

Postharvest Handling of Fresh Vegetables

**Proceedings of a workshop held in Beijing,
People's Republic of China, 9–11 May 2001**

Editors: Tim O'Hare, John Bagshaw, Wu Li, and Greg Johnson

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Foreword

WHEN the ACIAR project on postharvest handling of leafy vegetables that led to the workshop reported here was conceived, the remarkable changes in marketing systems for vegetables in China were only just beginning. The project developers thus showed considerable foresight in incorporating not only technology development, but also process mapping to identify gaps and needs in the chain between producer and consumer.

Since 1998, the Chinese and Australian project teams have had important opportunities to identify and address technology needs for marketing systems that have been changing year to year. As a result, the capacity for researchers in China and Australia to continue to provide dynamic technological solutions to constantly changing requirements has been considerably enhanced and I would like to commend all concerned with the project for both the opportunities and the outputs of their collaboration.

The project has examined the postharvest management of several key vegetables in China and Australia, and has generated options for enhancing their postharvest quality. It has been part of ACIAR's strategy to boost research and development investment in the postharvest sector, recognising that there was a critical need to both reduce losses, and extend the storage life and quality of vegetables in urban markets.

This workshop provided an opportunity to fully report on the project outcomes. It also introduced new research challenges that have been proposed in the fields of postharvest handling of melons and in improvements to microbial safety of fresh vegetables. Thus, we have coverage of not only what has been done, but also of what lies ahead.

Distribution and processing systems have played a significant role in the evolution of modern society over the last century. They are the means by which both developed and developing countries will bridge the gap between the haves and the have-nots of our society. They link the farmer to the towns, and the towns to the world.

When visiting a remote village in Jilin Province in northeastern China in 1998 to observe local government elections, Friedman (1999)¹ noted that, amongst the usual promises to the electorate of the two candidates for mayor, one candidate promised to get the villagers' vegetables to the township more quickly, while the other promised to give everyone the technology for making bean curd! Which candidate won? The one who promised to get the villagers' vegetables to the township!

Greg Johnson
Postharvest Program Manager,
Australian Centre for International Agricultural Research

¹ Friedman, T.L. 1999. *The lexis and the olive tree*. New York, Farrar Straus Giroux, 394p.

Preface

THIS workshop on postharvest handling of fresh vegetables was organised to highlight the impact of postharvest practices on the quality of vegetables reaching the consumer. It follows on from ACIAR project PHT/1994/016, 'Extending the shelf life of leafy vegetables', which included analysis of the current postharvest handling systems around the Beijing municipality, and in Zhejiang and Shandong provinces, in China.

The workshop was designed to provide an opportunity for postharvest specialists from China and elsewhere to discuss problems facing a number of commodities, and to build links between institutions to help solve these problems. To allow the full and efficient exchange of information, simultaneous translation during the workshop made all presentations available in both Chinese (Mandarin) and English.

Small group discussions were scheduled at various times during the workshop to brainstorm the main priorities for vegetable postharvest research and development in China. Key issues raised included:

- the need for technologies appropriate to cost structures in an industry;
- more emphasis on the whole postharvest handling system from farm to consumer;
- training and education of industry people and support staff;
- improved packaging and transport systems;
- improved storage technology for long-term storage of leafy vegetables;
- improved postharvest disease management;
- food safety;
- value-adding and processing;
- marketing strategies and supply-chain management; and
- export market access.

These and other issues were discussed in great detail at the workshop.

One of the benefits of a workshop such as this is the opportunity that it brings for postharvest specialists from a wide range of backgrounds to interact and develop closer linkages between the organisations they represent. It is our hope that this workshop has contributed to development of collaborative activities to improve postharvest handling of vegetables in China and elsewhere.

We thank the Australian Centre for International Agricultural Research (ACIAR) for sponsoring the workshop and publishing the proceedings. We also thank the Beijing Vegetable Research Center (BVRC) for organising the workshop, and all presenters and participants for their enthusiastic involvement.

The Editors

Opening Address

Wang Shixiong

Deputy Director, Beijing Municipal Commission for Science and Technology

Dear guests, ladies and gentlemen,

On the occasion of the opening of the workshop on postharvest handling of fresh vegetables, please allow me to extend warm congratulations on behalf of the Beijing Municipal Commission for Science and Technology. We welcome guests and representatives from the Australian Centre for International Agricultural Research and other organisations both from home and abroad.

Beijing, the capital of China, is a cosmopolitan city. Both vegetable production and supply play crucial roles in the Beijing market. Along with improving people's living standards and China's upcoming access to the World Trade Organization, both domestic and international markets require us to provide high-quality vegetable products. Postharvest technology will be very important in this regard.

China is rich in horticultural crop varieties. Vegetable acreage and output rank among the highest in the world. Exports of fresh vegetables and various processed vegetable products in recent years have been on the rise. Vegetable acreage in the suburbs of Beijing registered 60,000 hectares in 2000. Apart from supplying local markets, exports to other countries and other parts of the country reached 350,000 tonnes.

Agricultural modernisation of Beijing has been set as the principal target for future development. Industrialised, high-efficiency, agricultural demonstration projects conducted in recent years have promoted greatly the modernisation of Beijing vegetable production. Beijing is an important centre for research and extension of vegetable breeding, cultivation, and postharvest processing. Scientific progress in recent years has contributed a great deal to the production and supply of vegetables in Beijing.

International cooperative research projects and academic exchanges are important to the development of Beijing agriculture. Acknowledged experts and scholars both from home and abroad in the field of postharvest are attending this workshop. I hope the workshop will facilitate cooperation between the Australian Centre for International Agricultural Research and Beijing in postharvest handling of vegetables, and enhance research and the extension of postharvest technology.

May the workshop be a great success.

Thank you.

Problems and Countermeasures in Postharvest Handling of Fruits and Vegetables in China

S.Q. Feng*

Abstract

China is a large agricultural country and one of centres of origin of fruit. More than 30 species of fruits are produced for economic purpose, such as apple, citrus, pear, grape, peach, pineapple, lychee, longan, mango, banana etc. At the present level of fruit production, China has become the second largest producer in the world. Both her apple and pear production rank first in the world, and citrus production third. China is also one of the centres of origin of vegetables and is the world's largest producer of vegetables. However, the development of agriculture still faces great challenges, including the growing population, the continuously rising consumption level, the increasing demand for agricultural produce, the continuous shrinkage of farmland, the decreasing agricultural resources, and severe postharvest losses that need to be overcome.

The paper will deal with the postharvest problems encountered in agricultural products, especially fruits and vegetables. Topics to be covered include postharvest handling, storage methods, postharvest losses, packaging, food distribution, shelf-life extension, and some problems associated with social customs. It will introduce various aspects relating to the background, present situation, countermeasures, development, future targets, and international cooperation in the postharvest area.

IN China, agricultural research so far has been mainly concentrated on the improvement of crop production to achieve self-sufficiency in food in order to support the growing population. It is claimed that, in the near future, the food supply problems will be more complex as patterns of food consumption have improved in the region along with rising incomes and social development.

Postharvest technology should be given more emphasis, so as to prevent crop losses and use agricultural products more efficiently to meet the changes in the food demand, especially the demand for processed foods. The development of postharvest technology could contribute to securing a stable supply of food products in addition to an increase in agricultural income and improvement of the diet in China.

* Chinese Agriculture University, Beijing 100094, People's Republic of China.

Fruit and Vegetable Production

China is one of the centres of origin of fruit in the world and is recognised as the 'cradle of the orchard'. There are more than 300 species of fruit trees throughout the country and more than 30 species of fruits produced for economic purposes. They include apple, citrus, pear, grape, peach, jujube fruit, plum, apricot, hawthorn, kiwifruit, cherry, strawberry, banana, pineapple, lychee, longan, mango, red bayberry, coconut, and papaya.

Since the founding of the 'New China', the people's government has paid great attention to fruit production and has taken a series of effective measures so that fruit production has recorded a rapid development. Especially since the reform and opening-up policy and the lifting of restrictions on fruit markets, the enthusiasm of farmers for fruit production has markedly increased. Fruit production has contributed to crop production and become one of the major sectors in the

rural economy. By the end of 1994, China was devoting 7.264 Mha to fruit production, with an output of 35 Mt, increasing by 3.4 and 4.3 times, respectively, against the level of 1978. By the end of 1995 and 1996, fruit output was 42.15 and 46.53 Mt, respectively, and by 1998 and 1999, had reached 53.92 and 62.37 Mt.

At the present level of fruit production, China has become the second largest producing country in the world, with both apple and pear production ranking first in the world and citrus third. The outputs of apple, pear, and citrus were 11.13, 4.04, and 6.81 Mt, respectively, by the end of 1994. The outputs of apple, pear, citrus, and jujube fruit were 19.18, 8.59, 7.27, and 1.1 Mt, respectively, by the end of 1998. The outputs of apple, pear, citrus, grape, banana, jujube fruit, pineapple, and persimmon were 20.8, 7.74, 7.27, 2.7, 4.19, 1.1, 0.64, and 1.31 Mt, respectively, by the end of 1999.

China is also one of the centres of origin of vegetables and is the world's largest vegetable-producing country. Some 9.6 Mha of land are devoted to vegetable production, with an annual output of 2.4 billion tonnes by the end of 1995, rising to 4.05 billion tonnes by the end of 1999. Chinese cabbage, cucumber, tomato, flowery cabbage, glassy cabbage, purple cabbage, broccoli, eggplant, celery, potato, mini tomato, peppers, peas, lettuce, melons, mushrooms, chicory, kale, brussels sprouts, asparagus, and mini radish are among the most popular vegetables. More than 70 varieties are supplied to consumers and about 40 varieties can be marketed all the year round.

Postharvest Technologies and Problems

Lack of storage facilities and postharvest investment

The postharvest losses are still serious with a percentage of more than 35% in China. Although state financial support to agriculture has increased by 54 times and agricultural credit by nearly 26 times, the investment in postharvest technology is still very low compared with other sectors. State investment in postharvest technology is only 0.38% of that invested in production.

As living standards rise, people are seeking a greater variety of fruits and vegetables of higher quality. However, most fruits and vegetables are still stored in conventional warehouses, underground storehouses, and cave houses. The shelf life is usually very limited and the quality cannot be guaranteed.

There was no refrigerated storage for fruits and vegetables in 1950s. The first refrigerated storage for fruit was built in 1968 and the first controlled atmosphere (CA) storage in 1979, with a total capacity for storage by these means of less than 100,000 t at that time. At the beginning of the 1980s, refrigerated storage of fruits and vegetables increased rapidly, especially after the lifting of the restrictions on fruit marketing. The total storage capacity reached more than 6 Mt by the end of 1994, including 2.27 Mt of refrigerated and CA storage capacity. However, not all of the CA storage is operational because of technical problems including lack of fuel for some of the atmosphere-generating systems. Therefore, most fruits and vegetables destined for the market deteriorate very quickly after harvest. For example, only about 25% of apple production was put into some form of storage.

The situation and problems of postharvest techniques, handling, and transportation

There has been a remarkable development of storage technology and facilities over the past 10 years. Various types of CA equipment with good and reliable performance are now being designed and manufactured in China. Apple and garlic stalks stored by CA for 10 months fulfilled the quality requirements of international and domestic markets and were sold at a good price.

Modified atmosphere (MA) technology developed in China is now widely used. This includes: individual film wrapping of citrus fruits, cauliflower, broccoli, and other fruits and vegetables; storage of garlic stalks in large plastic bags; and tent storage of apples, garlic stalks, and other fruits. Using the MA technique, garlic stalks can be kept at a temperature of 0–1°C for 9 months with losses of about 5%. The firmness of apples stored by this technique in caves could be maintained at a value above 5.5 kg and the losses were less than 4% after 6 months of storage. MA packing storage provides a method that requires minimum capital and energy, and is not expensive to operate.

Although the production of fruits and vegetables is large, the quality of much of the output falls after harvest, because of poor postharvest handling. Treatments such as cleaning and washing, trimming, grading, sorting, pre-cooling, waxing, disease control, and suitable packing are usually not implemented before transportation, marketing, and storage. Most of fruits and vegetables are transported directly to market as raw products with no packaging whatsoever. Nevertheless, people have begun to pay increasing atten-

tion to postharvest handling. During the 1990s, over 40 sets of automatic washing, grading, waxing, and packing lines for citrus and apple were imported into several large production and commercial storage areas for fruits and vegetables.

China is a very large country. Most fruits and vegetables are transported by road without refrigeration. To reduce the temperature of fruits and vegetables, crushed ice is put between the products in the car during long-distance transportation. There are very few refrigerated vehicles for transportation of horticultural produce between provinces in China. Of the about 4200 refrigerated cars and more than 7000 refrigerated and insulated vans, most are used for transportation of agricultural products such as meat, poultry, fish, and eggs.

Owing to the poor transportation system, the total losses in transit can amount to more than 15–35%.

Recommended quality and packaging standards for several kinds of fruits and vegetables have been introduced. Commodities covered by these include apple, pear, kiwifruit, grape, tomato, cucumber, sweet pepper, egg plant, lettuce, Chinese cabbage, celery, broccoli, pod bean, and spinach. However, enforcement of the regulations is limited, except for export products. Most of packages currently used for fruits and vegetables are made of plant materials, for example, bamboo baskets, and are not suitable for soft products and stacking. Mechanical injury of fruits and vegetables is serious with the packages. Now cartons, and wooden and plastic boxes are used more commonly in storage and transportation in large cities.

Problems Existing in Agricultural Development and Future Targets

The development of China's agriculture faces great challenges such as the growing population, the continuous increase in the consumption level, the increasing demand for agricultural produce, the continuous shrinkage of farmland, and the decrease in agricultural resources. By the middle of the century, the population of China will reach 1.5–1.6 billion. While China is overall generally well endowed with resources, on a per capita basis the circumstances are not so favourable. For example, the area of land available per capita is only one-third of the world average.

Facing the aforementioned challenges, the Chinese Government has determined that it cannot import large quantities of agricultural products. Therefore, China

must adopt a strategy of self-reliance and integrated development, adhere to the national policy of family planning, expand rural reform and the opening-up policy, strengthen the international cooperation, develop and utilise land and other agricultural resources in a scientific and rational way, and preserve the agro-ecological environment.

China must also maximise the use of science, technology, and contemporary industrial methods to set a modern agricultural production system, and substantially increase land-use efficiency and labour and agricultural productivity, and reduce postharvest losses. With the development of agricultural science and technology and agricultural education, increased inputs of agricultural capital, technology, and materials (especially in the case of postharvest technology), and the improvement of performance of the market mechanism, the potential agriculture resources will be further tapped.

In the year 2000, the main target for agricultural development was to comprehensively improve the rural economy in order to steadily increase the outputs of the major agricultural products, and to satisfy the desire of the people for a comfortable life and the need to promote the development of the national economy in terms of quantity, variety, and quality. The aim was to increase annual fruit output 54 Mt and to reduce postharvest losses to less than 15%. Fruit output reached the target, but postharvest losses were still more than 15%.

The basic target for agricultural development in the year 2010 is to ensure that the major agricultural products, and products processed from them, satisfy both the needs of a people in transition from a comfortable life to a fairly affluent one, and that for a steady and comprehensive growth of the national economy. The output of fruits will reach 65 Mt and the total losses after harvest will be less than 10–15%.

Although China's agriculture is facing a very arduous task, the reform and opening-up policy to the outside world have created extremely favourable conditions for its development. With the enhancement of the reform and opening-up policy, China's agriculture and rural economy will be even more prosperous. The Chinese Government and people have the confidence and ability to rely on their own strength in solving the problems of food and clothing for domestic residents. China's agriculture will also make a contribution to the development of world agricultural production.

Agricultural Research, Education, Extension, and Cooperation

Following the introduction and development of a market economy in China, the existing agricultural science and research systems are no longer appropriate. The Chinese Government is making efforts to promote the reform of agricultural science and technology. So far, the basics of an agricultural science and research system administered both at central and local levels have been established, and the various agricultural universities and colleges have also built a relatively strong science and research force. According to 1993 data, in the agricultural sector nationwide, there are 1142 state-run independent research institutions. Between 1978 and now, they have won many prizes, and some of them are leading in the world. However, only some of their findings have been put into use. There are 67 agricultural universities and 210 agricultural schools. They have trained many agricultural specialists in China. The Chinese Government attaches great importance to technical and literacy education. By the end of 1994, continued education had been provided to 2.78 million farmers and adults.

China's agricultural extension system was first set up in the 1950s. At present, China has 213,000 agricultural extension units at township level and above. Among them, there are 59,500 extension units for crop farming, but only a few for postharvest of fruits and vegetables.

Up-to-now the Bilateral Agricultural Joint Committees or Joint Working Groups have been set up with more than 20 countries. Meanwhile, ties with major international agricultural organisations and more than 140 countries have been established for the exchange of agricultural science and technology and cooperation.

Summary and Priorities for Postharvest Technologies in China

It is clear that the low quality of fruits and vegetables is a result of poor postharvest facilities, technologies,

and processing practices. China should focus on the following problems of postharvest technologies:

1. Increase the capacity of refrigerated and CA storage for fruits and vegetables and improving the equipment used in storage, such as modern loading machines, transport belts and systems, cleaners, dryers, and elevators and automatic measuring units.
2. Improve the postharvest handling facilities and methods to achieve standardisation, commercialisation, mechanisation, and industrialisation of fruit and vegetable marketing.
3. Computerise the management of storage of fruits and vegetables so as to monitor product quality and ensure smooth distribution.
4. Apply integrated control against fungi, bacteria, and insects to reduce postharvest injury of fruits and vegetables during storage.
5. Improve methods of transport and develop a cold-chain distribution system from production areas to markets for fruits and vegetables.
6. Promote advanced research on postharvest physiology and technology of fruits and vegetables, especially for valuable fruits or new varieties such as Xhonghua peaches, Xinggao pear, jujube fruits, cherry, and some leafy vegetables.
7. Put new techniques of postharvest handling and storage for fruits and vegetables into use and reduce postharvest losses.
8. Establish postharvest technology training courses and a pilot centre to demonstrate postharvest handling treatment to farmers and students.
9. Formulate adequate policies in conjunction with technical measures.

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Postharvest Handling Systems Assessment for Vegetables in China and Australia

John Bagshaw*, Shufang Zheng†, Xiangyang Wang§, and Lung Sing Wong*

Abstract

The needs of industry are increasingly being targeted when planning research programs. This is frequently done informally by individual researchers or research groups, but often lacks a comprehensive study of the systems and people in the system. This may result in misdirected, inappropriate, or inadequate research programs that do not meet the needs of the industry groups concerned.

A component of the ACIAR project PHT/1994/016 “Shelf-life extension of leafy vegetables” was the assessment of postharvest handling systems for a range of vegetables in China and Australia.

The assessment methodology selected was an adaptation of ‘A commodity systems assessment methodology for program and project identification’ developed by J. La Gra of the University of Idaho, USA. We used the methodology in a series of case studies reflecting the main postharvest handling systems. Crops assessed were Chinese cabbage, oriental bunching onion, pak choi (in China), and broccoli (in China and Australia). We assessed:

- fresh and stored, and domestic and export, Chinese cabbage;
- stored oriental bunching onion;
- fresh pak choi; and
- fresh domestic and exported broccoli.

We also included in the assessment peri-urban production and product transported long distances to market.

This paper discusses the methodology used and its advantages and limitations.

THERE is increasing focus on targeting the needs of industry when planning research and development (R&D) programs. This is usually done informally by individual researchers or research groups, but often lacks a comprehensive study of the systems and

people in the system. This may result in R&D programs that do not meet the needs of the industry groups.

A component of ACIAR project PHT/1994/016, ‘Shelf-life extension of leafy vegetables’, was the assessment of postharvest handling systems for a range of vegetables in China and Australia.

A rigorous assessment of postharvest handling systems provides several benefits to R&D planning:

- it increases the likelihood that R&D outcomes will focus on industry needs;
- it improves adoption of research outcomes because they are more likely to be affordable, practical, and appropriate;

* Queensland Horticulture Institute, Queensland Department of Primary Industries, 80 Meiers Road, Indooroopilly, Queensland 4068, Australia. Email: <BagshaJ@prose.dpi.qld.gov.au>.

† Beijing Vegetable Research Center, PO Box 2443, Beijing 100089, People’s Republic of China. Email: <zhengshf@btamail.net.cn>.

§ Department of Food Science and Technique, Hangzhou University of Commerce, 29 Jiao Gong Road, Hangzhou City, Zhejiang Province 310035, People’s Republic of China. Email: <wangxyj@mail.hz.zj.cn>.

- it aids understanding of the impact of a technology or practice on the whole handling system. Conversely, it identifies where changes will need to be made in the whole system to accommodate a new practice or technology; and
- it identifies industry trends, allowing R&D focus to change accordingly.

The Methodology

The methodology selected was an adaptation of a more comprehensive systems assessment described by La Gra (1990). The method entailed the following steps:

- *Select case studies*

Case studies representing the main handling systems were identified using a range of criteria. Criteria will differ for each project.

- *Map process flows and document in a process flow chart*

Process flow charts were developed for each system, highlighting every step of the handling and marketing system. The scope of the study was from harvest to retail sale.

- *Describe and document each process in the handling system*

This was done concurrently with the above step. Qualitative and quantitative information was collected by observation, questioning, and measurement, and documented in summary table form.

- *Measure losses where they have been identified as significant*

Where subjective assessment indicated reasonable losses, then actual losses were measured. Losses can vary widely from consignment to consignment depending on weather, season, handling variables, and the people involved. Most of the losses measured were for normal handling conditions.

- *Identify key problems/issues in the handling systems*

Based on data, major loss points and causes of losses were identified.

- *Identify potential solutions, or further R&D required*

After analysing the data collected, the project team identified some potential solutions and future areas of R&D in the handling systems. These included training and extension needs where applicable.

The assessment approach used observation, interviewing, measurement, and qualitative judgment to gather and assess information. Postharvest technology R&D personnel conducted the assessments.

Case Studies

Case studies were selected to represent a range of vegetable postharvest handling systems in China. Studies were conducted in northern China (around Beijing) and central-eastern China (around Zhejiang Province). These are two of the major vegetable production regions in China. Case study selections in these regions were based on crops and season, whether the crop was to be stored or fresh marketed, whether it was for the domestic or the export market, and the distance to market. In addition, one case study was conducted in Queensland, Australia as a model assessment. Table 1 summarises the case studies conducted in this project.

A questionnaire was developed to ensure completeness of information and consistency between case studies. Information generated from these case studies was summarised into tables based on process flow diagrams for ease of analysis. The format of these tables is shown in an appendix to this paper.

Table 1. Postharvest handling assessment case studies.

Crop	Region (season/marketing profile)	Distance to market
Chinese cabbage	Beijing (autumn fresh domestic/export)	180 km
	Beijing (winter stored)	Peri-urban
	Hangzhou (summer/winter fresh)	Peri-urban to 800 km
	Hangzhou (winter stored)	1600 km (Shandong province to Hangzhou)
Broccoli	Beijing (summer fresh domestic/export)	180 km
	Queensland, Australia (winter fresh)	100 km
Oriental bunching onion	Beijing (autumn harvest stored over winter)	80 km
Pak choi	Hangzhou (summer/winter fresh)	Peri-urban to 25 km

Benefits of the Methodology

This methodology was developed to identify, in particular, the technical dimension of vegetable postharvest handling systems, the product losses within the systems, and the causes of losses. From this information, potential improvements and areas of research were identified. Staff from three research organisations conducted the assessments in China and Australia.

During the conduct of the assessments the following benefits became apparent.

- Technical experts can often identify issues and potential practical solutions that may not be recognised by those operating within the system. Outsiders to a handling system can bring a fresh perspective and wider knowledge of opportunities that, when tempered by input from the system participants, can provide very useful ways to improve a system, easily and at low cost.
- Researchers had the opportunity to observe and understand first-hand the whole handling system that their research programs aim to improve. Discussions with farmers, collectors, transporters, wholesalers, and retailers provide an understanding of the handling system from their perspective. Armed with this information, researchers are better equipped to undertake applied research and/or plan effective extension strategies.
- The scope of the assessments was from harvest to retail sale. This provided insights into all parts of the postharvest handling system, rather than focusing on one aspect or one client group within the system. As a result, the methodology enabled more understanding of the impact of a technical or process intervention on the whole system. This in turn highlighted where changes would be needed in the whole system to accommodate new technologies or processes, and who should be targeted in any training or extension programs.
- The methodology identified postharvest handling system linkages. These linkages between the players in the system may be financial or institutional. An understanding of the linkages helps to identify who wields influence in a handling system, and so who to target to bring about effective change.

Limitations of the Methodology

It is important to understand the limitations of any methodology or process so that measures can be taken

to minimise the effects of the limitations, and/or results can be interpreted in context. Limitations of this methodology include the following.

- Some businesses may be unwilling to be studied. There may be various reasons for this. Whatever they are, they must be respected. Approaches to businesses or systems need to be done tactfully, assurances given of confidentiality, and all information collected so treated.
- Because this method relies on a limited series of case studies, there is the danger that they will not adequately represent the range of handling systems within an industry. They need to be selected carefully to ensure most industry circumstances are represented. The number of case studies selected will depend on how well the assessment project is resourced.
- Each case study observes and measures at a point in time. Handling practices and losses may vary from season to season, or even consignment to consignment, depending on weather and market conditions, or any number of other factors. Measures to minimise this problem include conducting case studies during different seasons, targeting those periods of perceived greatest risk (for example, warm, wet, summer conditions in China), and to question people in the handling system about issues, activities, and problems outside the time of the case study.
- Little involvement of industry ‘players’ in determining solutions to problems or determining research needs. In our project, the assessment team (consisting of researchers) conducted this activity. There are many benefits from involving industry in this process including:
 - more complete consideration of practical issues, both technical and non-technical;
 - clearer identification of barriers to adoption of solutions, and so improved strategies for overcoming these barriers; and
 - improved adoption of technologies or processes as a result of more ‘ownership’ by the industry because they have contributed to the final R&D plan. This is more likely to happen if influential industry groups or individuals are involved in the planning phase.
- Our assessments concentrated mainly on the technical aspects of the handling systems, with some unplanned minor assessment of economic, social, and infrastructure issues as participants raised them. La Gra (1990) included these factors in his methodology, but we could not because we had

limited resources and staff. Factoring in this broader analysis with more resources and a more multidisciplinary team could improve the methodology.

Conclusions

The methodology has provided valuable information to the research organisations involved in the ACIAR project and given them a clearer vision for future R&D planning.

A critical step during development of R&D programs is to ensure technologies and processes suggested for improving the handling systems are

practical and appropriate to the infrastructure and resources available to people and organisations within the handling system.

Postharvest handling system assessments need to be linked to robust extension and training programs to ensure improvements are widely adopted by the industry.

Reference

- La Gra, J. 1990. A commodity systems assessment methodology for problem and project identification. Idaho, USA, University of Idaho, College of Agriculture, Postharvest Institute for Perishables.

Appendix

Format of tables used to summarise information gathered during surveys

Table 1. Case study: _____ **Region:** _____

Steps	Action type	Temperature	Distance	Time taken	Observations

Table 2. Case study: _____ **Region:** _____

Steps	Impact of losses (H = High, M = Moderate, L = Low)		Comments
	Quantity	Quality	

Table 3. Case study: _____ **Region:** _____

Step (loss point)	Cause of losses	Suggested solution/further research/ comments

Assessment of Postharvest Handling Systems for Vegetables in Beijing

Shufang Zheng, Wu Li, Lipu Gao, and Ping Wu*

Abstract

The postharvest handling systems for Chinese cabbage, broccoli, and oriental bunching onion were evaluated from harvest to market.

For Chinese cabbage there are three kinds of distribution: fresh, storage, and export. For fresh Chinese cabbage, for which no packaging was applied, losses (about 10–15%) were the result of trimming off old leaves. Pit storage and ventilated storage were used to store Chinese cabbage. Before storage, Chinese cabbage must be trimmed several times and sun-baked to remove excess water. During storage, energy consumption and abscission cause 20–30% loss depending upon the length of storage. No pre-cooling was applied to either fresh or stored Chinese cabbage. Chinese cabbage destined for export has strict handling requirements. First, the product must be trimmed to the degree specified by the purchaser. The cabbages are then pre-cooled in cold room and packed. Trimming before pre-cooling caused losses of 30–45%.

The harvest time for broccoli is usually in the hot season. For the domestic market, no cold chain is available to transport, pre-cool, and store broccoli. Also, the vehicles used to transport the crop provide poor conditions. After more than two hours transportation in hot weather, the quality of broccoli had obviously declined. For export broccoli, on the other hand, every available facility was provided to maintain the commodity, from coldroom through to high quality packaging. However, when coldroom pre-cooling was applied, water loss and efficiency were compromised.

Oriental bunching onion is popular as a spice and fresh vegetable. Harvest time is usually at the end of October. The only packaging used was to wrap the onion bunches in straw sheaves. Bunching onion is not very sensitive to mechanical damage. The main losses after harvest were from water loss and broken leaves. Bunching onion also can be backyard-stored during winter but with high losses. During storage the leaves become dry, but the stem remains fresh with the protection of outer leaves.

For the domestic market, none of the vegetables was provided with good packaging and pre-cooling because these are too costly. For export, all available cold resources were exploited to maintain the quality of produce, though not with any great expertise. At most times in Beijing the humidity is not high (about 40–60%). Thus, vegetables left without protection in the marketplace are inclined to lose water and become unattractive.

VEGETABLES play a very important role in Chinese food. In Beijing, for example, 140–160 kg of vegetables are consumed per capita each year. In contrast with

increases in the vegetable production area and volume, only in recent years has the postharvest handling system attracted the attention of farmers and government. In order to improve and promote new techniques in the postharvest handling system, we conducted assessments of the handling systems for three vegetable crops in the Beijing area: Chinese cabbage, broccoli, and oriental bunching onions.

* Beijing Vegetable Research Center, PO Box 2443, Beijing 100089, People's Republic of China. Email: <zhengshf@btamail.net.cn>.

Assessments

Depending upon crops and production time we conducted the assessments in different production areas and markets. We carried out evaluations in Daxing, Tongxian, and Yanqing counties, which are satellite towns of Beijing, and in Jixian County of Hebei Province, which is a suburb very close to Beijing. Every operation relating to postharvest handling and the losses at each step were recorded and analysed, from harvesting, through pre-cooling, packaging, and transportation, to marketing. At same time, farmers, businessmen, wholesalers, and retailers were interviewed about their operations and their level of skills in post-harvest techniques.

Chinese cabbage

Chinese cabbage is so important to Beijing that it was not until 1995 that the city government released its control on production and distribution of the crop. The production season for Chinese cabbage falls mostly in autumn, between early August and the end of October, but a small amount is also produced during summer. Although a very large area is planted to the crop, no heavy machine is used at any stage from seeding to

harvest. In China, intensive production of vegetables is adopted because of the low area of arable land per capita and the vast labour surplus.

According to its distribution, Chinese cabbage after harvest can be categorised into three groups: cabbage for export; cabbage for the fresh market; and cabbage for storage. The different treatments involved are illustrated in Figure 1.

Process analysis and description for Chinese cabbage

Chinese cabbage for export. Trimming is done twice: first, during harvesting, yellow or rot-infected leaves are removed; and second, at the collection centre, under the guidance of the collector. Damaged leaves are removed before packaging. Most export countries require green leaves (usually four or more) to be removed from the head. Coldroom pre-cooling is used and this causes some water loss. Refrigerated transport is used for export produce. Chinese cabbage is kept at a constant 0–2°C after harvest so losses are low and quality is guaranteed.

Chinese cabbage for storage. Chinese cabbage is stored over winter because crops cannot be grown during this time. Storage begins in early November and may last 4–5 months.

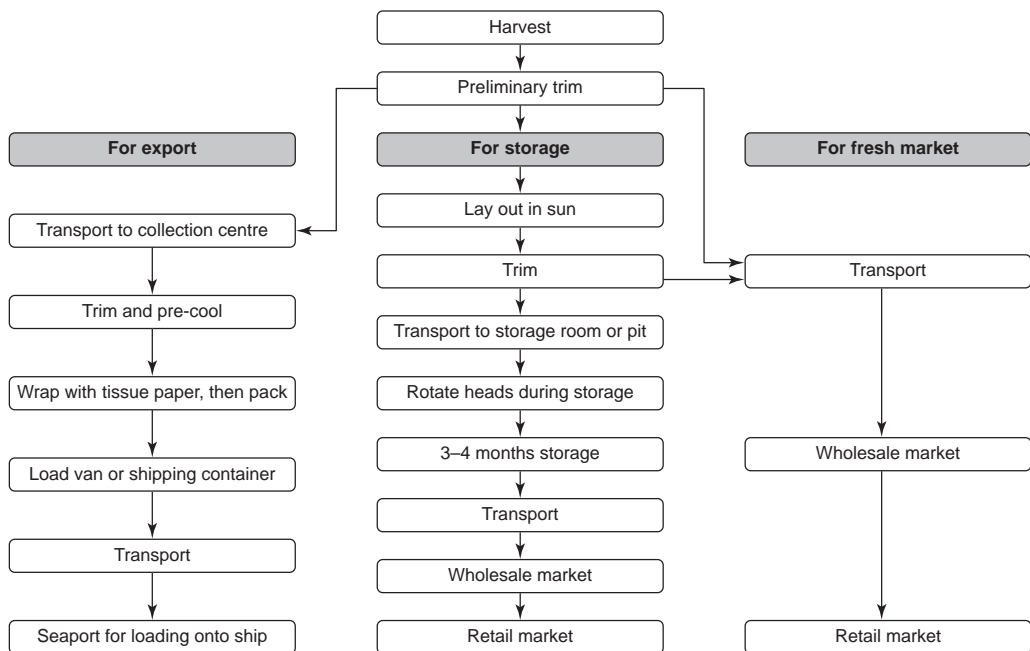


Figure 1. Postharvest process map for Chinese cabbage

During harvesting, yellow or rot-infected leaves are removed. Spreading out the crop in sunlight causes some water loss but hardens the heads to resist disease in storage. Before loading storage pits, leaf tips are removed to reduce rots. During long storage, heads are rotated and trimmed at intervals to remove abscised or yellow leaves. Freezing can sometimes affect heads in storage. During transportation to wholesale or retail markets, mechanical damage and freezing may result in minor losses.

Storage losses are the major loss point for Chinese cabbage and can be reduced by storing in temperature-controlled, ventilated rooms (around Beijing about 10% of Chinese cabbage is stored in this way). Growers who store Chinese cabbage in underground pits can reduce rots and leaf abscission by improving stacking of heads and ventilation of the pits to encourage more air movement around the heads.

Chinese cabbage for the fresh market. Fresh market Chinese cabbage is not pre-cooled or transported using refrigerated trucks. Domestic prices do not justify the use of expensive refrigeration. Most losses are caused by leaf trimming and mechanical damage. The heads of cabbage are trimmed three times: during harvest; at collection centres; and at wholesale markets. Some leaf trimming is essential and some can be avoided. Rough handling and lack of packaging during transport results in mechanical damage.

Good packaging and cold storage would certainly reduce unnecessary losses, but would not be cost-effective for domestic marketing.

Loss measurement of Chinese cabbage

The various handling operations resulted in different percentage losses of commodity, as detailed in Table 1.

Broccoli

Broccoli was introduced into northern China 10 years ago. As a nutritious and high-value crop, it has been widely accepted by farmers and consumers. Because broccoli is very sensitive to water loss and mechanical damage, farmers and businessman take much more care during harvest, packaging, transportation, and marketing of broccoli than they do for other crops. Also, as with Chinese cabbage there are two distribution channels for broccoli: commodity for the domestic market and commodity for export (Figure 2). High quality broccoli is usually segregated for export and handled with care, while lower quality produce destined for the domestic market is handled with much less care in terms of packaging and transportation.

Process analysis and description for broccoli

During harvest and transit to collection centres, there are almost no losses. Minor losses result from loose, infected, and damaged heads (rejected at harvest). Every operation is carried out by hand and with care.

At collection centres, the broccoli heads are sorted into export and domestic quality under the collector's scrutiny. As noted above, higher quality broccoli usually goes to the export market.

Broccoli for export. After sorting, the stems are trimmed to a standard length. Exporters favour compact heads of 20 cm diameter. The heads are then pre-cooled in a coolroom. Water loss of about 1% occurs during pre-cooling, and there is also some minor mechanical damage. A cold chain is used for export commodity. Other operations do not cause losses or damage.

Table 1. Measured losses of Chinese cabbage at various stages after harvest.

Cabbage for export		Cabbage for storage		Cabbage for the fresh market	
Operation	Loss (%)	Operation	Loss (%)	Operation	Loss (%)
Harvesting	5	Harvesting	5	Harvesting	5
Trimming at collection centre	45–50	Spreading out in sunlight	2–3	Trimming	3–5
Pre-cooling and packaging	2–3	Trimming	1–2	Transportation	3–4
		Storage	40–45	Market	5
		Transportation	3–4		
		Market	2–3		

Improved packaging and palletisation would reduce mechanical damage, and might be justified for export broccoli.

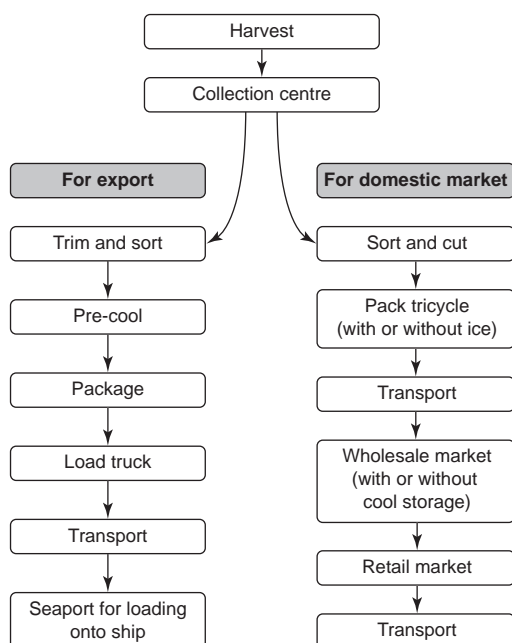


Figure 2. Postharvest process map for broccoli.

Broccoli for the domestic market. Substandard broccoli will be diverted to the domestic market, where even florets are tied together and sold. The main problem for the domestic market is that the cold chain cannot be guaranteed and broccoli suffers heat damage during the time between harvest and retail marketing. The shelf life is only 2 days. Losses occur at collection centres (from rough cutting and handling), during transport, and at wholesale/retail markets where high temperatures leading to rapid deterioration.

Loss measurement of broccoli

Broccoli for export was handled with care so the water loss and mechanical damage were very low. Produce for domestic market, on the other hand, was subject to large losses because of bad treatment and handling (Table 2).

How losses could be reduced

- Use stackable crates for field packing and transport to collection centres

- Handle the product with greater care at collection centres
- Introduce ice or pre-cooling, and insulated bases and covers, during transport to market
- Use cartons for transport and marketing
- Improve conditions at wholesale and retail markets.

Table 2. Measured losses (%) of broccoli at and at various stages after harvest.

Export broccoli		Broccoli for the domestic market	
Operation	Loss	Operation	Loss
Harvest	0	Harvest	0
Trimming and cutting	5–7	Trimming and cutting	10–15
Pre-cooling	1	Transportation	2
Packaging	0	Wholesale market	0.5
Transportation	0	Retail market	2–5

Oriental bunching onion

Bunching onions, one of the important spices in Chinese food, are harvested at about the same time as Chinese cabbage, just before the first frost. The stems of bunching onions are not sensitive to water loss because a protective sheath is formed after the surface dries. At low or freezing temperatures, bunching onions can be stored for 4–5 months, but with high losses because of drying of the leaves. In the Beijing area, bunching onions are usually stored in farmers' courtyards with little cover. The dry winter and spring thus cause massive water loss. Bunching onion is a crop that is treated with minimal care after harvest (Figure 3).

Process analysis and description for oriental bunching onions

Although bunching onions are handled roughly at all stages (dropped, tossed, and trodden on on top of loads), the crop is relatively resistant to mechanical damage. Most losses occur during transportation, storage over winter, and at the wholesale and retail markets.

During loading and transportation some leaves are broken and drop, and heat accumulation during transport stimulates water loss. At market, in order to display produce, it is exposed to sunlight and further loss occurs. Discoloured or wilted leaves are stripped from the stem.

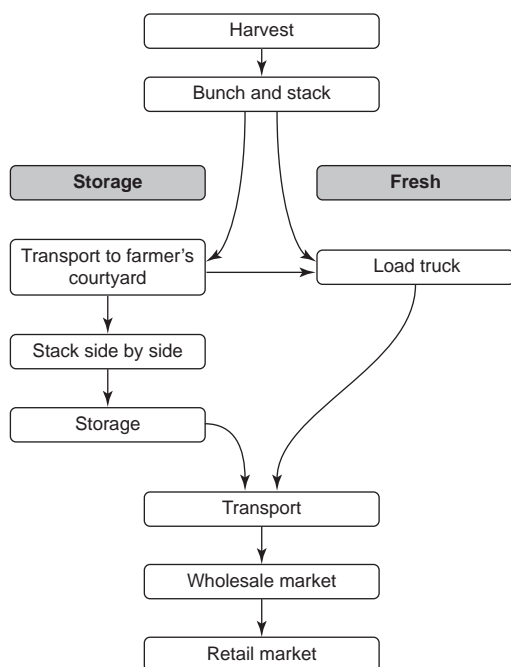


Figure 3. Postharvest process map for oriental bunching onion.

The greatest loss occurs during winter storage when water escapes from leaves and stem skin. Sometimes rot can spread through bunches when they are exposed to rain.

Cool storage and film packaging would be good technical choices for storage, but the low value of bunching onions does not justify the high cost of these technologies at present.

Loss measurement of oriental bunching onions

Water loss is the main cause of the postharvest losses in oriental bunching onions detailed in Table 3.

Table 3. Measured losses (%) of oriental bunching onions at and at various stages after harvest.

Onions for storage		Onions for the fresh market	
Operation	Loss	Operation	Loss
Harvest	0	Harvest	0
Bunching and stacking	0	Bunching and stacking	0
Transit to courtyard	0.5–1	Loading and transportation	5
Storage	45–55		
Wholesale market	0.5	Wholesale market	5
Retail market	0.5	Retail market	2–3