TECHNICAL ASSESSMENT

Agricultural Research Subproject

POSTHARVEST TECHNOLOGY OF FRUITS AND VEGETABLES

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by

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EXECUTIVE SUMMARY

- The purpose of this subproject was to strengthen the capabilities of four research centers to conduct research on reducing postharvest losses of fruits and vegetables.

- The U.S. provided training for 28 ICAR scientists at 8 U.S. research institutions, acquisition of U.S. and Indian manufactured research equipment and technical assistance by 8 U.S. consultants along with support for new staff, research and maintenance.

- The G.O.I./ICAR provided the development of postharvest research staff composed of multi-disciplinary scientists, postharvest research facilities, and support for office requirements, vehicles, in-country travel, staff and maintenance.

- Delays occurred in construction and remodelling of research facilities and in the purchase and delivery of research equipment.

- Positive impact of training, technical assistance and equipment received early in the project is apparent from the type and quality of research being conducted.

- Most of the research equipment has been only recently delivered and its impact is yet to be determined. The equipment is appropriate for serving the needs of multi-disciplinary scientists.

- Additional assistance will be required for installation and training on utilization of the research equipment..

- Postharvest research units were formed within each of the research centers.

- A research technical program was followed which paralleled development activities. The technical program addressed research on five components focused on reducing postharvest losses : (1) preharvest and harvesting factors, (2) loss assessment, handling and transport, (3) storage techniques, (4) processing methods and (5) waste utilization.

- Substantial progress has been made on these appropriate research topics.

- Workshops have ~~to be~~ been conducted by subproject participants and jointly with other ICAR and State Agricultural University postharvest scientists.

- The foundation has been established with appropriate inputs and activities for accomplishing the purpose of the subproject.

- Follow-up with assistance involving the new equipment and establishment of collaborative research between U.S. and ICAR scientists will greatly benefit the strengthening of the capacity to conduct research on postharvest losses and development of appropriate technologies for reducing postharvest losses.

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I. SUBPROJECT DESCRIPTION

A. Statement of Purpose

1. Purpose

The purpose of the Postharvest Technology (PHT) of Fruits and Vegetable ARP Subproject is to strengthen the capabilities of Indian agricultural research centers to conduct research on reducing postharvest losses of perishable fruits and vegetables having major national importance. Research strengthening activities are focused on four Indian Council of Agricultural Research (ICAR) centers strategically located in major production/market regions of two or more of seven important perishable horticultural crops. Through strengthening these postharvest research centers, scientific capabilities are to be achieved for developing technologies, developing solutions to problems and formulating recommendations for reducing postharvest food losses while consistently increasing the quantity and quality of food supplies in India.

The PHT Subproject was designed October 1982, printed May 1982, implemented April 1, 1985 by USAID and October 1985 by ICAR. Training locations, equipment and consultants to be provided by the U.S. were identified by the ICAR/PHT Management Team during a visit to the U.S. in mid-1986.

2. Linkage to Higher Goal

Linked to the purpose of the Postharvest Technology of Fruit and Vegetable (PHT) Subproject are several higher attainable goals, such as :

a) stimulation of postharvest research and technological development throughout India;

b) improvement in food supplies, nutritional status, employment and incomes for the Indian population;
c) marketing of perishable and preserved foods which meet international (export) quality standards;
d) facilitate development of private-sector businesses involved with food handling, marketing and preservation;
e) stimulation of Indo-U.S. scientific and business collaboration.

Indeed, accomplishing these higher goals will require more time than provided by the PHT project. However, by initially strengthening the capabilities to conduct research focused on postharvest preservation of perishable foods at four research centers, models of expertise and facilities can be established which will be capable of being multiplied throughout India for ultimately attaining the higher goals.

B. Specific Objectives

Postharvest losses of fruits and vegetables in India are realized to be extremely large. Expertise and research facilities to develop appropriate technologies and to develop usable procedures for reducing postharvest losses of perishables have been grossly inadequate. Traditionally, large losses in quantity and quality of foods from the time of harvest and through the marketing channels have been considered to be unavoidable, and new technologies are inconvenient, unavailable or uneconomical. Combined, the lack of knowledge, inability to generate new knowledge through research and existing improper postharvest handling/storage/marketing procedures have contributed to major losses in food availability.

The production of several perishable horticultural crops in India is highly seasonal and regional. Without proper postharvest handling technologies and procedures for

uniform distribution of perishable foods throughout India, this results in excessive supplies and large losses in some regions of the country and shortages in availability in other regions. Obviously, farmers would benefit from development of postharvest procedures and infrastructures that extends the marketability of their commodities and relocates surplus supplies from their production region. Furthermore, consumers would benefit from postharvest development by having increased availability to important nutrient resources with reduced fluctuations in costs, by having a safer supply of food with less risks of health hazards caused by mycotoxins or pathogens and by having improved availability of quality of perishables being marketed.

Prior to this PHT Subproject, most agricultural research in India focused on methods to increase food production without including training, facilities or support for research on reducing harvested food losses. Therefore, scientists, laboratories, programs and knowledge have been deficient in the development and advancement of information and technologies to reduce postharvest losses of perishable fruits and vegetables. The Indo-U.S. Subcommission on Agriculture realized that major improvements in food availability and quality could be accomplished by research and development of methods to protect crops after they were harvested. Subsequently, the PHT Subproject was designed with specific objectives to strengthen the capabilities of scientists and laboratories to conduct research on postharvest problems of regional and national importance.

1. Problem 1

Preharvest factors and harvesting techniques can influence the postharvest deterioration of perishable horticultural commodities during subsequent handling, storage and marketing. For example, selection of cultivars, production cultural practices latent pathogen

infection and stage of crop maturity at harvest greatly influence quality and durability after harvest. Also, damage which may not be initially apparent, can occur from adverse harvesting techniques.

Objective 1

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

Included with this objective are studies to reduce postharvest losses by improving the selection of cultivars, production practices (fertilization, disease control) and harvesting techniques. In additions, economic feasibility studies of any changes in preharvest and harvesting techniques were to be conducted. An important sub-objective was to disseminate information on proper preharvest and harvesting techniques to farmers.

2. Problem 2

Large quantities of perishable foods are realized to spoil during postharvest handling and marketing; however, information on the cause and extent of such losses is lacking. Identification of the major causes of losses would greatly assist in developing appropriate remedies. There are numerous technologies available to reduce postharvest losses such as proper temperature management, protective coatings and containers and sanitation and disease control; however, appropriate techniques for the conditions and resources available in India need to be developed.

Objective 2

Establish systems for precooling, handling and transport of fruits and vegetables which reduce postharvest losses and maintain quality characteristics. This objective was expanded to include the determination of causes and extent of postharvest losses from the field to

the retail markets. Evaluations within this objective were to include studies on methods of precooling, containerization, packing, protective coatings, ventilation, regulate ripening and prevent physiological disorders. Associated with the objectives were the requirements for economic evaluation of any changes to be recommended and for the development and dissemination of information.

3. Problem 3

Most horticultural crops are seasonally and regionally produced which results in cycles of surpluses and scarcities and large price fluctuations. Excess supplies usually results in extensive postharvest losses unless proper storage facilities are available. Storage technologies are available with utilization of temperature, humidity, atmospheric gas and sanitation regulation suitable for a particular commodity. However, information and appropriate techniques for storage of perishables in India are limited. Furthermore, information is lacking on the storability and storage requirements of the types and cultivars of crops produced in India.

Objective 3

Develop techniques for storage of fruits and vegetables to minimize losses and prolong quality characteristics. Within the objective were studies on the development of farm and commercial level storages, prestorage factors such as curing and cul ivar and storage environments suitable for each crop. Economic feasibility studies on conventional, and improved storage treatments and facilities were to be conducted. Instructional materials and programs were to be developed for farmers and commercial storage operators on proper storage procedures of perishable crops.

4. Problem 4

Processing provides a means of long term storage and protection of nutritional value of many foods. Crops unacceptable for fresh market utilization can often be processed into acceptable products. Although there are many benefits of processed foods, very small quantities of food are processed or utilized in India. This lack of utilization is based on traditional taste, availability of fresh, unprocessed foods, poor quality of processed foods being marketed and cost. Methods are needed to develop low cost processing/preservation procedures, improve quality of existing preserved foods, develop new acceptable food products and develop education and demonstration programs on food preservation.

Objective 4

Develop methods of processing fruits and vegetables for maintaining quality components during storage and marketing. Studies within this objective were to include emphasis on development and evaluation of dehydration, fermentation, acidification and other methods of preservation for farm, village and commercial operations. Studies were to be conducted on improving quality, packaging techniques and consumer acceptance of new or improved processed foods. The objectives also included studies on economic assessment of market potentials and development and presentation of instructional programs on food preservation.

5. Problem 5

Postharvest and processing wastes that are unacceptable for consumption may be utilized to manufacture products having value. For example, oils can be extracted from citrus peels or mango seeds which can be utilized for cooking, lubrication, etc. Sugar, vinegar, alcohols, pectin, pigments, flavorents and various other biochemicals can be developed from food waste materials. However,

information and technologies are lacking on methods to develop and evaluate utilization of waste materials.

Objective 5

Develop methods to utilize wastes from commercially unacceptable fruits and vegetables and from processing systems. Included within this objective were studies to be conducted to assess the types and quantities of waste generated and available for potential utilization, to develop methods of utilizing waste materials and to assess the economic feasibility of waste utilization for manufacturing usable substances.

C. Input/Output Matrices by Objectives

Development of postharvest research activities was assigned to four ICAR research centers each having different requirements for strengthening. The selection of these research centers was based on their strategic location in major production and/or market areas of major perishable food crops and on their potential for developing research capab lities to significantly reduce postharvest food losses. The following research centers and crops were selected to be involved with this Subproject :

1. Indian Agricultural Research Institute (IARI), New Delhi : Banana, Citrus, Mango, Onion, Potato, Tomato

2. Indian Institute of Horticultural Research (IIHR), Bangalore : Banana, Mango, Onion, Tomato

3. Central Institute of Horticulture for Northern Plains (CIHNP) Lucknow : Guava, Mango, Potato

4. National Research Center on Citrus (NRCC), Nagpur : Banana, Citrus

IARI is located in New Delhi which is a major terminal and cross-roads for produce handled in India. IIHR, CIHNP and NRCC are located in regions of seasonal - often surplus production of their assigned crops which experience extensive postharvest losses. IARI, IIHR and CIHNP had a few scientists, limited research equipment and inadequate facilities for developing research programs on reducing postharvest losses and/or processing. NRCC had no scientist or facilities at the beginning of this Subproject; however, its development had been sanctioned by ICAR.

Development of scientists, equipment and facilities at the four research centers were designed to occur simultaneous to conducting research assigned through the technical program. IIHR, CIHNP and NRCC were to conduct research on all five research objectives and IARI was assigned all but the first objective (Section B).

Postharvest technology is a multi-disciplinary field which benefits from the cooperative and coordinated efforts of different specialists working toward common goals. Therefore, formation of teams of scientists specialized in areas of biochemistry, physiology, pathology, microbiology, engineering, economics and processing trained and focused on research to reduce postharvest losses was a major input of this Subproject. Furthermore, development of facilities with equipment required for postharvest research were essential inputs of the Subproject. Most research instrumentation is usable by scientists from several different agricultural research disciplines, and a foundation of essential instrumentation for each facility was selected for serving the needs of several scientists. Therefore, independent inputs were not designed for accomplishing specific research objectives of this Subproject, since integrated efforts by several scientists sharing facilities and equipment common to conducting research on several objectives was developed for achieving the goals of the PHT Subproject.

1. Specification of Inputs

a. U.S. Inputs

U.S. inputs to the PHT Subproject were to provide training of ICAR scientists, assistance from U.S. consultants, U.S. and India manufactured research equipment, declining support for new staff and maintenance of PHT facilities, equipment and vehicles for five years (Table 1). The major inputs were training and equipment acquisition.

b. G.O.I. Inputs

Inputs by GOI/ICAR were to establish units of PHT scientists and supporting staff, develop facilities for modern scientific instrumentation and PHT research, to finance existing staff and increasingly assume support for new staff and to provide in-country transportation (Table 1).

2. Specification of Linked Outputs

The combination of developing units of trained PHT scientists, facilities equipped and operational for PHT research and supportive assistance by consultants was to provide the capabilities to conduct research on reducing postharvest food losses. Evidence of progress toward the development of PHT research capabilities would be observed from research productivity and accomplishments by each of the research centers. The quality of research and types of investigations capable of being conducted would be substantially improved by the cooperative inputs. This will result in improvements in scientific publications, development of recommendations, workshop and other public service outputs which address reducing postharvest losses of perishables.

II. Technical Assessment

A. Input Progress and Assessment

1. U.S. Inputs

a. Training

(1) Progress

Scientists in different postharvest disciplines belonging to postharvest technology units at the four research centers were provided training/research experience in the U.S. A total of 28 scientists received 111.5 months of training at eight different research institutions in the U.S. (Table 2A-2D). All of the scientists employed for PHT research received U.S. training, except one, who was unable to participate in his scheduled program due to personal problems. Training programs for the PHT scientists were conducted at nine different U.S. research institutions not including short visitations to others. Typically, PHT scientists were in the U.S. for four months, received training on appropriate subjects and instrumenta- tion while conducting a short research project, attended at least one professional conference and visited some other U.S. PHT laboratories. Scientists from the same I.C.A.R. research center usually received training at different U.S. research institutions.

Plans have been made to provide two months of training for four or five PHT research technicians in the U.S. before the end of the subproject. If final clearances are not obtained for this number of technicians to go to the U.S., then plans have been tentatively developed for the training to be conducted in India.

(2) Assessment

Originally, it was planned for each PHT scientist to receive about 12 months of training in the U.S.

However, less time in the U.S. was allocated by I.C.A.R. Reasonably, this reduction was necessary to avoid adverse disruption of research programs at the PHT centers. Therefore, the shorter time and fewer scientists sanctioned for the project resulted in utilization of less financial support then was allocated.

Training of the first scientists concentrated on research methodology and instrumentation including intensive short courses by equipment manufacturers. Subsequently, more appropriate training programs were developed which focused on conducting research on a particular subject while using different methods and equipment to conduct the analyses. This latter approach was highly successful at most of the host institutions, even though four months including orientation is inadequate to complete most research projects.

Accomplishment of exposing PHT scientists from a given I.C.A.R. research center to different U.S. institutions and PHT scientists was appropriate both for providing training and for expanding contacts and, possibly, future collaborative research activities between India and U.S. scientists. Most of the scientists have indicated that their training/research experience in the U.S. was appropriate and beneficial to their current research programs. One training program was expressed as being unsatisfactory due to improper execution of terms of reference by the instructor.

Although PHT training programs were planned to be predominantly conducted during Spring to Fall months to coincide with most postharvest/processing activities in the U.S., most of the programs were during Fall to Spring months. This shift in scheduling was primarily caused by delays encountered in obtaining clearance/approval for the scientists to

travel to the U.S. The U.S. scientists were able to accommodate indefinite and changing schedules; however, shifts in schedules affected efficient use of training time since programs could not be thoroughly prepared in advance. In addition, the I.C.A.R. scientists experience in the U.S. was partially restricted by the environmental conditions of U.S. winters.

The efficacy of I.C.A.R. is commendable in establishing a program of sending PHT scientists to the U.S. for training without excessively disrupting newly developed PHT units and associated research productivity at the research centers. The management support services provided by Winrock have been invaluable.

(3) Requirements

PHT scientists and technicians will need training on the operation, maintenance and use of the research equipment once it is installed at the research centers. Without this training, the purpose of this project will not be fully achieved.

b. Research Equipment

(1) Progress

Research equipment and accessories have been and are being delivered to the PHT research centers. Some adjustments in the amount of equipment had to be made in order to stay within the allotted funding. A substantial amount of U.S. and Indian manufactured equipment has been purchased. Combined, about $1,480,000 worth of equipment has been purchased for the PHT research centers. Table 3A-3D illustrate the U.S. manufactured equipment items designated for this subproject. About half of the items have been delivered during the past six months while the remainder are in India or awaiting shipment. A few

items had to be re-bid and their purchase is pending. Most of the equipment received in 1990 has yet to be installed, and the gas blending system received early in 1990 has only been partially assembled at one site.

(2) Assessment

Following the PHT management teams' visit to the U.S. and meetings with PHT scientists in 1986, a list of equipment required for PHT research was developed and presented to USAID in 1987 for purchasing. Through Winrock and the lead consultant, specifications were developed. Colorimeters, spectrophotometers, viscometers and aquameters were purchased and shipped to the respective research centers in 1987. These first equipment items were procured and shipped by Winrock, although it had been agreed that Sheladia Associates would procure the rest of the equipment. Approval of the Sheladia subcontract was not accomplished until February 1989, creating an 18 month delay. Subsequently, equipment procurement progressed, even though more than 200 days were required from the time Sheladia received specifications until the equipment was shipped, assuming there was no requirements for re-bidding. As a consequence of these delays, progress on in-country training of scientists by consultants, and utilization of the equipment for research purposes was curtailed. Now, at the end of the project the equipment is being received, and unless follow-up technical assistance and purchase of over-looked parts are provided, some of the sophisticated equipment may not be used properly.

The equipment selected by I.C.A.R. for their laboratories was highly appropriate for developing the capacity to conduct PHT research and to assist in solving PHT research problems. Most of the equipment that was selected will serve the requirements of

multi-disciplinary PHT scientists rather than individual scientists. The four items of equipment received early in the subproject have been heavily used and shared by the scientists at the research centers. Items of processing equipment received less priority and were not purchased (aseptic processing and scraped surface juice concentrator units).

(3) Requirements

Assistance with installation, operation, maintenance and trouble-shooting will be required during 1991 for an orderly establishment and proper utilization of the equipment transferred from the U.S. Supporting services and funding are, also, needed for obtaining spare parts and omitted accessories for the equipment. Support for the technical assistance will be necessary for nine months after the scheduled termination date of March 30, 1990. A qualified instrumentation engineer should be employed, even though equipment representatives have the initial responsibility for installation. The instrumentation engineer should be responsible for assuring that facilities are suitable for installation, coordinating installation and follow-up trouble-shooting.

c. Consultants

(1) Progress

Technical assistance has been provided by eight consultants for a total time of 10 months in India (Table 4). In 1987, a workshop on postharvest loss assessment was conducted which proved to stimulate major efforts by PHT scientists on assessing postharvest losses of crops assigned to the PHT subproject. Specialists in the areas of postharvest physiology, storage, pathology, processing, microbiology and flavour analyses have consulted with PHT scientists, presented seminars, participated in

workshops, assisted with new and existing instrumentation and/or presented short courses at the I.C.A.R. research centers. Plans are being developed for several consultants to participate with the final PHT subproject conference. An instrumentation engineer has assisted and should continue to assist with technical requirements of the research equipment.

(2) Assessment

The technical assistance has been appropriate and beneficial for the scientists and PHT subproject. Less than anticipated utilization of U.S. consultants has occurred due to the excessive delay encountered in obtaining the research equipment. Logically, U.S. consultants were planned to assist I.C.A.R. scientists with the functions and use of the equipment for conducting research; therefore, without having received the equipment, there was less requirement for technical assistance.

(3) Requirements

Technical assistance is needed for installing and checking out the newly arrived equipment. This assistance should be continued until all of the equipment has been received. Subsequently, U.S. consultants should be requested/provided for assisting the PHT scientists with experiments using the new scientific equipment. The U.S. consultants will, also, assist with providing instruction on operation, maintenance and trouble-shooting of problems involved with utilizing the equipment. Provisions for consultancy activities are needed periodically during 1991 which include U.S. and Indian consultants skilled with instrumentation. Consultants need more than one month advanced notice to obtain clearances and to adequately prepare for overseas assignments.

2. G.O.I./I.C.A.R. Inputs

a. Staffing

(1) Progress

PHT units were formed at each of the research centers soon after the subproject was initiated. At IARI, IIHR and CIHNP, PHT units were formed from existing scientists. New scientists were recruited to fill vacant positions sanctioned by I.C.A.R. Presently, 29 PHT scientists are working with the PHT subproject and three positions are vacant (Table 2A - 2D). The three vacant positions are at NRCC which was the latest facility to become established. The original design proposed that 49 scientists be employed for the PHT subproject; however, this number was scaled down by ICAR.

(2) Assessment

The units of PHT scientists are appropriate and qualified in terms of training in the multi disciplinary subjects and capabilities. Mainly, experience and skill with high technology research is lacking, but this should be corrected with sufficient training on their new equipment.

(3) Requirements

Vacant positions at NRCC need to be filled. Also, the scientists and technicians need to receive training to a level of self-sufficiency in operation, maintenance and management of the recently received and to be acquired research instrumentation. Undoubtedly, some scientists in PHT units who are located in other departments such as economists and engineers at IARI and IIHR may need to receive special attention to continue work on PHT problems.

b. Facilities

(1) Progress

PHT facilities have been completed at IIHR, are adequate at NRCC, need to be completed at IARI and need to be expanded/developed at CIHNP. At IIHR, a new library was constructed which allowed expansion of the PHT unit into the adjacent vacated space following remodelling. At NRCC, facilities were acquired and remodelled for PHT research. At IARI, a two story PHT facility connected to the existing laboratories is almost completed. At CIHNP, a leased, former residence has been partially remodelled for PHT unit research.

(2) Assessment

Facilities for PHT research have been/are being completed at three of the research centers. As witnessed by the arrival of the first items of equipment, space was rapidly acquired for installation and operation. However, at CIHNP space to install and utilize the more bulky items of equipment needs to be arranged. Overall, the development of PHT facilities has taken more time than earlier planned, although substantial development of appropriate facilities has occurred during the subproject for PHT research.

(3) Requirements

Facilities at IARI need to be completed. Facilities at the four centers should be re-examined by a qualified instrumentation engineer prior to equipment installation. Construction of PHT facilities at the CIHNP field research station which have been planned need to be initiated and completed as soon as possible.

c. Workshops

(1) Progress

Annual workshops have been held jointly with the

All India Research Project on Postharvest Technology of Horticultural Crops. Other workshops of the PHT units have been held periodically. Quarterly meetings have been held by the PHT subproject principle investigators and ICAR coordinators.

(2) Assessment

The workshops focused on work conducted by the PHT subproject scientists and PHT research conducted at other centers. These workshops were appropriate and sufficient for this subproject.

(3) Requirements

An international PHT symposium should be held once facilities are completed and the equipment is in operation. The workshop should be composed of invited speakers having international stature for the purpose of drawing world attention to PHT research in India and the elevated caliber in capacity to conduct PHT research. This program should, also, be used to develop mechanisms for collaborative research projects. The symposium will need to be held after March 30, 1991.

B. Output Progress and Assessment

Research on objectives of the PHT subproject was initiated soon after the subproject was approved. A technical program was developed for each of the research centers according to their capabilities and assigned role described in the subproject design document. Quarterly and annual reports were submitted by the center's principle investigators. Annual progress reports were presented at workshops held jointly with the All India Coordinated Research Project on Postharvest Technology of Horticultural Crops. The proceedings have been published and distributed by ICAR since 1987 (the 1987 report contains results from 1986). A voluminous document has, also, been developed which contains research results collected by the PHT subproject research centers.

The technical program was strictly followed which resulted in the generation of a large amount of information during the existence of the subprpject. Although activities adhered to the major objectives of the technical program, there were major changes in the type and quality of data that were obtained after the scientists received the first items of research equipment.

Output : The following section summarizes the major studies (outputs) accomplished as the result of the PHT subproject through 1989. All of the centers and scientists have contributed to the accomplishments according to their area of specialization.

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 publisized 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.

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. Objective 2

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 invaluable for learning the marketing systems, development of an information gathering network and pin-pointing 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 Objective 3

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 low cost cooling system for storage using solar energy has been planned. It needs to be constructed and 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.

f. Studies have been conducted on postharvest treatments to control sprouting of onions and potatoes. In constrast 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.

4. Objective 4

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

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. Objective 5

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.

Output Assessment (Qualitative)

Fortunnately, there was an abundant amount of research that could be conducted within each of the subprojects objectives without relying on imported equipment or new facilities. Therefore, considerable progress has been made

on developing background information and determining the problems, potential solutions and capabilities for future research. In some areas, sufficient advancements have been made for developing recommendations for commercial utilization.

In all areas there has been evolution in improvement of postharvest research quality and productivity directed toward practical applications. The stage has been established for the generation of appropriate information with the installation and operation of new equipment in suitable facilities.

B. Progress Toward Objective

1. Appropriateness of Objective Priorities

a. ICAR/SAU Systems

The objectives were and continue to be appropriate to ICAR responsibilities. Development of postharvest technologies had been neglected in India, and ICAR has been able to assume an important role in developing research centers focussed on reducing postharvest losses through the assistance of this subproject. The research objectives are on-target for contributing to the primary objective of reducing food losses. Through interaction with the All India Coordinated Research Project on Postharvest Technology of Horticultural Crops, the objectives of the PHT subproject have been extended to several State Agricultural Universities and other ICAR research centers for addressing as research priorities.

Prior to this subproject, most PHT research by the ICAR/SAU system was directed toward processing and product demonstration/manufacturing. Establishing objectives that emphasize preharvest and postharvest development of methods to retard deterioration of

fresh market produce have been particularly appropriate for ICAR/SAU activities whil continuing to involve the processing component. Although research on waste utilization is important as food processing becomes more important in India, research on this objective is not essential at least for near future requirements.

As in other countries, research objectives focused on reducing postharvest losses are appropriate/necessary for government and state university systems. The objectives dealing with postharvest handling, storage and marketing science and technologies should be vigorously pursued while continuing to maintain objectives directed toward processing. The Central Food Technology and Research Institute is very well equipped and experienced in food processing technologies and new product development. Increased efforts by ICAR in this areas may be an unnecessary duplication of resources and efforts. However, ICAR should maintain objectives that include studies on processing and processed products as long as the objectives are directed to reducing postharvest losses.

Importance of U.S. Interest

a. Current

U.S. interest and involvement have been important for the progress accomplished by ICAR scientists toward the objectives of the PHT subproject. Training and technical assistance provided by the U.S. have stimulated interest and solidified directions of the scientists in contributing to the objectives of reducing postharvest losses. Basically, the objective of providing U.S. training, technical assistance and research equipment will have been achieved by the end

of the subproject. However, an orderly transfer of assistance for utilizing the new equipment will need further U.S. intervention.

b. Future

The importance of U.S. equipment transfer for conducting PHT research will be demonstrated in the near future. Continued involvement by the U.S. will be essential to fully accomplish the objective of this subproject. The U.S. has a vast amount of experience, expertise and technologies which can assist in developing appropriate systems for reducing postharvest losses in India. Furthermore, interaction between U.S. and Indian scientists will be important and synergistic in PHT development.

3. U.S. Role and Advantage in Cooperation

Involvement by the U.S. in assisting with this subproject has been appropriate. There are several advantages that have or may develop through U.S. activities with the PHT subproject such as :

a. Development of mutual respect and trust for U.S. and Indian PHT research for future research collaboration.

b. Establishment of and progress on research of mutual interest.

c. Development of potential reciprocal benefits from advancement in technologies made by PHT scientists. For example, discoveries of low energy requiring methods for cooling could have tremendous benefits to the U.S. as would advancements on natural additives which assist in preserving foods.

d. Stimulation of technology transfer to India by U.S. manufacturers of commercial equipment.

e. Development of infrastructures required to export/import perishable and/or processed foods.

C. Progress Toward Purpose

1. Relevance

a. ICAR/SAU System

Excellent progress has occured in strengthening PHT research capabilities at ICAR research centers from the formation of units of PHT scientists, improvement of facilities, training and technical assistance and to a minor extent, the installation of a few imported research instruments. Further progress will be achieved when research facilities are completed and the new equipment is operable. Progress has been relevant to the ICAR system, and it should expand to the SAU systems. An important goal of ICAR is to establish centers of excellence for PHT research and that these centers will serve as models and as a resource of expertise to eventually elevate the capabilities and capacities for PHT research at SAU's and other appropriate ICAR research centers.

2. Mutuality of Interests

a. Current

The objectives of reducing postharvest losses addressed in this subproject are of mutual interest to U.S. and Indian research programs/scientists. Currently, scientists and resources are present in India to conduct research on problems of mutual interest with U.S. scientists. However, mechanisms that facilitate cooperative research are limited, and cooperative PHT research activities are non-existent between U.S. and Indian scientists.

b. Future

Mutuality of interest in research on reducing postharvest losses of perishables will continue and will be strengthened when cooperative activities develop.

3. Follow-on Cooperation

a. Scientists-to-Scientists

Many scientists in the U.S. and India are willing and capable to jointly establish research on PHT projects of mutual interest and benefits. Programs need to be established to facilitate collaboration.

b. Inter-Institutional (U.S. - India)

PHT research is scattered throughout the U.S. with certain areas of strength in the multi-disciplinary field located at each institution that contain a postharvest component. Therefore, establishment of programs of mutual interest with one or a few U.S. institutions would limit the diversity required for PHT research. Scientists-to-scientists programs would extend the availablility of capable scientists in the U.S. and Indian/ICAR/SAU systems having mutual interest which would be more difficult to accomplish by inter-institutional programs.

RECOMMENDATIONS

Following March 30, 1991, the termination date set for the PHT subproject, there are two areas of activity that are needed and that would greatly benefit from U.S. assistance.

1. Equipment

No further purchase of major research equipment is needed; however, assistance with the recently delivered and yet to be delivered equipment will be necessary. Assistance is needed for coordinating installation and training to be provided by the manufacturers. Some, but not all, of this work will be completed by March 30, 1991.

Furthermore, follow-up assistance is needed to procure missing or overlooked items or accessories which are required for operation of the equipment.

The services of Winrock International would be most efficient for accomplishing the requirements for an orderly establishment of operational equipment. It is estimated that no more than $50,000 would be required for obtaining equipment parts and accessories. Provisions for the services of a part-time instrumentation engineer should also be provided. The following should be provided/continued through 1991 :

a. Coordination of equipment installation.

b. Coordination of training of scientists and technicians on operation and maintenance of equipment. Courses provided by the manufacturers and other in-country programs should be scheduled.

c. Assistance with obtaining spare parts/accessories.

d. Follow-up/monitoring of operation of equipment.

e. Identification of reliable equipment service representatives/manufacturers for future reference. For example, which companies have or have not fulfilled their obligations.

2. Research Collaboration

Many of the ICAR scientists have requested to obtain the benefits of collaborative research with U.S. scientists. In part, this was realized from the brief training/research experience in the U.S. Provisions for supporting collaborative research for 2 years would provide substantial benefits in assistance with using the new equipment/facilities for designing experiments, data collection and analyses. Development of further cooperative research would be stimulated with long-term benefits to both Indian and U.S. scientists. Once collaborative research is initiated the scientists will be capable of seeking-out-funding sources for continued activities.

The first year (1991) will require the assistance of U.S. consultants with terms of reference dealing with conducting collaborative research. The second year (1992) should provide grants for sabbatical research activities to both U.S. and ICAR scientists. Advertising for this program would need to be conducted in 1991.

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Table 1. Allocation of U.S. and ICAR Inputs for PHT Subproject [1]

Impact Items	Proposed[2]	Adjusted Budget[2]	Amt.Used[3] thru Sept. 90	% Used o Adjusted Budg
U.S. ($'000)				
Training/ Workshops	1779	884	657	74
Consultants	528	235	176	75
Equipment	1319	1586	1361	86
Op.Research	56	56	67	120
Maintenance	420	420	0.3	< 1
Staff	601	240	293	122
Total :	4703	3421	2554	

Impact Items	Proposed[2]	Adjusted Budget[2]	Amt.Used[3] thru June '90	% Used of Adjusted Budge
ICAR (Rps '000)				
Facilities	9642	-	3240	37
Off.Materials	1321	-	1020	77
Vehicles	1036	-	827	80
Maintenance	589	-	134	23
Staff	3425	-	5816	170
Travel	760	-	468	62
Total :	16773	-	11505	69

[1] Based on the original proposed design, allocations (percent of total) t the respective research centers were as follows: IARI, 30%; IIHR, 34% CIHNP, 20%; NRCC, 15%. Includes local currency @ $1 = 9.5Rs.

[2] Source: Agricultural Research Project (Project No. 386-0470) Attachment '1' to PIL No.49 from Winrock documents.

[3] Source: Winrock International Quarterly Report and Workplan No.18, August 6, 1990.

PERSONNEL/TRAINING

Postharvest Technology Personnel Established at Designated Research Centers and U.S. Training Received.

Table 2,A. Indian Agricultural Research Institute (IARI), New Delhi

Name	Source	Speciality	U.S. Training Month	Year	Location
Dr. S.K. Roy	E	Storage/Processing, PHT subproject coordinator & all India PHT coordinator, member of management team	1	1986	Study Tour
			1.5	1990	Res.Mgt.Course
Dr. R.K. Pal	N	Postharvest Physiology	4	1990	U.of Arkansas
Dr.A.K.Chakraborty	T	PHT/Production Physiology	4	1987-88	U. of Georgia
Mrs. V.K. Murthi	T	Pathology, located in another Department	4	1989	U.California, Riverside
Dr. S.B. Maini	E	Processing/Waste Utilization	4	1987-88	Ohio State U.
Dr. D.S. Khurdiya	E	Processing	4	1987	Purdue U.
Mr. V. Ram	N	Processing	4	1989-90	U.of Florida
Dr. V. Sethi	E	Food Microbiology/ Preservation	4	1987-88	Michigan State University
Dr. B.R. Atteri	T	Ag.Economics/PHT Loss Assessment. Located in another Department	4	1988-89	U. of Georgia
Mr. H.S. Sharma	T	Ag.Eng./Packaging/Cooling Located in another Deptt.	5	1987-88	Michigan State University

Others - 8 Technical staff, 4 lab assistants, typist and driver

[1] Source; E, existing before PHT subproject; T, transferred from another program/dept; N, new addition.

PERSONNEL/TRAINING Cont.

Table 2,B. Indian Institute for Horticultural Research (IIHR), Bangalore

Name	Source[1]	Speciality	U.S. Training Month	Year	Location
Dr.S.Krishnamurthy	E	PHT Physiology/Biochemistry (Principle investigator)	4	1986	U. of Arkansas
Dr. G.K. Rao	T	PHT/Preharvest Physiology	4	1987-88	U.of Georgia
Dr. B.A. Ullasa	T	Pathology, located in another Department	4	1987-88	Univ. of California Riverside
Mr. E.R. Suresh	E	Food Microbiology/ Preservation	4	1987-88	Michigan State Univ.
Dr.K.H.Ramanjaneya	N	Processing- Left for private sector position after U.S. Training	4	1989-90	USDA, Hilo
Dr. D. Gowda	N	Processing	4	1989-90	U.of Florida
Mr. M.S. Madan	T	Ag.Economics/PHT Loss Assessment	4	1988-89	U.of Georgia
Mr. S.C. Mandhar	T	Ag.Engineering/Packaging/ Costing	4	1989	Michigan State Univ.

Others - 8 technical staff, lab attendant, clerk, typist

[1] Refer to 2A for explanation.

PERSONNEL/TRAINING Cont.

Table 2,C. Central Institute of Horticulture for Northern Plains (CIHNP), Lucknow.

Name	Source[1]	Speciality	U.S. Training Month	Year	Location
Dr.S.K. Kalra	E	Processing, Principle Investigator	4	1987	Purdue Univ.
Dr. B.P. Singh	N	PHT Physiology/Storage	4	1986	Univ. of California
Dr.S.E.S.A.Khader	N	Pre-PHT Physiology/Storage	4	1988	Oregon State Univ.
Dr. Om Prakash	T	Pathology	4	1987-88	Univ. of California, Riverside
Dr. D.K. Tandon	E	Processing/Waste Utilization	4	1987-88	Ohio State U.
Dr. N. Garg	N	Food Microbiology	4	1989-90	Cornell Univ.
Dr. M.D. Singh	N	Ag.Engineering/Packaging/ Costing	4	1989	Michigan State Univ.
Dr. Ajay Verma	T	Ag.Economics/Loss Assessment	4	1988-89	U. of Georgia

Others - 8 technical staff, lab assistant, clerk, typist, driver.

[1] Refer to 2A for explanation.

PERSONNEL/TRAINING Cont.

Table 2,D. National Research Center for Citrus (NRCC), Nagpur.

Name	Source[1]	Speciality	U.S. Training Month	Year	Location
Dr.S.A.Naqvi	N	Pathology, Principle Investigator	4	1989	Univ. of California, Riverside
Dr.M.S.Ladania	N	PHT Physiology/Storage	4	1988	Oregon State Univ
Mr. V.S. Rao	N	Processing	Unable to leave as scheduled for training.		

Others - 3 sanctioned professional positions are vacant (Physiology, Ag. Engineering and Ag. Economics); 6 technical staff, lab attendant and clerk positions have been filled.

[1] Refer to 2A for explanation.

Table 3

PHT - EQUIPMENT STATUS AS OF NOV. 20, 1990

IARI

EQUIPMENT	STATUS
X/Y RECORDER	DELIVERED TO INST.
CUVETTES	DELIVERED TO INST.
FRUIT FIRMNESS TESTER	DELIVERED TO INST.
CONST. TEMP BATH	DELIVERED TO INST.
CO2 ANALYZER	DELIVERED TO INST.
SYRINGES FOR GAS CHROM	DELIVERED TO INST.
ELECTRONIC BALANCE	DELIVERED TO INST.
FREEZE DRYER	DELIVERED TO INST.
CENTRIFUGE	DELIVERED TO INST.
THERMON/HYGROM	DELIVERED TO INST.
POUCH FILLER/SEALER	DELIVERED TO INST.
GAS BLENDING SYSTEM	DELIVERED TO INST.
REFRACTOMETER	DELIVERED TO INST.
ELECTRONIC THERMOMETER	DELIVERED TO INST.
STRIP CHART RECORDER	DELIVERED TO INST.
FLOURESCENT SPECTRO.	DELIVERED TO INST.
COLOR DIFFERENCE METER	DELIVERED TO INST.
AQUAMETER	DELIVERED TO INST.
VISCOMETER	DELIVERED TO INST.
DUAL BEAM SPECTROPHOTOM	DELIVERED TO INST.
TEXT.MEAS. DEVICE	WAREHOUSE - INDIA
TURBIDIMETER	WAREHOUSE - INDIA
DIGITAL VACUUM GAUGE	WAREHOUSE - INDIA
INSECT LIGHT TRAP	WAREHOUSE - INDIA
RODENT CONTROL DEVICE	WAREHOUSE - INDIA
ULTRAFILTRATION CELL	WAREHOUSE - INDIA
POWDER MILL	WAREHOUSE - INDIA
ANALYTICAL BALANCE	WAREHOUSE - INDIA
AGAR STERILIZER	WAREHOUSE - U.S.A.
CAN OPENER & PRSSR TSTER	WAREHOUSE - U.S.A.
TISSUE DISINTEGRATOR	WAREHOUSE - U.S.A.
COMPUTER	WAREHOUSE - U.S.A.
MICROWAVE OVEN & RAD TSTR	WAREHOUSE - U.S.A.
PHASE CONTR. MICROSCOPE	DELIVERY PENDING
REFRACTOMETER	DELIVERY PENDING
GAS CHROMATOGRAPH	DELIVERY PENDING
SHRINK WRAP MACHINE	DELIVERY PENDING
WATER BATH	DELIVERY PENDING
DIGITAL ANALYZER	DELIVERY PENDING
PHOTOGRAPHIC SYSTEM	DELIVERY PENDING

PHT - EQUIPMENT STATUS AS OF NOV. 20, 1990

11HR

EQUIPMENT	STATUS
XY RECORDER	DELIVERED TO INST.
CUVETTES	DELIVERED TO INST.
HPLC	DELIVERED TO INST.
FRUIT FIRMNESS TESTER	DELIVERED TO INST.
CO2 ANALYZER	DELIVERED TO INST.
SYRINGES FOR GAS CHROM	DELIVERED TO INST.
ELECTRONIC BALANCE	DELIVERED TO INST.
FREEZER DRYER	DELIVERED TO INST.
FREEZER	DELIVERED TO INST.
THERMOM/HYGROM.	DELIVERED TO INST.
POUCH FILLER/SEALER	DELIVERED TO INST.
GAS BLENDING SYSTEM	DELIVERED TO INST.
REFRACTOMETER	DELIVERED TO INST.
ELECTRONIC THERMOMETER	DELIVERED TO INST.
STRIP CHART RECORDER	DELIVERED TO INST.
COLOR DIFFERENCE METER	DELIVERED TO INST.
AQUAMETER	DELIVERED TO INST.
VISCOMETER	DELIVERED TO INST.
DUAL BEAM SPECTROPHOTOM	DELIVERED TO INST.
TEXT. MEAS. DEVICE	WAREHOUSE - INDIA
DIGITAL VACUUM GAUGE	WAREHOUSE - INDIA
CONST. TEMP BATH	WAREHOUSE - U.S.A.
TURBIDIMETER	WAREHOUSE - U.S.A.
AGAR STERLIZER	WAREHOUSE - U.S.A.
CAN OPENER & PRSSR TSTER	WAREHOUSE - U.S.A.
INSECT LIGHT TRAP	WAREHOUSE - U.S.A.
RODENT CONTROL DEVICE	WAREHOUSE - U.S.A.
ULTRAFILTRATION CELL	WAREHOUSE - U.S.A.
TISSUE DISINTEGRATOR	WAREHOUSE - U.S.A.
POWDER MILL	WAREHOUSE - U.S.A.
MICROWAVE OVEN & RAD TSTR	WAREHOUSE - U.S.A.
PHASE CONTR MICROSCOPE	DELIVERY PENDING
GAS CHROMATOGRAPH	DELIVERY PENDING
SHRINK WRAP MACHINE	DELIVERY PENDING
WATER BATH	DELIVERY PENDING
DIGITAL ANALYZER	DELIVERY PENDING
COMPUTER	DELIVERY PENDING
REFRACTOMETER	DELIVERY PENDING

PHT - EQUIPMENT STATUS AS OF NOV. 20, 1990

CIHNP

EQUIPMENT	STATUS
DUAL BEAM SPECTRO.	DELIVERED TO INST.
X/Y RECORDER	DELIVERED TO INST.
CUVETTES	DELIVERED TO INST.
HPLC	DELIVERED TO INST.
FRUIT FIRMNESS TESTER	DELIVERED TO INST.
CONST. TEMP BATH	DELIVERED TO INST.
SYRINGES FOR GAS CHROM.	DELIVERED TO INST.
ELECTRONIC BALANCE	DELIVERED TO INST.
THERMOM/HYGROM.	DELIVERED TO INST.
POUCH FILLER/SEALER	DELIVERED TO INST.
GAS BLENDING MACHINE	DELIVERED TO INST.
REFRACTOMETER	DELIVERED TO INST.
ELECTRONIC THERMOMETER	DELIVERED TO INST.
STRIP CHART RECORDER	DELIVERED TO INST.
COLOR DIFFERENCE METER	DELIVERED TO INST.
AQUAMETER	DELIVERED TO INST.
VISCOMETER	DELIVERED TO INST.
DUAL BEAM SPECTROPHOTOM	DELIVERED TO INST.
TURBIDIMETER	WAREHOUSE - INDIA
CAN OPENER & PRSSR TSTER	WAREHOUSE - INDIA
DIGITAL VACUUM GAUGE	WAREHOUSE - INDIA
INSECT LIGHT TRAP	WAREHOUSE - INDIA
RODENT CONTROL DEVICE	WAREHOUSE - INDIA
ULTRAFILTRATION CELL	WAREHOUSE - INDIA
POWDER MILL	WAREHOUSE - INDIA
AGAR STERLIZER	WAREHOUSE - U.S.A.
TISSUE DISINTEGRATOR	WAREHOUSE - U.S.A.
MICROWAVE OVEN & RAD TSTR	WAREHOUSE - U.S.A.
COMPUTER	WAREHOUSE - U.S.A.
GAS CHROMATOGRAPH	DELIVERY PENDING
SHRINK WRAP MACHINE	DELIVERY PENDING
WATER BATH	DELIVERY PENDING
DIGITAL ANALYZER	DELIVERY PENDING
PHOTOGRAPHIC SYSTEM	DELIVERY PENDING

PHT - EQUIPMENT STATUS AS OF NOV. 20, 1990

NRCC

EQUIPMENT	STATUS
FRUIT FIRMNESS TESTER	DELIVERED TO INST
CONST TEMP BATH	DELIVERED TO INST
CO2 ANALYZER	DELIVERED TO INST
SYRINGES FOR GAS CHROM.	DELIVERED TO INST
ELECTRONIC BALANCE	DELIVERED TO INST
THERMOM/HYGROM.	DELIVERED TO INST
POUCH FILLER/SEALER	DELIVERED TO INST
GAS BLENDING SYSTEM	DELIVERED TO INST
REFRACTOMETER	DELIVERED TO INST
SINGLE-BEAM SPECTROPHOTIMOMETER	- DO -
ELECTRONIC THERMOMETER	DELIVERED TO INST
STRIP CHART RECORDER	DELIVERED TO INST
COLOR DIFFERENCE METER	DELIVERED TO INST
TURBIDIMETER	WAREHOUSE - INDIA
CAN OPENER & PRSSR TSTER	WAREHOUSE - INDIA
DIGITAL VACUUM GAUGE	WAREHOUSE - INDIA
INSECT LIGHT TRAP	WAREHOUSE - INDIA
RODENT CONTROL DEVICE	WAREHOUSE - INDIA
ULTRAFILTRATION CELL	WAREHOUSE - INDIA
AGAR STERILIZER	WAREHOUSE - U.S.A
TISSUE DISINTEGRATOR	WAREHOUSE - U.S.A
COMPUTER	WAREHOUSE - U.S.A
GAS CHROMATOGRAPHY	DELIVERY PENDING
SHRINK WRAP MACHINE	DELIVERY PENDING
WATER BATH	DELIVERY PENDING
DIGITAL ANALYZER	DELIVERY PENDING
PHOTOGRAPHIC SYSTEM	DELIVERY PENDING

Table 4. U.S. Consultants in India for Postharvest Technology Subproject, 1985-90.

Name	Speciality	Month	Year
Dr.Lou Riesenburg	PHT Loss Assessment	0.75	1987
Dr. M. Menegay	PHT Loss Assessment	0.75	1987
Dr. Ron Buescher	PHT Physiology/Technical Adviser	2.0	1988
Dr. J. Eckert	PHT Pathology	1.25	1988
Dr. H. Chan	PHT Physiology/Processing	1.25	1988
Dr. D. Richardson	Storage/Handling/Physiology	1.0	1990
Dr.D.Splittsotesser	Food Microbiology	2.0	1990
Dr. J. Acree	Flavor Analysis/Sensory Evaluation	1.0	1990
	Total :	10.0	

TERMS OF REFERENCE

"Conduct a technical assessment on the Postharvest Technology of Fruits and Vegetables Subproject of the Agricultural Research Project/India."

Provide a description of the subproject as being implemented and to provide a qualitative assessment of the subproject including impact todate. The technical assessment should be conducted according to the outline entitled 'ARP Technical Assessment Subproject' which was provided.

CONDENSED VITAE

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Birthdate /Location

April 25, 1943 Washington, Indiana

Education

Ph.D. 1973 Purdue University,
Postharvest Horticulture/Physiology

M.S. 1967 Purdue University
Horticultural Crop Physiology

B.S. 1965 Purdue University
Horticulture / Marketing

A.S. 1963 Vincennes University
Agriculture

Employment

1973 - Present	University of Arkansas, Department of Food Sciences
1969 - 1973	Purdue University, Department of Horticulture
1967 - 1969	Purdue University, International Programs in Agriculture

Consultancies

Winrock International	1986 - Present
Vlasic Foods, Inc.	1987 - Present
Mt. Olive Pickle Co.	1990
Green Bay Food Co.	1990
Africare	1990
Holland Co.	1987 - 1989
H.J. Heinz	1984 - 1985
Campbells' Institute	1985
Postharvest Institute for Perishables	1982, 1984, 1985, 1990

Foreign Work Experience

Brazil	Honduras	Yemen Arab Republic
India	Haiti	England
Egypt	Mexico	