Postharvest Technology of Horticultural Crops

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Abstract

Temperature management is the most effective tool for maintaining quality and safety and for extending the postharvest- life of fresh horticultural commodities. It begins with the rapid removal of field heat by initial cooling and continues throughout the cold chain (refrigerated transportation, cold storage at wholesale distribution centers, refrigerated retail display, and cold storage at home). Management of relative humidity along with temperature is essential in reducing water loss. The following technological procedures are used commercially as supplements to temperature and relative humidity management: Treatments applied to commodities include curing of certain root, bulb, and tuber vegetables; cleaning followed by removal of excess surface moisture; sorting to eliminate defects; waxing and other surface coatings, including film wrapping; heat treatments (hot water or air, vapor heat); treatment with special chemical treatments (sprout inhibitors, scald inhibitors, calcium, growth regulators, ethylene-action inhibitors, such as 1-methylcyclopropene, postharvest fungicides); fumigation or irradiation for insect control; and ethylene treatment (de-greening citrus, ripening climacteric fruits). Treatments to manipulate the environment include packaging, control of air movement and circulation, control of air exchange or ventilation, exclusion or removal of ethylene, controlled or modified atmospheres, and effective water disinfection and other sanitation procedures to minimize microbial contamination and assure food safety. Strategies for increasing food security by reducing postharvest losses and waste include use of cultivars with longer postharvest life, use of an integrated crop management system that maximizes yield and quality, and use of proper harvesting and postharvest handling procedures to maintain quality and safety of horticultural crops and their products.

Introduction

Fresh horticultural crops are diverse in morphological structure (roots, stems, leaves, flowers, fruits, and so on), composition, and general physiology. Thus, commodity requirements and recommendations for maximum postharvest life vary among the commodities. All fresh horticultural crops are high in water content and are subject to desiccation (wilting, shriveling) and mechanical injury. They are also susceptible to attack by bacteria and fungi, with pathological breakdown. Biological (internal) causes of deterioration include respiration rate, ethylene production and action, rates of compositional changes (associated with color, texture, flavor, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological breakdown. The rate of biological deterioration depends on several environmental (external) factors, including temperature, relative humidity, air velocity, and atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene), and sanitation procedures. Fresh fruits and vegetables play a very significant role in human nutrition, especially as sources of vitamins (Vitamin C, Vitamin A, Vitamin B6, thiamine, niacin), minerals, and dietary fiber. Other constituents that may lower risk of cancer and other diseases include flavonoids, carotenoids, polyphenols and other phytonutrients. Postharvest losses in nutritional quality, particularly Vitamin C content, can be substantial and are enhanced by physical damage, extended storage duration, high temperatures, low relative humidity, and chilling injury of chilling-sensitive commodities.

Management of temperature and relative humidity

Temperature

Temperature is the most important environmental factor that influences the deterioration of harvested commodities. Most perishable horticultural commodities last longest at temperatures near 0ºC. At temperatures above the optimum, the rate of deterioration increases 2- to 3-fold for every 10ºC rise in the temperature. Temperature influences how other internal and external factors influence the commodity, and has a dramatic effect on the spore germination and growth rate of pathogens. Temperatures outside the optimal range can cause rapid deterioration due to the following disorders:

Freezing

In general, perishable commodities are high in water content (75 to 95%), and possess large, highly vacuolated cells. The freezing point of their tissues is relatively high (ranging from –3°C to –0.5°C), and the disruption caused by freezing usually results in immediate collapse of the tissues and total loss of cellular integrity.

Chilling injury

Some commodities (mainly those native to the tropics and subtropics) respond unfavorably to storage at low temperatures well above their freezing points, but below a critical temperature (between 5 and 13°C depending on commodity and maturity stage) termed the chilling threshold temperature or lowest safe temperature. Chilling injury is manifested in a variety of symptoms including surface and internal discoloration, pitting, water soaking, failure to ripen, uneven ripening, development of off flavors and heightened susceptibility to pathogen attack

Heat injury

High temperatures are also very injurious to perishable products. In growing plants, transpiration is vital to maintaining optimal growth temperatures. Organs removed from the plant, however, lack the protective effects of transpiration, and direct sources of heat, for example full sunlight, can rapidly heat tissues to above the thermal death point of their cells, leading to localized bleaching or necrosis (sunburn or sunscald) or general collapse.

Relative Humidity

Relative humidity (RH) is the moisture content (as water vapor) of the atmosphere, expressed as a percentage of the amount of moisture that can be retained by the atmosphere (moisture holding capacity) at a given temperature and pressure without condensation. The moisture holding capacity of air increases with temperature. Water loss is directly proportional to the vapor pressure difference (VPD) between the commodity and its environment. VPD is inversely related to RH of the air surrounding the commodity. RH can influence water loss, decay development, incidence and severity of some physiological disorders, and uniformity of fruit ripening. Condensation of moisture on the commodity (sweating) over long periods of time is probably more important in enhancing decay than is the RH of ambient air. An appropriate RH range for storage of fruits is 85 to 95% while that for most vegetables varies from 90 to 98%. The optimal RH range for dry onions and pumpkins is 70 to 75%. Some root vegetables, such as carrot, parsnip, and radish, can best be held at 95 to 100% RH. RH can be controlled by one or more of the following procedures: (1) adding moisture (water mist or spray, steam) to air by humidifiers; (2) regulating air movement and ventilation in relation to the produce load in the cold storage room; (3) maintaining temperature of the refrigeration coils within about 1ºC of the air temperature; (4) providing moisture barriers that insulate walls of storage rooms and transit vehicles; (5) adding polyethylene liners in containers and using perforated polymeric films for packaging; (6) wetting floors in storage rooms; (7) adding crushed ice in shipping containers or in retail displays for commodities that are not injured by the practice; and (8) sprinkling produce with sanitized, clean water during retail marketing of commodities that benefit from misting, such as leafy vegetables, cool-season root vegetables, and immature fruit vegetables (such as snap beans, peas, sweet corn, and summer squash).

Supplemental commodity treatments

Treatments applied to commodities include:

1. Curing of certain root, bulb, and tuber vegetables to encourage wound healing and drying of outer tissues. This is an essential step for reducing water loss and disease infection during subsequent storage.
2. Cleaning followed by removal of excess surface moisture to avoid creating a microenvironment that is favourable to growth of decay-causing pathogens during subsequent storage and distribution.
3. Sorting to eliminate defects and separate by quality grade that add value to the products and improve their marketability. Use of electronic sorting machines based on non-destructive measurement of fruit colour, size, and severity of defects is increasing.
4. Waxing and other surface coatings, including film wrapping are used to reduce water loss and, in some cases, modify the atmosphere (oxygen and carbon dioxide concentrations) around the commodity.
5. Heat treatments (hot water or air, vapor heat) may be used for decay control (such as anthracnose on mango and crown rot on banana) and/or for insect control to meet quarantine requirements for some commodities, such as mango and papaya.
6. Treatment with postharvest fungicides (in the wax or separately) at concentrations that assure that the residue level is below the

maximum residue limit (MRL) allowed by the regulatory authorities.

7. Special chemical treatments (sprout inhibitors, scald inhibitors, calcium, growth regulators, ethylene –action inhibitors, such as 1-methylcyclopropene, and/or postharvest fungicides)
8. Fumigation (with methyl bromide or phosphine) or irradiation (at less than 1 kGY) for insect control to satisfy quarantine requirements of the importing country.
9. Ethylene treatment to de-greening citrus fruits (1-5 ppm ethylene in air), and for ripening climacteric fruits, such as avocado, banana, mango, and tomato (100-150 ppm ethylene in air).
10. Supplemental treatments to manipulate the environment

Treatments to manipulate the environment include:

1. Packaging inserts, such as liners and consumer packages can be used to modify the atmosphere around the commodity (lower oxygen levels and higher carbon dioxide levels)

2. Control of air movement and circulation to minimize the impact on water loss rate and attain more uniformity of temperature and relative humidity throughout the storage area.

3. Control of air exchange or ventilation to avoid build-up of carbon dioxide and ethylene concentrations and deletion of oxygen levels in the storage atmosphere.

4. Exclusion or removal of ethylene to avoid build-up of ethylene concentration to levels that damage the commodity.

5. Controlled or modified atmospheres (CA or MA) may be used to extend the postharvest-life of some commodities, such as apple, avocado, cabbage, cherry, mango, pear, persimmon, pomegranate, and tomato (mature-green and breaker stages).

6. Effective water disinfection (with chlorine, chlorine dioxide, ozone, or other disinfectants) and other sanitation procedures (such as frequent cleaning of equipment used with sanitizing agents) to minimize microbial contamination and assure food safety Produce compatibility during transport and storage.

Storage under conditions outside the optimal window for each commodity is a common reason for postharvest losses in produce quality and quantity. The following factors determine compatibility in mixing various fruits and vegetables together during transport and storage:

1. **Temperature:** Fruits and vegetables are generally divided into two groups: (a) non-chilling-sensitive commodities (such as apple, broccoli, grape, lettuce, and pear) that are best kept at temperatures above their freezing points (-2 to -0.5°C) and up to 2°C; and (b) chilling-sensitive commodities (such as avocado, banana, citrus fruits, mango, melons, and tomato) that are best kept at 5°C to 15°C, depending on the commodity, cultivar, maturity-ripeness stage, and storage duration. Exposure of group (b) commodities to temperatures below their minimum chilling threshold should be avoided throughout the handling system because chilling injury is cumulative
2. **Relative Humidity (RH):** With the exception of a few commodities (such as dry garlic and onion bulbs, pumpkins and winter squash, dried fruits and vegetables, and nuts), fresh produce should be kept at 90-95% RH to minimize water loss. If the dried fruits, nuts, and vegetables are packaged in moisture-proof containers, they can be mixed with other produce kept at 90- 95% RH. Conditions that result in water condensation on the surface of produce should be avoided to reduce decay incidence.
3. **Ethylene:** Many ripening fruits (such as apple, pear, peach, banana, and tomato) produce ethylene gas, which can be detrimental to ethylene-sensitive commodities (such as avocado, broccoli, cabbage, carrot, kiwifruit, lettuce, persimmon, and watermelon). Symptoms of ethylene-induced disorders include yellowing of broccoli and cucumber, russet spotting on lettuce, softening of fruits, bitterness of carrots, tissue maceration in watermelons, and calyx abscission of eggplant. Exposures of ethylene sensitive commodities to ethylene are cumulative and must be avoided throughout the postharvest handling system. Continuous scrubbing of ethylene to below 1 ppm from the circulating air in the storage facility can facilitate mixing ethylene-producing and ethylene-sensitive commodities at the distribution centers and retail levels.
4. **Odor volatiles:** Commodities with strong odors (such as garlic, leek, onion, pepper, and potato)

should not be mixed with commodities that can absorb these odors (such as apple, avocado, citrus fruits, grape, and pear).

5. **Sulfur dioxide:** Some table grapes are shipped with SO2-generating pads to control decay caused by Botrytis cinerea. These grapes should be stored alone because SO2can damage most other fruits and vegetables.
6. **"Smart Fresh"** (1- methylcyclopropene) It is acceptable to mix commodities that had been treated with the ethyleneaction-inhibitor, "SmartFresh" (1- methylcyclopropene = 1-MCP) with untreated commodities since 1-MCP does not migrate from treated to untreated produce.
7. **Organic produce**: Ideally, organically grown produce should be handled and stored separately from conventionally grown produce to avoid any potential contamination by pesticide residues due to direct contact. Handlers of organic produce are required to keep a record of cleaning dates and products used for cleaning the storage room in which the organic produce is kept.

Conclusions

Procedures for increasing food security by reducing postharvest losses and waste include use of Cultivars (varieties) with longer postharvest life, use of an integrated crop management system that maximizes yield and quality, and use of proper harvesting and postharvest handling procedures to maintain quality and safety of horticultural crops and their products.

The postharvest handling systems for fresh produce begin with harvesting and involve preparation for fresh market or for processing (e.g. freezing, canning, drying), cooling, transportation, storage, and/or handling at destination (wholesale and retail marketing). In all these steps, proper procedures for providing the optimum ranges of temperature and relative humidity are essential for maintaining produce quality and safety and for minimizing postharvest losses between production and consumption sites.

Strategies for reducing postharvest food losses include: (1) Application of current knowledge to improve the handling systems (especially packaging and cold chain maintenance) of horticultural perishables and assure their quality and safety; (2) Overcoming the socioeconomic constraints, such as inadequacies of infrastructure, poor marketing systems, and weak R&D capacity; and (3) Encouraging consolidation and vertical integration among producers and marketers of horticultural crops.

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