*, breadfruit) and to develop the post-harvest technology required for their further commercial exploitation.

B. Specific Objectives

1. Characterization of fruit development through the monitoring of a number of morphological features and biochemical parameters.

2. To draw up a "Maturity Index" or system of staging fruit develop ent for the two species. This should allow for the identification of the stage at which physiological maturity is reached.

3. Characterization of fruit ripening through the monitoring of various biochemical parameters which will provide basic information about the timing and nature of the climateric.

4. Investigate the efficacy of various techniques in lengthening the post-harvest life of the fruits.

5. Under controlled conditions, the soursop fruit will be monitored for uniformity of ripening and fruit quality with the time course for ripening detailed.

6. Apply findings to the commercial handling and shipping of both fuits. Several trial shipments, in which quality of fruit will be monitored, will be attempted to assess the success of findings and recommendations.

C. Implementation

1. Technical Work Plan

The project is divided into several phases as indicated in this section by sub-headings and the timespan for each phase is given in brackets next to each sub-heading.

(a) Characterization of fruit development (Year 1)

Branches of the respective fruit trees will be tagged at anthesis to provide accurate ages of the developing fruit. A time course of maturation/ripening will be described for each fruit by taking samples of 6 fruit at particular time points and measuring (i) morphological features and (ii) biochemical parameters.

(i) morphological features: Fresh weight, dry weight, size and color (visually by comparison with the Royal Horticultural Society Color Chart) will be assessed. Firmness will be measured with an electronic force guage linked to a constant speed motor. These emperical measurements will then be compared with those obtained using a simple penetrometer to assess the reliability of the latter technique. Both breadfruit and soursop are compound fruit where many fertilized ovaries coalesce to form a single fruit. Remnants of this fusion persist as short spurs on the fruit of the soursop and in breadfruit as polygonal indentations of the fruit surface. A characterization of the development of these surface attributes will be made using wax impressions of the fruit surface. Breadfruits exude a milky latex which gums on exposure to air. The degree of latex exudation and physical properties of the latex will also be measured throughout fruit development.

(ii) biochemical parameters: Fruit color will be assessed by pigment extraction of the skin and measurement of chlorophyll and carotene concentrations by spectrophotometry. The principal sugars and organic acids present in soursop have already been identified from ripe fruit (10) and the levels of these in developing fruit will be measured by gas chromatography (GC) of their trimethylsilyl derivatives (ii). Starch levels will also be measured by absorbance of the KI-I,-starch complex following DMSO extraction. Levels of sugars and starch will also be assayed in breadfruit as well as the activities of various enzymes of starch metabolism.

With the compilation of this data certain trends should be apparent and the timing of these would be used to draw up a "Maturity Index" or system of staging fruit development for the two species. This phase of the work should allow the stage at which physiological maturity is reached for both fruit to be identified. This corresponds to the stage at which maximum growth and maturation have occurred. Distinct from this is the stage of commercial maturity which is the stage at which the fruit is required by the market. Such fruit may be immature physiologically but are nonetheless able to proceed through to ripeness under appropriate conditions.

(b) Characteristization of fruit ripening (Years 1 & 2)

A large batch of fruit at the mature state will be stored at room temperature (25-30°C) and groups of fruit sampled periodically and assessed on the same morphological and biochemical basis as during the maturation process (see above). In addition, respiration (as CO_2 production) and ethylene evolution will be assayed. This will be done by placing fruit in sealed polycarbonate jars through which humid air is constantly drawn. Ethylene and CO_2 will be determined by GC and infra red gas analysis (IRGA), respectively, of the effluent gas. Such a flow-through system prevents any build up of ethylene or CO_2 and hence any modification of the normal ripening process. These measurements will provide basic information about the timing and nature of the climateric. The respiratory climacteric in soursop is reported to be biphasic and this warrants further attention. In the case of breadfruit a fleshy peduncle often remains attached to the harvested fruit. It will be tested whether the presence of this stalk delays or shortens the pre-climacteric life of the fruit. As in the case of fruit development, an index of ripening will be compiled for each fruit.

(c) Maintenance of the pre-climacteric state (Years 2 & 3)

All studies will use soursop fruit of the apprropriate pre-ripe stage which have shown competence to ripen unaided. In the case of breadfruit, fruit will be of a stage suitable for consumption. For statistical reasons, the minimal sample size for any treatment will be 10 fruit.

(i) Refrigerated storage: Batches of fruit will be stored in refrigerated incubators at a range of temperatures below room temperature (viz. 30°C). The temperature at which chilling injury starts will be determined as well as the optimum storage temperature. The latter will be based on longevity under refrigeration without loss of ability of the fruit to ripen on being returned to room temperature. Other parameters shown to change with ripening such as fruit firmness, will be monitored during storage. Flow-through chambers containing fruit will also be placed in the refrigerated chambers and ethylene and CO_2 evolution monitored. Cooling fruit and vegetables down to their storage temperature, as quickly as possible, following harvest, is also an important factor in lengthening the post-harvest life of produce. So much so that techniques for doing this such as hydrocooling and vacuum cooling are commercial realities. The breadfruit is an especially large and bulky fruit and one would imagine it must take some time for internal tissues to equilibrate with storage temperature following transfer to a refrigerated chamber. It is planned to implant thermocouples in breadfruit transferred to such chambers to determine the cooling characteristics of the fruit. A simple type of hydrocooling will then be tested by submerging freshly picked fruit in tubs of cold water as low as can be endured without chilling injury. Such fruit, cooled to their optimum storage temperature, will then be transferred to refrigerated chambers and monitored for ripening changes. This will aslo be attempted with soursop. These experiments should indicate whether a commercial hydrocooler would be a sensible investment for the industry.

(ii) Controlled Atmosphere (CA) storage: This approach is seen as an adjunct to refrigerated storage rather than as an alternative. It is based on the fact that fruit storage life can be extended by raising CO_2 levels and lowering oxygen levels in the storage chamber [4]. Two batches of fruit, one under refrigeration at the optimum temperature for that fruit and the other at room temperature will each be placed in sealed polycarbonate jars with a constant flow-through of gas. In the case of the controls the gas will be humid air while the treated fruit will be exposed to high CO_2/ low O_2 air mixture. Such an air mixture will be obtained using a gas diluter to mix cylider-derived CO_2, O_2 and N_2 in appropriate ratios. Several CO_2/O_2 ratios (0-10% CO_2; down to 1% O_2) will be investigated over a series of experiments and their effect on pre-climacteric life determined. As a separate issue, the effect of ethylene removal will be investigated by storing fruit at their optimum temperature in the presence or absence of an ethylene scrubber such as $KMnO_4$/alumina.

(iii) Modified Atmosphere (MA) storage: Refrigerated fruit held at the experimentally determined optimum will be treated in one of two ways to achieve MA storage:- (a) coated with TAL-Prolong or fruit wax and (b) wrapped in various polymeric films, varying in gas exchange properties. The effects of these barriers on pre-climacteric lifespan will be measured using a suitable index of ripening. In addition, the rates of water loss and respiration of such fruit will be compared to control fruit.

(d) Controlled ripening of soursop fruit

Pre-climacteric soursop will be transferred from their refrigerated storage chambers to room temperature and the time course fro ripening detailed. Refrigerated fruit will also be transferred to jars through which various ethylene/air mixtures are drawn through. Comparisons will be made of the uniformity of ripening, not to mention fruit quality, obtained with these various procedures.

(e) Commercial trial shipment

Following on from the results obtained, a recommended handling procedure for both fruit will be devised. With CATCO's assistance several trial shipments will be attempted to assess the success of these protocols. Dr. Huber in Gainesville will assist with the assessment of fruit quality at the receiving end.

2. Scientific Collaboration

Dr. D.J. Huber of the Department of Vegetable Crops, University of Florida, Gainesville will collaborate on this project. He has experience in the post-harvest physiology of fruit such as melons, strawberries and tomatoes.

Dr. Steve New of CATCO in Barbados helped tailor this revised proposal to address some of the problems being faced by the fledgling fruit industry in the region. CATCO has a genuine interest in the results of this research and will lend assistance and guidance in whatever way it can

At the start of the project, the graduate student will go to Gainesville for 12 weeks training on post-harvest techniques. While there the graduate student will also make use of the library facilities. Dr. Huber will be a member of the graduate student's advisory committee and, as a result, will visit Barbados in both the second and third years of the project. The student will return to Gainesville during the writing of his thesis for a 6 week spell to use the library facilities there and for Dr. Huber to make an input into this final stage of his work.

3. GRANT BUDGET:

Year 1: 6/89 to 5/90

	US$	US$
Personnel		
Graduate student - 100% time	8,574	8,574
Equipment		
Infra-red gas analyser (IRGA)	6,000	
Multi-channel sampling unit	3,500	
Tubing, special glassware & hardware	2,000	
Electronic force guage/constant speed motor/recorder	4,000	
4 refrigerated incubators (19cu. ft.)	16,000	
Thermocouple probes & meter	1,000	
Sub-total		32,500
Supplies		
Chemicals	1,000	
Gas chromatography (GC) supplies	1,000	
Fruit	400	
Literature & journal subscription	1,000	
Sub-total		3,400
Training		
Graduate training at U. of Florida, Gainesville (4 months inclu. travel)	5,000	
Sub-total		5,000
Travel	0	0
Overhead costs (10%)	4,947	4,947
Total (year 1)		54,421

Year 2: 6/90 to 5/91

	US$	US$
Personnel		
Graduate student - 100% time	9,432	9,432
Equipment	0	0
Supplies		
Fruit	400	
Compressed gases/regulators & chambers (Compressed Atmosphere Storage - CAS)	1,500	
Gas diluter	2,000	
GC supplies	600	
Journal subscription	500	
Sub-total		5,000
Training	0	0
Travel		
Attendance of grad. student & principal investigator at Amer. Soc. Hort. Sci. conference	2,500	
Visit by Dr. Huber to Barbados (2 weeks)	2,000	
Sub-total		4,500
Overhead costs (10%)	1,893	1,893
Total (year 2)		20,825

Year 3: 6/91 to 5/92

	US$	US$
Personnel		
Graduate student - 100% time	10,376	10,376
Equipment	0	0
Supplies		
Fruit	400	
Compressed gases for CAS & GC	1,000	
Polyethylene films & fruit waxes	300	
Journal subscription	500	
Commercial trial shipments ($500 each)	5,000	
Sub-total		7,200
Training	0	0
Travel		
Visit by Dr. Huber to Barbados (2 weeks)	2,000	
Visit of student to Gainesville (6 weeks)	3,000	
Sub-total		5,000
Overhead costs (10%)	2,258	2,258
Total (year 3)		24,834
GRAND TOTAL		100,080