Section VII

Module 4 – Cooling and cold storage*

Learning outcomes

The learner should:

- develop an appreciation of the importance of cooling and storage of fresh produce; and
- understand the different methods of cooling and storage of fresh produce that can be applied at each stage in the horticultural chain.

Introduction

Cooling is the foundation of produce quality protection. It extends the shelf life of fresh produce by reducing the rate of physiological change (respiration, ethylene production, enzymatic processes and water loss) and by slowing the growth of microorganisms. Since every degree of reduction from ambient temperature increases storage life, every form of cooling is beneficial to fresh produce quality.

Simple low-cost cooling techniques for preserving produce quality are better than no cooling at all. Produce can be cooled by avoiding exposure to heat (e.g. keeping produce out of direct sun, harvesting at the cooler times of the day) and by imposing cool conditions (e.g. ventilating with cool air, evaporative cooling, pre-cooling and mechanical refrigeration). These cooling methods can be employed in combination with other storage methods for maintaining fresh produce quality.

This module describes different methods and developments in cooling and storage of fresh fruits and vegetables and their application in horticultural chains.

Importance and principles of cooling

Lowering the temperature of fresh produce retards metabolic activities and extends shelf life (Figure VII.4.1a). The lowest temperature required to attain the maximum shelf-life of a fresh produce item varies in accordance with its chilling sensitivity (see related topic below). Cooling retards microbial activity and arrests pathogen proliferation that produces decay (Figure VII.4.1b). Fresh produce can be directly cooled using cold water or ice, or indirectly cooled using cold air.

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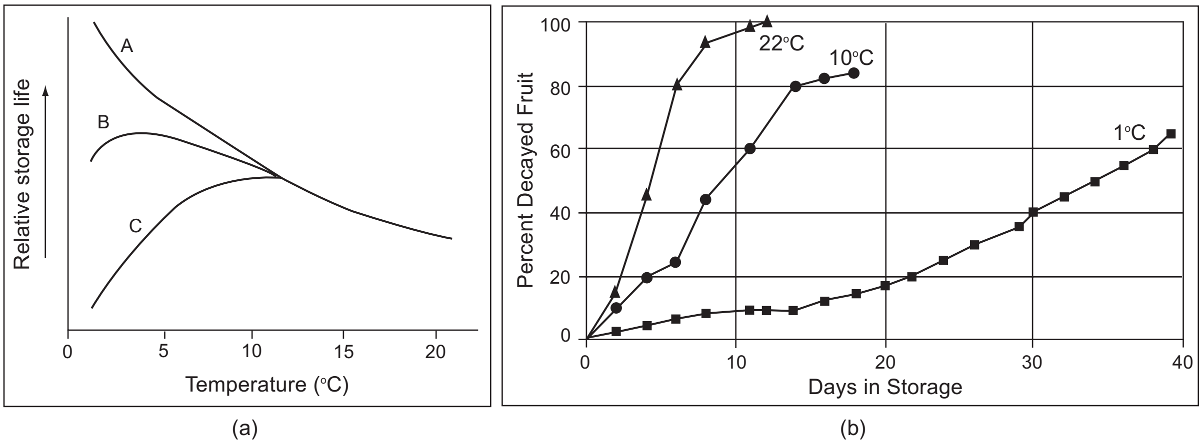
Figure VII.4.1. Storage life of produce and effects of temperature on fruit decay



Note: A = no; B = slight; C = high sensitivity to chilling injury

Source: KMUTT, 2007.

Pre-cooling techniques

Pre-cooling is the rapid removal of field heat from fresh produce. It is among the most efficient quality enhancements available to commercial producers and ranks as one of the most essential value-added activities in the horticultural chain. Proper pre-cooling can:

- prevent quality loss as a result of softening by suppressing enzymatic degradation and respiratory activity;
- prevent wilting by slowing or inhibiting water loss;
- slow the rate of produce decay by slowing or inhibiting microbial growth (fungi and bacteria);
- reduce the rate of ethylene production; and
- minimize the impact of ethylene on ethylene-sensitive produce.

Pre-cooling reduces the energy requirement or work load of a refrigeration system.

Cooling with cold air

Room cooling – This involves exposing the produce to cold air in a refrigerated room. Although room cooling may be used for most commodities, it is a slow process. Proper stacking is necessary to allow cold air to pass through the stack and packages of produce. If properly designed, a room cooling system can be relatively energy efficient. Room cooling is often inadequate for produce stored in large containers such as bulk bins or pallet loads, since heat is slowly removed from produce near the periphery of the container whereas at the centre of the container, heat is often generated by respiration more rapidly than it can be removed, causing the temperature within the container to rise. Room cooling is inadequate for produce such as strawberries that require rapid and immediate cooling after harvest.

Forced-air cooling – This is the most widely used method of pre-cooling. It makes use of fans that increase the rate of cooling in a refrigerated room by pulling cool air through packed produce, thereby picking up heat and greatly increasing heat transfer (Figure VII.4.2). Forced air cooling is generally 75 to 90 percent more efficient than room cooling. The rate of cooling is dependent on the temperature of the air and the rate of air flow through the packages. Anona, avocado, cucumber, melons, pumpkin, banana, mango, coconut, eggplant, okra, breadfruit, grape, orange, strawberry, Brussels sprouts, grapefruit, papaya, squash, carambola, guava, passion fruit, tangerine, cassava, kiwifruit, pepper, tomato, cherimoya, persimmon, pineapple, pomegranate and litchi can be cooled by forced air.

Figure VII.4.2. Forced air cooler, vacuum cooler and hydrocoolers for fresh produce

Source: KMUTT, 2007.

Cooling with water

Hydrocooling – This is appropriate for commodities that are not sensitive to wetting, such as celery, peas, asparagus, Chinese cabbage, pomegranate, beet, cucumber, broccoli, eggplant, radish, Brussels sprouts, green onions, spinach, cantaloupe, kiwifruit, squash, carrot, leek, sweet corn, cassava, orange and cauliflower. Cooling involves running chilled water (dip or spray) over the produce in order to facilitate the rapid removal of heat (Figure VII.4.2). At typical flow rates and temperature differences, water removes heat approximately 15 times faster than air. Hydrocooling is only about 20 to 40 percent energy efficient, as compared to 70 to 80 percent for room and forced-air cooling. During hydrocooling, the produce comes into contact with water. Good water sanitation must be observed to minimize microbial contamination. Once cooled, the produce must be kept cold.

Produce packed in wire-bound wooden crates, waxed fibreboard cartons, mesh poly bags and bulk bins can be hydrocooled. Palletized packages can be hydrocooled if they are carefully stacked to allow water to enter the packages. Little cooling occurs if water flows around rather than through the packages. Produce in waxed cardboard cartons with solid tops is particularly difficult to cool since the tops preclude the entry of water.

Ice cooling – Icing is particularly effective on dense packages that cannot be cooled with forced air. Ice rapidly removes heat when initially 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°C to 4.4°C. Ice must, however, be free of chemical, physical and biological hazards.

Icing is increasingly used in developing countries because of the increasing availability of ice. It can be used to cool produce during transport, distribution and storage. The temperature within a box of fresh produce can increase to between 35 and 40°C when sealed in the afternoon and transported the following morning but ice packing can lower the temperature to between 20 and 25°C.

Top icing involves the hand or machine application of crushed ice over the top of produce. Commodities that can be top-iced include broccoli, green onions and other leafy greens, Brussels sprouts, leeks, cantaloupes, parsley, carrots, peas and Chinese cabbage.

Liquid icing makes use of a slurry of water and ice injected into produce packages through vents or handholds without de-palletizing the packages or removing their tops. Crushed and liquid ice cooling can be effectively used in both small and large operations. 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 microbial development.

Individual package icing is the simplest method of ice cooling and is done by manually adding a measured amount of crushed ice to the top of each carton or package filled with produce (Figure VII.4.3a). 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. However, it is not usually recommended for high-volume production.

Ice bottles are also used for cooling fresh produce. Wrapping with paper precludes direct contact between the ice bottles and the produce (Figure VII.4.3b). Ice bottles are used for cooling of high-value produce during transport in China.

Figure VII.4.3. Ice cooling using crushed or flaked ice (a) and ice bottle (b)

(a) (b)

Packaging containers suited for icing. Many types and sizes of fresh produce containers can be successfully used for package icing. Popular types include waxed fibreboard cartons (Figure VII.4.3a), wooden wire-bound crates, baskets and hampers, and perforated plastic liners. Any container that will retain its strength after wetting can be satisfactorily used 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 with high surface to volume ratios and which would be very difficult to cool with forced air or hydrocooling. Brussels sprouts, carrot, peas, cauliflower, snap beans, celery, spinach, Chinese cabbage, sweet corn, leek, and Swiss chard are examples of fresh produce items that can be vacuum cooled. During vacuum cooling, produce is placed inside a large metal cylinder and much of the air is evacuated. The vacuum thus created causes water to evaporate rapidly from the surface of produce, lowering its temperature. To avoid excessive water loss, water can be applied during the vacuum process.

Comparison of pre-cooling methods

Table VII.4.1 compares the various pre-cooling methods for horticultural produce.

Table VII.4.1. Comparison of pre-cooling methods as applied to fresh fruits and vegetables

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.

Factors that govern the selection of a pre-cooling method

- *Nature of produce* – Different types of produce have different cooling requirements. Strawberries and broccoli, for example, require near-freezing temperatures, which injure bananas, mangoes or tomatoes.
- *Package design* – Package ventilation (i.e. number and size of holes) and palletization design can greatly impact on the rate of cooling of produce.
- *Product flow capacity* – Some methods of cooling are more efficient than are others. Rapid cooling methods, in general, are required for efficient cooling of large volumes of produce.
- *Economic factors* – Construction and operating costs vary in accordance with the method of cooling. Selection of a cooling method must be justified by the volume and selling price of produce. In cases where small volumes of produce are available and where electricity costs are high, the use of high-cost cooling methods cannot be justified by the end profit margins.
- *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.

Cold storage

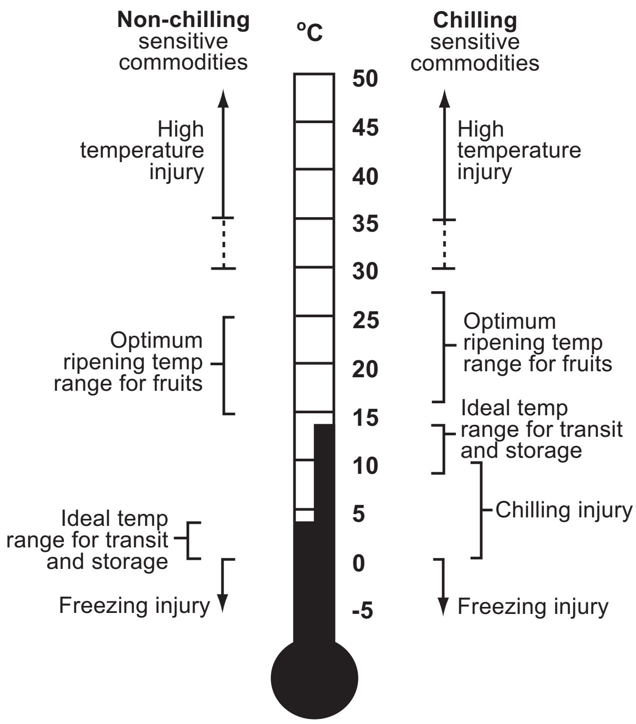
Temperature is the most important factor that determines the rate of produce deterioration. Cold storage is by far the most effective method of preserving quality and extending shelf life. Cold storage slows the biological activity of produce, slows the growth of microorganisms, reduces the rate of moisture loss from the surface of produce and reduces the susceptibility of produce to damage from ethylene gas. A farmer who has the ability to cool and store produce has greater market flexibility since the need to market immediately after harvest is eliminated. For small farmers, the problem is the set-up cost.

Temperate and subtropical produce are best stored at an optimum storage temperature close to 0°C, whereas tropical produce is best stored at temperatures above 10°C (Figure VII.4.4). A high but not saturated RH (85 to 95 percent) is optimal for most types of fresh produce. Table VII.4.2 gives the recommended temperature and RH conditions for the storage of some produce items. RH affects water loss, uniformity of fruit ripening, decay development and the incidence of some physiological disorders.

Disorders resulting from poor temperature management

Chilling injury – Tropical produce is generally sensitive to chilling and suffers injury when cool-stored at temperatures above their freezing points (Figure VII.4.4). Chilling injury is influenced by both time and temperature. The lower the temperature below the threshold and the longer the time of exposure, the faster and more pronounced the manifestation of injury. Maturity at harvest and the degree of ripeness are important factors that determine chilling sensitivity. The effects of chilling injury are cumulative in some produce items. Common visual symptoms of chilling injury include:

Figure VII.4.4. Responses of non-chilling and chilling sensitive produce to temperature



Source: KMUTT, 2007.

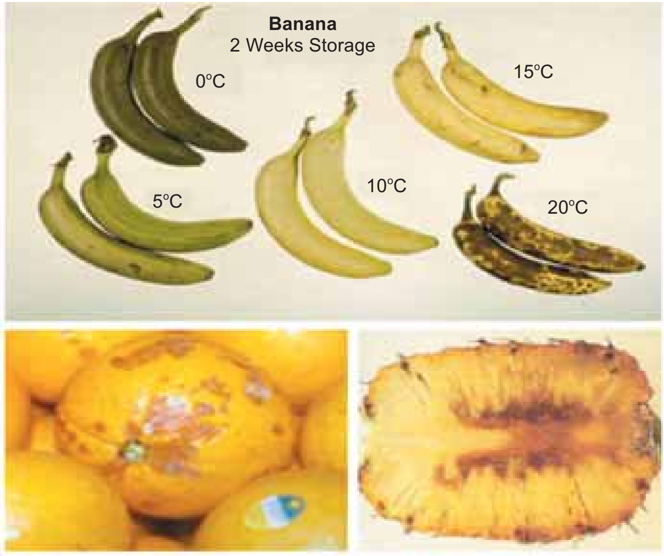
Table VII.4.2. Storage requirements of selected fruits and vegetables

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

Source: Sivakumar and Korsten, 2007.

- surface lesions – pitting, large sunken areas and discolouration (Figure VII.4.5);
- water soaking – disruption of cell structure and accompanying release of substrate favours the growth of microorganisms;
- 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.

Figure VII.4.5. Chilling injury symptoms in some fruits



Source: KMUTT, 2007.

Freezing injury – Horticultural produce freezes at temperatures below 0°C because of the presence of dissolved soluble solids in the cell sap. The soluble solids concentration varies not only with the produce item, but also between individuals and even parts of the same produce item. 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 under which the crop is grown and previous storage history. In general, leafy vegetables, that are fairly low in sugar, freeze at about -0.5°C, whereas those of high sugar content generally freeze at 2 to 5°C.

Freezing injury commonly occurs during shipping in refrigerated containers because of equipment malfunction or improper loading. Symptoms such as waterlogging or glassy areas in the flesh appear when produce is returned to non-freezing temperatures.

Storage of mixed loads of fresh produce

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. Produce to be stored at about 0°C should not be stored with produce that is sensitive to chilling injury below about 12.5°C.

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

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 (e.g. ripe bananas, apples and cantaloupe) can induce physiological disorders and/or undesirable changes in colour, flavour and texture in ethylene-sensitive produce such as lettuce, cucumbers, carrots, potatoes and sweet potatoes. Ethylene-sensitive produce should not, therefore, be mixed with high-ethylene producers.

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

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

Supplements to cold storage

Controlled atmosphere (CA) – Further reductions in produce respiration rates and microbial growth can be achieved by reducing oxygen levels and increasing carbon dioxide levels in the cold room with the use of CA generators or other CA systems. For commercial applications, the added cost of CA must be commensurate with produce value and shelf life extension. Specialized construction is required for cold rooms with CA.

Modified atmosphere (MA) – MA is less precise than CA in regulating oxygen and carbon dioxide levels and is exemplified by the use of polymeric films (see Module VI.3). The atmosphere created in the package at the beginning of the storage period is also likely to change during storage owing to respiration of the produce.

During CA and MA storage, produce must be maintained under appropriate temperature conditions (Table VII.4.3). Neither low temperature nor MA or CA can act alone to deliver full value to the customer. MA and CA each work in tandem with low temperature to slow the metabolism and aging of produce and keep the produce fresh for extended periods.

Table VII.4.3. Temperature and gas compositions for MA or CA storage of selected vegetables

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

[a] Optimum and range of usual and/or recommended temperatures. RH of 90 to 95 percent usually recommended.

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

Source: Kader and Saltveit, 2003.

Benefits of CA and MA – CA and MA can enhance the storage life of fresh produce by: delaying ripening and senescence processes; reducing decay by inhibiting spore germination and slowing bacterial growth; inhibiting sprouting thereby minimizing nutritional loss; inhibiting insect pests and providing a useful tool for controlling insects in some produce (e.g. as quarantine treatment).

Disadvantages of CA and MA – CA and MA storage can have a negative impact on the quality and safety of fruits and vegetables through:

- enhancement of decay as a result of excess humidity;
- induction of physiological disorders – if the desired gas composition is not maintained, physiological disorders develop (e.g. internal browning in apple and pear, brown stain in lettuce, failure to ripen in some fruits) and affect visual and eating qualities;
- risk of microbiological safety as a result of possible development of anaerobic pathogens; and
- fermentation – if desired O_2 levels are not maintained, fermentation occurs resulting in off-flavours and physiological disorders.

Surface coatings – Surface coatings are used to create MA around fruits. Many formulations have been developed, including solvent waxes, water waxes, emulsion waxes and edible coatings that have been commercially applied to different types of produce.

Surface coatings help to prevent decay by protecting against produce-to-produce 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. Surface coatings can also reduce weight loss and shrinkage by partially or completely plugging the stomata and serving as a barrier to water loss. Moreover, they retard metabolism and extend shelf life because of low oxygen and high carbon dioxide within the produce.

Current consumer preference towards additive-free diets may curtail the use of coatings in the fresh produce industry. Edible coatings of natural origin are growing in popularity in light of their environmental- and consumer-friendliness, their cost-effectiveness and potential for developing countries where refrigerated storage is not affordable.

Cold storage facilities

Cold storage facilities can be located in commercial packing 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 well-drained area is necessary to allow for the removal of condensate;
- *electricity* – the electricity supply in the area where the cold store is to be constructed determines the size of the cold storage equipment;
- *water* – water of good quality is necessary for sanitizing the storage facility; and
- *waste water disposal* – facilities for waste water disposal must be adequate.

The size and design of a cold storage facility are determined by:

- volume of produce to be stored;
- 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.

Temperature and relative humidity (RH) management within the cold storage facility

Cold storage facilities must be well insulated and adequately refrigerated with good air circulation in order to prevent temperature variation. They must be equipped with thermometers for temperature measurement, thermostats to control the operation of refrigeration units, and manual temperature controls that must be periodically checked. Alternating cold and warm temperatures within the cold store can result in the accumulation of moisture on the surface of produce (sweating), which may hasten decay.

RH within the cold store can be controlled using a humidistat and can be monitored with the use of a recording hygrometer. RH can be increased by: (1) adding moisture (water mist or spray, steam) to air with the use of humidifiers; (2) regulating air movement and ventilation; (3) maintaining the temperature of refrigeration coils to within about 1°C of the air temperature; (4) providing moisture barriers that insulate the walls of storage rooms and transit vehicles; and (5) by wetting the floor of the cold store.

Managing produce within the cold storage facility

Proper storage practices include temperature and RH control, air circulation, the maintenance of space between containers for adequate ventilation and the avoidance of incompatible mixes of produce. Managing the inflow and out flow of produce is also vital.

- Refrigerated storage is costly. Produce must be sorted and only produce that is of marketable quality should be stored. A First in First Out (FIFO) system should be used for the management of produce within the cold store.
- Produce should be pre-cooled prior to loading into cold rooms. If pre-cooling is not available, the daily intake of produce into the cold store should not exceed 10 percent of the cooling capacity of the room.
- Cold rooms should be brought down to the appropriate temperature for about three days prior to loading with produce. Rooms without floor insulation may take a week to reach equilibrium. Failure to pre-cool the cold room may cause slow cooling and excess water loss from produce.
- Packages of produce must be stacked in a manner that ensures even distribution of cool air throughout the room and around the packages. There should be a minimum gap of 8 cm between the stacks of produce and the walls and between the floor and the stack and 20 cm between drip trays under the cooling evaporators and the top of the stack.
- When boxes with no vents are used, gaps of about one cm must be left between adjacent packages. Bulk bins containing 200 to 500 kg of produce should have air gaps in the floor of 8 to 10 percent of the base area.
- Prior to arrival of produce, the intake personnel must have made arrangements already with the forwarding agent and prepared all documentation for receiving the produce. This documentation includes the anticipated arrival time, allocated chambers in the cold room, and temperature at which produce must be stored. On arrival, palletized produce must be placed in assigned location and damaged cargo should be placed in a demarcated area.
- The location of inventory must always be noted. Inventory information should include 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 there is an inventory verification policy between the customer and management of the storage facility.

Hygiene management in cold storage facilities

Cold rooms must be maintained under sanitary conditions to prevent pathogen build up on the walls, metal and cooling units. They must be thoroughly cleaned at the end of each season by washing the walls and floor with hypochlorite solution or other safe sanitizers. During cleaning, workers must wear facial masks since continuous exposure to disinfectants and high inoculum levels could have adverse effects on respiratory health.

Ozone generators can help keep cold rooms free of surface moulds and reduce the spread of fungal spores. Ozone is, however, toxic to humans. Humans can be exposed to 0.1 ppm repeatedly during an 8-hour working day. This limit is attained when the smell of ozone is noticeable by humans.

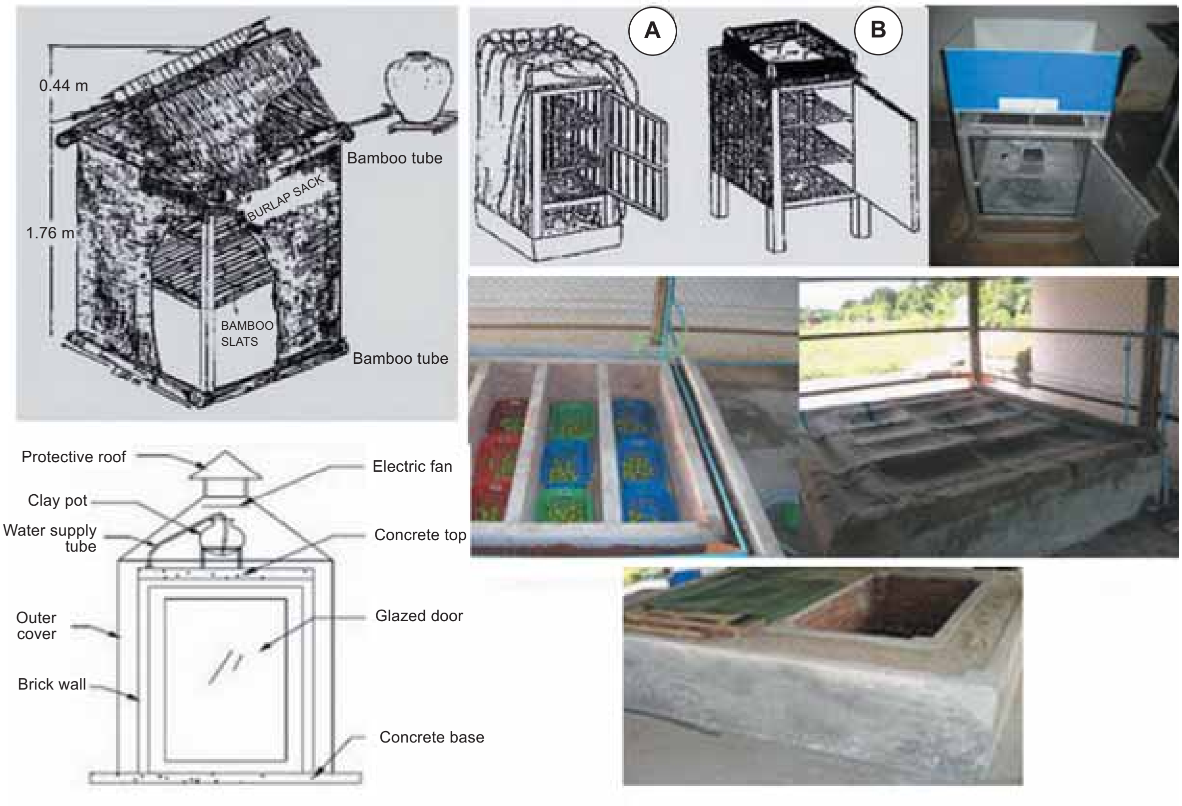
Cold rooms should be ventilated to prevent build up of carbon dioxide, ethylene and off-odours. For human safety, carbon dioxide must not exceed 5 000 ppm (about 0.5 percent). One change in the volume of room air every six hours is sufficient. An inlet valve should be placed at the rear of the low pressure zone and outlet at the opposite end of the room. Excess ventilation should be avoided because the entering warm air carries additional moisture that increases the need for a defrost cycle.

Alternative cooling technologies

Refrigerated storage is expensive both in terms of set-up and operational cost. Alternative cooling and storage methods are important for small farmers and entrepreneurs in developing countries.

Evaporative cooling is a simple and low-cost method of cooling. It involves the evaporation of water and results in a cooling effect. Water is provided in the vicinity of the produce and dissipates heat inside the storage chamber that may come from the produce (respiratory heat) and the external environment. Although the reduction in temperature is minimal, the increase in relative humidity to 90 percent or higher, makes evaporative cooling very effective in reducing water loss and water stress-associated processes (e.g. shrivelling, wilting, ripening). Several simple evaporative coolers have been developed and used by small farmers for the temporary storage of produce (Figure VII.4.6).

Figure VII.4.6. Simple evaporative coolers for fresh fruits and vegetables developed in Cambodia, Lao PDR, Philippines and Sri Lanka



Source: Acedo and Thanh, 2006.

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Suggested methods of instruction

Lecture using handouts and visuals and discussion.

Practical exercises

Practical Exercise III.3: Visit to a packing house.

Practical Exercise VI.2: Impact of ineffective cold chain management.

Time frame

1.5 hours for the lecture.

4 hours for the practical.

Section VII

Module 5 – Transport systems*

Learning outcomes

The learner should:

- understand the different transportation methods and transportation infrastructure in horticultural chains;
- understand the factors that could compromise produce quality during transportation; and
- develop an appreciation of the role of transportation management in the cold chain.

Introduction

Every handling step in the supply chain involves some form of transport. The worker who harvests the produce must carry and transfer it to a box or field bin that is moved to a central point for packing or to a packing house located either on or off the farm. Within the packing house, the produce may be moved into temporary cold storage before it is graded and packed. The packed produce is then assembled into convenient units, usually on a pallet. Palletized loads may be moved into a cold room before being transported by road to a central market, a retail distribution centre, a seaport or an airport. On arrival at their destination, these consolidated loads of produce may be broken down to individual packages, which may be gathered together with a wide range of other packaged produce for distribution to retail outlets. The last transport step of the chain is from the retail store to the consumer's home. Quality can be compromised at every handling step because of physical injury, rough handling and incorrect management of temperature. Physical injury provides opportunities for contamination by food-borne pathogens. Each transportation step costs money and if conducted properly adds value to the produce that is finally sold to a consumer.

This module briefly describes the transport systems at each stage in the supply chain and outlines precautionary measures to minimize mechanical injury and quality loss in horticultural chains during transportation.

Transport in horticultural chains

The transportation system for fresh produce depends on the stage in the supply chain, market destination, degree of perishability, value and volume of produce, storage temperature and humidity requirements, ambient conditions at origin and destination points, transit time, road access, freight rates, and the quality of the transportation service.

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Transport at the farm

All produce is susceptible to mechanical injury and must be handled with care. Impact, compression and vibration damage may be inflicted or initiated at the farm and during transportation.

Causes of impact damage (e.g. bruise, crack, split, cuts):

- dropping or throwing individual items or packages of produce; and
- crushing of produce because of package failure or spillage.

Causes of compression damage (e.g. bruise, crack, split, deformation):

- overfilling containers (over-packing);
- containers too deep or stacked too high;
- stacking of baskets without separating dividers between layers; and
- sitting on the package of produce.

Causes of vibration damage (e.g. abrasion, cuts):

- under-filling of containers (under-packing);
- poor suspension system of vehicle; and
- rough roads.

Small field containers (e.g. plastic or metal buckets with smooth surfaces) should be used for collecting produce on farm. The total weight per container should not exceed 20 kg so that the produce can be carried easily by one person. The containers (or boxes if packing is done in the field) should be gently loaded on to trailers for transport to the packing house. The trailer can be fitted with air bags to prevent injury.

The produce should be kept out of the sun and moved rapidly to the packing house. The temperature of produce when exposed to the sun can increase by 1°C per minute.

Transport in the packing house

Produce to be graded and packed in the packing house may be pre-cooled and temporarily stored or subjected to grading and packing prior to pre-cooling. Produce is frequently washed with clean water or with a sanitizer, treated with an approved fungicide, waxed and dried before grading and packing. Transport movement within the packing house and at each transfer point must be carefully conducted in order to avoid physical damage to the produce.

Packed produce is assembled into batches, usually on pallets, according to size and quality grade, and possibly market destination. These units are usually stabilized by strapping with strong plastic taping or plastic netting and are then moved by forklift truck or hand lift truck into a cold room for further cooling and storage or directly on to a road truck or shipping container van.

Transport to destination markets

Fresh produce is transported to domestic and export markets either by truck, rail, ship/boat, aircraft, or a combination of these transport systems. Trucks should be equipped with air bag suspensions in order to reduce transmission of road shocks and vibration to the produce. The packed produce may be loaded on to trucks or shipping containers by hand or by forklift if on pallets (Figure VII.5.1). The packages must be tightly stowed to prevent in-transit shifting and misalignment. Shifting of the load can cause serious damage to the produce. High forces can be transmitted to loads during heavy braking of trucks and shunting of rail trucks.

Non-refrigerated transport – Non refrigerated loads should be carried on canopied trucks with side curtains or at least enclosed with a tarpaulin to avoid exposure to the sun, rain, and strong air flow that could dry out the produce (Figure VII.5.1). Transport of cooled produce enclosed in tarpaulins should not exceed six hours to prevent reheating.

Mixed loads of high-ethylene producers and ethylene-sensitive produce may endanger the quality of the latter, especially during long journeys. Control measures such as proper ventilation and the use of scrubbing systems can be employed when available.

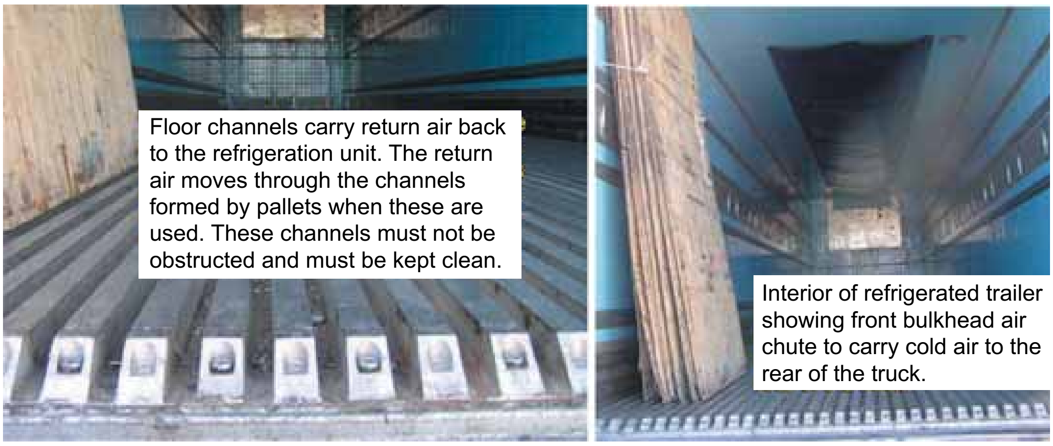
Figure VII.5.1. Canopied truck of packed produce in covered area at destination market and use of forklift truck for loading and unloading, but unfortunately under the heat of the sun

Source: KMUTT, 2007.

Refrigerated transport – Refrigerated trucks, trailers and shipping containers are designed to maintain temperature, not to remove the field heat associated with produce. Produce must, therefore, be pre-cooled before loading. The temperature of the transport load must also be reduced to the recommended produce temperature prior to loading. In situations where chilling sensitive produce is mixed with chilling-resistant produce, temperatures should be maintained in the range of 7 to 10°C.

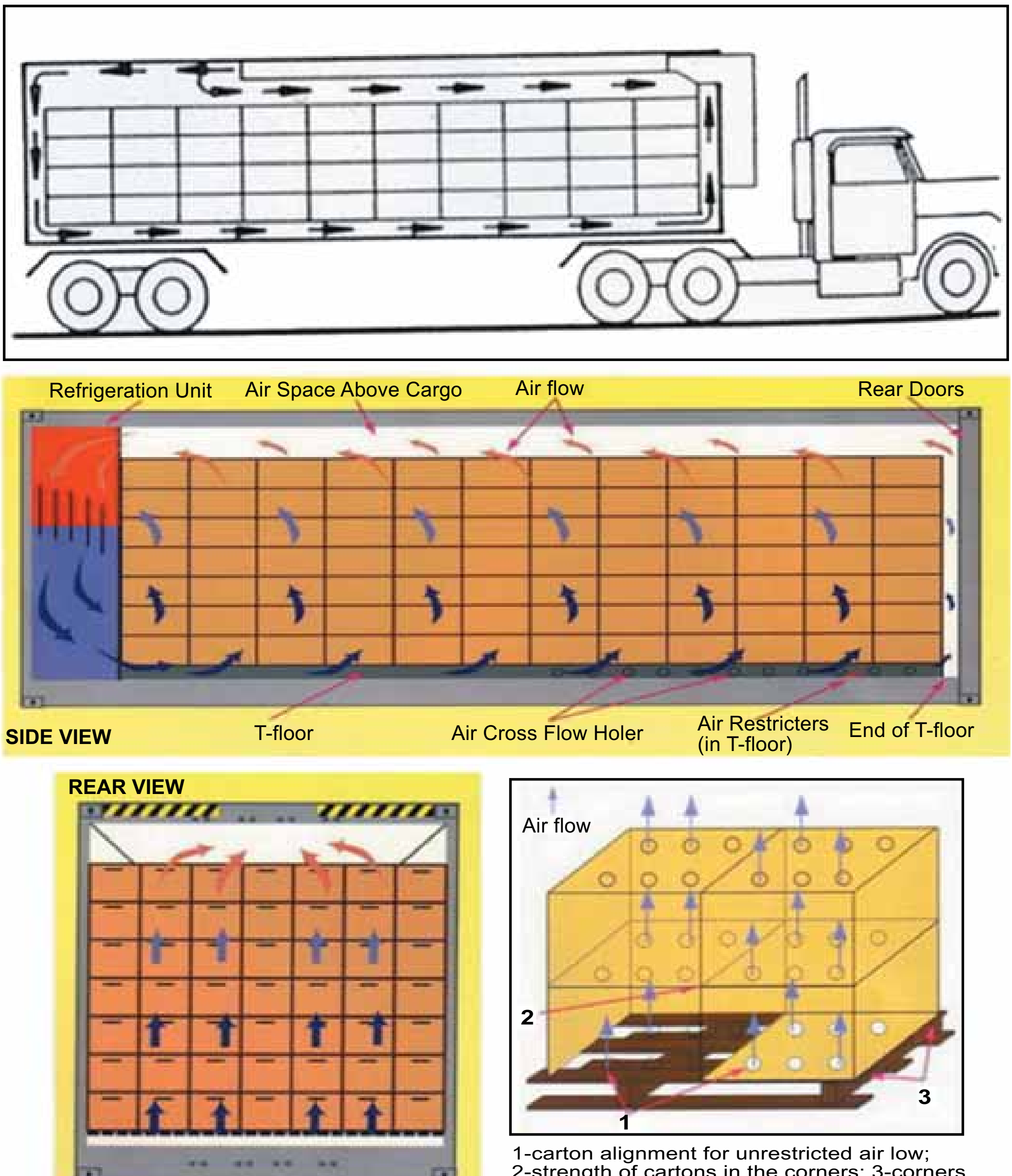
Refrigeration systems are designed to intercept heat entering through the walls, warm air entering via ventilation or leakage around the doors and from the air circulating fan. They are designed to blanket the produce with cooling air. In order to ensure that this blanket of cooling air is complete, road trucks and trailers must be equipped with floor channels (Figure VII.5.2). There must be an air gap between the walls and the produce, which can be achieved by ribbing, and a bulkhead at the front of the unit that allows unrestricted flow of return air to the heat exchanger. Similarly, the rear of the load must be braced and a clear gap left between the doors and the loaded produce. Finally, there must be an air delivery chute extending two thirds of the length of the trucks, and for trailers that are more than six metres long. This air delivery chute must be mounted on the ceiling (Figure VII.5.2). Figure VII.5.3 illustrates the desired air flow inside a refrigerated transport load.

Figure VII.5.2. Floor channels and air delivery chute in a refrigerated trailer



Source: KMUTT, 2007.

Figure VII.5.3. Air delivery chute and desired air flow around and through boxes of produce in a refrigerated load



1-carton alignment for unrestricted air low; 2-strength of cartons in the corners; 3-corners of cartons supported

Delivery and return air temperatures are continuously monitored and are used to thermostatically control the refrigeration unit. Control based on delivery air temperatures reduces the risk of freezing produce near the front top of the load. It is desirable to insert at least two trailing electronic resistance probes into boxes of produce to record produce temperatures during transit. One should be located near the top of the load near the delivery air and the second in the return air path near the front and bottom of the load.

Shipping containers should be pre-cooled prior to loading. As with road trucks and trailers, only pre-cooled produce should be loaded. The load must be tightly stacked, leaving gaps between the packed produce and walls and doors to ensure unimpeded air circulation around the load. Shipping containers are fitted with floor channels that run the whole length of the container. The cooling air is delivered into these channels under the stacked produce. The return air travels over the top of the load. A clear gap must be left between the load and the ceiling in order to allow unimpeded flow of the air returning to the heat exchanger. Rules covering pre-cooling, stowage, air circulation and ventilation of containers have been developed from research and commercial experience.

Figure VII.5.4. Refrigerated containers with controlled atmosphere generator

Low temperature combined with controlled atmosphere (CA) is increasingly used by companies for transporting fresh fruits and vegetables mainly to export markets. Since the containers are metal boxes, the door opening can be sealed with a plastic curtain.

Importing countries require in-transit cold disinfestation of selected fresh produce items. Typically, produce temperature must be maintained for 16 days at 1 to 3°C. Importing countries also require recording of produce temperatures at several points in the load. It is now practicable to record produce temperatures in containers on board ships and to access these in real time by satellite radio or internet communication and to adjust container temperatures during transit.

Refrigerated Air Transport – For produce transported by air, proper temperature management is similarly critical. Although aircraft holds are usually maintained at temperatures similar to those in the passenger compartments, fresh produce should be pre-cooled to recommended temperatures and maintained at these temperatures until delivery to the air freight terminal. Air freight containers may vary in shape to fit the contours of the aircraft freight deck (Figure VII.5.5). They are constructed of light metals and are not insulated. They may be lined with reflective insulation or sheets of expanded polymer insulation. Solid carbon dioxide (dry ice) can also be included in the container to provide some cooling and to increase the concentration of carbon dioxide around the produce. Rectangular loads on aircraft skids should be enclosed in plastic tarpaulins to slow heating of produce.

Figure VII.5.5. Cargo aircraft and its freight compartment with a system for anchoring loads to the floor and different types of containers designed to fit the aircraft fuselage

LD-3 CONTAINER	LD-3 COOLTAINER	88 × 125" COOLTAINER
External Dimension: 152 × 201 × 163 cms	External Dimension: 152 × 201 × 163 cms	External Dimension: 318 × 224 × 160 cms
Internal Volume: 4.3 m^2/153 cu.ft.	Internal Volume: 3.5 m^2/124 cu.ft.	Internal Volume: 7.0 m^2/247 cu.ft.
Maximum loading capacity: 1 587 kg/3 900 lbs	Maximum loading capacity: 1 500 kg/3 300 lbs	Maximum loading capacity: 4 000 kg/8 818 lbs
IATA ID Code: AVE	IATA ID Code: CC3 (Cooltainer)	IATA ID Code: RA2
IATA Rate classification: Type 8	IATA Rate classification: Type 8	IATA Rate classification: Type 2 (STD Igloo)
Tare weight: 84 ± 2 kg/185 ± 5 lbs	Tare weight: 150 kg/330 lbs	Tare weight: 326 kg/719 lbs
Loading possibilities: H747/DC10/A300	Loading possibilities: B747/DC10/A300	Loading possibilities: B747/DC10/A300

Source: KMUTT, 2007.

Aircraft containers are loaded at an exporter's or freight forwarder's warehouse and carried by road to the airport terminal. The trucks should be fitted with canopies and side curtains to reduce heating from direct exposure to the sun. Logistics and security requirements may result in containers of produce sitting on the tarmac for long periods during loading and unloading of produce. On arrival at destinations with hot climates, every effort should be made to quickly move the containers of produce under cover and to unload the produce into cold rooms.

Transport in markets

Containers are unloaded onto the selling floors in terminal markets or into cold chambers at distribution centres. Produce is moved primarily by forklift trucks or hand trolleys. At central markets, mixed loads of produce are assembled onto buyers' trucks for transport to retail stores. These trucks should be loaded under cover and fitted with canopies. In situations where canopied trucks are not available, the loads should be enclosed in tarpaulins.

Similarly at distribution centres, mixed loads are assembled for transport to retail stores. For journeys of less than six hours, the produce can be carried in non-refrigerated vans or trucks. It is, however, preferable that refrigerated trucks are used for all deliveries.

Cold chain and transport management

From the foregoing, it is clear that connecting the events that involve cooling and continued exposure of produce to controlled conditions of low temperature from the farm to retail would essentially form the cold chain. Cold chain management should strive to systematize the different activities and logistics within the chain in order to maintain produce under desired low temperature conditions from the farm or packing house until retail display on refrigerated shelves in a timely and efficient manner. Transportation plays a crucial role at all stages of the cold chain. Activities prior to transport (e.g. pre-cooling, loading and unloading in a refrigerated area) and destination handling (e.g. temporary holding in cold rooms) play supportive but equally important roles to ensure the integrity of the cold chain.

The cold chain

The cold chain starts at harvest by ensuring the prompt transportation of harvested produce from the field to the packing house where the first cooling operation (i.e. pre-cooling) is performed (Figure VII.5.6). This is of utmost importance in maintaining the harvest freshness of produce. On arrival at the packing house, the produce should immediately be cooled to remove field heat. Pre-cooling should secure the produce from microbial contamination and if hydrocooling with recirculating water is employed, clean and safe water containing a sanitizer should be used. The pre-cooled produce can then be moved into a cold room for storage or temporary holding prior to transportation in a refrigerated truck or container to the next destination. Temperature monitoring and data logging systems must be enabled. The 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 the recommended temperature regimes. The TTT period varies in accordance with the commodity, but for most commodities, it is six hours. On arrival at its destination, the produce must be unloaded and moved rapidly to an appropriate low temperature facility.

Maintaining the integrity of the cold chain

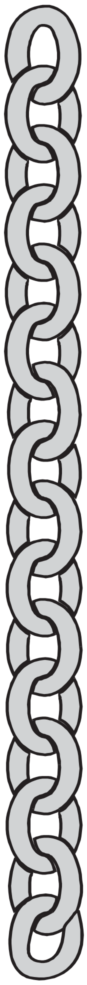
The integrity of the cold chain is dependent on using and maintaining the correct temperature throughout the chain. Optimizing temperature throughout the chain necessitates that handlers be aware of the temperature requirements of the produce and that produce is appropriately labelled with the correct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

Transport equipment and support facilities

Supportive facilities are required to facilitate the transportation of both refrigerated and non-refrigerated produce. In the case of non-refrigerated transport, these include canopied trucks equipped with side curtains, canvas or tarpaulins for use as a cover in the open cargo compartments of trucks; separators (e.g. wooden slabs), which are particularly important for separating basket containers and pallets; bracing materials to immobilize the stacks of produce; and forklifts or improvised conveyers (e.g. pulley-type) or staircases to facilitate loading and unloading. If non-refrigerated shipping containers (e.g. 20-foot or 40-foot vans) are used, ventilation holes should be provided. The use of ventilated non-refrigerated shipping containers was found to reduce losses in Philippine bananas as a result of green ripening during 36-hour domestic inter-island shipments. Other support facilities would include a packing house, appropriate packages, a covered/shaded loading and unloading area, and a storage facility.

Figure VII.5.6. The cold chain for fresh fruits and vegetables



Harvest
- Minimize delays before cooling
- Cool the produce 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 food service operators in refrigerated trucks
- Display at proper temperature range

Handling at home or food service outlet
- Store produce at proper temperature
- Use the produce as soon as possible

Source: Kader and Rolle, 2004.

For refrigerated transport and the cold chain, supporting facilities include refrigerated trucks and shipping containers (truck/ship/rail and air cargo containers), CA containers and their control and monitoring systems, standard pallets with post-loading bracing/blocking or plastic netting, forklifts, and refrigerated vessels (ship, train, aircraft) or vessel holds. Other infrastructural requirements include a packing house, pre-cooler, cold storage facility, and refrigerated shelves (retail).

Hygiene in transport systems

The quality of perishable produce can be adversely affected by poor 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 minimize potential damage to the produce. It is critical that all vehicles used for transportation of fresh produce are cleaned to remove the 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 in accordance with the manufacturers’ recommendations.

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Suggested methods of instruction

Lecture using handouts or visuals and discussion.

Practical exercises

Practical exercise VI.1: Impact of handling.
Practical exercise VI.2: Impact of ineffective cold chain management.

Time frame

1.5 hours for the lecture.
4 hours for the practical exercises.

Section VII

Module 6 – Handling in markets*

Learning outcomes

The learner should:

- develop an appreciation of handling operations to assure quality and safety of fresh horticultural produce in markets.

Introduction

Handling in markets is an integral part of horticultural chains. Handling operations should strive to maintain produce quality in order to ensure high marketability and repeat sales. Modern marketing systems, including well-equipped wholesale markets and supermarkets, employ sophisticated handling operations that require technologies and knowledgeable personnel with record-keeping capability to assure quality and track undesirable deviations that could compromise quality.

This module briefly discusses general considerations in produce handling in markets and specific operations in wholesale and retail markets aimed at preserving produce quality and safety.

General considerations

Fresh horticultural produce is subjected to handling operations at various stages of the chain, between the producer and consumer (Figure VII.6.1).

- The level of handling varies in accordance with the type of produce and intended buyer.
- Good temperature management is critical to minimizing warming or chilling of produce that could result in marketing losses.
- Careful handling is essential to avoiding physical damage to produce.
- Stacking and unitizing of different types, sizes and shapes of containers are major concerns in markets. Containers can be standardized (e.g. use of modular shapes/sizes) and produce-specific pallets can be standardized in dimensions and reusability to minimize disposal problems.
- Ethylene-producing and ethylene-sensitive produce are best kept separate in storage and on display shelves. Other sources of ethylene (forklifts, ripening rooms, decaying produce) must be controlled appropriately. Ethylene removal systems (e.g. ventilation during the night when air is coolest, use of ethylene scrubbers such as potassium permanganate, UV light) may be employed for this purpose.

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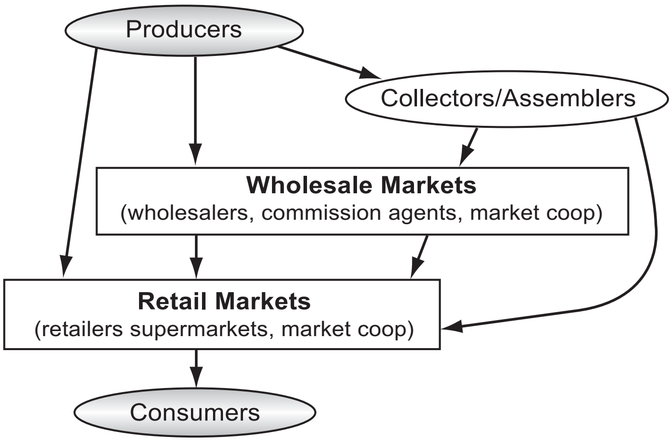
* A. Acedo Jr & S. Kanlayanarat

Figure VII.6.1. Supply chain stages where market handling operations are undertaken



Source: KMUTT, 2007.

Handling at wholesale markets

Wholesale markets serve as a basic source of produce supplies for retailers, as an outlet for producers and commission agents, as a centre of sale for imports as well as to dispatch produce to export markets. Wholesale markets may be owned and operated by private corporations, public corporations (market authorities), cooperatives, or mixed corporations.

Handling operations in wholesale markets may include the following:

- *Re-sorting or re-grading* – This is necessary for produce that is not of uniform quality, e.g. produce at different stages of maturity and produce that is diseased or mechanically damaged. Communication and understanding of quality control procedures is necessary.
- *Re-packing* – Re-sorted produce is packed in consumer packs that are better suited for retail distribution.
- *Storage* – Many produce items cannot be distributed on the day on which they are received, thus necessitating that they be stored. Storage facilities are necessary and proper storage management must be observed, i.e. proper temperature management and compatibility of mixed loads.
- *Ripening treatment* – Fruit that are most desired when ripe are, in general, treated with ripening agents prior to retail distribution. Ripening agents include ethylene (gas or liquid) and, in domestic markets, calcium carbide. Ripening rooms must be strategically located with the exhaust or door away from the storage or packing area, particularly if poorly ventilated.
- *Transport* – Moving small quantities of produce to retail outlets is a major activity in wholesale markets. Major concerns/problems that need to be addressed include high transit temperature, physical damage to packaging, physical damage to the produce, and improper loading, unloading and stacking.

Handling in retail markets

Retailing involves the sale of produce to consumers, i.e. produce is placed before consumers for acceptance or rejection. It is the last step in the supply chain and the outcome of retail sales determines profitability for all members of the supply chain. Each step in the supply chain adds cost (value) to produce, so by the time the produce is sold to a consumer its value may have increased fivefold to sevenfold. Successful retailers procure supplies in accordance with their understanding of supply and demand. They understand consumer preferences, promote the sales of produce, provide customer service, and handle produce with care in order to minimize losses.

Since retail outlets generally operate under ambient conditions, produce may undergo rapid deterioration. Retailers therefore require information on ways to slow deterioration including the merits of cold storage to maintain stock until placed on retail display.

Retail marketing outlets in Asia and the Pacific region range from roadside stalls, to open air markets, permanently covered markets (wet markets), grocery and convenience stores in permanent buildings, to supermarkets.

Handling operations in retail markets are similar to those in some wholesale market operations. These include:

- *Re-sorting* – This is done to ensure uniformity of quality.
- *Cleaning/refreshing* – This is done to enhance the fresh appeal of the produce. Green leaves are often added by retailers to achieve that effect.
- *Re-packing* – Some types of produce are repacked in consumer packs with plastic overwrap.

Sanitary practices in markets

Good sanitation is necessary in both wholesale and retail markets in order to maintain the safety and quality of produce and to reduce marketing losses. Sanitary practices include proper disposal of rotten produce, cleaning or sanitizing packaging and storage facilities, preparation areas and display bins.

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Suggested methods of instruction

Lecture using handouts or visuals and discussion.

Practical exercise

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

Time frame

30 minutes for the lecture and discussion.

Two hours for the practical exercise.

SECTION VIII

Effective monitoring in horticultural chains

Section VIII

Module 1 – Traceability*

Learning outcomes

The learner should:

- understand the importance of traceability in horticultural chains; and
- understand the key components of a traceability system.

Introduction

Consumers want to know that the horticultural produce they purchase is fresh and safe. Many consumers are also interested in knowing where and how the produce that they purchase was grown and handled during its transit in the producer-consumer supply chain. Identification of the origin of fresh produce is of prime importance for the protection of consumers, particularly when there is a likelihood of contamination. A good, well documented food safety and traceability system is of importance in reassuring consumers of the safety of the produce that they consume and in preventing the production and distribution of unsafe or poor quality produce.

This module describes the principles of traceability as applied to horticultural chains.

Traceability

According to Codex Alimentarius, 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: **tracking,** which refers to the ability to determine in real time the exact location and status of produce in the logistics chain; and **tracing,** which refers to the ability to reconstruct the historical flow of produce based on records maintained through the chain.

Key components of a traceability system

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 chain, i.e. in the field, at the packing house, at the supplier, the retailer and during transit between each of these points.

Various systems have been developed to deliver these requirements. A simple traceability system may consist of simple, handwritten or machine-printed product labels and handwritten records held at the various steps of the chain. Although such systems can be relatively inexpensive, their maintenance cost is high given the number of individuals involved in the process, and retrieving data is difficult and can be a slow process.

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* R. Rolle

More sophisticated and more costly systems make use of a computerized system for data recording, along with machine-readable barcodes that can be electronically transferred within a computerized information system. Although these systems are relatively faster and more accurate than are handwritten or printed product labels, the printed bar code on the package must be directly scanned with the use of an electronic scanner at the point of use. Use of printed bar codes, however, necessitates literate operators.

Radio frequency identification (RFID) tags, which continuously transmit data on the location of produce in real-time, are growing in use. RFID tags generally consist of three elements: a main processor chip that can interface with a reader or store data, an antenna, and a power source. RFID tags can be more rapidly and more easily read than bar codes.

RFID tags can also include sensors (RFID sensor tags) that can be used for the real-time monitoring of temperature, relative humidity, light and exposure to shock, as produce moves through the chain. This data is collected using wireless communication and can be accessed by reading the memory of the tag. Data collection is possible only when the RFID tag is located within the read range of the RFID reader.

Importance of traceability systems

Traceability systems are 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. Packing houses, for example, may utilize traceability systems for identifying bins of incoming fruit, for tracking palletized outgoing fruit, as well as incoming materials such as drums of fungicides, waxes. Traceability systems also allow produce to be tracked as it moves through the chain from producer to consumer.

Traceability systems can help in pinpointing the source and extent of safety and quality control problems in a horticultural chain and are of critical importance in situations where contamination arises, and the recall or withdrawal of the produce is required. They are useful also in situations where the credence characteristics of fresh produce, e.g. shade grown, organic, etc. are of importance to the consumer. Given their pivotal role in assuring consumer confidence, they consitute part of the brand advantage used by many supermarkets to position their produce as being safe and reliable with consumers.

Information collected by traceability systems can serve as a basis for improving quality assurance, packing house management and the overall management of fresh produce supply chains. This information is also useful in production planning, as well as in informing growers of the impact of their produce in the market.

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Suggested methods of instruction

Lecture using handouts or visuals and discussion.

Time frame

One hour.

SECTION IX

Logistical operations in horticultural chains

Section IX

Module 1 – Logistical operations in horticultural chains*

Learning outcomes

The learner should:

- understand the importance of horticultural chain logistics and components; and
- understand the key elements of logistics management.

Introduction

Horticultural chains require appropriate and timely logistics to produce and deliver the desired volume and quality of fresh produce from the farm to the demand points. Logistics is that part of the supply chain that deals specifically with transportation, storage, inventory, and transaction management. A breakdown in any one of these logistical operations could compromise the distribution and quality of produce.

This module briefly describes logistics management within the context of horticultural chains and the logistical challenges faced in food supply chains.

Horticultural chains and logistics management

A horticultural chain is the flow of produce and services from producers to retailers through different intermediaries (e.g. packing houses, wholesale markets, cool storage warehouses and distributors). These different steps of the chain are connected by transportation and storage activities and are integrated through information, planning and coordination activities. The level of costs and services at each stage of the chain varies.

The prevailing horticultural chains for fresh fruits and vegetables in many countries of Asia and the Pacific region are shown in Figure IX.1.1. Domestic supplies of fresh produce in the region are now served primarily by local producers and importers. With increasing trade liberalization, fresh produce imports have increased in many countries across the region. Both traditional and modern trading systems exist within the region and cold chain systems are increasingly used for transporting produce destined for both domestic and foreign markets.

Managing horticultural chains requires approaches that efficiently integrate producers, collectors, distributors, warehouses, storage operators, and marketers to ensure the production and distribution of fresh produce in the appropriate quantities and of the right quality, to the right location, at the right time. Costs must be minimized while satisfying service level requirements.

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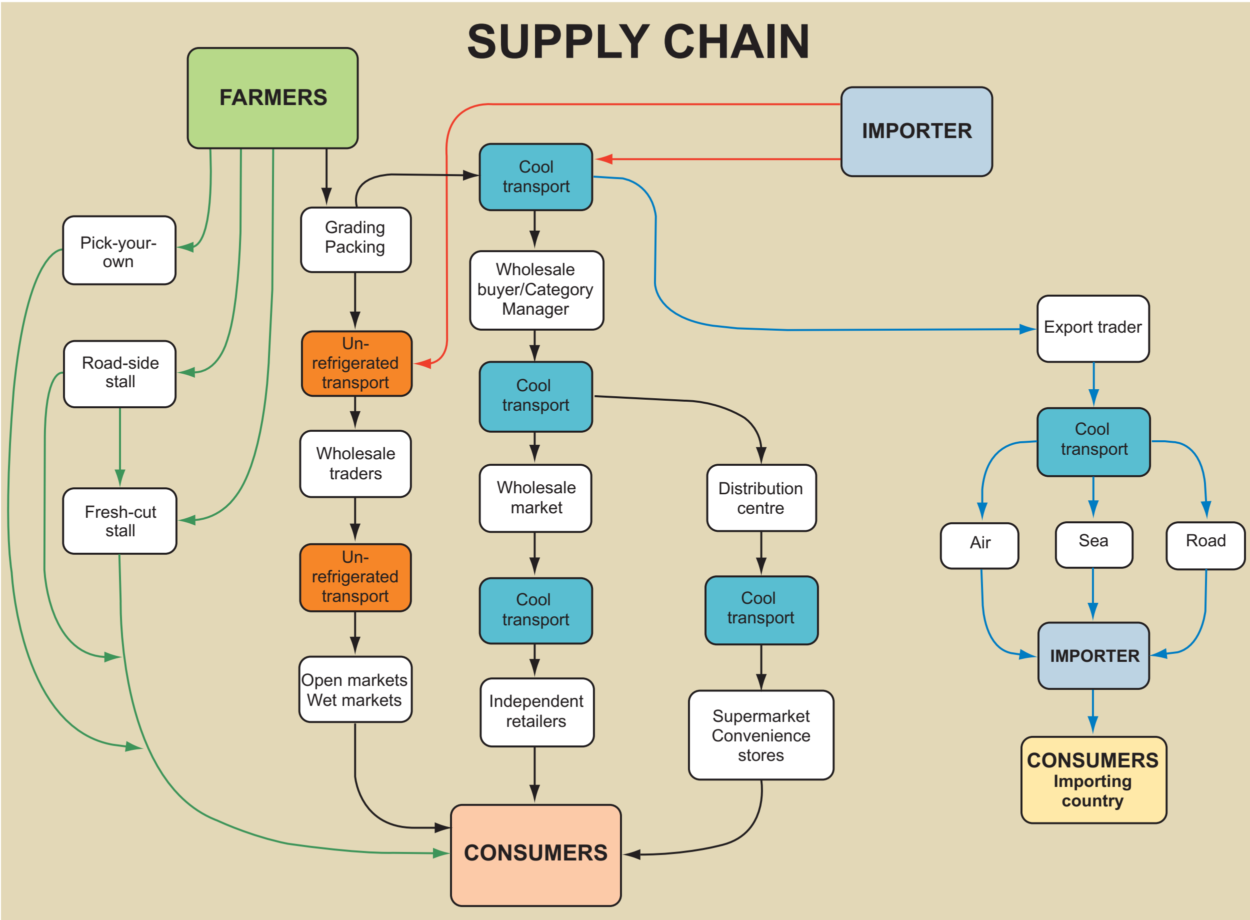
* T. Wasusri

Figure IX.1.1. Supply chain of fresh fruits and vegetables in the countries of Asia and the Pacific region



Source: KMUTT, 2007

Logistics management is that element of supply chain management that plans, implements and controls the forward flow of produce, and the forward and reverse flow of services and information between the farm and the point of consumption in order to meet consumer and customer requirements.

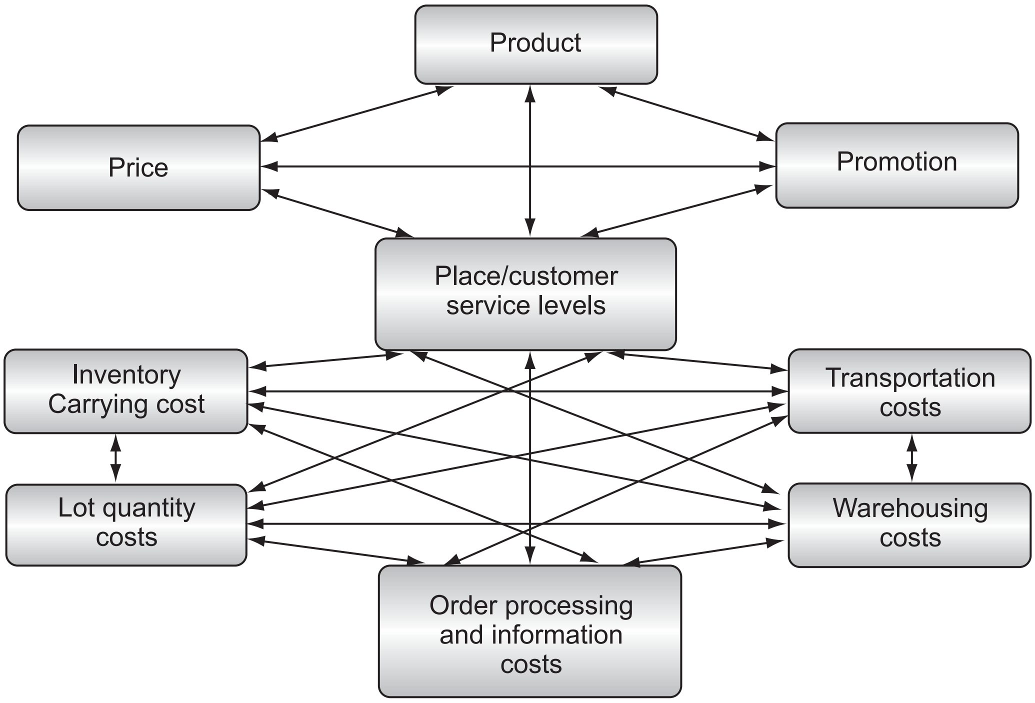
Logistical operations

Logistical operations begin on the farm and should assure the timely cooling and transport of produce to the packing house for quality maintenance. Proper temperature management, packaging and traceability labelling are performed in the packing house.

As shown in Figure IX.1.1, transportation, whether refrigerated or non-refrigerated, connects the different horticultural chain players and is therefore the core of logistical operations. A good logistics network links the farm, the packing house and the market, and at the same time makes use of transportation, storage and communication facilities to support efficiency and to maintain produce quality. Efficiency during transportation can be achieved by minimizing transaction delays and ensuring cargo tracking and tracing. Upon arrival at its destination, the produce must be held or rapidly transferred to shaded or temperature-controlled storage areas.

Logistical operations are more demanding in the cold chain system as temperature management is critical, starting at the farm (e.g. pre-cooling) before loading to refrigerated containers or the cargo load of the vehicle, during transport, packing house operations, distribution, and storage, up to retail display on refrigerated shelves. There are cost trade-offs in supply chain logistics as shown in Figure IX.1.2. One

Figure IX.1.2. Cost trade-offs required in horticultural chain logistics



example to describe the cost trade-off is the difference between transportation cost and inventory carrying cost. If produce is to be shipped by air, there is no need to have much inventory at the warehouse, reducing storage costs. Transportation costs are, however, high. Conversely, if produce is transported by shipping vessels, the cost of transport is low but inventory cost is high because of the long transhipment lead time. Therefore, it is the logistician's task to find the optimal solution that could give the lowest cost for the total system.

Logistical challenges of horticultural chains

Logistics planning is a prerequisite to efficient operation of horticultural chains. Supply and demand planning should analyse the capacities of the farmer, processor or packer, and transport operator, on the one hand, and the capacities of storage warehouses, food distribution centres and store outlets, on the other hand.

Changes in consumer diets, market globalization, produce branding and traceability requirements, and quality, safety and environmental concerns, all contribute to demand uncertainty. Similarly, there is supply uncertainty, particularly pertaining to the capacity of farmers to produce the desired quality and volume of the produce and the capacity of market suppliers to maintain and assure the quality of produce until it arrives at demand points. Between the supply and demand points, there is also process uncertainty, such as the availability and cost of transport and the consistency and maintenance of produce quality. Thus, supply chain and logistics planning, forecasting and management are pivotal to minimizing the uncertainties and balancing supply of produce with demand, identifying and integrating technological requirements that can be sourced from research and development institutions, reducing the logistical costs, and ensuring strong linkages among chain actors.

Conclusions

Horticultural chain and logistics management matches demand with supply of produce through collaboration among players who should work together for arrangements that are mutually beneficial and transparent. Communication along the chain ensures that all players are well informed of the requirements, demands and risks. Risks can be minimized through proper planning and integration of technological advances.

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Suggested methods of instruction

Lecture using handouts or visuals and discussion.

Time frame

One hour.

SECTION X

Good practice
for
quality maintenance in
selected horticultural chains

Section X

Module 1 – Good practices in selected fruit supply chains*

Learning outcomes

The learner should:

- develop an appreciation of models of good practice in existing fruit supply chains in Asia and the Pacific region; and
- be able to integrate the information received thus far and apply it to a real situation aiming to assure the quality and safety of fruits.

Introduction

Fresh fruits are major exports of many countries of Asia and the Pacific region. They are also widely available in the domestic markets of the region. Fruit supply chains vary in accordance with the market and intended use of the fruit.

This module reviews the activities in fruit supply chains, and model cases of fruit chain management.

Fruit supply chains

In general, harvested fruit moves from the farm to the contractor, consolidator, wholesaler, processor/packer, or directly to the exporter and domestic retailer (Figure X.1.1). From the contractor, consolidator or wholesaler, the produce may be shipped to the exporter, domestic retailer or processor/packer. The processor/packer generally interfaces directly with the exporter and domestic retailer. On arrival in an importing country, the produce is inspected first by a clearance agent before it goes to the importer/wholesaler and then to retail and food service outlets. Consumers are the end-point of the chain for both retail and food service outlets.

Fruits destined for export undergo varying treatments at each stage of the supply chain prior to shipment to importing countries (Figure X.1.2). Production and harvesting activities are conducted on the basis of advice and quality specifications from the contractor, supplier or exporter. Once transferred to the packing house, fruits are weighed and inspected for quality. They are subsequently graded, treated (e.g. washing to remove surface latex in bananas, sulphur dioxide fumigation to control peel browning in longan, or heat treatment in mangoes as a quarantine procedure against fruit flies), and packed in transport/shipping containers such as carton boxes or plastic crates in accordance with specific weight per pack recommendations. Packaged produce is subsequently palletized to facilitate loading and stacking in refrigerated container vans. Prior to loading, container vans are checked for soundness, cleanliness, and temperature/humidity conditions. Packaged produce and temperature conditions of the container are monitored during loading.

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* S. Tongdee

Figure X.1.1. Supply chains of fruits for domestic and export markets

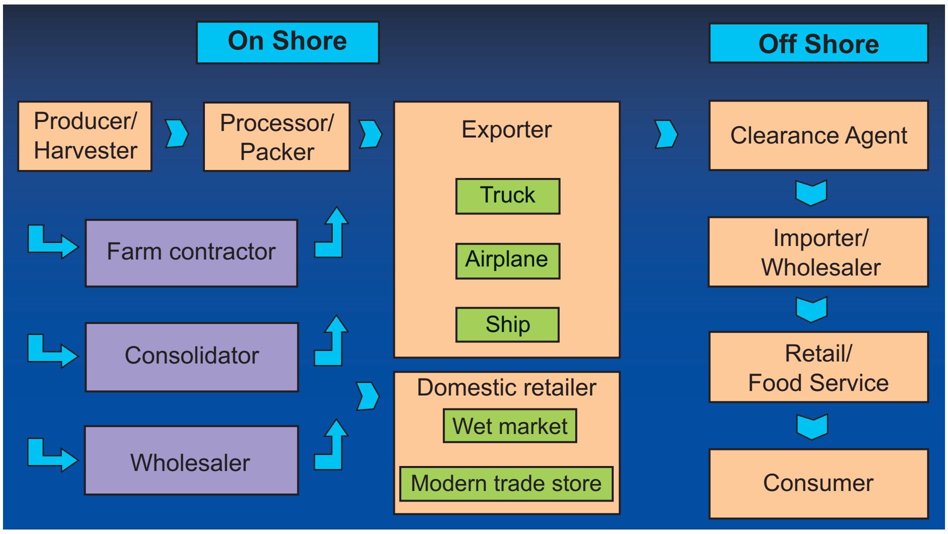
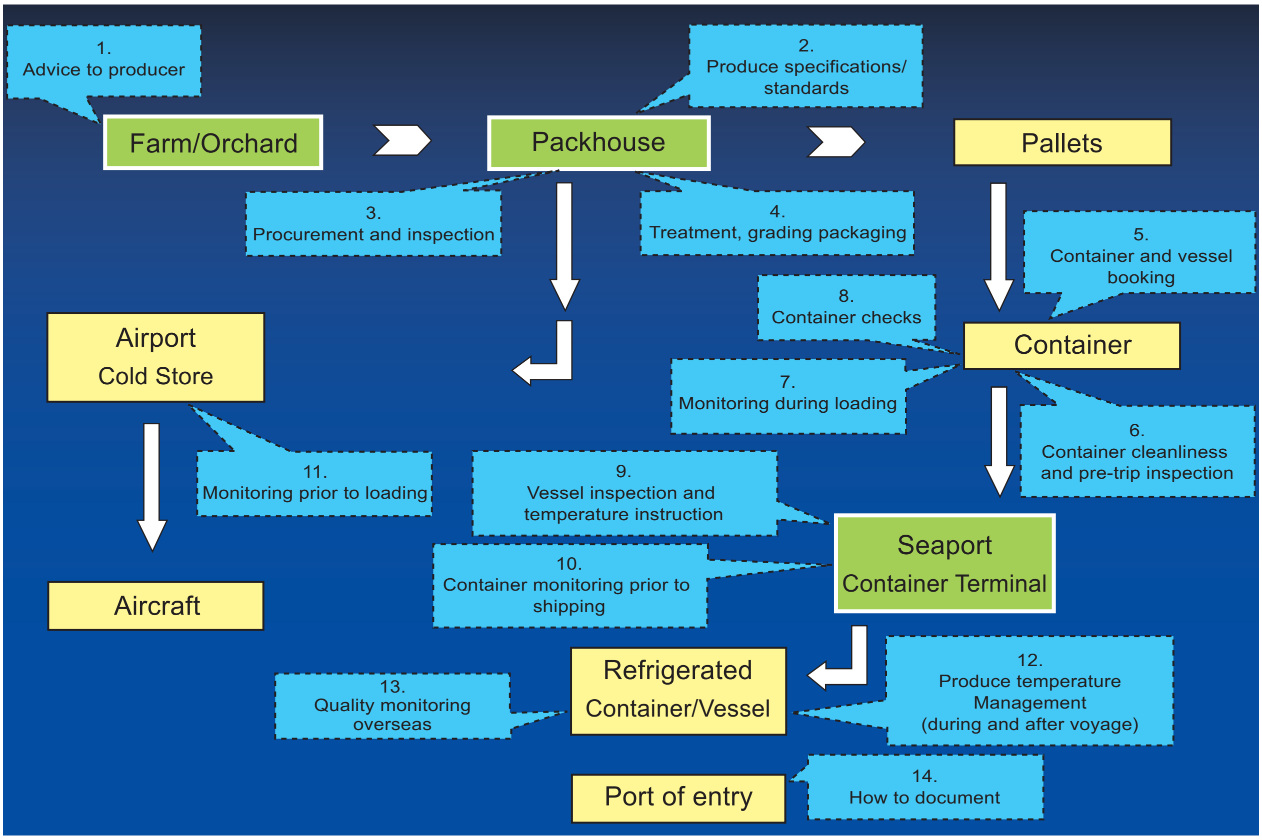


Figure X.1.2. Activities in fruit supply chains



Container vans are transported to the seaport for loading to refrigerated vessels which are also inspected and checked for their compliance with recommended temperature conditions. Throughout and after the shipment, produce temperature and quality are monitored.

Highly perishable fruits such as strawberries are commonly transported by air, wherein the packed produce is transported in refrigerated trucks to the airport or a cold storage facility at the airport. During storage and loading to the aircraft, produce temperature is checked and monitored.

Model cases of fruit supply chain management

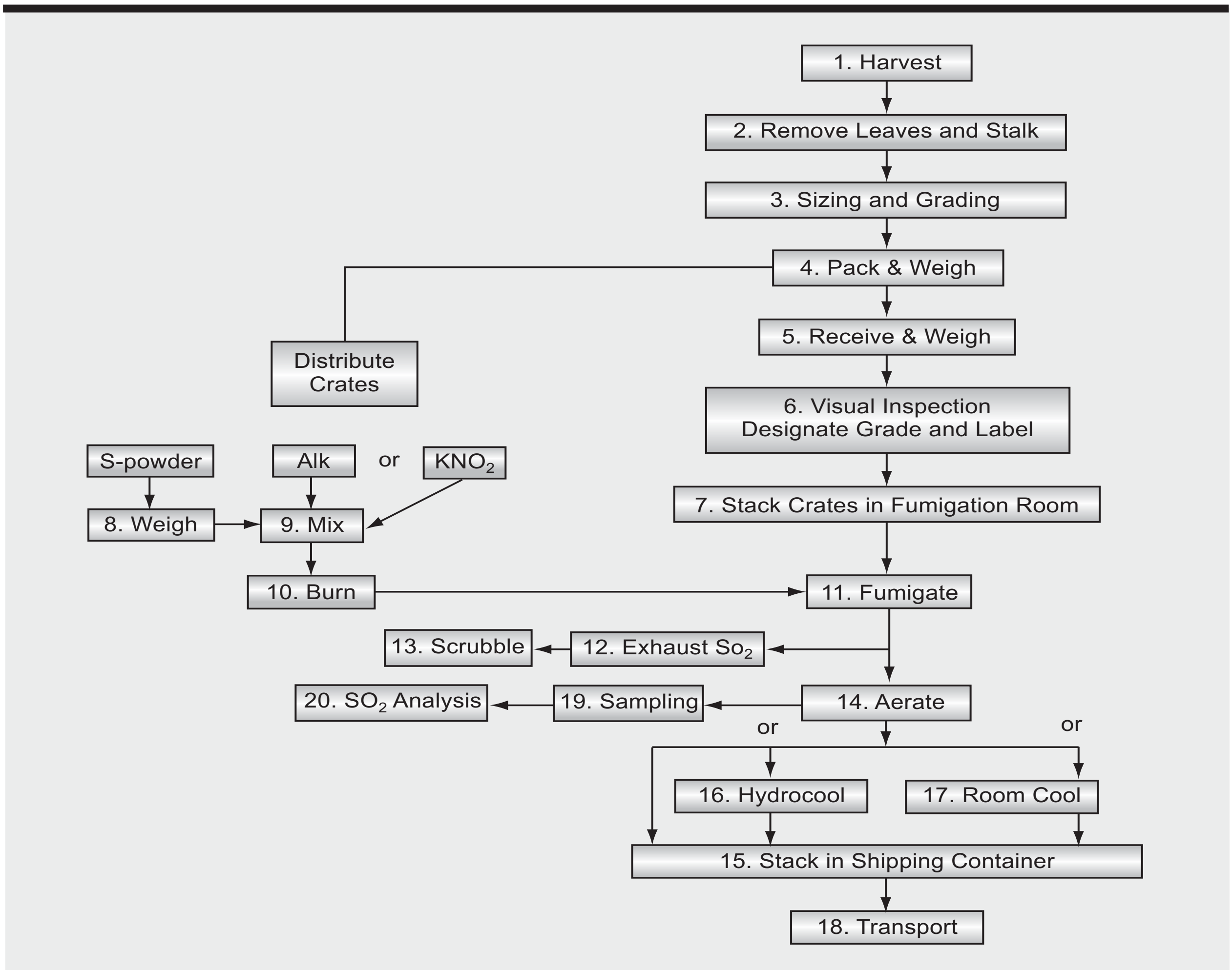
Two model cases are discussed here. The first of these describes the adoption of a post-harvest technique in the supply chain and the second describes a systems approach to chain management.

The post-harvest technique described in the first case is creative and innovative, and was developed through research and development to resolve a bottleneck in a specific chain. It was later disseminated through technology transfer. This intervention was, however, an isolated and piecemeal intervention. The systems approach described in the second case on the other hand, assumes an “adapt-and-adopt” strategy to address the technological requirements of steps within the chain and to ensure appropriate linkages, integration and cost-effective risk management. Managed integration of adapted and optimized technology is a key to the survival of the supply chain. In contrast, the adoption of a specific technology in the chain without consideration for other steps in the chain is regarded *as a key to success but without assuring* the sustainability of the chain.

Case 1 – Sulphur dioxide fumigation in longan fruit

Pericarp browning is a primary post-harvest constraint that rapidly degrades the quality of longan fruit. Sulphur dioxide fumigation was found to be the most effective treatment for addressing the problem. A protocol was therefore developed, specifying the operations before, during and after sulphur dioxide fumigation (Figure X.1.3).

Figure X.1.3. Flow diagram for sulphur dioxide fumigation of longan fruit



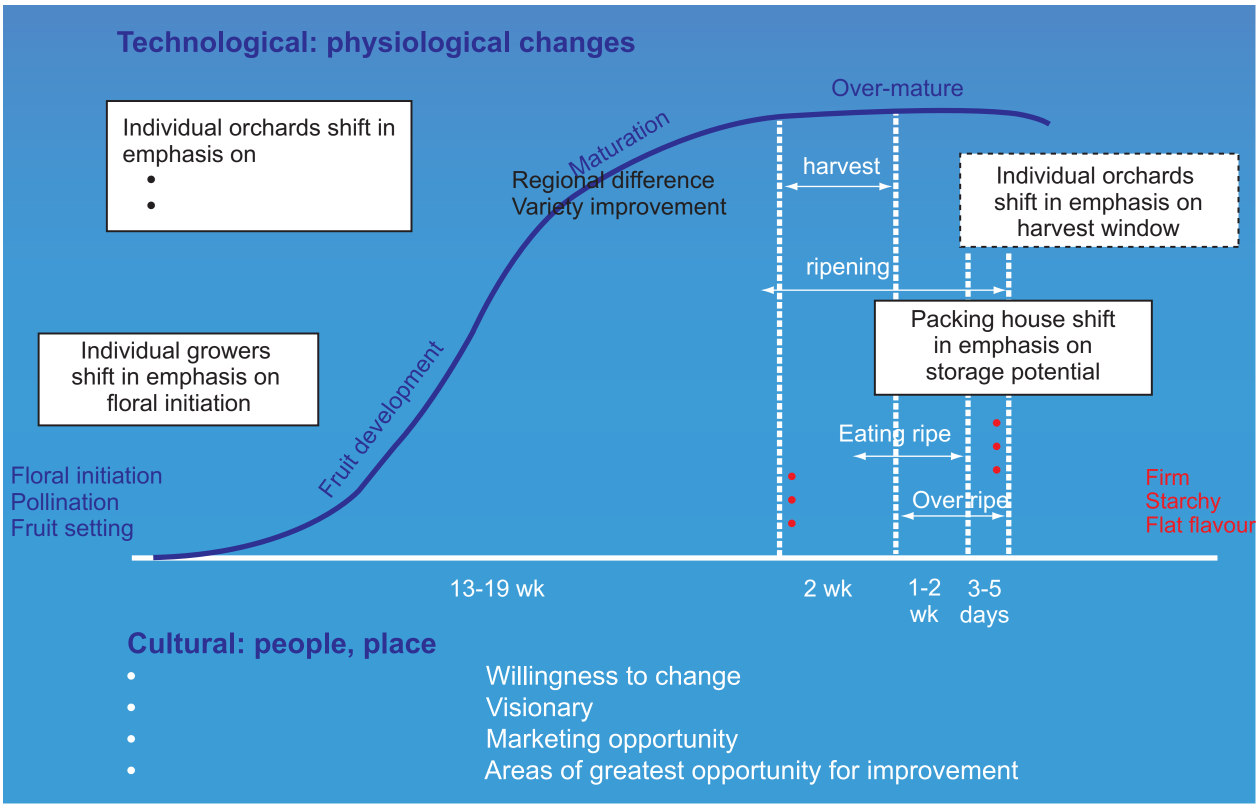
Leaves and stems are removed from harvested fruits following which they are sized or graded, packed in plastic crates, weighed, and transported to the fumigation facility. Prior to fumigation, the packed fruits are again weighed, visually inspected, and labelled. The crated fruits are stacked in the fumigation room allowing sufficient circulation through the stacks and packs. After fumigation, the fruits are aerated, cooled in a hydrocooler or cold room, and stacked in shipping containers for transport to destination markets. Following aeration, fruit samples are collected and analysed for residual levels of sulphur dioxide.

Sulphur dioxide fumigation currently faces a ban because of health and environmental concerns. This, therefore, necessitates that researchers develop alternative treatments for the control of browning. The seriousness of the gap created by the ban on sulphur dioxide could have been mitigated if from the start all the steps in the chain were considered as potential targets for interventions to maintain the quality of the fruit as it moves through the chain.

Case 2 – Systems approach to durian fruit quality management

A fruit quality management model for fresh durian was conceived, covering production through harvesting and post-harvest handling (Figure X.1.4). The model integrates consideration of both technological requirements and socio-cultural factors.

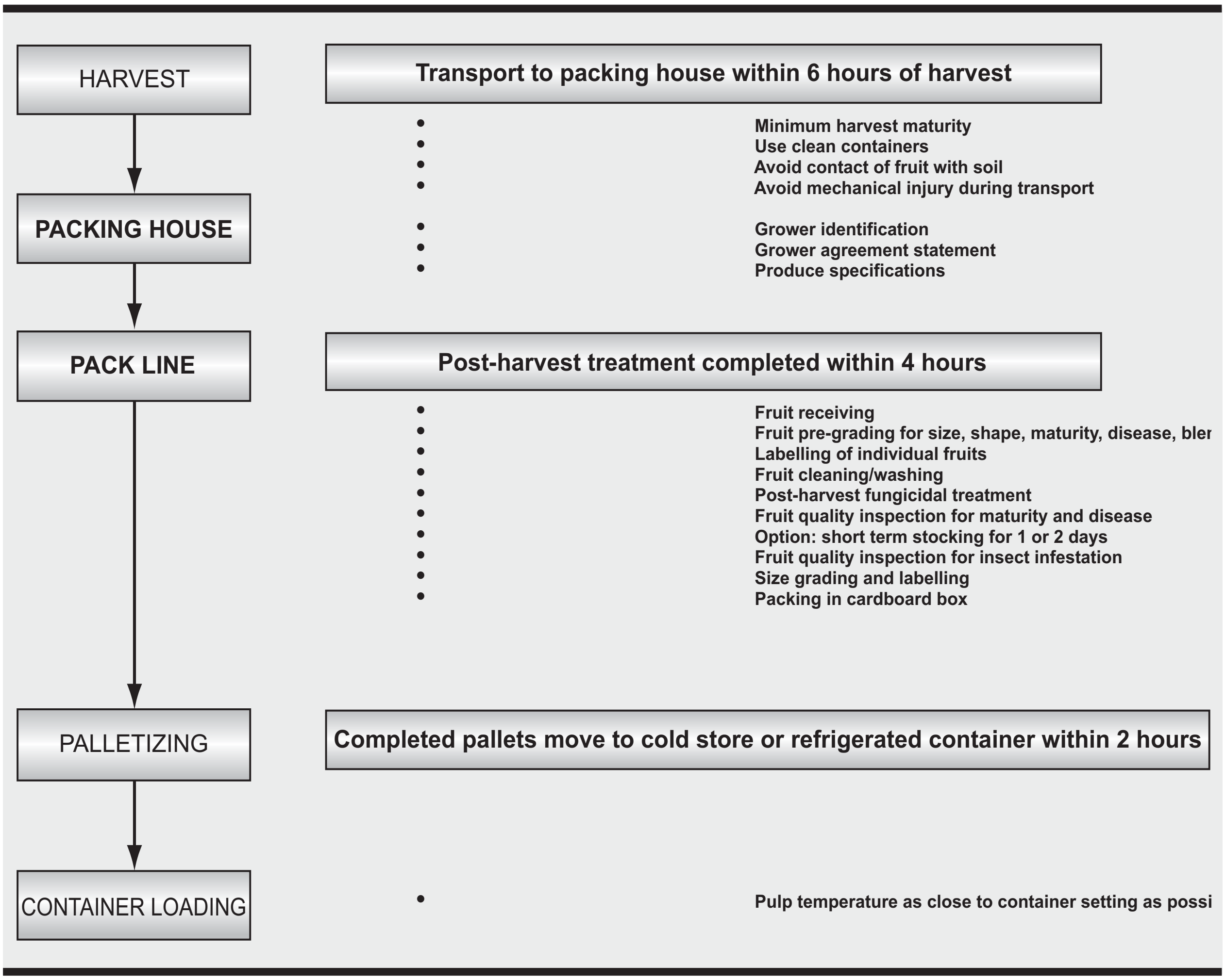
Figure X.1.4. Conceptual model for durian fruit quality management



By integrating the findings of physiological studies and technical observations of the tree and the fruit during on-tree development and after harvest, technological requirements were established. At the production stage, durian trees were found to show regional differences in performance. Work on varietal improvement, therefore, focused on selection for improved performance. At the same time, manipulation of flowering and fruit setting was studied with the objective of improving yields. With fruit development on the tree, the dry matter content increases during 13 to 19 weeks from fruit set and then levels off for about three to four weeks with maturation. This levelling-off period is critical to determining the correct stage of maturity for harvesting the fruit without compromising quality. Individual orchards shifted their emphasis to a focus on harvest windows whereas packing houses shifted their emphasis to the storage potential of the fruit. On the other hand, the socio-cultural factors included consideration of the location of the production area, stakeholders (including their willingness to change practices), presence of a shared vision among stakeholders, marketing opportunity, and areas of greatest opportunity for improvement.

On the basis of this model, a handling system for fresh durians was developed, from harvest to container loading for transport to destination markets (Figure X.1.5). At each step of the chain, simple technical and non-technical instructions were given to assure fruit quality maintenance and proper record keeping for traceability purposes.

Figure X.1.5



Section X

Module 2 – Good practices in selected vegetable supply chains*

Learning outcomes

The learner should:

- develop an appreciation of models of good practice in vegetable supply chains in Asia and the Pacific region; and
- be able to integrate the information received thus far and apply it to a real situation aiming to assure the quality and safety of vegetables.

Introduction

Vegetable supply chains are diverse because of differences in produce type, market outlets and distance to market. When driven by market demand, these supply chains become focused on maintaining produce quality and safety and become receptive to market changes and consumer requirements.

This module describes good practices in vegetable supply chains using model cases in selected countries of Asia and the Pacific region.

Vegetable supply chains

Traditional vegetable supply chains involve a number of steps and stakeholders that generally operate independently of each other (Figure X.2.1). In certain cases, the grower is financed by, or committed to a middleman. The middleman receives the crop and sells it in a wholesale market, wet market and/or supermarket. The grower may also directly sell the crop to a market. Traditional vegetable supply chains make use of low technology, with no temperature control and are reliant on selling produce within one day after harvest. Losses within such chains are very high, particularly under adverse weather conditions.

Modern vegetable supply chains are better organized. They involve value adding activities such as grading, sorting, and branding to meet market requirements for produce quality. The length of the chain and the degree of value addition is greatly dependent on the type of produce, the market and the country situation.

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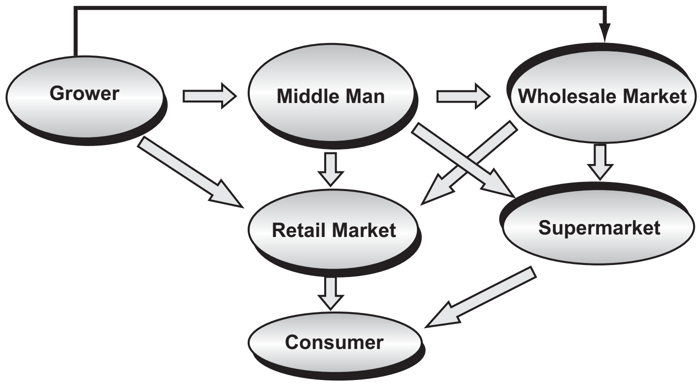
* A. Acedo Jr & S. Kanlayanarat

Figure X.2.1. Traditional supply chain for vegetables

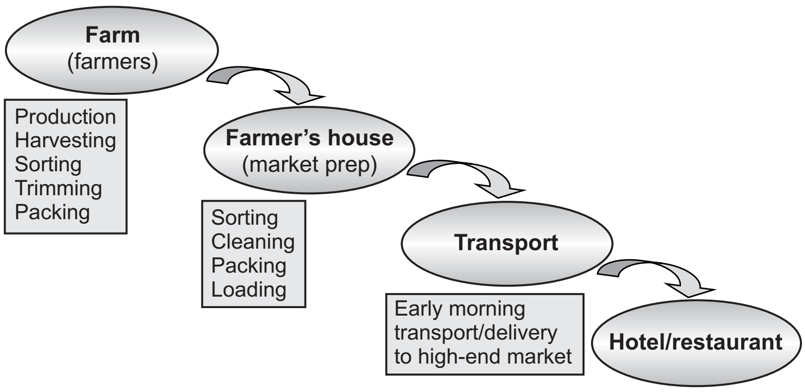


Models of vegetable supply chain management

Case of leafy vegetables in Lao PDR

This vegetable supply chain involves a small farmers group that produces a range of leafy vegetables for supply to institutional buyers in the capital of Vientiane, about 30 km from the farm. It is led by a farmer who also collects and markets the produce. Figure X.2.2 illustrates the steps of the supply chain.

Figure X.2.2. Vegetable supply chain from farmers to institutional buyers in Lao PDR



Production practices within the chain were developed through farmer experience as well as through the adoption of technologies disseminated by extension agents. Fertilizers (organic materials such as farm manure or compost and inorganic materials) and pesticides are applied in accordance with standard recommendations. Produce is irrigated using either a sprinkler system or by flooding the furrows through a network of plastic pipes attached to a water pump from a deep well. Staggered planting is employed in order to facilitate the daily harvesting and delivery of produce to market. Vegetables are harvested on a daily basis between 16.00 hours and 20.00 hours in order to avoid heat from the sun. Harvesting is performed with the use of a sharp knife or clipper in the case of pakchoi, petchai and green mustard, or by uprooting the whole plant in the case of kale and Chinese mustard.

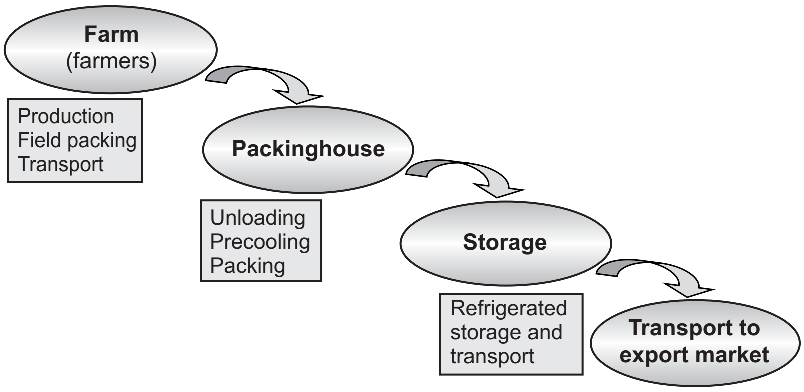
Harvested produce is trimmed, sorted on the basis of size uniformity and freedom from defects and is packed in baskets made of either bamboo or plastic strips. In the case of leafy vegetables such as kale, harvested produce is allowed to undergo temporary wilting (by holding at ambient temperature under shade in the field for about an hour) in order to reduce turgidity and susceptibility to leaf tearing during subsequent handling. All of these activities may be done in the field, under a makeshift shed, or beside a shaded part of the farm house.

On arrival at the farmer-collector's house, the vegetables are further cleaned or trimmed, sorted and repacked. The roots are trimmed off kale and Chinese mustard, after which they are cleaned of adhering soil and rehydrated by washing. Salad vegetables such as lettuce are repacked in plastic bags without washing, each bag weighing about 12 kg. Other vegetables are packed in plastic-strip baskets for large-volume orders. Prepared vegetables are delivered to hotels and restaurants.

Case of vegetables for export in Myanmar

The supply chain in Myanmar (Figure X.2.3) involves small farmers who supply vegetables to state-owned packing house facilities that specialize in the export of fresh fruits and vegetables. On arrival at the packing house, vegetables (e.g. lettuce and broccoli) in plastic crates are pre-cooled with water (1°C) containing a sanitizer. After air drying, the vegetables are packed in air-tight plastic bags and cartons. Packed produce is stored in cold rooms with 10-ton capacity and is subsequently transported by a refrigerated truck to the airport for shipment to importing countries.

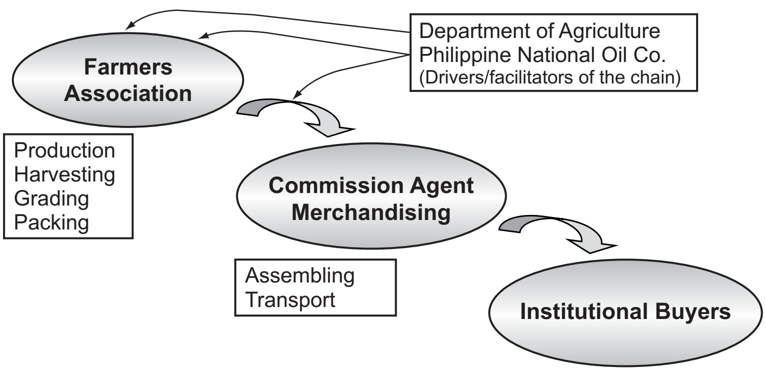
Figure X.2.3. Vegetable supply chain from farmers to export in Myanmar



Vegetable supply chains in the Philippines

Vegetable supply chain from farmers to institutional buyers – This supply chain (Figure X.2.4) involves a small farmer organization that is linked to institutional buyers in an urban market. There are three major chain participants: the furthest upstream is a farmers association, followed by the commission agent and wholesaler that delivers the produce to city institutional buyers such as hotels and restaurants as well as retailers in wet markets and grocery stores. Drivers and facilitators of the chain include extension workers from the Department of Agriculture and government-owned corporations.

Figure X.2.4. Vegetable supply chain from farmers to institutional buyers in the Philippines



The farmers association produces carrots, Chinese cabbage, pepper, salad vegetables (e.g. lettuce and pickling cucumber) and potatoes. The association has progressed from applying traditional open cultivation farm operations, to the adoption of partial and completely protected cultivation systems (e.g. use of plastic houses), particularly for lettuce, peppers and tomatoes. Vegetable planting is coordinated to meet market expectations and the volume requirements of buyers. The association keeps records of crops grown by farmers and the time of planting in order to facilitate programming and scheduling of harvest. Inputs are applied in a timely manner and vegetables are harvested on attaining commercial maturity. Harvesting is usually done late in the afternoon (15.00 hours to 16.00 hours) and sorting and grading are done on farm in the presence of the buyer who provides quality specifications as regulated by the Department of Agriculture. Timing and volume of harvest and price are negotiated between the farmers association and the buyer.

Produce is hauled to nearby access roads for transport to the city market using light trucks between 24.00 hours and 03.00 hours. On arrival at the market, vegetables are further sorted and stored in a warehouse if they cannot be distributed on the same day.

Lettuce cold chain – This supply chain involves small vegetable growers of a highland province who were initially involved in producing vegetables such as lettuce, carrots and garden peas for local traders in a city market some 75 km away. Approximately 100 kg of lettuce was sold to local traders on a weekly basis through a company that experienced difficulty because of the low price and 25 percent allowance for trimmings. An alternative market was sought resulting in the weekly sale of 200 kg lettuce to fast food outlets in a metropolitan city market on another island. This lettuce was transported by boat. An additional market (vegetable processor supplying large fast food outlets) in the country's capital was subsequently identified. This market required approximately 400 kg of lettuce on a weekly basis, by air freight shipment. Apart from the high cost of air freight, lettuce delivered to the processor did not meet the 61 percent yield specified in the marketing contract, because of the need for 16 to 20 percent trimming. Attaining the high quality standards of the fast food processor was a formidable challenge to the growers.

In order to reduce freight cost, refrigeration and shipping facilities were made available by the processor, who also facilitated the provision of technical advice on improved production and post-harvest practices. Lettuce orders increased to 3.5 MT per week, thus necessitating the use of a 20-foot refrigerated van. Other lettuce growers were involved and formed a cluster that shared production technologies to come up with a common quality standard.

The lettuce cold chain (Figure X.2.5) now makes use of refrigerated transport by land and sea and has reduced trimmings to 10 percent meeting the processor's requirement for a 61 percent yield recovery.

Lettuce is transported to the company's packing house immediately after harvest for consolidation, cleaning, sorting and air drying. It is cleaned by wiping with a cloth to remove soil and other dirt particles, following which it is air dried. Citrus (calamansi) juice, alum, or ascorbic acid is applied to the cut portion of the lettuce in order to prevent browning. Lettuce heads are carefully arranged in nestable plastic crates with a brown paper lining placed between layers of lettuce. Each layer of lettuce consists of 12 lettuce heads. Vents within the crates help to maintain vegetable quality in transit. Crates of lettuce are loaded into a 20-foot refrigerated van that is subsequently transported to the seaport and then to the capital city, via a 40 hour journey.

Vegetable supply chains in Thailand

Vegetable supply chain of a food corporation – This supply chain is controlled by a food corporation which supplies vegetables to its chain of supermarkets (Figure X.2.6).

Figure X.2.5. Lettuce cold chain in the Philippines

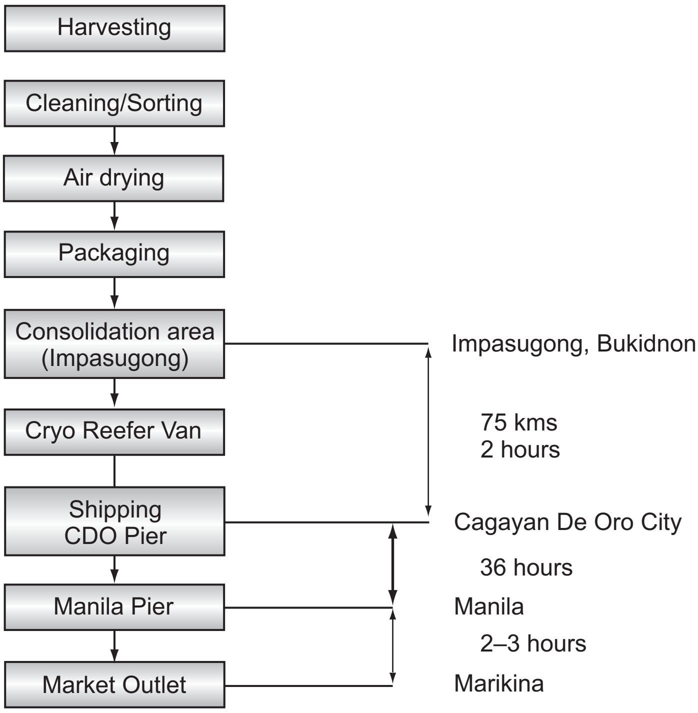
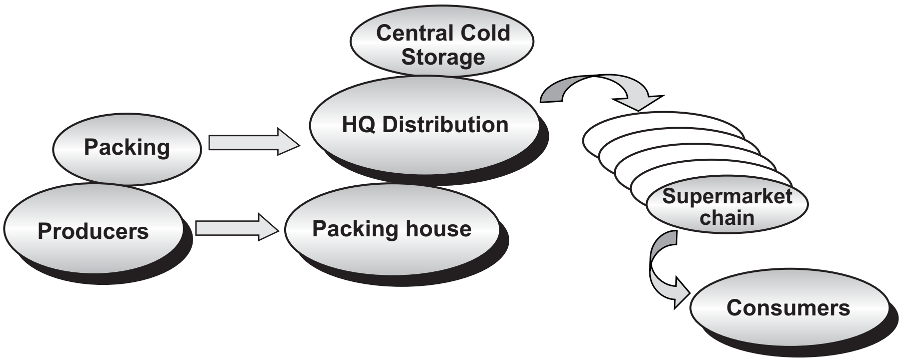


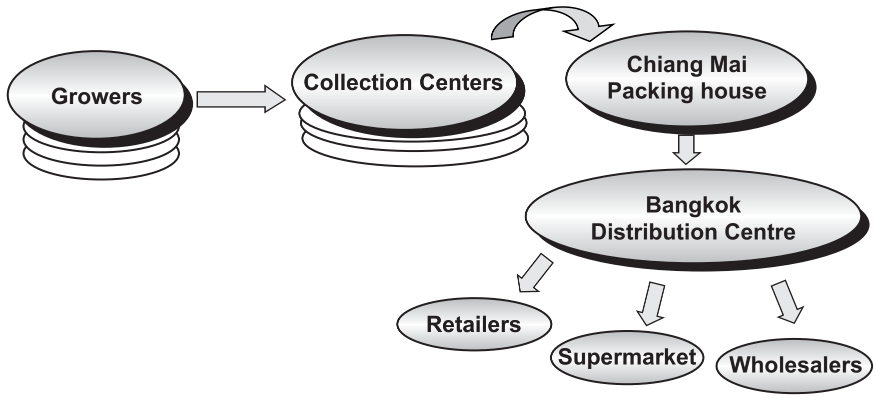
Figure X.2.6. Private sector-initiated vegetable supply chain in Thailand



Farmers are contracted to grow vegetables in accordance with recommended production practices established by research institutions. The pricing of farmers' produce is dependent on prevailing market prices. Depending on the crop, harvested produce is sorted, packed on farm and brought to the company's headquarters for subsequent distribution. Other crops are brought to the company's packing house for grading, in line with quality standards established by the company, packing and holding/storage. The packing house is located in the vicinity of the company's headquarters and distribution centre. If produce cannot be marketed on the day of arrival at the distribution centre, it is stored in the company's central cold room. Produce is subsequently distributed to supermarket outlets in refrigerated trucks and is displayed on refrigerated shelves.

Vegetable supply chain in the Northern Highlands of Thailand – This supply chain (Figure X.2.7) was developed as a Royal Project initiative in the northern highlands to eliminate opium cultivation, alleviate poverty, and preserve the highland environment.

Figure X.2.7. Public sector-initiated vegetable supply chain in Thailand



Vegetables (cabbages and other temperate crops) are produced in accordance with production techniques recommended by project researchers. They are subsequently harvested by growers who deliver them to collection centres. On arrival at the collection centre, they are evaluated for quantity and quality and are cleaned, trimmed and checked for chemical residues such as fertilizers and pesticides (if found to be unsafe, they are rejected). Vegetables are subsequently packed, pre-cooled (if needed), and stored in cold rooms.

Post-harvest centres are very well equipped with conveyors, carts, crates, measuring devices, displays showing quality guidelines, cutting and trimming devices, pre-cooling facilities and cold rooms. Produce is collected from the centres by small refrigerated trucks and is transported to the packing house, which serves as a central collection point. The packing house is fully equipped and generally employs more than a hundred people.

At the packing house, produce quality is checked and produce is trimmed, washed, evaluated for chemical residues, and then packed again. Produce of a low grade or excessive quantities of produce are reserved for sale to food processing companies.

Packed produce is transported to the central distribution centre in the capital city in large refrigerated trucks. On arrival at the central distribution centre, produce is again checked for volume and quality and is either transferred to cold rooms or is delivered to market outlets which make use of refrigerated shelves for retail display.

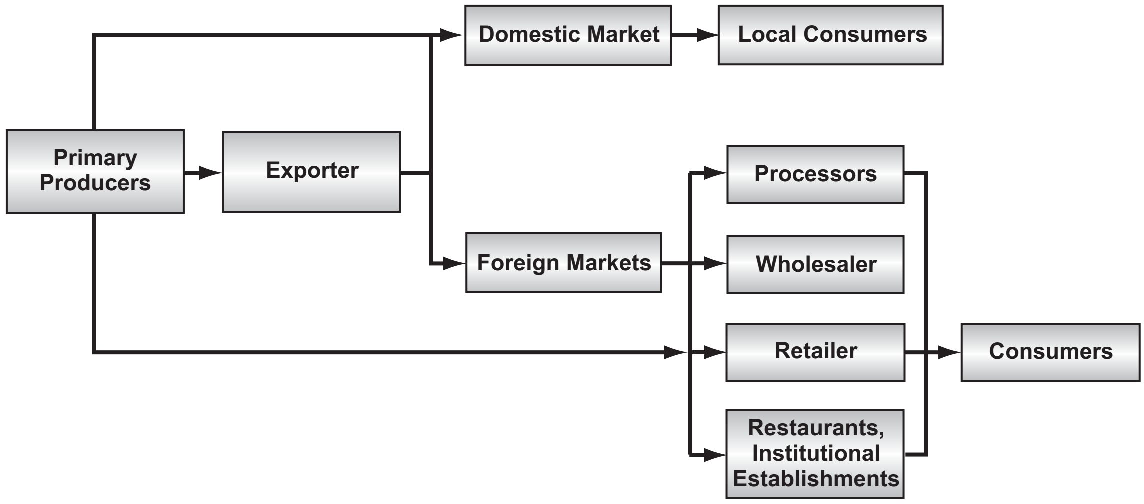
Asparagus supply chain for export – Asparagus is a high value cash crop that contributes approximately 11 percent of Thailand's total exports of fresh/frozen vegetables. It is produced primarily by small farmers (average land holding is about 3 rai/household, approximately 0.5 ha) for export. The asparagus supply chain is illustrated in Figure X.2.8.

A number of quality management problems are encountered in asparagus export chains. These include insect pests and diseases caused by moulds, thrips, insects and worms, non-compliance with pesticide MRL, physiological defects because of improper harvesting, packing and storage, bacterial decay caused by *Erwinia carotovora,* and non-compliance with quality specifications (e.g. size, breakage and bruising).

Government and private-sector initiated strategies have, therefore, been developed in order to address these problems.

- Government sector-initiated actions have included the promotion of organic farming, strengthening of pesticide monitoring systems, requirements for the registration of farmers and pesticide/pest testing for SPS clearance, the conduct of training and promotion of food safety programmes such as GAP at farm level and Plant Quality Management Systems on produce destined for export, to ensure food safety from farm to table.

Figure X.2.8. Asparagus supply chain in Thailand



- Private sector-initiated actions have included training on GAP and market quality specifications, information sharing including information pertinent to regulatory updates, quality system implementation, rigid monitoring of chemical usage and testing of chemical residues.

Implementation of quality management systems differ in accordance with farming arrangements. In situations where direct contract farming arrangements exist, exporters impose standards that are communicated to farmer leaders/trainers who train and monitor participating farmers. For middleman-mediated chains, national standards are followed. In the case of vertically integrated chains, private standards that are compliant with international standards such as GlobalGAP are used.

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Suggested methods of instruction

Lecture using visuals or handouts and discussion.

Practical exercise

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

Time frame

One hour for the lecture and discussion.
Two hours for the practical exercise.

PRACTICAL EXERCISES

I. Introduction to the practical exercises*

Learning by doing and observation facilitates the absorption of knowledge and increases the confidence of trainees in relaying such knowledge when they subsequently serve as trainers. In the same manner, the ultimate trainees, namely farmers and other participants in the horticultural chain, who are the direct users of technological breakthroughs and information, should more easily understand and accept what is being disseminated, thereby facilitating change in their usual thinking and practices. Practical exercises also invigorate trainees and create a livelier training environment.

This practical manual complements the theoretical manual and covers field observations, hands-on exercises and actual observations of pre-set experiments during field visits designed to enhance trainees' understanding of the theoretical aspects of the training given in the lectures and to initiate the development of skills needed to replicate the training in the respective countries of the trainees. This manual can be used as a guide for the development of context-appropriate national training programmes and hands-on training packages for small-scale farmer-learner programmes.

Each practical exercise is linked to one or more topics in the lectures. The different approaches used are as follows:

- **Surveys:** A market survey is introduced to expose participants to the different types of fresh produce marketing, to develop or enrich their skills in conducting surveys, and to enhance critical thinking when the survey results are analysed. The survey methodology is discussed prior to the survey. Results are then discussed in a plenary session.
- **Field visits:** Observations of actual operations in the fruit orchard or vegetable farm, packing house and market provide the participants with first-hand experience of horticultural chain operations and management. The guide to field visits gives some basic background information on the site to be visited and highlights the key points that should be observed during the visit.
- **Experimental exercises and observations:** These include introductory presentations and demonstrations by the trainers and actual execution and/or observation by the trainees. Each trainee or group of trainees assigned to a certain commodity or treatment takes notes, records results, and discusses and compares the results with the other trainees or groups of trainees in a plenary meeting. Experimental exercises are designed to be very demonstrative and informative using basic and inexpensive equipment and materials, such that they can be duplicated easily under the conditions faced by the trainees in their respective countries.
- **Problem solving:** This approach refers to brief discussions of classic case studies, which allow trainees to apply lesson concepts as they work through each problem.
- **Tasks:** Tasks are selected to provide the participant with a basic understanding of the issues at stake. The discussion sessions emanating from each task provide an opportunity for participants to contribute their experiences and to contextualize the ideas transmitted during the theoretical training.

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* S. Kanlayanarat, R. Rolle and A. Acedo Jr

II. Meeting the consumer*

1. Observing consumer behaviour and the diversity of products in the market

Purposes

- to apply the principles of consumer behaviour to real-life food product examples in different types of retail market; and
- to observe retail practices and document the diversity of fresh fruit and vegetable products.

Procedures

Trainees are separated into groups of up to six members. Each group is assigned one fruit or vegetable commodity. Three types of retail outlets: a traditional market; middle-level supermarket; and upper-level/expatriate supermarket (if available) will be visited. During these visits, the trainees will observe consumer behaviour and record their observations and the responses of retailers using the prepared data sheets as attached. The observations and results will be discussed in a plenary meeting.

Activities during the visit

- Observe the general appearance of the store.
- Observe the location of produce in the store.
- Observe the produce display in the store.
- Observe the produce packaging.
- Observe the produce quality.
- Observe consumer behaviour.
- Record the variety of products for the assigned commodity and other information requested in the data sheet. Interview the retailer or salesperson if necessary to obtain the required information.

Tasks following the visit

- Write a summary of critical observations and comparative results from the three types of retail market.

Discussions and feedback

- Trainees should present brief feedback on key observations in the markets and discuss their significance.

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* J.J. Cadilhon

Observing consumer behaviour and the diversity of products in the market

Commodity name: ___________________________________

Complete the table below about the variety of products on display in the **traditional market**

	Fill in as much detail as possible					Reply: Yes or No		
	Name or description of product	Price/kg or/unit (Thai baht)	Country of origin	Health and safety sign	Other quality signs	Ready to eat? Ready to cook?	Can buy in small quantity?	Price promotion?
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Commodity name: ___________________________________

Complete the table below about the variety of products on display in the **middle-level supermarket**

	Fill in as much detail as possible					Reply: Yes or No		
	Name or description of product	**Price/kg or/unit (Thai baht)**	**Country of origin**	**Health and safety sign**	**Other quality signs**	**Ready to eat? Ready to cook?**	**Can buy in small quantity?**	**Price promotion?**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Commodity name: ___________________________________

Complete the table below about the variety of products on display in the **upper-level and expatriate supermarket**

	Fill in as much detail as possible					Reply: Yes or No		
	Name or description of product	Price/kg or/unit (Thai baht)	Country of origin	Health and safety sign	Other quality signs	Ready to eat? Ready to cook?	Can buy in small quantity?	Price promotion?
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
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III. Field visits*

1. Visit to a fresh produce market

Purposes

- to observe the flow of produce, management of produce flow, cash flow and transactions, stakeholder interaction, hygiene, waste and quality management systems in a fresh produce market; and
- to understand the elements of supply chains that are integrated to assure the safety and quality of fresh produce.

Field site protocol

Visiting a fresh produce market is interesting, but it can also be risky if certain protocols are not followed. Participants are requested to observe these protocols to ensure that maximum benefit can be derived from the visit. Fresh produce markets are extremely busy during trading hours and participants are requested not to interfere with the normal flow of goods or with the work of traders and other workers. Participants should at all times remain with the group and ensure that no one falls behind; the group should remain at the sides of the halls to avoid injuries caused by fast moving forklifts and trucks.

Activities during the visit

- Make notes of critical questions and observations for discussion after the visit.
- Observe and take note of the general situation of the market (cleanliness, orderliness, produce presentation, other observations deemed relevant).
- Observe the transactions of produce delivery and note the stakeholders involved, produce packaging, produce quality if possible, payment schemes (cash, consignment, other payment modes if any). If possible, interview the people involved in a manner that will not disrupt their activities and gather information on: source of produce, treatments applied to preserve weight and quality, packaging units, transport method and duration, etc.
- Observe the produce on display and the transactions between sellers and buyers/consumers. In cases where there are no buyers, sellers must be interviewed to verify produce presentation, vending prices relative to acquisition prices, problems, methods for preserving quality, losses, waste disposal, other quality maintenance and hygiene practices.
- Note the strengths and weaknesses of the practices observed in the market.

Tasks following the visit

- Draw the supply chain for a selected fresh produce item, charting the different types of activities and links in the chain, and distinguishing between those that involve physical transformation and those that reflect service inputs.
- Write a one-page summary of critical observations of systems, failures and strengths of the market and relate it to the situation in your country.
- Make a report during a plenary discussion period for that purpose.

Discussion and feedback

- Present brief feedback on key observations at the market and on the supply chain for the selected produce item.
- Write a brief summary of key discussion points of practical value to your country.

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2. Visit to an orchard

Purpose

- to visit an orchard in order to observe the implementation of general principles of Good Agricultural Practices (GAP).

Field visit protocol

When visiting an orchard, adherence to strict codes of conduct must be observed in order to derive maximum benefit from the visit. Trainees should remain with the group at all times. A limited number of questions may be asked during the visit, but the tour guide should also be given ample time to explain the system.

Code of conduct for the visit

- Dress appropriately (wear closed shoes, for example).
- Do not smoke, do not litter, and be attentive to moving vehicles.
- Refrain from touching fruit in the orchard.
- Do not eat or drink while on the tour.
- Be respectful and friendly to all staff and workers.

Activities during the visit

- Make notes on critical questions and observations for discussion after the visit.
- Note strengths and weaknesses of the management systems and the handling operations and non-compliance with GAP principles.
- Observe the general sanitation of the orchard and note practices observing GAP and good hygiene practices (GHP).
- Observe systems for identifying orchard blocks to facilitate traceability of produce.
- Observe harvesting operations and the use of specialized tools during such operations.
- Observe harvesting containers (type and approximate size or weight).
- Observe field handling operations, including collection of harvested produce, collection containers, other packing materials, method of packing, stacking, and temporary holding prior to hauling.
- Observe produce quality.
- Observe produce sorted out in the field and its disposal.

Tasks following the visit

- Draw the flow of activities in the orchard until the harvested produce is ready for hauling to the pack house.
- Write a one-page summary of critical observations in the orchard regarding conformance and non-compliance with GAP principles.
- Present a report during a plenary reporting session.

Discussion and feedback

- Present a brief feedback on key observations in the field during a plenary discussion session.
- Write brief summary of key discussion points of practical value in your country.

3. Visit to a packing house

Purpose

- to observe process flow, pack line operations, hygiene, waste disposal and quality management systems in a packing house.

Field site protocol

When visiting a packing house, a strict code of conduct must be observed if maximum benefit is to be derived from the visit. Participants should remain with the group at all times. Participants should be aware of fast moving forklifts and other vehicles. A limited number of questions may be asked during the visit, but the packing house manager or representative should also be given ample time to explain the system.

Code of conduct for the visit

- If you have any septic wounds or are feeling sick do not enter the facility with the group (wait at the office).
- Dress appropriately (for example, wear closed shoes, hair tied back, warm jacket for visits to cool storage).
- Remove jewelry prior to entering the packing house.
- Wash hands thoroughly prior to entering the packing house.
- Wear protective clothing as provided; this may include hair or beard nets, clean coats, boots or shoe coverings.
- Do not smoke, do not litter, and be attentive to overhead structures and forklifts.
- Refrain from touching equipment and/or products.
- Do not eat or drink while on the tour.
- Be respectful and friendly to all staff and workers.

Activities during the visit

- Make notes on critical questions and observations for discussion after the visit.
- Note strengths and weaknesses of operations and any non-compliance with GAP or GHP.
- Observe the lay-out of the packing house and sketch the locations of the different activities and facilities.
- Observe the general sanitation of the packing house, drainage and waste disposal systems.
- Observe packing line operations and note the sequential activities.
- Observe each operation and if possible, ask questions pertinent to some specific treatments (e.g. wash water used, sanitizer, grading system, use of rejected produce, special treatments such as pre-cooling, fungicide treatment or waxing).
- Observe packing operations and note down the package used, other packing materials (e.g. liner, divider, foam nets, others), packing method (e.g. jumble or place pack, strapping, other relevant information), and stacking procedure.
- Observe storage procedures and facilities. If possible and if not given, ask a few questions on specific storage requirements (e.g. temperature and RH), storage period prior to dispatch, hygiene, and other relevant information.
- Observe surroundings of the packing house and note the sanitation conditions (e.g. well-paved or not) and adequacy for vehicle movement.

Tasks following the visit

- Write a summary of observations in the packing house: product flow, activities, sanitary practices, and other practices including compliance and non-compliance with GAP/GHP principles.
- Present a report during a plenary reporting session.

Discussions and feedback

- Present brief feedback on key observations in the packing house.
- Write brief summary of key discussion points of practical value in your country.

IV. Measuring fresh produce quality*

Introduction

The quality of fresh produce can be determined using physical, chemical and sensory methods. Physical measurements of the appearance (e.g. colour, visible symptoms of defects such as surface browning, decay and wrinkling) and textural quality (e.g. hardness or softness, odour or aroma) of the produce are carried out, whereas chemical measurements of the carbohydrate and organic acid content of the produce are carried out. Sensory measurements employ a taste panel for flavour evaluation (subtle and complex perception combining taste, mouth feel/texture and aroma). Sensory panels are also used to evaluate the appearance of produce and to detect undesirable changes in flavour (i.e. off-flavour or off-odour).

Purpose

- to understand the different methods of measuring the physical, chemical and sensory quality attributes of fruit and vegetables.

1. Colour measurement

Introduction

Colour perception depends on the type and intensity of light, the chemical and physical characteristics of produce and the ability of an individual to perceive the colour. Colour is measured using subjective and objective methods.

Guidelines on performing measurements

Subjective methods rely on the human eye. A colour index is formulated and is matched with a colour chart that corresponds to the developmental stages of a specific produce item. The Munsell colour atlas is used as a guide in developing colour charts for fresh produce (Figure IV.1).

Figure IV.1. Munsell colour chart (a) and colour chart for citrus (b)

(a) **(b)**

Examples of colour charts and indices are given in Figure IV.2 and Figure IV.3.

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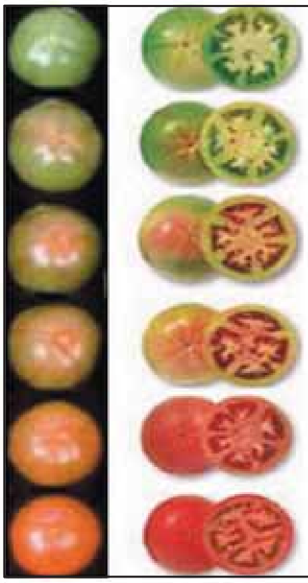
Colour indexing and colour chart matching are, however, prone to human error because of differences in colour perception. Trained panelists may be required to reduce the bias. The light exposure and quality of light at the time of measurement may also affect colour perception.

Figure IV.2. Peel colour index and USDA colour chart for tomatoes

Tomato color index



1	Green, varying from light to dark
2	Breaker, first appearance of pink, red or tannish yellow; not more than 10%
3	Turning; over 10% but not more than 30% pink, red or tannish yellow
4	Pink; over 30% but not more than 60% pink or red
5	Light red; over 60% but not more than 90% red
6	Red; over 90% red

Tomato color index (USDA)

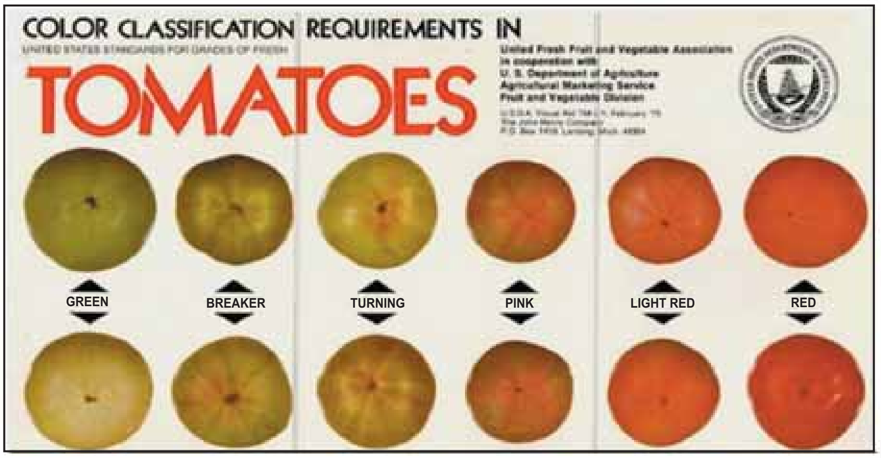
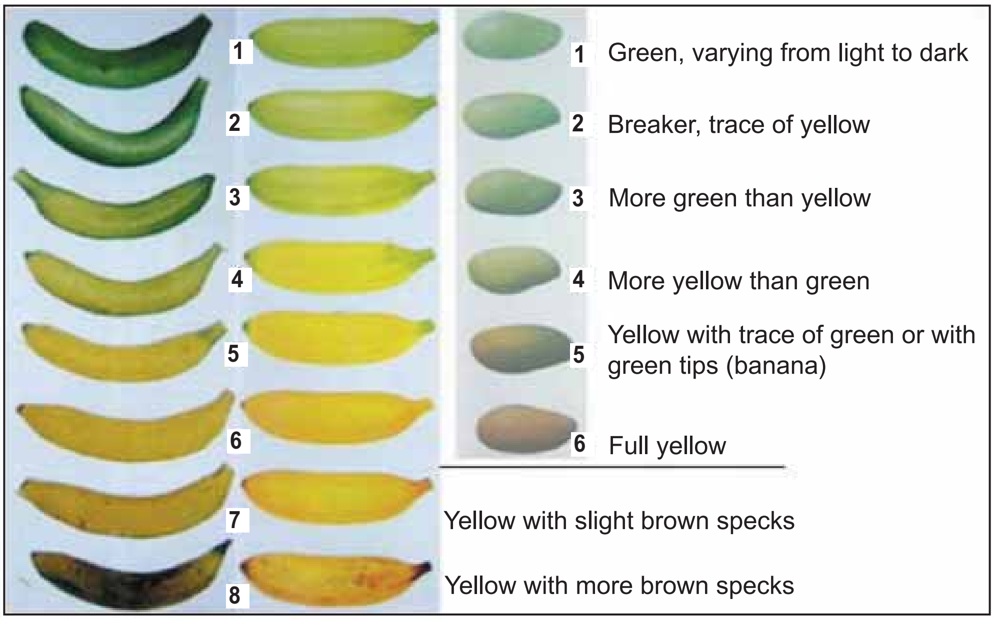
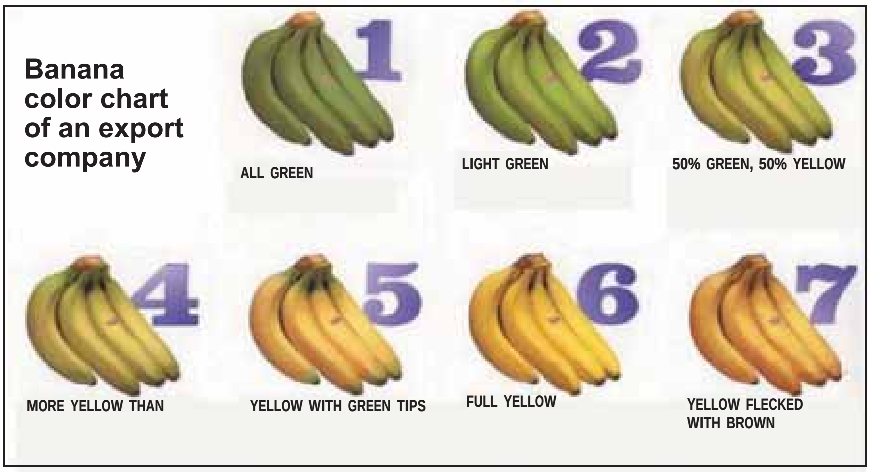
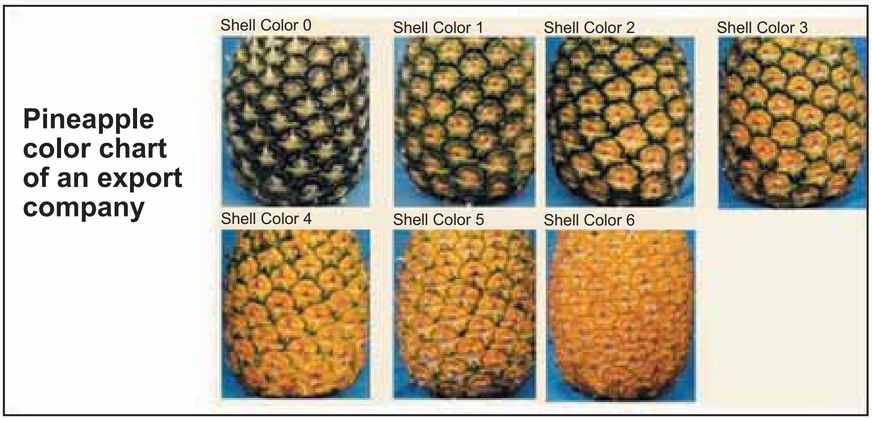


Figure IV.3. Peel color index for banana and mango and color charts for banana and pineapple

Banana and mango color index



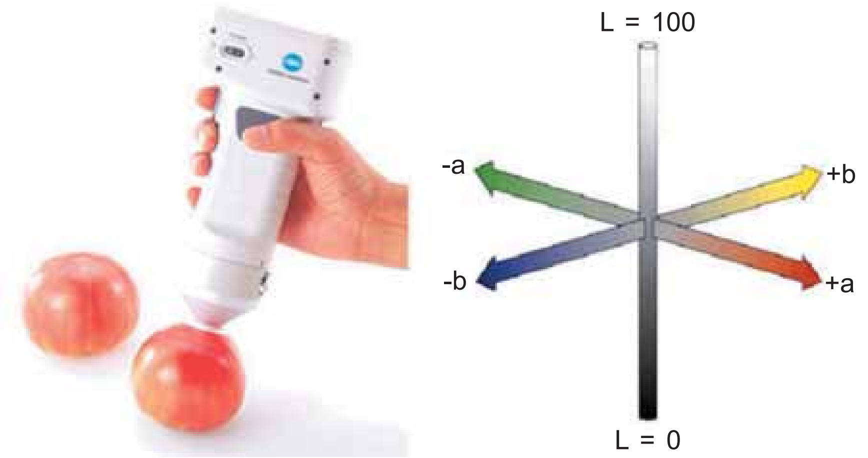




A **colorimeter** is used for the objective measurement of colour and can detect small differences in colour. It gives values for colour coordinates L* (lightness), a* and b* (Figure IV.4). Readings obtained with the use of a colorimeter show a small degree of variation.

Obtaining colorimetric measurements is however costly and more time consuming than using colour indices.

Figure IV.4. Colorimeter and colour attributes lightness (L*), a* and b*



Procedures

- Demonstrate use of a colorimeter with fruit and vegetable samples.
- Show trainees how to calculate hue angle (h°) and chroma (C*).
- Allow trainees to perform colour measurements and calculation using given samples.

2. Measurement of firmness

Introduction

During maturation and ripening, fruits and vegetables soften because of the dissolution of the middle lamella of the cell walls. Softening can be subjectively estimated by finger or thumb pressure. A more precise objective measurement of softness or firmness is obtained with the use of fruit pressure tester or penetrometer (Figure IV.5).

Sampling

Samples should be randomly selected, and should represent at least 3 percent of the total number of samples. The samples should be of uniform size and of uniform temperature.

Guidelines on performing measurements

Measurements must be taken at two points for each fruit sample. The peel of the sample must be removed using either a peeler or knife and the sample must be held against a hard surface prior to forcing the tip of the plunger at uniform speed. The size of the plunger varies in accordance with produce type: 11 mm for apples; 8 mm for avocadoes, kiwifruit, mangoes, papayas and peaches; 3 mm for soft fruit such as cherries, grapes and strawberries; and 1.5 mm for olives. The force required to penetrate a certain depth of tissue is measured either in Pounds (lb) or kg and is expressed in Newton (N = lb x 4.448 or kg x 9.807).

Procedure

- Demonstrate the use of different kinds of pressure testers on different fruit and vegetable samples.
- Allow participants to perform firmness measurements.

Figure IV.5. Firmness/texture testers for fruit and vegetables

Penetrometer

UC firmness tester
(force gauge mounted on drill press stand)

Plungers for penetrometer

Texture analyser

3. Measurement of soluble solids

Introduction

Sugars are the major soluble solids present in fruits and vegetables. Soluble solids content (SSC) is commonly measured with the use of a **refractometer.** A refractometer provides a measure of the refractive index, which indicates the extent to which a light beam is slowed when it passes through a sample.

Refractometers may be either hand-held or digital (Figure IV.6). Hand held refractometers have a high potential for operator error in reading values, thus care must be observed in performing measurements when using these. SSC is usually expressed in degree Brix (°B) or percent.

Figure IV.6. Hand-held and digital refractometers for soluble solids measurement

Sample preparation

In the case of small produce items such as cherries, strawberries and tomatoes, the whole fruit can be juiced. For larger produce items such as mangoes, watermelons and bananas, samples of the flesh must be extracted from the blossom end and centre of the fruit. Cheesecloth may be used to extract the juice and separate the pulp.

Guidelines on performing measurements

Prior to use, the refractometer must be standardized and set to zero using distilled water. The juice is then spread on the prism of the hand-held rafractometer and a reading is taken against the light. In the case of digital refractometric measurements, the sample must be spread on the receptacle of the digital refractometer and a reading is taken from the LCD display.

Procedure

- Extract the juice of each sample using cheesecloth.
- Clean the prism of the hand refractometer and the sample receptacle with distilled water and wipe dry with cotton or tissue paper.
- Add three drops of distilled water on to the prism or sufficient amount on the sample receptacle; be sure that the reading is zero.
- Dry the prism or sample receptacle as above and place a sample of juice on to the prism and take the SSC reading.
- Clean the prism or sample receptacle as above prior to taking the SSC reading of the next sample.
- Evaluate the results by comparing SSC taken by hand and digital refractometer and of the different produce item.
- Discuss the implications.

4. Measurement of acidity

Measurement of acidity by titration

Introduction

Organic acids are important in flavour development, cell defence systems and human nutrition and serve as food reserves for fresh produce. In the post-harvest state, organic acids either increase because of partial breakdown of sugars to acids or decrease because of their respiratory breakdown to water and carbon dioxide.

Figure IV.7. Manual and automatic titration system for acidity measurement

Hand titration | Automatic titration (auto-titration) set

Guidelines on performing measurements

Total and predominant organic acids can by measured by titration (titratable acidity or TA). The predominant organic acids are citric acid (e.g. citrus, berries, pineapple, tomato), malic acid (e.g. apple, banana, mango, pear, peach and peppers), and tartaric acid (e.g. grape), with milliequivalent weights of 0.064, 0.067 and 0.075, respectively.

Procedure

- Using the given fruit and vegetable samples and remaining juice extracted for SSC analysis, perform the following steps for TA analysis:
  - using a pipette transfer 5 to 10 ml juice (or any known juice volume, depending on produce) to an Erlenmeyer flask or beaker;
  - add two drops of 1 percent phenolphthalein indicator (preparation: dissolve 1 g phenolphthalein powder in about 60 ml 90 percent ethanol; pour the solution into a 100 ml volumetric flask or graduated cylinder; make the volume to 100 ml using the remaining 90 percent ethanol; store solution in a dark glass bottle);
  - titrate with 0.1N sodium hydroxide (NaOH) solution contained in a burette to pH 8.20 or faint pink colour develops and record the volume of NaOH used (preparation of 0.1N NaOH: dissolve 4 g NaOH pellets in distilled water and make the volume to 1 000 ml);
  - calculate TA using the formula:

$$\% \text{ TA (predominant organic acid)} = \frac{V \times N \times M}{W} \times 100$$

Where: V = titrated volume of NaOH, ml
N = concentration of NaOH, normality (N)
M = milliequivalent weight of predominant organic acid, g/meq
W = weight of sample equivalent to the volume of juice being titrated *(1 ml pure juice = 1 g)*;

calculate SSC/TA ratio (more important than SSC or TA alone in some produce).

Measurement of acidity with the use of a pH meter

Introduction

Colour, taste and flavour of produce are also influenced by pH. The pH of fresh produce varies in accordance with cultural practices and conditions of storage and transport. pH provides an indication of the degree of acidity or alkalinity and is usually determined using a pH meter. It should be noted that pH and TA are not directly related as pH is dependent on the concentration of free hydrogen ions and buffering capacity of the extracted juice.

Figure IV.8. pH meter

pH meter

Guidelines on performing measurements

Modern pH electrodes are singular units, having both poles in a double sleeved glass casing. A tapered fine glass tip allows for the osmotic passage of ions and thus the measurement of pH activity. When measuring pH activity, ensure this taper is completely immersed in the solution and is being actively stirred, usually with a magnetic slug stirrer.

Procedure

- Prepare the pH meter (some instruments may require 15 minutes warming and be sure that the electrode is dipped in distilled water).
- Blot the tip of the electrode using a soft tissue paper.
- Dip electrode into the juice extracted above from the given fruit and vegetable samples.
- Record the reading and rinse the electrode with distilled water in a wash bottle and blot dry with a tissue paper before taking the reading for the other samples.
- Evaluate the results and provide a brief summary of experience and possible application during the discussion period.

5. Sensory evaluation of quality

Introduction

Sensory analysis of fresh horticultural produce focuses mainly on the evaluation of appearance, flavour (taste and aroma) and texture. Sensory evaluation must be planned and standardized to be as objective and as scientific as possible. Factors to consider include: (1) screening and training of panel members; (2) suitable test environment; (3) techniques for sample preparation and sample presentation; and (4) statistically valid methods for obtaining and analysing results. There are two main types of sensory panel:

1. Consumer panels consist of a large group of people and are used to determine preferences of products. The panel must be large enough (usually more than 30) to overcome some of the extreme variability that occurs among individuals when asked for their preference. This type of panel is used mainly by marketing companies wanting to develop a new product.
2. Trained panels consists of 6 to 25 people who have been trained to discriminate and quantify the sensory properties of a product. The panel is selected and trained to discriminate between small variations in sensory characteristics. These people do not necessarily represent the consuming public.

Sampling methodology

The samples presented to the panel must be as consistent as possible in terms of size and appearance. Preparation should be done as close to sampling as possible to avoid any browning or physiological changes that might affect the results. If other chemical tests are being carried out, then a representative sample of the produce being used for sensory analysis should be used. The presentation of the samples is very important. All effort must be made to reduce any bias for the panelists. Some ways of standardizing the samples include using similar sample containers, providing similar sized samples, labeling with three digit random numbers, presenting samples to the panelists in a randomized order.

Guidelines on performing measurements

Appearance

Produce appearance can be evaluated by a sensory panel using a visual quality rating (VQR) of 9 (excellent) to 1 (not usable) (Figure IV.9). The number of days to reach a rating of VQR 5 is taken as a measure of potential shelf life. Specific defects (e.g. wilting, browning, physical damage, chilling injury) can also be scored using a scale of 1 (none) to 5 (very severe) (Figure IV.9).

Flavour quality

Taste (e.g. sweetness, sourness, acridity, spicy), mouth feel and aroma are commonly evaluated using either descriptive scoring or hedonic ratings.

Descriptive scoring – A 10 cm line with a word anchor placed at each end (e.g. 10 cm line for sweetness with “less” at 0 point and “more” at 10 point) can be used. The panellist is then asked to mark the line at a point between those words that represent the sample. The wording of the anchor points is important as some words or descriptions might bias the panellists. The words “less” and “more” are good anchor words to use.

Hedonic rating – a scale of 9 to 1 is usually used: 9-like extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither like nor dislike; 4-dislike slightly; 3-dislike moderately; 2-dislike very much; and 1-dislike extremely.

Evaluation procedure

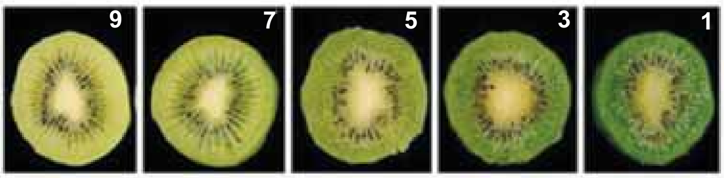
- Participants will be divided into two groups. One group will prepare the produce samples and the other group will serve as the panellists who will carry out the evaluation.
- The panellist-group will evaluate the visual quality, defect and flavour using a prepared rating system.
- Analyse results and provide a brief summary of experience and possible application during the discussion period.

Figure IV.9. Visual quality and defect rating scale and chart

Visual quality rating

9-excellent, no defect; 7-good, defects minor, 5-fair, defects moderate, limit of marketability; 3-poor, defects serious, limit of usability; 1-not usable

Kiwifruit

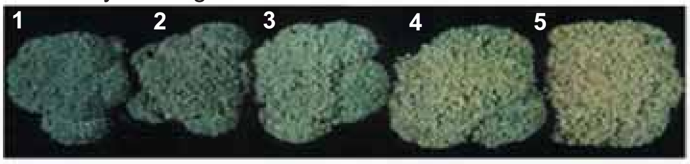


Bitter gourd

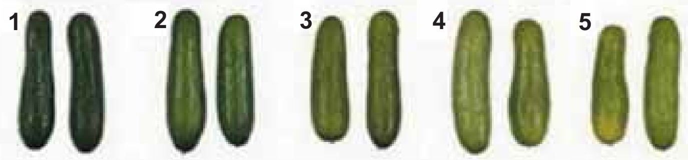
Defects rating

1-none; 2-slight or minor, may not affect price; 3-moderate, price may be affected; 4-severe, produce not marketable without substantial price reduction; 5-very severe, produce not usable

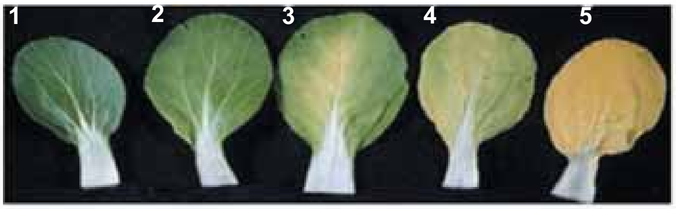
Broccoli yellowing



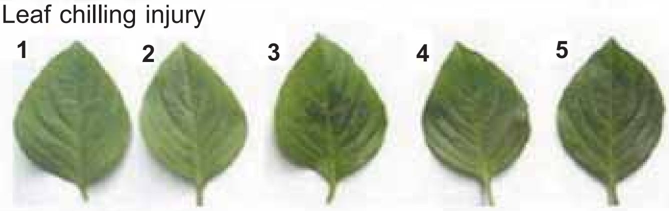
Cucumber yellowing



Mustard green yellowing

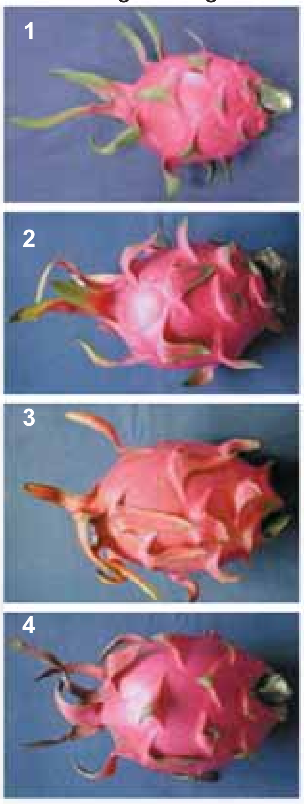


Leaf chilling injury



Sliced leaf browning

Bract wilting in dragon fruit



Disease rating in dragon fruit

V. Evaluating the microbiological and chemical qualities of produce*

Introduction

Understanding the nature of microorganisms is a basic requirement for designing and implementing containment measures to assure the safety and quality of fresh produce. Laboratory facilities are generally required for the study of microorganisms. A simple laboratory can be set up at the field level for rapid testing, using locally-available and low-cost substitute equipment and materials (Table V.1).

Once the growth, dispersal and infection mechanisms of a micro-organism are established, a targeted approach (rather than a "spray-and-pray" approach) can be pursued to prevent, minimize, or eradicate the problem.

This practical exercise introduces participants to microbiological facilities and methodologies for identifying spoilage and pathogenic microorganisms associated with fresh fruits and vegetables as well as pesticide residues and removal techniques.

1. Detection of post-harvest pathogens

Pathogen isolation is critical in disease translation, to establish the primary cause of a disease before appropriate control measures can be developed. The isolated micro-organism must also be proven to be the real cause of the disease by re-inoculating it into the produce to see if this produces the same symptoms (Koch's postulate).

Post-harvest diseases of fresh produce are mainly caused by fungal and bacterial pathogens. Fungi are, in general, isolated by the tissue transplanting method. Bacteria can be isolated by the streak plate, pour plate or dilution plate method.

Purposes

- to isolate fungal pathogens of fresh produce by the tissue transplanting method; and
- to demonstrate bacterial isolation using the streak, pour and dilution plate methods.

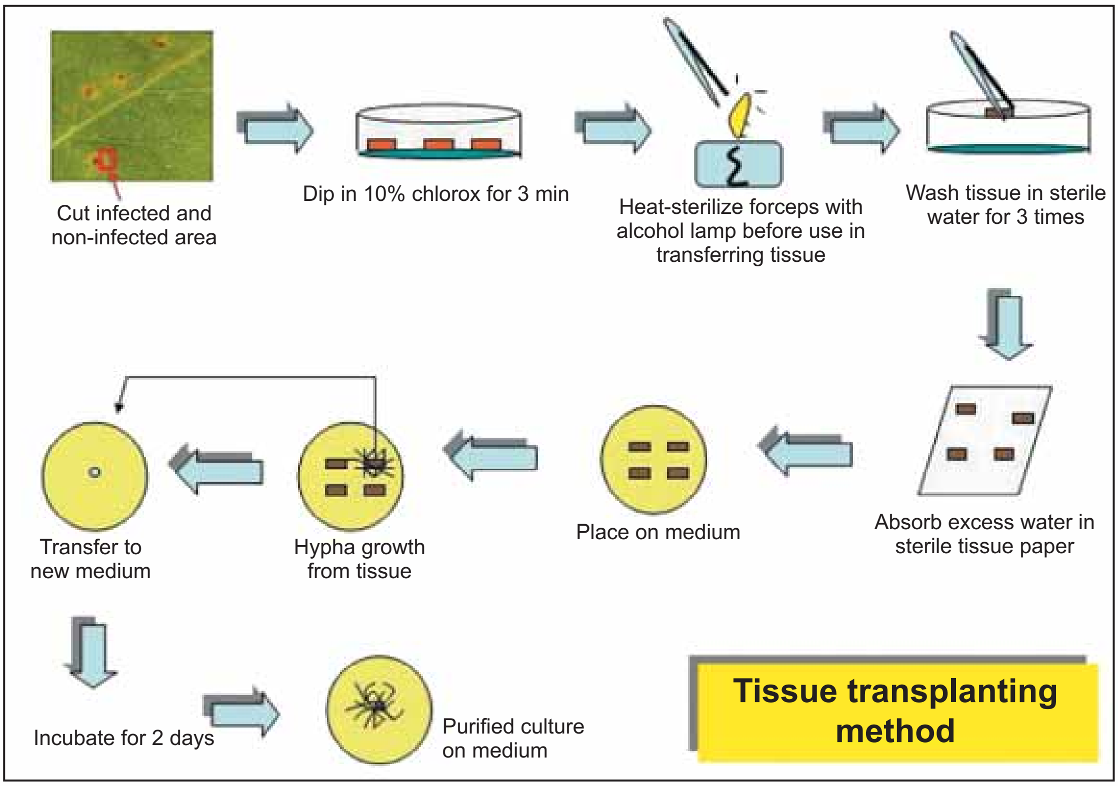
Procedure

Activity 1 – Fungal isolation by tissue transplanting method

- Prepare the following materials: fruit and vegetable samples with disease symptoms; potato dextrose agar plates or water agar; sterile plate, sterile water; 10 percent sodium hypochlorite (chlorox); Bunsen burner and knife and forceps.
- Following the steps in fungal isolation shown in Figure V.1 and inside a laminar flow hood, slice a small section at the advancing part of infected tissue with a portion of non-infected tissue of the produce.
- Dip the tissue slice in 10 percent chlorox solution for three minutes.
- Using heat-sterilized forceps pick out the tissue and wash in sterile water three times.
- Remove excess water using sterile tissue paper and inoculate tissue and transfer to a prepared medium.
- Incubate the culture for two days under ambient conditions and observe hypha growth.
- Transfer hypha section to a new medium to produce pure culture.

* P. Jitareerat

Figure V.1. Fungal isolation by tissue transplanting method



Source: Korsten, 2007

Table V.1. Requirements for Setting up a Basic Microbiology Laboratory

Cate-gory	Standard Items	Inexpensive/Local Substitutes	Purpose/Remarks
Infrastructure	Small room with washable surfaces (walls, floors and ceilings)	Given standard requirements are minimal and can be improvised	Room must be washed and disinfected prior to commencing microbiological work. Commercial disinfectants such as commercial bleach can be used for disinfecting surfaces. Commercial equipment can be purchased from a company that supplies laboratory equipment. A hardware store is an alternative inexpensive source of equipment
	One or two tables with washable surfaces	Given standard requirements are minimal and can be improvised	As above
	Shelf or storage cabinet	Given standard requirements are minimal and can be improvised	As above
	Basin with running tap water or portable bowl	Given standard requirements are minimal and can be improvised	As above
	Laminar flow hood for aseptic culture/sub-culturing	Improvised inoculation cabinet	As above

Table V.1. *(continued)*

Category	Standard Items	Inexpensive/Local Substitutes	Purpose/Remarks
Equipment and small laboratory apparatus	Autoclave	Pressure Cooker	For sterilizing items or culture media for microbiological use
	Analytical weighing balance	Digital kitchen balance, battery operated	For weighing chemicals or culture media according to prescribed recipe; For weighing produce samples
	Water bath	Large cooking pot	For heating water and/or improvising a water bath
	Hot plate/magnetic stirrer	Gas stove/electrical hot plate	For heating water and improvising a water bath
	Electronic thermometer	Bulb thermometer	For measuring water temperature and the settings of stove/hot plate; For controlling temperature of the water bath. A water bath at 50°C keeps agar molten until it can be poured
	Bunsen burner with LPG (liquefied petroleum gas)/ alcohol burner	Candle, alcohol, lamp	For aseptic work – to create a sterile environment and sterilize instruments before use
	Inoculation holder with loop	Wooden rod with thin wire	For transferring bacterial culture
	Tweezers	Fine pair of pliers	For transferring fungal cultures and plant material
	Spatula; weighing boats	Spoon; Foil/plastic lids	For weighing chemicals
	Spreading rod, plastic (sterile)	Spreading rod made of wire	For spreading sample on the surface of the agar plate
	Scalpel with blade	Sharp knife, ordinary blade	For aseptic cutting of fungal culture, produce sample, etc.
Supplies and Materials	70% ethanol	Surgical spirit/methylated spirit	For disinfecting working surfaces and instruments before use
	Distilled water	Bottled water, boiled clear water	For preparing culture media; chlorine in water inhibits growth of microbes – water purifier is ideal
	Sterile swabs	Cotton ear buds	For collecting samples from surfaces
	Scissors, foil, masking tape, permanent marking pens, matches and/or lighter, oven gloves	Scissors, foil, masking tape, permanent marking pens, matches and/or lighter, oven gloves	These are readily available in ordinary stores and supermarkets
	Erlenmeyer flasks or screw cap bottles (250–1 000 ml); beakers (100–1 000 ml); test tubes and test tube racks; disposable sterile petri dishes (90 mm); graduated cylinders (250–1 000 ml)	Erlenmeyer flasks or screw cap bottles (250–1000 ml); beakers (100–1 000 ml); test tubes and test tube racks; disposable sterile petri dishes (90 mm); graduated cylinders (250–1 000 ml)	Glassware or plastic ware items required in any simple laboratory
	Chemicals and culture media	Chemicals and culture media	These are commercially available from chemical companies; some chemicals can be substituted by local materials e.g. potato tuber for preparing potato dextrose agar; gelatine or starch as an agar substitute; table sugar as a sucrose substitute

Source: Korsten, 2008.

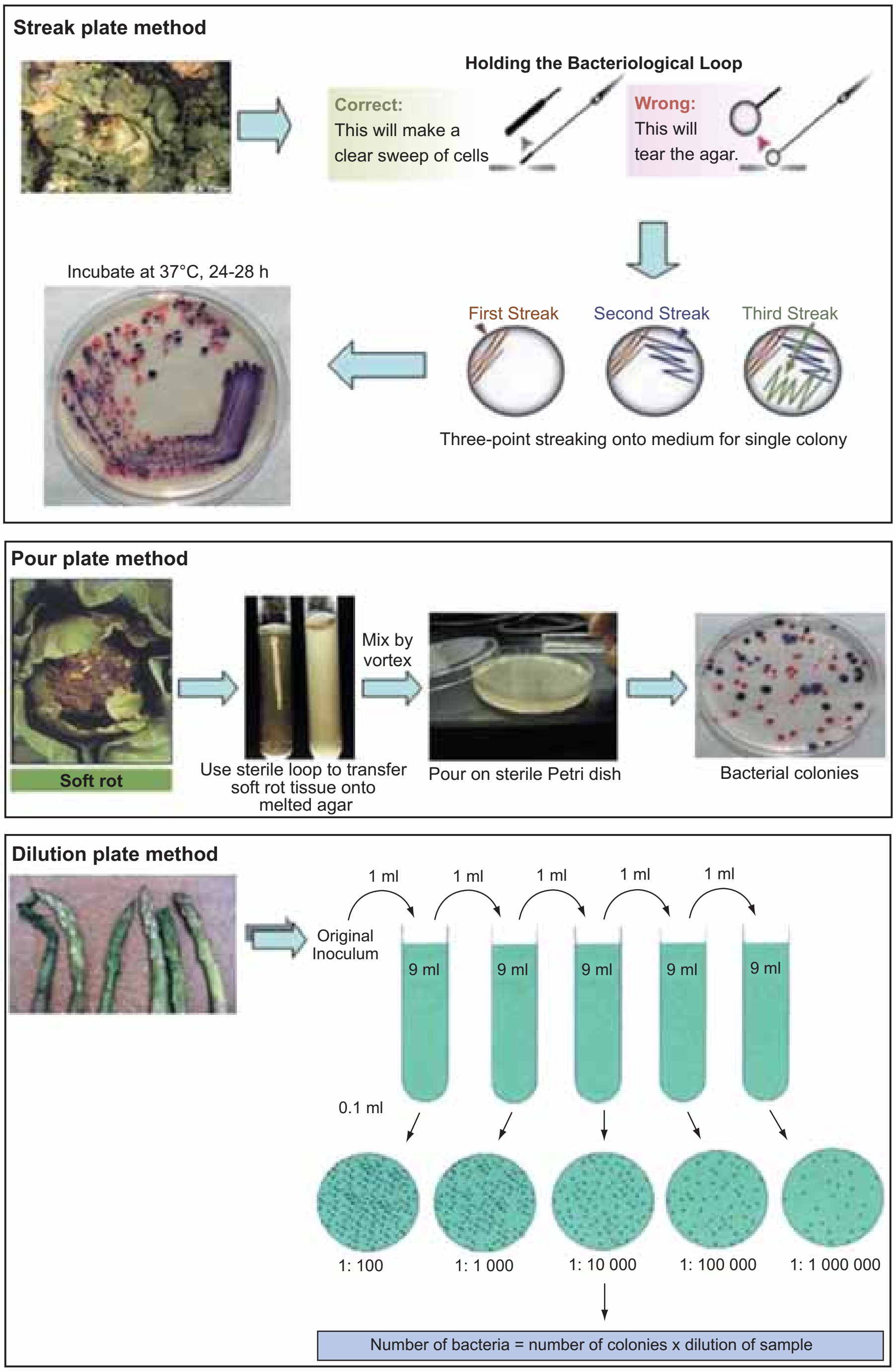
Activity 2 – Bacterial isolation by streak, pour and dilution plate methods (demonstration)

The following materials are used in bacterial isolation:

- *streak plate method:* produce sample; nutrient agar (NA) plates; Bunsen burner; bacteriological loop;
- *pour plate method:* produce sample; warmed NA in test tubes; Bunsen burner; sterile plates; Vortex mixture; bacteriological loop; and
- *dilution plate method:* produce sample; NA plates; 9 ml sterile water in test tubes; Bunsen burner; sterile plates; Vortex mixture; bacteriological loop.

The procedure for streak, pour and dilution plate methods as shown in Figure V.2 will be demonstrated.

Figure V.2. Bacterial isolation by streak, pour and dilution plate methods



2. Control of post-harvest diseases

Post-harvest diseases can be controlled by maintaining host resistance (e.g. conditions that delay ripening or senescence) or by using physical (e.g. heat treatment), chemical (e.g. fungicide), biological (e.g. microbial antagonist) or novel methods (e.g. elicitor of host resistance). Good Agricultural Practice (GAP) is also critical to reducing pathogen inoculum and in preventing the microbial invasion of fresh produce. One target of GAP is to prevent or reduce physical injury during harvesting and handling. Physical injury predisposes produce to infection given that most post-harvest pathogens are opportunistic or wound pathogens. Harvested produce is wounded as a natural result of separation from the mother plant. In the case of certain types of produce, such as cabbages, the cut butt end is of major concern since it is the main entry point of the bacterial soft rot pathogen *Erwinia* spp. Losses resulting from soft rot disease are enormous, with a worldwide estimate of US$100 million annually.

Purposes

- to examine the effects of physical injury on disease development; and
- to demonstrate simple methods of controlling bacterial soft rot in cabbage.

Procedures

Activity 1 – Demonstrate the effect of wounding on disease development

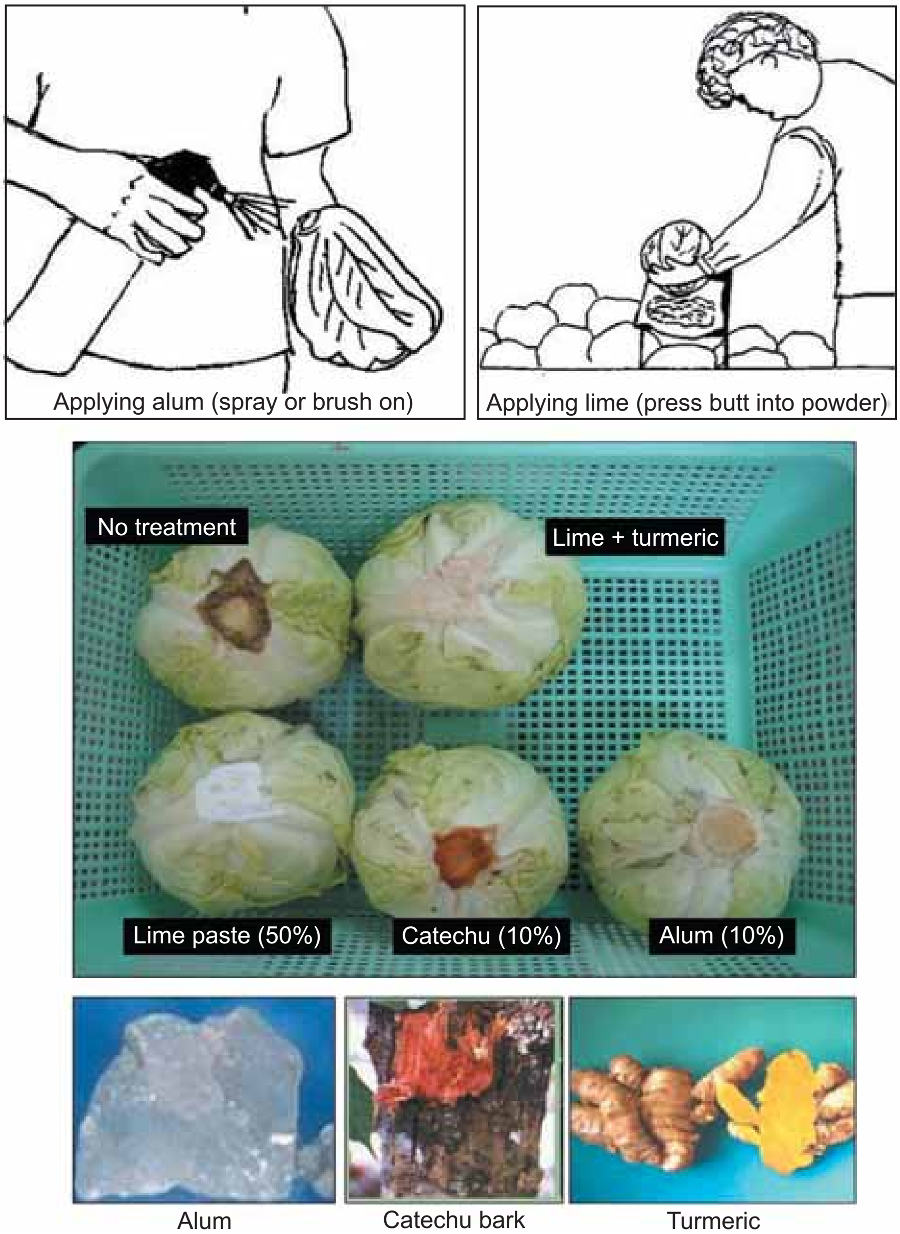
- Prepare the following materials: Chinese cabbage; sharp knife; cell suspension of *Erwinia carotovora* (soft rot disease); closed chambers; micropipette P-20 tip.
- Make a small wound using a sharp knife at the mid-rib of Chinese cabbage at a location similar to that shown in Figure V.3.
- Using a micropipette, apply 10 μl of *E. carotovora* suspension at the wound site.
- Apply 10 μl of *E. carotovora* suspension at the mid-rib without wounding for comparison.
- Incubate the leaves in closed chambers under ambient conditions.
- After one day, observe soft rot symptoms by counting the number of wound sites that develop the symptom that appears similar to that shown in Figure V.3.

Figure V.3. Soft rot development in wounds of Chinese cabbage inoculated with *Pectobacterium carotovorum*

Activity 2 – Demonstrate simple methods of controlling bacterial soft rot (demonstration)

- The following materials are required: head cabbage samples; 50 percent lime paste; lime paste containing turmeric; 10 percent catechu powder; 10 percent alum (aluminum potassium sulfate) solution (Figure V.4); small paint brush, sharp knife; cell suspension of *Erwinia carotovora* (soft rot disease); polyethylene bag.
- The procedure for preparing and applying the different control agents will be demonstrated using the treated and untreated samples prepared two days before the practical exercise and the responses observed will be discussed.

Figure V.4. Simple methods of controlling bacterial soft rot in cabbage



3. Monitoring microbial contamination and hygiene

Microorganisms are everywhere and can contaminate fresh produce through water, air or when in contact with still or moving objects and people in the field, packing house, storage area and market place. Of greater concern are food-borne pathogens that cause human diseases. Sanitation is therefore essential to minimize microbial contamination.

Purpose

- to demonstrate the omnipresence of microorganisms and determine the effects of some factors on potential microbial contamination of fresh produce.

Procedures

Activity 1 – Determine microbial load in air and effect of temperature

- Prepare nutrient agar (NA) plates and write the necessary label at the base corresponding to group number and storage environment: 4°C, 10°C and 13°C cold rooms and ambient room.
- In each room, open the NA plate for 10 minutes and then cover.
- Incubate the plates for 48 hours at room temperature.
- Record the number of fungal and bacterial colonies.
- Present results and their implications during the discussion period.

Activity 2 – Demonstrate the penetration of contaminated water into fresh produce

- Prepare the following materials: produce samples, scalpel or knife, beaker or bowl, water, blue food colouring, tongs, drying rack.
- Place sufficient water in a bowl; add ten drops of food colouring, and mix.
- Submerge produce sample for ten minutes.
- Remove sample from water with tongs and drain for ten minutes in a drying rack.
- Observe the amount of dyed water on the surface of produce – scoring of 0 (no dye) to 4 (lots of dye) may be used.
- Remove a 2 cm slice from the stem end of produce and rate the amount of dye penetration.
- Clean the knife, cut produce into half, and rate the amount of dye penetration.
- Present results and their implications during the discussion period.

Activity 3 – Determine microbial load on surfaces

- Prepare the following materials: sterile swabs; sterile water; NA plates; spreading rod; burner, ethanol; micropipette with tips.
- Using the sterile swab, slightly moisten with sterile water, press it firmly onto a 5 x 5 cm surface, and place back in the sterile tube. Then send the swab to a certified laboratory for determination of total viable count (TVC) or determination of presence of specific food-borne pathogen or faecal contamination.
- Place another swab in 9 ml sterile water and mix well.
- Prepare a dilution series and plate out onto NA plates.
- Incubate at room temperature for 24 to 48 hours.
- Count the number of colonies per plate.
- Present results and their implications during the discussion period.

Activity 4 – Determine microbial load on human hands and the effect of handwashing

- Prepare the following materials: NA plates, soap; warm water.
- Press the three middle fingers of left hand onto the surface of NA plate for 30 seconds.
- Close the lid and mark on the back of the plate 'not washed'.
- Wash hands with warm water and soap and dry following the correct procedures:
  adjust water to a comfortable temperature and wet hands;
  dispense small amount of soap into the palms and create lather;
  using as much friction as needed, thoroughly clean all surfaces of hands including between fingers;
  pay attention to the nails and nail beds by rubbing the nails of one hand across the palm of the other, creating enough friction to clean underneath the nails;

rinse hands in running water, making sure to hold the hands in a downward position;
use paper towels or warm air blower to dry hands thoroughly;
using the same paper towel, turn off the water supply.

- Repeat the first step and mark the plate “washed”.
- Incubate the plates at room temperature for 48 hours.
- Count the number of colonies per plate.
- Present results and their implications during the discussion period.

4. Pesticide residue analysis and post-harvest removal techniques

Fungicides, insecticides, herbicides, bactericides and nematicides are commonly used in fruit and vegetable production. Some pesticides are also applied to harvested produce whereas others have been banned (e.g. ozone-damaging methyl bromide which has been used as soil fumigant and quarantine treatment of produce). International regulations on maximum residue levels (MRLs) seek to limit or control the use of pesticides. MRLs refer to the maximum content of a pesticide residue (expressed as mg/kg fresh weight produce) recommended by the Codex Alimentarius Commission that can be legally permitted in or on foods and feeds. Table V.2 gives MRLs for some pesticides on fruits.

Table V.2. Maximum residue level (MRL) of chemicals on fruit as prescribed by Codex

Chemical	Produce	MRL (mg/kg)
Benomyl	Watermelon	0.5 to 2.0
Thiabendazole	Apple, citrus	10
	Banana	3
Ipodione	Apple, grape, apricot	10
Imazalil	Banana	2
	Orange	5
Thiophanate methyl	Apple	5
	Banana	1
	Cherry, grape, orange	10
Trifoline	Apple, cherry	2
	Blueberry	1
Prochloraz	Avocado, banana, citrus	5
	Mango	2
	Papaya	1

Pesticide levels can be determined by high pressure liquid chromatography, gas chromatography, immunological techniques, and with the use of rapid and simple test kits. Examples of such test kits are shown in Table V.3. Pesticide residues can be removed after harvest, using selected procedures (Table V.4).

Purpose

- to test for pesticide residues and the efficacy of different post-harvest removal techniques.

Procedures

- Prepare the following materials: produce samples; TV kit; test tube; hot plate; mortar and pestle; rice wash water; salt; vinegar; baking soda; potassium permanganate; water.
- Group the samples and apply the following treatments:
  control, no treatment
  dip in tap water for five minutes

dip in rice wash water for ten minutes
dip in calcium hydroxide (1ts/4L water) for ten minutes
dip in vinegar (1ts/4L water) for ten minutes
dip in salt solution (1ts/4L water) for ten minutes
dip in potassium permanganate (10 to 20 pellets/4L water) for ten minutes
dip in baking soda (1ts/4L water) for ten minutes
dip in 1 percent detergent solution for ten minutes.

- Air-dry at room temperature for five to ten minutes.
- Analyse pesticide residue following the procedure for using the TV kit as shown in Figure V.5 (the kit includes extract buffer, solutions 1, 2 and 3).
- Present results and their implications during the discussion period.

Table V.3. Test kits for detecting pesticides

Pesticide	Action	Test kit
Metolachlor	Herbicide	s/r-Metolachlor Plate Kit, Metolachlor-ESA Plate Kit, s/r-Metolachlor Tube Kit
Atrazine	Herbicide	Atrazine Plate Kit, Monoclonal Atrazine Tube Kit
2, 4-D	Herbicide	2, 4-D Plate Kit, 2, 4-D Tube Kit
Carbendazim/Benomyl	Fungicide	Carbendazim/Benomyl Plate Kit
Alachlor	Herbicide	Alachlor Plate Kit
DDE/DDT	Pesticide	DDE/DDT ELISA Kit
Glyphosate	Herbicide	Glyphosate ELISA Kits
Spynosyn	Insecticide	Spynosyn ELISA Kit
Triazine metabolites	Herbicide	Triazine metabolites ELISA Kit
Diuron	Herbicide	Diuron ELISA Kit
Abamectin	Insecticide	Abamectin Plate Kit

Table V.4. Some procedures for removing pesticide residues

Agent	Method and Process	% Removal	Ref.*
Water	1. Remove peel or outer sheet 2. Dip in clean water for 5 to 10 min 3. Rinse with clean water	27 to 72%	DOA
Water	1. Wash in running water for 2 min	25 to 39%	DOA
Rice wash water	1. Dip in rice wash water for 10 min	29 to 38%	DOA
Calcium hydroxide ($CaOH_2$)	1. Dip in $CaOH_2$ solution for 10 min 2. Rinse with clean water	34 to 52%	DOA
Acetic acid (vinegar, CH_3COOH)	1. Dip in acetic acid solution (1 TBSP + 4L water) for 10 min 2. Rinse with clean water	27 to 36%	DOA
Salt (NaCl)	1. Dip in salt solution (1 tbsp + 4L water) for 10 min 2. Rinse with clean water	29 to 38%	DOA
Heat	1. Heat during cooking	48 to 50%	DOA
Potassium permanganate ($KMnO_4$)	1. Dip in $KMnO_4$ solution (20 to 30 pellets + 4L water) for 10 min 2. Rinse with clean water	35 to 43%	
Detergent	1. Wash in water with detergent	65%	Bangkok Health
Sodium bicarbonate (baking soda)	1. Dip in baking soda solution (1 tbsp + 4L water) for 10 min 2. Rinse with clean water	65%	Bangkok Health

* DOA – Department of Agriculture, Bangkok, Thailand

Figure V.5. Pesticide Residue Analysis using a TV Kit

10 g produce

↓

Add 20 ml of extract buffer

↓

Homogenize in a test tube

↓

Shake for 5 minutes

↓

Transfer 1 ml of supernatant to a new tube

↓

Add 2 drops of Solution 1

↓

Add 2 drops of Solution 2

↓

Place sample in boiling water for 5 minutes

↓

Add 1 ml Solution 3

↓

Samples containing pesticides will be red-to violet in colour
Samples that do not contain pesticides will be colourless

VI. The impact of packaging and temperature management on produce quality*

Introduction

Fresh produce quality and safety are determined by methods and conditions of handling and storage. Mechanical damage is one of the primary causes of quality loss. It is caused by faulty practices during harvesting, packing house operations, poor packaging, transport and storage or along the supply chain from harvesting to marketing. Similarly, poor temperature management from harvesting to retail display of fresh produce could result in rapid quality deterioration or in the development of physiological disorders.

1. Impact of handling

Purpose

to demonstrate the importance of packing and packaging of different commodities.

Materials

The materials required are:

- fresh fruits and vegetables; and
- packaging materials.

Procedure

This task can be carried out as a group exercise, with different groups packaging different fruits for different target markets.

- Identify a fruit or vegetable.
- Identify a target market for the fruit or vegetable.
- Select appropriate packaging materials.
- Pack the fresh produce.

Discussion issues

- Who is the target market?
- Why was this type of packaging selected?
- What were the main considerations in selecting the packing configuration?

2. Impact of temperature management on produce quality

Purpose

to demonstrate the impact of ineffective cold chain management on the quality of different types of fresh produce.

Procedure

Trainees will be grouped according to produce assignment. Four fresh produce items: mangoes, bananas, papayas and eggplants, will be prepared and pre-stored under different temperatures:

ambient temperature (20°C)
cold storage temperature (10°C)
chilling temperature (0 to 5°C)
high temperature (37 and 55°C)
freezing temperature (-4 to 0°C).

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* K. Tanprasert, M. Buanong and S. Kanlayanarat

- Observe the overall quality of the intact produce items; using the data sheet provided, note the external appearance (presence of surface discolouration, pitting, etc.) of the produce and the degree of each defect observed (a scoring system may be used, e.g. 0-none, 1-slight, 2-moderate, 3-severe, 4-very severe).
- Slice the produce items and characterize the internal appearance using similar criteria as described for external appearance and record observations as previously.
- Extract portions of the pulp of selected fruits and evaluate their taste using a hedonic scale of 9 (like extremely) to 1 (dislike extremely).
- Summarize observations and present them during the plenary discussion session.

Discussion issues

- Quality differences among produce items stored at different temperatures.
- Implications of the observations.

Impact of temperature management on produce quality

Data sheet for observations of produce stored at different temperatures

Fruit	**Storage temperature**	**External appearance**	**Internal appearance**	**Taste** (if applicable)

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APPENDICES

Appendix 1

Important international bodies in global trade

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 cooperation between nations (www.un.org), and today the UN counts 192 states among its members. Over the past 57 years, the UN has expanded and currently encompasses six principal organs, 15 agencies and several bodies. Some of these agencies and bodies are involved in food safety directly. A number of specialized 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). FAO is the largest specialized 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, much of which is available on its Web site. FAO headquarters is located in Rome, Italy, with regional offices in Ghana, Chile, Thailand and Egypt.

World Health Organization

The World Heath Organization (WHO) (http://www.who.int) was founded in 1948. Prior to this, several international health organizations were in existence. These included: the Organization 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 organizations 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 organizations 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). 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 harmonized 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 worldwide recognition of the importance of international trade and the need to facilitate such trade, and at the same time ensure the quality and safety of food for consumers. The FAO/WHO Codex Alimentarius Commission (CAC), which is the body charged with the implementation of this programme, was instituted simultaneously. With the signing of the Marrakech Agreement, the CAC was recognized 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 standardize 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.

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 harmonize 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 specialized 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 harmonization of EC legislation to facilitate free trade. The single market also stimulated a change of perspective, from simple harmonization 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

Maximum residue levels

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 levels (MRLs) are recommended on the basis of appropriate residue data obtained from supervised trials. These data may vary considerably from region to region because of 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 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 levels

The Codex extraneous maximum residue level (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 levels/extraneous maximum residue levels 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.

Appendix 3

ASEAN GAP*

Introduction

ASEAN GAP was developed under the ASEAN Australia Development Cooperation Programme as one activity of a project on Quality Assurance Systems for ASEAN Fruits and Vegetables. The project aimed to contribute to greater economic integration and the enhancement of ASEAN competitiveness in the food and agriculture sectors through the provision of training and the development of quality assurance systems to increase productivity and reduce barriers for inter- and extra-ASEAN trade.

Stakeholders have worked together to develop a Good Agricultural Practices (GAP) standard for the production of fresh fruits and vegetables in the ASEAN region. ASEAN GAP was formally approved and adopted by the ASEAN in November 2006.

Purpose and scope

ASEAN GAP is a voluntary standard for Good Agricultural Practice during the production, harvesting and post-harvest handling of fresh fruits and vegetables in the ASEAN region. ASEAN GAP focuses on preventing or minimizing the risk of hazards. ASEAN GAP brings in a specific focus on hazards associated with food safety, environmental impact, worker health, safety and welfare, and produce quality.

The purpose of ASEAN GAP is to harmonize national GAP programmes in the ASEAN region. This will facilitate trade among ASEAN countries and to global markets, enhance the safety and quality of fruits and vegetables for consumers, improve returns to farmers, enhance the sustainability of the environment, and protect the health, safety and welfare of workers.

The scope of ASEAN GAP covers the production, harvesting and post-harvest handling of fruits and vegetables for fresh consumption. Organic production systems, the use of genetically modified crops (GMO material) and produce that presents a high risk to food safety, such as sprouts and fresh-cut produce are excluded.

ASEAN GAP is benchmarked against international GAP programmes. ASEAN countries must align their GAP programmes with ASEAN GAP.

ASEAN GAP reference points

ASEAN GAP was developed on the basis of many certified systems and guidelines for GAP from around the world. The main sources of information were:

- *Accreditation schemes for Malaysian farms*, Department of Agriculture, Malaysia.
- *Quality management systems: Good Agricultural Practices*, Ministry of Agriculture and Cooperatives, Thailand.
- *Good Agricultural Practice for vegetable farming*, Agri-Food and Veterinary Authority of Singapore.
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- *Guidelines for on-farm food safety for fresh produce*, Department of Agriculture, Fisheries and Forestry, Australia.

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* *ASEAN Secretariat, 2006.*

ASEAN GAP modules and guidelines

ASEAN GAP consists of four modules:

- Food safety module
- Environmental management module
- Worker health, safety and welfare module
- Produce quality module.

Each module can be used alone or in combination with other modules. All four modules can be integrated into one standard.

Detailed information for each module, the interpretation and implementation of the practices in ASEAN GAP, and the guidelines for implementing ASEAN GAP for fresh fruits and vegetables can be accessed from the ASEAN Web site: http://aseanbio.net/aphnet/workshop/GAP/ASEAN%20GAP/ASEAN%20GAP%20Interpretive%20Guide%20-%20Food%20Safety%20Module%20-%20DRAFT.PDF

ISBN 978-92-5-106240-1

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TC/D/I0782E/1/04.09/500