WORLD FOOD PRESERVATION CENTER BOOK SERIES

POSTHARVEST EXTENSION AND CAPACITY BUILDING FOR THE DEVELOPING WORLD

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CRC Press
Taylor & Francis Group

17 Punjab Horticultural Postharvest Technology Centre

Building and Strengthening Linkages between Postharvest Professionals and the Emerging Horticulture Sector in India

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17.1 INTRODUCTION

The predominant rice-wheat system in the state of Punjab contributed significantly towards food security in India, but created several problems, such as depletion of the water table, poor soil health, aggravation of insect pests, overuse of pesticides, and environmental pollution, etc. Evidently, diversification from monocropping of wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) to horticultural crops for the conservation of both soil and water is essential. Growing of fruits, vegetables, and flowers have received an impetus in Punjab under the program of the National Horticulture Mission. In Punjab, fruits and vegetables occupy an area of 325,000 hectare with the production of 6.5 million metric tons (MT). The postharvest management (PHM) of fruits and vegetables is a highly specialized area and needs focused attention in terms of creation of infrastructure at farm and market levels for the overall development of horticulture.

Horticulture is a vibrant sector that is growing at 5% per annum in Punjab, thus making a dent in the state's dominant but stagnant food grain economy. The perishable nature of horticulture produce, with a significant amount of postharvest losses (PHL) annually, is not only a drain on the profitability of the farmers and other stakeholders but is affecting the growth of this high value segment of agriculture, which is contributing 10% to the state's Agriculture Gross Domestic Product (GDP) from only 4% gross cropped area.

With rising health consciousness of society in general, and growth of the middle class with its improved purchasing power, there is increasing demand for horticulture produce, which is placed higher in the food chain due to its health-promoting nutritional, medicinal, and other therapeutic properties. Further, it is reported that the rotting and decomposing of 1 MT of fruits and vegetables produces approx. 1.5 MT CO_2, which contributes to global warming, thus making PHM the main concern.

Given this background, the state's initiative to establish the Punjab Horticultural Postharvest Technology Centre (PHPTC) has become the need of the times. The envisioned intervention will surely save huge value by reducing PHL to benefit all the stakeholders in the chain, including farmers, thus making the horticulture sector more profitable and putting it on a faster growth trajectory.

17.2 BACKGROUND AND RATIONALE

Postharvest specialists from the University of California, Davis (UC Davis), assisted the government of Punjab in the design and launch of a new applied research and extension center in the discipline of postharvest horticulture in 1998. Dr. Michael Reid, Associate Dean, and Dr. Lisa Kitinoja, Office of International Programs, both of UC Davis, and Dr. James R. Gorny, Vice President, Davis Fresh Technologies participated as trainers and instructors in the first extension program held during the last week of August 1998 by the newly launched PHPTC in the city of Ludhiana, Punjab,

India. The design of the center and preparation for the launch of the PHPTC was funded by the United States Agency for International Development (USAID) through Chemonics International, under the Agricultural Commercialization and Enterprise (ACE) Project, managed by Mr. Keith Sunderlal of SCS Associates in New Delhi.

The State Government of the Punjab, in response to farmer concerns with associated loss of income, requested assistance in setting up a research and extension center with the purpose of reducing PHL. Lisa Kitinoja, as a specialist in postharvest extension education, was invited to Punjab to lead the process of strategic planning of the proposed center during January and February 1998. At that time, she interacted with over 60 stakeholders representing governmental agencies, university faculty and administrators, local, state, and national funding agencies, extension professionals, and clientele from throughout the horticultural sector in Punjab. These diverse groups shared the common interest in improving postharvest handling, packaging, cooling, storage, and transport of perishables, and were ready to take on the task of designing and funding the PHPTC.

It was further decided that the government of Punjab would fully fund the center through the Punjab Agricultural Marketing Board (known as the Mandi Board) on applied postharvest research and training activities. The PHPTC, located on the campus of Punjab Agricultural University (PAU), would house modern laboratory facilities, temperature control chambers, and a state of the art postharvest reference room (with internet access, videos, slide presentations, and written publications), manage demonstrations of recommended postharvest technologies in a variety of locales in Punjab, and offer a wide range of short-term training programs for small-scale and commercial clientele groups.

During the summer of 1998, James Gorny and Lisa Kitinoja were invited by Chemonics International to assist with the development of training materials oriented to small-scale produce marketers in India that were reproduced and marketed through the PHPTC. They prepared a 400-page book entitled *Postharvest Technology for Fruit and Vegetable Marketers: Economic Opportunities, Quality and Food Safety*, covering topics from planning production, harvesting, and packing through storage of fresh produce, small-scale processing, and marketing options for the Indian horticulturalists. Another manual on small-scale postharvest handling practices, written in 1995 by Kitinoja and Adel. A. Kader of the Department of Pomology at UC Davis, has been translated into Punjabi for dissemination to local horticultural farmers and small-scale marketers.

17.3 ABOUT THE PHPTC

The PHPTC was established in 1998 after signing a Memorandum of Understanding (MOU) between the Punjab government, through its agency Punjab Agri Export Corporation Ltd; PAU, Ludhiana; USAID, through ACE; and UC Davis. It was decided that

- State government would provide funds for the establishment of laboratories and operational costs
- PAU would provide scientific staff in the fields of horticulture, vegetable science, food science and technology, processing and food engineering, and chemistry, along with suitable building space
- UC Davis would provide technical support, such as training required for faculty, farmers, and traders

17.3.1 Mission

In 2016–2017, the PHPTC was reorganized and relaunched with the mission "To be a leader in the postharvest management reducing losses, adding value, establishing cool chain to reduce global warming through collaborative efforts of the Government, the Universities, and the private sector to build and strengthen linkages between postharvest professionals and horticulture sector in India."

17.3.2 PHPTC Mandate

- To conduct training courses on postharvest handling for farmers, marketers, etc.
- To conduct applied research and develop appropriate postharvest technologies
- To assist the domestic horticulture industry to achieve international standards and to set a benchmark for quality produce in India
- To build and strengthen linkages between postharvest professionals and the horticultural sector in India
- To provide information on standards/specifications for export/domestic marketing of food
- To provide laboratory services for trade and industry (to estimate pesticides residue, quality parameters etc.)
- To provide reference room facilities for postharvest information

17.4 ACHIEVEMENTS

17.4.1 Research and Development

PHPTC conducted need-based research based on the feedback of farmers and industries, and developed the following protocols pertaining to postharvest handling, packaging, and storage of fruits and vegetables.

17.4.1.1 Enhancing Storage Life of Fruits

- **Storage of kinnow mandarin (*Citrus reticulata* Blanco):** The kinnow fruits harvested at optimum maturity and packed in ventilated corrugated fibreboard boxes can be stored for 45 days, with acceptable quality, at 5°C–6°C and 90%–95% RH.
- **Storage of pear (Hard pear and soft pear):** The "Patharnakh" pear (*Pyrus pyrifolia* [Burm. f.] Nakai) fruits can be stored in cold storage (0°C–1°C and 90%–95% RH) for 60 days with post-storage shelf life of two days at ambient temperature, and four to six days in the refrigerator. The "Punjab Beauty" pear (*Pyrus communis* L.) fruits can be stored in cold storage (0°C–1°C and 90%–95% RH) for 60 days with post-storage shelf life of one to two days at ambient temperature, and four days in the refrigerator.
- **Storage of ber (*Ziziphus mauritiana* Lam.):** The ber fruits of cultivar "Umran," harvested at color break stage, can be stored at 7.5°C ± 1°C and 90%–95% RH for two weeks with acceptable colour and quality.
- **Storage of plum (*Prunus salicina* Lindl.):** The "Satluj Purple" plum fruits, harvested at color break stage followed by postharvest treatment of a calcium nitrate (2%) solution for five minutes, can be stored for four weeks in cold storage (0°C–1°C and 90%–95% RH) with post-storage shelf life of two days at ambient temperature.
- **Storage of grapes (*Vitis vinifera* L.):** The "Flame Seedless" grapes, harvested at optimum maturity with firm berries having light purple color, packed in ventilated corrugated fiberboard boxes (4 kg) lined with polythene film containing one sheet of grape guard, can be stored with acceptable quality for 45–50 days at 0°C–2°C and 90%–95% RH.
- **Chlorpropham-assisted storage for maintaining low reducing sugars in ware potato (*Solanum tuberosum* L.):** Potato cultivars "Kufri Chandermukhi," "Kufri Jyoti," and "Kufri Chipsona-1" can be stored successfully for five months at 10 ± 1°C and 90%–95% RH, with two consecutive foggings of Chlorpropham (CIPC) at the rate of 40 ml/t. The first fogging is given at the initiation of sprouting, and the second 60 days after the first fogging. The stored potato maintain low reducing sugars (<0.25%) and are suitable for preparation as chips and for other culinary purposes.

17.4.1.2 Ripening Technology for Fruits

- **Ripening of banana (*Musa paradisiaca* L.) and mango (*Mangifera indica* L.) with ethylene gas:** The banana and mango fruits harvested at green mature stage can be successfully ripened in four days by exposing them to ethylene gas (100 ppm) for 24 h in a ripening chamber maintained at 16°C–18°C and 90%–95% RH for banana and 20°C–22°C and 90%–95% RH for mango.
- **Ripening of banana with ethrel treatment:** The banana fruits harvested at the green mature stage can be successfully ripened in four days by dipping in a solution of ethephon at 500 ppm (1.25 ml per litre of water) for 2–3 min. The fruits should be air-dried and kept at 16°C–18°C and 90%–95% RH. The fruits attain uniform color and excellent quality, with a shelf life of four days at 16°C–18°C and two days at 30°C–32°C.
- **Ripening of pear with ethylene gas and ethrel treatments:** Ethephon at 1000 ppm as postharvest dip or exposure of fruits to ethylene gas (100 ppm) for 24 h in a ripening chamber, followed by storing the fruit at 20°C for ripening, proved to be the most effective treatments for improving ripening and maintaining the marketable quality of "Patharnakh" pears. The fruits took eight days to ripen at 20°C, while four days at ambient conditions.
- **Ripening of tomato (*Solanum lycopersicon* L.):** Winter season tomatoes harvested at color break stage, free from bruises and diseases, packed in plastic crates lined with newspaper, can be ripened in seven to 10 days in ventilated polyhouse conditions or a ripening chamber (20°C temperature and 85%–90% RH). The fruit attains uniform color and quality during ripening. However, the sorting of ripened fruits should be carried out at regular intervals to avoid further PHL.

17.4.1.3 Shrink Wrapping of Fruits and Vegetables for Retail Marketing (Table 17.1)

The technologies developed for shrink wrapping of fruits and vegetables for retail marketing have been summarized in Table 17.1.

17.4.1.4 Drying Technology for Vegetables

- **Drying of Kasuri methi (*Trigonella corniculata* L.):** Methi can be dried successfully in a mechanical drier with a drying time of 9 h (2 h at 70°C, 3 h at 60°C and 4 h at 50°C).
- **Drying of bitter gourd (*Momordica charantia* L.):** Bitter gourd slices of 1–2 cm thickness can be optimally dried with acceptable quality at 65°C/2 h; 55°C/8 h, followed by equilibration at ambient conditions (35°C–40°C).

TABLE 17.1
Observed Shelf Life of Shrink Wrapped Fruits and Vegetables

Commodity	Packaging Film	Shelf Life under Ambient Conditions
Kinnow mandarin	Shrink	15 days
Daisy mandarin	Shrink	15 days
W. Murcott mandarin	Shrink	10 days
Peach	Shrink/Cling	4 days
		9 days (under supermarket conditions)
Capsicum	Shrink	10 days
Tomato	Shrink/Cling	6 days
Cabbage	Shrink/Cling	15 days
Brinjal	Shrink/Cling	7 days

17.4.1.5 Development of Low Cost Onion (*Allium cepa* L.) Storage Structures

Mechanically ventilated mild steel onion storage structures of 1.25 MT capacity, comprising a top cuboid portion of 1.2 × 1.2 × 1.2 m and a bottom triangular prism of 1.2 × 0.6 × 1.35 m with a 35° angle of inclination, coupled with mechanical ventilation of air in the range of 0.75–1.0 ms^{-1}, can safely store this commodity up to five months with acceptable quality.

17.4.1.6 Design of a Plastic Crate and Corrugated Fiber Board Box (CFB) for Packaging of Tomatoes

A plastic crate of internal size 440 × 285 × 135 mm can hold about 10 kg of tomatoes, while corrugated fiberboard box of internal size 325 × 210 × 180 mm (3–5 ply) can carry 5 kg of tomatoes for distant and domestic marketing with minimum PHL.

17.4.2 Establishment of Laboratories

The PHPTC has established three state of the art laboratories, the Postharvest Laboratory, the Quality Control Laboratory for Processed Foods, and the Grain Moisture Calibration Laboratory. The setup of these laboratories is as follows.

17.4.2.1 Postharvest Laboratory

The Postharvest laboratory is fully equipped with walk-in cold storage, precooler, ripening chamber, hydrocooler, package testing machines, shrink packaging machine, cling wrapping machine, Hunter color meter, moisture analyzer refractometers, penetrometers, etc.

17.4.2.2 Quality Control and General Analysis Laboratory

The Quality Control and General Analysis laboratory contains an Atomic Absorption Spectrophotometer (AAS), Gas Chromatography Mass Spectrophotometer (GC-MS), microwave digestion system, and many other supporting instruments.

17.4.2.3 Moisture Meter Calibration Laboratory

The PHPTC has established a moisture meter calibration and repair laboratory, which regularly provides services to the Punjab Mandi Board for calibration of moisture meters before procurement of wheat and paddy.

17.4.3 Capacity Building Through Training Programmes

The PHPTC has prepared need-based training modules of one day, five day, and three week duration on PHM, value addition, and marketing of fruits and vegetables for farmers, traders, processors, exporters, extension specialists, and scientists. The training programs consist of hands-on training, demonstrations, and specialized activities. The training programs were designed to familiarize farmers and other professionals with various techniques used during supply chain management of fruits and vegetables, such as harvesting, grading, washing/waxing, packaging, transportation and storage, etc. The center has organized more than 350 training courses (Figures 17.1 and 17.2). The PHPTC has also conducted training in collaboration with international agencies like UC Davis and Programma Uitzending Managers (PUM), Holland.

17.4.4 Reference Library

PHPTC has established its own library, where literature pertaining to the PHM of horticultural crops has been purchased or downloaded from Internet sites. The literature is placed in the folders for use by readers in the form of books, manuals, and journals published in India and abroad.

FIGURE 17.1 PHPTC scientists and other staff.

FIGURE 17.2 Training programs conducted by PHPTC scientists.

17.4.5 Linkages

The scientists of the PHPTC have received funding for research and training programs for the establishment of a state of the art quality control laboratory, postharvest laboratory, and training facilities from various agencies like Ministry of Food Processing and Industries, New Delhi; National Horticulture Board, Gurgaon; and National Horticulture Mission, New Delhi. In addition, many private companies, such as United Phosphorus Ltd (UPL), Container Corporation (CONCOR), G.N. Packaging Ltd, Nipro Fresh, and RajHans Fertilizer Ltd, have collaborated with PHPTC to test postharvest chemicals, wax coatings, packaging materials, etc. The scientists of the PHPTC are invited, as are source persons, to various institutes, such as Central Institute for Postharvest Engineering and Technology, Ludhiana; Guru Angad Dev Veterinary University, Ludhiana, and many other reputed universities in India, for delivering specialized lectures.

17.5 ROLE OF PHPTC IN THE ESTABLISHMENT OF POSTHARVEST INFRASTRUCTURE IN PUNJAB STATE

PHPTC is working in close collaboration with Punjab Mandi Board, Punjab State Department of Horticulture, and Punjab Agro Industrial Corporation to provide technical input for the establishment of modern postharvest and cold chain infrastructure. The scientists also provided technical know-how to farmers for the export of kinnow fruits from the Punjab to Russia, Ukraine, Thailand, etc. The details are as follows.

17.5.1 Postharvest Infrastructure Created by Punjab Mandi Board

PHPTC provided technical consultancy to Punjab Mandi Board for the establishment of the state of the art postharvest infrastructure in 13 fruit and vegetable markets of Punjab, comprising 16 multicommodity cold storages of 800 MT capacity and 52 ripening chambers of 520 MT capacity (Table 17.2).

TABLE 17.2
Cold Stores and Ripening Chambers Established by Punjab Mandi Board at Different Agriculture Produce Market Committee (APMC) of Punjab State, India

Serial No.	Name of APMC	Ripening Chamber (Capacity 10 MT Each Chamber)	Cold Room (Capacity 50 MT Each Chamber)
1	Ludhiana	6	5
2	Sangrur	2	1
3	Moga	4	1
4	Jalandhar	8	2
5	Nawanshahar	4	1
6	Batala	2	1
7	Ferozepur	2	1
8	Abohar	2	1
9	Patiala	2	1
10	Hoshiarpur	6	2
11	Bathinda	6	2
12	Kapurthala	2	1
13	Phagwara	2	1
	Total	**48**	**20**

17.5.2 Postharvest Infrastructure Created under National Horticulture Mission (NHM)

PHPTC provided technical consultancy to the center of excellence for fruits, vegetables, and potato for the establishment of precoolers, cold storage, and packaging machinery. Technical knowledge was also provided to various private entrepreneurs for the establishment of cold storage, ripening chambers, and integrated packhouses who received financial assistance under the National Horticulture Mission program. The detail is as follows.

17.5.2.1 Cold Storages and Ripening Chambers Established under NHM

In Punjab, there are about 560 cold stores having a capacity of about 1.96 million t, out of which 139 cold stores of 563,000 t capacities and 92 ripening chambers with 1255 t capacities are established by various private entrepreneurs with the financial assistance from NHM (Table 17.2).

17.5.2.2 Farm-Level Packhouses

Under NHM, approximately 472 packhouses have been set up in the state for fruits and vegetables. The packhouse is the basic need of the horticultural sector for collection, grading, and sorting of produce.

17.5.3 Postharvest Infrastructure Created by Punjab Agro Industry Corporation (PAIC)

PHPTC provided technical consultancy to Punjab Agro Industry Corporation for the establishment of washing, waxing, and grading lines for kinnow mandarin and postharvest infrastructure at "Mega Food Park." The scientists also provided technical know-how to farmers for the export of kinnow mandarins, through PAIC, from the Punjab to Russia, Ukraine, Thailand, and other countries.

17.5.3.1 Mechanical Washing, Waxing, and Grading Lines

At present, there are five mechanical washing, grading, and waxing plants established by PAIC. These washing and waxing plants are established at Chhauni Kalan and Kang Mai in Hoshiarpur district; Abohar, Jattan Tahliwala in Ferozepur district; and Badal in Muktsar district. Besides, many progressive growers (more than 200 in number) have also installed such facilities privately at their own farms.

17.5.3.2 Processing Plants

The Punjab Government has established two pilot-scale processing units (20 t per hour capacity) for processing of kinnow juice and other fruits and vegetables at Hoshiarpur and Abohar.

17.5.3.3 High Tech Packhouses

Five packhouses with cold storage and grading/sorting lines have been established by Punjab Agri Export Corporation (PAGREXCO) at Mushkabad (Ludhiana), Saholi and Lalgarh (Patiala), Kangmai (Hoshiarpur), and Babri (Gurdaspur).

17.5.4 Adoption of Technologies by Farmers and Entrepreneurs

The various technologies toward harvesting, grading, packaging, and storage of fruits and vegetables developed by PHPTC have been commercially adopted by farmers and entrepreneurs (Figure 17.3).

FIGURE 17.3 Adoption of PHM technologies by farmers and entrepreneurs.

17.6 PUBLICATIONS

Scientists of the center have published research papers, popular articles, and research reports, as well as a training manual and a compendium of lectures delivered in refresher courses.

Research papers	>100
Popular articles	>100
Training manual	2 (English and Punjabi)
Refresher courses	4
Newsletter	Quarterly

17.7 PHPTC WEBSITE

PHPTC has developed its own interactive website (www.phptc.org) for the benefit of farmers, traders, processors, students, scientists, and extension specialists. The website is regularly loaded with recent research and training activities and literature, etc.

17.8 FUTURE THRUSTS: VISION

The vision for the future involves reducing PHL and ensuring a higher profit to the farmers and other stakeholders through improvement in the PHM, supply chain, and market linkages of horticultural produce.

The horticulture sector in Punjab is swiftly surging ahead with an increasing share of horticulture in the state's Agriculture GDP from 6.11% in 2004–2005 to 10.30% in 2015–2016. Though many factors contribute to such growth, the perishable nature of horticulture produce and the "postharvest management factor" for this category of produce assumes increased importance. Horticulture production in Punjab has increased from 3.4 million t to 6 million t in the last decade, wherein the PHL of horticulture produce is assessed to be around 20%. It is a heavy drain on the state's economy, as well as the profitability of farmers who take risks for diversification. PHL and falling prices during glut periods can be converted into profitable value added products using efficient PHM protocols and cold chain infrastructure facilities. This in turn improves shelf life and availability of stored/value added or fresh quality horticulture produce to the consumers in distant markets when and wherever there is a high demand.

Rising health consciousness and awareness against pesticide residues in the local and distant domestic market, as well as increasing export potential with strict quality specifications, require standardized PHM protocols and accredited laboratory testing.

With this background, it is planned that PHPTC will contribute significantly to developing and strengthening the horticulture sector, with special emphasis on postharvest and cold chain infrastructure in the region. To achieve this, various activities of the center will be strengthened through following capacity building programs like the following.

17.8.1 Training and Human Resource Development

PHPTC will function with a professional approach in providing training to the entrepreneurs, cold store owners, self-help groups, progressive farmer's organizations, agro-marketing cooperatives, etc., on safe handling, storage, and value addition of horticultural produce.

17.8.2 Development of Protocols for Domestic and Export Markets

Fruits and vegetables are perishable commodities and require tender care after harvesting in order to avoid PHL. Marketing of fresh fruits and vegetables has become more challenging day by day due to increasing global competition for quality produce. Therefore, there is need to develop protocols, such as standardization of maturity indices, grading, eco-friendly packaging, postharvest treatments, edible coatings, storage, and safe ripening techniques for domestic, distant, and export markets. The PHPTC will invite private companies (dealing with molecules, chemicals, coatings, packaging materials, etc., used for shelf life enhancement) to get their products tested at reasonable rates, for the benefit of the horticultural industry of the state as well as India.

Based on the feedback of the industry and farmers, the center will undertake problem-oriented research studies on PHM of horticulture crops on a pilot scale for optimization of temperature, treatments, packaging, etc., for maintaining quality and reducing PHL.

The problems related to harvesting, precooling, packaging, storage, transport, and destination handling will be identified through active interaction with different organizations, such as Citrus Estates, Pear Estates, Litchi Estates, Horticulture Department, Punjab Mandi Board, Punjab Agro Industry Corporation, etc.

Concerted efforts will be made to reduce the PHL of fruits and vegetables by generating eco-friendly and suitable postharvest technologies, as well as dissemination of these technologies

through extensive hands-on training programs, seminars, field days, etc., for farmers, storage operators, marketers, and other stakeholders. Focused efforts to use the cold chain as a weapon to manage glut during peak season and promoting entrepreneurship will generate more value to the horticulture sector.

17.9 CONCLUSION

Horticulture has been identified as an important sector for diversification of agriculture to ensure faster and sustainable agriculture development in Punjab. However, because of the lack of awareness about postharvest handling practices and non-availability of adequate postharvest infrastructure, a huge quantity of valuable produce goes to waste. Keeping in view the challenges of PHL and global competition for the export of fruits and vegetables, there is an urgent need to focus on formulating research and training programs in the direction of postharvest handling, packaging, and storage of fresh horticultural produce. PHPTC is working as a nodal agency to guide farmers, entrepreneurs, and government agencies for the establishment of postharvest and cold chain infrastructure at farm and market levels. The various PHM technologies developed by PHPTC, such as the ripening of banana, packaging and storage of kinnow, grape, plum, peach, pear, ber, potato, tomato, capsicum, cabbage, etc. have been approved by PAU, Ludhiana for commercial adoption by farmers and aspiring entrepreneurs. The Punjab State Agriculture Marketing Board started a "farmers market" also known as *Apni mandi*, with a view to giving a boost to the small farmers around cities so as to provide direct access to the consumers by eliminating the middleman. PHPTC has been providing hands-on training to *Apni Mandi* farmers and other stakeholders of Punjab state since its inception. PHPTC would endeavor to generate farmer friendly, as well as export-oriented, technologies for fresh horticultural produce. The PHPTC as described in this chapter can serve as a successful model extension approach for reducing PHL in other countries.

ACKNOWLEDGMENTS

The significant contributions of former Directors of PHPTC, Dr. A.S. Dhatt and Dr. B.S. Ghuman, and other individuals involved in the establishment of PHPTC and designing of training and research programs, is duly acknowledged.

The author would also like to express special appreciation and thanks to Dr. Lisa Kitinoja, International Postharvest Consultant, Oregon, USA for reviewing, editing and providing valuable suggestions in compiling this chapter.