AN ASSESSMENT OF

POSTHARVEST PHYSIOLOGY RESEARCH TO REDUCE FOOD LOSSES IN FRESH MARKET HANDLING OF FRUITS AND VEGETABLES

Consultancy Report

To

Winrock International

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I. SUMMARY AND RECOMMENDATIONS

The principal charge to the consultant was to review postharvest physiological research as it related to the objective of reducing food losses, and to make recommendations aimed at strengthening these programs (see Appendix A). Another charge involved the assembly, calibration, and demonstration of new equipment purchased for these sub-projects.

To accomplish this, I have met with the administrators and researchers at the four centers and read the research reports for 1988 and 1989 prepared by these four centers (along with work done at other centers) which was presented at their annual workshops. Further, I set up and demonstrated operation of various instruments such as the Color Gard system for measuring color hue, chroma, and value, Ametech infra-red CO2 analyzers, gas blending equipment, Milton-Roy Spectronic 21 UV-VIS spectrophotometers, and gas chromatographs.

It can be concluded that the postharvest physiological research at each of the four centers (IIHR,CIHNP,NRCC, and IARI) is well on target with the objectives of reducing food losses, and that the scientists possess both the knowledge and training necessary to be able to accomplish those objectives. There is ample evidence of good cooperation between scientists in many studies. These team approaches are laudatory, and more joint efforts are strongly encouraged. Furthermore, I was impressed with the generally high level of motivation and the feeling that the researchers' efforts were going to have an impact on loss problems.

While there may have been some previous limitations on equipment, as the planned equipment arrives, most major equipment needs will be satisfied. A few items have been identified which are still needed, but most of these are not costly. An item that needs serious attention in a few cases, is the requirement for better conditions for the lab instrumentation (water supply, electricity supply and voltage control, and better dust-free environments).

A new research area yet within the PHT objectives involves in-transit temperature monitoring to determine how extremes affect quality and handling losses due to rots.

A. RECOMMENDATIONS:

1. Some type of written grades defining quality needs to be developed for each of the crops of focus by PHT groups.

These definitions or grades would describe a) maturity or ripeness stage, b) appearance in terms of color, shape, size, etc, and c) defects; such as rots, bruises, insect damage, misshapen. Further, tolerances for defects, maturity, etc, need to be developed to distinguish between mild, non-progressive factors lowering quality and the more serious, progressively worsening types of defects. These should parallel or match Codex Alimentarius, European Economic Cartel (EEC) Standards, or USDA Grade Standards for fresh fruits and vegetables such that any future plans for export will already have these standards in place. Mandarin oranges and Mangoes (two major varieties) should be the first to have grade standards defined.
The rationale here is that until there is a profit incentive to produce and protect high quality fruits in the handling and marketing chains, little effort will be expended by anyone in the chain to adopt new technologies, no matter how good they may be. Similarly, entrepreneurs who are attempting to market better quality fruits and vegetables constantly have to battle lower quality produce which drags down the price structure. Only when major disasters involving large quantities (such as truck loads) have been lost, or sellers forced to sell at well below expected market prices, do handlers perceive the need for better systems, and then only if they have in fact taken possession of the crop, rather than merely handling it. If possession is not taken, the costs of such loss are usually thrown back on the farmer, the person who can least afford the loss.

2. A true economic assessment must be done of the costs of utilizing refrigerated storage and transportation, relative to curbing the losses from higher than optimal temperature handling. This type of cost/benefit analysis is crucial to future research thrusts. It is hard to believe that refrigerated handling is not economically viable, although several comments have implied that it is not, without any data to support the claim.

3. More contacts should be made with fresh commodity producers and handlers so that efforts can be pin-pointed as to which handling steps in the chain are most amenable to change for loss reduction technologies coming out of research. Researchers at the centers must become thoroughly knowledgeable about the handling practices existent in the marketing system, and gain, in addition to the knowledge, some rapport with the handlers. Thus, when they have useful research findings, sufficient trust of them (research and extension) will facilitate technology transfer.
Television, radio programs, and newspaper articles informing about the losses, the research in progress to cut loss, and describing methods and alternatives to cut losses at all stages is needed, to reach farmers, handlers, and consumers alike.

4. Goals need to be set for loss reduction in each commodity, based first upon those points in the chain with the greatest losses, with added judgements regarding ease and costs of implementation. Now that several studies of losses in each link of the chain have been done, several alternatives must be researched to see which best solves the problem. These goals should include not only the percentage loss reduction, but also the time line planned to achieve that goal.

5. More research needs to be done to fine-tune the evaporative cool chamber technology, especially with scaled up versions. The ability to adapt these chambers to specific quantities of commodity needs further study. Stacking patterns inside the chamber, designs using thermosiphoning, and the number and location of cool air entry ports needs further study relative to how much air flow is needed for maximum efficiency.

6. Further studies on fibre laminated (cardboard) cartons are needed as eventual replacement for mango wood boxes. Quite likely, government policy will shift subsidies from mango boxes to cartons.

7. An attempt should be made to unify the produce handlers in some way (associations, cooperatives, etc) that would offer them the opportunity to learn how to cut losses, be pro-active in working with research and extension to set acceptable quality standards, and store produce particularly during the production glut, understand how this levels prices, and prolongs availability, and how export quality demands can be met. Similarly, processors should be unified, and their needs addressed.

II. PROGRAMS AT THE CENTERS

A. INDIAN INSTITUTE FOR HORTICULTURAL RESEARCH (Bangalore)

Scientists involved in the Post-Harvest Technology program include Dr. (Mrs.) Shantha Krishnamurthi and G.K. Rao, plant physiologists; B.A. Ullasa, plant pathologist; K.H. Ramanjaneya, processing specialist; S.C. Mandhar, agricultural engineer; S. Ethiraj and E.R. Suresh, microbiologists, and M.S. Madan, agricultural economist. The IIHR Director is Dr. S. Negi.

The PHT research at IIHR deals with mango, banana, guava, tomato and onion. Studies are appropriately being done on preharvest treatments with fungicides, sprout inhibitors, calcium to improve firmness, growth regulators (Gibberellic acids), optimum harvest maturity to protect against rapid ripening and reduce handling and fungal pathogen losses, evaluation of harvesting tools (eg, in mango), curing of onions, use of evaporative cool chambers (sometimes called "Zero-energy chambers") to reduce both moisture losses and respiratory heat and retard ripening without promoting fungal attack, use of precooling techniques, development of solar refrigerators, stages of maturity, evaluation of fungicides pre- and post-harvest to control pathogens, and the use of wax-like coatings and films to prolong storability, some evaluative work on packing box types is also being done.

Specific physiologic disorders include:

a) spongy breakdown in one or more varieties of mango,
b) blossom-end rot of tomato
c) anaerobic off-flavor development with certain wax treated bananas
d) cracking of guavas

RECOMMENDATION:

Studies should continue on fruit waxing experiments, trying a range of wax concentrations to optimize the effects for fruits grown in that region. The CO2 analyzer can give a fairly accurate estimate of gas exchange rates coupled with moisture loss rates. It does not, however, give any clues about what internal O2,CO2 concentrations may be.

Mango internal spongy breakdown studies should try to apply calcium sprays earlier in fruit development because of cuticular wax synthesis late in growth stages. Fruit location on the tree may well relate different stress exposures to the incidence and severity of the disorder. Fruit/shoot or fruit/leaf ratios may give some clues about crop load effects(if any).

Continue Ca sprays on guava to reduce cracking.

Postharvest hot water dip treatments to control latent rots should be evaluated with Dr. Ullasa for effects on fruit quality

and ripening of bananas and mangoes.

Tomato blossom-end rot is actually a localized calcium deficiency aggravated by heat stress and transpirational competition from vegetative growth. Because the tomato cuticle wax is so impermeable, about the only approach is to evaluate resistant breeding lines with Dr. Anand. There are genotypes with good BER resistance. Look for types which have a strong root system, canopy shading, and only moderate vegetative growth.

Work on onions is on target, getting adequate size and yield needs to balance off with obtaining curing conditions that lead to several dry outer scales, without splits, and tight necks.

Equipment Needed/Desired (see Appendix E.)

B. Central Institute of Horticulture for Northern Plains (Lucknow)

Scientists involved in the PHT program at CIHNP include Dr. S.K. Kalra, food biochemist; Dr. S.E.S.A. Khader, plant physiologist, Dr. B.P. Singh, storage physiologist, Dr. D.K. Tandon, waste utilization & processing; Mr. M.D. Singh, Agricultural engineer; Dr. N. Garg, microbiologist; Dr. A. Verma, agricultural economist; and Dr. O.P. Pandey, plant pathologist. CIHNP works predominantly on mango, potato, and to a lesser extent on guava. This center strives to be the dominant force in mango research.

The researchers are well-trained, and have a good level of motivation. The projects that are being carried out appear to be well targeted to the problems confronting the industry.

Mango postharvest loss assessments (Dr. A. Verma's studies) have clearly shown that ripening is the most important stage where losses (20%) occur.

Several hours were spent manipulating a modified Li-COR photosynthesis meter to be able to perform single fruit respiration measurements. We were successful in doing that. The Milton-Roy Model 1201 Spectrophotometer (UV-VIS) arrived with 115 volt wiring, so I was not able to actually run it, but I did go through most of the setup and usage procedures with Dr. Khader and his technician.

More time was spent in attempting to set up an older Varian 3700 GLC with dual column, dual detector for ethylene analysis so that Dr. Khader could analyze the mango ACC (1-amino-cyclopropane-1-carboxylic acid) and ethylene precursor, from samples taken from one of last year's studies. While the new columns were being conditioned, we started the recorder. Both the GLC and the recorder were in an extremely dusty location with no dust cover on the recorder. As the recorder was turned on, two flashes of sparks startled us. At least one component of the recorder, a

transistor or a capacitor had shorted out, yet the fuse was undamaged. Almost always this is indicative of shorting due either to loose wires or contacts, or due to dust or debris. In this case, the visible heavy accumulation of dust was the most likely culprit. I strongly recommended moving such sensitive equipment well out of the way of heavy foot traffic areas, preferably to a side room where dust can be controlled. Such a room exists adjacent to Dr. Khader's lab.

RECOMMENDATION:

While there is evidence of some good collaboration on projects, there are situations where better interactions would likely lead to improved understanding of the nature of the problems. Collaboration between the physiologists, pathologists, engineers, and economists is highly desirable. They might even consider a team meeting approach to constructively criticise each others research plans, and see how they can better work together.

Further research focussed on the physiology of ripening is critical to controlling losses.

Cooperative work on mango maturity stages, harvesting techniques, preharvest and postharvest pathogen control, packing, and grading of the mangos, and the economics of alternate handling practices as well as loss assessment in the chain, would all afford the scientists a better understanding of the overall process, and assist to better identify the most important areas to research.

Development of written grades for mango needs to be given high priority and should be done in cooperation with industry.

Maturity sorting of mangoes based on differences in specific gravity needs to be further evaluated. The variances caused by hollow portions of the seed may limit the usefulness of this method.

Although the use of calcium carbide as a source of acetylene to force ripening in mango is officially declared illegal by the GOI, nonetheless the practice is widespread. Two important studies need to be done for this problem. The first is that since about 250 times higher concentration of acetylene needs to be used compared to ethylene, it is critical that the acetylene treatment be made as efficient as possible so that amounts can be used well below the flammability/explosion hazard concentration. Secondly, the uneven ripening may simply be due to the escape of acetylene or be due to incomplete maturity of the mango itself. Usually ethylene in the range of 100 ppm is adequate, but there may also be a temperature interaction. Temperature optimum also needs to be established, and enclosed vs. somewhat open ripening containers need to be examined.

Studies on potato storage utilizing the "Zero energy" cool chamber merit expansion, with involvement of the Ag. Engineer to evaluate the effects of different air flow rates on pathogens, water loss, etc. Stacking patterns inside the chamber also need to be studied to determine the optimum configuration.

Hoes used to harvest potatoes result in 5% loss. Different implements, such as spading forks should be evaluated, as well as trying to educate the harvesters not to dig too close to the row. Hilling the row may also help to confine tuber location and facilitate harvest with less loss.

The 10% cool storage losses at 4 C can probably be reduced through various combinations of fungicides, attention to stacking patterns, and air circulation.

A physiologic disorder identified was hollow heart/black heart of potato. This is often high temperature stress associated, and may be lessened by decreasing nitrogen fertilizer, increasing calcium availability, and regulating irrigation more frequently.

Uneven ripening of mango was also identified. Mango seed weevil infestation may limit export potential. The CIHNP entomologists have isolated some fungal strains that kill mango mealy bug and mango seed weevil larvae. Internal softening near the stone may result from high fruit temperatures occurring on the tree.

While I normally elect not to mess with administrative protocol and procedures, I am going to make an exception in this case: When bright, responsible people have been hired and entrusted with academic honesty and the responsibility to do difficult research work that directly benefits society. There are enough frustrations with finicky equipment, difficult extractions, long hours at tedious tasks to challenge the most motivated among us at times. But when PhD (or MSc, for that matter) scientists have to repeatedly request approvals for very minor supply items and additionally go through multiple justifications for critically needed items, there is something drastically wrong with the management philosophy that perpetrates this time-wasting source of extreme frustration. Frankly, it makes my blood boil !!!

I am going to suggest an alternative that will reduce the frustration and time-wasted by at least 30%, take a substantial amount of hassle off the shoulders of the project leaders, and will increase motivation and morale by at least 50%, and I expect will increase productivity by more than 10%.

MAKE THE INDIVIDUAL SCIENTISTS ACCOUNTABLE FOR MANAGING 25% OF THEIR BUDGETS FOR REQUISITION PURPOSES, AND MAKE THIS AVAILABLE AT THE START OF THE YEAR WHEN BUDGETS ARE KNOWN.

Why should they have to even come to the leaders or directors for small items?? They can do this readily, everyone will be the happier for taking this or some similar action.

Equipment Needed/Desired (see Appendix E.)

C. National Research Center for Citrus (Nagpur)

The NRCC concentrates very heavily on citrus, particularly Mandarin orange and, to a lesser extent, limes. Two principal scientists, Dr. M.S. Ladaniya, plant physiologist; and Dr. S.A.M.H. Naqvi, plant pathologist, are performing the bulk of the PHT research. Dr. Kohli, horticulturist, also deals mostly with preharvest cultural and production studies, and complements the work of Drs.Ladaniya and Naqvi. Dr. Rao, Food Technologist, has also done some work on juices and squashes, and Dr. Ladaniya has been assigned to do processing research in Dr. Rao's absence.

Dr. Ladaniya has an active research program underway, despite the fact that several major items of equipment are yet to arrive. His work on fruit waxing, preharvest GA sprays, as well as more experiments on zero-energy storage techniques should be continued and refined. He and Dr. Naqvi make a logical team and seem well suited to collaborate with each other. Dr. Ladaniya's added responsibilities in the processing area will bring an interesting perspective (plant physiologist and biochemist). Factors which reduce bitter compound formation in juices will need research.

The survey of Mandarin orange losses was particularly well done by Dr. Naqvi and revealed that transit stacking of boxes while only causing 2.5% direct losses, in fact that loss is very concentrated in the sense that it is largely confined to about 30% of the rearmost boxes loaded on the trucks and each of these boxes may have 40% of the fruit damaged. Even more significantly, this likely contributes to 12% rots(sour-end, sour rot, Penicillium, and Aspergillus). As the wholesalers assess the entire truck based upon opening only 2 or 3 boxes, any rots that are apparent results in a lower price paid for that load. Preharvest and postharvest fungicide treatments are quite effective in cutting these losses.

Dr. Ladaniya and I visited the citrus collection and auction centers in Katol and a nearby village. I counted 19 handling steps from picking to secondary wholesale market. Resorting was one of the reasons for so many handlings. Since NRCC will very shortly be installing a sorting, washing, (waxing?) line, this research potentially can lead to cutting out up to half of all those handling steps, particularly if NRCC can successfully establish a system of grades.

Some of the preharvest GA sprays to delay ripening studies should be continued. This would allow late season fruits to be stored on the trees, and level off some of the market glut.

Clearly the inherent high internal quality of these Mandarin oranges offers high potential for export market development. But conformance with internationally recognized grade standards and 20 Kg carton packs will have to be adopted by the local industry before much expansion into the export arena can occur.

There were relatively few physiologic disorders identified, although waxing experiments clearly showed that if wax concentration blocks sufficient air exchange, anaerobic metabolism can occur. Very low temperature studies that might normally cause chilling injury, may be attempted with intermittent warming and/or waxing to reduce symptom development.

Considerable time was spent calibrating and demonstrating the Spectronic 21 UV-VIS, setting up, calibrating, the Ametek infra-red CO2 analyzer, and assembling the myriad pieces of the gas blending system for controlled atmosphere conditions. Frankly, I don't expect much from work on CA for citrus, but since the NRCC also does work on bananas, it may be useful there. We actually ran a small experiment to measure the respiration rate of waxed vs. non-waxed mandarin oranges. The waxing treatment reduced the respiration rate by almost 50%.

RECOMMENDATION:

NRCC should lead the effort to develop written standards for Mandarin oranges, and this will need to be done in cooperation with the industry leaders. There is enough close contact by the people who are dealing in oranges, that the added possibility of them forming some sort of an organized association or group needs to be encouraged. These standards need to approximate internationally recognized standards, such as that of the ECC. Convincing the industry leadership may be a bit tricky at the start.

Research on packing alternatives to mango wood boxes is worth expanding.

Color sorting for ripeness stage, besides adding to the steps toward international standardization, will be useful in terms of identifying internal quality, differential resistance to mechanical wounds, crushing, and moisture loss rates. Further, studies on how many layers of fruit are safe to pack in a box needs to be determined at each stage of ripeness.

Measurement of transit temperatures is highly desirable, both in terms of knowing what ranges of temperature are encountered by the fruits, but also in being able to simulate hot and cold transit temperatures. Quality changes, rots, damage, etc can then be associated with specific parameters. These studies may logically be done cooperatively with the ICAR-IARI colleagues in Delhi.

Equipment Needed/Desired (see Appendix E.)

D. Indian Agricultural Research Institute (New Delhi)

The IARI PHT group is led by Dr. Susanta K. Roy, and the two principal Postharvest Physiologists are Dr. R.K. Pal (fruits) and Dr. A.K. Chakrabarti (vegetables). Other team scientists include Dr. S.B. Maini, biochemist-waste utilization; Dr. D.S.Khurdiya and V. Ram, food processing; and Dr. V. Sethi, microbiologist.

This center deals with all of the fruits and vegetables identified as the seven priority crops for PHT activity. As such, what has been stated as problem areas applies here as well, insofar as the manifestations of the problems may be magnified upon arrival in Delhi.

Since the prototype zero-energy evaporative cool chamber was developed at IARI, this group has been most active in performing studies. Certainly for citrus, maintenance of high relative humidity and moderately low temperatures such as can be attained in evaporative coolers has shown very favorable results. Potatoes also benefit, as would any root crop such as carrots, beets, parsnips, and nearly all of the leafy vegetables.

This center has had active programs studying pre-cooling methods such as hydrocooling, ice bath, forced air, zero-energy, etc., applied to mangoes, bananas, and citrus.

CIPC potato sprout inhibitor studies have already shown loss reduction due to sprouting.

In Dr. Pal's lab, we set up and calibrated the Ametek infra-red CO2 analyzer which had just arrived. Tubing and respiration chambers had not yet arrived with the gas-blending CA system, so I was not able to demonstrate actual fruit respiration. I also set up the X-Y plotter attachment to the Milton-Roy spectrophotometer 1201, and demonstrated how to run a wavelength scan in the visible range such as one might for carotene, lycopene, or anthocyanins. We also spent several hours evaluating different arrangements for a new addition to the horticulture building that will house the new walk-in coolers, a ripening room, and two rooms for high temperature storage of processed fruit and vegetable products for accelerated aging and microbial growth. Other discussions centered on various analytical procedures, statistical methods for determining how many replicates/observations are needed for each type of measurement based upon preliminary variance data from trial experiments. (This was also discussed at Lucknow and Nagpur)

Because this week was also occupied with briefings with Dr. Chadha and Dr. Kaul, Dr. McClung and Mr. John Becker of USAID, as well as the writing of this report, there was not sufficient time to meet other cooperating scientists such as pathologists, agricultural engineers. I was pleased to meet Dr. Sharma, who is

a media specialist (among other responsibilities) and I believe he can be very important to help sensitize the public to PHT losses, help in adoption of PHT methods for cutting losses, and in general point out that this type of research is just as valuable as a new variety, higher yield, etc., because there is already a heavy investment in the crop at this stage and saving it here has a large economic multiplier.

RECOMMENDATION:

Studies should be continued by expanding the number and types of zero-energy chambers. Some consideration needs to be given to designing these chambers as research tools, ie., build them to vary air flow, locations of vents, thermosiphoning, volume of sand relative to bricks, shapes of the chamber, water flow rates, false bottoms; how well do they work in windy sites/conditions? high external relative humidity? Does it help to open the roof at night to take advantage of reradiational cooling? If fans are needed, can these be run off solar energy? What about small water pumps to provide water, can these be solar driven? If air flow is enough, can marginally compatible produce be stored together?

Researchers at IARI need to find out if anyone already is trying to export mango, citrus, or any other fresh fruit /veg. What problems are encountered? How will proposed grading standards be perceived by handlers in the Delhi markets?

Calculations of cost/benefit ratios to decide the economics of refrigerated storage may be most easily accomplished here in Delhi where a number of refrigerated cold storages already exist, and where some cost data may already be available from industry.

A survey needs to be made to list the major fresh market handlers(names, addresses, produce handled, etc). I counted 32 listings in the Delhi yellow pages that were not listed as dried fruit merchants. Do they have an association? Do they meet? Have them call you when they run into problems - get a feel for what they think are persistent problems. Later when you get some trust developed, offer to run demonstration trials in their storages. If they like your idea, they'll start demanding better care from their suppliers.

There will be good opportunities to do cooperative research with the other centers located at the source of supply. Studies monitoring transit temperatures, or scale-up research of treatments done outside of Delhi may involve IARI researchers taking the data as produce arrives in Delhi. Also, simulated long distance transit can be accomplished by returning produce to origin such that it experiences both legs of the journey.

IARI could provide analytical services for samples that the other centers might not be equipped to analyze. Some budget transfers may be necessary, but this can avoid costly duplication of equipment if it otherwise sits idle for most of the year.

Equipment Needed/Desired (see Appendix E.)

III. APPENDICES

A. Charge to Consultant: Terms of Reference for Dr. Richardson

1. Assess the progress made in post harvest physiology research in the case of mango, banana, citrus, guava, tomato, potato, and onion, and identify the gaps to be filled on a priority basis.

2. Identify postharvest physiological problems in these crops and advise on future thrusts.

3. Identify equipment essentially needed for the effective utilization of trained manpower to tackle efficiently the above identified problems.

4. Guide our scientists in operation & maintenance of the equipment being imported under this subproject for physiological studies.

5. Arrange to provide bibliography on PHT aspects of tropical & subtropical fruits & vegetables with special reference to those listed above.

6. Deliver lecture on recent advances in postharvest physiology of this group of horticultural crops.

7. Participate in group meeting/seminar to be organized for subproject cookers.

8. Prepare consultancy report and submit it at the end of the visit for follow up action.

B. ITINERARY FOR DR. D. G. RICHARDSON
Short term consultant on Post Harvest Technology Sub-Project

March 17 (SAT):	Arrive New Delhi @ 21:55 via AI 331 (stay at Hyatt Regency Hotel)
18 (SUN):	lunch with Dr. McClung (Winrock), Dr. Kaul (ICAR), and others related to this project.
	Delhi/Hyderabad , 17:50/19:50 via IC 568 (stay at Krishna Oberoi Hotel)
19 (MON):	Hyderabad/Bangalore 10:15/11:15 via IC 516 (stay at Taj Residency) 12:30 Visit to IIHR
19-24	Visit: IIHR-Bangalore
24 (SAT):	Bangalore/Madras 19:25/20:05 via IC 510 (stay at Trident Hotel)
25 (SUN):	Madras/Delhi 06:00/09:45 via IC 440
25 (SUN):	Delhi/Lucknow 19:20/20:10 via IC 435 (stay at Clark Avadh Hotel)
26-31	Visit: CIHNP-Lucknow
31 (SAT):	Lucknow/Delhi 12:20/13:30 via IC 410 (stay at Hyatt Regency)
April 01 (SUN):	Delhi/Nagpur 18:10/19:40 via IC 469 (stay at Radikha Hotel)
01-08	Visit: NRCC-Nagpur
08 (SUN):	Nagpur/Delhi 20:15/21:15 via IC 470
09 (MON):	08:15 Winrock, meet with Dr. McClung, et al
09-12	Visit: IARI-Delhi
11	14:30 Debriefing: Dr. Chadha, Dr. Kaul, Dr. McClung, Mr. Srinivasan, others
12	15:00 Debriefing: Mr. John Becker(USAID), Dr. McClung, others
13-14	Report finalization, other forms completion
April 15 (SUN):	00:50 Departure from Delhi.

C. POSTHARVEST FRUIT AND VEGETABLE HANDLING SYSTEMS VISITS

1. Tomato and onion harvesting of the research plots at IIHR was fairly typical of what was observed driving past commercial production. Observation of street venders afforded assessment of the fact that tomatoes are all pretty much harvested at the breaker stage of ripeness.

2. CIHNP experimental mango and guava orchards were visited, although the developing fruitlets were only about 1 cm. Size of trees are quite variable in commercial orchards with some approaching 20 m in height.

3. In the Nagpur area (NRCC), we had the best chance to see at Katol the extensive handling involved in marketing mandarin oranges. We were fortunate enough to find one of the very last orchards being harvested to see the actual picking stages. The bags, baskets, ladders, carts padded with rice or wheat straw to cushion the fruit, the condition of the roads to market, unloading, stacking on pole piles, and the bidding by buyers, the movement of the oranges to their packing tents, the mango wood boxes lined with paper and more straw, and finally the stacking into trucks for movement to some local or regional market were all very interesting. We counted 19 different handling steps up to the wholesale market step. In Nagpur we visited several fruit selling stalls in one of the produce sections of town. There were a lot of arguments between seller and buyers as to what constituted acceptable quality.

4. At IARI, Dr. Sharma took me on a quick tour of the citrus, mango, grape, and vegetable research plots. Observations of truck-loads of onions, potatoes in bags were common throughout Delhi. Unfortunately time was too short to visit the produce districts and see any refrigerated storages.

D. SEMINARS PRESENTED

24	March	at IIHR	"AN OVERVIEW OF FACTORS AFFECTING POSTHARVEST QUALITY"
30	March	at CIHNP	"PREHARVEST AND POSTHARVEST FACTORS AFFECTING QUALITY AND LOSSES IN FRESH FRUITS AND VEGETABLES"
06	April	at NRCC	"OVERVIEW OF POSTHARVEST QUALITY LOSS CONTROL AND SEAL-WRAP PACKAGING OF CITRUS"
11	April	at IARI	"POSTHARVEST HANDLING TECHNOLOGY- IMPORTANT PRINCIPLES AND PRACTICES"

E. EQUIPMENT NEEDED/ EQUIPMENT DESIRED

Each of the centers (IIHR, CIHNP, NRCC, IARI) should have:

(2) matched quartz or fused silica cuvettes for use with the UV-VIS spectrophotometers. Since so many will be purchased, you can buy many unmatched for the prices you would pay for matched cells and spend then match them when they arrive here. Actually, these can be ordered through Sigma Chemical catalogs.

(2) miniature temperature recorders suitable for transit temperature recording. Ryan Instruments, Redmond, Washington makes one called a "TempMentor" that can be adjusted to record different time intervals and can plot the memory micro-chip stored data either on their plotter or can be linked to a computer, and it comes with the software diskette. Price -- about US$600

(1) Hot-wire anemometer to measure air velocities. There are some very simple, relatively inexpensive units -about US$400.

(1 or 2) temperature and relative humidity recorders. Ryan Instruments, above has just developed a computer adaptable small recorder that does both. This could even be placed in transit vehicles, zero-energy chambers, etc. Price may be around US$800

(1) small plastic film-sealing hot-bar and a hot air blower to shrink wrap fruits, plus an assortment of films, such as Cryovac Corp D955 and D940 in several thicknesses.

Since I do not have the full equipment lists to compare what is already intended to come to each of the centers, the following recommendations apply only to the centers designated:

(IARI, NRCC, CIHNP*, *only if lab conditions are improved)
High Performance Liquid Chromatographs, equipped with variable UV-VIS detectors, columns and guard columns suitable for organic acid separation and for normal reverse-phase (C18) separations. I do not recommend refractive index detectors because of their extreme sensitivity to temperature and line voltage fluctuations. (sugars are best analyzed as alditol acetates by FID- GLC anyway)

Gas Liquid Chromatographs: I seem to recall that each center would receive one, equipped for O2, CO2, N2 by thermal conductivity detector, and Flame ionization detector for ethylene and other organics.

Since it is quite possible that I may have overlooked someone's wishes, I may need to make some revisions in the near future, and I reserve that privilege.