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Postharvest Institute for Perishables

WORKSHOP ON POSTHARVEST HANDLING AND PROCESSING OF APPLES

Presented by

Robert L. LaBelle
for the
Postharvest Institute for Perishables

Sponsored by

Universidad Técnica de Ambato,
Facultad de Ingenería
Escuela de Ingenería en Alimentos (EIAL)

and

The University of Florida

and

Consejo Nacional de Ciencia y Tecnología (CONACYT)

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Postharvest Institute for Perishables
University of Idaho
Moscow, Idaho 83843
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I. EXECUTIVE SUMMARY

The U.S. Agency for International Development Mission in Quito, Ecuador requested in cable Quito 9541 the participation of Mr. Robert LaBelle in a short course on postharvest technology. The course was to be related to apple handling and processing, and it was requested that he make presentations on the subjects of 1) horticultural aspects of apples, 2) postharvest physiology, 3) postharvest management, 4) controlled-atmosphere storage, 5) quality aspects, and 6) pre-processing aspects.

In response to this request Mr. LaBelle spent the period of February 14 through March 4, 1983 in Ecuador where he presented the course that is outlined in this report. There were 31 students or participants in the short course, all of whom were graduates in food engineering or were doing graduate studies. Therefore, they were prepared for the phases of the course that required a rather technical background.

Mr. LaBelle's participation in the workshop was part of the Rural Appropriate Food Technology Development Project that is being managed in Ecuador by the University of Florida in cooperation with the Consejo Nacional de Ciencia y Tecnología (CONACYT). Subsequent to the short course it was reported by personnel from the University of Florida that Mr. LaBelle's presentation was highly satisfactory and effective.

Recommendations were made for the plans and programs of a more effective workshop that could follow the one presented in this report.

II. WORKSHOP DESCRIPTION

This course was developed and planned cooperatively by Dr. Robert P. Bates of the University of Florida and Ing. Aníbal Saltos, Director of EIAL as part of the Rural Appropriate Food Technology Development Project (PITALPRO) sponsored in Ecuador by USAID's Rural Development Office working with Consejo Nacional de Ciencia y Tecnología (CONACYT). Teaching duties both in the lecture hall and processing laboratory ("pilot plant") were shared by Dr. Bates and myself with the active administrative and logistical support of Ing. Saltos and his staff.

Most, if not all, of the students registered in the course (31) were graduates of the food engineering curriculum of EIAL and further were involved at some stage of graduate study. Several were employed elsewhere and were either on leave while taking the short course or attending part time as best they could. Though largely unfamiliar either with apples or with actual practices of fruit harvesting, handling, storage, or processing, they nevertheless were faithful in attendance and notably attentive in both lectures and laboratory exercises. The broad scope of the subject matter together with the limitations on complete comprehension imposed by the language difference between students and teachers may have diminished somewhat their assimilation of the large body of information presented.

During the initial session or inauguration of the course, several of the officials and principals involved made introductory remarks to show the pertinence of the proceedings to the furtherance of appropriate technology with special reference to Ecuador. Dr. Bates, who has contributed a chapter to a recently published book on the subject, provided a more detailed introduction to the concept and practice. I had earlier provided my own ideas, more tentative than well-developed, in a preliminary written statement (see Section IV) but did not present it at this convocation.

The course format interspersed lectures and laboratory practice on a succession of subjects dealing with the nature of the fruit and the procedures employed in its utilization, from harvesting to processing and marketing. Some last minute adjustments were made in the order of presentation and to the proportion of time devoted to each topic to satisfy our developing perception of students' needs, the availability of fruit and facilities, and the natural progression of laboratory exercises. The lecture hall, while larger than was needed, was a truly excellent facility, boasting all needed visual aids. There were usually at least two persons present, including Sr. Saltos, who could translate from English to Spanish with some background in the subject matter aiding understanding. While the laboratory was only partly equipped with the machines and tools necessary for processing apples as intended, resourcefulness in substitution of function and borrowing from other laboratories permitted meaningful exercises to be carried out. The large size of the class made hands-on experience for all of the students difficult to achieve, but division into three or more groups at times helped to provide all with some direct share in the necessary planning and manual operations alike.

The apples growing in nearby orchards proved not to be quite ready for harvest during the latter half of February. Although an adequate supply of fruit was gradually acquired as needed and some was even ripened by storage at ambient during the first two days of the course, we were not able to determine the suitability of the two apple cultivars grown locally. The ubiquitous Jonathan is highly regarded elsewhere for both processing and fresh market use but seems to be of a different, perhaps inferior, quality in this very atypical milieu (no pronounced seasonal change in temperature). The other variety, Emilia, is of local origin and of seemingly indifferent quality. Both were, at that time, very immature - green and hard, with low acidity and sugar levels and little aroma. Their suitability for processing into the products standardized in the United States - juice, sauce, and slices - could not be determined at this early date.

Visits to local orchards just south of Ambato at an elevation of 3,000 meters (about 9,000 feet) were made in a vain search for reasonably mature fruit. Some apples were being offered at roadside stands, but they weren't ready either. These forays did provide the opportunity to see the orchards at first hand. The apple trees seemed quite scattered and of rather low productivity. Wooden boxes and wicker baskets were seen as the containers in common use. No storage facilities were obvious, but various adobe or stone buildings may be used in season, without refrigeration. No idea of the total production of this fruit area could be had because of the scattered nature of the small orchards and extensive interplanting with other fruits.

Some commercial products (juice, sauce, and "butter") were found in the markets (Supermercados), a few being packed or remanufactured in Ecuador (Guayaquil, Cuenca) but no local processing facilities were seen. There is at least some recognition of apples as a fruit processed in several forms, and it seems not to be high-priced relative to other canned foods. Several of these were examined and formally graded by the students in a laboratory exercise and found to be of widely varying quality between brands. There seems ample room for apple products of improved quality.

With a view toward eventual upgrading of the processing facilities at EIAL, a list of equipment presently available was prepared to serve as a reference or starting point (see Appendix). One or more plans for adding progressively to this pilot plant, consistent with available space and maintenance capabilities, could be prepared. Preferably, this should be done with the active collaboration of all those involved in the laboratory practice just completed.

Only a few of the students in this initial program were already involved in food processing at a commercial level, and none were directly connected with local production of apples. At most, the short course just completed was able to provide a glimpse of possibilities for the processing of part of the locally-grown crop as well as a pool of native technological talent who have been introduced to both its problems and promise. A second phase might be more specifically directed toward a necessarily smaller group already involved in apple production or utilization or with an already existing interest in pursuing the commercial possibilities. The subject matter and laboratory practice might then be confined to procedures and products of direct local significance and application, with more depth and less breadth of inquiry. It would also be important to have in place at EIAL specific equipment and facilities for handling, storing, and processing apples. Scheduling of the course in late March or April when fully mature fruit would be available should be considered. The capabilities developed by this approach - working with existing or potential entrepreneurs - would likely result in some productive commercial activity of direct benefit to both the industry and consumers in Ecuador.

III. WORKSHOP CONTENTS

Lecture + Laboratory*		Topics
1 + 0	A.	Introduction
		1. Criterion for the selection of technologies (Appropriate Technologies and not appropriate technologies)
		2. Appropriate technologies for the utilization of apples
1 + 0	B.	Horticultural aspects
		1. Botany
		2. Cultivation Practices
		3. Varieties
2 + 0	C.	Postharvest Physiology
		1. Biochemistry
		2. Disorders - Insects/diseases
3 + 2	D.	Handling Considerations
		1. Harvesting
		2. Packing/transportation
		3. Storage
2 + 0	E.	Controlled Atmosphere storage
		1. Principles
		2. Practices
		3. Facilities and equipment
1 + 0	F.	Marketing
		1. Current status in Ecuador
		2. Merchandising/promotion practices
		3. Export/import considerations
2 + 1	G.	Quality Attributes
		1. Grades and Standards
		2. Composition
		3. Monitoring quality
		4. Nutritional Value

*90-minute periods

Lect/Lab		Topics
1 + 1	H.	Preprocess preparations
		1. Sorting, inspection, cleaning
		2. Peeling, coring, slicing
		3. Chemical treatments and enzyme inactivation
		4. Puree and applesauce
1 + 1	I.	Juice preparation
		1. Crushing and expression
		2. Filtration
2 + 2	J.	Thermal Processing
		1. Sliced products
		2. Applesauce
		3. Juice and juice blends
		4. Jams, jellies and conserves
3 + 1	K.	Fermentation
		1. Alcoholic beverages
		2. Vinegar
1 + 0	L.	Chemical Preservatives and Synergists
		1. Preservatives
		2. Functional additives
1 + 2	M.	Dehydration, Concentration
		1. Drying methods and products
		2. Intermediate moisture products
		3. Concentration
2 + 2	N.	Product Development
		1. Plant design and layout
		2. Research needs
		3. Packaging considerations
2 + 0	O.	Waste utilization
		1. Energy and resource conservation
		2. Byproduct recovery and utilization

Workshop Contents, continued

Laboratory Exercises

1. Respiration rate and storage study
2. Apple inspection and grading
3. Quality assays
    a. Fresh product
    b. Processed products
4. Preprocess preparation
5. Canning Lab
6. Juice manufacture
7. Fermentation
8. Dehydration
9. Product Evaluations
    a. Sensory
    b. Objective

IV. APPROPRIATE FOOD TECHNOLOGY:
As applicable to apple processing in Ecuador

The application of existing technology, including methods and equipment, to a perhaps embryonic apple industry in Ecuador calls for some assumptions to be made about the existing and intended level of activity. At present I have no direct knowledge of it. We do not have to look back very far - to the time of my boyhood in the 1930's - to find in New York State, then as now No. 2 in apple production in the United States, an industry based on many small apple growers and small, local plants that processed the crop. Even storage was to some extent still decentralized on the farm. The problem of adaptation to present-day Ecuador is one of retaining such methods and equipment as were used then in New York, or may be in use now in Ecuador, and that are still appropriate because of scale of operation or of economic necessity (limited capital). Nevertheless, for each aspect of the operation one should still ask whether newer methods or knowledge, already in common use in New York and elsewhere, may not be applicable in part.

Harvesting and Handling

The determination of readiness for harvest of the fruit has progressed from the pressure of an indenting thumb and the ground color of the skin to simple laboratory tests of soluble solids (Brix) and acid content. The ratio of these (Brix/acid), which changes rapidly during maturation before harvest, as well as while ripening after harvest, is an excellent index of readiness for harvest and then again for processing. However, it is not readily applied to many small holdings because of the laboratory instruments and procedures needed and the time required for careful sampling and testing. Therefore, subjective judgment would still have to be relied on, except where large lots of a single variety might be available - no doubt an exceptional circumstance in Ecuador.

Machine-harvesting of apples has not yet become common in the United States, although the technology is already available, when tree-culture and economical conditions warrant its use. The harvesting of many other fruits and vegetables has already been mechanized. This would likewise be one of the very last innovations to be considered in Ecuador. Hand-picking into bag or basket and transfer the easily-handled 20-kg containers, or even to bulk in a truck or wagon that has ready entry into the orchard, would be used instead. Handling and transporting in bulk (where the vehicle becomes the unit container) requires some reasonable method of unloading into bulk storage at or near the processing plant without excessive injury to the fruit. This is especially true of skin-breaks or crushing damage that might lead to early spoilage of the fruit. Note that transport in smaller containers (producer-owned) might require that they be likewise unloaded into bulk storage at the plant.

Storage

Apparently rather moderate temperatures (10-25^{o}C) prevail throughout the season and year in the Andean highlands where apples are grown. Harvested fruit, protected from direct solar radiation, might suffer less from the hastening of ripening and spoilage promoted by high temperature storage after harvest than occurs in early season in much of the United States. It is unreasonable to expect that the considerable expense of cold storage, or of those equipped to apply controlled atmosphere techniques, could be borne by a fledgling industry or where capital, and more particularly refrigeration know-how, is scarce. Even in the U.S., controlled-atmosphere storage is rarely used for processing apples. Yard- or common-storage is employed for as much of the crop destined for processing as is practical under prevailing climatic conditions. What may seem to be excessive losses from spoilage are tolerated rather than to invest more heavily in costly storage facilities. It is too warm for prolonged yard storage in Appalachia and too cold after November in the Great Lakes region, including New York. So, some ordinary cold storage is dedicated to processing apples on that account.

A most promising level of technology for the economic and climatic conditions of the Andean highlands is that practiced in the U.S. in the 1940's, that is, managed common storage. This employed small farm storage buildings, necessarily well-built against the rigors of sub-freezing winter weather and snowstorms, which were designed for natural (convection) or fan-assisted ventilation. Small doors or vents in the lower walls and in the roof could be manually, or later even automatically, opened and closed to permit the entry of cool night air and the exhausting of heat from the metabolizing fruit. This natural system was often backed up by the use of a small refrigeration unit to supplement natural cooling when needed during warmer weather, or when the fruit was first loaded into the storage in a more active metabolic state. An adjunct procedure would be to load fruit into storage only in the morning after ovenight cooling outside, and never when the fruit had the heat of the day in it. To some extent common storage is still employed in New York in preference to unprotected stacks of bins (400-kg capacity) in the processing plant yard. However, the management of cool-air resources in these simple facilities often seems to be neglected.

Processing

The timing of processing should be related to the fruit ripeness, depending on cultivar (variety) and the particular product to be made. In practice, many other practical requirements, such as the readiness of the processing machinery for use or the availability of labor and containers, will intervene in decisions on when to process. Whether the processing operation is small or large, it should be commenced early enough so that the required pack (number of cases) or the anticipated receipts of fruit from growers are completed before the apples become overripe or seriously affected by microbial spoilage.

Processing may be divided into two categories of operations. The first consists of the mechanical (or sometimes chemical, as in washing and peeling) ones required for refinement of the product, as in the removal of undesirable plant parts, and for reduction to the desired piece size or physical form (solid piece, puree, juice). The other is concerned with preservation and usually involves heat (sometimes cold) or chemical action. In the case of dehydration, the necessary removal of moisture may be considered a special operation. Packaging is a further necessary step in maintaining the integrity of the product and of unitizing it for retail sales. In thermal processing (canning or freezing) packaging is usually accomplished before the final preservative step, but is often the last step in processing. All degrees of mechanization exist for these processing operations, ranging all the way from simple hand methods and stove-top containers to very large automatically-controlled continuous-flow equipment.

The machinery for peeling, coring, and cutting into pieces that was in general use a generation ago in New York is largely still available, new or used, and in sizes to fit the requirements of small-scale processing. So, too, are the pulper-finishers and presses necessary to reduce apples to puree or juice, although modern industry has gone on to, not always larger, but usually automatic, labor-saving machines of greater capacity. Another attibute of such equipment that is all too common is the expense, not only of first cost but also of maintenance. While the development of continuous processes that more reliably turn out uniform products has led to elaborate pumping and conveying systems, transfer between operations by hand is always possible and not a severe limitation.

Utilization

This is an area that I cannot deal with effectively until I become familiar with the type of apple products that might already be in common use in Ecuador, either in the marketplace or in the home. The domestic availability of packaging materials is a very important consideration in their selection in order to avoid the considerable expense of importing bulky, empty containers. Product and packaging types are tailored to consumer habits and expectations to some extent, though there is always a place for thoughtful or even daring innovation. It might be guessed that it would be easier to introduce successfully to the marketplace a new package than an unfamiliar product. Dehydrated products might at first glance seem well-fitted to a beginning, low-technology industry (as in New York a century ago) and for marketing in the more arid parts of Ecuador as well as in export trade where the reduced weight would be an advantage. However, a large part of even the Ecuadorean population lives in the humid tropics where the requirement for a package as well-sealed against the intrusion of moisture may be as important as hermetically-sealed cans or jars are to thermally-processed products. The market for any one product type may be small in Ecuador, as in any small country of diverse geography.

Bibliography

A brief, but comprehensive and representative bibliography is attached as an aid to further study.

BIBLIOGRAPHY

1. Bates, R.P. 1983. Appropriate Food Technology. Chapter 9, "Sustainable Food Systems." D. Knorr, ed. The AVI Publishing Co., Westport, CT.

2. Bhalla, A.S. (ed.) 1979. Towards global action for appropriate technology. Pergammon Press. Oxford, UK.

3. Jequier, Nicolas. 1979. Appropriate Technology Directory. OECD Press (Organization for Economic Cooperation & Development). Paris, France.

4. Knorr, Deitrich W. (ed.) - - Appropriate Food Production. In press.

5. Lepkowski, Wil. 1980. Appropriate technology prods science policy. C&EN, June 16, pp. 31-35.

6. Morgan, Robert P. 1977. Technology and international development: new directions needed. C&EN, November 14, pp. 31-39.

7. Norman, Colin. 1978. Soft technologies, hard choices. Worldwatch Paper 21, Worldwatch Institute.

8. Richardson, Jacques (ed.) 1979. Integrated technology transfer. Lomond Publications. Mt. Airy, MD.

9. Schumacher, E.F. 1973. Small is beautiful: economics as if people mattered. Harper & Row, New York.

10. Symposium. 1979. Appropriate/intermediate food technology. Food Techology 32 (4), 77-92. (6 papers)

11. Weiss, Charles, Jr. 1979. Mobilizing technology for developing countries. Science 203, 1083-1089.

V. APPENDIX

PILOT-PLANT EQUIPMENT LIST

Escuela de Ingenería en Alimentos
Universidad Técnica de Ambato, Ecuador

Spray dryer (NIRO, Copenhagen)

Air compressor (Champion Pneumatic Machine, Princeton, IL/Model HR-5-8)

Evaporator, single-effect (locally made)

Still, w/10-ft column (missing)

Water-bath, constant temp. (Lab-Line Instruments, Melrose Park, IL)

Centrifuge, refrigerated (Beckman/Model J-218) (not serviceable)

Autoclave, approx. 1 1/2 meters long and 1 meter diameter (locally made)

Kiln, w/rotating table, approx. 1 1/4 m cube (National Mgs. Co., Lincoln, NE)

Drying oven (Memmert, Schwabach, W. Germany/Model U-40) (30" x 24 " x 24")

Double-tube heat exchanger, brass, six 3-m sections (locally made)

Boiler (Kewanee Boiler Corp., Kewanee, IL) max. firing rate = 9 gph, 150 psi, 80 HP

Tunnel dryer (locally made, electrically-heated, wooden ducts, w/Japanese blower)

Laminated film bag-sealer (Koch, Kansas City, MO) "Multivac" Type AG 5 (made by Sepp-Hagenmuller AG, Allgau, W. Germany)

Centrifuge, 12" (Carl Padberg, Lahr, Schwarzwald) Type 18/4,500 rpm

Grinder & Mixer (Crypto-Peerless Ltd, London NW10) Model JB22F

Refrigerator/Freezer, 2x2x1 m (Ecuafrim)

Sieve-shaker (Bico, Inc., Burbank, CA)

Press, Carver (Fred S. Carver Inc., Summit, NJ)

Scale, 50 kg X 100 g (Fairbanks)

Cream Separator, hand-cranked, 32-80L (Alfa-Laval, Finland)

Vacuum drying oven, Model 19 (Thelco, Precision Scientific Co.)

Pilot - Plant Equipment List, continued

Slicer, Model R1 (Crypto, Peerless, London)

Centrifuge, Model 20B (Garver Electrifuge Mfg. Co., Union City, IN)

Furnace (2) Thermolyne Type 510 (Sybron)

Harvard trip balance, 2 kg X 0.1 g

Double-seamer, Type Tr 38, hand-cranked w/can reseaming attachment (Lanico-Maschinenbau, Otto Niemsch, Braunschweig)

Plate filter, "Koruna" Type S16 w/heat exchanger, multi-tube, 4 m^2 (Sundress, Stuttgart) (Maschinen u Apparatbau, Neuberg, Baden)

Sterilizer, HTST (Vaughn & Cameron, England, Ser. No. 0140-82)

Tank, cyl., open-top, stainless steel w/insulated wall, 1 m d X 3/4 m deep

Retort, 32" X 45" deep w/automatic control valve (out of service), 40 psig, blt. 1973 (Lee Metal Products co., Philipsburg, PA, Ser. No. A178945)

Vacuum pump, Size ND 674 (Nash Engineers, Winsford, Chesire, England)

Double-seamer, pedestal type (old ?)

Exhaust box, 28" X 45" X 8" deep

Filter press (Filtrox, Werk AG, St. Gallen, Switzerland/"Econom"/1976)

Tank, stainless steel, rectangular, 28" cube, on stand

Jacketed kettle, 20-gal, 40 psig, Style C (1974) (Hamilton, Cinncinati, OH) w/twin-pedestal mount

Press, 18" high X 6" diameter (Vogt Ideal no. 9)

Finisher, Langsenkamp w/Baldor 1.5 HP motor & Cincinnati Mechtronics variable-speed drive no. 277. and special feed chute

Mixer, Lightning (Mixing Equipment Co., Rochester, NY) on wooden stand

Scales, 60-lb hanging, dairy-type

Platform scale, 12 kg X 5g (EKS "Elizabeth", Sweden)

Tables, various, some w/stainless steel tops