Horticultural Chain Management for Eastern and Southern Africa

A theoretical manual

Horticultural Chain Management for East and Southern Africa

A TRAINING PACKAGE

THEORETICAL MANUAL

Commonwealth Secretariat
London, United Kingdom

Food and Agriculture Organization (FAO)
Rome, Italy

March 2008

Published by the Food and Agriculture Organization of the United Nations and the Commonwealth Secretariat
Edited by Jane Lanigan
Cover design by Tattersall, Hammarling and Silk
Printed by Hobbs the Printers Limited, United Kingdom

A catalogue record for this publication is available from the British Library.

ISBN 978-0-85092-858-7 Commonwealth Secretariat edition
ISBN 978-92-5-105956-2 FAO edition

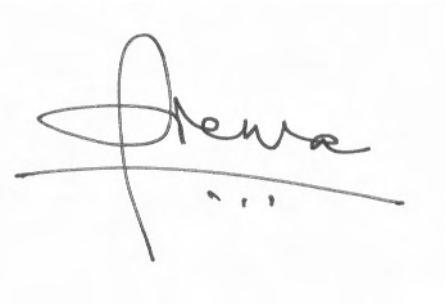
FOREWORD

In November 2005, the Rural Infrastructure and Agro-industries Division of the United Nations Food and Agriculture Organization (FAO) and the Special Advisory Services Division of the Commonwealth Secretariat agreed to work together to help strengthen human capacities in horticultural chain management in East and Southern Africa in response to needs expressed by member countries of that region. Formal agreements were established with the University of Pretoria, South Africa, for the development and implementation of a 'Train the Trainers' programme. The core curriculum of the programme focused on practical approaches to assuring the safety and quality of horticultural produce and on efficient organisation of the supply chain in order to improve the competitiveness of small and medium-sized enterprises (SMEs) and farmers in domestic and regional markets. The training programme was held at the University of Pretoria, South Africa, in June 2006 and drew participant trainers from nine countries in the East and Southern African region. This training package has been produced as a direct result of that programme.

The training package consists of a theoretical manual and a practical manual. The practical manual is designed to complement the theoretical manual and to provide the trainer with simple practical tasks that reinforce and enhance comprehension of theoretical training. The whole package is structured to provide the trainer with sufficient technical background and reference materials to allow him/her to customise training in accordance with the needs of the target group to be trained.

It is hoped that this training package will stimulate improvements in fresh produce supply chains across the region, leading to safer produce of higher quality and to better economic returns for SMEs and small-scale producers.

FAO and the Commonwealth Secretariat welcome feedback from the users of this training package. Comments and critiques, as well as contributions on the contents, will help to improve future editions. Comments should be e-mailed to Rosa.Rolle@fao.org and T.Williams@Commonwealth.int.



Geoffrey C. Mrema
Director
Rural Infrastructure and Agro-Industries Division
Food and Agriculture Organisation of the United Nations

George Saibel
Director
Special Advisory Services Division
Commonwealth Secretariat

Horticultural Chain Management

Theoretical Manual

Professor Lise Korsten, Principal Author
University of Pretoria, South Africa

Dr. Dharini Sivakumar, Contributing Author
University of Pretoria, South Africa

Dr. Rosa Rolle, Contributing Author and Technical Editor
Food and Agricultural Organization of the United Nations
Rome, Italy

Dr. Divine Njie, Contributing Author
Food and Agriculture Organization of the United Nations
Rome, Italy

Ms. Hester Vermulen, Contributing Author
University of Pretoria, South Africa

CONTENTS

ACKNOWLEDGEMENTS

The preparation of this training package was co-ordinated by the University of Pretoria Department of Microbiology and Plant Pathology. The contributions of Mr. D. Jordaan, Dr. K. Krüger, Ms. A. Lombard and Ms. K. Zeeman of the University of Pretoria, Dr. T. Williams of the Commonwealth Secretariat and Dr. S. Minae of the Food and Agriculture Organization (FAO) in the compilation of this training package are gratefully acknowledged.

ACRONYMS

ASAE	American Society of Agricultural Engineers
CAC	Codex Alimentarius Commission
CIAT	International Institute of Tropical Agriculture (Columbia)
COLEACP	Comité de Liaison Europe-Afrique-Caraïbes-Pacifique
DAFB	Days after full bloom
EFSA	European Food Safety Authority
EMRL	Extraneous maximum residue limit
EPPO	European and Mediterranean Plant Protection Organization
EPOPA	Export Promotion of Organic Products from Africa
FAO	Food and Agriculture Organization of the United Nations
FIFO	'First in first out' method of storage
GAP	Good Agricultural Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Point
IFOAM	International Federation of Organic Agriculture Movements
IFAD	International Fund for Agricultural Development
IMA	International Maritime Organization
IMF	International Monetary Fund
IPPC	International Plant Protection Convention
MAP	Modified atmosphere packaging
MRL	Maximum residue limit
PFA	Pest-free area
PPECB	Perishable Products Exports Control Board
SSC	Soluble solids content
SPS	Sanitary and phytosanitary standards
TSS	Total soluble solids
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture
VPD	Vapour pressure deficit
WB	World Bank
WHO	World Health Organization
WTO	World Trade Organization

SECTION 1

ORGANISATION, PLANNING AND EFFECTIVE DELIVERY OF THE TRAINING PROGRAMME

SECTION I

MODULE 1 – BACKGROUND TO THE TRAINING PACKAGE[1]

Learning outcomes

The learner should understand how to:

- Use the training manual effectively

Introduction

This training package is designed to provide background to guide the trainer in preparing training materials appropriate to the context in which the training will be delivered. In order to derive maximum benefit from the training package, it is essential that the trainer study the theoretical and practical manuals, selecting the practical examples that are best suited to the training context (country, crops cultivated, target audience and so on). In preparing training material, the trainer must take into account the literacy level, language and knowledge base of his/her target audience.

Working through the theoretical manual

The purpose of the theoretical manual is to take participants through a step-by-step approach of progressive learning. This manual provides the trainer with a platform of information that can be used to design and tailor-make courses that are applicable to the context in his/her respective country. Each theoretical section is presented concisely in a modular format and is followed by or linked to a practical exercise. On completion of each theoretical section, participants are required to share information assimilated during a plenary discussion session. Participants must also apply the knowledge acquired through practical experiments or tasks.

Throughout the theoretical manual, references have been listed that provide additional sources of information. It is essential that the trainer consult new information to ensure that he/she stays up-to-date with the latest trends and continuously improves and adapts the training materials. Many of the web resources cited are themselves continuously updated and represent an excellent source of basic information that can be used for tailoring courses to the needs of a target audience.

Appendices have been compiled to provide additional background material for the trainer. Additional resources can be added or information can be updated and included in the appendices to ensure that this information remains current.

Working through the practical manual

The practical manual is designed to complement the theoretical manual and to provide the trainer with simple practical tasks that reinforce and enhance comprehension of the theoretical training on horticultural chain management. It includes demonstrations, hands-on activities, tasks (the development of questionnaires and the conduct of interviews, for instance), problem-solving challenges and field visits with a focus on observation and recording. The trainer may also use the practical guide for the development of context-appropriate hands-on training packages for small-scale farmer-learner programmes.

[1] Prepared by L. Korsten.

REFERENCES

Food and Agriculture Organization of the United Nations (1998) Food quality and safety systems – a training manual on food hygiene and the Hazard Analysis and Critical Control Point (HACCP) System. Available at: http://www.fao.org/docrep/W8088E00.htm

SECTION I

MODULE 2 – PREPARING FOR THE TRAINING PROGRAMME[1]

Learning outcomes:

The learner should understand how to:

- Plan a training programme effectively
- Assess the training requirements of the programme participants

Introduction

A well-planned training programme is the basis of effective information transfer. It should integrate dimensions of academic excellence, hands-on experience, tasks, discussion sessions, excursions, formal lectures and a social dimension to allow for interaction and knowledge sharing. It is critical that these dimensions of the programme are presented in a balanced format so as to ensure maximum absorption of information and knowledge sharing.

The venue of the training programme should also create a stimulating environment that is conducive to learning and to the delivery of training. The programme must conform to the needs of the participants and must incorporate consideration for possible shortcomings of the facilities and other issues.

Planning the training programme

When planning a training programme, consideration must be given to basic principles of adult learning. A typical training programme should incorporate adequate breaks for reflection, discussion sessions to stimulate thought and to challenge participants and practical exercises that relate to the theoretical work covered during lectures. A training programme should not be too intensive and should include short sessions with an adequate number of short breaks in between. A sample training programme is shown in figure I.2.1.

Planning the practical exercises

Practical exercises must fit in with the training environment. The trainer must plan adequately in order to ensure that the required equipment and facilities are available for successful completion of tasks.

If possible, an excursion or two to a local fresh produce market, a fruit and vegetable shop, a supermarket or a retail outlet should be included in the programme. During the excursion, participants should be required to perform short tasks that allow them to link their observations to the theoretical training exercises. Tasks of this type keep trainees stimulated and give them time to reflect and consider their own experiences.

Tasks can be assigned for discussion in either horizontal or vertical groups (see below). By using either horizontal or vertical groups, the trainer can obtain different levels of input and areas of focus. In certain cases, a group opinion is important while with other tasks a cross-cutting opinion from various disciplines would be more appropriate. Regular discussion sessions are valuable in forcing participants to consider their own situations and to reflect on new knowledge acquired.

[1] Prepared by L. Korsten.

A balance is also essential for optimum interaction within the groups. Too many strong, dominant participants may suppress inputs from less vocal participants. In such cases it is preferable that groups include a balance of different personalities.

Horizontal groups – groups of people coming from different fields of experience and having different levels of responsibility, i.e. individuals from government, industry, the export sector, associations or co-operatives, commercial and small-scale farmers.

Vertical groups – individuals from more or less the same background, e.g. a group comprising small-scale farmers, or one made up of academics or government officials.

Planning the assessment process

An assessment of the approaches to be used during the programme should be determined. In certain cases an approach of continuous assessment in an informal manner may be more effective than the administration of an end-point examination, which can be stressful for participants. A range of assessment formats can be used, with those best suited to the needs of each specific audience being selected. Continuous assessment of trainer participation throughout the programme will necessitate the assistance of support staff. A combination of assessment tools is often best and makes the process less stressful for the organisers and the trainees.

Selection of presenters for the training programme

It is essential that presenters be selected on the basis of their experience and communication skills. The practical experience of a farmer or retailer is often more effective than theoretical presentations by academics. Speakers must be selected well in advance of the training programme. Arrangements must be made for their formal invitation, remuneration and their recognition prior to the workshop. Special transport and accommodation arrangements must be made for presenters if required. Presenters must be familiar with the venue, the audience and what is expected of them. A brief Curriculum Vitae (CV) may be required to introduce each presenter. Each presenter must be thanked and perhaps awarded a simple token of appreciation for his/her input and time. A courteous thank you letter afterwards is essential. Audience feedback is also helpful for improving future presentations.

Selection of the venue for the training programme

When deciding on the venue for the training programme, the following must be considered:

- Cost of in-house or out-sourced training;
- Budget available for training;
- Purpose of the training programme:
    - Is it designed to train small-scale farmers in rural areas?
    - Is it designed to train the public and or the private sector?
- The duration of the programme;
- The venue of the training programme: if in a rural area, provision must be made for the use of papers, posters and clipboards should electricity be unavailable;
- Number of participants that can be accommodated at the venue; and
- Transport costs, accommodation costs, as well as the cost of meals, refreshments and access to administrative support, i.e. fax and photocopy machines and so on.

Selection of participants

Selecting the correct combination of participants at various levels of involvement in the horticultural supply chain could be an effective mechanism for stimulating active participation in the training programme. An alternative approach is to offer the training to a defined group of stakeholders such as small-scale farmers. In such circumstances, it is essential that presenters from various sectors of horticultural chains be invited to contribute in their fields of specialisation.

Assessment of training requirements

Prior to selecting participants, the trainer must have some knowledge of the background of the trainees and their expectations. This can be done through a simple analysis, using a basic needs assessment form. The complexity of the form will depend on the composition of the group of trainees. In situations where the trainees make up a diverse audience (for example, a mix of exporters, transporters, government officials etc.) a form such as that shown in figure I.2.2 would be appropriate for this assessment, while in situations where trainees constitute a simple target group, the form shown in figure I.2.3 would be more appropriate. The forms should be analysed prior to the training programme in order to facilitate targeting of knowledge transfer, defining the level of detail that should be included in the course and to facilitate identification of the most relevant information.

On the basis of an analysis of the completed forms, specific learning objectives can be formulated by the trainer. The following should, therefore, be considered prior to planning the training programme:

- Purpose of the training programme
- Participant knowledge of the subject
- Learning goals of participants
- Participant interest in the subject
- Background of participants
- Commonalities shared by participants

Figure I.2.1. A sample programme for a training workshop

Training Workshop Schedule

Day 1: Arrival and registration

- Meet delegates
- Registration desks
- Welcoming address
- Opening address
- Presenter gives background information
    - Aims and objectives of the workshop
    - Explaining how the workshop will run
    - Household matters
    - Asks participants to complete the expectations form
- Welcoming reception

Session 1 Theme: 'Knowing the Consumer'

- Welcoming: plan for the day, household matters
- Lecture: *'Understanding the consumer'*
- Practical: How to design a questionnaire
- Coffee and tea break
- Lecture: '*Consumer behaviour*' (the nature of consumer behaviour)
- Lunch
- Visit a retail or informal market and interview consumers
    - ***Activity 1:*** *'Understanding consumer behaviour'*
      Application of the theory of consumer behaviour in terms of food products and food advertisement examples (small group discussions with feedback)
- Discussion session and data analysis
- Giving feedback from the day's activities
- Supper and social interaction

Session 2 Theme: 'Knowing your Customer'

- **Field visit 1: Visit an informal market**
- Coffee and tea
- Lecture: '*International trade requirements*'
    - Discussion session
- Lunch
- Lecture '*How food chains work*'
    - ***Activity 4:*** Draw your own value chain using your own product
- Coffee and Tea
- Lecture: '*Post-harvest handling*'
    - ***Activity 5:*** '*The impact of handling on product quality'*
    - Packing your own fruit and storing it under different conditions
- Wrap up day's activities and discuss activity and practical results

Session 3 Theme: 'Understanding the Food Chain'

- Welcome; activities and lectures for the day; household issues
- Lecture: *'Importance of markets in trade*'
    - Market access and establishment of new markets
- Coffee and tea
- Lecture: '*Understanding the challenges faced in product procurement and minimal processing*'
- Lunch
- Lecture: '*Putting the chain together again*'
    - Importance of transport systems in the food chain
    - Task: design product flow lines
- Coffee and tea
- Lecture: '*Pack house management, hygiene and standards'*

- Hygiene standards, food safety systems and HACCP
- ***Practical 4:*** *'Practical experiments to ensure food safety compliance'*

- Wrap up discussions, tasks and give feedback
- Supper and social interaction

Session 4 Theme: 'Impact Factors on Post-harvest Quality and Safety'

- Lecture: '*Post-harvest factors impacting on quality*'
  - How harvesting and handling impact on quality
  - Packing and packaging materials
  - How packing practices can impact on quality
- ***Practical 4***: *'How to measure quality'*
- Coffee and tea
- Lecture: '*Examples of some insect pest spp. of importance in sanitary and phytosanitary trade issues*'
- Lecture: '*Effective management of post-harvest diseases*'
  - Discussion session
- Coffee and tea
- Lecture: '*Chemical control of pests and diseases*'
  - Practical demonstrations: '*How to apply pesticides and calibrate equipment effectively*'
  - ***Task 8:*** *'How to calculate spray dosages accurately'*
- Closing session and thanking all
  - Feedback from all evaluations and practicals
  - Closing words
  - Participants evaluate course

Figure I.2.2. Sample form for the assessment of training requirements of a diverse audience

WHAT ARE YOUR EXPECTATIONS OF THE COURSE?

Please complete the form and answer all questions

Full name and surnames: …….
Job title: ……..
Company/institution that you work for: ……
Contact details, e-mail: ……..
Tel no: country code …… Area code ……. Number ..……
Fields of specialisation: (tick all applicable):
Horticulture …… Post-harvest technology …… Post-harvest pathology ……
Microbiology ….. Post-harvest physiology ……. Agricultural economics …..
Education …… Others ……
Fields of formal qualification:
Horticulture …… Post-harvest technology …… Post-harvest pathology ……
Microbiology ….. Post-harvest physiology ……. Agricultural economics …..
Education …… Others ……....
In which of these fields do you currently work?
Horticulture …… Post-harvest technology …… Post-harvest pathology ……
Microbiology ….. Post-harvest physiology ……. Agricultural economics …..
Education …… Others ……..…
What is your highest qualification? …….....

General questions:
Do you use your e-mail regularly? Yes …. No …. If yes, how often? …….
Does your company have a website? Yes … No … If yes, have you visited it? Yes ... No ….
What are your expectations of this training course? ……..
…….
……
……..……
……..……
……..
What do you plan to do with this information once you return to your respective country?
……..……
……..
Are you involved in training? Yes … No .... If yes, for whom? ……
What is the trainees' level of education? …… How many attend at a time? ……
How often do you train people per year? …… Do you enjoy it? Yes … Not really ……
Would you like to see more practicals in a training programme? Yes …. No ….
Why? …….
What kind of practicals? …….
What level do you think this course is going to be? ……..……
Do you think you need a test at the end? Yes … No …. If yes, why? ……..……
How would you like to be measured in terms of absorbing the knowledge? …….
……..…
……..
Any suggestions for the trainer in terms of your expectations? …….

Figure I.2.3 Sample form for the assessment of training requirements of a diverse audience

WHAT ARE YOUR EXPECTATIONS OF THE COURSE?

Please complete the form and answer all questions

Full name and surnames: …….
Contact details: …….
Do you have a cell phone? Yes ……No……
If yes, what is the cell phone number:…….
What are your highest qualifications? ……..…..
What language do you speak? …….
Do you own a farm? Yes ….. No ……. **If not, are you leasing one?** Yes …. No …….
What is the average size of the farm?:
> 20 ha …..; 10-19 ha ……; 5-9 ha…..: 2-4 ha…..;1 ha……; 0.5 ha……
Which crops do you cultivate on the land?
……
……
……

What fields are you interested in (tick all applicable):
Horticulture …… Post-harvest technology …… Post-harvest pathology ……...
Microbiology ….. Post-harvest physiology ……. Agricultural economics …….
Education …… Others ……
What information should the course focus on (tick all applicable):
Micro-finance…… Business transactions…...… Pesticide spraying …… Management ……
Pesticide storage and usage ……. Disease and pest names..... Control pests and diseases……..
Quality aspects ……. Harvesting methods…….. Quality assurance…….. Transport issues…….
Food safety …….. Export initiatives ……. Export Markets ……. Processing ……..…….
General questions:
What are your expectations of this training course? …….
……
..……
……..
..…….
..……
What do you plan to do with this information once you return to your respective country?
…….…….
…….…….
……...
Would you like to see more practicals in a training programme? Yes …. No … Why? …….
What kind of practicals? ……
What level do you think this course is going to be? ……. ……...
Do you think you need a test at the end? Yes … No …. If yes why? ……..……..
How would you like to be measured in terms of absorbing the knowledge? ……
……..……
…….
Any suggestions for the course presenters: ……
……

SECTION I

MODULE 3 – IMPLEMENTING THE TRAINING PROGRAMME[1]

Learning outcomes:

The learner should understand how to:

- Implement a training programme effectively

Introduction

Every effort must be made to ensure successful knowledge transfer during implementation of the training programme. Attention must be given to details that can impact on the flow and quality of the programme. Development of a basic planning schedule helps to ensure that details are covered and any last minute changes and rushing around are avoided. Regular meetings are also required to ensure that arrangements are carried out on schedule. A basic programme planning chart, such as that shown in figure I.3.1, can be used to ensure that all involved are reminded of their tasks.

Delivering lectures

When preparing for lectures, it is essential that visual materials be selected according to the needs of the training group. Visual materials can also be included to adapt the presentation to local conditions. When planning a lecture, the minimum rule of thumb of one slide a minute should be used. For a 30-minute lecture, for example the speaker should ideally select 30 slides, but might be able to go comfortably up to 45. A time frame of at least ten minutes must be included for discussions between lectures. Sessions should be conducted in two-hour blocks and must introduce tasks, practical exercises or group discussions in order to maintain the interest and attention of the trainees.

During the delivery of lectures, certain critical basic factors should be considered. The lecturer must:

- demonstrate an understanding of the learner's situation;
- create a caring and concerned environment;
- use a variety of instructional methods and materials that are suitable for the audience;
- exhibit enthusiasm and passion for the task; and
- develop a positive and participatory approach within the group.

Individual participants should feel:

- responsible/accepted/understood;
- an important part of the process; and
- that their opinions are being taken into account.

Consideration must be given to factors that impact upon the effective uptake of information and the ability to learn. The training of adult learners can be highly challenging, given that they often have different levels of:

[1] Prepared by L. Korsten.

- current knowledge and interest in the topic;
- confidence;
- capability, age and attitude;
- educational background, previous training and experience;
- capability to understand complex situations; and
- enthusiasm and ability to focus.

The effective uptake of information by trainees is dependent on the nature of the information being taught, the instructional methods and techniques used, the capability, enthusiasm and attitude of the instructor, the breadth of scope covered by the lectures and the practical exercises included within the programme. Knowing and understanding how adults learn is vital in developing and implementing effective adult education and training programmes. During the development of training material for adults, it is therefore essential that the trainer keeps the following in mind:

- adults are independent;
- adults have an extensive variety of real life experiences;
- adults are mostly concerned with their own immediate problems; and
- adults enter learning situations with their own goals, motivations, needs and experiences.

Adults learn better 'by doing' and if:

- they are involved;
- the topic relates to their own needs and daily activities;
- materials are structured to meet their specific needs;
- training is informal and given in an environment that is familiar to them;
- materials are presented through a variety of methods integrated with real life practical examples and visual demonstrations;
- subjects are well explained and text is supported with visual illustrations or drawings;
- activities and tasks are clearly structured, simple and relate to subjects, objects and examples familiar to them; and
- they are not tested or put under pressure.

Delivering practical training and administering to group activities

The method of instruction must consider the basic level of uptake of different forms of training. Visual images are remembered more effectively than words and adults prefer 'How to' and 'Hands-on' exercises. Adults therefore learn better when given opportunities to apply, explain and practice what they have learned or when working in groups.

Figure I.3.1. A sample programme planning chart

Date	Planned activity	Responsible	Completed
Pre-planning			
	Plan training schedule for the year		
	Develop marketing brochures for the training		
	Discuss training initiatives with public and private sector		
	Determine training needs		
	Establish course attendance fees		
	Draw up course attendance forms		
	Draw up needs assessment forms		
Planning workshop			
	Arrange first workshop		
	Invite participants or finalise attendant list		
	Send course attendance and needs assessment forms to participants		
	Send reminders to return forms		
	Arrange venue		
	Arrange meals and teas		
	Arrange accommodation for participants		
	Arrange for transport if required		
	Invite selected speakers		
	Send formal invitations to selected speakers		
	Arrange accommodation and transport for speakers if applicable		
	Plan training material package		
	Analyse needs assessment and consider it with final preparation of slides		
	Select slide series		
	Select practicals		
	Draw up training programme		
	Arrange for opening or welcoming speaker		
	Arrange staff to help with administration and finances		
	Arrange staff to help with practicals		
	Arrange staff to help with the flow of the workshop, to chair sessions, etc.		
	Prepare for practicals		
Workshop arrangements			
	Get training material ready for the workshop		
	Papers, writing pens, name cards, files, manuals, copy of slides		
	White board marker, sticky tape, overhead projector or data projector		
	Get gifts for speakers		
	Arrange participation certificates		
	Analyse feedback forms		
	Give feedback to presenters		
Post-workshop arrangements			
	After workshop send thank you letters for speakers		
	Follow up on participants to determine if knowledge has been implemented		
	Record data on participants		
	Archive training material		
	Itemised statement of expenditure		
	Audited statement of accounts		

SECTION I

MODULE 4 – MEASURING THE EFFECTIVENESS OF THE TRAINING PROGRAMME[1]

Learning outcomes:

The learner should understand how to:

- Assess the effectiveness of the training programme

Methods of assessment

Training assessment is important since it helps the trainer to reflect on the training programme and to continuously improve the materials, visuals, practical exercises and presentation of information. Trainers can ensure that information is continuously updated by using an effective assessment form, which can be adapted to the target group being trained. Assessment provides trainees with an opportunity to question and to be aware of what they have learned. It also gives them confidence to apply the skills they have acquired and helps them analyse the way in which they have acquired knowledge during the training programme.

Obtaining feedback

An effective mechanism for obtaining feedback is through the use of assessment forms to rate presenters (see figure I.4.1), the material presented by them, the content of their presentations and the level of confidence with which they presented the material.

An assessment of the training material (see figure I.4.2) is also valuable in that it improves the documentation and ensures that it is relevant and of practical use.

Providing feedback

Providing feedback throughout and at the end of the course is also essential. In cases where practical tasks were assigned, it is essential that a summary of results and findings is given. Different groups must be given the opportunity to provide feedback on their discussion sessions at the end of each day. Prior to the discussion of new activities, the day should start with a reflection on the presentations, discussions and practicals of the previous day.

Credit can be given for group discussion during the programme and individual participation may be acknowledged at the end of the workshop. Awarding tokens for the best participant, most vocal individual, funniest person etc. is always fun and makes the workshop memorable. The programme can be concluded with a test or puzzle to determine the level of effective uptake. Tasks may be given and a time frame to complete the tasks could be an alternative way of assessing the knowledge uptake of participants. If a test is given, it is essential that feedback be provided within a few days of completion of the course.

[1] Prepared by L. Korsten.

Figure I.4.1. Sample form for evaluating lecturers

Answer all questions using a scale from 0 to 5: 5 represents 'fully agree or excellent'; 3 – 'agree or acceptable'; 0 for 'disagree or unacceptable'. Add additional comments. **Date: …….**

Aspect to assess	Course chair	Presenter 1	Presenter 2	Presenter 3
1. Was the lecturer:				
Well prepared?				
Well versed in communication skills?				
Effective in presenting the course using available tools?				
Experienced in the field?				
Able to retain the concentration of the group?				
Able to stimulate discussions and get the group to interact?				
Able to create a stimulating environment?				
2. Lecturing material used in the presentation:				
Was it adequate?				
Was it well compiled?				
Was it well structured?				
Was there enough variation?				
Was it effective in bringing the message and concepts across?				
3. Lecturing notes offered – were they:				
Well set out?				
Well presented?				
Well organised?				
Well structured?				
Detailed enough?				
4. General impression				

Figure I.4.2. Sample form for evaluating training materials

Please provide written feedback highlighting positive and negative aspects of the training programme.

Course content **1. Was the course:**	**Written comments**
Detailed enough?	
Properly structured?	
Effective in presenting the message?	
2. Did the course meet your expectations?	
3. Did the course stimulate you?	
4. Was the course practical enough?	
5. Is the course effective as a 'train the trainer' course	
6. General feedback	

SECTION I

MODULE 5 – WRAPPING UP THE TRAINING PROGRAMME

Introduction
On completion of the training programme, trainees must be given oral feedback. Participants are generally awarded a certificate of participation, which includes the name of the participant, the date, venue, title and sponsors of the programme.

Keeping record
A basic databank should be developed and maintained to record the date, venue, type of training offered, number of trainees attending, their personal contact details and whether they have successfully completed the course. In certain cases, attendees, suppliers, exporters or their companies might request proof of course attendance at a later date. Keeping a databank of training programmes held can therefore aid in the efficient logistical management of events.

Staying in touch
It is essential to follow-up after the course and to find out if any technology or knowledge has been implemented. The level of uptake and implementation will reflect the effectiveness of the course.

REFERENCES

Food and Agriculture Organization of the United Nations (1998) Food quality and safety systems – a training manual on food hygiene and the Hazard Analysis and Critical Control Point (HACCP) system. Available at: http://www.fao.org/docrep/W8088E00.htm.

University of Maryland (2002) Improving the safety and quality of fresh fruit and vegetables – a training manual. Available at: http://www.jifsan.umd.edu/PDFs/GAPS_English/english.pdf.

Keye Productivity Centre (1991) How to be a better trainer. Available at: http://www.nationalseminarstraining.com/Onsite/TrainingTopic/KTR/index.html [accessed 8 January 2008]

Suggested method of instruction

Lecture, using handouts or PowerPoint presentation to promote understanding of the basics of adult learning.

SECTION II

CURRENT TRENDS AND THEIR IMPLICATIONS FOR HORTICULTURAL CHAIN MANAGEMENT

SECTION II

MODULE 1 – GLOBAL TRENDS[1]

Learning outcomes

The learner should:

- Develop an appreciation of the factors that currently impact upon the global food system
- Develop an understanding of opportunities in the global marketplace for small-scale horticultural producers, processors and exporters in the East and Southern Africa region
- Develop an understanding of actions that must be taken in order to maintain competitiveness within the horticultural sector

Introduction

Global food systems are currently undergoing profound changes that influence the way in which food is produced, distributed and consumed. Whilst these changes provide tremendous opportunities for growers and other stakeholders in the horticultural sector, accessing new markets is contingent upon meeting stringent requirements. Fulfilling these requirements poses a major challenge for small-scale farmers and other resource-poor stakeholders, many of whom risk being excluded from tapping into these opportunities.

This module discusses current changes in global agri-food systems and their implications for horticultural chain management. It outlines strategic actions that producers and other small-scale actors can take in order to maintain competitiveness and ensure their continued access to local, regional and international markets.

Drivers of change in the global food system

Globalisation

Globalisation refers to the growing integration of economies and societies around the world as a result of increased flows of information, capital, labour, technology, goods and services. Globalisation has been driven by four major factors:

- **Market liberalisation:** Since the 1908s many countries have removed entry barriers to their markets through the privatisation of public enterprises, while at the same time opening up monopolised sectors to competition and removing or reducing government regulations and restrictions.
- **Growth of international trade:** Rapid growth in international trade has taken place since the 1980s owing to the concerted actions of many countries to reach bilateral and multilateral trade agreements, thereby reducing trade barriers.
- **Increased capital flows:** Growth in world trade has resulted in an increase in international financial transactions and capital flows. One of the most important types of capital flows is Foreign Direct Investment (FDI), which refers to the long-term investment by an enterprise in one country into an enterprise in another country.
- Advances in **Information and Communication Technologies** (ICTs) and in logistics and transportation technologies.

[1] Prepared by D. Njie and R. Rolle.

While these factors create export opportunities for horticultural produce from developing countries, they have also propelled competitiveness on a worldwide scale and have so increased the vulnerability of producers in developing countries to competition from inexpensive (or subsidised) foreign imports that may be of higher quality than can be produced in their local markets.

Rising per capita incomes

Rising per capita incomes in developing countries over the last two decades has led to a shift from the consumption of basic carbohydrate-rich staple foods toward the consumption of higher priced products, including fresh fruits and vegetables. Rising incomes have also facilitated the acquisition of household amenities such as refrigerators and microwave ovens, which enable consumers in developing countries to purchase, store and prepare fresh fruits and vegetables and other perishable food products.

At the same time, rising per capita incomes, coupled with increased travel, have resulted in growth in consumer demand in developed countries for a broader range of relatively expensive commodities such as off-season produce, exotic fruits and vegetables and organic produce on a year-round basis. Consumers in these markets also increasingly demand differentiated horticultural products such as pre-mixed vegetables and chopped fruits.

Exploiting the growing market opportunities for horticultural produce created by these changes necessitates developing horticultural chains that can meet the horticultural produce requirements of these markets competitively.

Rapid urbanisation

Rapid urbanisation has created a growing demand for high-quality horticultural produce in urban centres of developing countries. At the same time, the fast-paced life in these centres has led to growth in demand for produce in a convenient format. This demand has in turn increased the procurement of pre-packaged horticultural produce.

Moving produce from production zones in rural and peri-urban areas in the East and Southern Africa region to urban markets necessitates improving efficiency in horticultural chains in order to minimise losses and maximise quality.

The increasing number of women in paid employment

The movement of women out of the domestic sphere into paid employment has generated growth in the demand for foods in a convenient format. This has in turn led to growing demand for pre-prepared, pre-packaged and value-added fruits and vegetables, as well as to increased numbers of people eating away from the home in fast-food restaurants and similar venues.

Taking advantage of these new and growing market opportunities for horticultural produce will necessitate developing the requisite production capacity to satisfy these opportunities, and managing quality, safety and efficiency in horticultural chains.

Consumer interest in healthy living

Growing consumer interest in products that promote healthy living has led to increasing demand in developed countries for exotic tropical fruits and vegetables, organic produce and off-season horticultural produce.

While this trend provides market opportunities, it necessitates proper management within horticultural supply chains in order to deliver produce that conforms to these consumer requirements.

Safety and quality consciousness of consumers

Over the last 10 to 15 years consumers in developed countries, and to a lesser extent those in urban areas of developing countries, have become increasingly aware of food quality and safety issues as a result of widely publicised crises such as the outbreaks of *E. coli* infection. The social and environmental impacts of practices used in chains that supply agricultural produce are also of increasing concern.

Food safety and quality concerns of consumers have resulted in stringent public sector food safety regulations and the emergence of numerous private sector codes of practice and technical protocols in international markets. Continued access to these markets therefore necessitates that requisite infrastructure and quality management systems be put in place in developing countries to assure the safety, quality and traceability of horticultural produce.

The increasing number of private sector standards

Since the mid 1990s an increasing number of standards have been developed by multiple chain supermarkets and other private-sector companies in order to comply with public sector regulations, differentiate themselves from their competitors and to facilitate co-ordination in their supply chains. This trend is widespread in the European Union, a key destination for horticultural produce and value-added products sourced from the East and Southern Africa region. Standards developed by companies in the European Union include Tesco's *Nature's Choice*, Carrefour's *Filière de Qualité* and Loblaw's *President's Choice*.

Groups of firms or business associations in the European Union have also developed private standards, the most widely applied being the EurepGAP/GlobalGAP standard, which was developed by an association of fresh produce importers and retailers. The EurepGAP/GlobalGAP standard provides for the use and application of pesticides and chemicals and the environmental impact of farming systems, and labour standards. It also allows for the interpretation of guidelines on a regional basis. Countries of the East and Southern Africa region, such as Kenya and Uganda, have made use of this opportunity to develop their own GAP standards.

Global sourcing by supermarkets in developed countries creates diversified opportunities for developing countries – not only to supply whole fresh fruits and vegetables, but also to carry out value-adding processes such as washing, pre-packing, mixing, labelling and bar-coding.

Compliance with the plethora of public and private sector standards necessitates the development of technical and infrastructural capacities in order to manage information flows within horticultural chains and to implement quality and safety management systems effectively.

Supermarket growth in developing countries

Since the 1990s, the supermarket sector has taken on an increasingly important share of food retailing in the developing world (see box II.1.1, below). Although one of the major drivers for this growth has been urbanisation, supermarkets are rapidly extending from wealthy suburbs of major cities into poorer neighbourhoods and towns in rural areas of developing countries. Tapping into the market opportunity for horticultural produce created by the growth of supermarkets necessitates the proper management of horticultural chains, along with the appropriate organisational arrangements and technological capabilities to meet consumer requirements for quality and safety competitively.

Implications of global trends for countries of the East and Southern African region

From the foregoing discussion, it is clear that in order to successfully and competitively tap into the market opportunities created by changes in global food systems, skills and capacities

must be developed to manage quality, assure safety and manage information flows within the horticultural chains of the region.

Box II.1.1 Supermarket chains in East and Southern Africa

Kenya: Kenya boasts four domestic chains (Uchumi, Nakumatt, Tusker and Ukwala Group, in descending order of size). There are also two foreign-owned chains, Metro Cash & Carry (Lucky brand name) and Woolworths, as well as several independent supermarkets.

Tanzania: The supermarket sector began to develop quickly after the liberalisation of foreign direct investment (FDI) in the late 1990s, and the South African chains Shoprite and Pick n' Pay entered the Tanzanian market in 2000 (Shoprite bought the Pick n'Pay stores in 2002). In addition, there are two domestic chains (Imalaseko and Shopper's Plaza).

Uganda: There are two foreign-owned chains Shoprite (South Africa) and Uchimi (Kenya).

Zambia: Zambia is a major destination of FDI by the South African chain Shoprite (18 supermarkets).

REFERENCES

Brown, O. (2005) Supermarket buying power, global commodity chains and smallholder farmers in the developing world. HDR Office Occasional Paper. New York, USA: United Nations Development Programme (UNDP).

Humphrey, J. (2005) *Shaping Value Chains for Development: Global Value Chains in Agribusiness*. Eschborn, Germany: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ).

International Monetary Fund (IMF) (2001) *Market Access for Developing Countries' Exports, 2001*. Washington, D.C.: International Monetary Fund and the World Bank.

International Monetary Fund (IMF) (2001) *Global Trade Liberalization and the Developing Countries, November 2001*. Washington, D.C.: IMF.

Jaffee, S. (2003) From Challenge to Opportunity: Transforming Kenya's Fresh Vegetable Trade in the Context of Emerging Food Safety and other Standards in Europe. Agriculture and Rural Development Discussion Paper No. 2. Washington, D.C.: the World Bank.

Mrema, G.C. and R.S. Rolle (2003) Status of the Post-harvest Sector and its Contribution to Agricultural Development and Economic Growth. In Y. Mori, T. Hayasi and E. Highly (ed.) *Value Addition to Agricultural Products*. Japan International Research Centre for Agricultural Sciences (JIRCAS) *International Symposium*, 11: pp. 13-20.

Neven, D. and T. Reardon (2004) The Rise of Kenyan Supermarkets and the Evolution of their Horticulture Product Procurement Systems. *Development Policy Review*, 22 (6): pp. 669-699.

Seale, J., A. Regmi and J. Bernstein (2003) International Evidence on Food Consumption Patterns. United States Department of Agriculture (USDA), Economic Research Service (ERS) Research Brief TB-1904, October 2003.

Trail, B. (2006) The Rise of Supermarkets? *Development Policy Review*, 24(2), pp. 163-174.

Weatherspoon, D.D. and T. Reardon (2003) The Rise of Supermarkets in Africa: Implications for Agri-food Systems and the Rural Poor. *Development Policy Review*, 21 (3): pp. 333-355.

Weinberger, K. and T.A. Lumpkin (2005) Horticulture for Poverty Alleviation – the Unfunded Revolution. AVDRC Publication No. 05-613, Working Paper No. 15. Shanhua, Taiwan: AVDRC (The World Vegetable Center).

Suggested methods of instruction

Lecture, using visuals or handouts to highlight the implications of global trends for horticultural chain management, followed by a discussion on global trends.

Time frame

The duration of the lecture and discussion is two hours.

SECTION II

MODULE 2 – CONSUMER TRENDS[1]

Learning outcomes

The learner should:

- Develop an appreciation of current consumer trends that impact upon the fruit and vegetable sector

Introduction

A number of international companies, such as the market intelligence providers ACNielsen and Datamonitor, constantly keep track of trends in retail markets all over the world. These activities also include the monitoring of food retail markets. Data reported by these agencies is generally based on the analysis of scanner data and primary consumer research. An understanding of food consumption trends at a global and the national level can help role players in the agricultural and food industries to react to consumers' needs and to plan for the future.

This module will expose the learners to some major food consumption trends at the global level and at the country level, using South Africa as an example.

International consumer trends

According to ACNielsen (2004), three major international consumer trends dominate the global food arena:

- focus on health and diet
- focus on convenience
- focus on private supermarket labels

Consumer focus on health and diet

In terms of consumers' focus on health and diet, three secondary trends are identifiable:

- **Preference for healthy dietary choices**. Certain foods are perceived by consumers to be 'healthy;' for example, organic or natural products, and high-protein/low-carbohydrate foods such as meat, fish and eggs.
- **Healthy staples**. Consumers perceive fruit and vegetables to be healthy and have increased their consumption of these food groups. Frozen fruit, fresh ready-to-eat salads, fresh vegetables and shelf-stable fruit are increasingly demanded by consumers.
- **Healthy alternatives**. Consumers perceive certain products to be healthy alternatives for existing products; for example, healthier cooking oil, such as olive oil.

Consumers focus on convenience

The increasing pace of consumer lifestyles has lead to needs related to convenience. Consumers are increasingly 'eating-on-the-go' with fragmented eating occasions. They also

[1] Prepared by H. Vermulen, D. Njie and R. Rolle.

undertake more frequent shopping trips. A range of products that offer convenience is sought by consumers. These include products in a format that can:

- be easily handled and stored prior to consumption (i.e. products in appropriate packaging formats);
- be easily prepared with respect to time and effort required (e.g. pre-prepared, ready-to-cook and ready-to-eat products);
- be readily consumed (i.e. not requiring a conventional eating venue, serving utensils and cutlery, and being able to be eaten 'on the run'); and
- be easily disposed of after consumption (e.g. appropriate packaging format for collecting and disposing peelings).

Growing impact of supermarket labels

Private supermarket labels are usually value-for-money discount brands offering an average discount of 50 per cent over other product brands. The proportion of spending on private supermarket label products is 23 per cent in Europe and more than 30 per cent in the UK.

Other consumer trends

Demand for quality – Consumers increasingly demand specific quality attributes regarding the taste, appearance and smell of produce.

Concern about food safety – Consumers increasingly demand produce that is safe, i.e. free of physical, chemical and microbiological contamination. As a guarantee of safety, produce that is easily and quickly traceable to its origin (i.e. place of production) is preferred.

Preference for variet*y* – Consumers show a preference for variety in terms of:

- a specific produce item (e.g. various types of tomatoes – cherry tomatoes, Roma tomatoes, etc.) and across the range of produce (e.g. okra, papaya, kale, cabbage, spinach, etc.) available to them;
- combinations of produce (e.g. stir fry mixes combining baby corn, zucchini (courgette) wedges, etc.); and
- preparation options (e.g. produce that can be either cooked in a microwave, oven baked, pan fried or boiled).

Demand for differentiated and innovative products – Differentiated produce having added value (e.g. tray-wrapped fruits instead of fruits sold in loose form), as well as innovative products with novel features are increasingly demanded by consumers.

Demand for customisation – Customers also increasingly demand customised products that meet particular preferences or lifestyle choices (e.g. vegetarian, organic, shade-grown).

Consumer trends in South Africa

Focus on health

Consumer focus on health drove growth in two of South Africa's fastest growing food categories during 2003/04: bottled water and yoghurt (ACNielsen, 2005). Only wealthier consumers can, however, afford the premium price (an average premium of about 30 per cent) of health foods. Diet-related products attract a small, wealthier proportion of the South African population. Healthy staples are the most widely available health-based product types in SA, with rapid growth in the consumption of larger quantities of fruit and vegetables in certain sectors. South Africa lags behind global trends in terms of healthy alternatives such as sugar substitutes, edible oils and soya-based products.

Focus on convenience

Longer working hours, more women entering the work force and the current lack of efficient public transport (ACNielsen, 2005) have created a demand for greater convenience among South African consumers. Convenience requirements of consumers include portable food products, prepared food products and convenient shopping locations. Baby foods are one convenience product that showed a 24.5 per cent growth trend during 2003/04. During the period 1994-2004, a dramatic number of service station/garage forecourt stores opened up in response to consumer requirements for convenient shopping locations in South Africa.

Affordable convenience is an important need among SA consumers. Given that South African consumers are affected by price constraints to a considerable degree, private supermarket labels are also growing in importance in South Africa; however, at the time of writing they still accounted for less than 10 per cent of annual value share. These labels offer an average discount of 20 per cent over other brand labels.

REFERENCES

ACNielsen (2004) What's Hot Around the Globe. Executive News Report from ACNielsen Global Services, December 2004. www.acnielsen.com [accessed 8 January 2008]
ACNielsen (2005) What's Hot in SA? ACNielsen Market Intelligence Report, 1 February 2005. www.foodreview.co.za [accessed 8 January 2008]
ACNielsen (2006) SA Spend Trends. ACNielsen Market Intelligence Report, January 2006. www.foodreview.co.za [accessed 8 January 2008]

Suggested methods of instruction
Lecture, using visuals or handouts to highlight the consumer trends in the food sector, followed by a discussion on consumer trends.

Practical exercise
Practical exercise III.1: Visit to a fresh produce market.

Time frame
The duration of the lecture and discussion is one hour.
The duration of the practical exercise is around two hours.

SECTION III

ORGANISATIONAL STRATEGIES TO ENHANCE COMPETITIVENESS IN HORTICULTURAL CHAINS

MODULE 1 – UNDERSTANDING MODERN HORTICULTURAL SUPPLY CHAINS[1]

Learning outcomes

The learner should:

- Develop an appreciation of the supply chain as a mechanism for delivering horticultural produce that meets market requirements
- Develop an appreciation of key role players in supply chains and their functions
- Develop an appreciation of how the consumer drives modern supply chains
- Develop an appreciation of the rationale for supply chain co-ordination

Introduction

Market liberalisation and growth in international trade have created export opportunities within the horticultural sectors of many developing countries. At the same time, rapid urbanisation and income growth in these countries have lead to increased consumption of horticultural produce, thereby expanding opportunities for small-scale producers, packing houses and other stakeholders in the horticultural sector. Tapping into these market opportunities is, however, contingent upon their meeting a plethora of stringent requirements.

Produce destined for export must comply with the sanitary and phytosanitary (SPS) regulations of importing countries. It must also comply with private-sector standards and codes of practice, which have been put in place by importers and multiple chain supermarkets in order to respond to consumer requirements. Fresh produce sold in local formal markets and in supermarkets must also satisfy consumer requirements for safety and quality. Coupled with these exigencies for produce safety and quality, are requirements for guaranteed supplies and consistent volumes of a variety of fresh produce items.

Fresh produce can no longer, therefore, be taken to the market on the off chance that it will be purchased. Access to markets requires that produce be supplied through market driven systems, in which market requirements known prior to production are used in specifying input quality as well as production practices and post-production handling.

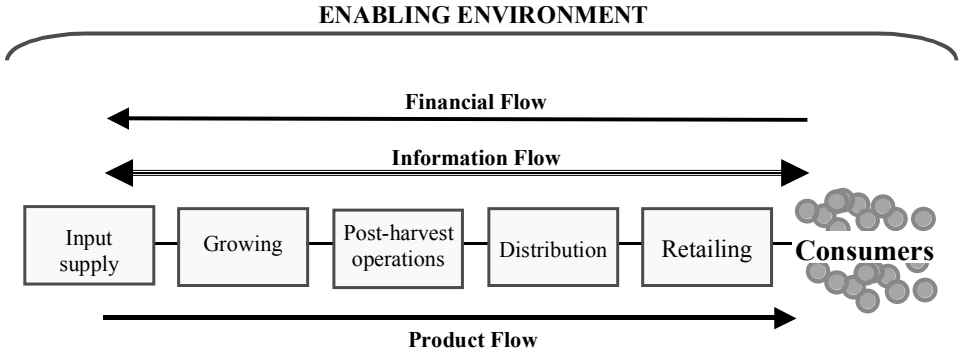
This module discusses the horticultural supply chain, a systemic structure involving the participation of various stakeholders and which provides the co-ordination and flexibility required to respond to market requirements for fresh horticultural produce effectively and efficiently.

The horticultural supply chain

The horticultural supply chain refers to the entire vertical chain of activities from the supply of input (seed, fertiliser, chemicals and so on) through production, post-harvest operations, distribution and retail (see figure III.1.1).

[1] Prepared by D. Njie and R. Rolle.

Figure III.1.1 Key elements of the supply chain for horticultural produce



Key stakeholders within horticultural supply chains

The *consumer* is the ultimate buyer and/or end-user of produce in horticultural supply chains. A consumer may be a business, a household or an individual.

Customers within the chain refer to businesses within the chain that have direct dealings with each other. Packing houses, for example, are the customers of growers of horticultural produce, while retail stores are customers of packing houses.

Flows within the modern supply chain that govern optimal functioning

As shown in figure III.1.1, three major flows within horticultural supply chains govern their optimal functioning:

- **Product flow** – Fresh produce flows in one direction through the chain, starting with input supply and ending at the retailer, who makes the final product available to consumers.

- **Financial flow** – Financial flow takes place in the opposite direction of produce flow, whereby payments go to suppliers as produce moves downstream (from the producer through the various customers within the chain) toward consumers. Financial flow is generated through the willingness of the consumer to pay for produce that meets his/her requirements.

- **Information flow** – Information flows in both directions throughout the supply chain. Market information on consumer requirements, as well as information about what is demanded by customers at successive steps of the chain, travels upstream (from the retailer through the various customers to the producer), while information about supply conditions and product attributes travels downstream. Information flow is very important in co-ordinating activities at the different steps of the chain in order to assure that these activities satisfy market requirements. It facilitates planning and co-ordination of supply and therefore helps to minimise losses. Information related to the identity of produce (for example, origin, variety, orchard block from which harvested), treatment at the pack house and handling (for example, the temperature and relative humidity during distribution) through the chain, can be recorded and stored at the different steps of the chain. Stored data is used in providing traceability (tracing and tracking of produce) in the chain. Stored data may also serve during later verification of compliance with protocols, such as those related to the application of Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP).

The enabling environment

An enabling environment consists of those factors external to the chain, that impact upon optimal functioning of the chain. Elements of the enabling environment include:

- enabling policies and regulations;
- an infrastructural support base to facilitate chain operations; and
- business development support services, which include:
    - banks that provide loans;
    - companies that provide market information;
    - equipment hire services;
    - logistics companies that transport and/or store produce; and
    - trainers and technical assistance providers.

Consumers, the driving force of the horticultural supply chain

Value-creating activities are applied within horticultural supply chains to impart attributes that are of value to – and which are demanded by – the final consumer. Urban consumers, for example, prefer horticultural produce that is uniform in size and colour and which is attractively presented in unitised packaging. The success or failure of a horticultural supply chain is ultimately determined by the degree to which produce satisfies consumer requirements for quality and safety. It is these preferences of consumers that drive modern horticultural supply chains. Consumer demands define the quality of production inputs as well as production, post-harvest and distribution practices. Information flow up and down the chain is, therefore, a crucial element in meeting consumer requirements.

Each participant in the chain requires its upstream customer to supply produce that will allow it to meet the requirements of the downstream customer. This is applied until the end of the chain, where the retailer provides produce that satisfies consumer requirements. Thus, by delivering value to its customer, each supply chain partner effectively delivers value to the final consumer.

A packing house, for example, requires growers to supply fruits of the appropriate quality that will allow it (the packing house) to grade, treat and package the produce to meet the needs of retailers. These retailers will, in turn, supply fruits that meet the needs of consumers.

Value chains

A value chain is a particular form of supply chain that is created when chain partners have a shared vision and common goals that aim to meet specific market objectives and consumer needs. The value chain may encompass the entire spectrum of the supply chain, from consumer to producer. It is differentiated from a generic supply chain by the following characteristics:

- participants in the value chain have a long-term strategic vision;
- participants recognise their interdependence and are disposed to work together to define common objectives, share risks and benefits and make the relationship work;
- participants have a shared commitment to control product quality and consistency; and
- participants have a high level of confidence in one another, which allows greater security in business and facilitates the development of common goals and objectives.

Horizontal and vertical co-ordination within value chains

Horizontal co-ordination refers to co-ordination among entities operating at a particular link of the value chain, for example, a group of farmers supplying fruit to a particular packing house.

Vertical co-ordination refers to the synchronisation of activities at successive stages of the chain, from input supply, through growing, harvesting, packing-house operations and distribution to retailing.

Range of vertical co-ordination possibilities in supply chains

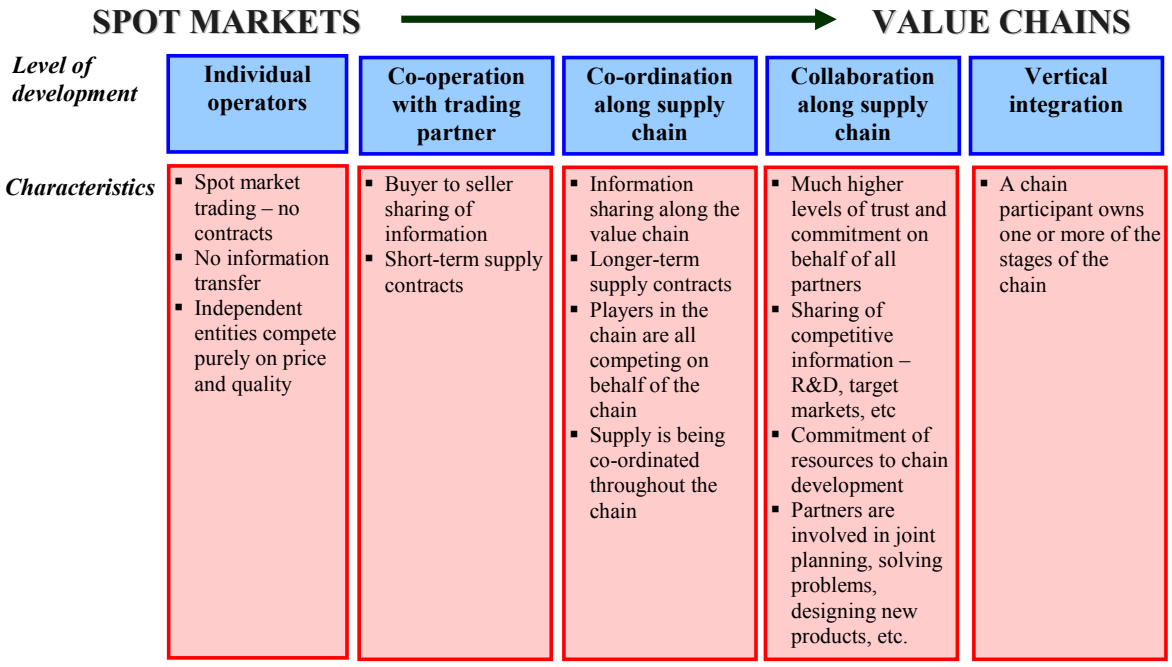
The continuum of co-ordination possibilities in a supply chain ranges from spot-market transactions on one extreme to vertical integration on the other (see figure III.1.2, below).

Spot market transactions are transactions that involve independent buyers and sellers who have no long-term relationship. Resources move between the parties involved as a result of price signals alone.

Vertical integration is a form of vertical co-ordination in which a firm such as a supermarket, a commercial supplier or a multinational, owns one or more of the stages of the chain. It represents the greatest degree of control that a firm can gain over the output from a chain partner. Ownership ensures complete power over decisions regarding product attributes, location and timing of delivery.

In between the extremes of spot market transactions and vertical co-ordination lie various co-ordination possibilities, including contracts and joint ventures.

Figure III.1.2 Levels of development in the supply chain



Source: Adapted from Kennedy, 2006

REFERENCES

Codron, J., K. Grunert E. Giraud-Heraud L. Soler and A. Regmi (2005) Retail Sector Responses to Changing Consumer Preferences: The European Experience. In A. Regmi and M. Gehlhar (ed.) *New Directions in Global Food Markets*. AIB-794, US Department of Agriculture / Economic Research Service (USDA/ERS), February 2005. Available at: http://www.ers.usda.gov/publications/aib794/aib794.pdf [accessed 8 January 2008]

Dolan, K.C. and J. Humphrey (2000) Value chains and upgrading: The impact of UK retailers on the fresh fruit and vegetables industry in Africa. *Journal of Development Studies,* 37: pp. 147-176.

Gehlhar, M. and A. Regmi (2005) Factors Shaping Global Food Markets. In A. Regmi and M. Gehlhar (ed.) *New Directions in Global Food Markets*, AIB-794, USDA/ERS, February 2005. Available at: http://www.ers.usda.gov/publications/aib794/aib794.pdf [accessed 8 January 2008]

Hobbs, J. E., A. Cooney and M. Fulton (2000) *Value chains in the agri-food sector. What are they? How do they work? Are they for me?* Department of Agricultural Economics, University of Saskatchewan. Available at: http://www.usaskstudies.coop/pdf-files/valuechains.pdf.

Kennedy, Q. (2006) Build Supply Chain Links that Work. *Australian Organic Business*, Winter 2006, Vol 16 p. 13. Available at: http://www.bfa.com.au/_files/x06abj_013p.pdf [accessed 8 January 2008]

King R. P. and L. Venturini (2005) Demand for Quality Drives Changes in Food Supply Chains. In A. Regmi and M. Gehlhar (ed.) *New Directions in Global Food Markets*, AIB-794, USDA/ERS, February 2005. Available at: http://www.ers.usda.gov/publications/aib794/aib794.pdf [accessed 8 January 2008]

Lundy, M., M.V. Gottret, W. Cifuentes, C.F. Ostertag and R. Best (2004) *Design of Strategies to Increase the Competitiveness of Smallholder Chains*. Cali, Columbia: CIAT (International Institute of Tropical Agriculture). Available at: http://www.ciat.cgiar.org/agroempresas/pdf/Field_Manual_Competitive_Strategies.pdf [accessed 8 January 2008]

University of Queensland (2005) *A practical guide to value chain management in floriculture*. Book 3: Value Chain Management Series. Australia: University of Queensland. Available at: http://www.uq.edu.au/lcafs/documents/ValueChain.pdf [accessed 8 January 2008]

University of Queensland (2005) *Market research for new floricultural products*. Book 1: Value Chain Management Series. Australia: University of Queensland. Available at: http://www.uq.edu.au/lcafs/documents/marketresearch.pdf [accessed 8 January 2008]

Tracey-White, J. (2005) Rural-urban marketing linkages. An infrastructure identification and survey guide. FAO Agricultural Services Bulletin, No. 161. Rome, Italy: Food and Agriculture Organization (FAO).

van Roekel, J., S. Willems and D.M. Boselie (2002) *Agri-Supply-Chain Management: To Stimulate Cross-Border Trade in Developing Countries and Emerging Economies*. Washington, D.C.: World Bank. Available at: http://www.regoverningmarkets.org/en/filemanager/active?fid=167 [accessed 8 January 2008]

Suggested methods of instruction

Lecture, using visuals or handouts to highlight the role of co-ordinated supply chains in supplying market requirements.

Practical exercise
Practical exercise III.1: Visit to a fresh produce market.

Time frame
The duration of the lecture and discussion is one hour.
The duration of the practical exercise is around two hours.

SECTION III

MODULE 2 – INTEGRATION OF SMALL FARMERS INTO HORTICULTURAL CHAINS[1]

Learning outcomes

The learner should:

- Develop an appreciation of modalities for increasing market access for small-scale farmers through horizontal and vertical co-ordination mechanisms
- Develop an understanding of contract farming arrangements for small-scale farmers

Introduction

Many small-scale farmers within the Eastern and Southern Africa region are unable to satisfy market requirements for horticultural produce in importing countries and in urban centres of the region. This is owing to the small size of their operations, poor organisation, use of low technologies**,** dependence on unskilled labour, lack of capital and poor support services.

For many commercial entities (such as packing houses, exporters and supermarkets), the prospect of working with a multitude of individual small farmers raises concerns about communication, management, quality, reliability of supply and transaction costs.

This module discusses co-ordination mechanisms through which small farmers can overcome these impediments, better satisfy the requirements of packing houses, supermarkets and other companies and thereby become integrated into modern horticultural supply chains.

Horizontal co-ordination through the formation of farmer groups

Horizontal co-ordination of farmers entails the formation of a group, association or other collaborative structure through which information, inputs, technical and quality assistance and various other needs can be accessed. As an organised group, small farmers can work together to function like larger businesses and thus offer many of the advantages of a larger operation. These advantages include:

- Improved access to credit, training and business services;
- Improved access to technology and equipment through shared resources;
- Increased efficiencies and economies of scale through collaborative production and marketing, reduced transaction costs, and bulk purchases of raw materials and contracted services;
- Collective knowledge of markets, production standards and customer requirements;
- Pooled creativity for developing innovative products and services;
- Reduced costs/risks for the development of new products and services;
- Improved ability to avoid oversupply and a resulting decline in prices;
- Collective efforts to overcome shared obstacles; and
- An improved market position, with increased production capacity, a broader range of produce offerings and a more diversified skill set.

Horizontal linkages are not limited to farmer groups. They can be formed, and are beneficial, at all levels of the supply chain. Small packing-house operators in a given setting

[1]Prepared by D. Njie and R. Rolle.

could, for example, form such a group. Horizontal linkages may emerge due to collaboration among concerned parties (e.g. participating farmers) or may be fostered by an external party (e.g. an NGO).

Vertical co-ordination through contract farming

One vertical co-ordination option that is suited to the integration of small-scale farmers into horticultural supply chains is contract farming.

Contract farming

According to Eaton and Shepherd (2001), contract farming can be defined as: 'an agreement between farmers and processing and/or marketing companies for the production and supply of agricultural produce under forward agreements, frequently at predetermined prices'. The arrangement also invariably involves the provision of a degree of production support by the purchasing company, through, for example, the supply of inputs and the provision of technical advice to the farmers.

The basis of such arrangements is a commitment on the part of the farmer to provide a specific commodity in quantities and at quality standards determined by the company and a commitment on the part of the company to support the farmer's production and to purchase the commodity.

Contract farming schemes typically involve the provision of inputs (seed, fertilisers, and pesticides) on credit by the company, often with extension advice, but may also include a range of other services such as ploughing and crop spraying. Costs are recouped when the produce is sold.

Advantages of contract farming for the small farmer

The prime advantage of a contractual agreement for farmers is that the purchasing company will normally undertake to purchase all produce grown within specified quality and quantity parameters. Additional advantages include:

- Provision by the purchasing company of basic inputs (seeds and fertilisers), production services (field preparation, harvesting, spraying etc.) and a wide range of managerial, technical and extension services;
- Access to credit, either advanced, arranged or facilitated by the purchasing company;
- Access to appropriate technology and opportunities to upgrade agricultural commodities for markets that demand high quality;
- Transfer of skills and knowledge (e.g. record keeping, improved methods of applying chemicals and fertilisers, knowledge related to quality and the requirements of export markets etc.);
- Guaranteed and fixed pricing structures, as prices are fixed in advance; and
- Access to reliable markets, which would otherwise be inaccessible to small farmers.

A well-organised contract farming scheme can therefore provide the right incentives and forward and backward linkages required for small farmers in developing countries to participate in modern horticultural supply chains successfully.

Models of contract farming

Some of the most widely used contract farming models include:

- **Centralised model or 'outgrower scheme***'* –** This model involves a centralised packing house or exporter buying from a large number of small farmers.

- **Nucleus estate model** – This model is similar to that of the centralised model, except for the fact that the company also manages a central estate or plantation.

- **Multipartite model** – This model involves statutory bodies and private companies jointly participating with farmers.

- **Informal model** – This model applies to individual entrepreneurs or small companies, who normally make simple, informal production contracts with farmers on a seasonal basis.

Combining vertical and horizontal co-ordination: contract farming involving farmer groups

Vertical co-ordination through contract farming and horizontal co-ordination through the formation of farmer groups often work best together, with farmer groups contracting with companies that supply them with a range of services, within a suitable framework such as an out grower model.

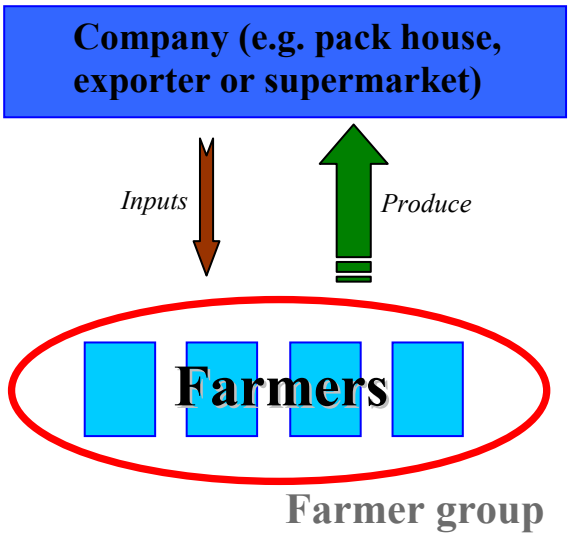
Contract farming involving farmer groups increases access to new market opportunities. When dealing with a purchasing company, the negotiating strength of a farmer group is greater than that of its constituent individual members. Companies favour working with farmer groups because group liability for credit reduces lending risks, while economies of scale reduce transaction costs.

Generalised model for contract farming involving farmer groups

In order for a company to contract small-scale fruit and vegetable growers in a particular setting, extension agencies, NGOs, development agencies or the company itself should assist growers in forming a group if one does not exist or assist in improving the cohesiveness of existing groups (e.g. by training growers on group forming skills, formally registering the group and providing literacy and numeracy training).

Small-scale growers are better placed to deal with exporters, supermarkets and other larger companies when they co-ordinate among themselves within such a group. A group can better comply with contractual requirements of the company than its individual members, and serves as a convenient organisational unit around which the company can coordinate procurement of produce and provide inputs, credit and technical assistance to the growers (see figure III.2.1, below).

Figure III.2.1 Generalised model for contract farming involving a farmer group



Box III.2.1 Case study

Kathiriti-Kanjau Horticulture Growers in Kenya is a registered farmer group founded in 2001 with a membership of 27 farmers. Recognising that the function of brokers was to assemble lots for exporters, and that they could achieve such lots by pooling produce, the farmer group was formed out of a desire to eliminate brokers and deal directly with exporters. Contractual arrangements between the farmer group and exporters resulted in higher returns to farmers as compared to the broker market. The contracts between the farmer group and the exporters require the farmer group to supply specified volumes of produce on a weekly basis, depending on the market season, while exporters provide seeds on credit with an agreement to purchase produce outputs and recover their costs from the sales proceeds of the farmers groups.

REFERENCES

Coulter, J., A. Goodland, A. Tallontire and R. Stringfellow (1999) Marrying Farmer Cooperation and Contract Farming For Service Provision in a Liberalising Sub-Saharan Africa. *Natural Resource Perspective*, No. 48, November 1999. London, UK: Overseas Development Institute.

Eaton C. and A.W. Shepherd (2001) Contract Farming – Partnerships for growth. Food and Agriculture Organization (FAO) Agricultural Services Bulletin No. 145. Rome, Italy: FAO.

Hobbs, J.E. (2001) Developing supply chains for nutraceuticals and functional foods: Opportunities and challenges. Research Series SR.01.05 (part 4), Université de Laval. Paris: Cahiers du CRÉA.

Hobbs, J.E., A. Cooney and M. Fulton (2000) *Value Chains in the Agri-Food Sector. What Are They? How Do They Work? Are They For Me?* Saskatchewan, Canada: Specialized Livestock Marketing Research Group, Department of Agricultural Economics, University of Saskatchewan.

Minot, N. and M. Ngigi (2004) Are Horticultural Exports a Replicable Success Story? Evidence from Kenya and Côte d'Ivoire. Environment, Production and Technology Division (EPTD) Discussion Paper No. 120. Markets, Trade and Institutions Division (MTID) Discussion Paper No. 73. Washington, D.C., USA: International Food Policy Research Institute. Available at: http://www.ifpri.org/divs/eptd/dp/papers/eptdp120.pdf [accessed 8 January 2008]

Young, L.M. and J.E. Hobbs (2002) Vertical Linkages in Agri-Food Supply Chains: Changing Roles for Producers, Commodity Groups, and Government Policy. *Review of Agricultural Economics,* 24 (2): pp. 428-441.

Suggested methods of instruction

Lecture, using visuals or handouts to highlight the mechanisms for integrating small producers into markets.

Time frame

The duration of the lecture and discussion is one hour.

SECTION III

MODULE 3 – TRADITIONAL AND MODERN MARKETING CHANNELS FOR HORTICULTURAL PRODUCE IN THE REGION[1]

Learning outcomes

The learner should:

- Develop an understanding of marketing channels and intermediaries involved in traditional and modern horticultural supply chains in countries of the Eastern and Southern Africa region

Introduction

Horticultural produce in the region is moved from production areas to consumers via a number of different channels. This module will briefly describe the main local, regional and international marketing channels and intermediaries involved in horticultural supply chains in the Eastern and Southern Africa region.

Marketing channels for horticultural produce in the region

Horticultural produce from countries of the Eastern and Southern Africa region is sold to local, regional and international markets. The main marketing channels within these countries are depicted schematically in figure III.3.1.

Horticultural produce is marketed to rural and informal urban markets through traditional supply chains; these are largely supply driven, with relatively little co-ordination. Marketing channels for formal and export markets on the other hand make use of well co-ordinated modern supply chains, which are driven by consumer requirements.

Marketing channels for rural consumers in the region

Producers of horticultural crops can, in general, access nearby rural consumers easily through informal transactions involving sales at the farm gate or village market centre. The smallest rural markets are informal and are held periodically at an appropriate location in the village. These are in close proximity to production areas, so the produce is transported to market by head-load, bicycle or animal porterage. Direct transactions between farmers and consumers often take place.

Larger rural markets may be registered and supported by the local government. These may also be periodic and are likely to be outfitted with permanent stalls where traders sell to consumers and other traders. These markets draw farmers from further distances, so that produce is transported to market by minibuses and small trucks.

Marketing channels and key stakeholders in urban areas

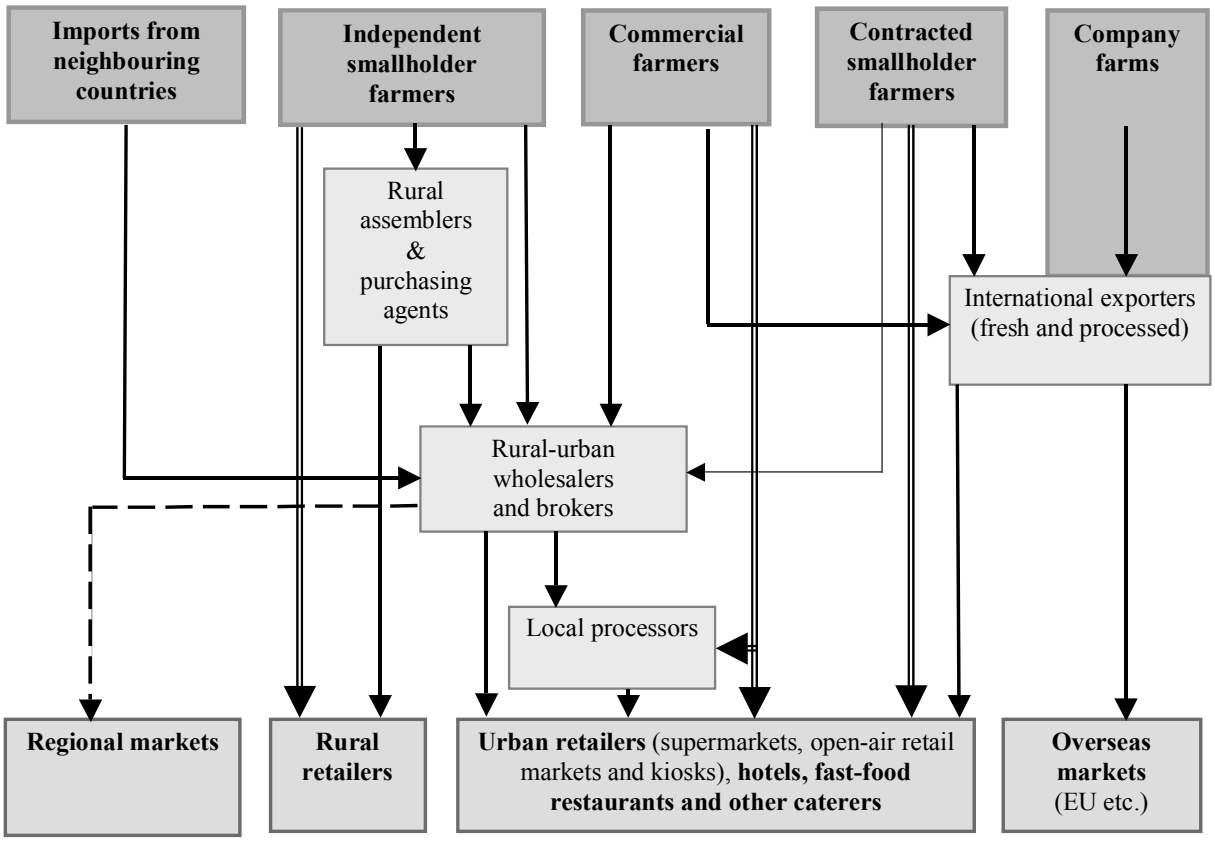
Produce is moved from rural to urban areas through a chain of intermediaries, which may include assemblers, brokers, wholesalers and retailers.

[1]Prepared by D. Njie and R. Rolle.

Assemblers and wholesalers

Assemblers and wholesalers supply produce to urban markets after purchasing it directly from farmers or from rural markets. Produce is transported either by minibus (for small quantities) or truck (for larger quantities).

Figure III.3.1 Marketing channels for fresh produce in East and Southern Africa



Commission brokers

Commission brokers, acting on behalf of large and long-distance traders, play an important role in sourcing supplies and in organising procurements into economical loads. These individuals also play an important role in marketing, especially given the wide-ranging agro-ecological zones within the region, the geographical distribution of production and the small sizes of farms.

Terminal wholesale and semi-wholesale markets

Terminal wholesale and semi-wholesale markets are located within or near to major cities and may be supplied by purchasing/assembly centres in rural areas or directly from farms, particularly those in peri-urban areas. Produce is supplied either by agents, traders or by farmers themselves. As shown in figure III.3.1, above, wholesalers and brokers in each country generally source produce from other countries of the region in order to supply the urban retail market.

Informal retailers

Informal retailers include small-scale traders operating in traditional open-air retail markets or makeshift sheds and stands in high-density residential areas, on pavements in busy urban

streets or in door-to-door hawking in residential areas. Although primarily involved in retailing, informal markets – also referred to as farmer's markets – may have a semi-wholesale function, particularly if farmer trading takes place in those markets.

Formal retailers

Formal retail markets include supermarkets, convenience stores and small retail shops. Small retail shops – also known as urban self-serve stores, urban countertop stores, 'corner' shops and roadside stands, depending on their particular operation – supply produce in the vicinity of the home of the consumer. These establishments generally procure their produce supplies from wholesale markets.

Supermarkets also procure their produce supplies from wholesale markets, although the leading supermarket chains will often by-pass wholesale markets and rely primarily on brokers and on direct procurement arrangements with contracted commercial farmers and organised small and medium-sized farmers.

These formal retailers may also source produce from distant sources, requiring the operation of modern logistics and cold chains.

Market channels for exports

Conveying produce to export destinations also requires the operation of modern supply chains and cold chains. The channels used vary widely, but can be classified into roughly three categories according to the degree of vertical co-ordination:

- **Vertically-integrated exporters** – These are exporters who grow produce on their own farms, arrange shipping to overseas destinations and even distribute the goods to supermarkets and wholesalers in foreign markets.

- **Exporters who consolidate produce grown under contract directly** – This category includes exporters who obtain produce from contract farmers. In a majority of cases, large or medium-scale farmers supply exporters directly on contract. In a few cases, a number of small farmers may also supply produce to exporters on contract (see figure III.3.1, above).

- **Exporters who consolidate produce procured by brokers** – In this case fresh produce is sourced through brokers, who in turn consolidate produce from farmers in spot market transactions, or alternatively through farmer groups to ensure the minimum standard of quality that will attract exporters or traders.

REFERENCES

Dixie, G. (2005) Horticultural Marketing. Food and Agriculture Organization (FAO) Marketing Extension Guide 5. Rome, Italy: FAO.

Jaffee, S. (2003) From Challenge to Opportunity: Transforming Kenya's Fresh Vegetable Trade in the Context of Emerging Food Safety and Other Standards in Europe. Agriculture and Rural Development Discussion Paper 1. Washington, D.C.: World Bank. Available at: http://lnweb18.worldbank.org/ESSD/ardext.nsf/11ByDocName/FromChallengetoOpportunityKenya/$FILE/ARD_DP1_Kenya_e-final.pdf [accessed 8 January 2008]

Lundy, M., M.V. Gottret, W. Cifuentes, C.F. Ostertag and R. Best (2004) Design of Strategies to Increase the Competitiveness of Smallholder Chains. Columbia: International Centre for Tropical Agriculture (CIAT). Available at: http://www.ciat.cgiar.org/agroempresas/pdf/Field_Manual_Competitive_Strategies.pdf [accessed 8 January 2008]

Minot, N. and M. Ngigi (2004) Are Horticultural Exports a Replicable Success Story? Evidence from Kenya and Côte d'Ivoire. Environment, Production and Technology Division (EPTD) Discussion Paper No. 120. Also published as Markets, Trade and Institutions Division (MTID) Discussion Paper No. 73. Washington, D.C., USA: International Food Policy Research Institute. Available at: http://www.ifpri.org/divs/eptd/dp/papers/eptdp120.pdf [accessed 8 January]

Tracey-White, J. (2005) Rural-urban marketing linkages: An infrastructure identification and survey guide. FAO Agricultural Services Bulletin, No. 161. Rome, Italy: FAO.

Tschirley, D., K.M. Muendo and M.T. Weber (2004) Improving Kenya's domestic horticultural production and marketing system: current competitiveness, forces of change, and challenges for the future. Volume II, Horticultural Marketing. Working Paper No. 08B/2004. Kenya: Egerton University, Tegemeo Institute of Agricultural Policy and Development. Available at: http://www.aec.msu.edu/fs2/kenya/wp8b.pdf [accessed 8 January 2008]

van Roekel, J., S. Willems and D.M. Boselie (2002) Agri-Supply-Chain Management: To Stimulate Cross-Border Trade in Developing Countries and Emerging Economies. Washington, D.C.: World Bank. Available at: http://www.regoverningmarkets.org/en/filemanager/active?fid=167 [accessed 8 January 2008]

Suggested methods of instruction

Lecture, using visuals or handouts to highlight the differences in the supply chains for different target markets of the region.

Practical exercise

Practical exercise III.1: Visit to a fresh produce market.

Time frame

The duration of the lecture and discussion is one hour.
The duration of the practical exercise is around two hours.

SECTION IV

HORTICULTURAL PRODUCE QUALITY

SECTION IV

MODULE 1 – QUALITY[1]

Learning outcomes

The learner should:

- Develop an appreciation of the quality attributes of horticultural produce
- Develop an understanding of the components of quality

Introduction

According to Kader and Rolle (2004), quality can be defined as: 'a combination of attributes, properties, or characteristics that give a commodity value in terms of its intended use'. The relative importance given to a specific quality attribute depends on the commodity, individual or market concerned with the quality assessment of the produce item and how it will be utilised.

The quality required by a target market should be known as early as during production planning. Produce that is acceptable on local markets often differs from that desired by the buyer in other markets, both in terms of variety and attributes associated with desirability.

Quality attributes and stakeholder assessment

Quality means different things to different people. To the horticultural producer a quality produce item must be high yielding, of good appearance, easy to harvest, must be resistant to pests and diseases and must withstand transport/shipping to markets. Wholesale and retail markets evaluate quality on the basis of appearance, firmness and shelf-life, while consumers judge the quality of horticultural produce on the basis of appearance, nutritional value, flavour and firmness at the time of initial purchase. Subsequent purchases depend upon the consumer's satisfaction in terms of the flavour (eating) quality of the edible portion of the produce item.

Components of quality

Horticultural produce can be evaluated on the basis of a number of specific quality attributes, including:

- **Appearance** (visual) – relates to the size, shape, colour, gloss and freedom from defects such as sprouting, shrivelling, bruising, insect or bacterial infection and decay. The uniformity of produce in terms of size, colour and ripeness is a key attribute noted by consumers.
- **Texture** (feel) – relates to the feel of the produce item in the hands or in the mouth. Textural attributes can be described in the context of firmness, crispness, juiciness, mealiness and toughness, depending on the commodity. The textural quality of horticultural crops is not only important for their eating and cooking quality, but also for their ability to be transported through the horticultural chain.

[1] Prepared by R. Rolle and D. Njie.

- **Flavour** (eating) – relates to the smell and taste of the produce item. Flavour attributes can be described in terms of sweetness, sourness (acidity), astringency (due to tannins), saltiness, bitterness, aroma (volatile compounds), off-flavours and off-odours. Flavour quality involves perception of the tastes and aromas of many compounds.
- **Nutritional** – these attributes relate to the vitamin, mineral, lipid, protein, carbohydrate, phytonutrient (antioxidant and flavonoid content) and dietary fibre content of fresh produce.
- **Safety** – these attributes relate to factors that could make the consumption of fruits and vegetables unsafe. Included in this group are contaminants such as chemical residues and heavy metals, environmental pollutants, pesticide residues, physical hazards (e.g. glass, metal etc.), pathogenic micro-organisms, naturally occurring toxic plant products such as oxalates and nitrates, as well as toxigenic fungal products such as mycotoxins.

An additional dimension of quality, which has evolved in international markets, relates to credence attributes – that is, attributes that depend on the method of production, regardless of whether the method of production has a visible or analysable impact on the produce. Examples of credence attributes desired by consumers include sustainable environmental profiles or fair trade conditions.

Monitoring quality in horticultural supply chains

Standards that integrate consideration of parameters such as appearance, shape, colour, bruising, blemishing, diameter, size, maturity, skin defects and residues are used for monitoring quality in horticultural supply chains and for ensuring that produce complies with the requirements of the buyer.

Such standards facilitate labelling, provide a basis for reporting on market prices and are the legal framework used for the settlement of commercial disputes.

Factors that contribute to quality loss in horticultural produce

Quality loss results from factors that are both internal (physiological processes) and external (microbiological, chemical, environmental and mechanical) to harvested produce. Respiration and transpiration are physiological processes that can be greatly influenced by environmental conditions such as temperature, relative humidity, the composition of the gaseous environment and mechanical or physical damage to the produce. Microbial and chemical contamination can compromise the safety of horticultural produce greatly. Microbial contamination can be transmitted through improper cultural practices, by workers and through contact with soil and unclean surfaces.

Mechanisms for preventing and controlling quality loss and contamination in horticultural supply chains are the core of this training programme.

REFERENCES

Kader, A. and R.S. Rolle (2004**)** The role of post-harvest management in assuring the quality and safety of horticultural produce. Food and Agriculture Organization (FAO) Agricultural Services Bulletin 152. Rome, Italy: FAO.

Suggested method of instruction

Lecture, using visuals, followed by a discussion of observations made on quality during practical exercise II: Meeting the consumer and observing consumer behaviour.

Time frame

The duration of the lecture and discussion is one hour.

SECTION IV

MODULE 2 – TECHNICAL DIMENSIONS OF HORTICULTURAL CHAIN MANAGEMENT TO ASSURE QUALITY[1]

Learning outcomes

The learner should:

- Develop a perspective of the critical technical issues to be considered in horticultural chain management

Introduction

The horticultural chain spans the continuum from the producer to the consumer and integrates a number of stakeholders. Horticultural chains vary considerably in length and complexity, depending on the distance between the producer and the target market. Every stakeholder in the chain (the producer, harvester, pack house employee, logistics service provider and so on) is an important and critical link in assuring the safety and quality of horticultural produce as it moves through the chain. Stakeholders must be properly trained and must be aware of the factors that could compromise the safety and quality of horticultural produce, both pre- and post-harvest. Weak links within the chain and poor logistical operations could compromise the competitiveness of horticultural produce, leading to risks to consumer health and considerable economic losses.

Critical considerations in horticultural chain management

Quality maintenance in horticultural chains hinges on temperature and relative humidity management, as well as protection from mechanical injury. The safety of produce must be assured by minimising risks of contamination from pre-harvest, through post-harvest handling, distribution and retail.

Distance and time to market are critical considerations in horticultural chain management, given that fresh produce progressively deteriorates with increasing time between harvest and consumption. Direct and efficient marketing routes combined with appropriate logistical arrangements are required to assure the timeliness of delivery of fresh produce of high quality.

A well-equipped and hygienically maintained infrastructural base is a pivotal support element of the chain. The technological level of the equipment within that infrastructural support base must be appropriate to the needs of the target market and the length and complexity of the chain. For simple chains, such as where the producer is within hours of the market, a simple infrastructural base consisting of packing and well-ventilated transportation facilities is adequate. For longer, more complex chains, packing houses, cooling systems and logistics infrastructure (refrigerated transportation, storage/warehousing and containerisation, for example) supported by appropriate logistical operations are required to assure the maintenance of quality and timeliness of delivery to the target market.

[1] Prepared by R. Rolle and D. Njie.

Record keeping and documentation systems at every step of the chain allow the seamless flow of information up and down the chain and facilitate the tracking and tracing of produce between the producer and the market.

There is no substitute for good hygiene, proper handling, proper temperature management and efficiency within the chain if the quality and safety of fresh produce is to be guaranteed.

REFERENCES

Kader, A. and R.S. Rolle (2004) The role of post-harvest management in assuring the quality and safety of horticultural produce. Food and Agriculture Organization (FAO) Agricultural Services Bulletin 152. Rome, Italy: FAO.

Suggested method of instruction

Lecture, using visuals, to provide an overview of the critical issues that must be considered in horticultural chain management if quality is to be assured.

Time frame

The duration of the lecture and follow-up discussion is one hour.

SECTION V

QUALITY IMPACT FACTORS IN HORTICULTURAL SUPPLY CHAINS

SECTION V

MODULE 1 – PHYSIOLOGICAL FACTORS[1]

Learning outcomes

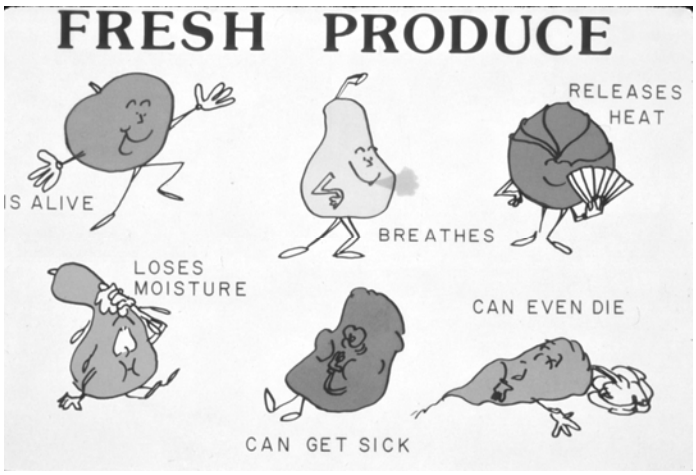
The learner should:

- Understand the physiological factors that impact on the quality of horticultural produce

Introduction

Harvested fresh produce is 'living' and continues to perform its metabolic functions in the post-harvest state. These metabolic functions impact greatly on the quality and shelf life of fresh produce.

A basic understanding of post-harvest physiological processes and mechanisms for their control is critical for effective quality maintenance throughout horticultural supply chains. This module describes the physiological factors that impact on the quality of horticultural produce.



Source: Kader and Rolle, 2004

Physiological processes of fresh produce

Respiration

Harvested produce is alive, which means that it is constantly respiring. Respiration involves the breakdown of carbohydrate reserves in the plant or in harvested produce and results in the production of carbon dioxide, water and heat (see figure V.1.1, below). Respiration occurs both pre- and post-harvest.

[1] Prepared by R. Rolle and D. Njie.

Figure V.1.1 Aerobic respiration

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6H_2O + \text{Heat (2830 kJ)}$$

In the post-harvest phase, respiration is supported by carbohydrate reserves of the produce; this leads to a net loss in its dry weight or negative growth. The more rapid the respiration rate, the faster the produce will consume its carbohydrate reserves, the greater will be the heat produced and the shorter will be the post-harvest life of the fruit or vegetable.

Carbohydrate breakdown during respiration leads to losses in food value, flavour, texture and weight, and thus to overall quality loss. Loss in weight, in particular, results in economic loss to the producer. Every effort must, therefore, be made to slow down the respiration rate of produce in order to minimise quality losses, extend shelf life and minimise economic losses to the producer.

Factors that impact on respiration rates:

- Temperature
- Atmospheric composition
- Physical stress

Temperature

Temperature has a significant influence on the respiration rate of harvested produce and without doubt has the greatest impact on the deterioration of produce post-harvest. The higher the storage temperature of fresh produce, the greater is its rate of respiration. The rate of deterioration of horticultural produce increases two to three-fold with every 10°C increase in temperature (see table V.1.1, below).

Table V.1.1 Effect of temperature on the deterioration rate of a non-chilling- sensitive commodity

Temperature °C	Assumed Q_{10}^*	Relative velocity of deterioration	Relative post harvest life	Loss per day (%)
0	--	1.0	100	1
10	3.0	3.0	33	3
20	2.5	7.5	13	8
30	2.0	15	7	14
40	1.5	22.5	4	25

Source: Kader and Rolle, 2004

$$Q_{10}^* = \frac{\text{Rate of deterioration at temperature T + 10 °C}}{\text{Rate of deterioration at temperature T}}$$

Respiration rates can be slowed by storing produce at a low temperature that does not cause physiological damage to the produce (chilling injury – see explanation in Section VII.1). Temperature management is pivotal to controlling respiration and to maintaining quality.

Atmospheric composition

Adequate levels of O_2 are required to support the process of aerobic respiration in harvested produce. The exact level of O_2 required to reduce respiration rates, while at the same time

allowing aerobic respiration, varies in accordance with the commodity concerned. An O_2 level of around 2 to 3 per cent generally produces a beneficial reduction in respiration rates and in other metabolic reactions of fresh produce. Lower O_2 levels could lead to anaerobic respiration and off-flavour development as a result of alcohol formation.

Post-harvest handling treatments such as waxing, coating, film wrapping and controlled atmosphere packaging (as described in Section VI) can be used to regulate the availability of oxygen to harvested produce and so to reduce respiration rates.

Physical stress

Mild physical stress can perturb the respiration rates of produce. Bruising can, for example, result in substantial increases in the respiration rate of harvested produce. The avoidance of mechanical injury through proper packaging and handling is critical to assuring produce quality.

Transpiration or water loss

Fresh produce contains between 70 and 95 per cent water and is losing water constantly to the environment in the form of water vapour. The rate of water loss varies in accordance with morphological characteristics (such as tissue structure, dimensions and number of stomata and the presence of a waxy layer) of the epidermis (skin) of the produce item, the exposed surface area of the produce and the vapour pressure deficit (VPD) between the produce and its environment. The VPD bears an inverse relationship to the relative humidity of the environment. Under conditions of low relative humidity the VPD is high and water is lost rapidly. The rate of water loss increases exponentially with increasing temperature and linearly under conditions of low relative humidity.

Water lost due to transpiration in harvested produce cannot be replaced, thus resulting in wilting, shrivelling, loss of firmness, crispiness, succulence and overall loss of freshness. These undesirable changes in appearance, texture and flavour, coupled with weight loss, greatly reduce the economic value of horticultural produce. Wilted leafy vegetables may, for example, require excessive trimming to make them marketable.

Water loss can be controlled through temperature management, packaging and adjustment of the relative humidity of the storage environment of the produce. However, care must be taken to avoid condensation of moisture on the surface of the produce, since this could contribute to the development of decay.

Ethylene production

Ethylene (C_2H_4) is a naturally occurring organic molecule that is a colourless gas at biological temperatures. Ethylene is synthesised in small quantities by plants and appears to co-ordinate their growth and development. It is also associated with the decomposition of wounded produce. Given its gaseous nature, ethylene readily diffuses from the sites where it is produced. Continuous synthesis is, therefore, needed for maintenance of biologically active levels of ethylene in plant tissues.

Ethylene is also an environmental pollutant, being produced by internal combustion engines, propane powered equipment, cigarette smoke and rubber materials exposed to ultra violet light.

Fresh produce can be categorised as being either climacteric or non-climacteric (see table V.1.2, below) on the basis of its ability to produce ethylene during the ripening process.

- **Climacteric produce** – produces a burst of ethylene and shows an increase in respiration on ripening (see figure V.1.2). Ripening of climacteric fruit after harvest typically involves softening and a change in colour and taste in terms of sweetness.
- **Non-climacteric produce** – does not show increased ethylene production on ripening, with relatively little quality change after harvest. Non-climacteric produce undergoes slight softening with a loss in green colour after harvest, with relatively little change in eating quality. Examples of climacteric and non-climacteric fruit are shown in table V.1.2.

Table V.1.2 Examples of climacteric and non-climacteric fresh produce

Climacteric produce	Non-climacteric produce
Apple, pear, apricot, cantaloupe	Cherry, strawberry, cucumber
Nectarine, peach	Grape, orange, lemon, mandarin
Mango, avocado, banana	Watermelon, honeydew melon
Tomato, sapodilla, papaya	Root vegetables, pineapple
Rockmelon, passion fruit	Leafy greens

Ethylene has both beneficial and harmful effects on the quality of horticultural produce. Ethylene enhances produce quality by promoting desirable colour development and stimulating the ripening of climacteric fruit. However, its undesirable effects include accelerated ripening and softening of fruits, accelerated senescence and loss of green colour in leafy, floral and immature fruit/vegetables, russet spotting on lettuce and the abscission of leaves.

Because of these diverse and often opposite effects of ethylene, controlling its action in fresh produce is of great economic importance to producers, wholesalers, retailers and consumers of fresh fruits and vegetables.

The deleterious effects of ethylene can be overcome through low temperature storage, controlled or modified atmosphere storage, ventilation of ripening rooms, segregation of ethylene producing commodities from ethylene sensitive ones, the use of ethylene absorbers such as potassium permanganate ($KMnO_4$) in cold rooms as well as the scrubbing of ethylene from cold rooms. The ethylene inhibitor 1-methylcyclopropene, currently sold under the trade name 'Smart Fresh' is currently approved for use on selected produce items in the United States.

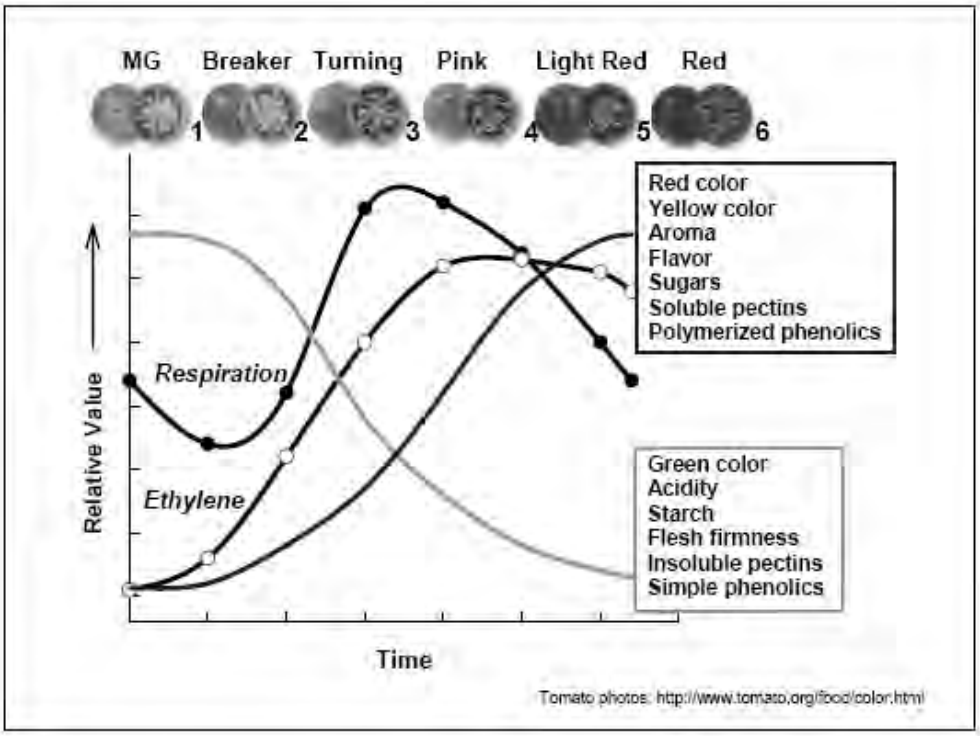
Assuring produce quality

The foregoing discussion has underlined the importance of temperature management in:

- lowering respiration rates
- slowing ethylene production
- reducing water loss
- minimising the harmful effects of mechanical injury

Temperature management is also critical in slowing the spread and growth of decay organisms.

Figure V.1.2 Profile of key physiological changes that occur in tomatoes during the various stages of ripening



REFERENCES

Kader, A. and R.S. Rolle (2004**)** The Role of Post-Harvest Management in Assuring the Quality and Safety of Horticultural Produce. Food and Agriculture Organization (FAO) Agricultural Services Bulletin 152. Rome, Italy: FAO.

Web sources

California Tomato Commission: **http://www.tomato.org/Member/Content.aspx?id=4** [accessed 8 January 2008]

Suggested methods of instruction

Lecture, using handouts or visuals to emphasise the physiological processes that impact upon maintenance of fresh produce quality.

Time frame

The duration of the lecture is one hour, including a discussion of observations relevant to produce quality made during Practical Exercise II.1: Meeting the consumer and observing consumer behaviour.

SECTION V

MODULE 2 – MICROBIOLOGICAL FACTORS[1]

Learning outcomes

The learner should:

- Understand the causes of plant diseases
- Understand how plant diseases are spread
- Understand mechanisms for the control of post-harvest diseases
- Develop an appreciation of the categories of pathogenic microorganisms that are known to contaminate fresh produce
- Understand the factors that influence the growth and survival of pathogenic microorganisms in horticultural chains

Introduction

The quality and safety of fresh produce is greatly impacted by several factors prior to, at the time of, and after harvest. Micro-organisms play a significant role; they can negatively impact on plant growth and on the ultimate quality of fresh produce, and they can render produce unsafe for human consumption. This module describes micro-organisms and their impact on quality and safety in horticultural chains.

Plant diseases

Plant diseases are caused by a variety of factors and may be grouped broadly into two categories:

- *Infectious plant diseases* – caused by biotic or living organisms such as fungi, bacteria, nematodes, prokaryotes, viruses, viroids, protozoa, arthropods and parasitic plants; and
- *Non-infectious plant diseases* – caused by physical or environmental factors (abiotic factors), such as changes in temperature and pH, lack of or excess moisture or light, lack of oxygen, air pollution etc. (see figure V.2.1). Symptoms of non-infectious diseases appear before harvest and can generally be culled.

Post-harvest diseases

Classical post-harvest diseases develop either from 'invisible' or latent infections or from spores present at harvest, which then go on to infect through wounds in the produce. Inoculation (introduction of an infective agent) of fresh produce during handling and storage practices can result from poor sanitation and inadequate quality assurance standards.

Fruit and vegetable crops differ in terms of growth, climatic requirements and the way in which the commodity is subsequently harvested, handled and stored. Different categories of post-harvest diseases can be described based on the crop's growth stage and its subsequent exposure to an inoculum whether from soil, water or the environment, time of actual infection and onset of symptom development. Symptom development can be initiated pre-harvest, pre- and post- or post-harvest. The majority of symptoms start developing at the pre-harvest stage and the commodity is subsequently discarded or culled during harvesting, grading and

[1] Prepared by L. Korsten.

packaging. Symptoms that develop post-harvest are usually not detected prior to packing and shipping and result in significant losses to the producer.

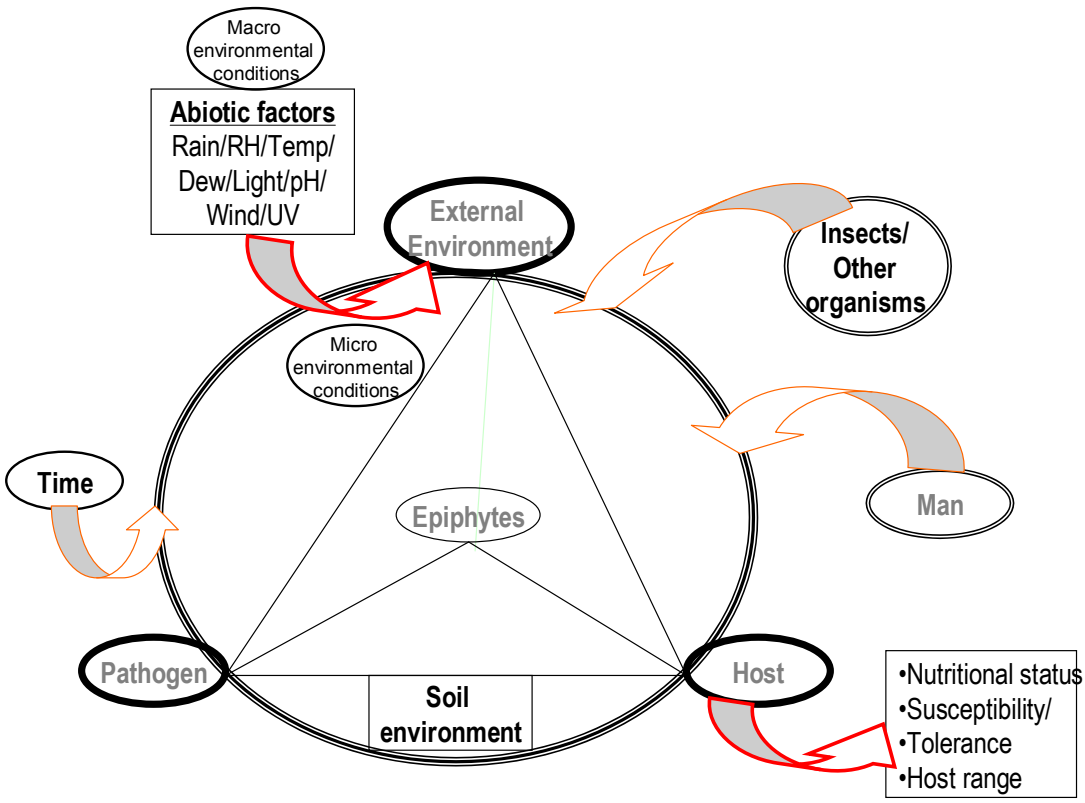


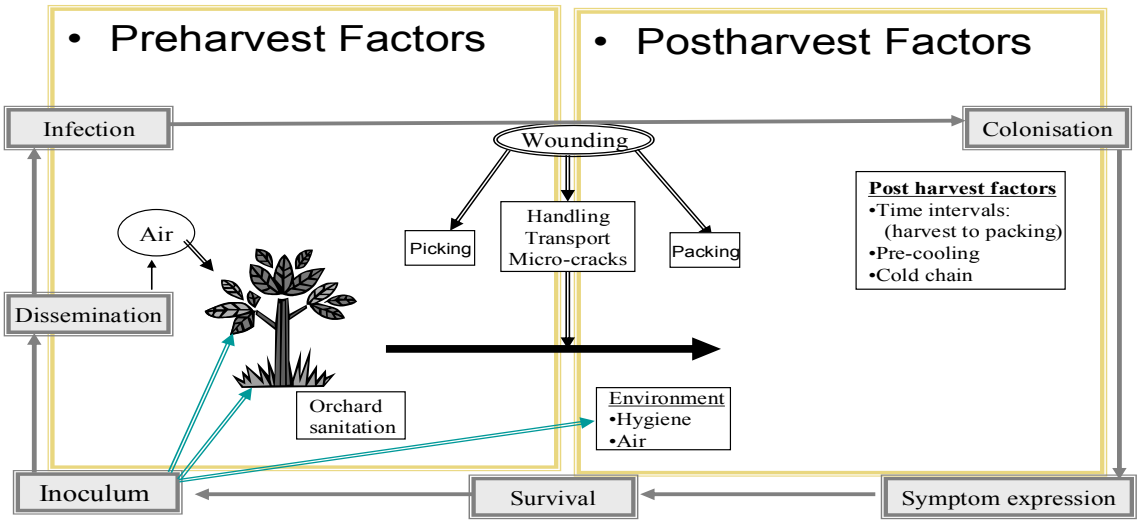
Figure V.2.1 Schematic representation of the classical disease triangle in the pre-harvest environment

Disease cycles can be easily described on the basis of a pre- or post-harvest scenario (see figure V.2.2, below). With pre-harvest diseases, the inoculum is often present in the field and spreads, leading to attachment and partial infection. The inoculum source in the pre-harvest scenario is often associated with planting material or soil and can be reduced with good field hygiene practices, although wind and wind-borne rain can facilitate the dissemination of pathogens.

Post-harvest inoculum is usually present in containers, trucks, pack houses or cold store facilities, and can be controlled though good hygienic practice. Some pre-harvest inoculum, such as soil, may also be present in the post-harvest phase. Air currents in pack houses and cold room environments can also facilitate the movement and dispersal of micro-organisms.

Various other factors come into play. These include humidity, movement of people or forklifts and gravitation as spores settle on surfaces. The various factors responsible for infection will be discussed in subsequent sections.

Figure V.2.2. Pre- and Post-harvest factors that contribute to post-harvest diseases



Fungal infections

Fungal plant pathogens are often wind-borne and are thus disseminated easily. Once on the surface of the crop, the fungal spore attaches and will germinate when conditions are favourable for infection. In certain cases, pathogens may form an appressorium (resting structure) and remain latent until after harvest.

Alternaria alternata is an example of a fungal plant pathogen that occurs regularly in temperate tomato producing regions and subtropical countries. Strains of *A. alternata* are also known to produce toxins. Other plant pathogens, such as *Aspergillus flavus* and *A. parasiticus*, the causal agents of *Aspergillus* rot in various commodities, can produce aflatoxins, rendering infected produce unsuitable for human consumption. *Botrytis* and *Pencillium* are classical post-harvest plant pathogens. Effective control strategies for these diseases necessitate careful quality control, particularly of fruit destined for processing.

Latent infections

Latent infections of fruit by pathogenic spores can occur as early as during flowering. These pathogens do not cause disease during fruit development, but symptoms of infection will usually manifest during fruit ripening, when the fruit's natural resistance declines (see figure V.2.3, below). Typical latent fruit pathogens include *Colletotrichum gloeosporioides* Penz. (*Anthracnose* on mango) and *Botrytis cinerea* (strawberry grey mould).

Spread of diseases in horticultural chains

Provided effective quality assurance systems are in place at the pack house, fruits and vegetables with disease symptoms are generally eliminated prior to packing, thus preventing their entry into the market place. However, during grading, a limited number of infected produce items can be overlooked or can be accepted due to allowable small lesions. These 'insignificant' lesions can develop further, particularly during lengthy storage or transit periods, either remaining limited to a single commodity or spreading to adjacent fruits or vegetables.

Classic post-harvest plant pathogens

Fungal pathogens

Penicillium is one of the most important post-harvest plant pathogens. Over 150 recognised species of the genus *Penicillium* exist, of which more than 50 occur frequently. The classification of *Penicillium* species is complex and includes four subgenera: *Aspergilloides*, *Furcatum*, *Biverticillium* and *Penicillium*. The majority of important toxigenic and food spoilage species are found in the subgenus *Penicillium*.

Penicillium is a classical wound pathogen and is easily disseminated through air. *Penicillium* rots cause the typical blue and green mycelial growth on food, particularly citrus, litchi and apple. Various species of *Penicillium* cause post-harvest diseases, which lead to significant losses in crops and in the post-harvest environment. *Penicillium* species have been shown to cause up to 90 per cent of total fruit decay during transport and storage. Mycotoxins are also produced by *Penicillium* species.

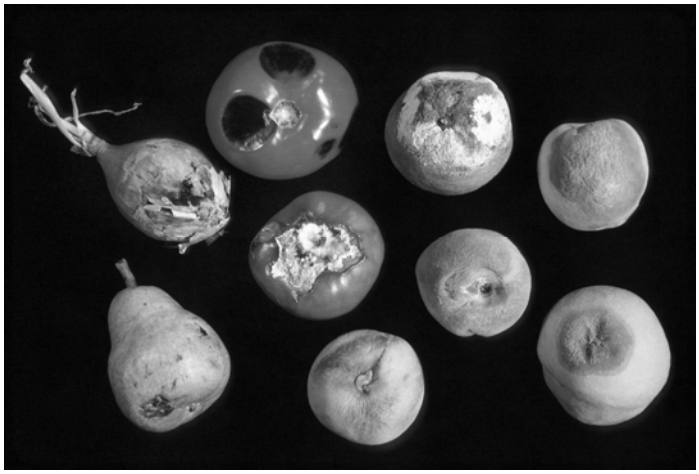
Penicillium digitatum is a well-known post-harvest pathogen that causes green mould rot on citrus. The occurrence of this pathogen increases when the substrate that it contaminates is exposed to damp conditions. *Penicillium* spores can typically survive unfavourable conditions for long periods. They can even survive from one season to the next and serve as inoculum for infections in subsequent seasons. The spores can survive in contaminated bins used to store equipment and even on pack house walls. This fungus causes an 'off-flavour' in juice owing to the production of acetoin and diacetyl. It grows at temperatures ranging between -6ºC and 35ºC.

Control of post-harvest fungal diseases

Post-harvest fungal diseases can be controlled through the application of pre- and post-harvest measures to reduce inoculum levels. These include pre-harvest field spray programmes, the application of good hygienic practice in the pack house and the use of specific post-harvest treatments.

Several alternative approaches have been developed for the control of post-harvest diseases at the pack house level. Integrated control, which combines fungicides with biological control products and other physical control measures, has been used successfully. Hot water treatment is perhaps best known for its efficacy against mango and citrus post-harvest diseases. The use of disinfectants has also gained ground in recent years, while modified atmosphere packaging has recently provided a challenging alternative, especially to replace sulphur dioxide fumigation treatments.

Figure V.2.3 Symptoms of decay caused by various fungi



Source: Kader and Rolle (2004)

Bacterial infections

Although not as commonly involved in plant diseases as fungi, bacteria can also cause spoilage of fruit and vegetables in the field, during harvesting or subsequent handling, and particularly during washing. Bacteria that cause spoilage of vegetables are grouped into two categories: (i) the soft rot group and (ii) groups that cause blemishes or surface defects.

Soft rot bacteria

Spoilage of vegetables is caused primarily by the soft rot group of bacteria. Soft rots are characterised by the maceration of plant tissue by bacterial enzymes. The disease progresses rapidly under favourable conditions of temperature and humidity. *Erwinia* and *Pseudomonas* spp. are the most important bacteria associated with soft rot.

Pectobacterium carotovorum (potato soft-rot), previously known as *Erwinia carotovora,* is a latent pathogen of vegetables (see table V.2.1, below). The bacterium can occur in the lenticels without causing any disease until host resistance mechanisms weaken. Tuber soft rot can be caused during storage and transit by environmental factors such as temperature, relative humidity, free moisture and gas composition.

Table V.2.1. Bacteria that commonly cause soft rot of fruits and vegetables and their temperature requirements

	Bacteria	Crop	Temperature
			^{0}C
1.	*Erwinia carotovora* subsp. *atroseptica*	Vegetables, potatoes, some fruit	27
2.	*E. carotovora* subsp. *carotovora*	Vegetables, potatoes, some fruit	27
3.	*E. chrysanthemi*	Vegetables, some fruit	29
4.	*Pseudomonas marginalis*	Pineapple	35
5.	*P. chicorii*	Vegetables	28
6.	*P. cepacia*	Chicory, endive, cabbage, lettuce	30
7.	*P. gladioli* pv. *allicola*	Onion	32
8.	*Bacillus polymyxa*	Onion	32
9.	*Clostridium paniceum*	Potato, pepper	-
10.	Low temp. *Clostridium*	Potato	-
		Potato	22

Blemishes and surface defects

Several bacterial species cause blemishes or surface defects that affect the market quality of produce. The disease may be evident as an infection of the vascular system or may result in distinct lesions on leaves, fruits, tubers or roots. Much of the affected produce may be rejected during inspection and packing, but inconspicuous lesions may progress during transit and storage and allow soft rot bacteria to enter and cause extensive spoilage.

Factors that contribute to bacterial spoilage

- *pH of the fresh produce* – the neutral pH of vegetables (pH 4.5-7.0) makes them more highly susceptible to bacterial spoilage than fruit (pH < 4.5). Up to 75 per cent of salad cargoes are lost owing to bacterial soft rot.
- *Wounding* – bacteria cannot penetrate intact surfaces.

Control of bacterial diseases

Bacterial diseases can be controlled by reducing the opportunity for contamination in the field and during post-harvest operations. This can be achieved by:

- removal of debris at the field level;
- harvesting at optimum maturity;
- avoiding mechanical damage;
- rapid cooling after harvest;
- use of chlorine dioxide in washing/hydro-cooling and fluming in the pack house; and
- treatment of the produce with antibiotics:
    - Streptomycin, oxytetracycline, polymyxin, neomycin
    - Zineb, Chloramphenicol for potatoes.

Mycotoxins

During primary metabolism, micro-organisms produce substances known as primary metabolites that are essential for their growth. They also produce secondary metabolites toward the end of their exponential growth phase. These secondary metabolites are not essential for growth or for maintaining the organism that produces them. Mycotoxins are one of these secondary metabolites. Mycotoxins are secondary metabolites produced by microfungi that are capable of causing disease and death in humans and other animals (Bennet and Klich, 2003). Fungi can be found everywhere. Therefore, if conditions are favourable for mycotoxin production, these toxins will build up.

Mycotoxins are produced by fungi to give them a competitive edge over other micro-organisms occupying the same ecological niche. Numerous species of fungi produce a range of mycotoxins that each target specific cell structures or processes in other microbes. The substrate of growth also plays a role in the type and amount of mycotoxin produced. Approximately 300 mycotoxins have so far been described and the majority of these belong to the genera *Aspergillus, Fusarium, Penicillium* and *Alternaria*. Of these, *Aspergillus flavus* and *Aspergillus parasitica* are the most important.

Fungi that produce mycotoxins are referred to as toxigenic fungi. They are broadly divided into two groups:

- Those that produce mycotoxins while still in the field, before harvest. The pathogenic genera involved here are mostly *Fusarium* and *Clavicep*s spp.
- Those that produce toxins after harvesting and during storage. The organisms involved are mainly saprophytic (living on 'dead' material). Examples are of the genera *Aspergillus* or *Penicillium*.

Of all the known mycotoxins, very few have been recorded as natural contaminants of food items. Several mycotoxins have, however, been found to be toxic at levels in which they commonly occur as natural contaminants in food items.

Aflatoxin contamination is mainly encountered in tropical and subtropical countries, where environmental conditions are conducive to the development of pathogens. *Citrinin* and *Alternaria* toxin, *tenuazonic* acid, have been found in tomatoes. Other tomato and chilli pathogens such as *A. flavus,* which causes *Aspergillus* rot, can also produce aflatoxins, which render infected produce unfit for human consumption. Chillies are generally dried to low moisture content, which is sufficient to prevent fungal growth. This is of particular importance since several fungal species, such as *A. flavus,* attack improperly dried material and can produce toxins such as aflatoxins.

Control of mycotoxin contamination
In order to control the production of mycotoxins, it is necessary to control the organisms that produce them. This can be done through:

- Pre-harvest practices that focus on preventing the build up of fungal inoculum and subsequent contamination of the crop during its growth. Because of the subtropical climates in most African countries, controlling fungal growth remains a challenge and production practices should be adopted to minimise infection. Removal of inoculum from orchards (orchard hygiene) is therefore important.
- Sanitation, harvesting and handling methods that minimise injury to the fruit. Wounding, bruising and other injuries to fresh produce must be avoided.
- Storage of fruits and vegetables under dry conditions or in cold storage in order to prevent further fungal growth.

Prevention, elimination and detoxification are therefore the three major approaches to combating the entry of mycotoxins into the food chain.

Regulatory issues pertinent to mycotoxins
Mycotoxins pose an ever-increasing threat to the health of humans and animals. There is the need to create public awareness of the risks associated with exposure to mycotoxins. The public and all role players in the food chain need to understand what mycotoxins are and how they can be controlled. In many countries testing for the presence of mycotoxins in food and feed remains a critical component of national food safety programmes. According to The Food Safety Act of 1990 (South Africa), it is an offence to supply food that is contaminated with an unacceptable level of ochratoxin A. Regulations concerning precise and definite maximum levels of allowed ochratoxin A have been published. There are regulatory limits for ochratoxin A in nuts, and nuts are more frequently monitored for the toxin than are fruit samples as a result.

Natural toxicants associated with horticultural produce
Several common vegetables contain toxic substances. Potatoes contain the alkaloid solanine, as well as arsenic and nitrite, while green leafy vegetables can contain toxic oxalates. In terms of human lives lost from phenols originating in plants, salicylate aspirin is probably the most dangerous. The salicylic acid content of vegetables has attracted attention from both consumers and food processors, but is not often considered to be of importance in developing countries.

Pathogenic bacteria
Food-borne pathogens known to contaminate produce include bacteria, viruses and parasites such as protozoa (see table V.2.2). Of these, bacteria are of greatest concern in terms of reported cases and seriousness of illness. Although not their natural habitat, most fruit and vegetables contain nutrients required to support the growth of infectious or toxigenic microbes. Food-borne pathogens are known to be able to attach to fruit surfaces.

Storage temperature and pH are reported to be the two principal determinants of growth for food-borne pathogens associated with fresh produce. Psychrotrophic bacteria – organisms that can grow under conditions of refrigeration – vary widely in their acidic tolerances and are the most important spoilage group for fruits and vegetables (see table V.2.3). The most important of these from a food safety point of view are *Listeria* and *Clostridium*. The fact that these organisms can grow at refrigeration temperatures makes them very important from an export point of view. Beuchat (1998) listed several important food-borne pathogens from a fresh fruit and vegetable point of view and expressed their

relevant importance as a percentage of frequency reported: *Escherichia coli* 0157:H7 and Salmonella were found in more than 8 per cent, *Listeria monocytogenes* varied between 4 and 8 per cent, and Campylobacter 3 per cent.

Table V.2.2 Examples of pathogenic micro-organisms potentially found on fresh produce

Bacteria	Viruses	Parasites
Salmonella	Hepatitis A virus	*Cyclospora*
E coli O157:H7	Norovirus	*Cryptosporidium*
Shigella spp.	Enteric viruses	*Giarda*
Aeromonas spp.		*Toxoplasma*
L. Monocytogenes		*Helminths- Ascaris*
Klebsiella spp.		
Citrobacter freundii		
Campylobacter spp.		
Vibrio Cholera		

Source: Suslow, undated

Other important factors that influence the growth and survival of micro-organisms in horticultural chains include: available moisture on the product surface in the form of condensate due to changing temperature conditions and product respiration; water activity; atmospheric conditions; presence of ethylene; availability of nutrients; other competitive micro-organisms and antimicrobial factors.

Table V.2.3 Psychrotrophic spoilage micro-organisms

Bacteria		
Acinetobacter	*Aeromonas*	*Alcaligenes*
Arthrobacter	*Bacillus*	*Chromobacterium*
Citrobacter	*Clostridium*	*Corynebacterium*
Enterobacter	*Erwinia*	*Escherichia*
Flavobacterium	*Klebsiella*	*Lactobacillus*
Leuconostoc	*Listeria*	*Microbacterium*
Pseudomonas	*Moraxella*	*Proteus*
Micrococcus	*Serratia*	*Streptococcus*
Streptomyces	*Vibrio*	*Yersinia*

Source: Bracket, 1993

The neutral pH (pH 4.5-7.0) of vegetables, melons and soft fruit makes them more highly susceptible to bacterial spoilage than fruits such as apples and oranges, which are more acidic (pH < 4.5).

Potential exists for the contamination of fruit and vegetables owing to the wide variety of conditions to which they are exposed to during growth, harvesting, packing and distribution.

REFERENCES

Agrios, G.N. (1997) *Plant Pathology*. Fourth Edition. London, UK: Academic Press.
Beuchat, L. R. (1998) Surface Decontamination of Fruits and Vegetables Eaten Raw: A Review. Food Safety Unit, World Health Organization. WHO/FSF/FOS/98.2.
Bennet, J.W, and M. Klich, (2003) Mycotoxins. *Clin Microbiol Rev*. 16(3): 497-516.
Bracket R.E. **(**1993) Microbial Quality. In Shewfelt and Prussia (eds) *Postharvest Handling. A Systems Approach*. Chapter 6. Academic Press Inc. 356 pp.
Jay, J.M. (2000) *Modern Food Microbiology*. 6th Edition. New York, USA: Springer.
Kader, A. and R.S. Rolle (2004**)** The Role of Post-harvest Management in Assuring the Quality and Safety of Horticultural Produce. Food and Agriculture Organization (FAO) Agricultural Services Bulletin 152. Rome, Italy: FAO.
Pitt,JL. (2001) An Introduction to Mycotoxins. In *Mycotoxin Prevention and Control in Foodstuffs*. Available at: http://www.fao.org/inpho/vlibrary/x0036e/x0036e04.htm [accessed 8 January 2008]
Suslow, T. (undated) Microbial Safety of Horticultural Foods: Good Agricultural Practices: A Systems Approach. Available at: http://www.ucce.ucdavis.edu/files/datastore/234-642.pdf

Suggested method of instruction

Lecture using visuals or handouts to explain the role of bacteria and fungi in plant diseases and infections, and their impact on the safety and quality of horticultural produce.

Practical exercises

Practical exercises IV: Microbiology and V: Detection of post-harvest pathogens.

Time frame

The duration of the lecture is one hour.
The duration of the practical exercises is three hours.

SECTION V

MODULE 3 – AGRICULTURAL INPUTS AND PRACTICES[1]

Learning outcomes

The learner should:

- Develop an appreciation of the importance of input quality and cultural factors on the quality and safety of horticultural crops
- Understand the importance of Good Agricultural Practices (GAP) and the training of workers to assure safety and quality in horticultural chains

Introduction

The goal of a producer is to supply safe, high-quality produce, which conforms to consumer and market requirements. This objective hinges on good quality inputs, good cultural practices (planting, weeding, fertiliser application etc.) as well as good hygiene management during production so as to minimise microbial and/or chemical contamination of produce.

Planting material and cultural factors

To attain optimum quality attributes that conform to consumer and market requirements, the producer must select planting material that is well suited to the soil and climatic conditions of the area in which the produce will be grown. Commercial growers must ensure procurement of seeds through certified suppliers to ensure optimum yields and resistance to pests and disease. Moreover, when purchasing nursery seedlings or trees it is essential that the nursery is certified to a local standard and is preferably part of a national plant improvement programme. If growers do not buy seed from a registered supplier, they risk buying infected or poor quality seed or seed with low vigour.

During the growth period, the crop must be supplied with an appropriate balance of minerals, light intensity, nutrients and water. It must also be cared for using appropriate cultural practices in order to assure the yields and quality in terms of size, colour, freedom from defects of the final output.

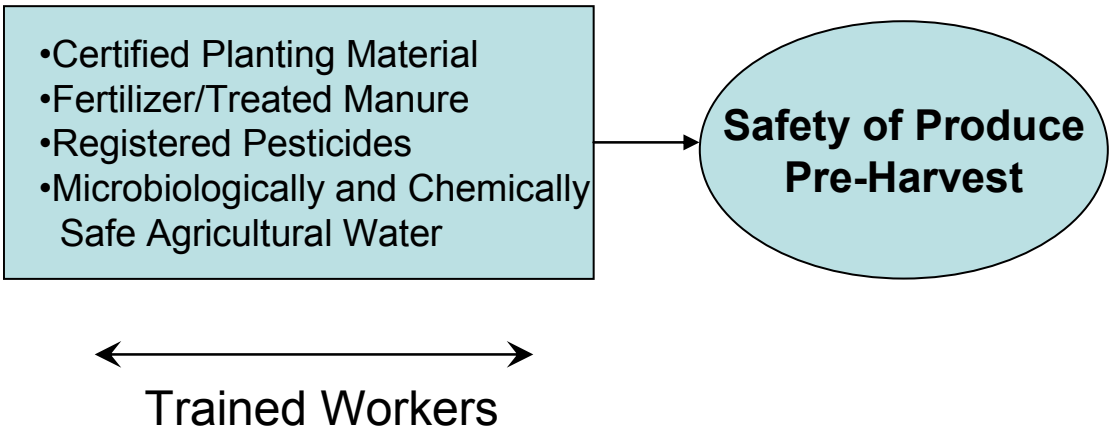
Agricultural practices

Contributors to the pathogenic contamination of horticultural produce (pre-harvest) include: general soil quality; the history of land use and proximity to animals, manure or faecal matter; and hazardous water storage areas. Enteric (intestinal) pathogens are common contaminants of vegetables, where contaminated or polluted water is used for irrigation or where sewage sludge is used as fertiliser. Pathogenic micro-organisms can also be transferred to fruits and vegetables by workers engaged in the harvesting, packaging and handling of produce. Most fruits and vegetables contain nutrients that can support the growth of these pathogenic microbes. Once contaminated, the removal or destruction of pathogens on fresh produce is very difficult. Prevention of microbial contamination pre-harvest and at all steps of the horticultural chain is strongly advised over treatments to eliminate contamination.

[1] Prepared by R.S. Rolle and L. Korsten.

Worker training and the application of Good Agricultural Practice (GAP) are pivotal in preventing the pathogenic contamination of horticultural produce. A properly implemented GAP programme to assure the safety of fresh produce should include consideration of: the history of land use; worker hygiene and sanitary facilities; the control of wildlife and pests; water quality and the application of water; and management of soil fertility. Input requirements to assure the safety of pre-harvest crops are summarised in figure V.3.1, below.

Figure V.3.1 Input requirements to assure the safety of crops pre-harvest



Documentation of manure use, water test results and food safety awareness training of workers at the farm level are also critical elements of such a programme.

Manure

Animal manure (biofertiliser) or other waste products are often used to promote plant growth and soil fertility. These materials can, however, lead to microbiological contamination of fresh produce with food-borne pathogens.

Manure in any form should be treated (i.e. composted, dried, heated or decontaminated in some other way) prior to application in the field, in order to minimise the risk of contamination. Animal manure must not be spread between crops if there is the likelihood of direct contamination.

Agricultural water

Water used during crop production, if not of an appropriate quality, could introduce water-borne pathogens into the horticultural supply chain. Water used for irrigation is, therefore, an important control point in fruit and vegetable supply chains.

Water sources must be frequently tested for microbial contamination. In situations where water quality cannot be controlled (e.g. water obtained from rivers, lakes and dams), producers should use other good management practices to minimise the risk of contamination.

For instance, in situations where a high standard of water quality cannot be assured, irrigation practices must be modified in order to minimise contact of water with the edible portion of the plant. Many small farmers are reliant on natural rainfall and are therefore not affected by this requirement.

Animal faecal contamination

Within the African context, wild and domestic animals and birds often roam rural landscapes and can pose a contamination risk. Steps must be taken to exclude the presence of these animals in production areas during the growing and harvesting season. If herds of animals are known to frequent or roam certain agricultural plots, alternative plots should be selected or a diversion strategy implemented.

Pesticide use

As part of its policy of protecting consumers, retailers and the government, GAP aims to minimise the exposure of consumers to pesticide residues in food. Every pesticide stipulates a critical withholding period (the minimum recommended interval that should elapse between the last application of a formulated product to any crop or pasture and its harvesting) and this should be adhered to at all costs. It is therefore essential that all farmers understand the importance of using only allowable pesticides and allowable Maximum Residue Levels (MRL) in conformance with the country where the produce is grown and where it will be sold. Failure to consider the withholding period can lead to rejection of entire shipments if detectable residue levels are found.

Farmers must adhere to correct spray dosages and withholding periods and purchase from recognised pesticide dealers.

Worker training

All workers must be trained in hygiene practices with constant reinforcement of the importance of personal hygiene and sanitation. Workers must also be adequately equipped with hand washing and sanitation facilities in accordance with specific requirements of the country concerned.

REFERENCES

Food and Agriculture Organization (FAO) (2003) Development of a Framework for Good Agricultural Practices. Available at: http://www.fao.org/DOCREP/MEETING/006/Y8704e.HTM [accessed 8 January 2008]

Jay, J.M. (2000) Modern Food Microbiology. 6th Edition. New York, USA: Springer.

Rangarajan, Anusuya, Elizabeth A. Bihn, Robert B. Gravani, Donna L. Scott, and Marvin P. Pritts. In *Food safety begins on the farm: A growers guide*. Available at: http://www.sfc.ucdavis.edu/pubs/articles/foodsafetybeginsonthefarm.pdf [accessed 8 January 2008]

Suslow, T. (undated) Microbial Safety of Horticultural Foods: Good Agricultural Practices: A Systems Approach. Available at: http://ucce.ucdavis.edu/files/datastore/234-642.pdf

Suslow, T. (undated) Key Points of Control and Management of Microbial Food Safety for Growers, Packers and Handlers of Fresh-Consumed Horticultural Products. Available at: http://ucgaps.ucdavis.edu/Key_Points_-_Horticultural_Products/ [accessed 8 January 2008]

Suggested methods of instruction

Lecture using handouts or visuals to explain the importance of preventing microbial contamination of fresh produce pre-harvest through Good Agricultural Practices (GAP).

Practical exercise

Practical exercise III.2: Visit to an orchard.

Time frame

The duration of the lecture is one hour.
The duration of the practical exercise is one day.

SECTION V

MODULE 4 – INSECT PESTS [1]

Learning outcomes

The learner should:

- Understand the impact of insects on horticultural chain management
- Become familiar with the most important insect pests associated with horticultural produce
- Become familiar with methodologies for the control of insects in horticultural chains

Introduction

Global trade requires strict control of phytosanitary measures to prevent the importation of insect pests. Pests such as the Mediterranean fruit fly can seriously disrupt trade among countries. For effective quarantine, 100 per cent pest control is required. In order to prevent the rejection of export consignments it is therefore critical that countries implement effective insect quarantine measures for the eradication of insect pests.

Post-harvest losses resulting from insect pests vary across regions and can be extremely high in African countries. Several examples of quarantine pests occurring in African countries will be discussed in this module, while their control and phytosanitary status will also be highlighted.

Insect quarantine measures

A large number of insects attack fruits and vegetables both pre- and post-harvest. Insect pests can negatively impact on the export of fresh produce, so it is essential that producers control these pests effectively and that governments monitor their spread and epidemiological development and determine their levels of risk.

Insect infestation can jeopardise export market opportunities, resulting in major economic losses to producers. Insects are visible with the naked eye and can, therefore, be physically removed and controlled more easily than microorganisms. Approximately 750,000 insect species are currently known, of which 450 are considered serious pests. Fruit handling generally disrupts the activity and survival of insects.

Fruit flies

Economically disruptive fruit flies associated with horticultural produce include amongst others the Mediterranean fruit fly *Ceratitis capitata* (Wiedeman) (see figure V.4.1) and the five-spotted fruit fly *C. quinaria* (Bezzi) (Diptera: Tephritidae); these species are present in Africa and are considered quarantine pests in other parts of the world. Fruit flies attack many cultivated fruits and vegetables, causing substantial crop losses throughout the world. Due to their economic importance, their biology and control have been studied extensively. Many fruit fly species are of quarantine importance in non-infested areas, particularly the United States and Japan. Their presence places severe constraints on the export of fresh fruits and

[1] Prepared by K. Krüger.

vegetables to areas free of the species in question (European and Mediterranean Plant Protection Organization (EPPO) 1997).

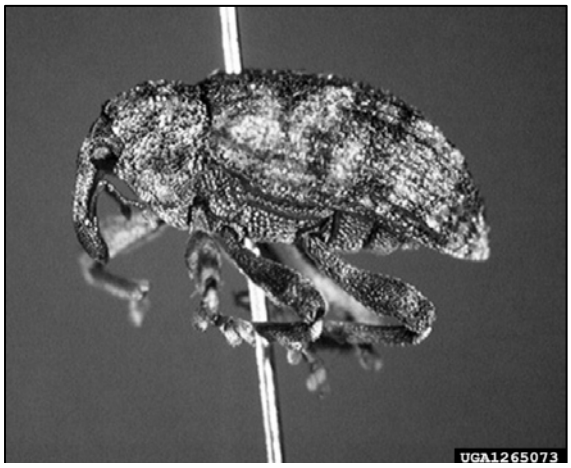
Figure V.4.1. The Mediterranean fruit fly *Ceratitis capitata* (Wiedeman)

Source: Scott Bauer, USDA Agricultural Research Service, www.forestryimages.org

Mango seed weevil

The weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae) (see figure V.4.2, below) is a pest of mango in parts of Africa and some other regions in the southern hemisphere including limited areas in North and Central America and the Caribbean. Mango seed weevil infestation may go undetected, owing to the fact that it develops within the mango seed and infected fruit appear normal. Yields are not severely impaired in general, but quarantine restriction may affect the export of fruit to mango-growing regions in the European Union (EU) or the Middle East, for example (EPPO, 1997).

Figure V.4.2. The mango weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae)



Source: USDA APHIS PPQ Archives, USDA APHIS PPQ, www.forestryimages.org

Information on the biology, identification, economic importance and phytosanitary risk of quarantine pests is available from a number of web resources (see References).

Managing insect pests

Chemical control

Numerous insecticides have been developed over the years. Further to the recent re-registration of pesticide requirements from the EU and the Montreal Protocol (United Nations treaty) to phase out methyl bromide (ethylene dibromide or EDB) numerous alternative approaches have attracted attention. The use of EDB was phased out in developed countries in 2005, with the objective of phasing out its use in developing countries by 2015. The Protocol, however, allows exemption for some uses, including quarantine treatment.

Physical treatments

Cold sterilisation treatment – Cold sterilisation protocols exist for insects such as fruit flies, i.e. Caribbean fruit fly, Mediterranean fruit fly and so on. While these treatments involve the storage of produce at given temperatures over specified time periods (such as 0°C for 10 days or 16 days at 2.2°C) the chilling sensitivity of the produce in question (see table V.4.1, below) can be of major concern. Produce can also be cold sterilised while in transit.

Table V.4.1. Example of exposure time combinations for cold sterilisation of *Ceratitis capitata*

Temperature °C or below	Exposure period (days)
1.11	14
1.67	16
2.22	18

***Source*: Adapted from USDA-APHIS-PPQ, Treatment Manual (2002)**

Heat treatments – Heat treatments for the eradication of insect pests can be accomplished by several means (see table V.4.2, below), including the use of hot water, vapour and hot air treatments. Such treatments involve increasing the temperature of the host commodity above the thermal limits of survival of the pest. In general, temperature and the duration of the treatment depend on the commodity and insect pest concerned. For example:

- **Hot water immersion** – is used primarily for the control of fruit fly hosts. The duration of the treatment depends on the commodity and origin of the target pest. Typically, the pulp temperature of the commodity is raised to between 46°C and 48°C for a specific period of time.
- **Vapour heat treatment** – this treatment makes use of air saturated with water vapour to raise the temperature of the commodity to a specific temperature for a specific time period. Typically, the pulp temperature of the commodity is increased to between 43.3 °C and 44.4°C over a period of six or eight hours and held at the required temperature for a further six or eight hours. Of importance is the combined effect of warming, holding and cooling periods.
- **Hot air treatment –** is particularly suitable in situations where humidity can cause damage to fresh produce. Produce subjected to hot air treatment may require rapid cooling after treatment. Hot air treatments can, however, push the limits of produce to the extreme and could cause physiological damage.

Table V.4.2. Examples of approved heat treatments to control fruit flies in fruits imported to the United States

Fruit	Pest	Heat	Temperature °C	Time[a]
Mango	Fruit flies	Hot water	46	65-110 min
Citrus from Mexico	Mexican fruit fly	High temperature forced air (HTFA)	44[b]	≥ 190 min
Mango from Mexico	Fruit flies	HTFA	50	Conclude treatment when surface of seeds reaches 48°C

a Depending on fruit size, origin of fruit etc.
b Fruit centre temperature
Source: adapted from USDA Treatment Manual

Controlled atmospheres – One promising alternative method of disinfestation is the use of controlled atmosphere (CA) treatment, which is based on a combination of temperature, atmospheric composition (low oxygen and high carbon dioxide concentrations) and exposure time. An oxygen concentration of 3 per cent or less, coupled with high carbon dioxide levels is generally used for CA disinfestation treatments. These atmospheric conditions are generally supplemented with appropriate temperature and relative humidity levels to maintain the quality of fresh produce. Insect infestation is controlled by maintaining low oxygen concentrations for an extended period of time, leading to reduced metabolism of the insect. Susceptibility to this treatment is affected by the developmental stage of the insect. Pupae and larvae, for example, are more sensitive than are eggs and adults. Although CA can increase insect respiration, and increase O_2 demand, at higher temperatures it could compromise produce quality. CA treatment is a potential alternative to methyl bromide. Controlled atmosphere storage is described in more detail in Section VI, module 6.

Irradiation – In general irradiation has been the most tested and most controversial quarantine alternative. Either a Cobalt 60, Caesium 137 or an electron accelerator (as with that used in X-rays) is used as the irradiation source. The dosage of irradiation varies in accordance with the produce item. Produce is generally of limited tolerance. Plant pathogens are generally more resistant (requiring more than 1 kiloGray or kGy) to irradiation than are insects (requiring less than 1kGy).The efficacy of irradiation in sterilising insects still needs to be proven.

In terms of the disadvantages of irradiation, the treatment creates a stress response in fresh fruits and vegetables, which results in increased respiration rates and the hastening of senescence resulting from free radical formation. Global negative sentiments remain the most restrictive factor for the commercial adoption of irradiation on a large scale.

Combination treatments – Combinations of the different methods of treatments, such as methyl bromide fumigation followed by cold sterilisation, have been used with some success. Controlled atmosphere treatments are generally used in combination with heat or cold treatments to shorten the duration of these treatments and to reduce their negative effect on commodity quality.

Alternatives/additions to post-harvest treatments

A number of other measures can be used as alternatives or in addition to post-harvest treatments. These include:

- Systems approaches
- Non-host status
- Pest-free areas
- Pest eradication

Systems approaches

A systems approach requires the integration of different measures, at least two of which act independently, with a cumulative effect (FAO, 2002). The systems approach relies on sound knowledge of pest and host biology and may include a number of components, such as:

- quarantine pest identification and risk management measures;
- pest surveillance, trapping and sampling;
- cultural practices;
- field treatment;
- post-harvest disinfestation;
- use of non-hosts or resistant hosts, including harvest maturity;
- pest-free areas; and
- limited harvest and shipping periods.

Non-host status

Commodities may be exported if they are shown to be non-hosts of a quarantine pest for all or part of its life cycle –that is, an insect cannot complete its life cycle on the host. The non-host status of a commodity can be difficult to establish, however.

Pest-free areas (PFAs)

These are areas in which a quarantine pest does not occur and which are kept free of that pest. Distribution of the Mediterranean fruit fly is, for example, limited to some areas in Australia, others being free of this pest. Export from these fruit fly-free areas is permitted by some importing countries.

Pest eradication

Eradication of a pest involves the elimination of all individuals of a species from an area where recolonisation is unlikely to occur. Eradication efforts are generally targeted at introduced pests to eliminate them from a given area or to prevent their further spread. Techniques for pest eradication include the sterile-insect technique and male annihilation (see below). In such cases, the treated area must be isolated – males from untreated areas should not be able to migrate to treated areas, for example.

- **Sterile-insect technique (SIT)** – involves the release of many males that have been sterilised by radiation or chemical means in the target areas. These mate with wild females and produce non-viable offspring. This technique is used worldwide.
- **Male annihilation technique (MAT)** – is based on the manipulation of male behaviour. It involves the use of many traps with insecticide-laced lures that attract and kill large numbers of males of a particular species, reducing the opportunity for females to mate.

REFERENCES

Food and Agriculture Organization (FAO) (2002). The use of integrated measures in a systems approach for pest risk management. ISPM No. 14. Rome, Italy.

Follet, P.A. and Neven, L.G. (2006) Current trends in quarantine entomology. Annual Review of Entomology, 51: pp. 359-385.

Kader, A.A. (ed.). (2002) Post-harvest Technology of Horticultural Crops. Agricultural and Natural Resources Publication 3311. USA: University of California.

Myers, J.H., Savoie, A., and van Randen, E. (1998) Eradication and pest management. Annual Review of Entomology, 43: pp. 471-491.

Web sources

Food and Agriculture Organization of the United Nations (FAO) www.fao.org [accessed 8 January 2008]

European and Mediterranean Plant Protection Organization (EPPO). Data Sheets on Quarantine Pests (www.eppo.org [accessed 8 January 2008])

European Union (www.europa.int)

World Trade Organization (WTO) www.wto.org [accessed 8 January 2008]

Suggested methods of instruction

Lecture, using visuals or handouts to explain the impact of pest infestation on horticultural chains and methodologies for controlling insect pests.

Time frame

The duration of the lecture and discussion is one hour.

SECTION V

MODULE 5 – PROCESSING WATER [1]

Learning outcomes

The learner should:

- Understand the importance of water quality in post harvest operations

Introduction

Clean water containing an appropriate concentration of sanitisers is required to minimise the transmission of pathogens from water to produce during post-harvest operations. Water is likely to contaminate produce in dump tanks, on washing lines, as well as during grading and pre-cooling operations. The concentration of sanitiser used must be sufficient to destroy microbes before they become attached to, or internalised in, produce.

Maintaining sanitary water conditions in pack house operations

Washing in potable water containing a sanitising agent can significantly reduce the microbial load associated with fresh produce. Given its low cost, chlorine is the most widely used sanitiser in produce handling.

The usefulness of chlorine in pack house management systems has often been debated. This is mainly due to the inability to effectively manage chlorine levels in receival baths and dump tanks where there is a constant introduction of dusty produce. Chlorine is very reactive and can easily break down in the presence of organic matter, which is often present in dirty or re-used wash or dip water. Moreover, the effectiveness of chlorine varies with pH (being more effective under conditions of acidic pH and less so under neutral or alkaline conditions) and should thus be carefully monitored and adjusted. Chlorine concentrations as free chlorine and pH should regularly be determined in chlorine wash waters

The concentration of free available chlorine and pH must be specified. Recommended chlorine concentrations are as follows:

- < 10mg/litre of chlorine is required at neutral pH
- 50-100mg/l of chlorine is required in situations where solid debris is present
- Chlorine dioxide (2g/litre)
- Sodium hypochlorite (2g/litre available chlorine)

Continuous filtration of circulated water is essential in maintaining the freshness and safety of the water and to manage microbial counts effectively. Regular replenishment of hot water baths is also critical and these should be routinely cleaned with a disinfectant to ensure effective removal of biofilms. Biofilms regularly build up in pack house dips and wash baths and should be removed regularly to prevent build-up of microbial populations.

Biofilms in water

Biofilms are present on everyday household products such as fruit (see figure V.5.1, below), vegetables, cutting boards, kitchen sponges and dish cloths, and can be found on almost any

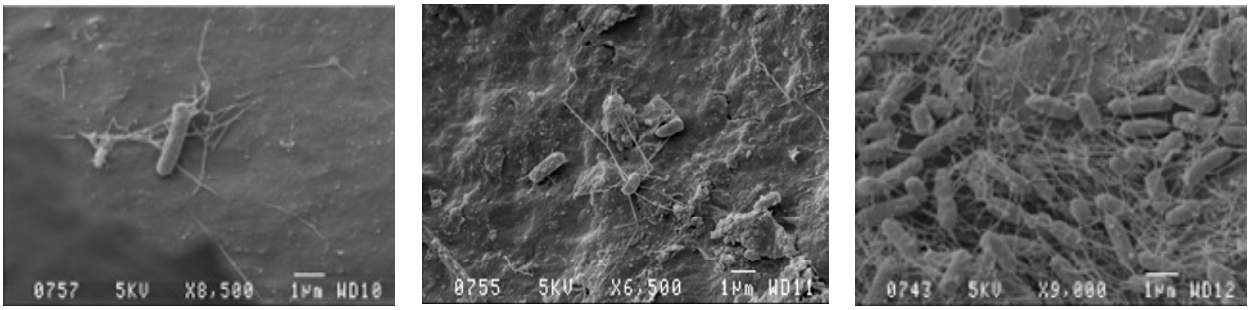
[1] Prepared by L. Korsten

surface where sufficient nutrients and water are present. Because pathogens such as *Salmonella* can be sequestered in these biofilms, it is important for them to be regulated and controlled. If a biofilm contains microbes, such as human pathogens, and is not removed or disinfected properly, it can serve as a continuous source of contamination. Biofilms can build up in pack house dips and wash baths and should be removed regularly to prevent the build-up of microbial populations.

Organisms within established biofilms can withstand nutrient deprivation, pH changes, oxygen radicals, disinfectants and anti-microbials much better than planktonic cells; they can also tolerate high concentrations of anti-microbial agents.

Biofilms can either be physically (ultrasound or mechanically) or chemically controlled. Although physical methods have been proven to be more successful than chemical methods, it is difficult to supervise the effectiveness of these methods. Biofilms can be controlled by limiting the availability of, or removing, nutrients required for the re-growth of the organisms that are responsible for biofilm formation

Figure V.5.1 Biofilm formation on orange surfaces after (a) 1, (b) 30 and (c) 60 minutes



(a) **(b)** **(c)**

Source: Courtesy of G. Britz

REFERENCES

Korsten, L. (1999) Perishable Products Exports Control Board (PPECB) Training Program on Good Packhouse Practices and Hazard Analysis and Critical Control Point (HACCP).

Suggested methods of instruction

Lecture, using visuals or handouts to explain the importance of water quality in post-harvest operations.

Practical exercises

Practical exercises VI: Monitoring sources of contamination during post-harvest operations.

Time frame

The duration of the lecture is one hour, including a discussion on water quality in pack house operations.

The duration of the practical exercise is three hours.

SECTION VI

HANDLING OPERATIONS TO ASSURE QUALITY MAINTENANCE IN HORTICULTURAL CHAINS

SECTION VI

MODULE 1 – ASSESSMENT OF MATURITY[1]

Learning outcomes

The learner should:

- Understand the importance of maturity indices and their impact on shelf-life and quality
- Understand the differences between subjective and objective maturity indices
- Develop an appreciation of how maturity indices are determined

Introduction

During fruit maturation, textural changes result in a loss of flesh or fruit firmness, starches are converted to sugars and acidity decreases. At the same time, flavour development takes place and a change in skin colour occurs.

Fresh produce must be harvested at the correct stage of maturity if it is to maintain its quality attributes throughout its post-harvest life. Prematurely harvested produce is highly susceptible to shrivelling and mechanical damage and is of inferior flavour and colour when ripe. Over-mature produce may be fibrous, soft and of poor eating quality in terms of sweetness, flavour and colour. It is, therefore, essential that those involved in harvesting receive training to identify the correct maturity indices for the produce concerned.

Physiological and commercial maturity

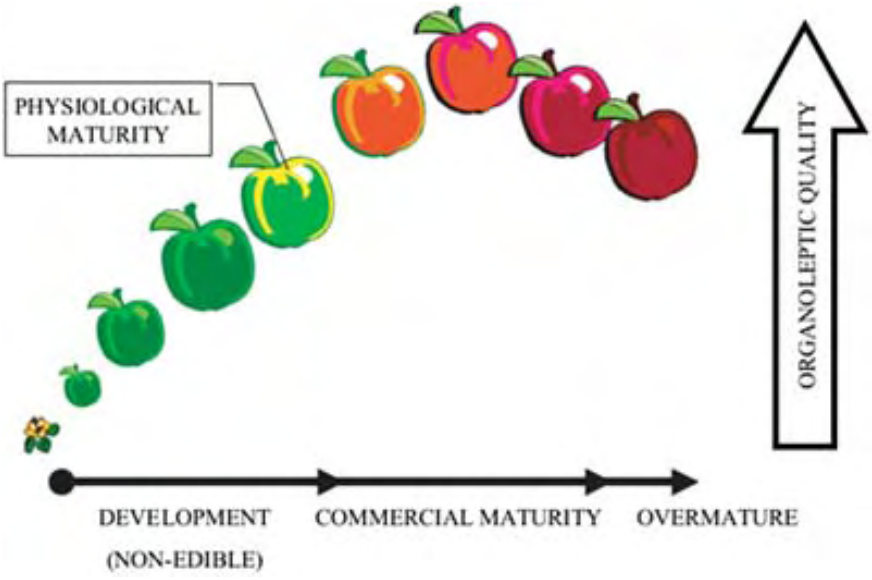
Fruit quality is greatly impacted by maturity at harvest.

- **Physiological maturity** – refers to a particular stage in the development of a plant or plant organ. A fruit is physiologically mature when its development is over. A physiologically mature fruit may not necessarily be commercially mature. For example, papayas are harvested for domestic markets at physiological maturity, i.e. when three-quarters of the fruit assumes a yellow-to-green colour.
- **Commercial maturity** – pertains to the timing of harvest to meet specific market and consumer requirements. A fruit is commercially mature when it reaches a developmental stage at which it can be marketed for a specific purpose, e.g. for consumption in the fresh state, or for processing. Papayas, for example, are harvested for export at the mature stage, i.e. when the fruit is firm and easy to handle. On arrival at the destination the fruit is ripened in ripening rooms.

Commercial maturity has little impact on physiological maturity (see figure VI.1.1).

[1] Prepared by D. Sivakumar and L. Korsten.

Figure VI.1.1. Organoleptic quality of a fruit in relation to its ripening stage



Source: Lopez-Carmelo, 2004

Maturity indices

The maturity index of a fruit provides an indication of its stage of development or maturation. Maturity indices are based on characteristics that are known to change as the fruit matures. Maturity indices for harvest can be either subjective or objective (see table VI.1.1).

Table VI.1.1. Established methods for the evaluation of maturity in horticultural crops

Subjective maturity indices	Objective maturity indices
Appearance – colour, size and shape	Total soluble solids concentration (TSS)
Touch – texture, hardness or softness	Titratable acidity (TA)
Smell – odour or aroma	Firmness measurements
Resonance – sound when tapped	Oil content
Sweetness – sourness, bitterness	Dry matter
	Measurement of starch and sugars
	Total soluble solid concentration and acidity ratios (TSS:TA)

Subjective criteria for evaluating fruit maturity

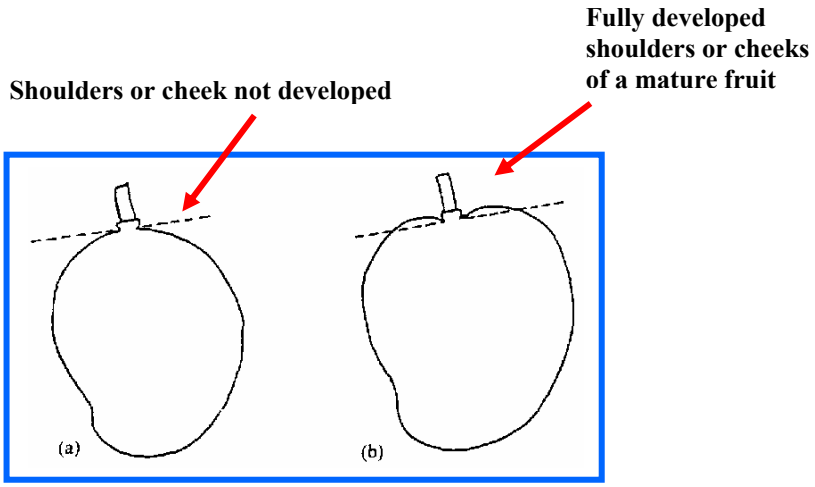
Fruit shape and size

Fruit shape may in some cases be used to evaluate maturity. Some cultivars, for example, become less angular in cross section with development and maturation. The size and shape of stone fruit such as peaches in particular is affected by variety, seasonal conditions, crop load and orchard variability. Constant measurement of these fruit is, therefore, vital in order to determine when they are of a marketable size. A Cranston fruit-sizing loop (see figure VI.1.2) is used for measuring the size of stone fruits.

Figure VI.1.2 A Cranston fruit-sizing loop used to measure fruit size

Stone fruit are considered mature when fruit shoulders and sutures are well developed and filled out. Similarly, the fullness of the cheeks adjacent to the pedicel in mangoes (see figure VI.1.3) provides an indication of maturity.

Figure VI.1.3 Physical cheek development of mangoes



In the case of bananas, the width of individual fingers can be used to determine harvest maturity. The maximum width of a finger located in the middle of the bunch is measured with the use of callipers. This measurement is referred to as the calliper grade.

Number of days after full bloom

'Days after full bloom' (DAFB) can provide an approximate harvest date or a 'ballpark guess'. This approach relies on a reproducible date for the time of flowering and a relatively constant growth period from flowering through to maturity. The major problem with this type of measurement is that there is little consistency from year to year and a wide range in suggested DAFB values.

Fruit aroma

Volatile compounds synthesized during ripening give fruit their characteristic odour and provide an indication of the level of maturity. Fruit odour is generally detectable by humans when the fruit is completely ripe and is of limited use in commercial situations.

Fruit colour

As fruit mature and ripen they undergo a colour change from green to red or yellow (see figure VI.1.4, below). The appearance of the colour for certain cultivars, e.g. tomatoes and litchis (see table VI.1.2) can, in some cases, signal an appropriate time to harvest. Skin colour is not, however, considered the most accurate index of maturity.

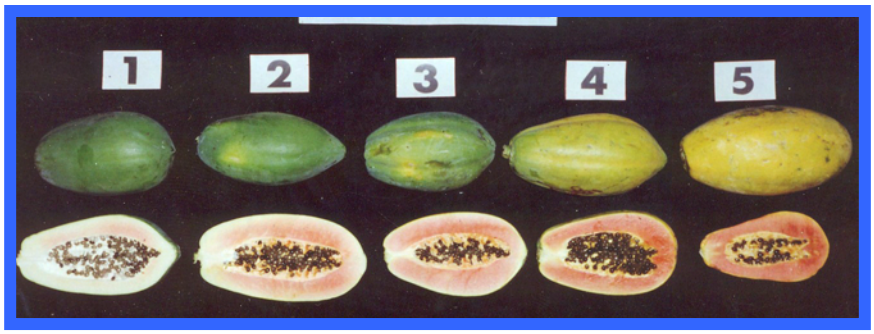
Table VI.1.2. Established methods for evaluation of maturity in selected horticultural crops

Maturity index (subjective)	Produce
Abscission[2]	Rockmelon
Colour	Tomato
Colour	Litchi
Stage of development	Lettuce
Cheeks, size, colour, dry matter	Mango
Shape	Banana
Waxiness and gloss	Grapes

[2] Process by which parts such a fruit break off naturally.

Figure VI.1.4. Standard colour charts showing fruit at various stages of maturation and ripening

Lemon: optimum harvest maturity based on colour and SSC:TA



Papaya cv. Ratna

Papaya: optimum harvest maturity based on size and colour initiation for uniform ripening (commercial maturity)

Mango: optimum harvest maturity based on cheek development and colour initiation (commercial maturity)

Tomato: optimum harvest maturity based on colour break, size for commercial maturity

Objective criteria for evaluating fruit maturity

Measurement of soluble solids or total soluble solids content

The sugar content of fruit, measured as total soluble solids (TSS) or soluble solids content (SSC) is influenced by factors such as irrigation, the nutritional status of the plant, weather conditions and the position of the fruit on the tree. It is only partially influenced by fruit maturity. While TSS data does not help in deciding when to harvest, it provides and indication of when the fruit has attained an appropriate level of sweetness. Apples, for example, should not be presented for sale if they have a TSS of less than 10 per cent. The TSS can be measured with the use of a refractometer (see figure VI.1.5). Minimum SSC measurements for selected produce items are listed in table VI.1.3

Figure VI.1.5. Refractometer

Refractometer – Sugars, organic acids and other soluble components are the main soluble solids in fruit juices. The sugar content provides an indication of the sweetness of fruits. A hand-held refractometer can be used to measure the percentage of SSC (equivalent degrees Brix for sugar solutions) in a small sample of fruit juice. Measurements of SSC are affected by temperature. An increase of about 0.5 per cent SSC occurs for every 5˚C temperature change. SSC must be measured at ambient temperature.

Table VI.1.3. Minimum soluble solids content (SSC) measurements for selected fresh produce items

Produce item	Minimum SSC (%)
Apricot	10
Cherry	14-16
Litchi	16-17
Papaya	15
Pineapple	12
Watermelon	10

Measurement of fruit firmness

Fruit firmness is affected by seasonal and orchard variability, tree vigour, fruit size, the nitrogen and calcium levels of the fruit and the pre-harvest use of growth regulators. Fruit firmness is measured with the use of a penetrometer (or pressure tester; see figure VI.1.6). Penetrometer measurements provide an indication of the storage performance of the fruit. In many instances pack house operators refuse fruit for long-term storage if the penetrometer reading is below a specified level. In the case of apples, this reading is 14 lbf (pound force).

Figure VI.1.6. Firmness testers used in the fruit industry

Firmness or hardness tester for tomatoes

The degree of softness can be estimated by applying pressure to the produce. Firmness is measured by resistance to compression or pound force (lbf). Fruit must be of uniform dimensions and at ambient temperature, since firmness measurements are affected by temperature. Measurements must be taken from both sides of the fruit or on opposite cheeks if the fruit is small in size. A range of firmness testers is available.

Fruit firmness tester for apples

Firmness tester for mangoes

Firmness tester for cherries

Measurement of starch content

The storage life of fruit is greatly influenced by the starch content. As fruit ripen, starches are converted to sugars. This starch to sugar conversion is initiated in the core of the fruit, moves to the flesh and ultimately to the skin.

An iodine test provides an indication of the distribution of starch in the fruit and helps to estimate the extent to which starch has been converted to sugars. This test can be performed by cutting the fruit in half and dipping it in an iodine solution. Iodine reacts with the starch, resulting in a navy blue/black colour. The stained pattern is compared with the use of a rating scale and the average rating of the sample, known as the starch index, is calculated. This is a reliable method. Iodine solution (2 per cent) is readily available from a local chemist. The starch test should be performed on a weekly basis or every three to four days for varieties that undergo rapid starch breakdown.

Figure VI.1.7. Starch measurement and rating system

A commonly used rating system for starch is a 1-6 scale:

1. = Full starch (all blue-black)
2. = Clear of stain in seed cavity and halfway to vascular area
3. = Clear through the area including vascular bundles
4. = Half of flesh clear
5. = Starch just under skin
6. = Free of starch (no stain)

Measurement of juice content

The juice content of many fruits increases as the fruit matures on the tree. The juice content is determined by extracting the juice from a representative sample of fruit in a standard and specified manner. The volume of juice extracted is related to the original mass of fruit, which is proportional to its maturity. Minimum values for citrus juices are presented in table VI.1.4.

Table VI.1.4. Minimum juice percentages required for good marketability of different citrus varieties

Citrus fruit	Minimum juice content (%)
Clementines	40
Grapefruit	35
Lemons	25
Mandarins	33
Naval oranges	30
Other oranges	35

Measurement of oil content and dry matter

Oil content can be used to determine the maturity of fruit such as avocados. Oil content can be determined by weighing 5-10g of avocado pulp and then extracting the oil using a solvent (such as benzene or petroleum ether) in a distillation column. This method has been used successfully for cultivars that are naturally of a high oil content.

Acidity

The level of acidity in many types of fruit, changes progressively during maturation and ripening. In the case of citrus and other fruits, the level of acidity is reduced progressively as the fruit matures on the tree. Titration of a juice sample against a standard alkaline solution gives a measure that can be related to the optimum time of harvest. The sugar to acid ratio or total soluble solids (TSS) to acid ratio (Brix: acid ratio) is often better related to the palatability of the fruit than either sugar or acid levels alone.

Specific gravity

Specific gravity is the relative gravity or weight of solids or liquids as compared to pure distilled water at ambient temperature. Distilled water has a specific gravity of one. The specific gravity is obtained by comparing the weights of equal bulks of other bodies with the weight of water. In practice, the item of fresh produce is weighed in air, then in pure water. The weight in air divided by the weight in water gives the specific gravity. As a fruit matures, its specific gravity increases.

Specific gravity is rarely used in practice to determine time of harvest, but could be used in cases where development of a suitable sampling technique is possible. However, it is used to grade crops according to different maturities post-harvest. This is done by placing the fruit such as mangoes in a tank of water; those that float are less mature than those that sink.

Sampling of fruit for evaluating maturity

In order to determine the optimum harvest date within an orchard, a random sample of 20 fruit must be collected from each orchard block and the soluble solids, firmness and starch content measured. The following steps must be followed for correct sampling:

- Select five trees at random within the orchard block
- Depending on the size of the fruit, pick fruit (about ten for small fruit such as litchi) of similar size from each tree at eye level, approximately 1.5m from the ground
- Select a mix of fruit from the inside and outside of the canopy and from a north, south, east and westerly direction; damaged fruit should be avoided

Sampling should be done a number of times leading up to harvest.

Maturity indices for selected crops

Maturity indices for selected fruits and vegetables are shown in tables VI.1.5 and VI.1.6.

Table VI.1.5. Maturity indices of selected tropical fruits

Apple	Banana
• Textural properties – firmness, tenderness, starch and sugar content • Burst of internal ethylene production	• Bunches are harvested when the top leaves start drying • The colour of the axis of the fingers changes from dark to light green • Brittleness of the floral ends should fall with slight touch • Changes in the angularity of fingers from triangular to round or sharp • Number of days from emergence of inflorescence: 95-110 days • Pulp to skin ratio – 120:1.2
Citrus	**Mango**
• Change in colour (green to orange) • Ease of separation • Starch content • Rate of respiration • Days from blooming • Seed colour (green to brown) • Change in organic acid • Juice content (>50 per cent)	• Slight colour development of the shoulder or fullness of the shoulders; change in colour of pedicel from green to brown • Growth of the fibres on the stone/corrugations • Flow of latex from the stalk, e.g. faster drying latex • Summation of days taken from flowering to maturity by tagging flowers • Appearance of bloom on the surface of the fruits • Computation of heat units or cumulative degree days • Change in lenticel morphology • Specific gravity of 1.0-1.02 for varieties Alphonso and Pairi
Papaya	**Pineapple**
• 33% colour development for long-distance market and 85.5% colour development for local market • Harvested when fruit show signs of yellow to purple colour	• When fruits show signs of yellowing • High TSS and low acidity (TSS 13%; acidity 0.5– 0.6%) • Tips of the bracts projecting as the eyes start drying • Acid ratio 21-27 and specific gravity 0.98-1.02.

Table VI.1.6. Maturity indices for vegetables

Asparagus	Carrots
• Spears grow above the ground • Spears should be harvested when they are not too long, before tops begin to spread	• Size is the primary consideration and at least ¾ diameter • Proper colour development, without zoning
Cauliflower	**Okra**
• Head size and condition and before heads become discoloured, loose, ricy or blemished • Over-mature flowers result in flower stocks that are too long; they elongate, becoming fuzzy and ricy	• Pods are still young and tender, exhibiting maximum growth • The pods are readily shaped when picked • When mature, pods are fibrous and tough
Peas	**Tomato**
• Sugar content > 5-6 per cent; sugar declines with maturity; ratio of starch to protein increases • Tenderness and appearance of pods – should be well filled with young tender peas • Changing in colour from dark to light green, with firmness of 5kg/cm^2	• Mature green, pink or breaker (just starting to turn red) and red ripe • Pulp surrounding the seeds is jelly-like, seeds slip away from the knife • For long-distance shipment, is harvested at the mature, green stage • The ripe stage indicates that most of the surface is pink or red, and firm •

REFERENCES

California Pear Bulletin No. 1 (1972). Sacramento, USA: California Tree Fruit Agreement.
FAO (1986) Improvement of post-harvest fresh fruits and vegetables handing: a manual. Bangkok, Thailand: Food and Agriculture Organization (FAO).
Kader, A.A. (1999) Fruit maturity, ripening and quality relationships. Acta Horticulturae, 485: 203-208.
Kitinoja, L. and A. Kader (2002) Small-scale post-harvest handling practices: A manual for horticultural crops (Fourth Edition). Post-harvest Horticulture Series No. 8E. Davis, CA: UC Davis.
Lopez-Carmelo (2004) Manual for the Preparation and Sale of Fruits and Vegetables. FAO Agricultural Services Bulletin, 151.
Subbanna, V.C. (2006) Status of post-harvest in India. In R.S. Rolle (ed.) Post-harvest management of fruits and vegetables in the Asia-Pacific Region, pp. 143-151.
The Trade Chain of the South African Fresh Fruit Export Industry: Quality Management Book 8. Newlands, South Africa: Fresh Produce Exporters' Forum.

Suggested methods of instruction

Lecture using handouts or visuals to explain the basics of maturity or harvesting indices.

Practical exercise

Practical exercise VII: Assessment of fresh produce quality, activities 1-4.

Time frame

The duration of the lecture is one hour.
The duration of the practical exercises is 3 hours.

SECTION VI

MODULE 2 – HARVESTING[1]

Learning outcomes

The learner should:

- Develop an appreciation of harvesting methods that are appropriate for small-scale and commercial farmers
- Understand the impact of inappropriate harvesting methods on quality and safety
- Develop an appreciation of the importance of using appropriate harvesting equipment and containers
- Develop an appreciation of good practice for maintaining harvesting equipment

Introduction

Careful and correct harvest techniques are essential in ensuring the integrity of harvested produce and preventing rejections at the pack house. Wounding during harvest can provide entry points for pathogens, so causing decay. Those involved in harvesting must be trained in efficient and careful handling of fresh produce.

Manual harvesting

Manual harvesting is one of the most popular methods of harvesting produce. Workers must, however, be properly trained if quality is to be assured (see figure VI.2.1). Selective harvesting (see figure VI.2.2) by well-trained and experienced harvesters ensures that fruit is harvested only at its peak ripeness. With the provision of incentives, such as bonuses for high-quality produce, field sorting as a first stage in selective harvesting can be encouraged.

Correct harvesting procedures with the use of the appropriate harvesting tools (see figures VI.2.3 and VI.2.4) can also prevent damaged or contaminated produce from entering the pack house, thereby reducing wastage and possible contamination of sound fruit.

[1] Prepared by D. Sivakumar and L. Korsten.

Figure VI.2.1. Training requirements to assure proper manual harvesting of produce

Quality

Care at harvesting

Careful field handling is crucial

Grower's responsibility

Training the workers for manual harvesting:

- Use clean containers of the correct dimensions
- Use clean, white, cloth gloves
- Do not overfill containers
- Handle produce carefully
- Use selective harvesting and correct maturity indices
- Use proper equipment and harvesting techniques
- Pay attention to the time of harvest and to weather conditions

Figure VI.2.2 Selective harvesting for good quality and temporary storage of fresh produce

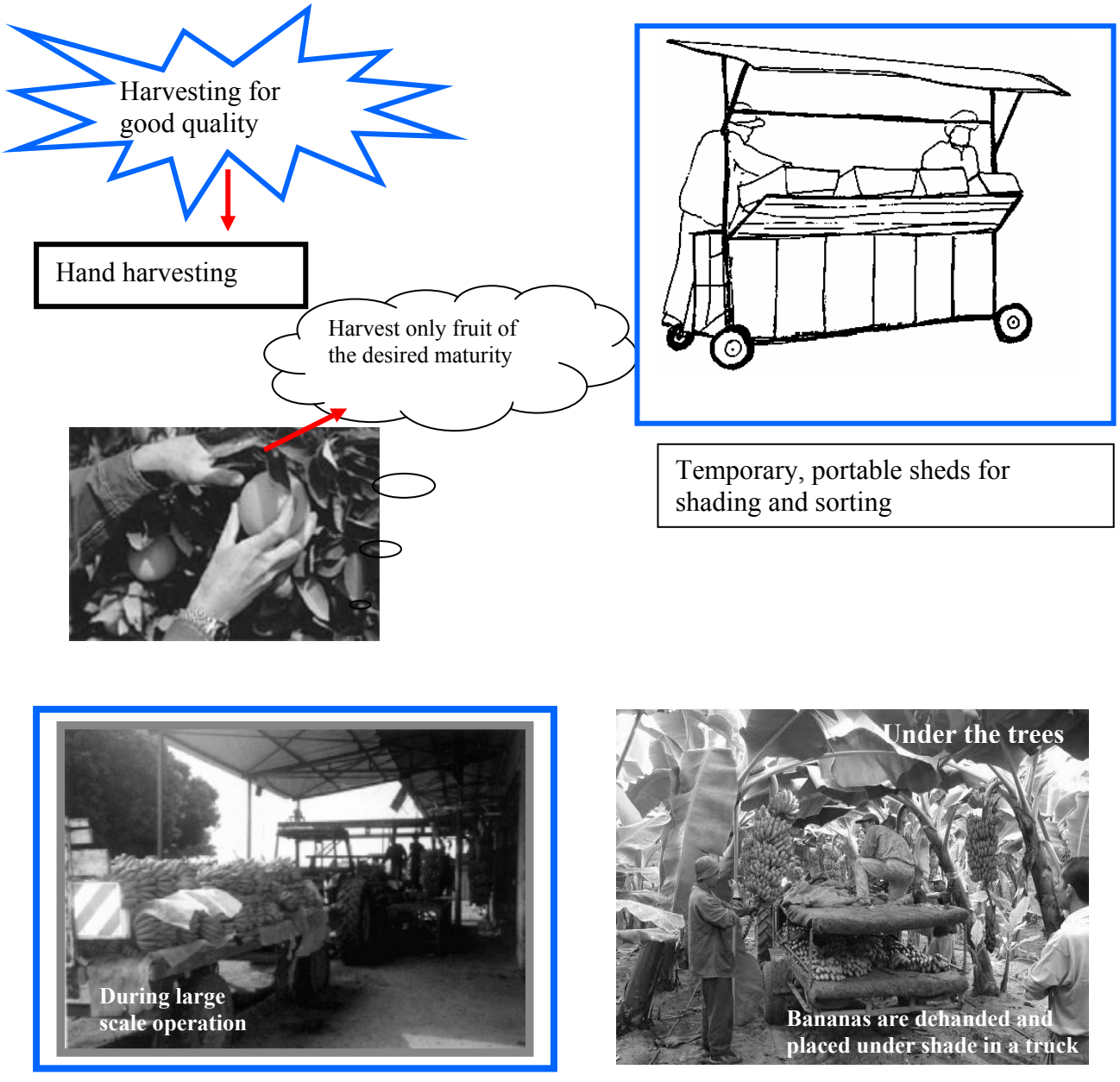
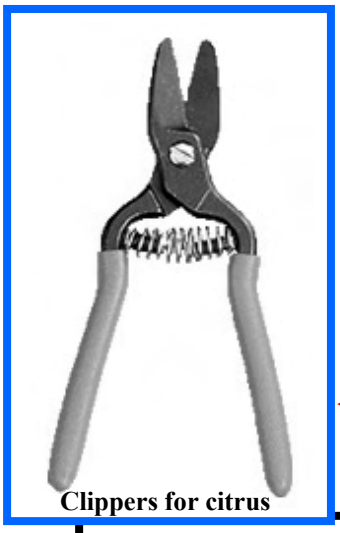
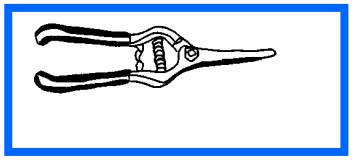


Figure VI.2.3 Manual harvesting equipment

Equipment for hand harvesting



Clippers for citrus

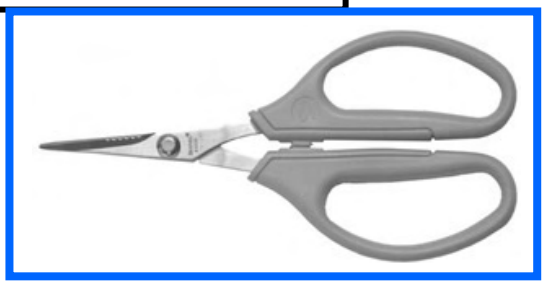


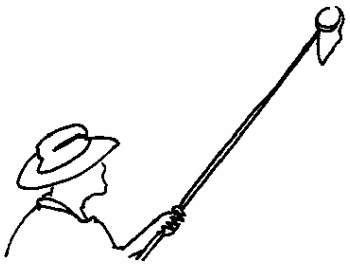
Thin, curved blade for grapes and fruits

- Clippers must be sharpened and kept clean
- Peduncles, woody stems or spurs should be trimmed as close as possible to prevent fruit from damaging neighbouring produce during transport

These clippers are designed for rapid, high-volume harvesting of oranges and other types of fruit; they are recommended for rapid harvesting operations.

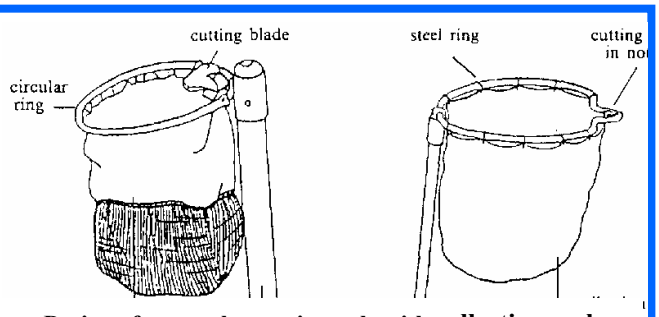
The clipper on the right was designed for harvesting of grapes, but it is also used in citrus nurseries; the design facilitates the ease with which it can be used throughout the day.





Picking pole

Picking poles and catching sacks can be made by hand or purchased from horticultural supply companies. The collection bags can be hand woven using strong cord or sewn from canvas. A hoop can be used as the basket rim and cutting edges can be made from sheet metal.



Design of mango harvesting pole with collection sack

Using the equipment to harvest mangoes

Source: FAO, 1989

Figure VI.2.4 Harvesting avocadoes using a picking pole

Ladders are used to reach fruits in tall trees. Fruits from tall avocado trees are harvested using picking poles with collection sacks. The collected fruits are then transferred into the round-brimmed collection sack, which is attached to the ladder.

Harvesting containers

Rigid containers, such as wooden and plastic crates, and plastic buckets (see figure VI.2.5), can be used for the field collection of harvested produce. Containers must be smooth, with no sharp edges or projections as these could damage the produce. They must be clean and must not be overfilled.

Harvesting bags equipped with either shoulder slings around the neck, or waist slings, can be used for the collection of firm-skinned fruit such as citrus and avocados. They are easy to carry and leave both hands free to harvest. Harvesting bags must be designed to open at the base, so as to allow produce to be emptied easily into a field container without tipping the bag (see figure VI.2.6).

Figure VI.2.5 Collection of fruit in different containers to minimise damage

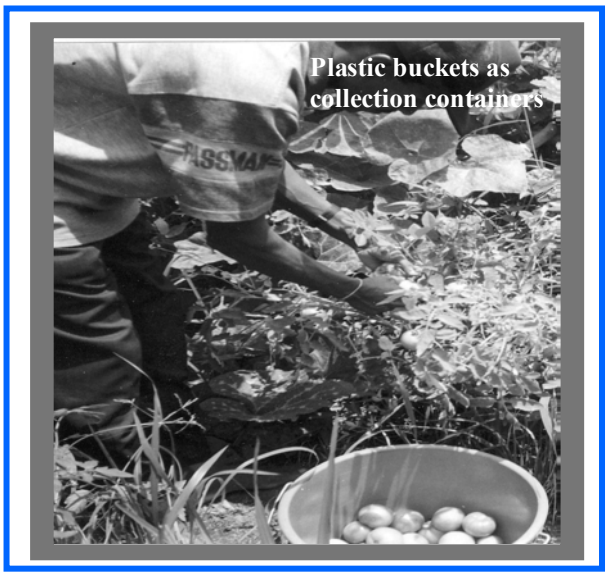


Figure VI.2.6 Harvesting bag

.

Mechanical harvesting

Mechanical harvesting results in a significant reduction in management and labour costs and can result in savings as high as 30-45 per cent.

Mechanical harvesters are primarily designed for a shake-catch action, which helps to detach the fruits by shaking or vibrating trees or bushes. Given that they have no means of detecting quality, even carefully adjusted harvesters will harvest significant quantities of unacceptable fruits. Immature, overripe, diseased and damaged fruit, which would ordinarily be discarded by a human picker, are often harvested by mechanical harvesters. Elimination of unacceptable fruit and foreign matter is difficult and costly. Mechanical harvesting is, therefore, recommended for large-scale operations where labour is not available.

Good practice during harvesting

- Containers used for field collection:
  - must be smooth, with no sharp edges or projections to damage the produce;
  - must be clean; and
  - must not be overfilled.
- Harvested produce:
  - must not come into contact with the soil or contaminated surfaces, e.g. surfaces that are visibly contaminated with dirt, oil or chemicals;
  - must not be dropped; and
  - must be gently transferred to collection bins and protected from sun or rain until such time it can be transported to the pack house.
- Cuts and bruises must be avoided during harvesting operations

Time of harvest

The time of day and prevailing weather conditions can influence produce quality and shelf life:

- Produce must be harvested during the coolest time of the day, i.e. early morning or late evening when the physiological activity of the fruit is low
- Produce must not be harvested when wet (from rain or dew), because wet produce generates heat and decays quickly
- Harvested produce must be maintained in a cool and shady location with adequate ventilation

Temperature management at harvest

At harvest, the temperature of the fruit is close to that of the ambient air, which varies according to the location and time of year. In order to ensure the lowest possible temperature at harvest, it is generally recommended that fruits and vegetables be harvested during the coolest part of the day, which is usually early morning. Citrus fruit are one exception to this recommendation, given that they are damaged if handled in the morning when they are turgid.

Harvested produce must be retained under shade or in a cool temporary storage area, and must be pre-cooled within the shortest period of time in order to remove the field heat.

Good practice for the maintenance of harvesting equipment

All field equipment used in harvesting produce must be cleaned and repaired on a regular basis. It is important that farmers ensure that all equipment (i.e. knives, pliers and so on) issued to harvesters is accounted for at the end of the picking day. Farmers must also check whether all equipment is still sound and unbroken. If a knife blade is broken, the harvester's batch numbers must be traced and the produce put on hold to prevent physical contamination. If produce has been delivered to a pack house, the manager should be informed and the batch put on hold. If a pack house is HACCP (Hazard Analysis and Critical Control Point)-certified, it is essential that pack house management be notified. Under such circumstances, pack houses might implement online metal detectors for the identification of contaminated batches.

Torn bags, broken boxes and other containers used in harvesting must be repaired if produce damage is to be avoided. Wooden splinters from containers, for example, could cause wounding of produce, ultimately resulting in infection and decay. Broken equipment is also difficult to maintain in a hygienic condition since small cracks provide the ideal niche for microbes, which may cause decay or present a food-safety concern.

Regular cleaning of all harvesting equipment is essential. All harvesting tools must be washed daily in a soap solution and in certain cases, as occurs with heavy soil or sticky substances, a disinfectant such as bleach should be used at recommended concentrations. The intervals for cleaning larger items of harvesting equipment, such as large collection containers, will vary in accordance with the type of produce harvested. It is generally recommended that harvesting bags be washed at the end of the harvesting season, while harvesting crates should be washed daily to remove dirt and debris. Crates used for mangoes should be washed on a daily basis to remove the latex secretions from the stem-end of the fruit; if not removed regularly, the mango crates will become stained and soiled, which could pose a food-safety risk.

All harvesting equipment should be stored overnight in a closed facility, protected from rats and birds. The most important reason for protecting the equipment at night, or over weekends or during non-harvesting periods, is to ensure that the equipment stays intact and is not contaminated with animal faeces unnecessarily, which could introduce a food-safety risk further down the chain. Maintaining harvesting equipment makes sound economic sense, since such equipment often reflects considerable investment by the farmer.

REFERENCES

Food and Agriculture Organization (FAO) (1985) Prevention of post-harvest food losses: a training manual. FAO Training Series No. 10. Rome, Italy: FAO. p. 120.
FAO (1989) Prevention of post-harvest food losses: fruits, vegetables and root crops. A training manual. Rome, Italy: FAO.
Reid, M.S. (1985) Product maturation and maturity indices. In Kader et al. (eds.) Post-harvest technology of horticultural crops. Special Pub. 3311, Cooperative Extension, Division of Agriculture and Natural Resources. Berkeley, (CA), USA: University of California.
Rickard, J.E. and Coursey, D.G. (1979) The value of shading perishable produce after harvest. *Appropriate Technology*, 6: p. 19.

Web sources

Post-harvest horticulture at the University of Florida, available at:
http://www.postharvest.ifas.ufl.edu/ 12.06.2006.

Suggested method of instruction

Lecture, using handouts or visuals to promote an understanding of harvesting, highlighting the importance of correct harvesting methods, use of harvesting devices and collection bins.

Practical exercises

Practical exercise III.2: Visit to an orchard.

Time frame

One-hour lecture.
One day for the practical demonstration.

SECTION VI

MODULE 3 – PACK-LINE OPERATIONS[1]

Learning outcomes

The learner should:

- Develop an appreciation of pack-line operations and their impact on quality
- Understand the importance of record keeping and the types of records that should be kept in the pack house
- Understand the importance of good hygienic practices during pack-house operations
- Understand the importance of hygienic maintenance of the pack line

Introduction

Fresh produce sold to the local or international markets or directly to retailers must be sorted, graded and packed; in certain cases it must also be washed, dried and chemically treated and waxed. These activities usually take place in pack houses.

Basic pack line operations

The following are typical pack-line operations in a fresh produce pack house:

Dumping – Produce can be off-loaded using either water-assisted methods (wet dumping) or onto a conveyer or padded, sloped ramp (dry dumping). Wet dumping makes use of moving chlorinated water to carry produce, and in the process helps decrease bruising and abrasion damage. During wet dumping, produce should be transferred to the dump tank only while the packing line is operational, in order to minimise the time spent within the dump tank.

Injury during dry dumping is reduced with the use of padded, sloped ramps or moving conveyor belts.

Documentation – which comprises detailed records pertinent to the grower/producer, orchard number or location, fruit variety/cultivar and the volume of produce off-loaded or dumped.

Pre-sorting – Injured, decayed or defective produce is removed during pre-sorting, thus helping to reduce the spread of infection to other produce items.

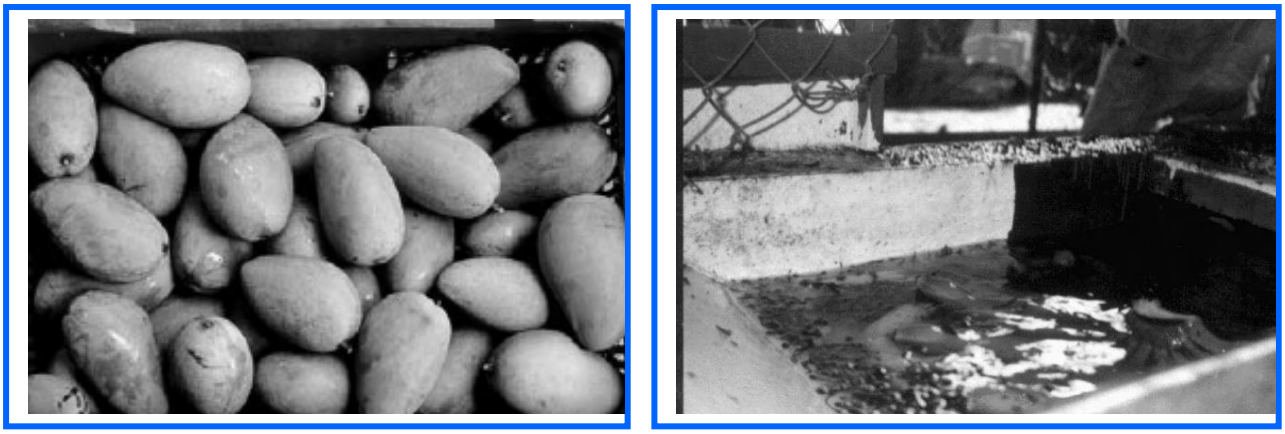
Cleaning – Dry brushes are used to clean commodities such as potatoes, kiwi fruit and avocadoes. Some commodities (for example, banana and mango – see figure VI.3.1) require washing to remove latex.

Washing – this reduces chemical or microbial contamination from the surfaces of produce. Proper sanitation of the wash water is essential in controlling the spread of disease from one produce item to another, and for limiting spore build-up in the wash water. Chlorinated wash water (100-150 ppm chlorine) helps to control pathogen build-up during pack line operations.

[1] Prepared by D. Sivakumar and L. Korsten.

A series of washes with fresh, clean water is more effective than a single wash in terms of preventing the build up of microbial and chemical contaminants.

Figure VI.3.1. Latex staining on mango (left) and a typical wash bath used to remove latex from bananas (right)



Source: Martin and Miezitis, 1964

Maintaining the temperature of the wash water below 10˚C will reduce the growth of micro-organisms in the wash tank. Produce of a high water content such as apples and tomatoes are, however, susceptible to micro-organisms entering the skin via the stomata if the temperature of the wash water is less than that of the produce item, resulting in the produce becoming internally contaminated. These produce items must, therefore, be pre-washed in water 10˚C above the temperature of the produce to remove the bulk of the soil, and then subsequently washed in cooler water.

Sizing – is important when grading fruit. In small pack houses, fruit can be manually sized with sizing rings. Operators must be trained to use these rings and to pack produce directly into containers. Visual sizing is difficult, subjective and is seldom uniform.

Mechanical sizing of produce reduces cost and increases the efficiency of operation. Sizing operations are shown in figure VI.3.2.

Figure VI.3.2. Sizing fruit

Waxing – During this process, food-grade waxes are used to replace some of the natural waxes removed during washing and cleaning operations. If the produce is waxed, the wax coating must be allowed to dry throughout the handling process. Waxing prevents water and weight loss, retards ripening, gives a glossy appearance and serves as a carrier for certain anti-fungal compounds.

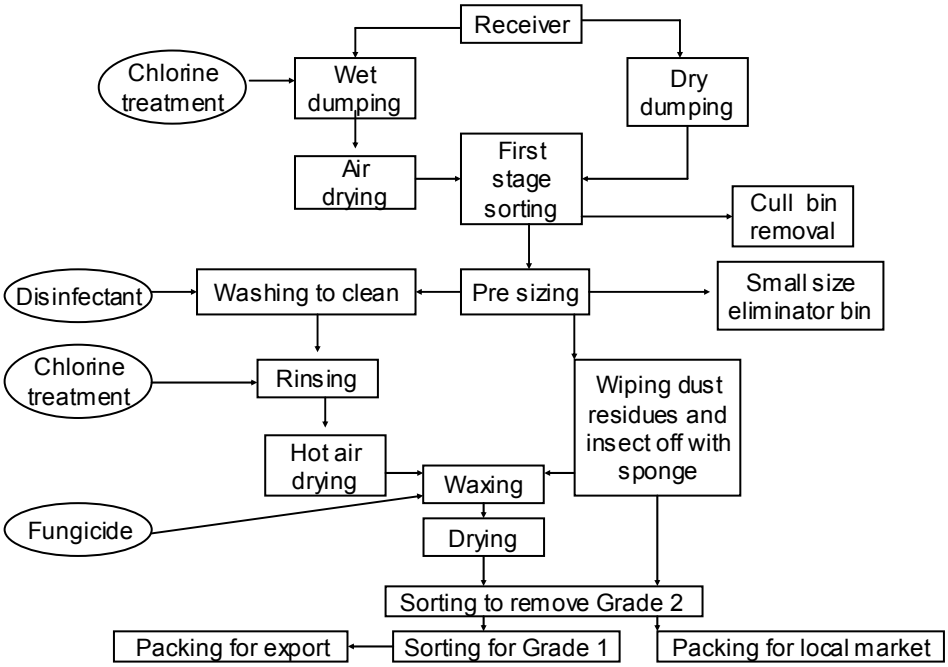
Wax is applied only to the surface of citrus fruit, some pome fruit varieties, avocados and mangoes (see figure VI.3.3).

Figure VI.3.3. Appearance of waxed mangoes

Source: Govender et al., 2005

Figure VI.3.4 provides a diagrammatic presentation of pack-line operations for sorting and grading fruit.

Figure VI.3.4 A diagrammatic presentation of the different pack-line operations for sorting and grading fruit



Source: Kader, 1993

Record keeping
Local and international regulations and laws pertaining to food safety require that pack house operations be kept on record. This includes records of food safety incidents (such as chemical residues exceeding the maximum residue level set by a particular country), corrective actions taken, the time at which these corrective actions were taken and by whom. Pack houses should supply buyers and/or government officials with records that enable them to trace fruit back to a particular orchard soon after a request has been received, particularly in situations where food safety is at risk. For this reason, pack houses should keep detailed records of each carton packed for export, including grower/producer details, orchard number or location, fruit variety/cultivar details and chemicals used on the produce in the pack house.

Process control
Monitoring of produce on the pack line is best done using a statistical sampling or chart technique. Quality factors should be monitored and rapid adjustments or corrective actions should be made promptly. Statistical analysis of data gathered from samples collected following the sorting operation provides valuable information on grading and sorting, different growers or fields and processing methods.

Good hygienic practices
Good hygienic practices are especially important in the handling of food that will be consumed by humans. A high level of general and personal cleanliness is essential, requiring hair coverings, protective clothing and footwear for staff working in food-handling areas. No one should smoke, eat or drink in areas where the fresh produce is handled. Injuries should be reported and treated immediately to prevent product contamination. No one with a contagious disease should be allowed in the produce-handling areas until they have been issued a clean bill of health.

Doors to and from produce handling areas should be kept closed to limit potential contamination by animals and birds, or any pets entering the area. Chemicals should be sealed and stored in a locked area identified by a hazard sign and should never be used after their expiry date. Expired chemicals should be disposed of in a place and manner that does not harm people or the environment.

Hygienic maintenance of the pack line
The pack line and all surfaces that come into contact with produce areas should be routinely cleaned with cleaning and sanitising products that satisfy consumer requirements. The manufacturers' instructions for use of these products should be strictly adhered to. Any debris on the line must be physically removed using a top-to-bottom approach to avoid re-soiling of cleaned surfaces. The packing line should be left free of produce every day, and must be cleaned regularly. All closed surfaces must be sanitised by fumigation. The sanitisers used must be safe when in contact with food.

REFERENCES

Food and Agriculture Organization (FAO) (1986) Improvement of post-harvest fresh fruits and vegetables handling – a manual. Bangkok, Thailand: UNFAO Regional Office for Asia and the Pacific.

FAO (1989) Prevention of post-harvest food losses: fruits, vegetables and root crops. A Training Manual. Rome, Italy: FAO.

Govender, V., L. Korsten and D. Sivakumar (2005) Semi-commercial evaluation of Bacillus licheniformis to control mango post-harvest diseases in South Africa. *Post-harvest Biology and Technology*, 38: pp. 57-65.

Kader, A.A. (1993) Post-harvest handling. In Preece, J.E. and P.E. Read *The Biology of horticulture – An Introductory Textbook*. New York: John Wiley & Sons, Inc.

Martin, D. and E.O. Miezitis (1964) A wipe-on device for the application of materials to butts. Field Station Record, Vol. 3, No. 1. Hobart, Tasmania: CSIRO Tasmanian Regional Laboratory.

Reyes, M.U. (ed.) (1988) Design concept and operation of ASEAN packing house equipment for fruits and vegetables. Laguna, the Philippines: Post-harvest Horticulture Training and Research Centre, University of Los Baños, College of Agriculture.

Shewfelt, R.L., Prussia, S.E. (1993) *Post-harvest handling: A systems approach*. San Diego, USA: Academic Press Inc.

The Trade Chain of the South African Fresh Fruit Export Industry (2004) Production, Book 2 of 9. Newlands, South Africa: Fresh Produce Exporters' Forum.

Suggested method of instruction

Lecture, using handouts or visuals to promote an understanding of factors that could compromise quality during pack-line operations, the importance of maintaining proper documentation systems in the pack house and good hygiene management at the pack house level.

Practical exercises

Refer to practical exercise III.3: Visit to a pack house.

Time frame

One one-hour lecture.

Three hours for the practical demonstration.

SECTION VI

MODULE 4 – PRE-COOLING OPERATIONS[1]

Learning outcomes

The learner should:

- Develop an appreciation of the importance of pre-cooling
- Be able to compare different pre-cooling systems

Introduction

Temperature management is important throughout the period between harvest and consumption in order to maintain good produce quality. Cooling practices provide marketing flexibility by making it possible to market produce at the optimum time and over longer distances. In order to select the best cooling method, it is necessary to understand the basic principles of cooling.

Importance of pre-cooling

Pre-cooling prior to shipment, storage or processing is essential for the removal of field heat from many perishable crops. Proper pre-cooling can:

- prevent quality loss due to softening by suppressing enzymatic degradation and respiratory activity;
- prevent wilting by slowing or inhibiting water loss;
- slow the rate of decay of produce by slowing or inhibiting the growth of decay-producing micro-organisms (moulds and bacteria);
- reduce the rate of ethylene production; and
- minimise the impact of ethylene on ethylene sensitive produce items.

Factors that govern the selection of a pre-cooling technology

The choice of cooling methods is dependent on a number of considerations:

- **Nature of the produce, e.g. fruit or vegetable** – different types of produce have different cooling requirements. Strawberries and broccoli, for example, require near-freezing temperatures, whereas similarly low temperatures would damage bananas, mangoes or tomatoes.
- **Package design** – the level of package ventilation (i.e. number and size of ventilation holes) as well as palletisation design can greatly impact on the rate of product cooling.
- **Product flow capacity** – some methods of cooling are more efficient than others. Rapid cooling methods, in general, are required for the efficient cooling of large product volumes.
- **Economic factors** – construction and operating costs vary among cooling methods. The selection of a cooling procedure must be justified by the volume and selling price of the produce item. In cases where small volumes of produce are available and where electricity costs are high, higher-cost methods of cooling cannot be used since the cost incurred cannot be justified by the end profit margins.

[1] Prepared by L. Korsten, D. Sivakumar and R.S. Rolle.

- **Social factors** – in low-income areas and in areas that lack electricity or cooling infrastructure, the use of simple and appropriate, inexpensive cooling methods makes sense.

Pre-cooling technologies

Cooling with cold air

Room cooling

Room cooling involves exposing the produce to cold air in a refrigerated room to start the cooling process and to remove field heat. Room cooling may be used with most commodities, but may be too slow for produce that requires rapid cooling. If properly designed, a room cooling system can be relatively energy efficient.

Room cooling is very often inadequate for produce stored in large containers, such as bulk boxes or pallet loads. During the room cooling of such large containers of produce, heat is slowly removed from produce positioned near the periphery of the container. Meanwhile at the centre of the container, heat is often generated by natural respiration more rapidly than it can be removed, causing the temperature to rise.

Room cooling is also inadequate for produce requiring rapid and immediate cooling. Strawberries, for example, must be cooled as quickly as possible after harvesting if their quality is to be preserved. Even a delay of several hours may be enough to reduce their quality considerably. Room cooling is not rapid enough to prevent serious damage.

Forced-air cooling

Forced-air cooling makes use of fans that increase the rate of cooling in a refrigerated room by pulling cool air through packaged produce, thereby picking up heat and greatly increasing the rate of heat transfer. Although the cooling rate is dependent on the air temperature and the rate of airflow through the packages, this method is usually 75 to 90 per cent more efficient than room cooling. A number of horticultural produce items that can be cooled using forced air are listed in table VI.4.1.

Table VI.4.1. Produce items that can be cooled by forced air

Anona	Coconut	Mango	Prickly pear
Avocado	Cucumber	Melons	Pumpkin
Banana	Eggplant	Okra	Rhubarb
Breadfruit	Grape	Orange	Strawberry
Brussels sprouts	Grapefruit	Papaya	Summer squash
Carambola	Guava	Passion fruit	Tangerine
Cassava	Kiwifruit	Pepper (Bell)	Tomato
Cherimoya	Kumquat	Persimmon	Pineapple
Pomegranate	Litchi		

Cooling with water

Hydro-cooling

Hydro-cooling is appropriate for commodities that are not sensitive to wetting (see table 4.2). This cooling process involves the flow of chilled water over the produce, rapidly removing heat. At typical flow rates and temperature differences, water removes heat about 15 times faster than air. Hydro-cooling is only about 20-40 per cent energy efficient, as compared to 70 or 80 per cent for room and forced-air cooling, respectively.

During hydro-cooling, the produce comes into contact with water. Good water sanitation practices must, therefore, be observed during the hydro-cooling process in order to minimise contamination. Once cooled, the produce must be kept cold.

Produce packaged in wire-bound wooden crates, waxed fibreboard cartons, mesh poly bags and bulk bins can be hydro-cooled. Palletised packages can be hydro-cooled if they are carefully stacked to allow water to enter the packages. If the water flows around and not through the packages, little cooling will occur. Produce in waxed cardboard cartons with solid tops is particularly difficult to cool since the tops preclude the entry of water. Table VI.4.2 shows a range of commodities that can be subjected to hydro-cooling.

Table VI.4.2. Produce that can be hydro-cooled

Artichoke	Celery	Peas
Asparagus	Chinese cabbage	Pomegranate
Beet	Cucumber	Rhubarb
Broccoli	Eggplant	Radish
Brussels sprouts	Green onions	Spinach
Cantaloupe	Kiwifruit	Summer squash
Carrot	Leek	Sweet corn
Cassava	Orange	Swiss chard
Cauliflower	Parsley	

Cooling by contact with ice

Icing is particularly effective on dense packages that cannot be cooled with forced air. Ice removes heat rapidly when first applied to produce but, unlike other cooling methods, continues to absorb heat as it melts. Because of this residual effect, icing works well with commodities such as broccoli that have high respiration rates. Icing is relatively energy efficient. One pound of ice will cool about three pounds of produce from 29.4^{o}C to 4.4^{o}C. Ice must, however, be free of chemical, physical and biological hazards.

Top icing

Top icing is used to cool a variety of commodities (see table VI.4.3). In the top-icing process, crushed ice is added either by hand or machine over the top of the produce.

Table VI.4.3. Crops that can be cooled by top icing

Broccoli	Green onions
Brussels sprouts	Leek
Cantaloupe	Parsley
Carrot	Peas
Chinese cabbage	

Liquid icing

Liquid icing involves injecting a slurry of water and ice into produce packages through vents or handholds without de-palletising the packages or removing their tops. Growers with both small and large operations can use crushed and liquid ice cooling methods effectively. Liquid icing is an excellent cooling method, despite the fact that the produce is wet during the process. The surface of warm, wet produce, however, provides an excellent site for the development of post-harvest diseases.

Individual package icing

The simplest method of icing is to manually add a measured amount of crushed ice to the top of each carton filled with produce. This method is sufficient in many instances, but can result

in uneven cooling since the ice generally remains in the location where it was placed until it has melted. The process is also slow and labour intensive since each carton must be opened, iced and re-closed. Individual package icing has been automated to some extent by ice-dispensing devices and the use of package conveyors and roller benches. This method of icing is not usually recommended for high-volume production.

Packaging containers suited for icing

Many types and sizes of fresh produce containers can be used successfully for package icing. Popular types include waxed fibreboard cartons; wooden wire-bound crates, baskets and hampers; and perforated plastic liners. Any container that will retain its strength after wetting can be used satisfactorily for icing. Waxed fibreboard cartons are particularly well suited for icing operations. They have minimal openings, offer some insulation to help reduce the rate of melting and their strength is unaffected by wetting.

Vacuum cooling

Vacuum cooling is effective on produce having a high ratio of surface area to volume (see table VI.4.4). This includes produce items such as leafy greens and lettuce, which would be very difficult to cool with forced air or hydro-cooling. During the vacuum cooling process, the produce is placed inside a large metal cylinder and much of the air is evacuated. The vacuum so created causes water to evaporate rapidly from the surface of the produce, lowering its temperature. The process may cause wilting from water loss if overdone.

Table VI.4.4. Crops that can be vacuum cooled

Brussels sprouts	Lettuce
Carrot	Peas
Cauliflower	Snap beans
Celery	Spinach
Chinese cabbage	Sweet corn
Leek	Swiss chard

Table VI.4.5 provides comparison of the various pre-cooling techniques used for horticultural produce.

Table VI.4.5. Comparison of pre-cooling methods

Variable	Cooling method				
	Ice	Hydro	Vacuum	Forced-air	Room
Cooling times (h)	0.1-0.3	0.1-1.0	0.3-2.0	1.0-10.0	20-100
Water contact with the product	yes	yes	no	no	no
Product moisture loss (%)	0-0.5	0-0.5	2.0-4.0	0.1-2.0	0.1-2.0
Capital cost	high	low	medium	low	low
Energy efficiency	low	high	high	low	low

Source: Kader and Rolle, 2004

Evaporative cooling

Evaporative cooling is an appropriate, effective and inexpensive means of providing low temperature and high relative humidity conditions for cooling produce. The process involves misting or wetting produce in the presence of a stream of dry air. Evaporative cooling works best when the relative humidity of the air is less than 65 per cent. Produce should be picked during the coolest parts of the day and kept in the shade away from direct sunlight.

Appropriate cooling technologies

A solar assisted cooling chamber

A solar assisted cooling chamber that is suitable for the temporary storage of fresh fruits at the farm level is shown in figure VI.4.1. The hollow walls of the chamber, which are made of porous clay bricks, are kept moist by a water source. Evaporation of moisture from the outer surfaces of the walls, due to solar energy carried by the wind, results in drop in the temperature within the chamber by 4-5^{o}C below ambient temperature. The moist walls of the cooler maintain a relative humidity of 85-90 per cent within the chamber. The storage life of fresh fruit stored within the chamber can be prolonged by two to three weeks.

Figure VI.4.1 Solar assisted evaporative cooler for storage of fresh fruits

Source: Palipane, 2006

REFERENCES

Gast, K.L.B. and R. Flores (1991) Pre-cooling produce. Manhattan, Kansas, USA: Kansas State University Cooperative, extension.

Kader, A.A. (ed.) (2002) Post-harvest technology of horticultural crops. Agricultural and Natural Resources Publication 3311. USA: University of California.

López Camelo, A.F. (2004) Manual for the preparation and sale of fruits and vegetables from field to market (volume). FAO Agricultural Services Bulletin 151. Rome, Italy: FAO.

Palipane, K. (2006) Good practice for assuring the post-harvest quality of tree fruit crops in Jamaica: A Guide. Rome, Italy: FAO. In press.

Thompson, J.F., F.G. Mitchell, T.R. Rumsey, R.E. Kasmire and C.H. Crisosto (1998) Commercial cooling of fruits, vegetables, and flowers. Oakland, USA: University of California, Publication Series 21595.

Roy, S.K. (1989) Post-harvest technology of vegetables crops in India. Indian Horticulture, 7678.

Suggested methods of instruction

Lecture, using handouts and visuals to promote an understanding of pre-cooling and its impact on fresh produce quality.

Practical exercises

Visit to a pack house to observe pre-cooling operations (practical exercise III.3).

Time frame

One-hour lecture.

Three hours for the practical demonstration.

SECTION VI

MODULE 5 – PACKING AND PACKAGING OF FRESH PRODUCE[1]

Learning outcomes

The learner should:

- Understand the principles and importance of proper packaging
- Develop an appreciation of the key considerations to be made in selecting the appropriate packaging container for a produce item
- Develop an appreciation of the suitability of different types of packaging for different target markets

Introduction

The longer the distance between the producer and the market, the greater is the cost of marketing and the requirement for proper packaging to minimise injury to produce. This module discusses packing and packaging materials and techniques that ensure produce integrity and quality.

Packing of fresh produce

Packing is the act of arranging or organising produce. Perishable produce may be packed on the farm where it is produced, or can be moved to another location such as a co-operative or pack house for packing. Careful handling is crucial during packing to ensure produce integrity and to maintain quality. Packing can greatly influence airflow rates around a commodity, thereby affecting its temperature and relative humidity while in transit. Produce may be either packed by hand or by using a mechanical packing system.

Packing techniques

Packing techniques must ensure that:

- Produce is correctly arranged within the packaging material to reduce the risk of damage;
- Produce is not damaged by wounding during the packing process – for example, by micro-wounding because of nails sticking into the produce, thereby creating an ecological niche for microbial infection; and
- Hygienic conditions are maintained – contaminated hands or contaminated containers may transfer food-borne pathogens to the produce. Fresh produce packers must observe high levels of personal hygiene: gloves can be worn during packing, but should be washed at regular intervals to prevent them from becoming a trap for food-borne pathogens.

Packing must also be done against a tight time schedule to ensure that produce can be moved efficiently through the supply chain.

[1] Prepared by D. Sivakumar and L. Korsten.

Packaging

Packaging is used to:

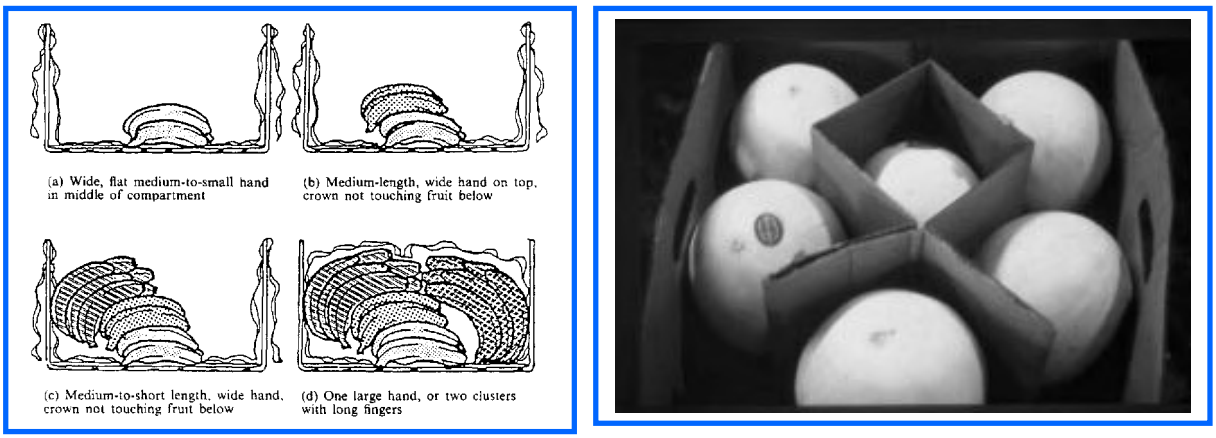
- **protect** produce from mechanical injury, contamination and disease;
- **display** produce and therefore facilitate marketing; and
- **contain** produce, thereby increasing the efficiency and ease of handling, transport, storage and distribution.

Packaging materials

Boxes, crates and bags

Boxes, crates and bags etc. are commonly used as packaging containers for fresh produce. Packaging accessories such as trays, cups, wraps, liners, sleeves, shredded paper and pads (see figures VI.5.1-VI.5.3) may be used to immobilise the produce within the packaging container, while serving the purpose of facilitating moisture retention, the control of pests and disease and ethylene absorption. Packaging can greatly influence airflow rates around a commodity, thereby affecting the temperature and relative humidity of the produce while in transit.

Figure VI.5.1. Use of packaging accessories to immobilise produce in packaging containers



Source: FAO, 1989

Figure VI.5.2. A simple, stackable wooden tray with raised corners, used for the packaging of fragile produce such as ripe tomatoes

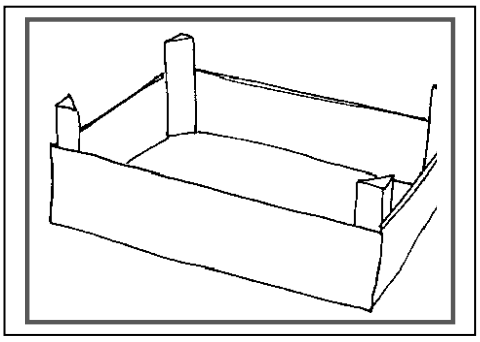
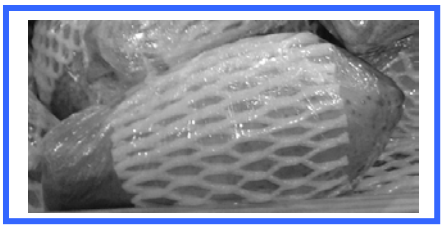


Figure VI.5.3. Sleeving used to protect fragile papayas and paper lining for guavas to minimise abrasion damage during transportation



Good packaging practice is essential to ensure the quality and storage-life of the packed commodity. Packages must be properly vented to facilitate temperature management and must be sturdy enough to prevent collapse during handling and transportation. The use of waxed cartons, wooden crates or rigid plastic containers as packaging materials is preferable to the use of bags and open baskets. Although waxed cartons, wooden crates and plastic containers are costly, they are cost effective when used in packaging for the domestic market. This is because of their reusability and their ability to stand up well to conditions of high relative humidity in the storage environment.

Packaging films

The packaging industry has become increasingly responsive to the specific gas requirements of fresh produce and is now providing films tailored to the requirements of given types of fresh produce. Films are available for commodities having low, medium and high respiration rates. The oxygen transmission rates of the films are matched to the minimum level of O_2 required for the produce to retain its quality.

Modified atmosphere packaging films

Modified atmosphere packaging (MAP) employs packaging films to manipulate the respiration rates of fresh produce and thereby extend shelf life. MAP makes use of the carbon dioxide produced by respiration and oxygen consumed during the respiration process, for the production of an environment within the package that slows the metabolic activity of the produce. The goal of MAP is to create an equilibrium atmosphere, such that the oxygen concentration is adequately low and the carbon dioxide concentration is adequately high, to be beneficial and not injurious to the produce.

Packaging films such as low density polyethylene, which can be easily sealed and offer good permeability to O_2 and CO_2, are durable at low temperatures and which have good tearing resistance, are appropriate in use for MAP. MAP films can be impregnated with minerals in order to absorb and remove ethylene produced in the storage environment around the bagged produce. Impregnated MAP films are particularly suitable for transporting bulk fresh fruit and vegetables to distant markets or between farmers and consumers at supermarkets and retail outlets.

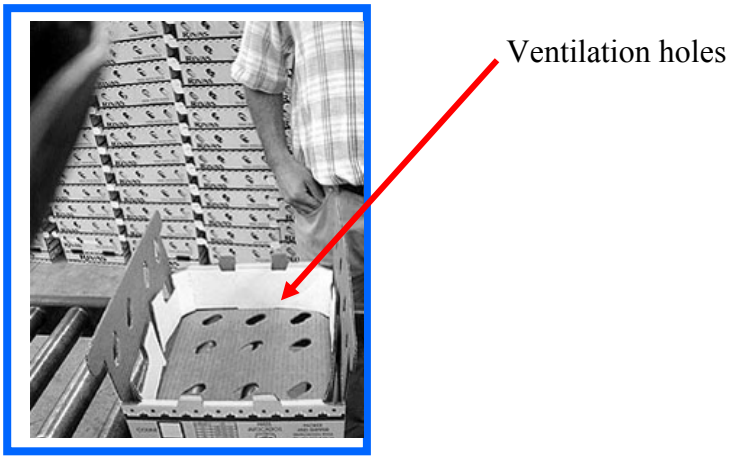
Produce contained in MAP must be maintained under appropriate temperature conditions and must be properly handled and packaged prior to transport if freshness is to be maintained, shelf life extended and safety assured. Neither low temperature nor MAP can act alone to deliver full value to the consumer, the reason being that both factors work together to

slow the metabolism and aging of the produce thereby extending the shelf life and maintaining the quality.

Key considerations when selecting packaging materials suited to fresh produce

- **Container dimensions** – Containers must be of the appropriate weight and measurements. They can be altered to suit the needs of the handler and the produce item. For example, tomato boxes must be 39cm long and 25cm wide, with 3.5cm raised corners such as triangular corner supports (see figure 5.2, above) to increase the strength of the carton.
- **Ventilation** – Fresh-air exchange helps prevent unwanted ripening and the accumulation of odours, and ensures longer shelf life for many perishables. Holes within the packaging facilitate both horizontal and vertical airflow, thereby facilitating cooling of the produce. Temperature management can be difficult if packing materials block ventilation holes (see Figure VI.5.4, below).
- **Ease of handling** – The weight and size of boxes must facilitate easy handling.
- **Compliance with standard design and marketing demand** – The specific packaging requirements of buyers must be taken into account during the selection of packaging materials. Many supermarket chains differentiate themselves from others through unique packing or branding. Chemicals that are banned in certain importing countries may not be used in packaging. In fact, a number of importing countries now stipulate that packaging must be recyclable and must clearly identify the product and its origin so that it can be traced back to its source.

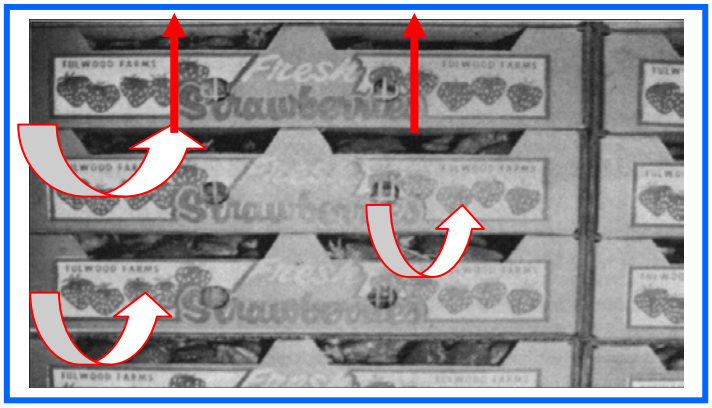
Figure VI.5.4. Packaging material design must include holes (5 per cent) for ventilation



- **Ease of palletisation** – cartons are the primary form of outer packaging used for the international export of fruit. Pallets provide a strong base for transporting and storing cartons that weigh up to 1 tonne. The stacking pattern of palletised cartons is dependent on the height of the carton and the positioning of the ventilation holes. Pallets must be constructed from environmentally friendly materials and must comply with the standards of the exporting and importing countries. Effective as of 2005, all packaging material made of wood must be either heat- or chemically-treated to comply with international standards. The following basic care must be taken during palletisation:

- *Surface finish* – the surface of the package must be smooth in order to prevent damage to the produce
- *Easy of cleaning* – packaging must be easily cleaned if it is to be re-used

Figure VI.4.5 Diagrammatic indication of the airflow through stacked cartons



Packaging materials for produce destined for local markets

Woven plastic packaging:

- withstands impact;
- provides protection against insects if closely woven;
- is somewhat effective in preventing contamination; and
- does not absorb moisture.

Fibreboard:

- provides some protection against insects.

Plastic crates:

- withstand impact during transportation;
- can be easily stacked and palletised; and
- offer some protection against contamination.

Jute bags:

- provide good protection against impact damage;
- do not absorb moisture;
- are biodegradable; and
- retain produce odour.

Corrugated cardboard boxes:

- withstand impact forces and localise the produce;
- if they are waxed, provide protection against moisture and humid environments;
- contribute to prevention of produce contamination; and
- are stackable and can be palletised during transportation.

Packaging materials for produce destined for long-distance and export markets

Bulk bins

Bulk bins (1000 x 1200mm), which are capable of carrying 300kg of fruit, are used for the export of produce items such as oranges for juicing. Bulk bins can be stacked on top of each other and fastened with securing strips. The combined weight of the bins must be less than 900kg.

Cartons

Fruit cartons made from corrugated cardboard, polystyrene and polypropylene are used for the export of fresh produce. The packaging container must comply with standards set by the exporting and importing country. Cartons must be strong enough to bear the weight of the produce, must either be waxed or should not absorb moisture easily and should be adequately ventilated so as to allow horizontal and vertical airflow.

The number of cartons stacked on a pallet is dependent on the size and depth of the cartons. For example, a total of 75 cartons measuring 600 x 400 x 120mm can be stacked on a 2.1m pallet, while 260 cartons measuring 400 x 300 x 70 mm can be accommodated on a pallet stacked to a similar height.

Each carton may contain fruit packaged in small units or secondary packaging units such as fruit wrappers, plastic bags, nettings or punnets. Nets offer the advantage of allowing the fruit to breathe freely. Punnets are generally made of polypropylene or polyethylene and are used for the packaging of small fruits such as plums, apricots and grapes. Some buyers require that grapes be packed in polycot, carry or ‘zip lock’ bags.

Labelling

Labelling helps handlers to keep track of the produce as it moves through the horticultural supply chain. Labelling assists the wholesale agents and retailers in using proper practices. Labels are pre-printed or glued, stamped or stencilled on to the packaging container.

The label must mention the following:

- count, cultivar, class type or size;
- weight;
- producer’s code;
- pack house code;
- name and address of the exporting packer;
- country of origin;
- any special treatment given e.g. SO_2 fumigation or type of approved wax or pesticides used etc.; and
- recommended storage temperature and special handling instructions.

REFERENCES

Brecht, J.K, K.V. Chau, F.A.R. Fonseca, F.A.R. Oliveria, F.M. Silva M.C.N. Nunes and R.J. Bender (2003) Maintaining optional atmosphere conditions for fruits and vegetables throughout the post-harvest handling chain. *Post-harvest Biology and Technology,* 27: pp. 87-101.

Food and Agriculture Organization (FAO) (1989) Prevention of post-harvest food losses. FAO Training Series, No.17/2. Rome, Italy: FAO.

Kader, A.A. (1989) Modified and controlled atmosphere storage of tropical fruits. In Champ, B.R., Highley, E., Johnson, G.I. (eds.) Proceedings of (Australian Centre for Agricultural Research (ACIAR) Conference on post-harvest handling of tropical fruits, 50: pp. 239-249.

Kader, A.A. (1997) Biological bases of O_2 and CO_2 effects on post-harvest-life of horticultural perishables. In Saltveit, M.E. (ed.) Proceedings of the Seventh International Controlled Atmosphere Research Conference, July 13–18 2007, Vol. 4. Vegetables and ornamentals, pp. 160-163. Davis, USA: University of California.

Kader, A.A. and M.E. Saltveit (2003) Atmosphere modification. In Bartz, B. and Brecht, J.K. (eds) *Post-harvest Physiology and Pathology of Vegetables*, pp. 229-246. USA: Marcel Dekker, Inc.

Lalel, D.J.H, Z. Singh and S.C. Tan (2005) Controlled atmosphere affects fruit ripening and quality of 'Delta R2E2' mango. *Journal of Horticultural Science & Biotechnology,* 80: pp. 551-556.

Sivakumar, D. and L. Korsten (2006) Influence of modified atmosphere packaging and post-harvest treatments on quality retention of litchi cv. Mauritius. *Post-harvest Biology and Technology,* 41: pp. 135-142.

Suggested methods of instruction

Lecture, using handouts or visuals to promote an understanding of proper packing techniques, the selection and use of appropriate packaging and the importance of proper labelling.

Practical exercises

Practical exercise VII.5: Impact of handling.

Time Frame

One-hour lecture.

Two hours for the practical exercise.

SECTION VI

MODULE 6 – SPECIALISED TREATMENTS TO IMPROVE QUALITY[1]

1. CONTROLLED AND MODIFIED ATMOSPHERE STORAGE

Learning outcomes

The learner should:

- Understand the basic principles of modified and controlled atmosphere storage
- Understand the positive and negative impacts of modified atmosphere (MA) and controlled atmosphere (CA) storage on produce quality

Introduction

The shelf life and quality of fresh produce can be significantly improved under optimal conditions of storage. Storage of horticultural produce in a modified gaseous environment can enhance shelf life by retarding the rate of chemical and biochemical deterioration.

Modified and controlled atmosphere storage

Modified atmosphere (MA) storage

Modified atmosphere storage is the technique for storing actively respiring produce in an atmosphere that is different from that of ambient air in order to control its respiration rate. During MA storage, it is often desirable to generate an atmosphere that is low in oxygen or high in carbon in order to increase the storage or shelf life of the produce. The atmosphere created in the storage container at the beginning of the storage period is, however, likely to change during storage owing to respiration of the produce.

Controlled atmosphere storage (CA)

Controlled atmosphere storage involves storing produce in an atmosphere in which the levels of O_2 and CO_2 are regulated throughout the entire storage period in order to maintain the desired gas composition, while controlling the respiration rate.

During both CA and MA storage, produce must be maintained under appropriate temperature conditions (see table VI.6.1). Neither low temperature nor MA or CA can act alone to deliver full value to the customer. The reason for this is that MA and CA each work in tandem with low temperature conditions to slow the metabolism and aging of the produce so that it stays fresh over longer periods.

[1] D. Sivakumar and L. Korsten.

Benefits of CA and MA storage

CA and MA storage:

- **Enhance storage life** – CA and MA storage help to delay ripening and senescence processes in fresh produce;
- **Inhibit the direct development of post-harvest decay** by inhibiting spore germination and slowing bacterial growth;
- **Prevent sprouting**, thereby minimising nutritional loss during storage;
- **Prevent insect damage** and provide a useful tool for controlling insects in some commodities (in this way quarantine requirements of importing countries are met); and
- **Slow the rate of chlorophyll loss**.

Table VI.6.1. Temperature and gas compositions for MA or CA storage of selected vegetables

Vegetables	Temperature[a]	Atmosphere[b]	
	°C	O_2	CO_2
Broccoli	5-10	1-2	1-10
Brussels sprouts	0-5	1-2	5-7
Cantaloupe	2-7	3-5	1-20
Cauliflower	0-5	2-3	3-4
Cucumber	8-12	1-4	0
Lettuce (Crispy)	4-5	1-3	0
Spinach	4-5	7-10	5-10
Tomatoes			
Greens	12-14	3-5	2-3
Ripe	10-14	3-5	3-5

[a] Optimum and range of usual and/or recommended temperatures. A relative humidity of 90% to 95% is usually recommended.

[b] Specific CA recommendations depend on cultivar, temperature and duration of storage.

Source: Based on Kader & Saltveit, 2003

Disadvantages of MA and CA storage

CA and MA storage can also negatively impact on the quality and safety of fruits and vegetables through:

- **Enhancement of decay** as a result of excess humidity.
- **Physiological disorders** – If the gas composition within the package is not suited to a particular commodity, physiological disorders (e.g. internal browning in apples and pears, brown stain in lettuce) result; these affect the overall quality of the produce, particularly its cosmetic appearance and eating quality.
- **Risks of microbiological safety** – resulting from the possible development of anaerobic pathogenic flora.
- **Fermentation** – can occur if effective O_2 levels are not maintained between 2 and 10 per cent in CA and MA systems.
- **Off-flavour and odour development** – this is a common symptom encountered owing to improper gas compositions around fruit. Off-flavours adversely affect the eating quality and consumer acceptance of the produce. At CO_2 levels ranging between 1 and 5 per cent, fruit fail to ripen.

Atmosphere modification in containers for transport and storage

Conditions for the establishment of MA environments can be created by flushing the storage container with N_2 gas. Ethylene can be removed with the use of absorbers such as $KMnO_4$, or with activated and brominated charcoal – alone or in combination with $KMnO_4$. Palletised shipping containers are covered with polyethylene and are sealed (with tape, heat seal etc.) to establish a gas tight environment. A partial vacuum is then established within the pallet cover and the desired gas mixture is introduced. This method can permit the shipping of commodities that are temperature compatible, but which require different MA conditions during transit at the same temperature.

Containers can be suitably equipped with flow-through supplies of gases to maintain CA conditions within the container.

Treatment with surface coatings

Surface coatings are used to create a modified atmosphere around fruits. Many formulations have been developed, including solvent waxes, water waxes, emulsion waxes and edible coatings, which have been commercially applied to a variety of different produce items.

Surface coatings help to:

- **Prevent decay** – by protecting against fruit-to-fruit contact during storage and transportation. This protective effect can be improved through the incorporation of GRAS compounds such as food grade sodium bicarbonate or bio-control agents; and
- **Reduce weight loss and shrinkage** – by partially or completely plugging the stomata, thus affecting the transport of O_2, CO_2, and C_2H_4.

Current consumer preference trends towards additive-free diets may curtail the use of coatings in the fruit industry. The emerging popularity of edible coatings of natural origin is, however, considered environmentally friendly and cost-effective and offers great potential for developing countries where refrigerated storage is not affordable.

REFERENCES

Brecht, J.K, K.V. Chau, F.A.R. Fonseca, F.A.R. Oliveria, F.M. Silva, M.C.N. Nunes and R.J. Bender, R.J. (2003) Maintaining optional atmosphere conditions for fruits and vegetables throughout the post-harvest handling chain. *Post-harvest Biology and Technology,* 27: pp. 87–101.

Gamagae, S.U, D. Sivakumar and R.L.C. Wijesundera (2004) Evaluation of post-harvest application of sodium bicarbonate incorporated wax formulation and Candida oleophila for the control of anthracnose of papaya. *Crop Protection,* 23: pp. 575–579.

Kader, A.A. (1989) Modified and controlled atmosphere storage of tropical fruits. In Champ B.R., Highley, E. and Johnson, G.I. (eds.) Proceedings of ACIAR Conference on post-harvest handling of tropical fruits, 50: pp. 239-249.

Kader, A.A. (1997) Biological bases of O_2 and CO_2 effects on post-harvest-life of horticultural perishables. In Saltveit, M.E. (ed.) Proceedings of the Seventh International Controlled Atmosphere Research Conference, Vol. 4. Vegetables and ornamentals, pp. 160-163. Davis, USA: University of California.

Kader, A.A. and M.E. Saltveit (2003) Atmosphere modification. In Bartz, B. and Brecht, J.K. (eds) *Post-harvest Physiology and Pathology of Vegetables*, pp. 229-246. USA: Marcel Dekker, Inc.

Lalel, D.J.H, Z. Singh and S.C. Tan (2005) Controlled atmosphere affects fruit ripening and quality of 'Delta R2E2' mango. *Journal of Horticultural Science & Biotechnology,* 80: pp. 551-556.

Romanazzi, G., A. Nigro, D. Ippolito, D.I. Venere, and M. Salerno (2002) Effects of pre- and post-harvest chitosan treatments to control storage grey mold of table grapes. *Journal of Food Science,* (67): pp. 1862-1867.

Sivakumar, D. and L. Korsten (2006) Influence of modified atmosphere packaging and post-harvest treatments on quality retention of litchi cv. Mauritius. *Post-harvest Biology and Technology,* 41: pp. 135–142.

Sivakumar, D., Y. Sultanbwa, N. Ranasinha, P. Kumara and R.L.C. Wijesundara (2005) Effect of the combined application of chitosan and carbonate salts on the incidence of anthracnose and on the quality of papaya during storage. *Journal of Horticultural Science & Biotechnology,* 80: pp. 447-452.

Suggested method of instruction

Lecture, using handouts or visuals to promote an understanding of the principles of CA and MA storage and their impact on quality.

Time frame

Thirty-minute lecture.

2. RIPENING AND DE-GREENING OF PRODUCE

Learning outcomes

The learner should:

- Understand the importance and value of ethylene treatments in ripening produce
- Understand the importance and value of de-greening of produce to ensure marketability

Introduction

The exogenous application of ethylene is used to improve ripening as well as to promote desirable colour development, thereby enhancing the marketability of produce.

Ripening at the wholesale and retail level

Consumer demand for fruit in a fully ripened state has led to the practice of produce ripening prior to marketing. Ripening facilities that are often associated with repacking centres have been established in several countries.

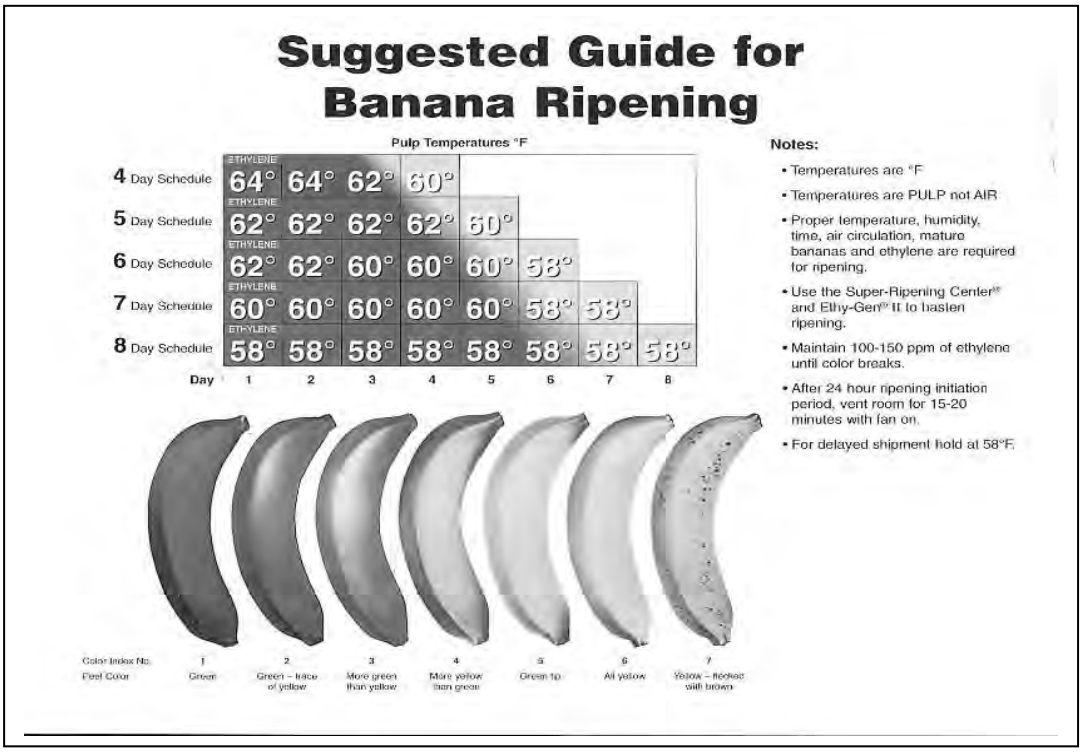
Ripening at the wholesale and retail level allows normally damage-prone fruit such as avocadoes, papayas and bananas to be shipped in a relatively bruise-resistant, immature state over long distances. The fruit can then be ripened with the exogenous application of ethylene under appropriate temperature conditions (see table VI.6.2).

Table VI.6.2. Ripening conditions for some fruit crops

Fruit	Temperature (°C)	Ethylene (ppm)	Treatment time (hours)
Avocado	18-21	10	24-72
Banana	15-21	10	24
Tomato	13-22	10	24-48

Figure VI.6.1, below, shows the ripening schedule to plan the marketing sequence for bananas. In order to ripen bananas over a four-day schedule, the pulp temperature is maintained at 64°F over two days, is dropped to 62°F on the third day and thereafter dropped further to 60°F. The ethylene concentration is maintained between 100-150ppm until the fruit reach colour stage 3, i.e. colour break stage as shown in Figure 6.1.

Figure VI.6.1. Ripening guide for banana using Ethy-Gen® 11 as ripening agent



De-greening of citrus

The exogenous application of ethylene is also used for the de-greening of citrus. The de-greening process involves treatment with ethylene gas in specially constructed de-greening rooms. During the process, chlorophyll is destroyed, allowing the yellow or orange peel colour to predominate.

Conditions required for the de-greening of citrus:

- Temperatures of 28-29 ^{o}C.
- Relative humidities (RH) ranging between 90 and 95 per cent.
- Ethylene concentrations of five parts per million (ppm) are adequate for the maximum de-greening rate, although some packers successfully use 3ppm ethylene.
- Ventilation – fresh air should enter the room at the rate of one air change per hour, based on the volume of the empty room. The rate of de-greening is reduced at a CO_2 concentration of 0.1 per cent and will practically stop at 1.0 per cent or above. A constant supply of fresh air eliminates any need to periodically open rooms for ventilation.
- Air circulation – should be a minimum of 3m^3 per minute per field box or 30 per m^3 per minute per pallet box. This airflow rate is necessary to maintain uniform temperature, ethylene concentration and humidity at the surface of each fruit in the de-greening room.

Safe handling of ethylene

Ethylene gas used for de-greening is sold in compressed gas cylinders containing slightly less than 100 per cent ethylene. Although non-toxic, ethylene can cause asphyxiation at high concentrations as the gas displaces oxygen in the atmosphere. Ethylene is a potentially explosive gas.

Be sure to follow these important safety rules when working with ethylene:

- Do not move compressed gas cylinders without the cover cap in place (which protects the valve).
- Only remove the cap when the cylinder is in place and ready to be used.
- Securely fasten cylinders to walls, holding cages or other non-tip structures.
- Check for gas leaks using a solution of soapy water. If the cylinder is leaking, contact your service provider and have it replaced.
- Verify that ethylene flow regulators are operating correctly.
- Keep flames or spark producing equipment away from de-greening rooms and ethylene cylinders. Place 'no smoking' signs in the area of cylinder storage and ensure that all workers are trained in safety signs and are aware of the negative effects of ethylene gas.
- All piping should be grounded to prevent electrostatic discharge.
- Check ethylene flow often to ensure that safe concentrations are maintained. Some ethylene monitoring equipment will sound an alarm if concentrations become too high.

REFERENCES

Blanke, M.M. (1991) Respiration of apple and avocado fruits. *Post-harvest News Information*, 2: pp. 429-436.
Kader, A.A. (1992) Post-harvest technology of horticultural crops. Publication 3311. Berkeley, CA, USA: Division of Agricultural and Natural Resources, University of California.
Reid, M. (1992) Ethylene in Post-harvest technology. In: Kader, A.A. Post-harvest Technology of Horticultural Crops. Publication 3311, pp. 97-108. Berkeley, CA, USA: University of California.
Wills, R.B.H., M.A. Warton and V.V.V. Ku (2000) Ethylene levels associated with fruit and vegetables during marketing. *Australian Journal of Experimental Agriculture,* 40: pp. 357-392.

Suggested method of instruction
Lecture, using handouts or visuals to promote an understanding of commercially beneficial uses of ethylene.

Time frame
Thirty-minute lecture.

SECTION VII

QUALITY MAINTENANCE DURING STORAGE AND TRANSIT

SECTION VII

MODULE 1 – MAINTAINING FRESH PRODUCE QUALITY DURING COLD STORAGE[1]

Learning Outcomes

The learner should:

- Understand the importance of maintaining temperature and relative humidity conditions during cold storage
- Understand factors that could compromise quality during the storage of mixed loads
- Understand the management of hygiene in the cold store

Introduction

Fresh produce must be stored under appropriate temperature and relative humidity conditions in order to avoid chilling injury and moisture loss, to reduce susceptibility to damage from ethylene gas and to minimise microbiological decay.

Purpose of cold storage in horticultural chains

Cold storage is designed to:

- Slow biological activity of produce by maintaining the lowest temperature that will not cause chilling injury;
- Slow the growth of micro-organisms;
- Reduce the rate of moisture loss from the surface; and
- Reduce the susceptibility of produce to damage from ethylene gas.

Temperature management

Temperatures within the cold storage facility must be regulated in accordance with the optimum temperature requirement of the horticultural produce to be stored. Storage temperatures for a given produce item vary in accordance with the cultivar and growth conditions. The storage temperature within a storage facility should be kept within 1^{o}C of the desired storage temperature range for the commodity to be stored. Temperatures either above or below the optimal storage temperature range for fresh produce (see table VII.1.1) can cause rapid deterioration due to freezing or chilling injury. Condensation of moisture on the commodity due to alternating cold and warm temperatures can result in the accumulation of moisture on the surface of the produce (sweating), which may hasten decay.

Produce in the cold store must be packaged appropriately in order to allow the free movement of air around the produce and its packaging

Chilling injury

Some commodities are sensitive to chilling and suffer injury when cool-stored at temperatures above their freezing points. Both time and temperature are involved in chilling injury. Damage may occur in a short time if temperatures are considerably below the danger threshold, but some crops can withstand temperatures a few degrees into the danger zone for

[1] D. Sivakumar and L. Korsten.

a longer time. Maturity at harvest and the degree of ripeness are important factors in determining the chilling sensitivity of fruits. The effects of chilling injury are cumulative in some crops.

Some of the more common visual symptoms of chilling injury include:

- surface lesions: pitting, large sunken areas and discolouration;
- water soaking of the tissues: disruption of cell structure and accompanying release of substrate favours growth of micro-organisms;
- internal discolouration of the pulp;
- failure to ripen in the expected pattern following removal to ripening conditions;
- an accelerated rate of senescence;
- increased susceptibility to decay; and
- compositional changes.

The lower the temperature below the threshold and the longer the time of exposure, the more pronounced the manifestation of the symptoms of chilling injury.

Figure VII.1.1 Chilling injury in bananas

Source: Sivakumar, 2006

Freezing injury

Horticultural produce freezes at temperatures below 0^{o}C owing to the presence of dissolved soluble solids in the cell sap. The soluble solids concentration varies not only with the type of fruit and vegetable, but also between individuals and even parts of the same fruit or vegetable. It is difficult to cite precise values for freezing points of a particular commodity, since the actual freezing point will vary between cultivars and with factors such as the conditions where the crop is grown and previous storage history. In general, leafy vegetables, which are fairly low in sugar, freeze at about -0.5°C, while those with high sugar content generally freeze at 2-5°C.

Relative humidity management

A storage environment having a high, but not saturated (85-95 per cent) relative humidity (RH) is optimal for most produce items. The RH of the cold store can influence water loss, decay development, the incidence of physiological disorders and uniformity of fruit ripening. Table VII.1.1 shows recommended relative humidity ranges and temperatures for the storage of fruits and vegetables.

Table VII.1.1 Storage requirements of selected fruits and vegetables

Commodity	Storage temperature (°C)	Relative humidity (%)	Average storage life
Broccoli	0	90-95	10-14 days
Carrot	0	90-95	4-5 months
Cauliflower	0	90-95	3-4 months
Celery	30	90-95	2-3 months
Cucumber	10-12	90-95	4-8 days
Eggplant	7-12	90-95	10-14 days
Sweet pepper	7-10	90-95	2-3 weeks
Apple	-1-4	90	3-8 months
Avocado	10-12	90-95	3-10 days
Grapefruit	4-10	85-90	3-1 week(s)
Orange	0-4	85-90	3-10 weeks

Storage of mixed loads

At times, it is necessary to cold store different commodities in the same cold room. Under such circumstances, it is very important to combine only those commodities that are compatible with respect to temperature, relative humidity, ethylene production and ethylene sensitivity.

Temperature – Consideration must be given to the temperature requirements of individual produce items in a load if quality is to be maintained during storage. Produce that must be stored at or around 0°C should not be stored with produce that is sensitive to chilling injury below about 12.5°C.

Odour transfer – The cross-transfer of undesirable odours among produce items is likely to occur during storage. Combinations that should be avoided in storage rooms include: apples or pears with celery, cabbage, carrots, potatoes or onions; celery with onions or carrots; and citrus with any strongly scented vegetables. Pears and apples acquire an unpleasant, earthy taste and odour when stored with potatoes. Green peppers will taint pineapples. It is recommended that onions, nuts, citrus and potatoes each be stored separately.

Ethylene – Many commodities, such as apples, avocados, bananas, pears, peaches, plums, cantaloupes, honeydew melons and tomatoes, produce ethylene as a natural product. High ethylene producers (such as ripe bananas, apples and cantaloupe) can induce physiological disorders and/or undesirable changes in colour, flavour and texture in ethylene-sensitive commodities such as lettuce, cucumbers, carrots, potatoes and sweet potatoes. Ethylene-sensitive produce should not, therefore, be mixed with produce items that produce ethylene gas.

The ripening effect of ethylene is negligible at 5-10°C, but may cause harm at higher temperatures. Produce such as cucumbers, peppers and acorn squash, which require storage at a minimum temperature of 7°C and in which retention of green colour is desired, should not, therefore, be stored with apples, pears, tomatoes or other ethylene-producing produce items.

Penicillium digitatum (green mould of citrus) and probably other decay organisms also produce ethylene. Decayed produce should, therefore, be removed promptly from storage rooms.

Managing produce volumes and inventory in cold stores

On arrival at the cold storage facility, the intake personnel must have already made arrangements with the forwarding agent and must have prepared all documentation for receiving the produce. This documentation should include the anticipated arrival time of the supplier, allocated chambers within the cold store and the temperature at which the fruit must be stored. Palletised produce must be placed in assigned locations within the cold store, and damaged cargo should be placed in a demarcated area.

The location of inventory must always be noted. Inventory information should include information on the type of produce, quantity, harvest date, packing date, pre-cooling method used, storage entry date and any special handling procedures. It is also advisable that an inventory verification policy be established between the customer and management of the cold storage facility.

Stock management is a core activity in every cold storage facility and often the indicator of how efficiently the facility is being run. Generally the 'first in first out' (FIFO) method of inventory rotation is practiced in cold storage facilities, i.e. the oldest items are shipped first. This system assures that each lot of produce remains in storage for a minimal length of time. Recent developments in the fresh produce industry include a move from the FIFO method to a pick-week reference method, in which produce picked first is shipped first.

Effective hygiene management in cold stores

Cold stores must be maintained under sanitary conditions in order to prevent build up of inoculum on the walls, metal and cooling units. The cold store must be routinely cleaned in accordance with a 'cleaning schedule' that is adequate to ensure effective maintenance of basic hygiene. Approved, environmentally-friendly sanitisers must be used for sanitisation of the cold store in accordance with the manufacture's instructions. During the cleaning process, facial masks must be worn by the cleaning staff as a protective measure since continuous exposure to disinfectants and high inoculum levels is not conducive to healthy lungs and may later cause respiratory diseases.

REFERENCES

The Trade Chain of the South African Fresh Fruit Export Industry (2004). Production, Book 1 of 9. Newlands, South Africa: Fresh Produce Exporters' Forum.

South African Mango Growers'Association (2000) Protocol 1999/2000. Tzaneen, South Africa.

Gast, K.L.B and R.A. Flores (1992) Post-harvest Management of Commercial Horticultural Crops – Storage Operations. MF1033. Kansas, USA: Kansas State University.

Kader, A.A (ed) (2002) Post-harvest Technology of Horticultural Crops. Publication 3311. California, USA: University of California, Agricultural and Natural Resources.

Thompson, J.F., F.G. Mitchell, T.R. Rumsey, R.F. Kasmire and C.H. Crisosto (1998) Commercial cooling of fruits, vegetables and flowers. Publication 21567. California, USA: University of California, Agricultural and Natural Resources.

Suggested methods of instruction

Lecture, using handouts or visuals to promote an understanding of the factors that must be considered during the cold storage of fresh produce.

Practical exercises

Practical exercise III.2: Visit to a pack house.

SECTION VII

MODULE 2 – MAINTAINING FRESH PRODUCE QUALITY DURING TRANSIT[1]

Learning outcomes

The learner should:

- Understand the factors that could compromise quality during the transportation of fresh produce
- Understand the factors to be considered during the transportation of mixed loads of fresh produce

Introduction

Transportation facilitates the rapid movement of fresh produce within the horticultural supply chain. Fresh produce must be properly protected during transportation in order to minimise mechanical damage, temperature abuse, taint and contamination by food-borne pathogens. It is the responsibility of the transport provider to ensure that the transport vehicle is well maintained and is in a hygienic condition.

Mechanical damage

Mechanical damage of fresh produce results in tissue darkening or colour changes on the skin of the commodity and markedly affects its nutritional and sensory quality, i.e. its taste, texture, appearance and flavour. Mechanical damage can also lead to moisture loss, pathogen invasion and can stimulate the production of ethylene, which triggers the senescence process in horticultural crops such as apples, papayas and tomatoes.

Types of mechanical damage that occur during transportation

Impact damage occurs due to:

- collision between produce items or between produce and hard surfaces;
- rapid acceleration or deceleration, e.g. when fruits are dropped; or
- exertion or removal of forces (such as impact, compression, vibration and abrasion) within a short time (duration impact).

Impact damage can result in bruising with or without skin injury.

Compression damage:

- occurs when produce is subjected to heavy commodity weight, with or without physical movement, as occurs when containers are of inappropriate depth, over-packed, packed in containers of poor structural integrity, improperly packed or stacked too high;
- generally results in distortion cracks and splits;
- is usually caused by package failure; and
- is also caused by stacking or sitting on top of produce.

[1] Prepared by D. Sivakumar and L. Korsten.

Abrasion damage:

- occurs when the surfaces of produce slide across another surface causing friction;
- can result in removal of the cuticle and wax layers of produce; and
- can be minimised with the use of lining or padding materials, such as paper or sleeves to protect the produce (see figures VII.2.1-VII.2.3).

Figure VII.2.1. Paper lining material used to pack bananas in order to prevent abrasion damage during handling and transportation

Figure VII.2.2. Sleeving or netting used to minimise abrasion damage during transportation

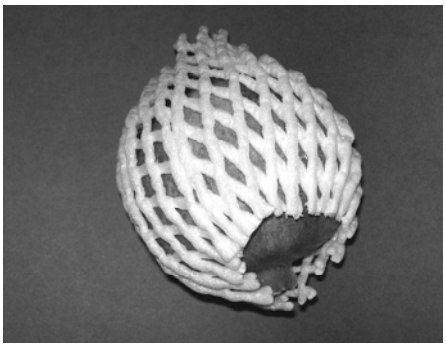
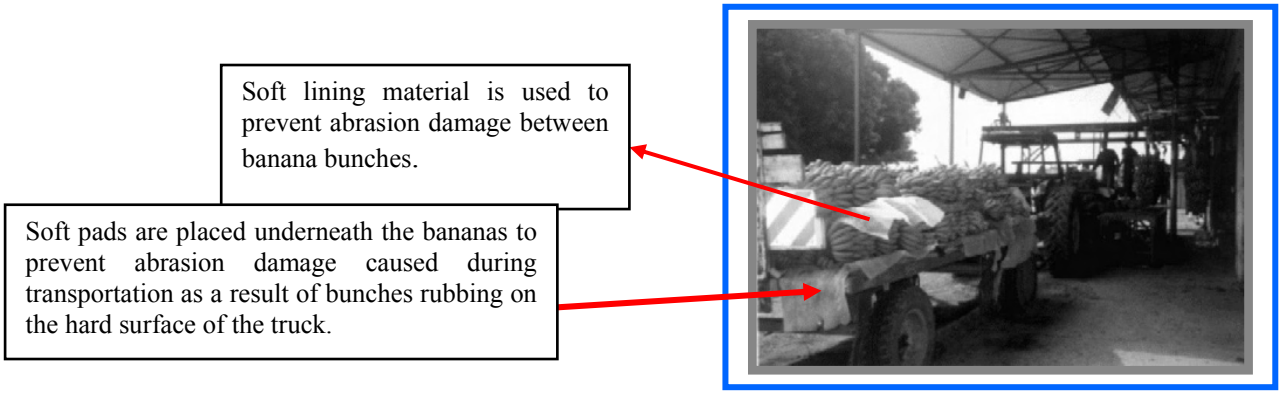


Figure VII.2.3. Precautions taken before transport of bananas to optimise quality retention and shelf life



Vibration damage
The level of vibration of a moving vehicle is greatly influenced by the nature of the road and the suspension system of that vehicle. Vibration occurs when produce moves repeatedly for prolonged periods within a container during transport. Vibration can result in damage due to compression, impact and abrasion.

Vibration damage can be prevented, or limited, by the following practices:

- Use plastic crates for transportation – vibration damage is less with plastic crates than with cartons since plastic crates absorb and dissipate the force, thereby keeping the effects of vibration within the crate.
- Use rigid containers to limit the movement of the base of the container in the transport vehicle.
- Use a vehicle with a firm suspension system.
- Use radial tires, which absorb more impact than other types for road transport.

Minimising mechanical damage
Mechanical damage can be minimised through the use of packaging that can withstand:

- rough handling during loading and unloading;
- compression from the overhead weight of other containers;
- impact and vibration during transportation; and
- high humidity during pre-cooling, transit and storage.

Overheating
Overheating occurs due to external sources (such as the sun, heat from the road, the walls of the vehicle etc.) as well as from heat generated by the produce within the transport vehicle. Overheating causes natural breakdown and decay and increases the rate of water loss from the produce. Overheating can, therefore, result in overall quality loss.

Factors that contribute to overheating include:

- heat generated by the produce due to respiration;
- lack of ventilation, as occurs in closed vehicles;
- restricted movement of air between and through packages;
- lack of adequate ventilation in packaging; and
- exposure of packaged produce to the sun while waiting to be transported or unloaded.

Overheating can be avoided by:

- use of well-ventilated vehicles;
- proper stacking to allow for the disposal of heat;
- use of well-ventilated packaging;
- avoidance of exposure to the sun on loading and off-loading tarmacs; and
- travelling early in the morning or at night if non-refrigerated transport is used.

Loading patterns in transport systems to minimise overheating
Stacking patterns in transport vehicles should minimise contact between the produce and the floor and wall surfaces of the vehicle to reduce the transmission of heat from the outside of the vehicle into the loaded produce. Typical stacking patterns to allow for proper ventilation in cooled containers are shown in figure VII.2.4. Centre-loading leaves an insulating air space between the load and the outside walls of the vehicle.

Figure VII.2.4 Stacking of produce in cooled containers to allow adequate ventilation

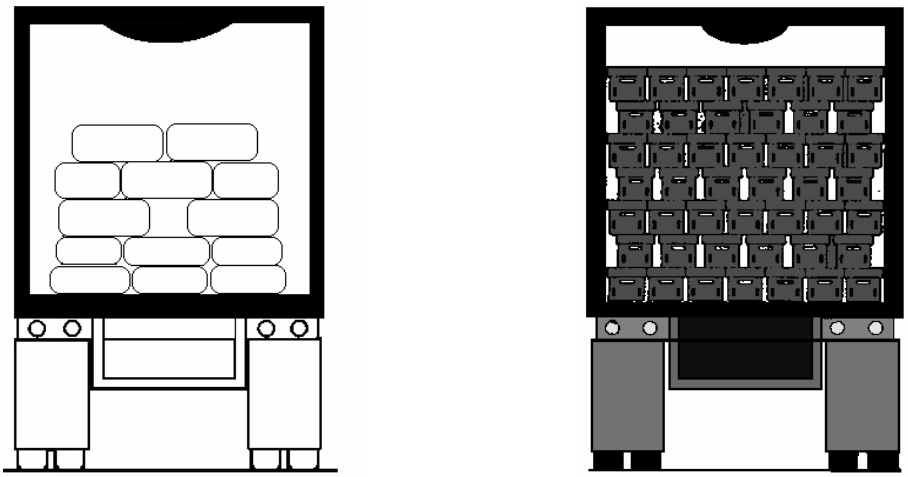


Illustration: Redmond, 2006

Produce transported in cartons should be stacked to allow adequate air circulation throughout the load (see figure 2.5). The industry norm is to load palletised fruit, i.e. fruit in cartons placed on a pallet. Palletisation makes loading easier and more cost effective than loading loose cartons into the container. Palletising is usually done after other pre-cooling methods, but before forced air-cooling. Pallets must, however, be properly secured by strapping, corner bracing or net wrapping.

Build up of gases in the transport system

Inadequate air circulation during the transportation of fresh produce can lead to the build up of ethylene or carbon dioxide. Care must therefore be taken to assure proper ventilation within the transportation vehicle in order to avoid gas build up.

Transportation of mixed loads

Mixed loads can be of serious concern when temperature optima are not compatible or when ethylene-producing commodities and ethylene-sensitive commodities are transported together. Wet and dry produce items must be transported in separate mixed loads in order to avoid the transfer of contamination from wet to dry produce.

Hygiene in transport systems

The quality of perishable produce can be adversely affected by a lack of standard hygiene in transportation systems. Soil, typically found in a field, can encrust the floor area of the transport system. In order to prevent contamination by food-borne pathogens, transport systems should make use of good sanitation practices, ensure proper temperature and humidity management and minimise potential damage to the produce. It is critical that all vehicles used for transportation of food products are cleaned and washed routinely to remove decaying remains of agricultural produce. Water, used for washing, must be safe and clean. If pallets are cleaned by fumigation, only recommended/permitted fumigants or chemicals must be used and such use must be according to the manufacturers' recommendations.

Figure 2.5 Recommended stacking of carton boxes to allow minimal contact with container surfaces and sufficient air-flow

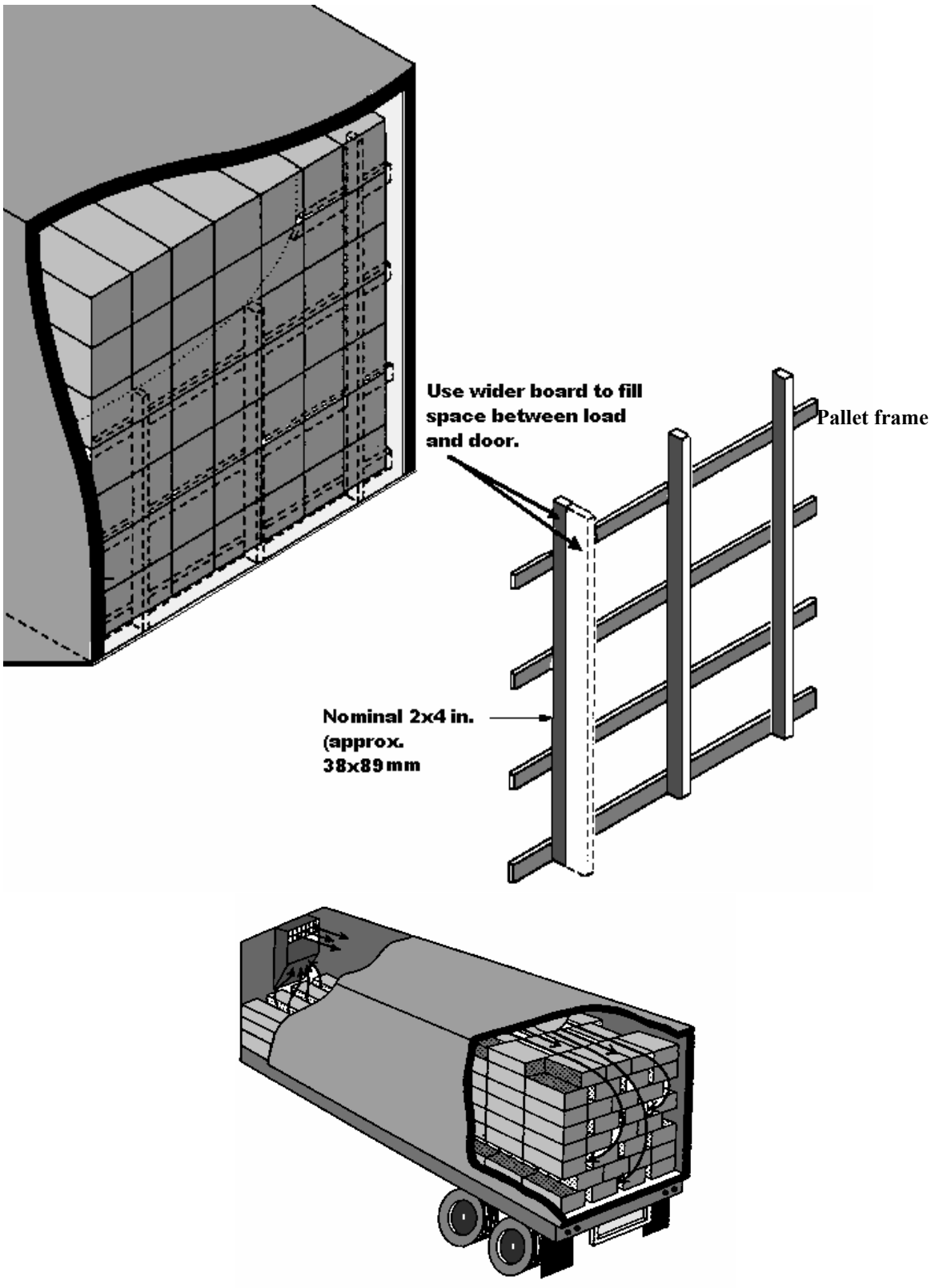


Illustration: Redmond, 2006

REFERENCES

Ashby, B.H. (1987) Protecting perishable foods during transport by truck. US Department of Agriculture (USDA), No. 669.

Heap, R., M. Kierstan and G. Ford (1998) *Food Transportation*. London; New York: Blackie Academic and Professional.

Food and Agriculture Organization (FAO) (1989) Prevention of Post-harvest Food Losses: Fruits, Vegetables and Root Crops. A Training Manual. Rome, Italy: UNFAO.

Kasmire, R.F. and R.T. Hinsch (1987) Maintaining Optimum Transit Temperatures in Refrigerated Truck Shipments of Perishables. University of California Perishables Handling Transportation Supplement No. 2. USA: University of California.

McGregor, B. (1989) Tropical products transport handbook. USDA, No. 668.

Nicholas, C.J. (1985) Export Handbook for U.S. Agricultural Products. USDA, Office of Transportation, Agricultural Handbook No. 593.

Thompson J.F, P. Brecht, T. Hinsch and A. Kader (2000) Marine Container Transport of Chilled Perishable Produce. Davis (CA): University of California, Division of Agriculture and Natural Resources.

Suggested methods of instruction

Lecture, using handouts or visuals to promote an understanding of the factors that compromise quality during transportation.

Time frame

One hour lecture, including an informal discussion on the impact of transportation on produce quality.

SECTION VIII

EFFECTIVE MONITORING IN HORTICULTURAL SUPPLY CHAINS

SECTION VIII

MODULE 1 – TRACEABILITY[1]

Learning outcomes

The learner should:

- Understand the importance of traceability in horticultural supply chains
- Understand the key components of a traceability system

Introduction

The identification of the origin of horticultural produce is of prime importance for the protection of consumers, particularly when there is a likelihood of the contamination.

Traceability

According to Codex Alimentarius[2], traceability or product tracing is 'the ability to follow the movement of a food through specified stages of production, processing and distribution.' This definition encompasses two concepts: (i**) tracking,** which refers to the ability to determine in real time the exact location and status of produce in the logistics chain; and (ii**) tracing,** which refers to the ability to reconstruct the historical flow of produce on the basis of records maintained through the chain.

Importance of traceability systems

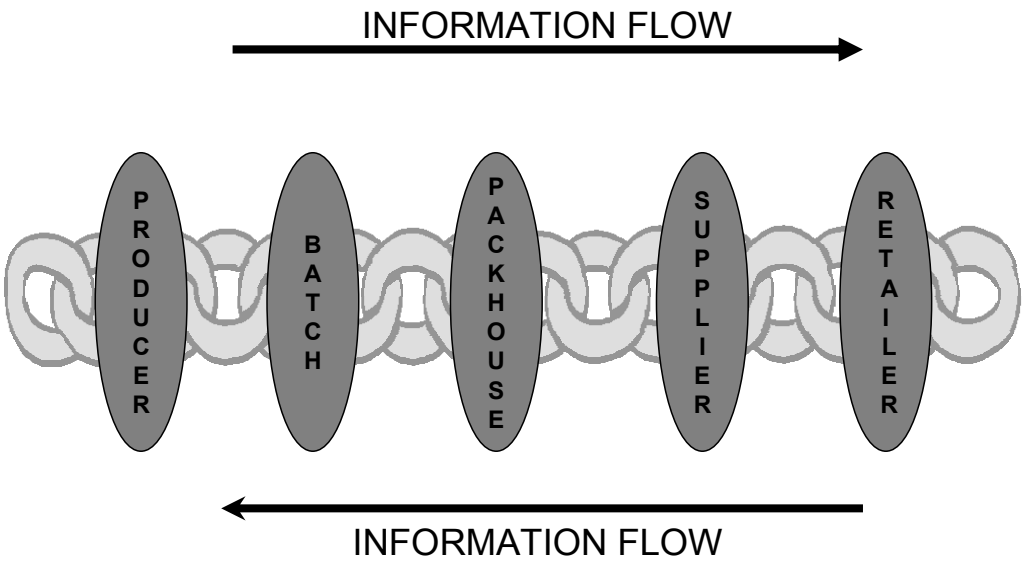
Traceability systems provide an important element of quality and safety assurance in horticultural chains. They allow the history of produce to be traced back through the supply chain to the site of production, including inputs used, operations undertaken during production, post-harvest handling and marketing; they also allow produce to be tracked as it moves through the chain from producer to consumer (see figure VIII.1.1). In so doing, traceability systems facilitate efficient product recall and withdrawal, and assist in identifying the origin of food safety problems, in complying with legal requirements and in meeting consumer expectations for the safety and quality of fresh produce.

Key components of a traceability system

At a minimum, an effective traceability system should include a documentation system and a mechanism for marking or uniquely identifying the produce, thereby allowing it to be followed from the farm to the consumer. Records must be kept at every step of the horticultural supply chain, i.e. in the field, at the pack house, at the supplier, the retailer and during transit between each of these points.

[1] Prepared by R. Rolle, D. Njie and L. Korsten.
[2] Codex Alimentarius Commission (2004); see Appendix 1.

Figure VIII.1.1 Traceability in horticultural supply chains



Various systems have been developed to deliver these requirements. A simple traceability system may consist of simple, handwritten product labels and handwritten records held at the various steps of the chain, while a more sophisticated system makes use of a computerised system for data recording, along with machine-readable barcodes which can be electronically transferred within a computerised information system. The most sophisticated computerised systems now employ radio frequency identification (RFID) tags, which continuously transmit data on the location of the product in real time. While simple handwritten records are inexpensive, they are slower, less accurate and prone to human error. Electronic systems allow for fast and accurate data transfer. RFID tags usually carry sensors that can be used for real-time monitoring of temperature, relative humidity and other parameters of the environment surrounding the produce in question.

REFERENCES

Codex Alimentarius Commission (2004) Report of the Twentieth Session of the Codex Committee on General Principles, Paris, France, 3-7 May, 2004. Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Food Standards Programme. Twenty-seventh Session, Rome, Italy, 28 June-3 July 2004.

van der Heijden, C. and R. Vernède (2004) Food Safety at Which Cost? Turning the Increasing Demands for Traceability into Opportunities for Developing Countries. North-South Policy Brief 2004-1. The Netherlands: Wagenigen University.

Vernède, R., F. Verdenius and J. Broaeze (2003) Traceability in food processing chains. State of the art and future developments. KLICT Position paper, 20 October 2003 Agrotechnology and Food Innovations (nr 015), Wagenigen University, Netherlands.

Suggested methods of instruction

Lecture, using handouts or visuals to promote an understanding of the importance of traceability in horticultural supply chains.

Time frame

One-hour lecture, including an informal discussion on traceability.

SECTION IX

LOGISTICAL OPERATIONS IN HORTICULTURAL CHAINS

SECTION IX

MODULE 1 – LOGISTICAL OPERATIONS[1]

Learning outcomes

The learner should:

- Understand the importance of logistical arrangements in horticultural chains
- Understand key elements of cold chain operations

Logistics

Logistics is the part of the supply chain that deals with transportation, warehousing or storage, carrying inventory, administration and management of produce between the primary point of production and the point of delivery to the final consumer. A good logistics network links the farm, the pack house and the market, while making use of transportation and communications facilities to support efficiency and maintain quality.

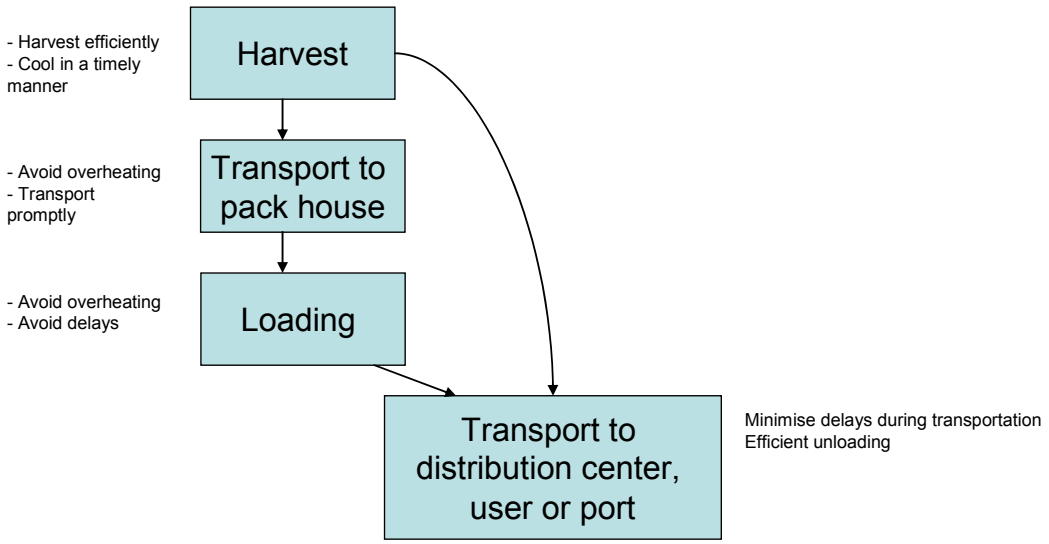
Logistical arrangements in horticultural chains

Horticultural chain management begins on the farm, where proper logistical arrangements are pivotal in assuring timely cooling of produce for quality maintenance. During pack-house operations, care must be taken to assure proper temperature management, proper and appropriate packaging as well as proper labelling in order to assure traceability.

Transportation, whether refrigerated or non-refrigerated, is core to logistical operations in horticultural chains. Efficiency during transportation is critical to assure timely delivery of produce. Transaction delays during transportation must be minimised if efficiency and quality maintenance are to be assured. Care must also be taken to ensure that cargo tracking and tracing is enacted during transportation. On delivery, produce must be transferred rapidly to shaded or temperature-controlled storage areas. Logistical operations in a typical horticultural chain are summarised in figure IX.1.1.

[1] Prepared by R.S. Rolle and L. Korsten.

Figure IX.1.1. Diagram of logistical operations in a horticultural chain



The cold chain

The cold chain is an example of a logistics system for maintaining produce quality from production to consumption. It involves a series of temperature-controlled events from harvesting through handling, storage, transport and distribution.

Efficient transportation of harvested produce from the field to the pack house at the start of the chain is of utmost importance in reducing the risk of damage. On arrival at the pack house, produce should immediately be pre-cooled to remove field heat. Pre-cooling should ensure that produce is not contaminated or vulnerable to the internalisation of pathogenic micro-organisms. Once the core temperature of the produce has been reduced, it can be moved into cold storage; here it will be further cooled to the correct shipment temperature or stored. Lowering the core temperature of the produce is more effective if it is carried out in systematic stages over time. This form of temperature management can reduce temperature and chilling injury effectively, while at the same time extending the shelf life of fresh produce. The temperature of the storage facility must be compatible with the required storage temperatures of the produce.

The cooled produce should be transferred from the holding store to either a refrigerated container or a refrigerated truck, and temperature monitoring and data logging systems for monitoring temperature and traceability of produce must be enabled. Produce must be loaded into the truck or container within a specific time, temperature tolerance (TTT) period in order to ensure that it does not deviate from its designated temperature regimes. The TTT period varies from commodity to commodity, but for most commodities is six hours.

On arrival at its destination, produce must be unloaded and moved rapidly to an appropriate temperature-controlled storage facility.

A diagram of the cold chain for perishables is shown in figure IX.1.2.

Maintaining the integrity of the cold chain

The integrity of the cold chain is dependent on using and maintaining the correct temperature throughout the chain. Optimising temperature throughout the chain necessitates that handlers be aware of temperature requirements of the produce and that produce is appropriately labelled with the correct handling and storage temperature information.

Continual monitoring (measurement and recording) and management of temperature is critical throughout the chain. The use of precision temperature management tools and time-temperature monitors greatly facilitates temperature monitoring during cooling, storage and transport operations. Temperatures can be either measured directly (by contact with the food) or indirectly (measuring the temperature of the environment or between packages). Figure IX.1.2 summarises critical factors for maintaining the cold chain for perishables.

Figure IX.1.2. Maintaining the cold chain for perishables

Harvest	· **Minimise delays before cooling** · **Cool the product thoroughly as soon as possible**
Cooling	· **Store the produce at optimum temperature**
Temporary storage	· **Practice 'first in first out' (FIFO) rotation** · **Ship to market as soon as possible**
Transport to market	· **Use refrigerated loading area** · **Cool truck before loading** · **Load pallets towards the centre of the truck** · **Put insulating plastic strips inside door of refrigerated truck if it is to make multiple stops** · **Avoid delays during transport** · **Monitor product temperature during transport**
Handling at destination	· **Use a refrigerated unloading area** · **Measure produce temperature** · **Move produce quickly to the proper storage area** · **Transport to retail markets or foodservice operations in refrigerated trucks** · **Display at proper temperature range**
Handling at home or foodservice outlet	· **Store produce at proper temperature** · **Use the produce as soon as possible**

REFERENCES

Brennan, P.S. and R.L. Shewfelt (1989) Effect of cooling delay at harvest on broccoli quality during post-harvest storage. *Journal of Food Quality*, 12: pp. 13-22.

Donkin, D.J., T. Mans, J.G.M. Cutting and M.J. Slabbert (1994) Progress report: Cold storage temperature regimes and tolerance of avocado fruit to cold storage. *South African Avocado Growers' Association Research Journal,* 17: pp. 18-20.

Downs, C.G., A.E. Pickering and M. Reihana (1989) Influence of temperature between harvest and storage on the ripening of Packhams triumph pears. *Scientia Horticulturae,* 39: pp. 235-246.

Everett, K.R. and L. Korsten (1998) The effect of six post-harvest temperature regimes on ripe rots of Hass avocado. Proceedings of the New Zealand Plant Protection Society, 51: pp. 112-116.

Faubion, D.F. and A.A. Kader (1997) Influence of place packing or tray packing on the cooling rate of palletised 'Anjou' pears. *Hortechnology,*7: pp. 378-382.

King, G.A., K.G. Henderson and R.E. Lill (1988) Shelf-life of stored asparagus is strongly related to post-harvest accumulated heat units. *Annals of Applied Biology,* 112: pp. 329-336.

Legard, D.E., C.L. Xiao, J.C. Mertely and C.K. Chandler (2001) Management of Botrytis fruit rot in annual winter strawberry using captan, thiram, and iprodione. *Plant Disease,* 85: pp. 3-39.

Nunes, M.C.N., A.M.M.B. Morais, J.K. Brecht and S.A. Sargent (1995) Quality of strawberries after storage is reduced by a short delay to cooling. Harvest and Post-harvest Technologies for Fruits and Vegetables, American Society of Agricultural Engineers 1-95: pp. 15-22.

Toerien, J.C. (1986) Temperature control of avocados for sea export. *South African Avocado Growers' Association Yearbook*, 9: pp. 31-32.

Vorster, L.L., J.C. Toerien and J.J. Bezuidenhout (1990) Temperature management of avocados – an integrated approach. *South African Avocado Growers' Association Yearbook,* 13: p. 43.

Suggested methods of instruction

Lecture, using handouts or visuals to emphasise the importance of logistical arrangements in the maintenance of quality in horticultural supply chains.

Practical exercise

Practical VII.6: Impact of ineffective cold chain management.

Time frame

One hour lecture, including an informal discussion on logistical operations.

SECTION X

INFRASTRUCTURAL SUPPORT SYSTEMS FOR HORTICULTURAL CHAINS

SECTION X

MODULE 1 – TRANSPORT SYSTEMS[1]

Learning outcomes

The learner should:

- Develop an appreciation of key features of systems for transporting horticultural produce

Introduction

Transportation systems are important in moving fresh produce from production areas to distribution points. Transport systems vary from country to country.

Factors that govern the selection of the mode of transportation

The mode of transportation is influenced by:

- The destination of the produce
- The value of the produce
- The degree of perishability
- The volume of produce to be transported
- Recommended storage temperature and relative humidity conditions for the load
- Ambient temperature conditions at origin and destination points
- Time in transit to reach the destination by air, land or sea transport
- Road access
- Freight rates
- Quality of the transportation service

Transport equipment

Equipment used for the transport of fresh produce includes:

- **Refrigerated and non-refrigerated vehicles** – for highway transport
- **Containers** for air, rail and highway transport, and for lift-on/lift-off ocean transport
- **Break bulk refrigerated vessels** – for handling palletised loads in the refrigerated holds of vessels
- **Pallets** – for air cargo and highway transport
- **Horse carts, donkeys**
- **Wheelbarrows and carts** – for transportation over distances of 1-8km

Refrigerated and non-refrigerated vehicles

Refrigerated or non-refrigerated vehicles can be used for the bulk transportation of fresh produce.

[1] Prepared by L. Korsten, D. Sivakumar and R. Rolle.

Non-refrigerated vehicles

Non-refrigerated vehicles must provide sufficient cooling of the produce during transport. The load should be covered with a white/light-coloured canvas to avoid overheating and to allow adequate air circulation throughout the produce.

A truck-ventilating device, such as that shown in figure X.1.1, can be used to facilitate airflow in non-refrigerated trucks. The system shown in figure 1.1 consists of wind catchers and ducts, which are constructed using wooden crates or galvanised iron. The open-ended crates are wired together into a sturdy pattern. Air flows upwards through the load during transport, so avoiding extensive overheating of the produce. Best results can be obtained if produce is transported during the early morning hours before sunrise.

Figure X.1.1. Measures to facilitate ventilation during truck transport of fresh produce

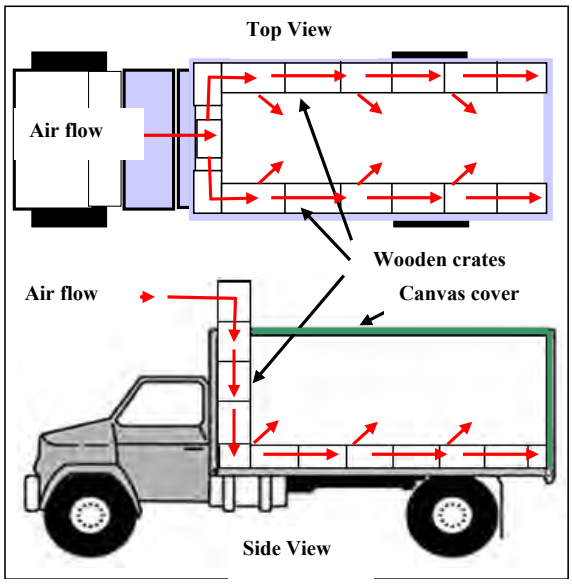
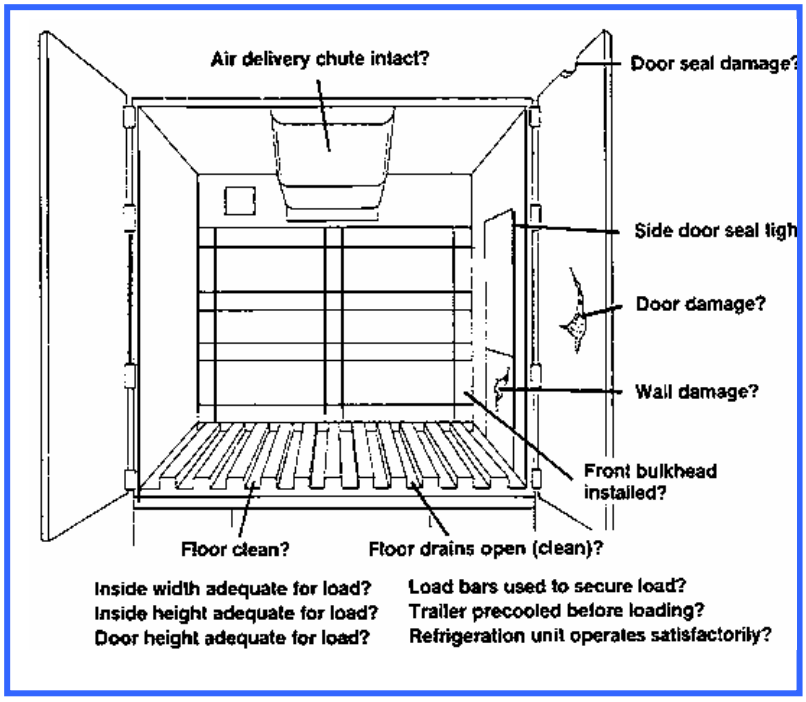


Illustration: Redmond, 2006.

Refrigerated trailers

Refrigerated vehicles/trailers must be properly insulated, have a high-capacity refrigeration unit and fan and an air-delivery duct. The vehicle should be well insulated to maintain a cool environment for pre-cooled commodities and adequately ventilated to allow air movement through the produce. The desired features in a top-air delivery trailer are shown in figure X.1.2, below.

Figure X.1.2. Desired specifications for a top-air delivery trailer



Source: Kasmire and Hinsch, 1987

Containers

Containers are insulated metal boxes that are designed for the transport of large volumes of produce over long distances. They are generally equipped with thermometers and/or data loggers, which measure discharge air temperature at their specific locations and provide performance records of the operation of the refrigeration unit.

Refrigerated containers

Refrigerated or reefer containers are generally equipped with a cooling unit, and require an external source of electricity to power the cooling unit and air circulation fans. Reefer containers are available in both 20-foot (6.1-m) and 40-foot (12.2-m) lengths. The 40-foot reefer container is the most commonly used in the fruit export industry worldwide. The 20-foot container is generally considered a relatively expensive option when compared to the 40-foot container.

Modern containers incorporate microprocessors and computers for controlling the refrigeration system. The 40-foot standard container can usually accommodate 20 ISO (International Organization of Standardisation) pallets, while the 20-footer can accommodate nine pallets.

Porthole containers

Porthole containers are insulated containers in which cold air is supplied by an external cooler at the required temperature. The warm air within the porthole container is extracted from the top of the load. Air flows to and from the porthole container via vents or portholes.

Controlled atmosphere (CA) containers
Controlled atmosphere containers are designed to maintain the composition of the storage atmosphere around fruits within the container (see Section VI.6).

Categories of CA containers:

- **Refrigerated** – here the containers are fitted with special equipment to maintain controlled atmosphere (CA) conditions.
- **Add-on** – here containers have the basic controls fitted in the refrigeration unit, but require the addition of gas and chemicals to establish and maintain CA conditions.
- **Central system containers** – these containers have basic fittings that need to be connected to a central plant on board the ship to establish and maintain CA conditions.

Break bulk refrigerated vessels
Break bulk refrigerated vessels consist of a number of cold rooms, which can accommodate palletised produce. Between 140 and 400 pallets per cold room can be accommodated in break bulk refrigerated vessels.

Palletisation
The palletisation of produce facilitates handling during shipping. Palletisation reduces damage to produce and increases the efficiency of loading and unloading operations. Plastic netting of palletised loads helps in preventing vibration and impact damage to the produce during transit.

REFERENCES

Heap, R., M. Kierstan and G. Ford (1998) *Food transportation*. London, New York: Blackie Academic and Professional.

How, R.B. (1991) *Marketing fresh fruits and vegetables*. New York, USA: Van Nostrand Reinhold.

Kasmire, R.F. and R.T. Hinsch (1987) Maintaining Optimum Transit Temperatures in Refrigerated Truck Shipments of Perishables. University of California: Perishables Handling Transportation Supplement No. 2.

Nicholas, C.J. (1985) Export handbook for US agricultural products. Office of Transportation, Agricultural Handbook No. 593. United States Department of Agriculture (USDA).

Pantastico, E.B. (1980) Food and Agriculture (FAO)/United Nations Environment Programme (UNEP) Expert Consultation on Reduction of Food Losses in Perishable Products of Plant Origin. Working Document 2: Fruits and Vegetables. Rome, Italy: FAO.

Selders, A.W. (1992) Facilities for roadside markets. Northeast Regional Agricultural Engineering Service. USA: Cornell University Cooperative Extension.

Thompson J.F., P. Brecht, T. Hinsch and A. Kader (2000) Marine container transport of chilled perishable produce. Davis, California, USA: University of California, Division of Agriculture and Natural Resources.

USDA (undated) Maintaining product quality during transportation. In Agricultural Export Transportation Handbook. Available at: http://www.ams.usda.gov/TMD/export/maintaing_product_quality.htm [accessed 8 January 2008]

Suggested methods of instruction

Lecture, using handouts or visuals to describe the essential features of transport systems and their hygiene management to assure produce quality maintenance is horticultural supply chains.

Time Frame

One hour lecture, including an informal discussion on transportation systems.

SECTION X

MODULE 2 – PACK HOUSES[1]

Learning outcomes

The learner should:

- Understand the factors that are important in identifying a site for the establishment of a packing house facility
- Appreciate key infrastructural design features of pack houses

Introduction

Pack houses are facilities where fresh produce can be packed according to the customer's needs or can be sorted and separated for fresh marketing, juicing, drying or other processing needs. Pack houses can be located on-farm, and thus managed as part of the commercial farming operation (usually larger commercial operators), or are otherwise owned co-operatively or privately.

Location of a pack house facility

Several critical factors must be taken into account when identifying the site for the establishment of a pack house facility. These include:

- **Location of the pack house** – the pack house must be located in an area with minimal risk of water or air contamination. In this regard, knowledge of the history of the site selected for establishment of the pack house is required.
- **Availability of supporting infrastructure** – electricity (3-phase in commercial pack houses), water and sewage disposal facilities are all critical requirements for commercial pack houses.
- **Accessibility** – The pack house must be: centrally located; close to farms supplying produce; well connected to a road network system; and must provide direct access to nearby ports (sea or air), markets or manufacturing plants.

Factors that influence the size and design of a pack house

The size and design of a pack house and the level and scale of pack house equipment is dependent on the:

- type of produce to be handled;
- volume of produce to be handled;
- market requirements;
- access to and availability of local infrastructure (electricity, potable water, etc.); and
- capital cost.

Infrastructural design and standards for a typical commercial pack house

Pack house surroundings

The pack house must be easily accessible. The area surrounding the pack house should be a prepared surface (concrete or tarmac) with adequate drainage. Adequate space should be

[1] Prepared by L. Korsten.

allowed for turning trucks and to allow effective on- and off-loading of produce. This area must be well maintained in order to prevent rodent pests.

A temporary waste holding area can be marked or built to separate waste from other areas of the pack house premises.

Elements of hygiene design within the pack house

The design of the pack house must integrate consideration for basic food safety requirements.

Floors – should be finished, preferably with an impervious material such as polymer, epoxy resin, and should be safe to walk on when wet. All concrete floors in production areas should be sealed. The floors should be sloped to allow quick water run-off and should have an internal drain. Ideally the floor and wall junctions should be coved to aid cleaning.

Walls – should be free of cavities to prevent debris from lodging and harbouring pests. Walls should be finished to provide easily cleanable surfaces. Painted epoxy coating or sealed sheeting can also be used to line the walls. Walls should be designed so that there are no shelves or other protruding items. Pallets must not be stacked up against the walls in order to minimise the possibility of rodent infestation.

Windows – should keep out insects and birds. Glass should be shatterproof or plastic coated to prevent glass splinters from contaminating the produce if broken. Wood should be avoided in the pack house for similar reasons. The use of stainless steel is recommended.

Window sills and ledges – should be sloped.

Ceilings – should be suspended, to ensure there is no exposed roof structure over the packing area. If the ceiling is not suspended, the roof joints should be cleaned regularly in order to prevent the build-up of dust or dirt, which may contaminate the produce.

Lighting – must be adequate, particularly above grading and sorting areas. All lights must be covered with shatterproof plastic diffuser or sleeve covers.

Doors – (external) must be lockable and kept closed to prevent the entry of pests. Rubber swing doors or overlapping plastic strip curtains can be used in areas where forklifts move frequently; these should be closed at night. Noticeboards should be covered with Perspex sheets (not glass) to prevent pins or other potential contaminants entering the food chain. Noticeboards should not be positioned in the production area.

Pre-cooling facilities – a pre-cooling room should be built close to the unloading area to keep incoming produce and start the removal of field heat. When selecting refrigeration systems, one should take into account the size of the room and the volume of produce that will be stored at any one time.

Cold storage facilities – must be designed with easily cleaned walls and floors.

Worker sanitation facilities – must include:

- An adequate number of toilets – Urinals and toilets should comply with the national legal requirements. The toilet must be ventilated and separated from the packing area by a separate door.

- Hand washing facilities – wash basins must be selected that can be cleaned regularly and will not be broken easily. Preferably, both hot and cold water should be provided. Soap containers, paper towel dispensers and/or hot air blowers should be built into the wall, so that they cannot be removed easily.

Generalised features of floor plan design

The packing house design must include:

- **A receiving area** with space for initial sorting to remove wounded, diseased and unmarketable fruits; this area should be elevated so that the produce can be unloaded easily from the trucks or wagons carrying it from the field;
- **A washing area**, which must include a dump tank for the initial cleaning and cooling of produce and/or a spray washer/brusher;
- **An area for grading and sizing**;
- **Stations for specific post-harvest treatments** – sorting, hyrdocooling, waxing and so on;
- **An area for packing produce**;
- **An area for off-loading produce**;
- **An area for the storage** of empty crates;
- An **administration** office;
- A **reception** area; and
- A small **workshop** for general maintenance (e.g. repair broken of pallets etc.).

The general flow of produce must be well planned to ensure that produce moves through the facility from input, where there can be high levels of contamination, to output, where there should be lower levels of contamination.

REFERENCES

Food and Agriculture Organization (FAO) (1989) Prevention of post-harvest food losses: fruits, vegetables and root crops. A Training Manual. Rome, Italy: FAO.

Reyes, M.U. (ed.) (1988) Design concept and operation of ASEAN packinghouse equipment for fruits and vegetables. Laguna, Philippines: Post-harvest Horticulture Training and Research Centre, University of Los Baños, College of Agriculture.

Shewfelt, R.L. and S.E. Prussia (1993) *Post-harvest handling: A systems approach*. San Diego, USA: Academic Press Inc.

The Trade Chain of the South African Fresh Fruit Export Industry (2004) Production, Book 2 of 9. Newlands, South Africa: Fresh Produce Exporters' Forum.

Suggested methods of instruction

Lecture, using handouts or visuals to emphasise the importance of the location, infrastructural design and hygiene in the pack house.

Practical exercise

Practical exercise III.3: Visit to a pack house.

Time Frame

One-hour lecture.

One day for the practical exercise.

SECTION X

MODULE 3 – COLD STORAGE[1]

Learning outcomes

The learner should:

- Understand the factors that are important in identifying a site for the establishment of a cold storage facility
- Appreciate key infrastructural design features of cold storage facilities

Introduction

The function of a cold store is to warehouse cooled fruit until such time that it is collected for onward shipment. It is important that cold stores are appropriately managed and hygienically maintained.

Location of the cold storage facility

Cold store facilities can be located in commercial pack houses, at produce collection points, trucking stations, dry ports or in close proximity to airports or export harbours. Critical considerations in the selection of the site for a cold storage facility include:

- **Drainage** – A cold storage facility must be in a well-drained area, to allow for removal of condensate;
- **Electricity** – The electricity supply available in the area in which the cool store is constructed will govern the size of the cold storage equipment;
- **Water** – Water of good quality is necessary for washing and sanitising the storage facility; and
- **Wastewater disposal** – Facilities for waste water disposal must be adequate.

Factors that govern the size of the cold storage facility

The size and design of a cold store is dependent upon:

- the volume of produce to be stored;
- the type of produce container to be stored (pallet bins, boxes, bulk containers etc.);
- volume required per container;
- aisle space needed (mechanical or manual operation);
- lateral and head space that is appropriate to the height of the stored produce; and
- available site space.

Key operational features of a cold store

Cold stores should be well insulated, adequately refrigerated and should allow for air circulation to prevent temperature variation. They must be equipped appropriately with thermometers for temperature measurement, thermostats to control the operation of the refrigeration unit and manual temperature controls, which must be periodically checked.

Relative humidity (RH) within the cold store can be controlled using a humidistat and monitored with the use of a recording hygrometer. RH within the cold store can be adjusted by the following suitable methods:

[1] Prepared by L. Korsten, D. Sivakumar and R. Rolle

- attaching humidifiers or humidity-retaining water bags;
- regulating air movement and ventilation in relation to the produce load in the cold store;
- minimising temperature differences between produce in cold storage and during transport or transit; and
- ensuring proper insulation of the cold store.

Settings of the thermostat and the humidistat should be standardised periodically.

Effective hygiene management of cold stores

Growth of fungi such as *Penicillium* spp on the walls, metal and cooling units of cold stores can be problematic, since these fungi can serve as an inoculum source for produce stored in the facility. Cold stores must be hygienically maintained to prevent the build-up of inoculum. Cleaning must be carried out routinely in accordance with a schedule that ensures effective maintenance of basic hygiene. Approved, environmentally-friendly sanitisers can be used to sanitise the cold store; these should be used in accordance with the manufactures instructions. Facial masks must be worn during cleaning as a protective measure since continued exposure to disinfectants and high inoculum levels could lead to respiratory diseases.

REFERENCES

Flores, R.A. and K.L.B. Gast (1992) Storage Construction – Fruits and vegetables. *MF* 1039. Kansas, USA: Cooperative Extension Service, Kansas State University.

Suggested methods of instruction

Lecture, using handouts to emphasise important features of cold storage systems for horticultural produce and hygiene management of such systems.

Practical exercise

Practical exercise III.3: Visit to a pack house.

Time Frame

One-hour lecture, including an informal discussion on cold storage.
One day should be allowed for the practical exercise.

SECTION XI

GOOD PRACTICE FOR QUALITY MAINTENANCE IN SELECTED HORTICULTURAL SUPPLY CHAINS

SECTION XI

MODULE 1 – GOOD PRACTICE IN MANGO SUPPLY CHAINS[1]

GOOD PRACTICE APPROPRIATE FOR SMALL MANGO FARMERS

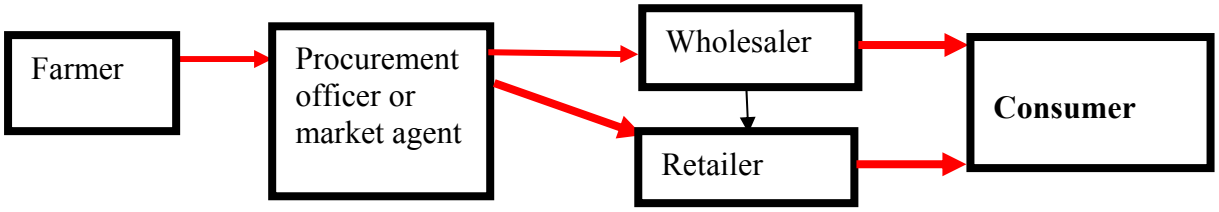
Learning outcomes

The learner should:

- Be able to integrate and apply principles he/she has learnt to the small farmer context

Introduction

Horticultural chain management aims to maintain the quality of produce between harvest and the consumer. It also aims to reduce food losses from the farm gate until the point of consumption and to prevent contamination by food-borne pathogens (food safety) at each step of the chain. Small farmers in many African countries face limitations and constraints in terms of applying the sophisticated technologies adopted in developed countries. These limitations stem from lack of credit for investment in modern, post-harvest technologies, and lack of available transport facilities, cooling facilities, packaging and trained personnel to educate the farmers. In many African countries, market agents or middlemen are responsible for the direct procurement of produce from the farmer before it is moved to the wholesaler or retailer. These agents also derive maximum financial gain, while producers seldom get the same financial reward when compared to their initial input. The supply chain is not always beneficial to the small-scale farmer and the longer the chain, the lower the profit.



Produce losses and poor quality generally result from improper harvesting practices, rough handling, a lack of appropriate packaging materials and inadequate cooling and temperature management.

This section, therefore, aims to introduce good management practices or protocols for the harvesting and post-harvest handling of mangoes, which are appropriate for use by small farmers. These practices can be implemented effectively by educating agricultural extension agents, farmers, agricultural students and all stakeholders within the chain – i.e. collection agents, wholesalers, retailers and the consumer.

Figure XI.1.1. Bagging mangoes

[1] Prepared by D. Sivakumar and L. Korsten.

Pre-harvest handling

The bagging of fruits during fruit maturation helps to assure quality at harvest. Bagging (see figure XI.1.1, above) can also help to reduce the incidence of diseases such mango black spot, which is caused by a bacterial pathogen, and anthracnose, a classical pre-harvest pathogen that causes post-harvest losses. Care should be taken not to enclose the entire fruit as this could provide an opportunity for pest and disease infestation.

Maturity indices

Mangos normally reach maturity within four to five months of flowering. In the mature state, their quality improves as soluble solids content (Brix) increases and acidity (titratable acidity) decreases. When fully-grown and ready for harvesting, the stem of the mango snaps easily with a slight pull. If a strong pull is necessary, the fruit is still somewhat immature and should not be harvested. In the red varieties of mangoes, an additional indication of maturity is the development of a purplish-red blush at the base of the fruit.

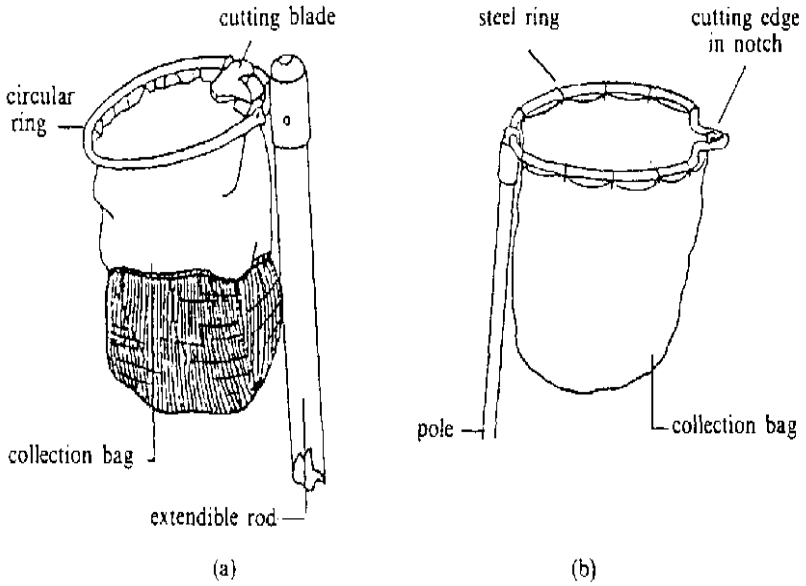
If the market is within close proximity of the field and the pack house, the fruit can be harvested at almost the fully-ripe stage. If fruit are to travel over long distances to be marketed, they must be harvested at the mature stage (see section VI). The advantage of harvesting at the mature stage is that the fruit is firm and is less susceptible to damage during handling and transportation.

Activities in the supply chain

Harvesting

Dropping fruit during harvesting should be avoided as this could cause bruising and eventual spoilage. The use of a long-poled harvesting bag, which holds no more than four fruits, is recommended for harvesting (see figure XI.1.2, below). When low-hanging fruits are harvested with clippers, it is desirable to leave a 10-cm stem to avoid the spurting of milky/ resinous sap. It is recommended that mangoes be placed with the stem-end in a downward position after final clipping in order to prevent leakage of the sap from the stem, since this could burn the fruit and result in black lesions, which in turn may lead to rotting.

Figure XI.1.2 Harvesting bags that include facilities for cutting



Field packing

Harvested mangoes must be protected from direct sunlight. This is achieved by either moving them into a shaded area or by transporting them directly to the field packing shed. Harvested mangoes can also be packed in the field. Prior to packing the fruit, the stem is cut off 6mm from the base of the fruit.

Sorting

Defective fruit, such as mechanically injured fruits, diseased, misshapen fruits or fruits that show signs of insect infestation, must be removed during first stage sorting. At the pack house, fruit must be sorted according to size for different markets.

Ripening

Ethylene treatment (ethral) may be used for colour development of the fruit. With ethylene treatment, mature mangoes at colour break develop full colour within 48 hours depending on the degree of maturity, while untreated fruits require 10 to 15 days for colour development. Other advantages of ethylene treatment are that fewer harvestings are required and the colour of the harvested fruit after treatment is more uniform. Generally, 24 hours of exposure to ethylene is sufficient if the fruits are harvested at the correct stage of maturity.

Packing

In order to avoid excessive heat build-up and consequent spoilage, fruits can be padded with paper shavings and packed in ventilated wooden crates with smooth surfaces for transportation.

Transportation

Mangoes can be transported in either padded wooden or plastic crates. Fruits must either be individually wrapped in newspaper or be padded with paper shavings. Transportation by truck is recommended. The load should be covered with a light coloured canvas and adequate air movement through the canvas must be allowed.

Display at the market
Mangoes must be displayed under shade and protected from cigarette smoke and exhaust fumes to prevent premature ripening.

Maintaining hygiene throughout the mango supply chain
All workers that come into direct contact with mangoes must be trained in, and implement good practice for, the hygienic harvesting and handling of fruit. Adequate potable water should be supplied with soap and a clean towel to ensure that all workers have access to, and understand the importance of, personal hygiene. It remains the responsibility of the farmer to ensure that effective personal hygiene practices are implemented by all involved in harvesting and packing, and that a regular supply of potable water is supplied to workers for drinking and hand washing.

GOOD PRACTICE APPROPRIATE FOR COMMERCIAL MANGO FARMERS

Learning outcomes

The learner should:

- Be able to integrate and apply all information received thus far to a practical situation

Export market trends

The world market demands uniformly-graded mangoes of improved visual appearance, with long storage and shelf lives. A large price difference generally exists between good-, average- and poor-quality mangoes on domestic and export markets. Customers and consumers are increasingly demanding safe, high-quality fruit.

Growers involved in large-scale production and export must focus on quality management throughout the horticultural supply chain. Important factors to be considered include: quality inspections, hygiene management, pesticide residue analysis, standardisation of instruments for temperature recording, maintenance of records and traceability. Large-scale operations generally benefit from investing in costly handling machinery, high-technology post-harvest treatments and reliable cold chain management.

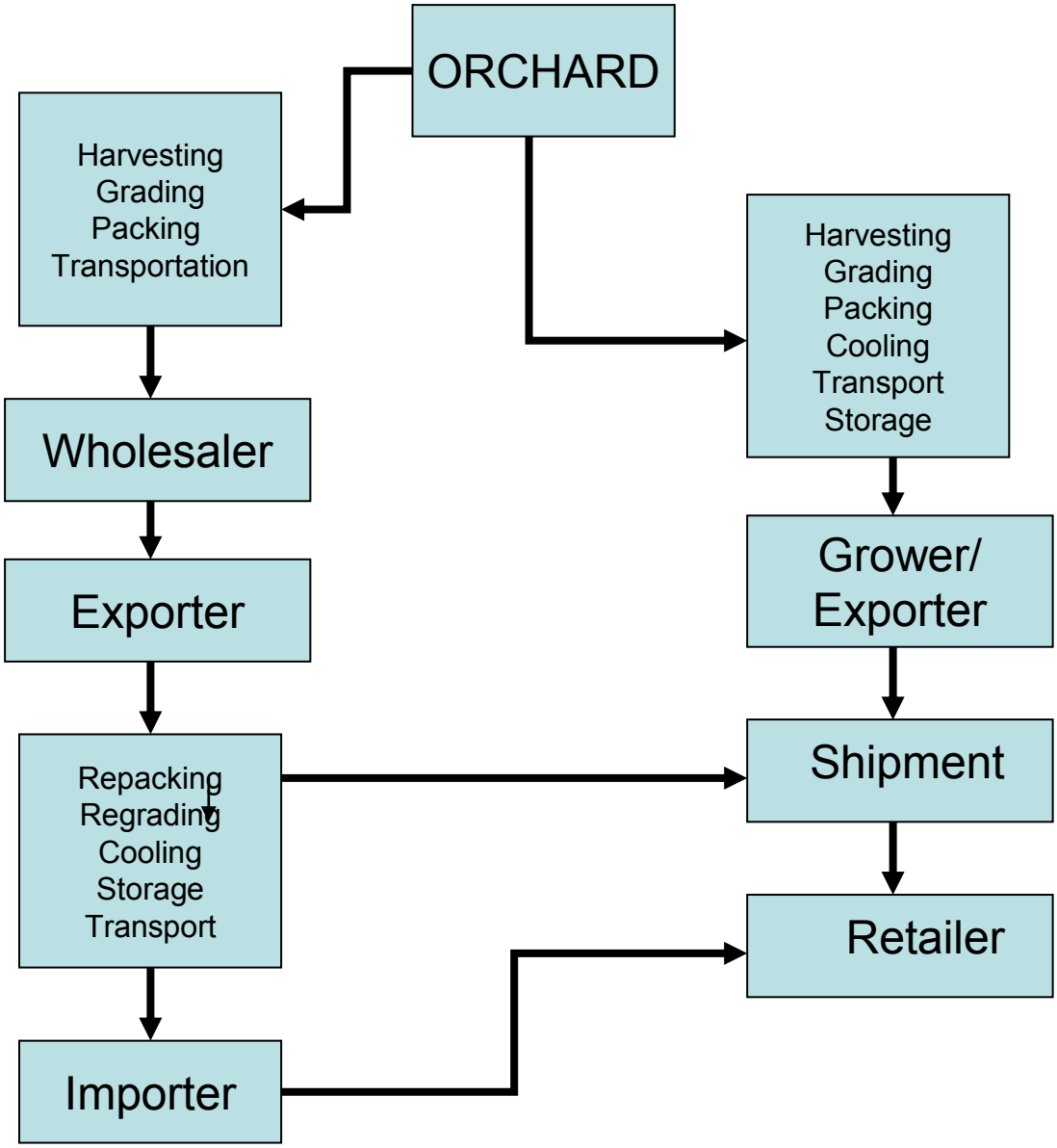
Consumer acceptance of mangoes on the international market is based primarily on size and taste.

Quality criteria for mangoes

Volume sales of mangoes are based on the presence of a red colour, stage of ripeness, uniformity of size grading, uniformity of stages of ripeness and the absence of disease or damage. According to Medlicott (2003), export market requirements dictate that on arrival at their destination mangoes should:

- be physiologically mature;
- be 30 per cent to 50 per cent coloured and have commenced ripening;
- be significantly red in colour at the shoulders;
- be relatively firm and intact;
- be fresh in appearance;
- have a minimum sugar content of 10 per cent;
- be uniform in shape;
- be free from disease, decay, sunscald, cracks, bruises, latex stains, insect and mechanical damage;
- be free from damage due to low temperature storage;
- be free from abnormal external moisture;
- conform to weight and size specifications; and
- be free from any foreign smell and/or taste.

Figure XI.1.3 Activities in the commercial mango supply chain



Assuring quality in the mango supply chain

Careful handling to avoid injury and damage and the observance of good hygiene practices during harvesting and handling operations are pivotal to assuring that quality specifications for mangoes are met. Those involved in harvesting and handling must, therefore, observe the following good practices:

- ensure the use of clean harvesting bags, lug boxes or bins;
- select only mature fruit in order to avoid immature fruit from being picked (this necessitates training harvesters according to criteria for a specific cultivar);
- use appropriate harvesting equipment;
- do not place the fruit on the soil in order to avoid fungal infections;

- place harvested fruit in the shade in order to start the process of removal of field heat; and
- assure good personal hygiene and observe good hygiene practices when harvesting and handling produce.

Maturity indices for mangoes

Harvest maturity for most mango varieties can judged on the basis of the position of the shoulders in relation to the position of the stem. Maturity indices for Julie and Graham mangoes and other varieties, which show similar morphological characteristics, are as follows:

- **Immature:** shoulders below the stem insertion with ridges absent; firm and green.
- **Partially mature**: shoulders in line with the stem, with slightly ridged edges; firm and green.
- **Fully mature:** outgrown shoulders; formation of a depression with ridges at the stem end; firm and green.

Figure XI.1. 4 Stage of maturity for harvesting of mango

Source: Palipane and Rolle, 2006

Harvest maturity for export markets

Ripe fruits are highly susceptible to bruising and mechanical damage during handling and transport. Mangoes that are to be exported by air should be harvested at the physiologically mature, hard, green stage of development. Partially mature or 'half mature' fruits may be included in the shipment, but should not make up more than 25 per cent of the total consignment. Fruit harvested at the ripe stage or fruit having more than 15 per cent yellow colouration, should be removed during field sorting and should not be included in export shipments.

Mangoes that are to be exported by sea should be harvested at the partially mature stage of development. Fruit should not show any signs of softening or de-greening (yellow colour development). Immature fruit should not be shipped.

Activities in the supply chain

Harvesting

Where possible, mangoes should be harvested by hand from the ground, by snapping the mango from the stem. Fruit on any one tree differ in age owing to the fact that flowering and

pollination occur over a period of several weeks. Fruit must, therefore, be harvested from individual trees on several occasions throughout the harvest season.

Fully mature fruit will detach easily, while 'half mature' fruit will not. Optimum harvesting involves cutting the stem 1-2 cm away from the fruit with the use of secateurs. This technique reduces latex exudation and staining and reduces the possibility of fugal infection.

In situations where harvesting by hand from the ground is not possible, harvesting implements should be used. The most suitable is a long pole equipped with a cutting blade and a small bag under the blade to catch the fruit. Alternatively, climbers may use cotton bags that are filled and then lowered to the ground. Mangoes should never be knocked from the tree, dropped or thrown to the ground.

Field handling of harvested mangoes

After harvest, latex should be allowed to drain away from the fruit. Preliminary sorting should be performed in order to separate out immature, undersized, damaged, bruised, scarred or ripe fruit. Fruit should be transferred to plastic field crates. Each crate should be labelled with an orchard reference number in order to facilitate traceability.

Harvested mangoes should not be left in direct sunlight, wind or rain, either in the field or during transport from the field to the packing facility. The time between harvest and delivery to the pack house must not exceed 12 hours.

Delivery of mangoes to the pack house

On arrival at the pack house, the origin of the fruit and orchard reference number must be recorded by pack house staff. Mangoes must be off-loaded gently in order to prevent unnecessary mechanical damage or bruising. Immature, under-sized, damaged, bruised, scarred or ripe fruit must be removed. Fruit must be weighed and the pack out (number or percentage of fruit that are of good marketable quality) determined.

Acceptable fruit should be transferred to a water bath/dump tank containing 100ppm sodium hypochlorite for washing to remove debris and latex stains.

Washing

Water in the wash tank must be changed whenever a high level of organic material builds up. The wash tank must be properly cleaned prior to refilling and the correct concentration of chlorine must be maintained in the water tank at all times.

Treatments for the control of post-harvest diseases

Mangoes must be transferred to a hot water bath (50°C) containing 0.05 per cent thiabendazole (a fungicide), for a minimum of three minutes and a maximum of five minutes. The hot water bath should be cleaned regularly in order to avoid the build up of micro-organisms and fruit sap.

Air-drying

After washing and fungicide treatment, the fruit should be allowed to cool and dry in preparation for grading and packing.

Export grading

Fruit must be checked prior to packing in order to ensure the absence of blemishes, bruises, insect and mechanical damage. Fruits should be graded in accordance with specifications of their variety, size (giving a range of counts for each shipment) and maturity.

Grading must be carried out under sufficient light. Graders should be informed of any expected blemishes and diseases according to the orchard pre-grading report.

Packaging

Mangoes should be packed in single layers in one- or two-piece full-telescopic, self-locking, fibreboard or corrugated cardboard cartons having a bursting strength of 113-125/6.45cm^2. When packed, the fruits should lean to the side rather than directly on the base of the carton. Cartons should be adequately ventilated and should include handle holes to facilitate easy handling. A layer of shredded paper should be placed in the base of the carton in order to assist with cushioning the fruits. Each alternate mango in a carton should be wrapped in tissue or fruits must be confined to separate compartments within the package in order to reduce fruit-to-fruit rubbing. The attachment of small identity labels to alternate fruit will assist in product presentation.

Net weight requirements are 4 to 5kg per carton depending on the carton and the destination market. Cartons must not be over-filled during packing.

Labelling

Labelling requirements for individual markets should be followed. Labels must include an orchard code reference number as well as a packing-house reference number in order to facilitate traceability.

Palletisation

Packaged mangoes must be palletised for sea-shipment.

Cooling

The cooling requirements of mangoes vary in accordance with the cultivar**.** Improper cooling can lead to cold damage or dehydration and will shorten the shelf life.

If mangoes are to be exported within two to three days of harvesting, as occurs in the case of air shipments, then pre-cooling is recommended, but not essential. Mangoes transported by sea should be pre-cooled to a minimum of 12°C prior to loading either into containers or into ship holds. Forced air-cooling is generally used for this purpose. Cooling in temperature-controlled rooms may be slow if stacking and spacing do not allow free and even airflow or if the refrigeration capacity is low. The pulp temperature taken from fruit located at the centre of the pallet should be reduced to within 2°C of the optimum temperature specification within 24 to 34 hours of harvest.

Storage

Mangoes can be stored appropriately at 12°C and 85-95 per cent relative humidity. At storage temperatures below 12°C, unripe mangoes develop chilling injury, which will lead to a drastic reduction in fruit quality and increases spoilage. Fruits to be shipped by airfreight should not be stored for more than three to five days. Fruits to be shipped by sea freight can, however, be stored for longer periods.

Fully mature fruits show reduced storage capacity when compared to half-mature fruits, and this becomes more important as the season progresses. Strict quality control of fruit maintained under low-temperature storage conditions is essential as blemishes, bruises, damage and infections will manifest to a greater degree under such conditions.

Storage life of mangoes

Mangoes can be stored successfully for up to three weeks after harvest, if they have been harvested at the appropriate stage of maturity with proper post-harvest handling and storage.

The ideal time frame between harvest and consumption should be between 27 and 39 days. A profile of the time frame between harvest and consumption is shown in table XI.1.1.

Table XI.1.1. Recommended time frame between harvesting and sale of mangoes

Treatment	Recommended time (days)
Harvesting and packing	1
Cooling	1
Transport and holding	3-5
Sea shipment	16-18
Importer holding	2-4
Supermarket	3-5
Consumer	1-5
Total time	27-39

Ripening

Optimum temperature conditions for the ripening of mangoes vary according to variety and origin, although a temperature range of 20° to 25°C is usually appropriate. Higher temperatures (25° to 30°C) may result in off-flavour development and mottling of the peel. Initiation and synchronisation of ripening and shortening of the ripening period of mangoes can be achieved through direct exposure to ethylene gas.

Ethylene treatment is carried out in an airtight room over 24 hours at temperatures ranging between 20°C and 25°C and relative humidities ranging between 90 and 95 per cent. Ethylene concentrations ranging between 10 and 100ppm (0.001-0.01 per cent) should be applied. Air circulation should be adequate in order to enable uniform distribution of gas throughout the room. Carbon dioxide build-up must be avoided as this reduces the effect of ethylene and will have a detrimental effect on fruit ripening. Under optimum conditions, the air should be changed on a regular basis (once every four hours) and ethylene reapplied.

Shipping

For air-shipments it is preferable, although not essential, that produce be transported on aircraft pallets rather than in containers. Shipment in aircraft containers may result in the build-up of heat and ethylene, both of which can accelerate the ripening process. For sea shipments, efficient reefer (refrigerated) containers should be used in preference to break bulk systems in the hold. Stacking systems should allow for sufficient ventilation to assist in temperature maintenance.

Handling in the importer's market

Unripe mangoes are susceptible to chilling injury below temperatures of 12°C and will not ripen normally. Mangoes should be stored in importing countries at 12°C to 14°C. Unripe fruit can be ripened by storage at 18-25°C and treated with ethylene gas at 100ppm (0.01 per cent) for 24 hours. Systems used for the ripening of bananas can also be used for mangoes. Ripened mangoes produce ethylene and should be kept separate from ethylene-sensitive commodities.

Potential causes of loss in the mango supply chain

Mechanical damage

Mechanically-damaged fruit will normally deteriorate rapidly and should not be exported. Damaged fruit are susceptible to microbial infection, particularly under conditions of low temperature and long-term storage. Mangoes should be handled carefully during harvesting and other handling operations such as grading, packing and transportation.

Chilling injury

Storage at temperatures below 12°C will result in chilling injury, the symptoms of which include inhibition of ripening, pitting, internal discolouration, grey scald-like discolouration of the skin, increased water loss, increased susceptibility to decay and detrimental changes in flavour.

Jelly seed

Jelly seed is usually found only when the fruit is sliced. Affected fruit show watery, translucent tissue around the stone toward the stem-end, which then spreads. This condition occurs in harvested fruit, but develops as the fruit ripen. The only means of control at present is early harvesting, although this could result in the export of immature fruit.

Soft-nose

Softening of tissue at the apex of the fruit is referred to as soft-nose. Flesh appears over-ripe and may discolour and become spongy. This disorder may be related to calcium deficiency.

Fruit fly infestation

Fruit fly restrictions are imposed on mangoes that enter the USA and the UK. Fruit flies must, therefore, be controlled in the orchards.

Pathological disorders

- **Anthracnose.** Caused by *Colletotrichum gloeosporioides*, this disorder begins as a latent infection in unripe fruit and develops when the mangoes begin to ripen. Lesions may remain limited to the skin or may invade and darken the flesh.

- **Diplodia stem-end rot.** Caused by *Lasiodiplodia theobromae*, this disorder affects mechanically-injured areas on the stem or skin. The fungus grows from the pedicel into a circular black lesion around the pedicel.

- **Soft brown rot or stem-end rot**. Caused by *Botryosphaeria spp*, this is a typical example of an endophytic pathogen that invades the fruit during development and results in symptom expression at harvest.

REFERENCES

A manual of post-harvest handling systems for perishable food crops, No. 001 (1986). Mango, Ministry of Agriculture. Lands and Food Production, and UCA, Trinidad and Tobago.

Kader, A.A. (undated) Mango facts. Davis, University of California: Postharvest Technology Research Information Center.

Medlicott, A. (2003) as cited at http://www.agribusinessonline.com/crops/mangophh.asp [accessed 8 January 2008]

Pakistan Export Development board (2005) Mango marketing strategy. Available at: http://www.phdeb.org.pk/MktStrategies/Mango.pdf [accessed 8 January 2008]

Recommended Procedures for the Export of Mangoes by Sea (2005). Doc No HP 21. PPECB, South Africa. Available at: http://www.ppecb.com/NR/rdonlyres/27377F02-0A0E-4B6B-9FC9-4CCAC23AD5D7/748/HP21Recommendedhandlingproceduresforexportofmangoe.doc [accessed 8 January 2008]

Palipane, K. and Rolle, R.S, (2006). Good Practice for the Post Harvest Handling of Tree Fruit Crops in Jamaica: A Training Resource. FAO of the U.N., Rome, Italy (in press).

Suggested methods of instruction

Lecture, using handouts.

Time frame

One-hour lecture.

SECTION XI

MODULE 2 – GOOD PRACTICE IN SWEET PEPPER SUPPLY CHAINS[1]

GOOD PRACTICE APPROPRIATE FOR SMALL FARMERS

Learning outcomes

The learner should:

- Be able to integrate and apply post-harvest handling activities to a practical situation

Introduction

Sweet peppers belong to the *Solanaceae* (nightshade) family. Although the fruit of the sweet pepper plant are referred to colloquially as pods, they are actually berries. Sweet pepper varieties differ greatly in colour, shape and size. Sweet peppers are often green or red in colour, although yellow, white, purple and black varieties exist. Green and red sweet peppers are of one and the same variety, the difference in colour being due to different harvest times. Green sweet peppers are not fully mature and although they continue to ripen during storage, they do not turn red, unlike peppers that have been left to mature fully on the plant.

Maturity indices

Sweet peppers mature through three distinct stages during development, namely: immature green, mature green and mature red. As peppers progress from the immature green to the mature green stage of maturity, pepper fruit increase in firmness and pungency and the cell walls thicken. Sweet peppers are generally harvested at the red colour stage. Peppers having traces of green colour are often unacceptable for marketing. The change in colour from green to red can be accelerated through the foliar application of ethephon once colour development has been initiated on the plant. A long growing season is required in order to allow sweet peppers to turn red naturally on the plant.

Activities in the supply chain

Harvesting

It is highly recommended that harvesters wear clean cotton gloves to avoid bruising and damage to the surface of the pepper. If harvesting is done with bare hands, the nails of the harvester must be clean and cut in order to prevent damage to the outer surface of the pepper during handling and harvesting.

Hand clippers or pruners should be used to cut peppers from the plant in order to avoid excessive stem breakage. Peppers should be harvested during the early morning when the air temperature is low.

[1] Prepared by D. Sivakumar and L. Korsten.

Post-harvest handling
Harvested peppers must be collected in shallow boxes, with care taken to avoid bruising and overfilling of boxes. The harvested peppers must be moved promptly to a shaded area. They must be not handled together with commodities that generate large quantities of ethylene.

Packing
Field packing of peppers is recommended for small-scale farmers. Peppers should be packed in shallow boxes with vents. Shredded paper can be used to prevent damage due to bruising during transportation. Peppers can also be packed in two layers, with a lining paper separating the two layers.

Storage
Peppers should be stored for no more than two or three days. If evaporative cooling structures are used for the storage of peppers, care must be taken to store the peppers separately from ethylene-producing commodities.

GOOD PRACTICE APPROPRIATE FOR COMMERCIAL PEPPER FARMERS

Learning outcomes

The learner will:

- Be able to integrate and apply all information received thus far to a practical situation

Introduction

Sweet peppers are highly susceptible to water loss, sunscald and heat damage in the post-harvest state. These problems are likely to occur if harvested peppers are allowed to sit for more than an hour in direct sunlight. Harvested peppers should, therefore, be immediately transferred to shade and cooled within a short time frame.

Field packing of peppers is generally preferred in that it limits handling and therefore reduces mechanical damage. A portable refrigeration unit or a nearby cooling facility is, however, required for the rapid removal of field heat.

Activities in the supply chain

Harvesting

Peppers should be selected on the basis of uniformity of maturity, colour, shape, size and for freedom from defects. Any pepper showing signs of sunscald, mechanical or insect damage, or disease should be discarded**.**

Post-harvest handling

Harvested peppers must be washed with water containing 75-100ppm chlorine. Excessive water should be removed. Peppers should be pre-cooled using either room cooling or forced air-cooling.

Storage

Freshly harvested peppers must be stored at 7 to 10°C and 95 per cent relative humidity. The typical storage life of peppers under these conditions is three to five weeks. Storage life is limited by moisture loss. Peppers are sensitive to chilling injury when exposed to temperatures below 7°C. Symptoms of chilling injury include pitting and water-soaking of the tissue. The rate of deterioration increases with exposure to ethylene.

Controlled atmosphere storage (see table XI.2.1) increases the shelf life of sweet peppers.

Table XI.2.1 Controlled atmosphere storage conditions for peppers

Temperature	Relative humidity	O_2	CO_2	Suitability for controlled atmosphere
7.2-10°C	90-95%	3-5%	0-3%	Moderate

Ripening
Peppers are ripened by spraying the harvested fruit with ethylene. This method is not always successful, given that peppers vary in their ability to change colour from green to red once detached from the parent plant. Application of 100ppm ethylene followed by storage for three days at 20-25°C and 85-90 per cent relative humidity can improve colour.

Packaging
Sweet peppers are packaged in crates, fruit crates or cartons that hold approximately 5-6kg. They are often sold loose or in nets. Wrapping in perforated plastic film has proven effective in minimising weight loss, as sweet peppers easily become shrivelled and shrink.

Transport
Peppers must be transported in either a refrigerated container equipped with a fresh air supply or under conditions of controlled atmosphere storage (see table 1.1).

Cargo handling
Since sweet peppers are highly sensitive to impact, they must be handled with appropriate care. The required refrigeration temperature must always be maintained between 7-10°C even during cargo handling. In damp weather (rain), the cargo must be protected from moisture, otherwise there is a risk of premature spoilage.

Potential causes of loss in the sweet pepper supply chain
Storage diseases
Alternaria and *Botrytis* rots are the major post-harvest diseases of peppers. *Phytophthora* rots can also occur if the pepper fruit are exposed to prolonged periods of heavy rainfall. Fruit infected by *Phytophthora* have water-soaked lesions.

Fungal rots can be controlled by cooling harvested fruit promptly, avoiding bruising and injury and through post-harvest hot water dips at 52-55°C for two minutes.

Shrinkage
A weight loss of between 2 and 3 per cent can occur in sweet peppers, leading to a rapid onset of shrivelling and shrinkage.

Mechanical influence
Because of their high impact- and pressure-sensitivity, sweet peppers must be treated with great care during cargo handling, transport and storage, since they may otherwise undergo premature spoilage.

Contamination
Sweet peppers are sensitive to dirt, fats and oils. The holds or containers used for the transportation of sweet peppers must therefore be clean and in a thoroughly hygienic condition before loading.

REFERENCES

Biles, C.L., M.M. Wall, and K. Blackstone (1993) Morphological and physiological changes during maturation of new Mexican type peppers. *Journal of American Society of Horticulture Science,* 118: pp. 476-480.

Cantliffe, D.J. and P. Goodwin (1975) Red colour enhancement of pepper fruits by multiple applications of ethephon. *Journal of the American Society of Horticulture Science,* 100: pp. 157-161.

Lockwood, D. and H.M. Vines (1972) Red colour enhancement of pimiento peppers with (2-Chloroethyl) phosphonic acid. *Journal of the American Society of Horticulture Science* 97: pp. 192-197.

Suggested methods of instruction

Lecture using handouts.

Time Frame

One-hour lecture.

APPENDICES

Appendix 1

1. IMPORTANT INTERNATIONAL BODIES IN GLOBAL TRADE[1]

United Nations
The forerunner to the United Nations (UN) was the League of Nations, which was established during the First World War and disbanded at the onset of the Second. During 1945, 50 countries met in the United States to draw up the United Nations Charter, which resulted in the establishment of the UN in the same year. Its purpose was to promote peace and co-operation between nations (www.un.org [accessed 8 January 2008]), and today the UN counts 151 countries among its members. Over the past 57 years, the UN has expanded and currently encompasses six principal organs, 15 agencies and several agencies and bodies. Some of these agencies or bodies are involved in food safety directly. A number of specialised agencies of the UN are involved in activities related to food. These include the Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO), International Maritime Organization (IMO) and the International Fund for Agricultural Development (IFAD).

World Trade Organization
The World Trade Organization (WTO) was established in 1995 as a result of the Uruguay Round of negotiations (http://www.wto.org). The most important functions of the WTO include:

- providing a forum for multilateral trade negotiations;
- contributing to the transparency of national trade policies;
- administering and implementing multilateral trade agreements; and
- seeking to resolve trade disputes.

Agreement on the application of sanitary and phytosanitary standards (SPS) is the most important agreement on food safety. It deals with measures that can either directly or indirectly impact on international trade and sets out rights and obligations for food safety and animal and plant health standards (as applicable to signatory countries). Of importance is the fact that the SPS agreement also addresses equivalency between control systems used by various countries. Although it does not have a mandate to develop food safety standards, the WTO places emphasis on the use of food safety measures to avoid their use as unjustified or disguised barriers to trade.

Food and Agriculture Organization of the United Nations
The Food and Agriculture Organization of the United Nations (FAO) was founded in 1945 with a mandate to raise levels of nutrition and standards of living, agricultural productivity and to better the conditions of the rural poor (http://www.fao.org [accessed 8 January 2008]). FAO is the largest specialised agency in the United Nations and the leading body for agriculture, forestry, fisheries and rural development in the world. FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and to debate policies. The Organization is also a source of knowledge and information (see website). FAO's headquarters is located in Rome, Italy, with regional offices in Ghana, Chile, Thailand and Egypt.

[1] Prepared by L. Korsten.

World Health Organization

The World Heath Organization (WHO) – http://www.who.int/about/overview – was founded in 1948. Prior to this, several international health organisations were in existence. These included: the International d'Hygiene Publique (OIHP), operational since 1907; the League of Nations Health Organization, created after the First World War; the Health Division of the United Nations Relief and Rehabilitation Administration (UNRRA), which dealt with health activities in the aftermath of the Second World War; and regional organisations such as the Pan American Sanitary Bureau and the Egyptian Sanitary, Maritime and Quarantine Board. During the 1945 United Nations Conference on International Organizations held in San Francisco, the decision was made to merge all the separate health organisations into a single entity (World Health Forum, 1988). The WHO defined health as: 'a State of complete physical, mental and social well-being and not merely an absence of disease and infirmity'. Basic principles were identified for happiness, harmonious relations and security for all people. The main responsibilities of the WHO include human health and, in particular, a mandate to establish food standards.

Codex Alimentarius Commission

The Codex Alimentarius Commission (CAC) was established in 1962 following a resolution passed by the 11th Session of the FAO Conference and the 16th World Health Assembly (http://www.codexalimentarius.net [accessed 8 January 2008]). These two bodies adopted statutes and rules of procedure for the commission, which manages the joint FAO/WHO Food Standards Programme. The main objectives of Codex are to:

- protect the health of the consumer; and
- facilitate international trade in food.

The Codex Alimentarius comprises international standards for fresh, processed or semi-processed food. Codex Standards are not compulsory, but provide a government-to-government platform for international harmonised rules and guidelines and can be used as a reference point for WTO arbitration activities. The standards, codes, guidelines and recommendations address safety and quality of food exchanged in international trade. Some important aspects addressed by Codex on food safety include:

- food standards for various commodities;
- hygiene practices;
- pesticide evaluation and residue limits;
- veterinary drugs; and
- guidelines for contaminants.

The establishment in 1962 of the Joint FAO/WHO Food Standards Programme took place as a result of a worldwide recognition of the importance of international trade and the need to facilitate such trade, while at the same time ensuring the quality and safety of food for consumers. The FAO/WHO Codex Alimentarius Commission, which is the body charged with the implementation of this programme, was instituted simultaneously. With the signing of the Marrakech Agreement, the CAC was recognised as the international norm to be applied in the case of *inter alia* international trade disputes relating to product standards. Codex Alimentarius appointed a number of expert committees to assess various food hazards. Governments of Codex member countries must standardise their safety requirements in line with Codex directives. The CAC meets on a biennial basis and works through its secretariat in Rome at FAO Headquarters. The Commission sets up general subject and commodity committees or task forces, and then identifies the need for standards and arranges drafting. Specialist groups are requested to draft a standard following eight steps. During this

procedure, the standard is reviewed twice by the CAC and twice by governments and subsequently by interested groups. South Africa currently has a National Codex Committee (NCC) organised under the auspices of the Department of Health, Directorate: Food Control with representatives from the South African Bureau of Standards (SABS), Agriculture, Foreign Affairs, Trade and Industry and the National Consumers Forum.

International Plant Protection Convention

The International Plant Protection Convention (IPPC) was established in 1952 to ensure that international sanitary and phytosanitary standards (SPS) are adopted. The purpose of the IPPC is to set phytosanitary standards and to harmonise measures that might affect trade. It also aims to prevent the spread and introduction of plant pests and diseases, and to promote effective control measures. In addition, it requires member countries to establish appropriate checks and balances and certification schemes and disinfection systems. This international treaty requires the safety of imports and exports of plants and plant products that are likely to contain pests or diseases. As of 2007, eight SPS standards had been adopted.

European Union

The European Parliament (EP) is directly elected by members of the European Community (EC). The Amsterdam Treaty has given the EP increased decision-making powers, particularly in relation to health and consumer protection. The Council of the European Union (Council) is the Community's legislative body. It exercises its legislative power in collaboration with the EP. It represents the member states and their views and is designed to find common ground among them. The Council can only act on the basis of a proposal submitted by the Commission and may confer implementing powers on the Commission. The European Commission is the European Union's (EU) executive body and the guardian of its treaties. It represents the general interests of the EU. It proposes Community legislation, monitors compliance with legislation and with treaties and administers common policies.

The powers of the Commission for implementation of legislation are exercised through specialised committees comprising representatives from member states. Four of these Committees deal specifically with food safety (Veterinary, Food, Animal Nutrition and Plant Health). The Commission can institute legal proceedings against member states or businesses that fail to comply with European law and, as a last resort, can bring them before the European Court of Justice. The Court of Justice is the judicial body of the Union. Its responsibility is to ensure that Community legislation is interpreted and applied correctly. At the time the European Community was established, each member state had its own food safety legislation. This created many potential barriers to trade within the Community, as each country wanted to be sure that the others met its national standards. This led to a gradual process of harmonisation of EC legislation to facilitate free trade. The single market also stimulated a change of perspective, from simple harmonisation to the objective of a high standard in health.

The European Parliament and the Council of the European Union established the European Community with Articles 37, 95, 133 and 152 (4)(b) relating to general principles and requirements of food law. They also established the European Food Safety Authority (EFSA), which addresses principles of transparency, general obligations of food trade, rapid alert systems, crisis management and emergencies. The EFSA was officially adopted on 21 January 2002, when the European Council of Ministers adopted the key legislation providing the legal basis for establishment of the EFSA and a new framework for EU law. The primary objective of EFSA is to provide independent scientific advice to support EU action on food safety.

Appendix 2

2. MAXIMUM RESIDUE LIMITS[1]

Maximum residue levels

The primary purpose of setting maximum limits for pesticide residues in or on food, and in some cases in animal feeds, is to protect the health of the consumer. Codex maximum residue limits (MRLs) are recommended on the basis of appropriate residue data obtained from supervised trials. These data may vary considerably from region to region owing to differences in local pest control requirements. Consequently, residues in food, particularly at a point close to harvest, may also vary. As far as possible, when establishing Codex MRLs, these variations in residues – which result from differences in Good Agricultural Practices – are taken into consideration on the basis of available data.

Variable MRL levels are a particular problem in the European Union (EU) where countries have different MRL requirements. This makes it extremely difficult for exporters, who must ensure they adhere to the MRLs of the receiving and destination countries. Exporters must, therefore, ensure they have the most recent list of MRLs prior to exporting.

Codex extraneous maximum residue limits

The Codex extraneous maximum residue limit (EMRL) refers to residues of compounds that were previously used as pesticides, but are no longer registered; such residues may arise from environmental contamination (including former agricultural use of pesticides) or from the use of these compounds other than for agricultural purposes. These residues are treated as contaminants. Recommendations of EMRLs are based primarily on residue data obtained from national food control or monitoring activities. Codex EMRLs must cover widely varying residue levels in food, reflecting differing situations with respect to contamination of food by environmental and persistent pesticide residues. For this reason, Codex EMRLs cannot always strictly reflect the actual local residue situation in given countries or regions. Codex EMRLs represent acceptable residue levels that are intended to facilitate international trade in food, while at the same time protecting the health of the consumer. They are established only when there is supporting evidence concerning human safety in relation to residues as determined by the Joint FAO/WHO Meeting on Pesticide Residues.

Codex maximum residue limits/extraneous maximum residue limits and consumer protection

Codex MRLs and EMRLs help to ensure that only the minimum amount of pesticide is applied to food, consistent with actual pest control needs. Codex MRLs are based on residue data from supervised trials and are not directly derived from 'acceptable daily intakes' (ADIs) ADI is a quantitative expression of acceptable daily amounts of a residue a person may ingest on a long-term basis (as established from appropriate toxicological data from animal studies). The acceptability of Codex MRLs is judged on the basis of a comparison of the acceptable daily intake with estimated daily intakes, as determined on the basis of suitable intake studies. Intake data from such studies, when compared with acceptable daily intake, help in determining the safety of foods with respect to pesticide residues. Guidelines for predicting dietary intake of pesticide residues were published in 1989 under the joint sponsorship of FAO, UNEP and WHO. The Guidelines have since been revised with the objective of obtaining more realistic estimates than those derived using the existing Guidelines.

[1] Prepared by L. Korsten.

Appendix 3

3. VOLUNTARY STANDARDS, SCHEMES AND CODES[1]

Introduction

The multiplication of new or own voluntary standards has become one of the most serious concerns for all role players in supply chain. While these standards or schemes differ in terms of specific technical issues or themes, they inherently focus on safer food production and good agricultural practices. Several international initiatives have been established to address the multiplication of standards and to establish benchmarking schemes. A number of initiatives, designed to support small-scale farmers in developing countries, play a crucial role in providing technical and training support for the implementation of some of these standards, schemes or codes. Some of these initiatives are discussed briefly in this section.

Organic standards

The demand for organic produce has soared in recent years. This demand is driven by the fear of unsafe and ecologically unsound production systems, and their negative effects on nature and human health. Growth in organic food sales has provided producers and marketing agents with an opportunity to differentiate and add value to their produce. The world's largest organic markets reside in the European Union and in North America, where consumers are willing to pay premium prices for food they perceive as being 'safer and more natural'.

According to the International Federation of Organic Agriculture Movements (IFOAM), organic agriculture includes all systems that promote environmentally, socially and economically sound production of food and fibre.

Since the late 1990s, the production and marketing of organic produce in Africa has been supported by the Export Promotion of Organic Products from Africa (EPOPA) programme. EPOPA has assisted exporters with technical assistance, training, certification, market surveys and buyer contacts. EPOPA has also supported the development of national organic standards, based on IFOAM standards.

Organic foods are produced on farms using traditional land husbandry practices, linked with natural biological and manual methods to grow and protect the crop without any synthetic inputs. With growing international moves towards organic certification, producers are forced to comply with one of the many organic private standards or legal requirements based on Codex. Small-scale farmers are required to provide reliable evidence of certification and to ensure that produce maintains its 'organic' status further down the chain. Specific post-harvest treatments, storage and distribution systems are required for organic certification. The export of organic produce from African countries is largely driven by commercial producers, who also drive the certification process and provide the technical know-how to access this emerging niche market.

In the global trade environment, where the focus has moved almost entirely towards product safety and environmental sustainability, any management system that supports basic 'good agricultural practices' will be in demand and will thus ensure market acceptance.

[1] Prepared by L. Korsten.

Ethical trade

Ethical trade covers the assurance of good labour practices and environmental standards in export production, within all developed and developing countries. Several 'Fair Trade'-assigned organisations are negotiating with African producers to market their fresh produce abroad under the Fair Trade banner. These selected niche markets are gaining popularity as a viable alternative for disadvantaged producers.

The aim of Fair Trade labelling is to bring development opportunities to socially disadvantaged producers and workers by giving their producer organisations access to markets under controlled, fair trading conditions. Social development encompasses protection of the natural environment and encourages producers to protect the environment and seek additional ecological certification. Demand for the produce item is also important.

Producer organisations applying for certification must have established systems that bring the benefits of Fair Trade to disadvantaged producers and/or workers engaged in the production or processing of the Fair Trade produce. When a producer organisation applies for registration, the accredited certification body will first determine who is benefiting in the organisation. Beneficiaries can include disadvantaged workers and/or independent producers who are usually members of a co-operative or association.

Produce grown under the Fair Trade label must comply with internationally recognised standards and conventions and must meet export quality requirements. Producer organisations must abide by national legislation regarding protection of the environment. Furthermore, producers must implement a system of integrated crop management, with the aim of establishing a balance between environmental conservation and business results. The Fair Trade premium can be used to further reduce impact on the environment and encourage producers to work towards organic certification.

Harmonised Generic Framework for African Codes of Practice for the Horticultural Sector (COLEACP)

Several codes have been, or are being developed, under separate initiatives by respective export trade associations in East and Southern African countries. However, the use of several African codes, all having different standards, risks undermining the position of African exports in European markets by creating confusion in the marketplace. In order to improve market recognition of African produce, and to respond to the market demands for environmentally and socially responsible conditions of production, COLEACP took the initiative to encourage horticultural export associations from Eastern and Southern African countries to move toward harmonisation of their codes of practice.

During a meeting in November 1999, a harmonised framework was developed that has since been evaluated on a yearly basis. Specific objectives and core criteria of this framework include:

- That the welfare of workers and outsourcers be ensured (via fair remuneration, fair labour conditions, no exploitation of minors and fair purchasing policies for producers/outgrowers);
- That workers' occupational health and safety be ensured (by preventing risks and providing adequate provision of health services);
- Control and reduction of environmental degradation from agro-chemical use (via reducing quantity used, its safe transport, usage, storage and disposal, along with minimising or avoiding environmental contamination);
- Safeguarding soil, water and air (through sustainable water resource and land-use management, soil conservation, management of hazardous waste, reduction in non-renewal energy resources and use of environmentally-friendly packaging); and

- Safeguarding consumer health (via due diligence in crop production and pesticide use, safeguarding produce from contamination throughout the chain, identification and control of hazards, assurance of workers' personal hygiene, effective temperature management to prevent spoilage and ensuring that packaging material is not a source of contamination).

Distributors' own brands and contracts

Distributor brand products, also referred to as 'own label' products, are produced by third-party packers in accordance with very specific standards. The majority of the brand owners conduct technical audits of their suppliers at regular intervals and/or use third-party auditors for this purpose.

African producers who supply international supermarket and retailer groups (such as, Tesco and Euro Retailer Group), must also adhere to internal codes of conduct or good agricultural practices as stipulated by these customers. The codes of conduct and quality prerequisites prescribed by these supermarket and retailer groups are typically more stringent than minimum standards required by European Union and United Kingdom legislation.

REFERENCES

Barrientos, S., S. McClenaghan and L. Orton (1999) *Gender and Codes of Conduct: A case study from horticulture in South Africa*. UK, London: Department of International Development (DFID).

Eksteen, H.C. (1995) Sustainable organic farming in Africa. Available at: http://www.ifoam.org/organic_facts/food/pdfs/Sustainable_ Farming_South_Africa.pdf [accessed 8 January 2008]

Mursal, A., A.N. Osman, T. Nielsen and P.M. Smith (2004) Organic farming in East Africa: the potential for small farmers. Available at: http://www.kursus.kvl.dk/shares/methods/400_projects/ [accessed 8 January 2008]

Perkins, J.H. and R. Garcia (1999) Social and economic factors affecting research and implementation of biological control. In T.S. Bellows and T.W. Fisher (ed.), chapter 40, *Handbook of Biological Control: Principles and applications of biological control*. San Diego, California: Academic Press.

Robinson, M. (2005) Africa Needs Fair Trade, Not Charity. YaleGlobal, 23 August 2005. Available at: http://yaleglobal.yale.edu/display.article?id=6210 [accessed 8 January 2008]

Satin, M. (1999) Food Quality and International Trade. Available at: http://www.fao.org/ag/ags/agsi/gtz/5Fhtml.htm

Van Bruggen, A.H.C. (1995) Plant disease severity in high-input compared to reduced-input and organic farming systems. *Plant Disease,* 79: pp. 976-983.

Useful websites

http://www.coopamerica.org/programs/fairtrade/ [accessed 8 January 2008]

http://www.fairtradefederation.org/mft.html

http://www.fairtraderesource.org/faqs.html [accessed 8 January 2008]

http://www.fairtrade.org.uk/about_faq.htm [accessed 8 January 2008]

http://www.foodnet.cgiar.org/about/Proposal.PDF [accessed 8 January 2008]

http://www.newint.org/issue322/contents.htm [accessed 8 January 2008]

Horticultural Chain Management for Eastern and Southern Africa is a two-volume work designed to help trainers develop suitable materials to assist small farmers and producers to supply high quality horticultural produce for sale.

This *Theoretical Manual* takes trainers through a step by step approach of progressive learning. It provides the trainer with a platform of information that can be used to design and tailor-make courses applicable to the context in their respective countries. Each section is concisely presented in a modular format and is followed by or linked to a practical exercise. On completion of each section, participants are required to share information assimilated during a plenary discussion session. Participants must also apply the knowledge acquired through practical experiments or tasks.

Throughout the theoretical manual, references have been listed that provide additional sources of information. Trainers should consult new information to ensure that they stay up to date with the latest trends and continuously improve and adapt the training materials. Many of the web resources cited are continuously updated and represent an excellent source of basic information that can be used for tailoring courses to the needs of a target audience. Appendices have also been compiled to provide additional background for the trainer.

Commonwealth Secretariat edition
ISBN 978-0-85092-858-7

FAO edition
ISBN 978-92-5-105956-2

ISBN 978-0-85092-858-7
9 780850 928587 >

Commonwealth Secretariat