POSTHARVEST TECHNOLOGY OF FRUITS AND VEGETABLES: ACCOMPLISHMENTS, DEFICIENCIES AND RECOMMENDATIONS

Agricultural Research Subproject

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TERMS OF REFERENCE
FOR
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SHORT TERM CONSULTANT TO THE POST-HARVEST TECHNOLOGY ON FRUITS AND VEGEGATBLES PROJECT, I.C.A.R., FROM MARCH 17 - APRIL 6, 1994

1. To carry out an overall review of the progress made in the project since its inception at the four (4) Centers with respect to establishing required facilities, training of manpower, and in particular execution of the technical prgram.

2. To clearly define the gap identified at each Center in (1) above and suggest specific course of action making use of recommendations made by the consultants.

3. To determine and define broad strategies for future research in different aspects of Post-Harvest handling and additional inputs required for the same.

4. To determine and suggest collaborative support required in specific areas to improve implementation of the technical programs.

5. To give presentation of overall review of the project at the I.C.A.R. Coordination Committee Meeting.

6. To prepare and present his consultancy report at the end of his visit.

DEFINITION OF ABBREVIATIONS

ICAR	Indian Council for Agricultural Research
PHT	Postharvest Technology
USAID	United States Agency for International Development
CIHNP	Central Institute of Horticulture of the Northern Plains
IARI	Indian Agricultural Research Institute
IIHR	Institute for Indian Horticultural Research
NRCC	National Research Center for Citrus
HPLC	High Performance Liquid Chromatography

Post-Harvest Technology of Fruits and Vegetables: Accomplishments, Deficiencies and Recommendations

(Dr. Ron Buescher April 5, 1991)

I. Introduction

Recognizing that postharvest losses in quantity and quality of fruits and vegetables in India are large, an Indo-U.S. cooperative project was established in 1985 to develop the capabilities of Indian Agricultural Research Centers to conduct research on reducing postharvest losses of perishables. Development activities were focused on four Indian Council of Agricultural Research (ICAR) Centers based on their locations in major production and/or market regions of important crops and on their potential for contributing reducing postharvest losses and improving quality of fruits and vegetables.

The objectives of this Post-Harvest Technology (PHT) project were to be accomplished mainly by ICAR forming units of multidisciplinary scientists with supporting staff, procurement of local equipment, development of appropriate facilities for operation of scientific equipment and for conducting research designed for reducing postharvest losses of perishable crops. Assistance by USAID was for training of PHT scientists, technical support from consultants, and purchasing of imported scientific instrumentation for equipping the new PHT facilities. (Annex Table 1).

Winrock International was contracted to provide management support services for accomplishing training, technical assistance and equipment acquisition and delivery.

A technical assessment of the PHT project was conducted in 1990 (11/29/90). Status reports on the progress of each of the Centers from October, 1985 through February, 1991 were presented at an ICAR Coordination Committee Meeting held on March 25, 1991. Throughout the life-of-the-project there has been a substantial amount of documentation on progress of positions filled, training, equipment, facilities, research activities and expenditures which have been compiled and distributed through the ICAR Coordination Committee on PHT and Winrock International. In addition, designated scientists are in the process of completing reviews of research accomplishments achieved during this project. The reviews are being compiled according to specific research objectives (components).

The objectives of this report are to provide an overall review of progress of the PHT project, to identify deficiencies or unfinished work and to provide recommendations for future PHT program activities (see Terms of Reference). This report attempts to constructively review the accomplishments and limitations of the project while avoiding unnecessary repetition of well-documented listings and reports.

II. Formation of Scientific Units

A. Progress

Assignment of principle investigators and establishment of scientists in PHT units coincided with the early development of the project. Some of the scientists were actively involved with PHT research at the time of initiating the project, some were transferred or appointed from other departments and a few were newly employed. Very few of the scientists were experienced in areas of postharvest storage/handling/physiology research since these subjects were uncommon to agricultural programs in India. Most PHT research had focused on processing prior to the PHT project.

All sanctioned PHT scientific positions have been filled at CIHNP and IARI. One position at IIHR and three positions at NRCC are vacant. The following table indicates the number of scientists working in particular areas although actual post titles may deviate from the research direction:

PHT Scientists

Discipline	CIHNP	IARI	IIHR	NRCC
Pathology	1	1	1	1
Storage/Handling/Physiology	3	3	2	1
Process/Waste Utilization	2	3	1	-
Microbiology	1	1	1	-
Engineering	1	1	1	-
Economics	1	1	1	1

There have been eight PHT technician positions for CIHNP, IARI and IIHR and six positions sanctioned for NRCC. All of the technician positions have been filled.

Considering the number of positions involved in this project, there has been very minor changes or turnover of personnel. The formation of these stable units of scientists and technicians from multidisciplinary subject areas to conduct research on postharvest problems is commenable.

B. Deficiencies

1. NRCC has facilities to efficiently utilize additional PHT scientists. At present three positions are vacant.

2. Scientists at CIHNP are too crowded to effectively conduct PHT research.

C. Recommendations

1. The program at NRCC will further increase its productivity and contributions on solving PHT problems by having scientists specialized in PHT microbiology, processing, physiology and engineering.

2. The number of scientists at CIHNP should be reduced to a number that allows efficient research within the existing over-crowded facility.

3. The vacant position at IIHR should be filled with a scientist trained in analytical food chemistry/biochemistry to assist with problems of processed horticultural crops confronted by the processing industry.

III. Training

A. Progress

A total of 28 scientists was provided 111.5 months of training/research experience at eight different research institutions in the U.S. (Technical Assessment, 11/29/90). The three-member management team conducted a one-month study tour in the U.S., and two members of the management team (Drs. Roy and Ambadan) attended a six-week shortcourse on research management in the U.S.

Five PHT technicians were approved for training and four of them were able to initiate a two-month training program which is in progress at the University of Arkansas.

Most of the scientists were in the U.S. for four months, received experience conducting research and working with instrumentation utilized in their area of specialization, collected appropriate reference material, attended a professional meeting and visited other research laboratories. Two of the very recently employed PHT scientists (Dr. Narayana, storage and ripening, at CIHNP and Dr. Vijaya, Economics, at NRCC) did not attend a program in the U.S.

A training program for the laboratory technicians (S. Sreedhara, IIHR; S. Srivastava, IARI; S. Kumar, CIHNP; and A. Dixit, CIHNP) has been designed to focus mainly on operation and maintenance of equipment similar to what has arrived to the PHT laboratories. This program for the technicians will be completed about May 25, 1991.

B. Deficiencies

Some of the PHT scientists are sufficiently knowledgeable and confident to adequately handle and utilize the sophisticated research equipment. In a few cases, there is a lack of appreciation and understanding of the necessary requirements to maintain and operate analytical research instrumentation.

Furthermore, some of the scientists new to the field of PHT need to increase their knowledge on basic principles such as gas/pressure/diffusion laws, heat transfer, cooling (heat absorption), temperature/humidity, ventilation, chromatography, enzymology and published literature in their respective area of specialization,. Overall most of the scientists are well-trained, competent professionals.

Indeed, the inadequacies in managing and operating research equipment is understandable from the lack of experience with instrumentation; however, the responsibility to develop appropriate skill is now that of each individual scientist.

C. Recommendations

1. The PHT scientists (all users of equipment) need to study the manuals provided with the equipment and put into practice the instructions on maintenance and operation.

2. Instruction is to be provided at no additional cost by the country representatives for the Waters HPLC, Hewlett Packard gas chromatograph and Instron following installation. Arrangements for appropriate training should be developed and scheduled by the project coordinator and principle investigators.

3. An intensive shortcourse should be provided for all PHT scientists that are deficient in understanding the principles and practices of postharvest science. Primarily, the deficiences in this area are at Centers not involved in teaching or presenting their own shortcourses. Therefore, development of shortcourses by scientists at these Centers would assist in development of appropriate background knowledge by the scientists while providing an important service to the private sector.

4. Each scientist must develop their own comprehensive information bank and keep up-to-date in their knowledge of PHT published literature.

IV. Facilities

A. Progress

1. CIHNP, Lucknow

No new facility was developed for PHT research at CIHNP. Only minor remodelling has occured for the purpose of installing analytical equipment. Remodelling of their rental house has consisted of enclosing, air-conditioning and wiring of two relative small rooms for some of the instrumentation. A room was established for computers and another (garage) was established for microbiological research. Two walk-in refrigerated store rooms were installed at R.B. Road property several kilometers from the laboratory house.

No plans are evident for the development of a suitable PHT research facility.

2. NRCC, Nagpur

NRCC has occupied a building that has abundant space for PHT research. Three laboratories, including a pilot plant, has been established for the PHT scientists. One of the rooms for analytical equipment is air-conditioned and protected from dust. In addition, space has been allocated for walk-in coolers. A large room is used for a packing line constructed for sorting, washing, waxing, drying and sizing citrus. There is sufficient space available to add new laboratories and offices. Plans have been developed to construct a new permanent facility.

3. IARI, New Delhi

Construction of a new two-story addition to the existing horticulture building facility is almost completed; however, progress toward completion has not advanced for many months leaving an indefinite time of completion. Following completion of the new structure, the existing processing pilot facility is planned to be remodelled. Presently, a clean room has been allocated for the analytical equipment (HPLC and gas chromatography equipment) and storage of supplies. Considerable attention has been given to construction of large brick rooms based on evaporative-cooling for storage of horticultural crops. Installation of crated (Blue Star) walk-in refrigertor rooms has not been initiated.

A laboratory designated for PHT packaging research has been developed at the Division of Agricultural Engineering. This is a spacious laboratory, capable of accommodating research activities on packaging and other subjects of engineering, additional equipment and personnel.

4. IIHR, Bangalore

A new building was constructed for laboratories and the structure previously used for a library was remodelled into a processing hall for PHT research. Enclosed, air-conditioned rooms are used to provide a clean, temperature controlled environment for the analytical equipment. Laboratory benches and work areas are in process of being constructed and installed. Several walk-in cold rooms have been installed for PHT research. A laboratory in a separate building has been

established for PHT engineering research.

B. Deficiencies

1. CIHNP, Lucknow

Unquestionably, there are major deficiencies in the facility at CIHNP to conduct PHT research and to utilize the newly acquired scientific equipment. The deficiencies include space, environment, water supply and convenient access to storage structures. No space is available for installing the gas blending/delivery system and shrink wrap machine. The space and environment to effectively utilize the HPLC gas chromatograph, pouch/filler sealer and spectrophotometer are highly questionable.

Processing pilot plant facilities, laboratories for PHT engineering, storage/handling physiology and pathology have not been developed. Furthermore, no evidence has been observed that indicates plans for future development of PHT facilities.

2. NRCC, Nagpur

The combined laboratory/processing facility requires further protection from dust and insects. As new scientists are employed in the vacant PHT positions, additional laboratories will be required. For example,

a laboratory will be needed for microbiology and engineering. A separate environmentally controlled room for computers would be beneficial.

3. IARI, New Delhi

At present, there are severe deficiencies in the facility at IARI. The schedules for completing the new building and remodelling the processing hall are unknown. Laboratories used for PHT microbiology (Department of Horticulture), pathology (Department of Plant Pathology) and Packaging/ Engineering (Department of Agricultural Engineering) are well maintained with space and environments favourable for scientific research.

4. IIHR, Bangalore

Laboratory facilities will be complete with the installation of work benches and fume hood.

D. Recommendations

1. CIHNP, Lucknow

CIHNP has the potential with its scientists and equipment, regional industry and experimental farm to be a world center for mango/guava PHT research and

development. However, with inadequate, poorly maintained facilities, producing reliable scientific contributions and developing a repetition as a center of excellence will be unlikely. Suggested solution to the CIHNP deficiencies are :

a) Reduce the number of scientists and items of equipment to fit the present facility. This would require transferring scientists and equipment to other centers that can accommodate and efficiently benefit from additional PHT scientists and scientific equipment. The remaining core of scientists (3-4) would probably be more efficient and productive in their research than the present overcrowded group of scientists and technicians. After suitable facilities are developed, then the scientists should return to CIHNP.

b) The other alternative is to immediately locate and occupy an appropriate facility for PHT research with processing facilities, laboratories and offices.

2. <u>NRCC, Nagpur</u>

a) New PHT laboratories should be developed as additional scientists are employed.

b) Dust needs to be filtered from outside air ventilating the PHT processing laboratory.

c) Walk-in cold storages need to be installed.

d) A fume hood should be installed in the analytical laboratory.

3. IARI, New Delhi

a) The new building and remodelling of the processing hall should be completed within the next two months. This is particularly important for the installation and operation of several new equipment items prior to warranty expiration and the commitments of this project terminate.

b) If construction scheduling and completion is indefinite, then suitable rooms/laboratories should be obtained for installation and operation of equipment.

4. IIHR, Bangalore

The new PHT laboratories will be completed when laboratory benches and the fume hood are installed.

V. Equipment

A large amount of imported and domestic scientific equipment has been procured for PHT research. The equipment identified and purchased for the PHT scientists has been appropriate for developing modern capabilities to investigate and solve problems for reducing postharvest losses and improving quality of perishable horticultural crops. Most of the equipment will serve the requirements of the multi-disciplinary PHT scientists. The purchasing of equipment for this project required a major amount of time, effort and budget of this project.

A. Progress

Annex Table 2 indicates the imported equipment and accessories purchased for each PHT location. In addition to the imported equipment, major items of domestically manufactured equipment have been purchased for the scientists, such as laminar flow clean air hoods, package/container compression, drop and vibration testing equipment, voltage stabilizers, a fume hood, fruit mills and various processing instruments. At NRCC a citrus conveyor/packing line was obtained.

At this time, almost all of the equipment has been received by the PHT research centers. The microscope, gas chromatograph, photographic equipment and PH meter have been purchased and they are in process of being delivered. In 1987, the color difference meter (colorimeter), Milton-Roy Spectrophotometer, Brookfield Viscometer, Aquameter and fluorescence spectrophotometer were acquired. With the exception of the aquameter (used for determining water content of materials or solutions) and fluorescence spectrophotometer

(which needed repair), the imported instruments were frequently utilized for research. Useful accessories were subsequently purchased. Presently, two of the four colorimeters and one of the two UV/Vis spectrophotometers that were obtained in 1987 are not operable due to electronic problems. During 1990-91, the other items of equipment have been delivered.

Most of the equipment items have been unpacked and installed sufficiently to determine their condition and operational status. Although uncompleted, construction of the gas blending/delivery system at IARI, IIHR and NRCC has progressed to almost usable systems. A few connectors are needed to complete its construction. No attempt has been made to construct this system at CIHNP.

B. Deficiencies

There is a need for acquiring a few minor missing or replacement items and repair of damaged and malfunctioning equipment. Also, there are deficiencies with the facilities, laboratory environments and experience of some personnel. Furthermore, there are deficiencies in certain scientists in assuming responsibility and taking the initiative for maintaining and learning to correctly operate some of the equipment. This leads to overloading with responsibility the few scientists who have the incentive to master the equipment.

C. Recommendations

1. Missing and defective items need to be identified, diagnosed, replaced and repaired. Construction of the gas blending system needs to be completed.

2. It is critical that electronic, analytical equipment be maintained in a clean environment. This includes small items, such as the electronic thermometer/hygrometer, etc. and large items such as the freeze-dryer, Instron gas chromatograph, HPLC, etc. Unconnected tubes of the HPLC should be covered.

3. It is critical that the scientific equipment be operated through voltage stabilizers with a uniform constant flow of electricity. Surge protection may be necessary, unless the stabilizers provide this protection. It is likely that erratic current caused the disfunction of the colorimeter and spectrophotometer.

4. The scientists must read the manuals provided with the equipment, understand the operations and intended purposes and put into practice recommended maintenance and precautions.

5. If adequate space and suitable facilities/ environment are not available, then the equipment should be transferred to other PHT laboratories which have suitable conditions.

6. The condition and utilization of the equipment should be monitored. If after one year from the time of delivery, the equipment is not being properly maintained or if it is not being used, then it should be transferred to a more suitable laboratory/research center.

7. The equipment must be accessible and usable for all PHT scientists.

8. Sources of technical assistance, supplies and educational programs provided by the equipment companies must be obtained for each of the PHT centers. It is important to develop procedures to minimize down time in the operation of the equipment. Scientists from each center will need to develop their own procedures since technical representatives and sources of supplies, such as gases for gas chromatography will vary according to location. Proper diagnosis of problems will allow the scientists to conduct most of their own minor repairs.

9. Support services provided by Winrock should continue until all imported equipment has been delivered, checked-out and damaged items repaired or replaced. Assistance by Winrock will be possible only at centers which have established suitable facilities for installing and operating the equipment.

10. Waters HPLCs and Hewlett Packard gas chromatographs are being used in many laboratories in India. For example, Mr. K. Saha, Regional Manager, for Waters in New Delhi indicated that there were 15 Waters HPLCs at IARI. Therefore, programs by the companies and experienced scientists from other laboratories/institutions should be contacted for providing training sessions on operation, methodology, and trouble-shooting.

11. With proper maintenance and operation, the equipment obtained through the project should provide reliable results for many years (20 or more).

VI. Research Programs and Future Directions

A. Objectives

The primary research objectives of this project were to focus on reducing postharvest losses of bananas, citrus, mangoes, guava, onions and potatoes during harvesting, farm handling, storage, marketing and processing. To assist in identifying directions of research activities, it was important to determine when, why and how much loss of each crop occur. It was realized that direct transfer of advanced technologies was not appropriate in most situations for reducing postharvest losses in India and that creative research was needed to development innovative information and technologies for reducing postharvest losses of commercially important horticultural crops.

To accomplish the primary objectives, the research program consisted of five components which included emphasis on (1) preharvest and harvesting techniques, (2) precooling, handling and transport, (3) storage, (4) processing and (5) waste utilization. Within each major topic area (component) there were six to nine more specific objectives and common to all of the components was the requirement to assess the economic feasibility of the new procedures/technologies, to develop instructional materials and to provide training programs on appropriate practices to reduce postharvest losses.

B. Progress

It is important to realize that most of the scientists in the now established PHT units were not trained or experienced in PHT research prior to the development of this project. Other than a few scientists that were experienced in postharvest storage/physiology, processing and microbiology, very few of the scientists had backgrounds in the subject matter of PHT. Therefore, considering the need for the development of knowledgeable, experienced scientists, development of facilities, acquisition of equipment and overseas training, there has been a substantial amount of progress accomplished on most of the research topics.

As indicated in the Introduction there has been a continuous documentation of results accumulated on the objectives of this project. In addition, designated scientists are in various stages of completing technical reviews on accomplishments towards achieving the objectives of each of the five research components along with formulating recommendations, identifying problems requiring further investigation and suggesting future strategies. These reports will be particularly valuable for future research activities, and they should be submitted as soon as possible.

Annex 3 is a section from the Technical Assessment (November 29, 1990) that has been slightly revised to reflect new developments. This Annex is intended to provide a summary of major accomplishments/results reported throughout this project.

C. Deficiencies

The primary deficiency of the research program has been the lack of results that have or will be actually applied for reducing postharvest losses or that are publishable in refereed journals. At this stage, each scientist should critically assess his/her program activities and make every effort possible to continue or adjust activities for having a realistic impact on PHT development.

Results that have commercial value need to be implemented and activities that have no commercial value or that do not contribute to the development of applicable solutions to problems should be discontinued.

Although the expected "End of Project Status" (PHT Project Design) has not been accomplished, it is evident that a foundation has been established for future research activities and future implementation of results that should provide significant contributions for reducing postharvest losses.

D. Recommendations/Future Strategies

1. Research on reducing postharvest losses and improving quality of fruit and vegetables and their products should continue to receive major emphasis.

2. Research activities that are on-track should be reinforced and those that are off-track should be remodelled.

3. Results that confirm or conflict with previously published results and results that are new should be indicated in the summary reports.

4. New research problems that can benefit from the new instrumentation needs to be included in the research programs.

5. Potential users of the research results must be identified and included in planning/collaboration of research programs.

6. Goal oriented research should be coupled with participation of the private sector in defining problems and developing research activities with usable results.

a) <u>Example</u>

Certain perishable crops have extreme fluctuations in market price depending on the season of the year and location in India. The period of high price occurs regularly and can be predicted from economic data. A final goal would be to economically market the out-of-season crops while retaining suitable quality. To accomplish the goal, an advisory panel consisting of participating scientists and private enterprise persons, such as those presently involved in handling/storage/marketing of horticultural crops should be formed. Actually, only one cooperator may be needed or the panel could be representatives from an association. Once the hypothesis (goal) is solidified as being commercially important and attainable, then procedures for accomplishing the goal are established. For example, to take advantage of market windows for tomatoes, it may be

necessary to accomplish storage for one month. The research agenda should then focus on how to achieve the time of storage and maintain marketable quality. Activities on this project would benefit from scientists involved in pathology, preharvest, economics, handling and storage. After the procedures are established for accomplishing the goal in laboratory conditions, then commercial trials in cooperation with the cooperators/ collaborators must be conducted. At this stage, modifications in procedures may be necessary. Also, throughout the program the advisory panel should be periodically informed of progress and consulted for advice in achieving applicable procedures. From the beginning, it will be necessary to maintain realistic directions. If the goal is not achievable within a reasonable amount of time, then it and the research agenda will need to be re-evaluated, modified and perhaps discontinued. Basically, the concept is to conduct goal oriented research having attainable objectives and which has the immediate attention and input (advice) of the ultimate beneficiary of the usable results.

b) **Example**

PHT developed for the export of horticultural crops or their products has many possibilities for research inter-ventions. However, first and most importantly, the primary goal needs to be defined which will depend on the crop, its intended destination and the requirements of domestic and foreign markets/marketers. Therefore, a thorough study needs to be conducted to identify the ultimate requirements, cooperators and specific problems (missing links). Each crop (apples to zuccini) will have

its own set of requirements and problems, and the limiting factor which constrain exportation and quality characteristics/maintenance will need to be clearly defined.

c) **Example**

There are severe losses of onions during storage and some PHT research has been directed towards this problem. What appears to be missing are commercial trials for implementing production and storage practices. Therefore, a goal should be to commercially implement methods to reduce postharvest losses of onions which will require the cooperation of the private sector. Indeed, if losses can be reduced by half and if the procedures to accomplish this reduction are practical then there should be numerous interested cooperators for the commercial trials. It is important that scientists be involved in the monitoring of pilot/commercial trials in order to validate procedures, results and to make further improvements. Undoubtedly, additional research on this subject will be needed; however, the actual requirements will be determined through the commercial trials/cooperators.

7. The above examples are only a few suggested goals and primary strategies. Each scientist, team of scientists and/or coordination group should develop a prioritized list of potential goals. Anticipate the problems and what is wanted to be accomplished. For each item on the list there must be usable end results. From

this list, private sector/association cooperators can be identified and contacted to establish advisory groups and to refine the goals according to actual commercial value.

At present, there is being generated by the PHT scientists a list of future research activities; however, the list is composed of research that will provide pieces of information without emphasis on a major goal and in most cases without an interested audience.

8. A workshop should be held to address goal oriented strategies for future PHT research activities. The workshop should be composed of private sector representation and ICAR scientists.

9. A management team composed of ICAR personnel and possible private sector representative should conduct a study of U.S. programs of research institutions that are linked to private sector problems.

VII. Consultants

A. Progress

Technical assistance for the PHT project has been provided by 10 different U.S. consultants for a total of 51 weeks. Specialists in the areas of postharvest physiology, storage, pathology, processing, microbiology and flavour analyzes have consulted with the PHT scientists, presented reference lists, presented seminars, participated in workshops and assisted with equipment.

B. Deficiencies

The project was designed with the anticipation of utilizing expatriate technical assistance for conducting collaborative research with PHT scientists at the respective ICAR centers. The research activities were to involve the use of the new equipment and new PHT facilities. However, since both the acquisition of equipment and development of facilities were delayed, the requirements for consultants were much less than had been earlier planned. Even now, with the arrival of most equipment, CIHNP and IARI are not able to efficiently benefit from technical assistance since facilities have not developed.

In two areas, economics and engineering, there has not been suitable consultants identified or available to assist with the project.

C. Recommendations

1. Technical assistance should be obtained for assisting with the development of procedures for using the new equipment in research programs. Assistance should include the application of procedures and methods of trouble-shooting problems during actual research activities.

2. Technical assistance would be useful in defining research goals with the scientists and developing domestic and foreign linkages with potential cooperators of the private sector.

3. An economist would be useful to assist with the next stage of loss assessment programs.

4. An engineer should be contracted to assess the PHT engineering program and to assist with future directions.

5. Almost every consultant indicated in their recommendations that more communications and collaborations between PHT scientists and commercial practitioners of PHT must develop. This issue should be thoroughly addressed and specific strategies should be developed. A workshop on research strategies focused on applied goals composed of ICAR scientists, consultants and private sector representatives would be valuable for developing future directions.

April 04, 1991

Summary

- This subproject focused on improving the capabilities to conduct research at four ICAR centers for the purpose of reducing postharvest losses of fruits and vegetables.

- PHT units composed of multidisciplinary scientists and supporting technical staff have been formed at each of the centers. Vacancies should be filled at IIHR and NRCC.

- Each PHT scientist received about four months of training/ research experience in the U.S. Four technicians are presently in the U.S. for a two month program. Additional training on operation/maintenance of equipment is needed.

- Facilities suitable for PHT research and modern equipment have been developed at IIHR and NRCC, need to be completed at IARI and have not been initiated at CIHNP.

- Equipment and personnel should be allocated to facilities that allow efficient and productive utilization of their capabilities.

- The delivery of scientific equipment to the PHT centers is almost complete. Only IIHR and NRCC have adequate space to install and operate the equipment. Installation and utilization of the equipment should be monitored.

- PHT research activities on preharvest/harvesting, loss assessment, handling, storage, processing and waste utilization have been coordinated since the beginning of the project.

- Completed studies that provide important information and methods that will have a commercial impact on reducing postharvest losses need to be published

- The technical program should be re-structured to focus on research that provides usable results to the private sector. Goals need to be identified cooperatively with private sector representatives.

- Consultants have assisted with the subproject in areas of postharvest physiology, storage, pathology, processing, microbiology and flavor analyses.

- Further assistance from consultants specialized in conducting research with the new equipment, economics, engineering and development of collaborative research activities should be pursued.

ANNEX TABLE 1

Budget Allocation and Utilization for PHT Project

(Presented at the
Twelfth ICAR PHT Coordination Committee Meeting
at New Delhi on March 25, 1991)[a]

A. Foreign Exchange (U.S.$)

Item	Allocated	Utilized
Equipment	1,331,000	1,327,118[b]
Training	802,007	639,248
Consultants	235,048	212,420

B. Local Currency (Rs. lakhs)

Item	Allocated	Utilized
Pay and Allowance	90,313	86,480[c]
Training/Workshops	5,239	4,683[c]
Recurring Contingency	23,930	26,377
Non-recurring Contingencies		
a) Research Equipment	56,608	44,393
b) Office Equipment	9,869	9,965
c) Works (Facilities)	31,472	37,982
d) Vehicle	6,539	8,269

[a] Expenditures are through December 1990 except

[b] which is through February 1991 and

[c] which is through March 1990

ANNEX TABLE 2

Imported Equipment Purchased for PHT Research Centers[a]

Item	Delivered Cost of each item ($000)[b]	IARI	IIHR	CIHNP	NRCC
Color Difference Meter (Gardner)	c	x	x	x	x
Spectrophotometer	14.0	x	x	x	o
Aquameter	c	x	x	x	o
Viscometer	c	x	x	x	x
Fluorscence Spectrophotometer	c	x	o	o	o
Phase Contrast Microscope	14.9	x	x	o	o
CO_2 Analyzer	9.4	x	x	-	x
Firmness Tester	0.4	x	x	x	x
Electronic Balance	2.1	x	x	x	x
Freeze Dryer	21.2	x	x	o	o
Centrifuge	26.1	x	o	o	o
Thermo/Hygrometer	0.6	x	x	x	x
Vacuum/CA Pouch Sealer	6.7	x	x	x	x
Refractometer	0.6	x	x	x	x
Recorder	2.4	x	x	x	x
Temperature Recorder	3.7	x	x	x	x
Recorder for Spec 1201	3.1	x	x	x	o
Cuvetter	2.0	x	x	x	o
Syringes	0.6	x	x	x	x
High Performance LC	78.1	x	x	x	o
Instron	66.4	x	x	o	o
Gas Blending System	13.1	x	x	x	x
Agar Sterilizer/Dispenser	15.3	x	x	x	x
Viscometer accessories	4.4	x	x	x	x
Colorimeter spare parts	2.6	x	x	x	x
Virtis Homogenizer	3.1	x	x	x	x

... 2/-

ANNEX TABLE 2 (continued)

Item	Delivered Cost of each item ($000)[b]	IARI	IIHR	CIHNP	NRCC
Ultrafiltration Unit	5.5	x	x	x	x
Microwave Oven	0.7	x	x	x	o
Electronic Insect Trap	0.6	x	x	x	x
Powder Mill	8.8	x	x	x	o
Turbidimeter	2.7	x	x	x	x
Ultrasonic Rodent Repeller	0.4	x	x	x	x
Electronic Vacuum Gauge	0.4	x	x	x	x
Analytical Balance	1.7	x	o	x	x
Shrink Wrap Machine	31.3	x	x	x	x
Gas Chromatograph (HP)	30.3	x	x	x	x
Photographic Equipment	1.4	x	x	x	x
Water Bath	4.4	x	x	x	x
Aquameter spare parts	0.4	x	x	x	x
Computer	7.5	x	x	x	x
Battery Pack for Computer	0.1	x	x	x	x
Digital PH meter	1.2	x	x	x	x
Freezer	9.9	o	x	o	o
Spectronic 20	6.5	o	o	o	x

[a] Cross marks (x) indicate items purchased for the respective centers; (o) indicate items not purchased for a center.

[b] Cost may vary according to time of purchase and shipping charges to each location. An additional computer ($8,224) was imported for ICAR headquarters.

[c] The combined cost for these items was $156,000.

ANNEX 3 RESEARCH OBJECTIVES AND ACHIEVEMENTS OF THE PHT SUBPROJECT

1. Objective 1

Determine methods to maximize quality and minimize postharvest losses of fruits and vegetables by improvement of preharvest and harvesting techniques.

a. Preharvest fungicides have been tested for controlling postharvest decay. The type of fungicide, concentration and time of application for reducing postharvest losses have been examined, and recommendations for commercial application of safe chemicals to several crops are close to being finalized.

b. Preharvest application of gibberellic acid (GA, natural growth regulator) and calcium salts have been studied. GA has been observed to retard ripening of oranges, mangoes and guavas while still on the trees or after harvesting. Calcium was found to improve storage/market life and color development of mango and guava. These trials have been repeated several times and recommendations for commercial application need to be developed.

c. Several trials have been conducted on preharvest application of sprouting inhibitors for preventing sprouting of onions or potatoes during storage. The results have been inconclusive, and it appears that other methods of inhibiting postharvest sprouting of these crops in India needs to be examined.

d. The effect of time of day, maturity stage and specific gravity at harvest on postharvest losses and quality of several crops have been studied. The results have been positive for reducing postharvest spoilage and recommendations should be publicized to farmers, shippers and market operators.

e. The effect of the time of irrigation prior to harvesting onions on postharvest losses and storability was found to be important. The practice of restricting irrigation before harvesting of onions to be stored needs to be instructed to the individuals involved with onion storage.

f. Methods of harvesting mangoes and guavas have been studied. Stems left on mangoes reduced postharvest deterioration while stems left on guavas enhanced water loss and shrivelling. Also, devices for harvesting mangoes have been refined for the purpose of facilitating harvesting and protecting fruits from physical injury.

2. <u>Objective 2</u>

Establish systems for precooling, handling and transport of fruits and vegetables which reduce postharvest losses and maintain quality characteristics.

a. Assessment on the cause and extent of postharvest losses of the 7 crops assigned to this subproject have been conducted. Primarily, the PHT agricultural economists and pathologists at the 4 research centers cooperatively evaluated losses attributed to harvesting, handling, shipping, wholesale and retail marketing. These studies have been very valuable for learning the marketing systems, development of an information gathering network and pinpointing where major efforts need to be concentrated for reducing postharvest losses of each crop.

b. Container and wrapping materials have been studied for protecting perishables during storage and/or handling. Certain wrapping materials were more protective than others. Attempts are being made to use containers constructed of materials other than wood for commercial handling of fruits and vegetables.

c. A few studies have been conducted on cooling prior to marketing. However, this treatment was combined with storage trials and little or no relevant information on cooling systems for direct marketing of perishables has been obtained.

3. <u>Objective 3</u>

Develop techniques for storage of fruits and vegetables to minimize losses and prolong quality characteristics.

a. Studies have been conducted on the effect of precooling methods for improving storage of fruit crops. Precooling was found to prolong storability and, interestingly, reduced the development of spongy tissue in Alphonso mangoes.

b. Various postharvest applications of fungicides and calcium on response of reducing postharvest storage losses have been examined. Positive results have been found and recommendations should be formulated.

c. Identification of pathogens responsible for market and storage losses have been studied along with methods for their control.

d. A cooling system for storage using solar energy has been constructed and it needs to be tested.

e. Studies have been conducted on an evaporative cool storage chamber. The chamber has provided a reduced temperature atmosphere favourable for retarding deterioration of several crops. A large version of the system has been constructed and will be used to examine its potential commercial application. The original small scale chamber should have farm-level application and needs to be implemented.

f. Studies have been conducted on postharvest treatments to control sprouting of onions and potatoes. In contrast to preharvest application, the sprout inhibitor was effective as a postharvest treatment and mist application was most beneficial.

g. Storage structures for onions have been modified to reduce storage losses.

h. Certain physiological and quality characteristics of stored crops in response to various postharvest treatments have been examined at least as much as existing laboratory materials and instrumentation allowed.

i. Hot water treatment of mangoes for reducing decay during ripening was demonstrated, and commercial trials by a major processor has been designed for 1991.

4. <u>Objective 4</u>

Develop methods of processing fruits and vegetables for maintaining quality components during storage and marketing.

a. Varieties of fruits and vegetables have been examined for their suitability for processing. Several quality characteristics were evaluated.

b. Extensive studies have been conducted on juice preparations, which have included methods of preservation, storage stability, carbonating, extracting, yields and liquification of pulp by enzymes.

c. Methods of preservation of fruits and vegetables have been investigated. Efforts have focused on the use of chemical preservatives, dehydration and fermentation for preserving different commodities or products such as wines and vinegars.

d. Some work on the microbiology of foods has been conducted.

e. Trials were established for testing packaging materials for storage/marketing of dehydrated products.

f. Methods of peeling crops for processing were studied. A mechanical mango peeler was constructed.

5. <u>Objective 5</u>

Develop methods to utilize wastes from commercially unacceptable fruits and vegetables and from processing systems.

a. Studies were conducted on extraction and characteristics of pectin from fruit materials and starch from potatoes.

b. Waste materials were examined for their potential utilization as animal feed. Studies included methods of stabilizing the waste materials during storage. A feeding trial was conducted using fresh and dehydrated waste materials.

c. Alcohol and vinegar production from extracts of mango wastes (peels and pits) was investigated.

d. The potential for developing pickled products from mango peels was investigated. The development of acceptable products was reported.