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POST-HARVEST TECHNOLOGY OF FRUITS & VEGETABLES SUBRPOJECT

CONSULTANCY ACTIVITIES REPORT

BY

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DEFINITION OF ABBREVIATIONS

AIFPA	All India Food Preserver's Association
CIHNP	Central Institute of Horticulture for Northern Plains
crore	10,000,000 ten million
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IIHR	Indian Institute of Horticulture Research
lakhs	100,000 one hundred thousand
NFPA	National Food Processor's Association, Washington D.C.
NRCC	National Research Center for Citrus
PHT	Post Harvest Technology Subproject
Rs	Rupee, equivalent to $0.055 US dollar
RTS	Ready to serve beverage, single strength, ready to drink
USAID	United States Agency for International Development
WIN	Winrock International

INTRODUCTION

I am very grateful for the opportunity to come to India and participate in the review of the PHT project. In the past month I have done some teaching, helped on "hands on demonstrations," discussed how best to attack certain research problems, listened a great deal and have given some recommendations. Some of my suggestions in this report may not be practical for adaption at this time. India has a proud heritage of more than 4,000 years. Please excuse the short sightedness from my perspective of but a few weeks.

Let me make 4 or 5 points before turning to the Methods of Accomplishment.

1. What can be done to make ICAR, the Institutes and Centers, and the individual scientists more financially autonomous? There are numerous problems and opportunities. Many of the problems could be at least partly solved with a little more money.

Possibilities: A) The Government of India taxes processed food items at a rate of 12% to 15% (Personal Communication Dept. of Revenue,1991) which produces a minimum of Rs.282 crores (GOI Budget figures 1989-90) (US$154 million) in excise tax revenue. Other taxes such as sales tax and surcharges will increase this amount substantially. A significant portion of this income could be reinvested in income producing assets to improve the food processing infrastructure. This would expand and stabilize the capital invested, as well as the wage and processed food tax bases! I feel it is wise financial management to "invest in income producing assets."

Imported items are taxed at a rate of 224 per cent. Despite this rate, there is a "thirst" for imported food processing technology. This "juxtaposition" has "held down" food processing development in India and produced some monumental failures. A new era of a greater dependence on Indian scientists to solve India's food processing problems is coming. It is further suggested that the

Administrative costs for such a project be kept under 10% along the lines suggested later in this report.

B) Develop a Competitive Grant Program which addresses "major" problems facing a whole segment of the food processing industry. Input from AIFPA and other food industry groups could be prioritized by ICAR. Partial funding by USAID would be possible for projects which would also benefit US food processors. Additional projects could be sponsored by "matching" Government and industrial funds. These projects would tend to be "pre-competitive" and more basic in nature.

It is my feeling that ICAR and the PHT project are essentially "top down" in leadership. The Director must take the "lead" in supporting and funding these suggestions. The researchers are looking to you for support and direction.

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2. What are the advantages of having industrial input into PHT and ICAR food processing projects?

Possibilities: The All India Food Preserver's Association (IAFPA) could be expanded and strengthened to provide industrial input on technical issues like food safety, food laws, labelling requirements and preparation of technical training workshops and materials -- to name a few.

The IAFPA's involvement would help "catalase" industrial support for projects, transfer of technical information via newsletters and Indian Food Packer.

This industrial support could be very beneficial for both industrial and research interests when the National Government is making food policy decisions. This group could provide the muscle to stand up against "narrow self-interest" groups in the political process.

Input from the National Food Processor's Association (NFPA) in Washington D.C. and similar groups in the EEC could be sought in setting up guidelines for an expanded IAFPA. In the NFPA the dues are pro-rated on the value of the cases of food packed. This help equalize dues for the large and small manufacturer.

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3. What can be done to make it easier and more profitable to operate a food business in India?

Possibilities: A) A feasibility study could be commissioned to determine the major contributors to the low profitability and propose alternatives. I once worked on a project to calculate the cost/benefit ratio for a "protection tax" for Florida citrus growers. The tax was designed to equalize advertising expenditures. What the tax did was exactly the opposite. The tax insured a competitive price advantage for those processors outside of Florida!

I feel that until such time as food processing gives a financially competitive return on investment, progress and growth will be stagnant.

B) Ask business men both large and small. What Government Regulations costs you the most time and money? Do you have alternatives to these current programs to be considered?

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4. How do consumers affect the pace and progress of the Indian food processing industry?

Possibilities: I have the feeling the consumer's interests are "under representated" in research policy and priority decisions. The backing of a strong, well organized consumer group could be a powerful ally.

TERMS OF REFERENCE (ASSIGNMENT)

Objectives of this assignment were provided by Dr.G.L.Kaul, ICAR, Dr.F.J. Williams, WIN, and Mr.J.A. Becker, USAID.

1. Assess the technological problems faced by the commercial processing of citrus, mango, banana, guava, tomato, potato, and onion.
2. Assess the progress made under the PHT project and identify the gaps which need to be filled on a priority basis.
3. Give special emphasis to citrus juice concentrate, preservation of citrus juices, including debittering, and packaging.
4. A major portion of the consultant's time will be spent on setting up, commissioning and discussing planned research activities utilizing the newly delivered analytical instruments.
5. Supply bibliography on processing of tropical and subtropical fruits and vegetables. Instruction on computerized retroactive searching and maintaining a computerized bibliography of research reprints will be helpful.
6. Deliver lectures on: Recent Advances in Fruit and Vegetable Juice Processing, Packaging Innovations, Appropriate Technology for Developing Countries and Innovations in Food Processing Equipment.
7. Identify those research developments from the PHT which are ready to transfer to the food industry.
8. Prepare a consultancy report and submit it at the end of the visit for follow up action.

I. METHODS OF ACCOMPLISHING (ASSIGNMENT)

Before leaving from the United States, I talked with businessmen from multinational companies who had experience in India, consultants who had worked in India and librarians who were familiar with computer searching. Reports from previous PHT consultants, postharvest technical materials, and background materials were also reviewed.

Appropriate technology equipment in the form of a Village Level Portable Pasteurizer system was requested by researchers in India. Several researchers at ICAR and IARI had previously seen this equipment demonstrated during their trip to the States. Arrangements to purchase the equipment, package and ship a Portable Pasteurizer were made. "Handouts" for easy translation in training on the Village Level Portable Pasteurizer have been prepared. (see Attachment A).

As per the Terms of Reference, retroactive computer searches were conducted on literature pertaining to the processing of citrus, mango, guava, onion and banana. Several days were spent reviewing this literature and five summary reports written. Additionally, reprints and abstracts on citrus and mango processing were photocopied for distribution to researchers in these areas. Computerized searches on potato, tomato and carrot were also preformed. A "special" search of current citrus processing literature was completed. About 2,000 references consisting of author, title, source and abstract were transferred to floppy disks.

It was wisely decided that a concentration of my time and effort should be made at the research for citrus (NRCC) in Nagpur and at the Research Institute (IARI) in Delhi. Researchers from IIHR in Bangalore and CIHNP in Lucknow travelled to these Centers for simultaneous training. Please see Appendix B for a schedule of the major activities.

II. QUESTIONS AND RECOMMENDATIONS

Several citations to published literature are included in this text. The full citations can be found in Appendix C. I have inserted several questions in this report that need answering. These questions are numbered in the margin. If time permits during the next PHT meeting in March, would you please discuss these questions and include your answers and suggestions as part of this report?

MAJOR PROBLEMS FACING THE FRUIT AND VEGETABLE INDUSTRY:

Many of the problems facing the major crops have been detailed in the Literature Summaries in Appendix D.

1. In my opinion the number 1 problem facing the food industry is a low level of communication. Communication of new information brings insight. Insight during each step of the process--from how to grow better cultivars to how to process these cultivars, will result in overall better food products. Without expanded communication among researchers and the food industry, neither party will know or understand the needs of the other.

Possible solutions: Individual industrial research advisory boards can be set up for each center. For example the NRCC could have a board of 12 members from the citrus processing and production industry. Individual researchers could present their findings and future research direction. This would open new avenues of communication with the industry. Informal discussions before and after the meetings need to be encouraged. This board, meeting in closed session, would offer their advice on these projects.

At the other end of the communication spectrum are International Food and Packaging Exhibitions like the one held in Delhi 18-23 January 1991. This event was sponsored by the Trade Fair Authority. Would it be profitable for ICAR to become involved in the planning of such events? A tremendous number of contacts with

the food industry and other sponsoring associations could be made. This could have a real positive public relations benefit.

Part of the communication problem is the aspect of keeping the food industry and researchers up to date with the latest development world wide. Mighty winds of change are sweeping the food industry in the US and EEC. Quality Assurance based on Hazard Analysis Critical Control Point (HACCP), Just In Time Manufacturing, Zero Inventory, Food Safety both microbial and chemical aspects, and consumer's Demand-Pull orientation have already arrived. It is imperative the food industry in India keep pace with this ever increasing rate of change. Are there plans in place to do this? Will researchers and teachers be kept "up to date" so they can transfer this information to their students and to the industry? What new methods need to be implemented?

The need for an increased level of communication is exemplified by the shortage of fundamental training for the food processing industry in quality control, plant sanitation, and microbiology for new persons entering the food processing industry. What can we do besides sit back and wait for Food Science graduates to find their place in the industry, move into responsible positions in management, and then make these much needed changes? This would probably take another generation without outside encouragement and pressure.

2. In an article titled "Of rot in food processing industry" Mr. Gambhir,1991, points out India's fruit and vegetable production of about 54 million tonnes also produces tremendous losses. With an estimated loss of 30% and a low estimated cost of Rs 2 per kg., this loss equals to Rs 32,400,000,000! I understand this is part of the motivation for the entire PHT project. Are there industrial groups which can be identified who will benefit from this enormous savings and may be willing to support this research?

3. Research and development activities need to be directed to utilize new technology and adapting these developments for India's sometimes smaller scale conditions. Operating parameters which were optimized for the US or Europe are different here in India. We are all aware of notable failures when the "quick" adoption of "Western" technologies took place. These failures may have wrongly placed blame and the feeling of some that India is a "bad place" to do business. We need to set about changing this.

Possible solutions: While attending the International Food Congress in Madrid, I met a scientific entrepreneur from Korea. He had a working solution for solving the multitude of problems faced by very small food processors. He first bought and meagrely equipped a 10 square meter laboratory. While this equipping was going on, he got to know the people and the problems of the family operated fish processing industry. Then he did his homework and outlined affordable proposals to do applied research and solve these problems. After several success, he hired another young bright scientist and set him up in another lab. It worked! Problems were solved, more labs built which branched into other sections of the food industry and the industry developed the kind of trust in these laboratories that comes only with time.

Can a similar program work in India? Seed money from banks or the Government could be used to tap India's burgeoning pool of under-employed, well trained scientists. Some of which are in rural areas. Bank loans and tax breaks could be phased in to help these new entrepreneurs get started developing food processing industry in rural areas. These would pave the way to a broader tax base and healthier future for all of India's consumers.

4. There are major raw material shortages for processing. According to Mr. Jasol, Chairman of Agricultural and Processed Food Products Export Authority, the 4,000 or so licensed food processors in India are only utilizing about 35% of their capacity because

they cannot get high quality raw material (Gambhir, 1991). Consistently high quality raw materials must be brought to the food plant. Processors can preserve the quality of the raw product not improve it! Fruit that has surface blemishes but does not have any rot will be suitable. "Rotten fruit makes rotten products."

Possible solutions: A) Opportunities and initiatives for growers to make a good living must be provided. Governmental programs to establish Grower's Cooperatives can following successful examples in grape growers and sugarcane. B) Excessive profits for middlemen from the "auction" type system must be eliminated. Elected government officials must be willing to "wean" themselves from the influence of the few wealthy middlemen in order to provide for a greater good for the masses of "small holders" and consumers in general. This attack on the middle man may be politically viable in today's climate of searching for a better life for all. C) Part of this problem lies in the lack of an adequate and prompt transportation system. I understand there were massive losses of citrus last season because diesel shortages prevented timely movement of the crop from Maharashtra to markets.

What about setting minimum Government support prices which is done for many crops in other countries? Mr. Srivastava, of Modern Food Industries, has proposed "contract growing" of suitable cultivars in a manner conducive to produce high quality raw material for processing, (Srivastava, 1990). This is widely practised in the US production of fruits and vegetables for processing. This way the processor has maximum control over his raw product.

Again back to the communication problem. A grower can beat mangoes off the tree with a stick and let them drop 3 meters to the ground. If he eats the fruit within one or two days there will be little spoilage. This same fruit is "a non starter" for processing or shipping.

One mango processor listed the unavailability of raw materials as "his only problem." This plant was forced to buy mangoes at all stages of maturity, store and sort them to insure they only processed mature fruit. I am aware of a multi-national company which desires to purchase 1,000 tons of mango pulp. However, it must be of an excellent quality and uniformly consistent. This contract worth several million Rupees goes unfulfilled.

Another possibility is the processing of indigenous fruits and vegetables into bulk containers. These bulk quantities could be economically transported and sold overseas. There is an increasing cry for fruits and vegetables containing biochemicals which can promote health (Roy, 1990).

In order to present the other side of the picture, there have been tremendous strides in fruit and vegetable research. Some of these are covered in the Research Technologies Ready to be Transferred to Industry section. Chadha and Ramphal, 1989, point out the current accomplishments of vegetable research, the need for available certified seed from improved cultivars and (once again) communication to the growers about improved cultural techniques.

5. It is "highly unlikely" that fruit juice based beverages will ever be able to economically compete with beverages containing no fruit juice. It may be the case here in India that the predominance of beverages without juice tend to set the price structure for juice containing beverages.

<u>Possible solutions:</u> Market segmentation is one way around this problem. If I were marketing a blended 100% juice beverage I would price and advertise it to an upper middle class market. A market that is already "health conscious", concerned about "excess sugar" in their diet and desirous of "all natural" juices. It would be an uphill battle but it can be done especially if outrightly encouraged by the Government. This happened in Australia. A tax

break was given to juice processors based on the juice content of their finished beverage.

Any one can figure out it is going to be cheaper to make a beverage with sugar, acid and flavouring rather that use real juice. This proposed tax incentive would "level the playing field" and make it economical for juice containing beverages to compete with "belly wash." If you are supportive of this proposal, how can it be promoted into law?

6. It has long been known that the best post harvest preservation of most fruits and vegetables is proportional to minimizing their physical damage, removing the field heat and storing at a cool temperature. There appears to be a lack of refrigerated cool transportation and storage available in India. I have been told that the refrigerated storage which does exist is used > 90% for potatoes and the rest of the time for apples. At least part of the answer to this problem lies in the development of zero energy input "cool chambers" under development at IARI and NRCC. See the section on Technology Ready for Transfer to the Industry.

III. TRAINING ON VILLAGE LEVEL PORTABLE TUBULAR PASTEURIZER

Before I begin a short discussion of the results of this system, there are a group of people I want to thank. First, the researchers here in India for their open acceptance of this new technology. Secondly, I am thankful for the monumental effort on the part of Mr. Srinivasan and the capable staff at Winrock. They wrenched the pasteurizer from the Custom's officer's grip, hand carried it 1600 km to Nagpur, then arranged and coordinated a demonstration for US-AID officials. Their assistance is deeply appreciated.

Hands on demonstrations were conducted for processing researchers at NRCC, IARI, IIHR and CIHNP. We processed fresh and reconstituted citrus juices as well as sugar cane juice. This system will have to be adapted to Indian conditions and fruit. A novel idea of rapidly pasteurizing sugarcane juice acidified with lime juice produced a good testing product on the first attempt. Technical problems during each run were overcome with the capable input of each of these researchers. Indepth discussions followed on how to best utilize this technology here in India. About a dozen other persons have seen this technology and have expressed a keen interest in pursuing their own applications.

For my part I have "put this technology in your hands, it is up to you how you use it." During the course of this training I received many helpful suggestions for further development of this technology.

Possible future steps: A) A food machinery manufacturer has been contacted to make 5 or 6 of the pasteurizing coils at a cost of only Rs.1,000 per coil. The rest of the equipment is readily available from Indian manufactures. Researchers at each of the 4 Centers and other interested parties have expressed a desire to purchase these coils. B) Plans need to be made to determine how

can ICAR get maximum "milage" in bringing this and similar technology to the people. What are your ideas? C) One possible avenue is to utilize the existing Extension network to train persons who would operate the equipment in the village. Persons in the village would gather the fruit, bottles and fuel. The pasteurizer would be brought into the village by someone with a limited knowledge of food processing. Will you please keep me updated periodically on the progress of this technology? I am glad to have additional input on this project.

It is estimated that 30 persons could make 1000 to 1500 bottles of a finished beverage in a day. The glass bottles and caps are recycled so container costs are minimal. If these beverages were consumed "at home" they would improve the nutrition of the people. If they were sold for 4 to 10 Rs, the villagers could realize additional income. The person who operates the pasteurizer could be paid in bottled product, thus helping insure a high quality product and a minimal expense to the people in the village.

In addition to the pasteurizing unit, we discussed other appropriate technology equipment which we have developed which might be useful here in India. Two of these were a bicycle powered pump which can be used to pump liquid food products or other liquids. It mounts in place of the back tyre on a bicycle. The pump is a sanitary design in that it does not contact the liquid being pumped. A bicycle powered reamer has also been designed. It will extract 6 to 8 kg of citrus fruit a minute and enables 4 persons to extract as much fruit as 24 people using hand powered reamers.

In my opinion, there are several advantages in developing appropriate technologies for India. As pointed out in the 1989-1990 Ministry of Agricultural Annual Report, this technology meets several of their expressed goals. It can assist in providing increased employment in agro processing industries for rural

communities. This can be especially important to include women in food processing and entrepreneurial activities. This rural economic development should help decrease urban migration. I am excited by the enthusiastic reception of this technology and will look forward to following its progress.

IV. COMPUTERIZED LITERATURE SEARCHING

Everyone knows the "cheapest and easiest" research is done in the library. In my experience, library research before starting a new project is rarely done by students or established researchers. Only after the research is completed and the journal article is well underway, do "most" researchers bother to see if someone else has worked on this particular aspect of the problem. Why don't
11) researchers use libraries more? I believe part of the reason is that it is too much trouble. Only when literature is available "at your finger tips" will it be utilized to a maximum extent.

With the wise procurement of Zenith 286 computers for each of the centers in the PHT project, researchers will have the power to create their own research data base. I have brought diskettes with pertinent references for each of the major processed crops here in India. I would strongly recommend each researcher on this PHT project become familiar with the operation of these computers and establish their own reference data base. These computers should be reserved for PHT Research first and not "usurped" for administrative word processing or accounting.

IARI has "one of the best libraries in Asia" according to Mr. Chhotey Lal, Head Librarian. They are just getting the facilities for CD Rom interactive searches, Agricola and Silver Platter. Each of the PHT researchers needs to become personally familiar with
12) these powerful research techniques. What do you think about holding a "hands on workshop" in conjunction with a PHT or other meeting in Delhi to be sure this is accomplished?

In Appendix D there are short 3 page summaries of five of the major crops. These summaries make reference to economic aspects, processing, postharvest and by-product utilization of these individual crops. Suggested possible research topics have also been included. Some references to current literature on cultural

practices for these crops is also included but the search routines concentrated on processing aspects especially juice per my assignment. There are about 2,000 references which are included on floppy diskettes. I hope this information will serve as a spark to get computer data bases going. Software like Question and Answer will be helpful in doing rapid retrieval of authors or topics.

Along the same line, Dr. Buescher in his 1988 consultancy report recommended PHT scientists review Current Contents and administrators at CIHNP and NRCC subscribe to this abstracting
13) service. Has this been done? If not, let me re-emphasize you are "wasting" a precious resource. I would further suggest that ICAR explore funding of each scientists for one subscription to a professional journal as a part of ICAR's professional staff development. I know foreign journals are terribly expensive, but these journals routed among the researchers at a center will pay enormous dividends.

V. RESEARCH TECHNOLOGIES READY TO TRANSFER TO INDUSTRY

Before I give my opinion about the technologies which I feel are ready to be released, let me make a couple of points. First, in my experience getting commercial interest in a project takes a long time. I sometimes start with my industrial contacts before I begin the initial research. This way the commercial person feels he/she has maximum input and their hand is outstretched to receive the results of the research project. Secondly, within the limitation of this trip, it was only possible to focus with about 25% of 34 researchers on this PHT project. My recommendations reflect the people I met with. Other technologies may be ready for release. In any event the bottom line is DO NOT WAIT TO BEGIN CONTACTS WITH YOUR INDUSTRIAL COUNTERPARTS. Be creative in how you approach these people and try to see things from their perspective.

The leadership in ICAR must indorse an opening of contacts with industry. I believe this needs to begin with the Directors of ICAR meeting with the leaders of food processing companies. This must be done on an individual person-to-person basis. I know this will require time from an already busy schedule. Once an atmosphere of openness and trust is established, then the researchers can produce a "beautiful harvest" of industrially appropriate research.

One last point. I strongly feel researchers need to be rewarded for their efforts in this area. Dynamic leadership and a tangible reward will produce the results you want!

In my few weeks work four or five technologies surface as being ready to test in the "practical" arena. To me it is a conformation of your research when someone is willing to invest money to try it. It is the final conformation when someone can make money using your research. When that happens they will come back to you for more ideas. The technologies which I feel are ready for industrial trails are 1) the Zero Energy Cool Chambers, 2) carbonated,

cloudy citrus juice based beverages, 3) low cost preservation systems, 4) a dried fruit bar and 5) improved hand powered mango harvester.

1. Right now, I would suggest working with owners and users of refrigerated cool storage warehouses to run "split plot" samples of produce from their refrigerated storage in the cool chambers at IARI. See Research Bulletin No.43, Michael, 1985 for additional details. At predetermined intervals the samples from each store will be brought together for comparison. It is vital to have as many "evaluators" from industry as is reasonable. This will help stem charges that ICAR is helping just one user. The news media can be contacted to cover the developments. Similarly, split samples of citrus can be evaluated at Nagpur. Mr. Suddam Hussain gave this project a "national spotlight" in view of its goal in saving energy. The enormous energy savings of converting even a small percentage of India's refrigerated warehoused to passive cool stores needs to be calculated and given to the news media. Good luck!

2. The second project in carbonated beverages will take some additional effort to find an opening into the industry. One possible avenue is to have a highly respected beverage manufacturer serve on the committee of a student working in this area. Student projects tend to pull everyone together in a "support team" to insure the student's success. Another possibility is to determine an existing problem in the beverage industry, like the ones we have discussed. Hold a workshop/ information exchange and either report on the progress of the citrus beverage at the meeting or serve samples to participants. In my opinion both of the beverage projects at IARI and NRCC could benefit from industrial input. Don't be "put off" by their suggestions if they happen to be negative. Evaluate their suggestions, use what you can and throw the rest away. (Please see Khurdiya, 1988, for additional information.)

3. The third "ready" project involves the development of technologies to preserve fruits and vegetables for less than Rs.1/kg. Simple, cheap, steeping solutions; heat and preservative combinations as well as fermentation technologies are ready for transfer to the general public and industrial trials. I believe consumers in India can benefit from using these technologies to preserve, for example, tomatoes when they are Rs.2/kg. and use these tomatoes when the price is Rs.20/kg. The researcher in this area has already put on village level demonstrations, T.V. and radio talk shows. I feel simple, non-technical "recipes" could be written in English and local languages. Encouragement of this project is a must. (See Sethi, 1990 for additional information.)

4. India grows more than half of the world's mangoes. There are ample opportunities to produce nutritious, good tasting mango products. One of these products is the mango bar developed at Bangalore. There has been some commercial interest expressed. I feel formal consumer evaluations need to be made and an industrial manufacturer sought.

5. Researchers at Lucknow have developed a mango harvester which cuts the mango's stem and guides the mango to the ground. I would hope a couple of dozen of these harvesters would be made and sold at a subsidized price to growers. Periodic checks would reveal how well they were received. A manufacturer should be contacted to determine his interest and an estimated price.

VI. GAPS IN THE PRESENT RESEARCH PROGRAM

It is my opinion that the researchers in the PHT project are all pretty much on target. There is a dire need to add additional staff at NRCC in the processing area. Additional persons with a) food processing background b) analytical or organic chemistry and c) microbiology are sorely needed. The person who is covering all of these bases is trained and interested in the postharvest area. He is spread too thin to adequately cover what he has been assigned. Release of some administrative details would also help.

Infact, my number 1 suggestion for each of the researchers I interacted with would be to a) make a list of your strengths, weaknesses, interests and dislikes b) make a list of your current and planned research activities c) compare your strengths list to your research plans d) now cut out 25 to 33% of those things you are doing or plan on doing for which you have less interest or abilities. Remember the saying, " Today I shall concentrate on what I do best."

Because I spent most of my time talking to researchers working on citrus and have the greatest expertise in this area, let me first speak to the technology gaps facing citrus. Most of these gaps are common to the seven major crops.

A) First there is a technology gap in Indian fruit and vegetables based on raw materials. Because the <u>vast</u> majority of fruit and vegetables are consumed fresh, the PHT project has correctly place their initial emphasis on reducing post-harvest losses. Progress is well underway. There may be some gaps in the area of post-harvest diseases and physiological disorders. I am sure you realize post-harvest "preservation" normally is limited to increasing the shelf life a few weeks in most cases.

B) There is a gap in the emphasis on mandarin fruit. Mandarin fruits are easy to peel and have a mild orange flavour. However, both of the world's major citrus processors rely on sweet oranges. In Florida it is the Valencia and in Brazil it's Para. The "easy peeling" mandarin type oranges are used in Florida to blend with sweet orange concentrate and add colour. There is a maximum limit of 10% mandarin juice that can be used in this way and mandarin fruits usually sell at a processing plant well below Valencias. To my knowledge there is no international marketing of concentrated mandarin juice. It would be difficult for India to begin with an unsuitable citrus variety (mandarin) and compete effectively with the mammoth, highly automated international citrus concentrate industry.

India's production is estimated to be more than 60% of the mandarin types. Japan with a similar situation of mostly mandarin for processing, uses up to 35% mandarin juice in a beverage to blend with imported sweet orange concentrate. This could be done in India to make a RTS juice based beverages. The Japanese also make a whole citrus juice vesicle RTS beverage. I have discussed the outline of this process with these researchers.

C) There seems to be a general agreement among researchers working on citrus that the major problems are 1. Bitterness of the mandarin juice 2. Loss of cloud and 3. Browning. As was pointed out by Khurdiya, 1986, a lot of the processed fruits are consumed as beverages. This may be due to the facts that citrus beverages can avoid the bitterness from mandarin juice by diluting it with water and sugar and the lack of adequate fruit supplies as already pointed out.

C.1) In research planning meetings, we have discussed the chemical compounds responsible for the development of bitterness in processed mandarin juice. The factors which increase bitterness such as processing immature fruit, using excessive extraction and

finisher pressures, including high levels of insoluble solids (pulp) in the juice and incorporating seed or peel materials into the juice.

Research projects aimed at minimizing the bitterness problem are well under way. There is a need for better communication between IARI and NRCC on this project. Would it be possible for the researchers from IARI to spend one or two days in Nagpur comparing specific goals and techniques in this processing area?

C.2) In my experience with cloud loss in beverages the best solution is to put only particles in the beverage which will probably remain in suspension. We have discussed this at length with the interested researchers. Basically a cloud particle must be small enough (0.5 to 1 micron) and have a specific gravity close to the finished beverage, about 1.04. There are several techniques to increase the proportion of cloud particles which fall into these parameters and work is well underway.

C.3) There is ample research to show that the degree of non-enzymatic browning which takes place in beverages is largely temperature dependent, Crandall and Graumlich, 1982. Therefore, Zero Energy Cool Chambers like those discussed below could be used to reduce the browning in India's citrus beverages. The metal crowns would need to be waxed to prevent rusting. Another way to reduce browning is to use less citrus juice. A lower proportion of citrus juice will usually brown less than a beverage with a high percentage of juice.

We have the technology to make between 300 to 400 products from citrus. About a dozen of these can be made profitably. When this current phase of PHT research is completed and the results published in referred and popular press articles, there are several by-products which can be looked at. Please, don't start on something new without getting "closure" on what you are doing now.

Three possible new areas are the citrus oil and flavouring compounds, secondly the carbohydrates like pectin and thirdly the natural clouding agents. From information I received at NRCC, India imports about 600 tons of pectin. Pectin could sell from Rs.200 to 350/kg. Can you see someone interested investing money in an import replacement item like pectin? A limited amount of research funds needs to be sanctioned to equip researchers with specialized instruments to work on this valuable citrus by-product.

VII. MISCELLANEOUS COMMENTS

In this Section I would like to give my impressions and suggestions about what I have seen. The USAID support is vital to several of these programs and institutions. It will be important to seek ways to maintain this funding until alternative sources of funding can be established. Start now seeking additional, new sources of funds.

There is almost Rs.10 crore worth of equipment in all of these USAID projects. It would be a travesty for this equipment to sit idle for lack of repairs or maintenance. A repair section should be set up within ICAR so that a qualified engineer could visit each of these 4 centers at least every 2 months. Sooner if required. A budget needs to be set aside to order repair parts.

I feel Post Harvest Technology needs to be gives a higher national priority. The enormous amount of good they can do in reducing waste is reason enough. Other wages would be to quickly complete the new building at IARI. Considerations should be given to making the multidisciplinary group at IARI a separate Division in status. It is really a separate part outside of Horticulture. At NRCC only two of 14 priorities have anything to do with postharvest research. I feel more emphasis and manpower needs to be placed on PHT.

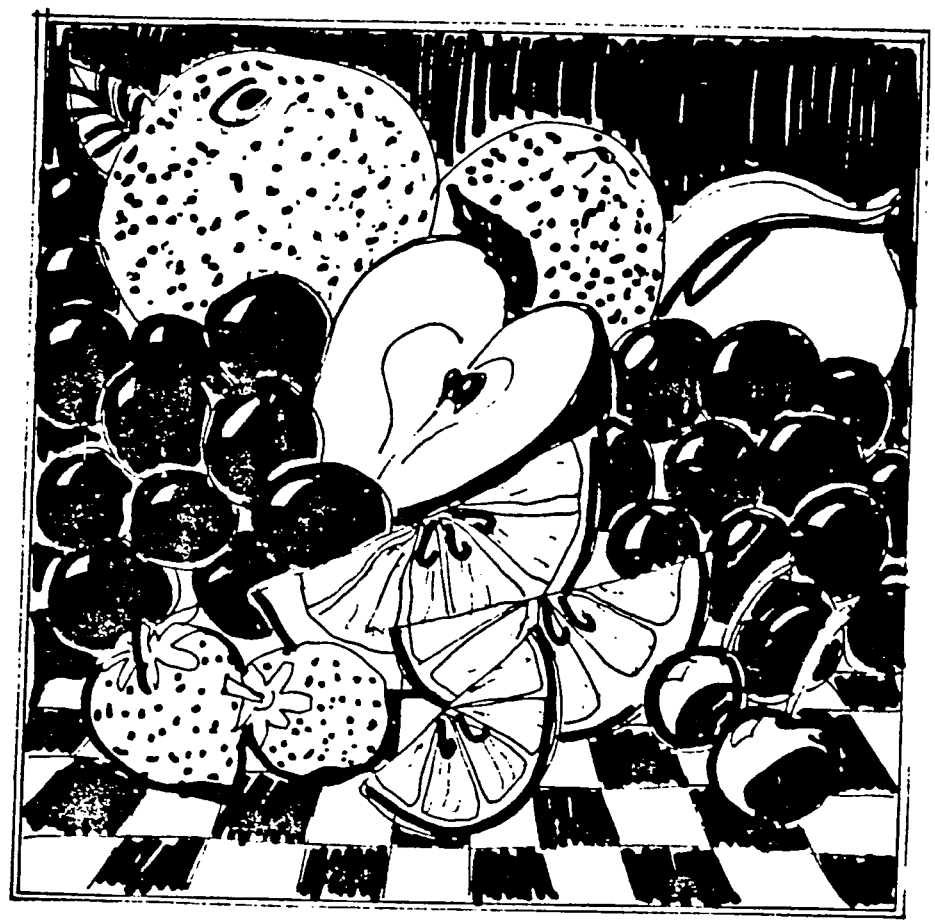
PHT Scientists within ICAR could benefit from additional training at the Central Food Research Center at Mysore. Additional ways for ICAR and Mysore Scientists to interact like joint projects need to be undertaken. I would like to see ICAR Scientists enjoy the same privileges on 1) communicating directly with industry, 2) consulting with industry and 3) sharing in patents that Scientists at the Central Food Laboratory enjoy.

It is my feeling that an Indian Scientist, Dr. D.S. Khurdiya, is capable of a further assessment of the ever changing technological

problems facing the fruit and vegetable processing industry. He needs expanded industrial contacts but has the technical background and has already published in this area, Khurdiya, 1986.

APPENDIX A. TRAINING LITERATURE FOR THE PORTABLE PASTEURIZER

PORTABLE TUBULAR PASTEURIZING & BOTTLING SYSTEM



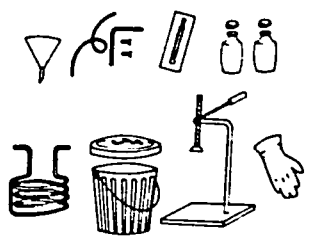
PORTABLE TUBULAR PASTEURIZING & BOTTLING SYSTEM

Introduction:
This tubular pasteurization and bottling system is designed to be simple and inexpensive for people who have small scale fruit production and wish to process these products. This system is portable, easily set up and operates in remote villages. Products which were previously lost during storage and transporting can be saved. Properly processed orange and apple juices can be stored at least 6 months at cool place.

CAUTIONS

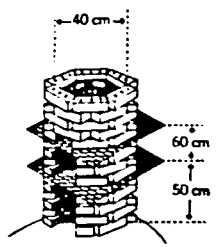
- Only use this system for acid fruit (pH less than 4.5) like oranges, limes, lemons, grapefruit, pomelos, passion fruit, apples, strawberries, cherries, pineapples, grapes, guavas, nectarines, papayas, peaches, raspberries, blueberries, pomegranates, plums, etc.
- Use clean water.
- Bottles and caps should be washed inside and soaked in boiled water.

1



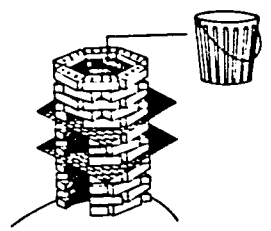
Supplies for processing and bottling juice: funnel, plastic tubes & clamps, thermometer, washed bottles (empty beer or coke bottles gotten in local place), washed caps, stainless steel coil, water can, capping machine and gloves.

2



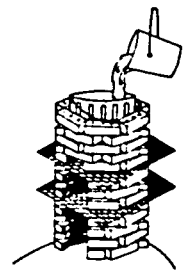
Fireplace made of local materials such as: bricks with iron grating on bottom to hold logs and on top to hold can.

3



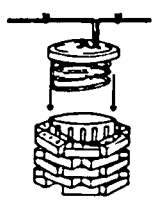
Set can in fireplace with bricks stacked ¾ way up the side and 3.5 cm from can.

4



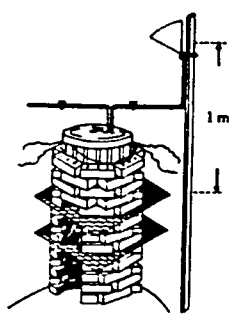
Fill can with water.

5



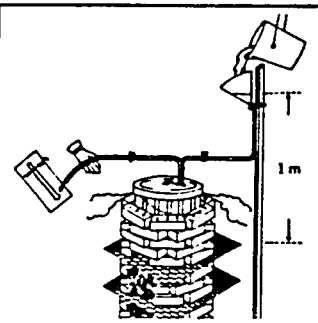
Push both ends of coil through hole in lid. Connect one piece of stainless steel tubing to each end of coil. Use clamps to connect plastic tubing to coil. Blue to blue and red to red. Put coil in can of water — the lid covers the can.

6



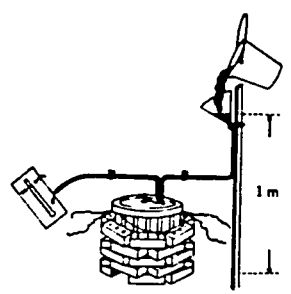
Attach funnel to the plastic tubing blue on end of coil that goes to bottom of can. Set funnel beside fireplace. The height from the bottom of the coil to red mark on funnel is 1 meter. Light fire. Boil water.

7



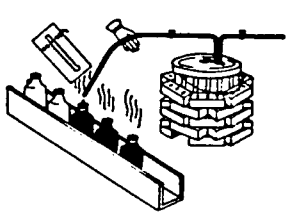
Continuously pour fresh water into funnel up to red line while holding the other plastic tubing outlet toward the ground. After 3 minutes check water temperature from coil to be sure it is over 90° C. As long as coil is hot it needs juice or water flowing through it to prevent burn on.

8



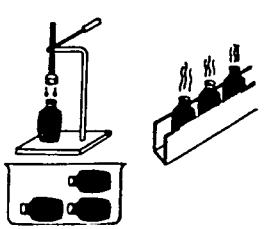
Pour juice into funnel before the last of the water is gone to keep air bubbles out.

9



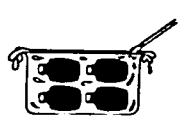
Washed bottles are warmed with hot water previously heated in coil to prevent breaking upon filling. Pour juice, at least 90° C into washed bottles. Every few minutes check juice temperature to be sure it is over 90° C. Keep fire hot enough so water in can is boiling. Add water to can as needed to keep coil covered. (To make outlet juice temperature higher: slow juice flow rate by lowering the height of the funnel or filling the bottles higher off the ground.)

10



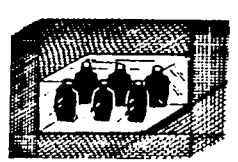
Quickly cap bottles with a hand capping machine and immediately lay capped bottles flat in pan to sterilize the cap for 5 min.

11



Cool bottles with cold running water for 20 minutes or until they are just warm to the touch.

12



Store bottles in a dark and cool place. Clean coil, after all of the juice has been heated by running clean water through it for 10 min. (The coil may be boiled with water in it to remove burned on juice. Sanitizing agents like bleach or soap may be used and must be rinsed from the stainless steel coil.)

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APPENDIX B. MAJOR CONSULTING ACTIVITIES

Wed.16 Jan.1991	Arrived in Delhi (0010 hrs). Orientation at Winrock International. Met Deputy Director General, Assistant Director General and staff at ICAR, Director and Science Adviser, USAID. Left for Nagpur by train (2100 hrs.)
Thur.17 Jan.1991	Arrived in Nagpur
Fri. 18 Jan.1991) Sat. 19 Jan.1991)	Met with Director of NRCC and Postharvest Researchers from NRCC and began setting up analytical equipment (see list below).
Mon. 21 Jan.1991) Thur.24 Jan.1991)	Installed and tested analytical equipment; hands on demonstration of Village Level Pasteurizer; delivered lectures and research seminars; held research goal discussions and visited NOGA Foods; worked on Report.
Fri. 25 Jan.1991	Returned to Delhi
Sat. 26 Jan.1991) Sun. 27 Jan.1991)	Worked on Report Visit to Agra

Mon. 28 Jan.1991)	Met with PHT Project Director;
Tue. 29 Jan.1991)	held in-depth discussion with researchers;
Wed. 30 Jan.1991)	installed and tested analytical instruments;
Thur.31 Jan.1991)	hands on demonstration of Village Level Pasteurizer;
Fri. 01 Feb.1991)	delivered lectures.
Sat. 02 Feb.1991)	Worked at Winrock International -
Sun. 03 Feb.1991)	rough typing of Report
Mon. 04 Feb.1991)	Installed and commissioned analytical
Tue. 05 Feb.1991)	equipment;
	discussions with researchers and toured cool chambers.
	Discussed research priorities and gaps in present program.
Wed. 06 Feb.1991)	Finished writing reports;
Thur.07 Feb.1991)	Met with Winrock International staff and ICAR staff
Fri. 08 Feb.1991)	Leave for home.
	Leaving more than a dozen new friends in India.
	I'd like to come back!

ANALYTICAL EQUIPMENT

Some of this equipment was unpacked, most of it needed assembly. After assembling and reviewing operating procedures, we conducted preliminary experiments to assure the researcher was familiar with the operation, precautions and potential. Possible research opportunities were demonstrated. Below is a list of the equipment with which I had "hands on" experience.

2 Nephelometric Turbidimeters.
Digital Viscometer with circulating Water Bath and separate refrigeration unit.

2 High Pressure Ultrafiltration Cells.
CO_2 bottling and capping machine.
Digital Refractometer.
Vacuum Packaging machine.
Powder Grinding Mill.
Refrigerated Water Bath.

2 Can Openers
Insect Trap
Sonic Rodent Repeller

APPENDIX C. REFERENCES FOR THIS REPORT

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KHURDIYA, D.S. 1989. Factors affecting the quality of lime juice based carbonated drink. India Food Packer 43(4): 17-20.

MICHAEL, A.M. 1985. Zero Energy Cool Chamber. Indian Agricultural Research Institute. Research Bulletin No.43.

ROY, S.K. 1990. Proc. National Seminars on Production, Processing, Marketing and Export of Untapped Indigenous Fruits and Vegetables.

SETHI, V. 1990. Evaluation of different vegetables for lactic fermentation. Indian Journal of Agricultural Sciences 60(9) 638-40.

SRIVASTAVA, J.S. 1990. Scope for marketing indigenous fruit based beverages in India. In Proceedings of National Seminars on Indigenous Fruits and Vegetables.

APPENDIX D. SUMMARY OF THE CURRENT LITERATURE

CITRUS PROCESSING

More than 25,000 citrus references were examined to find those references which pertained to processing, juice quality, waste treatment or the economics of citrus. I have left several citations to cultural practices which affect juice quality and citations and abstracts for these references are contained on a diskette. The advantage of having the references "soft" is that the data base can be repeatedly searched with many types of search strategy. I have gone through 55 pages of references and picked out several papers which seemed pertinent. I have just listed the first author and the date with some of my ideas on how to use the information.

Fallahi, 1989, found the fruit weight and juice content was higher in the internal canopy vs. the external portion of citrus trees. This is an extension of the work of Reitz and Seits in the 1950's. This might be good information to become familiar with before recommending field trials where researchers go out and pick oranges.

There were several articles from the 6th International Citrus Congress held in Israel in 1988. This Conference covers most of the production and plant protection aspects but there are 5 papers on processing. The Conference summarizes reports from many countries in the world and has several ideas on new products, processes, consumer tests, and emphasizes future trends.

Barone, 1988, found Italy produces more than 100 mt of essence oil from citrus bergamia a year. Bergamin oil is highly prized in the flavour and perfume industry. It requires considerable hand labour and may be an alternative crop worth evaluating for India.

Economics *In this Citrus Congress, Menini, 1988, summarizes an FAO project which has been going on since 1970. This project strives to more effectively extend scientific expertise and ideas to countries developing citrus production and processing. He examines the mechanisms to foster technical exchange. Abstract attached.

Fernandes, 1988, details factors affecting the increased fruit production and quality in Columbia. His examples might serve as a guide to working out a criteria for India.

Meredyk, 1988, summarized the production and processing of fruits (including citrus) and vegetables in Turkey. Caution must be used in evaluating his suggestions on how and where to increase economic inputs to get the greatest return to the agriculture economy.

Giacomo, 1987, gave a paper with an overview of the Italian citrus production.

Choudhary, 1987, looked at fruit and vegetable import trends for many of the countries in the world. This would give you an indication of what kinds of citrus products are being purchased by what countries.

Maeda, 1987, developed automated equipment to grade and size citrus fruit using a colour camera. Barresi, 1989, extended this using image processing for grading oranges up to 8-9 tons/hour. This increased the productivity of the graders 2 to 3 times.

Ejiofor, 1989, produced a mosquito larvicide from lime juice. I would suggest evaluating peel oil (d-limonene) a known biocide to act as a larvicide because it would float on the surface of swamp water and should kill the mosquito larva.

Ogawa, 1989, used hydrostatic pressure 3-4 kbars in combination with and without pasteurization to kill bacteria, yeast and moulds. This is a new processing technique which may prove out as a method to reduce the heat treatment given citrus juice.

Mashonas, 1989, measured the changes in volatile flavour compounds in aseptically packed orange juice (OJ). This is of concern because there is a significant loss of flavour with time in aseptically packed juice.

<u>Waste treatment</u> .Gupta, 1988, used citrus and many other processing wastes for feeding pigs and poultry. Results indicate these wastes can be a valuable source of animal food.

Tanabe, 1988, used a pectinase to treat citrus processing waste water. Pectinases would reduce the pectin to galacturonic acid. I have reservations about how fast these pectinases could work and many of the waste decomposing bacteria and mould already have exogenous pectinases.

Dasberg, 1988, used water high in salts and found there was an insignificant increase in salts in the juice. I am familiar with other work where a salt tolerant gene from tomatoes grown along the sea coast to South America was going to be transferred to commercial tomatoes to permit irrigation with sea water.

Bala, 1989, found there were antimutagenic factors in whole citrus juice. These factors offered some degree of protection against known mutants in the Ames test. Dr. Ekasari of our Lab has worked extensively in this area. There is considerable interest in the work from governmental health agencies.

Carotenoids Tada, 1987, identified 26 carotenoids in unshiu juice. Carotenoids play a significant role in the colour of citrus juice. Dr. Rouseff and Fisher of Lake Alfred, Florida have worked in this area.

Fisher, 1986, developed a simplified HPLC procedure for quantifying 3 of the citrus carotenoids.

Singhrot, 1987, made measurements on the post harvest effect of several peel treatments. He found several of these treatments decreased weight loss and decay. Citrus fruit could be helped 28 days under the best treatment. This could prove to be important in smoothing out the supply to a small citrus processing facility.

Rouseff, 1987, studied the levels of naringin, narirution and neohesperidin in 52 cultivars of citrus. His information is useful in detecting adulteration of orange juice with grapefruit juice.

Sardzhveladze, 1987, compared 3 lemon cultivars and found the Meyers lemon to be non-typical. Meyers lemon oil contains significant amounts of thymol and lacked neural and geraniol which impart lemon characteristics to the oil.

Wilson, 1987, evaluated 3 methods to measure Vitamin C content in aseptically packed orange juice. He found electro chemical detectors were 100 times more sensitive.

Daito, 1985, studies the effect of maturity of the composition of sugars and acids in mandarin fruit. He lists the predominant sugars and organic acids.

MANGO

More than 20,000 references were examined to find those references which pertained to mango processing, juice or pulp quality. I have included several references on the cultural practices, prevention of insect infestation and economics of the industry. These citations and abstracts are contained on a 3 1/2 inch diskette. They are in IBM compatible format in High Density 1.44 MB. The advantage of having these references "soft" is that they can be added to at any time, repeatedly searched with many types of search strategies. I have gone through the 16 pages of references and have selected some which are in my opinion the most interesting. I have referenced these by first author and date and have included some of my ideas on how to use this information.

Much of the work which has been done on mangoes has been done by researchers in India. There are major companies in the USA and elsewhere which are interested in increased utilization of mango an mango products. Two of the major problems seem to be 1) that there is a great deal of variability in the mango juice and pulp, both from different cultivars and over the maturity season and 2) there are no consistent large sources of high quality supplies. I believe help could be forthcoming from potential customers to utilize research in overcoming these and other deficiencies.

Economics Srivastava found in 1987, that mango occupied about one million hectares or about 40% of India's fruit cultivation area. For the year 1984, growers made little profits, while commission agents charged 8% on the transaction, wholesalers' profit was more than 80% and retailer's profits were about 40%. This study proposed the exploitation of the growers by various intermediaries

and need for processing mangoes. Choudhary, 1987, studied the volume and value of agricultural imports between 1970 and 1981 identifying the leading importing countries of a number of crops of importance to India. (Are there any plans to update this study?) Joughin, 1986, prepared a 90 page report on seven different aspects entitled : The Market for Processed Tropical Fruit. The various products which have been commercialized were reviewed along with the market for pulp, purees and juices into Europe, USA and Japan. Future prospects are discussed. (This looks like an excellent report and should be acquired from the UK. See Reference citation on the disk).

King, 1988, studied the role of pectin esterase (PE) in the role of mango peel softening during ripening. They concluded that the solubility of PE and the accessibility to the pectin substrate were the major factors in **in situ de esterification** of pectin in mango peel. I have major questions concerning this abstract. Why did they use a pH of 8.5 to 9.5? I would guess that mango peel is 1/1000 times less basic than this. From what is known in citrus, it would be important to determine : Is the PE in mango membrane bound? (In citrus >95% of the PE is membrane bound to the walls of the juice vesicles).

In what adjoining tissues are the pectins found? What is the degree of esterification and molecular weight of the pectin and how does it change during maturation? Is there any polygalacturonase or other softening enzymes present? This information would make new information available to fresh market and processors and could be used for refereed publications.

Zauberman, 1988, looked at chilling injury of mangoes stored at 5°C then transferred to 20°C for ripening. They found an increase in the activity of peroxidase and cellulase. I think this information could be incorporated into an experiment which would include the information of King, 1988. It might be important to determine which of the enzyme systems were the most active during ripening, which substraits were more significantly modified, the specific activity of the PE and the cellulase, ect... All of these factors could be summarized into a "mango ripening model" to aid those selling fresh mangoes and mango processors trying to obtain consistent textural quality.

Cultural Considerations Suman, 1985, studied 10 quality characteristics on 84 mango cultivars. Tandon, 1986, looked at 12 of the important horticultural characteristics on 2 cultivars over a two-year period. They studied the fruit from 8 to 10 year old trees. I am glad to see a study for more than one year which will give an idea of the variability between seasons. Syamal, 1987, studied 12 quality characteristics on 10 mango cultivars.

These reports appear to be good preliminary studies which are necessary before making some of the cultivar selections for fresh fruit marketing and processing. Again, the most important characteristics need to be combined and summarized so they will be considered during the planning stage of future research.

Singh, 1986, found that of the 5 cultivars tested, **Safeda Jauhari**, had the best quality pulp, tasted the best and had the highest storage quality when manufactured into juice and squashes. I feel this is the kind of preliminary information which needs to be developed in selecting which cultivars should be planted.

New mango products Marel, 1988, reported on a new product available in France called "Latella". This is a combination of whey and fruit juice. It is allowed to stand for 16 hours, then pasteurized at 85°C. This product is reported to keep for 3 months without refrigeration. I think this product should be evaluated with consumer taste panels because it is probably a high acid, high protein drink which could prove to be nutritious. The article is in French. Rivera, 1986, developed a new product using indigenous fruit sources to augment rice. They used ground rice plus 10 to 40% mango or other fruits. These were finely ground in a colloid mill, then drum dried.

The nutritional quality was increased by using dry skim milk and adding sugar improved the taste. I would like to see someone try to mix the ingredients without using a colloid mill. These mills are expensive, have a low throughput, are normally designed for use to produce "colloidal" size particles (>10 microns) and develop considerable heat. After mixing these ingredients an extruder could be used to heat process and shape the product. This would eliminate the expensive and low throughput drum dryer. Drum dryers can impart considerable heat damage to products with delicate flavour or high sugar concentrations. Thirdly, someone could look at adding flavouring oils after the heating step, before packaging, to improve the taste. See the reports listed below for some of the volatile and flavour compounds which are important in mango. Bhanmurthy, 1986, reported on four ready to reconstitute products developed by the Indian National Dairy Research Institute. One of these products was spray dried mango and milk for a high protein fruit drink. It contained 18% mango and 14% milk fat. The major constraints for commercial adaption are discussed. (Also see the report by Bardall, 1986).

Mango flavours Sharaf, 1989, examined mangoes harvested at 3 stages of maturity and measured 12 acids in mango pulp. They identified 30 volatile compounds and the major fatty acids. Bartley, 1987, studied the major volatile components in mango and found ethyl butanoate and terpinolene. Shibahara, 1986, found a gas chromatograph peak corresponding to methyl octadecenoate in the fatty acids in mango pulp. This was identified as ciz-Vaccenic acid.

I feel these reports are a good first step to attacking the major problem of reducing the variability in flavour of mango pulp.

Postharvest Medlicott, 1987, treated "Tommy Atkins" cultivar of mango with gases to initiate ripening under commercial situations. They found treating with ethylene at 0.01 ml/L or acetylene at 1.0 ml/L could be used. See also report by Farooqi, 1985. This work on mango was based on an earlier study in which Medlicott, 1986, studied the temperature and controlled atmosphere needed to ship fresh mangoes from Jamaica to the UK. Optimum quality occurred after 8 days storage at 22°C or 5 days storage at between 27° to 37°C. Spalding, 1988, studied two cultivars, "Tommy Atkins" and "Keitt", to examine the effects of irradiation with a Co-60 source at 150 to 1500 Gy. They found an overall reduction in decay at levels above 750 Gy, but recommended levels around 250 Gy for insect control and small amounts of detrimental effects.

Of course, efforts must be made to integrate the research information developed by researchers in the postharvest area with that developed during processing or product development.

Ethiraj, 1988, found a micro-organism, Pichia membranefaciens which is resistant to sodium benzoate levels up to 300 ppm in broth and 1500 ppm in mango juice. This could be a problem in mango juice preserved with sodium benzoate. What are the typical thermal processing times and temperatures given mango juice and pulp? Are these sufficient to kill this organism? If the juice is pasteurized and kept free of post process contamination, this may not be a problem. Has the organism been recovered from commercially processed juice or pulp?

Waste abatement Punji, 1988, expanded on the utilization of processing and animal wastes. Part of their study involved mango seed kernels (MSK), their availability and problems with utilization. Gupta, 1988, at the same conference, outlined the requirements for processing MSK for feeding pigs and poultry. Pradhan's, 1988, report on MSK was along the same line, covering the problems and progress farmers and the compound feed industry has made in using MSK.

Ballot, 1987, studied ways to increase iron absorption by Indian women. Eating citrus markedly increased iron absorption; while eating mango had an intermediate effect on increasing iron absorption following a meal of rice.

BANANAS

Bananas are the number one fruit crop grown in the world. However, there are few successful processed commercial banana products. Work has been going on for more than 20 years on an aseptic banana puree which could be shipped in bulk drums similar to bulk citrus concentrate. There are several problems to overcome in processing bananas, one of which is the apparent ease of producing an "artificial banana" odour and flavour from organic compounds like isoamyl acetate, which is easily synthesized.

There were a total of 546 references pertaining to banana from the total of more than 20,000 references which were searched. Of these references on banana, only 42 concerned the processing or processed banana. These references and their abstracts are recorded on a 3 1/2 inch IBM compatible diskette. Recording these abstracts in a "soft" format will enable someone to search these references using a computer and print out the abstracts pertaining to their particular research topic. Only the first author and the date are referenced in this write-up.

In contrast to some of the other fruits and vegetable topics searched, there appears to be several good basic papers on processing and postharvest aspects of bananas. These articles may provide some insight for future research or ideas for practical applications. There are also some articles on tissue culture.

Economics It is important to establish some of the basic information about the current production of bananas in India. Information on exports appears to be available. Ho-Kwon-Ping, 1982, wrote a unique and interesting examination of the export of "luxury foods". These are foods which are processed close to where the crop is grown, then exported fresh. One example, for this

study is the banana industry in the Philippines. Ramirez, 1986, outlined the role of cooperatives in the processing and marketing of bananas in Colombia. These Colombian cooperatives were compared to cooperatives in other countries in the way they dealt with problems. Ramirez's article is in Spanish. Aldana, 1987, wrote about the positive benefits of technological developments for bananas in Columbia. He also discussed methods for minimizing the detrimental effects of these technological changes. Jacob, 1987, reported on possible improvements to a mixed, 8 to 12, crop cultivation and processing system by small holders in Sri Lanka.

Processing Jayaraman, 1987, found a change in polyphenoloxidase activity, polyphenol and ascorbic acid all played a role in the rate of browning of banana pulp. This information could be quite helpful to processors of bananas who want to reduce the brown colour of their processed products. Chocon, 1987, developed a mathematical model to integrate physical and chemical data into a banana ripening scale.

There were several articles on the biochemistry of banana ripening which may be important in understanding the texture of processed banana products. Garcia, 1988, studied the chemical and physical changes in banana starch during ripening. He also evaluated the actives of 7 amylases. Smith, 1989, followed the chemical and textural changes during banana fruit softening. He found that softening was due more to the changes in the starch fraction than to the activity of pectinesterase. Zyer, 1989, found a strong correlation between the ripening process and one of the three forms of the enzyme 6-phosphofructokinase.

Toukairin, 1989, developed a HPLC method for determining the seven compounds which are B-6 derivatives in bananas and other fruit. Kent, 1987, summarized 260 references on the electrical and dielectrical properties of food including bananas.

Gujarat, 1988, did a postharvest study which may have implications for banana processors. He tested four treatments and found the best treatment retarded ripening by less than three days. There may be applications of this work to storing bananas prior to processing; however the treatment effects on the final products should also be evaluated. (See an additional article by Semple, 1989).

Irizarry, 1985, reviewed 15 years of work in Puerto Rico on several aspects of plantain production and processing.

New Products Rivera, 1986, produced a pulp flavoured rice flake. Ground rice was mixed with 10 to 40% banana and other fruit pulps. This mix was finely ground in a colloid mill, then drum dried. If this product warrants investigation for India, I would suggest using 1) mixing without a colloid mill or 2) drying on something other than a drum dryer 3) an extruder could do the mixing, heating and when the flake is formed hot it can dry. The dry product could be flavoured by using isoamyl acetate or commercially available flavours. (See additional comments in the New Product section in mangoes).

Hansen, 1987, found that banana flavouring masked the off flavours which developed in UHT milk. This article would be worth reading and doing some follow up research if there are requirements in India for a long shelf life milk. Prajapati, 1987, blended banana paste with acidophilus milk and found the banana increased the survival of lactobacillus after spray drying.

Oettle, 1987, gave ten healthy adults two high sugar manufactured snacks and two whole foods (bananas and peanuts). Plasma glucose levels tended to rise higher with the manufactured snacks. Ballot, 1987, found that when Indian women ate a banana with a rice meal, they had increased absorption of iron.

By product utilization Aker, 1987, proposed that the large quantities of cull bananas be used to grow *Candida utilis* for a high quality single-cell protein for animal feed. He projected that 20,000 kg/d of feed bananas would produce 3,000 kg/d of a crude protein. Tewari, 1985, saccharified banana peel and increased the ethyl alcohol production to 1.4% v/v with cellulase and 0.8% with H_2SO_4 treatment.

Corominas, 1986, identified the succession of micro-organisms in an agricultural compost pile containing banana leaves. He also evaluated lignin breakdown. Bhatt, 1987, also evaluated the production of ethanol from banana and guava juices. It might be important to test the production of ethanol from the whole fruit with a minimum of processing.

ONION

A total of 732 references on onion were surveyed from a total of more than 20,000 references. Of these only 83 pertained to onion drying, juice, pulp, flavour or processing. I have put these 83 references on a 3 1/2 inch IBM compatible diskette. Thus, these files on onion can be added to or searched retroactively whenever there is a new research topic being investigated. There are many references to cultural practices including horticultural quality factors. Some of these articles on cultural practices were picked up with the search logic; however, most of the cultural practices on onions were excluded.

Economics Choudhary, 1987, studied the value and volume of certain types of agricultural imports for the 10 years before 1981. He identified a number of countries which were high volume importers of onions from India. This would be a good place to start to investigate the market demand for onion and dried onion products. It might also give an idea of the potential demand for some new onion products. Hopefully, there is an updated study with this information.

Rehman, 1988, studied the current production and potential expansion of onion and other agro-industrial crops in the Budaun District of Uttar Pradesh. Kil'chevskii, 1987, developed a model for selecting varieties of onions based on environmental parameters. It might be interesting to look at this work, but certainly the environmental factor is only one of the parameters to consider in forming a model for selecting onion varieties.

Fuller, 1989, summarized the dry onion production in Texas and the demand in the United States. Krings, 1988, examined how small-holder families were able to irrigate onions and survive during the drought in West Africa's Sahel. This seems amazing! These accounts might prove useful depending on the market demand in India for similar products from the farms of smallholders.

Processing Hasson, 1988, wrote an article about harvesting onions and specifications for equipment for small scale producers. He covered such things as an "in-store" drying techniques. This appears to be an article written fro a small scale and can be obtained from the UK. (See the Hansson citation.) Deal, 1986, used CGYE agar to evaluate the microbiological load on dehydrated onions and other vegetables. He felt the limit of 300 cfu/gm may be too low for some dry vegetables. This article could contain some very important information because some onion drying operations may not be able to meet the lower micro specifications.

Anan'ina, 1986, studied the disaccharides, polyfructosans and nitrogen compounds of 5 Russian onion varieties and correlated these chemical analysis to the onion flavour. Litvinenko, 1984, examined the dry matter and soluble solids contents of several Russian onion cultivars. This information should be evaluated to see if there are potential applications in using chemical "markers" of flavours in breeding and processing onion selection programs.

Reddy, 1989, did research on onion seed using a gas chromatograph and found the oil contained the fatty acids of palmitic, stearic, oleic, and linoleic. Lau, 1989, developed a spectrophotometric method to determine the sorbic acid content of onion juice.

Saimbhi, 1987, ran trials over a 2 year period to develop fertilization requirements for onions which were to be dehydrated. This looks like it is pertinent research because tests ran for more than one year and seem to integrate the study of Food Science with Horticulture.

Bakowski, 1982, evaluated Polish varieties of several vegetables including onions for fresh and drying. This article may provide data relating to developing methods of evaluation for onion cultivars. Biramontri, 1989, evaluated two dosimeters to control the gamma radiation of onions. Davidson, 1988, examined the flavour blocking capacity of four milk containers to several odours including onion. The best barrier was the opaque plastic milk carton (probably polyethylene). There probably are plastics which are better odour barriers, but these plastics are not usually used for milk. There may be an application of this work to other food products containing onions in which you want to retain the flavour of the onion.

New products An article called Frozen and Chilled Foods does not have an author's name, but it is found on page 27, line 39 on the diskette file on onion. The writer outlines about a dozen new food products from Europe, some of which contain onion as a food ingredient. Roberts, 1984, preserved foods with a natural enzyme called lysozyme. The abstract is unclear as to whether the intent is to use onion power as a preservative or to try to preserve onion power with lysozyme. The water activity in onion power should be low enough to preserve it, and the dry conditions in onion power may prevent an enzyme from being active.

By-product utilization Lubberding, 1988, studied the digestion of onion waste material by rumen micro-organisms. The abstract does not make it clear whether he correlated his findings with actual feeding studies or if he was proposing using rumens to dispose of onion processing wastes. Wilson, 1988, ran a series of experiments using a bench scale rotating biological contactor. This reactor was evaluated on onion-pickling waste. Information on scaling up to commercial size is presented. This may be an expensive way to treat something like onion waste; other methods should be evaluated.

All in all, I was disappointed by the amount and breath of information found on onion processing. If someone is planning research in this area, I would suggest starting with books or reviews then use a very broad search technique. There is probably a lot more information available.

There is one bright spot. In three articles there is information about the use of the phytochemicals in onion. This is an active research area in several laboratories around the world. Ito, 1986, studied 10 vegetable species to find a suppression of the effect of an inducer on the chromosome aberrations in rat bone marrow. Youssef, 1985, showed that methanolic extracts of onion skin depressed blood pressure in rats. Strel'chuk, 1987, looked at a different angle in treating onion bulbs with an extract of Eleutherococcus. This treatment with low concentration of the extract may have neutralized the free radicals and acted as an antimutagenic compound for the onion.

A conference was held in Washington, D.C. in the fall of 1990 to discuss the antimutagenic activity of onions and garlic. I assume the proceedings will be published from this conference.

GUAVA

More than 20,000 references were searched to find 172 references on guava. Of these only 18 had to do with guava processing, flavour, juice, or pulp. I have left the references files with complete citations "soft" on a 3 1/2 inch IBM compatible diskette. This way these files can be added to and searched retroactively whenever there is a new topic. There are also references to articles on horticulture practices, histological anatomy and cultural practices. A few of the articles are in Spanish and these are labelled with LA (language of the article) Spanish; and most have LS (language of the summary) in English.

Economics Joughin, 1986, examined the major markets for guava and other processed tropical fruits. He prepared a 90 page report with seven different sections on the marketing of tropical fruits. I think this might be a good place to start to assess the "market demand" for guava and guava products.

Processing Yusof, 1988, studied 6 different stages of maturity in the development of guavas. Stage 4 was when the fruit had been artificially ripened with 1000 ppm of ethylene for 1.5 days. This stage was the most desirable for processing because the sugar content increased and the ^{0}Brix / acid ration was the highest. This appears to be a significant work on a number of the chemical and physical quality parameters for guava. I might suggest this report be examined very carefully as an outline for additional work on other Indian guava cultivars or mangoes. Gonzalez, 1985, studied 6 physical characteristics of 4 guava breeding lines. He graded guavas with white flesh down in comparison to other attributes.

Sharaf, 1986, studied guava at 3 maturity levels and measured 5 quality and chemical parameters. Idstein, 1985, did a very complete study on the compounds present in guava fruit pulp. He identified 154 substances, 116 for the first time. Lipid peroxidation products predominated.

These studies could provide a "launching pad" for future work on the processing, quality and sensory attributes of guava. Similar things could be done on Indian cultivars if the market is sufficiently large to warrant this information.

New products Joshi, 1985, combined whey and pulp from guava in a 1 to 1.5 ratio to form a jelly. This jelly had "acceptable" consistency. I have several questions about this work and would like to read the complete article to find out why whey was added to guava which has already been reported to be a good source of pectin. What was the maturity of the guava? Maturity has a marked effect on the pectin in things like citrus fruit. What was the method of preparation of the jelly? Citrus pectin is damaged by prolonged heating in an acid environment such as in a jelly. Heating can lower the jelling power of the pectin. How were the jelling strength and consistency measured?

Post harvest Grech, 1988, summarized the effects of harvesting and handling of fresh guavas. He also looked at processing of the fruit and juice in Taiwan.

Ballot, 1987, found when Indian women ate citrus fruit, guava (Psidium guajava) or paw paw in addition to their rice meal, they had increased absorption of iron. This information would be especially useful for those who are working with people who have iron poor diets or lower rates of absorption.

By-product utilization Ibrahim, 1988, used solid waste from guava juice processing with "good results" in the growing of maize and wheat. I wonder how long this study was conducted and if there are compounds in the waste from guava which might build up in the soil. These wastes could also be treated by microbial decomposition prior to using as fertilizer.

Bhatt, 1987, used 2 yeast strains to compare the production of ethanol on a substrate of mixed juices from damaged guava and banana. S. cerevisiae produced the maximum ethanol in the minimum time. One idea might be to repeat this work and use macerated whole fruit rather than the juice which implies processing and separation out some of the solid portions of the damaged fruit. There may be some inhibitory compounds to the micro-organisms in the whole fruit or seeds.