CHAPTER

3

Classification of Horticultural Commodities

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3.1 INTRODUCTION

A whole plant or any of its parts (e.g., the fruit, the leaf, the stem, the root, etc.) may become a horticultural commodity. "Vegetable" is the generic name for any edible part of a plant; even the fruit of some plants are named fruit vegetables. Thus there are leafy vegetables, flower vegetables, root vegetables, stem vegetables, tuber vegetables, bulb vegetables, and fruit vegetables. Fruits of many plants are very diverse. Ornamentals are a special group of horticultural commodities whose purpose is basically decorative. Fruits, vegetables, and ornamentals refer to as the horticultural products member classes. They are very diverse in their structure, composition, physiology and postharvest handling requirements. Based on different criteria, there are several ways to classify them for different reasons, mostly to group them in diverse classes that are similar in some characteristics, to facilitate their postharvest handling as groups (Tables 3.1–3.29). Some of the bases of classifications include type of product (fruit, vegetable, ornamental, medicinal), taxonomic criteria (order, family, genera), botanical (Tables 3.1–3.2) criteria (simple fruits, aggregate fruits, syncarpous fruits, composite fruits), geographical origin (temperate, subtropical, tropical), season of production (summer or winter), reproductive cycle (annual, biannual, perennial), edible part of the plant (root, stem, leaf, fruit), perishability (very low, high, very high), physiological behavior (climacteric or nonclimacteric), respiration rate (low, medium, high, very high), ethylene production (low, medium, high, very high), ethylene sensitivity (sensitive, resistant), chilling sensitivity (sensitive, resistant), among several others classification systems. The purpose of the present chapter is to describe different classification systems for the diverse horticultural commodities based on their postharvest requirements in order to facilitate their postharvest handling.

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TABLE 3.1 Botanical Classification of Some Fruits

Family	Common Name	Botanical Name
Actinidiaceae	Kiwifruit	*Actinidia deliciosa*
Anacardiaceae	Cashew	*Anacardium occidentale*
	Chironji	*Buchanania lanzan* Spreng.
	Mango	*Mangifera indica* L.
	Pistachio	*Pistacia vera* L.
	Marula	*Sclerocarya birrea* (A. Rch.) Hochs.
	Ambarella	*Spondias cythera*
	Yellow mombin	*Spondias mombin* L.
	Red mombin	*Spondias purpuria* L.
Annonaceae	Cherimoya	*Annona cherimola* P. Mill.
	Soursop	*Annona muricata* L.
	Sweetsop	*Annona squamosa* L.
	Atemoya	*A. squamosa* × *A. cherimola*
	Pawpaw	*Asimina triloba* (L.) Dunal
	Biriba	*Rollinia mucosa* (Jacq.) Baill.
Apocyanaceae	Karonda	*Carissa congesta* Wight.
	Natal plum	*Carissa macrocarpa* (Ecklon) A. DC.
Araceae	Ceriman	*Monstera deliciosa* Liebm.
Aracaceae	Betel nut	*Areca catechu* L.
	Sugar palm	*Arenga pinnata* (Wurb) Merr.
	Coconut	*Cocos nucifera* L.
	Oil palm	*Alaeis guineensis* Jacq.
	Date palm	*Phoenix dactylifera* L.
Betulaceae	Hazelnut	*Corylus avellana* L.
Bombacaceae	Baobab	*Adansonia digitata* L.
	Durian	*Durio zibethinus*
	Malabar chestnut	*Pachira aquatic* Abul.
Boraginaceae	East African cordia	*Cordia Africana* Lam.
	Indian cherry	*Cordia dichotoma* Forster f.
Bromeliaceae	Pineapple	*Ananas comosus* (L.) Merril
Cactaceae	Pitahaya	*Hylocereus undatus* (Haworth) Britton & Rose
	Cactus pear	*Opuntia ficus-indica* (L.) Miller
	Barbadoas gooseberry	*Pereskia aculeate* Mill.
	Pitaya	*Stenocereus queretaroensis* (F.A.C. Weber) Buxbaum
Caricaceae	Papaya	*Carica papaya* L.

TABLE 3.2 Botanical Classification of Some Vegetables

Family	Vegetable Common Name	Botanical Name
CLASS—MONOCOTYLEDONEAE		
Alliaceae	Onion	*Allium cepa* L.
	Multipliar onion	*A. cepa* var. *aggregatum* L.
	Top onion	*A. cepa* var. *viviparum* (Metz.) Alef.
	Welsh onion	*A. fistulosum* L.
	Shallot	*A. cepa* var. *ascolonicum* L.
	Chive	*A. scheonoprasum* L.
	Leek	*A. ampeloprasum* L. var. *porrum* (L.)
	Garlic	*A. sativum*
	Great-headed garlic	*A. ampeloprasum* L.
Araceae	Taro	*Colocacia esculenta* (L.) Schott.
	Giant taro	*Alocacia indica*
	Elephant foot yam	*Amorphophallus campanulatus* (Roxb.) Blume
Diascoreaceae	Lesser yam	*Diascorea asculenta* (Lour.) Burkill
	Greater yam	*D. alata* L.
	White yam	*D. rotundata* (L.) Poir
Gramineae (Poaceae)	Sweet corn	*Zea mays* L.
Liliaceae	Asparagus	*Asparagus officinalis* L.
CLASS—DICOTYLEDONEAE		
Aizoaceae	New Zealand spinach	*Tetragonia tetragonioides* (Pall.) O. Kuntze (syn. *T. expansa* Murr.)
Amaranthaceae	Small amaranthus	*Amaranthus blitum* L.
	Large amaranthus	*A. tricolor* L.
Basellaceae	Indian spinach or basella	*Basella rubra* L. var. *alba* (green type) *B. rubra* L. var. *rubra* (red type)
Chenopodiaceae	Beet root	*Beta vulgaris* L. var. *rubra*
	Spinach beet	*B. vulgaris* L. var. *bengalensis* Roxb.
	Spinach	*Spinacea oleracea* L.
Compositae	Lettuce	*Lactuca sativa* L.
	Head type	*L. sativa* var. *capitata* L.
	Leaf type	*L. sativa* var. *crispa* L.

Continued

TABLE 3.2 Botanical Classification of Some Vegetables—cont'd

Family	Vegetable Common Name	Botanical Name
	Cos type	*L. sativa* var. *longifolia* L.
	Asparagus or stem type	*L. sativa* var. *asparagina* L.
Convolvulaceae	Sweet potato	*Ipomea batatas* (L.) Poir
Cruciferae	White cabbage	*Brassica olaracea* L. var. *capitata* f. *alba* DC.
	Red cabbage	*B. oleracea* L. var. *capitata* f. *rubra* (L.) Thell
	Savoy cabbage	*B. oleracea* L. var. *sabouda*
	Cauliflower	*B. oleracea* L. var. *botrytis* L.
	Broccoli	*B. oleracea* L. var. *italic* Plenck
	Brussels sprout	*B. oleracea* L. var. *gemmifera* DC.
	Kale	*B. oleracea* L. var. *acephala*
	Knolkhol	*B. oleracea* L. var. *gongylodes* (syn. *B. caulorapa*)
	Chinese cabbage (Pet-sai)	*B. compestris* sp. *pekinensis* (Lour.) Rupr. (syn. *B. pekinensis*)
	Chinese cabbage (Pak-choi)	*B. compestris* sp. *chinensis* L. (syn. *B. chinensis*)
	Turnip	*B. compestris* sp. *rapifera* Metz. (syn. *B. rapa* L. var. *glabra* Kitamura)
	Rutabaga (Swede)	*B. napobrassica* (L.) Rchb. (syn. *B. napus* var. *napobrassica* Peterm)
	Leaf mustard	*B. juncea* (L.) Czern. and Coss. var. *cuneifolia* Roxb.
	Radish	*Raphanus sativus* L.
	Small radish	*R. sativus* L. var. *sativus* Mansf.
	Chinese radish	*R. sativus* L. var. *longipinnatus*
	Rat tail radish	*R. caudatus* L. (syn. *R. sativus* var. *caudatus*)
	Horse radish	*Armoracia rusticana* Gaertn, Mey and Schereb. (syn. *A. lapathifolia*)
Cucurbitaceae	Cucumber	*Cucumis sativus* L.
	Gherkin	*C. anguria* L.
	Muskmelon	*C. melo* L.
	Snapmelon	*C. melo* L. var. *momordica* Duth & Full.
	Longmelon	*C. melo* L. var. *utilissimus* Duth. & Full.
	Netted melon	*C. melo* L. var. *reticulatus*
	Pickling melon	*C. melo* L. var. *onomon* Mark.
	Cantaloupe	*C. melo* L. var. *cantaloupensis* Naud.

TABLE 3.2 Botanical Classification of Some Vegetables—cont'd

Family	Vegetable Common Name	Botanical Name
	Mango melon	*C. melo* L. var. *chito*
	Watermelon	*Citrullus lanatus* (Thunb.) Matsum & Nakai (syn. *C. vulgaris* Schard)
	Round melon	*C. lanatus* var. *fistulosus* (Stocks) Mansf. (syn. *C. fistulosus* Stocks or *Praecitrullus fistulosus* Pang.)
	Bottle gourd	*Lagenaria siceraria* (Molina) Standl.
	Bitter gourd	*Momordica charantia* L.
	Ridge gourd	*Luffa acutangula* (L.) Roxb.
	Sponge gourd	*L. cylindrical* Roem. (syn. *L. aegyptica* Mill.)
	Pointed gourd	*Trichosanthes dioica* Roxb.
	Snake gourd	*T. anguina* L.
	Wax gourd (Ash gourd)	*Benincasa hispida* (Thunb.) Congn.
	Ivy gourd	*Coccinia grandis* (L.) Voigt. (syn. *C. indica* Wright & Arn. or C. cordiflia)
	Chow-chow (Chayote)	*Sechium edule* (Jacq.) Sw.
	Pumpkin	*Cucurbita moschata* (Duch.) Poir
	Summer squash	*C. pepo* L.
	Winter squash	*C. maxima* Duch.
Euphorbiaceae	Cassava/Tapioca	*Manihot esculenta* Cranz.
Leguminosae (Fabaceae)	Garden pea	*Pisum sativum* sp. *hortense*
	Field pea	*P. sativum* sp. *arvense*
	French bean	*Phaseolus vulgaris* L.
	Lima bean	*P. lunatus* L.
	Scarlet runner bean	*P. coccineus* L. (syn. *P. multiflorus* Lam.)
	Cluster bean	*Cyamopsis tetragonolobus* (L.) Sweet. (syn. *Dolichos lablab* (L.) Roxb.)
	Cowpea	*Vigna unguiculata* (L.) (syn. *V. sinensis* Endl)
	Asparagus bean	*V. unguiculata* sp. *sesquipedalis*
	Sword bean	*Canavalia gladiate* (Gucav.) DC.
	Jack bean	*C. ensiformis* (L.) DC.
	Winged bean	*Psophocarpus tetragonolobus* (L.) DC.
	Broad bean	*Vicia faba* L.

Continued

TABLE 3.2 Botanical Classification of Some Vegetables—cont'd

Family	Vegetable Common Name	Botanical Name
	Moth bean	*V. acontifolia* (Jacq.) Marechal
	Soybean	*Glycine max* L.
	Agathi	*Sesbania grandiflora* Poir
	Fenugreek	*Trigonella foenum-graecum* L.
Malvaceae	Okra	*Abelmoschus esculentus* (L.) Moench
Moringaceae	Drumstick	*Moringa oleifera* Lamk. (syn. *M. pterygosperma* Gaertn.)
Polygonaceae	Rhubarb	*Rheum rhaponticum* L.
	Sorrel	*Rumex acetosa*
Portulacaceae	Parsley	*Portulaca oleracea* L.
Rutaceae	Curry leaf	*Murraya koenigii* (L.) Spreng
Solanaceae	Tomato	*Lycopersicon esculentum* Mill.
	Common	*L. esculentum* var. *commune* Bailey
	Large leaved	*L. esculentum* var. *grandifolium* Bailey
	Upright	*L. esculentum* var. *validum* Bailey
	Pear-shaped	*L. esculentum* var. *pyriforme* Bailey
	Cherry	*L. esculentum* var. *cerasiforme* Bailey
	Currant tomato	*L. pimpinellifolium* (Juslen) Mill.
	Potato	*Solanum tuberosum* L.
	Brinjal	*S. melongena* L.
	Round fruited	*S. melongena* var. *esculentum*
	Long, slender fruited	*S. melongena* var. *serpentinum*
	Chilli and capsicum	*Capsicum annuum* L.
	Bird pepper	*C. frutescens* L.
	Tamatillo	*Phesalis ixocarpa* Brot.
	Husk tomato	*P. pubescens* L.
	Tree tomato	*Cyphomandra betacea*
Umbelliferae (Apiaceae)	Carrot	*Daucus carota* L.
	Parsnip	*Pastinaca sativa* L.
	Parsley	*Petroselinum crispum* (Mill.) Nym. Ex Hill. (syn. *P. hortense* Hoffm.)
	Turnip-rooted parsley	*P. crispum* var. *tuberosum*
	Celery	*Apium graveolens* L.
	Leafy type	*A. graveolens* L. var. *secalinum*

TABLE 3.2 Botanical Classification of Some Vegetables—cont'd

Family	Vegetable Common Name	Botanical Name
	Blanched celery	*A. graveolens* L. var. *dulce* (Mill.)
	Celeriac (turnip-rooted celery)	*A. graveolens* L. var. *rapaceum* (Mill.) DC.
	Coriander	*Coriandrum sativum* L.
	Cumin	*Cuminum cyminum* L.
	Fennel	*Foeniculum vulgare* Mill.
Zingiberaceae	Ginger	*Zingiber officinale* L.
	Turmeric	*Curcuma longa* L.

TABLE 3.3 Classification of Some Horticultural Commodities on the Basis of the Plant Part Used for Consumption

Name	Edible Part
(A) FRUITS	
Apple	Fleshy thalamus
Banana	Mesocarp and endocarp
Cashew nut	Peduncle and cotyledons
Coconut	Endosperm
Custard apple	Fleshy pericarp of individual berries
Fig	Fleshy receptacle
Guava	Thalamus and pericarp
Grape	Pericarp and placentae
Mango	Mesocarp
Orange	Juicy placental hair
Papaya	Mesocarp
Pineapple	Fleshy thalamus
Pomegranate	Aril
(B) PLANT CROPS AND SPICES	
Coconut	Endosperm
Arecanut	Seed (fresh and dried)
Cocoa	Beans (seed)
Coffee	Seed (beans)
Black pepper	Dried wrinkled fruit

Continued

TABLE 3.3 Classification of Some Horticultural Commodities on the Basis of the Plant Part Used for Consumption—cont'd

Name	Edible Part
Clove	Unopened flower bud
Cinnamon	Bark
Chili	Fruit with seeds
Turmeric	Rhizome
Ginger	Rhizome
Onion	Leaves and bulb
Garlic	Cloves
(C) VEGETABLES	
Radish, carrot, turnip, beetroot, sweet potato	Roots
Knolkhol, potato	Stem
Amaranthus, spinach, fenugreek	Leaf
Cauliflower, broccoli	Flower
Tomato, brinjal, okra, cucurbits	Fruit
Beans, pea	Pod
Onion	Bulb

3.2 THE OBJECTIVES AND BENEFITS OF CLASSIFICATION OF HORTICULTURAL COMMODITIES FOR POSTHARVEST HANDLING

The huge diversity of horticultural commodities results in the huge diversity in postharvest handling requirements. Therefore the classification of these commodities into different groups with similar characteristics is very helpful to facilitate their postharvest handling as groups rather than as individual commodities. Different classification systems are based on several different characteristics (as indicated in other sections in this chapter), not only for commodities that can be maintained under similar holding conditions, but also for those that, as a group, can receive certain treatment, such as curing (bulbs, tubers), conditioning (citrus), degreening (citrus), use of higher concentrations of carbon dioxide (berries), and use of sulfur dioxide fumigation (grapes), etc.

3.3 VEGETABLES

A great number and diversity of vegetables are produced. These are very diverse in their types, anatomical, morphological, physiological, and biochemical characteristics, and therefore in their postharvest handling requirements. However, there are also different criteria and systems to classify them into subgroups.

TABLE 3.4 Characteristics of Some Leafy Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Lettuce	VC	0	95	2 weeks	Desiccation
Celery	VC, HV, HC	0	98	2–3 months	Wilting, C_2H_4
Brussels sprouts	HC, FC, IC	0	95	3–5 weeks	Wilting, high respiration
Cabbage	VC, RC	0	95–100	From 4 weeks up to 7 months	
Green onions	HC, IC	0	95	2 weeks	
Spinach	HC, IC	0	95	10–14 days	
Cauliflower	VC, HV, HC	0	95	2–4 weeks	C_2H_4
Broccoli	HC, IC	0	95	1–2 weeks	C_2H_4, high respiration

VC, *vacuum cooling;* HC, *hydrocooling;* HV, *hydrovacuum;* RC, *room cooling;* IC, *ice cooling;* C_2H_4, *ethylene.*

3.3.1 Leafy Vegetables

This type of vegetables, which include crops such as lettuce, celery, cabbage, spinach, and cauliflower (Table 3.4), can be adapted very well to low-temperature storage. They are characterized by having high respiration and metabolism rates, and are not sensitive to chilling injury. Therefore they all adapt to maintenance at the lowest possible low temperature, above freezing point (0°C). This group of vegetables also needs to be maintained at very high relative humidity (90%–95%), as they are all very sensitive to water loss. These commodities are commonly sensitive to ethylene (C_2H_4), and they should be protected by excluding ethylene exposure, including that which is produced by other horticulture commodities during mixed loads storage and transport. Leafy vegetables are the most adapted horticultural commodities to vacuum precooling. However, their main feature is a short postharvest and storage life. Table 3.4 shows information on different types of leafy vegetables.

3.3.2 Flower Vegetables

Flower vegetables include crops such as broccoli and artichoke (Table 3.5). These commodities are characterized by high metabolic rate, and are sensitive to water loss and ethylene exposure. They are insensitive to chilling, and can be maintained best at the lowest possible temperature above freezing (0°C) and the highest possible RH (95%–98%). Their postharvest life is commonly short (1–4 weeks).

TABLE 3.5 Characteristics of Some Flower Vegetables (Inflorescences)

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life (Weeks)	Sensitivity
Cauliflower	VC, HV, HC	0	95	2–4	C_2H_4
Broccoli	HC, IC	0	95	1–2	C_2H_4, high respiration
Artichoke, globe	HC	0	95–98	2–3	Wilting

VC, *vacuum cooling;* HC, *hydrocooling;* HV, *hydro-vacuum;* IC, *ice cooling;* C_2H_4, *ethylene.*

TABLE 3.6 Characteristics of Some Root Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life
Carrot	HC	0	98	~6 months
Radish	HC	0	95	2 weeks
Horseradish				2–4 months (no foliage)
Sweet potato	HC, RC	12–14	85–90	~6 months
Turnip	HC, RC	0	95	4–5 months
Beetroot	HC, RC	0	95	2–4 weeks

HC, *hydrocooling;* RC, *room cooling.*

3.3.3 Root Vegetables

Root vegetables include commodities, such as carrot, radish, horseradish, sweet potato, turnip, and beetroot (Table 3.6). They are characterized by a low rate of metabolism and therefore their postharvest life is relatively long. Some of them, such as carrots and sweet potatoes, may germinate during storage, especially after long storage durations and when maintained at less-than-optimum holding conditions. Sweet potatoes need a special curing treatment in order to heal wounds that are often formed during harvest. Curing is commonly done immediately after harvest, and consists in exposure at high temperatures combined with high relative humidity for several days. Curing allows outer skins to dry and harden prior to storage, thus preventing damage due to rough handling, and also rotting. Most root vegetables are tolerant to chilling, and therefore these are well adapted to holding at the lowest possible temperatures after freezing (0°C) and are precooled with cold water (hydrocooling). Table 3.6 shows information on different types of root vegetables.

3.3.4 Stem Vegetables

Stem vegetables include commodities such as asparagus and kohlrabi (Table 3.7). In general, stem vegetables adapt well to low temperatures, but they lose weight easily; therefore they should be maintained at very low temperatures (0°C) and high-humidity atmospheres.

Except for sweet potato and jicama, which are of tropical origin, leafy, root, and stem vegetables are therefore very well adapted to be maintained at low (above freezing) temperatures.

TABLE 3.7 Characteristics for Some Stem Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life
Asparagus	HC, VC	0	90	2–3 weeks
Kohlrabi		0	98–100	2–3 months

VC, *vacuum cooling;* HC, *hydrocooling.*

TABLE 3.8 Characteristics of Some Immature Fruit Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Eggplant	RC	12	90–95	1 week	CI, C_2H_4
Cucumber	RC, HC	10–13	95	10–14 days	CI, C_2H_4
Squashes	RC	Summer 5–10 Winter 10–13	95 50–70	1–3 months	CI
Sweet peppers	RC	5–7	85–90	1–2 weeks	
Snap beans	RC, FC	4–7	95	7–10 days	CI
Lima beans	RC, FC	5–6	95	5 days	CI
Okra	RC	7–10	90–95	7–10 days	CI
Sweet corn	HC, RC	0	90–100	8 days	
Peas	HC, IC	0	95–100	1–2 weeks	

HC, *hydrocooling;* FC, *forced-air cooling;* RC, *room cooling;* IC, *ice cooling;* CI, *chilling injury.*

3.3.5 Fruit Vegetables (Immature)

Immature fruit vegetables include commodities such as squash, sweet peppers, snap beans, lima beans, okra, sweet corn, and peas (Table 3.8). Most immature fruit vegetables are sensitive to chilling injury; exceptions include sweet corn and peas. Therefore most of them have a very short postharvest life. Some of these commodities, such as cucumber and eggplant, are very sensitive to ethylene exposure (C_2H_4). Most of these commodities are precooled with forced air.

3.3.6 Fruit Vegetables (Mature)

Mature fruit vegetables include commodities such as tomato, melons, and winter squash (Table 3.9). All mature fruit vegetables are sensitive to chilling injury and therefore they should be maintained at safe/moderate temperatures above their chilling sensitive point, depending on each commodity. As a result, most of them have a relatively short postharvest life. All these commodities need to be maintained at a high relative humidity in order to reduce their loss of weight by transpiration, except for winter squash, which should be held at low RH.

TABLE 3.9 Characteristics of Some Fruit Vegetables (Mature)

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Tomato	RC, FC	13–15	90	1–3 months	CI
Melon	FC	7–10	90	~2 weeks	CI
Watermelon	RC	10–15	90	2–3 weeks	CI, C_2H_4
Winter squash	RC	10–13	50–70	2–3 months	CI

FC, *forced-air cooling;* RC, *room cooling;* CI, *chilling injury.*

TABLE 3.10 Characteristics of Some Tuber Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Potato	No need	4–10	95–90	3–9 months	
Sweet potato	RC	4	85–90	~6 months	CI
Jicama	RC	13–18	65–70	1–2 months	CI
Jerusalem artichoke		−0.5 to 0	90–95	4–5 months	
Yam	RC	12–15	85–90	~6 months	CI

RC, *room cooling;* CI, *chilling injury.*

3.3.7 Tuber Vegetables

Tuber vegetables include commodities such as sweet potato, jicama, yam and Jerusalem artichoke (Table 3.10). They are modified roots or stems that are enlarged to store nutrients. Tuber vegetables are characterized by a relatively low metabolism, and as a consequence they all have a relatively long postharvest life. Sweet potato, jicama and yam are chilling sensitive. Tuber vegetables are susceptible to wounding during harvest, and therefore, the application of a curing treatment immediately after harvest for wound healing is highly recommended. Potatoes may sprout during storage, which can be inhibited by preharvest application with maleic hydrazide. In addition, potato tubers should be protected from light exposure to avoid the development of solanine, a glycolipid that appears as green pigmentation on the tuber.

3.3.8 Bulb Vegetables

Bulb vegetables include onion and garlic. A bulb vegetable is a food storage organ for periods of plant dormancy. As a plant structure, a bulb is a short stem with edible fleshy leaves. These vegetables are insensitive to chilling, and therefore they are maintained best at 0°C. They also require a relatively low relative humidity (65%–70%) to avoid development of decay. These vegetables are characterized by a low metabolic activity (i.e., low respiration rate), and therefore they are characterized by a relatively long postharvest life. Bulbs require curing in order to prevent rot, and they may be treated with a sprout suppressant before harvest (such as maleic hydrazide).

3.4 FRUITS

Fruits have been grouped in many different forms based on different characteristics. For example, based on climatological origins and requirements, fruits are divided into temperate, subtropical, and tropical.

TABLE 3.11 Characteristics of Some Bulb Vegetables

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Onion	RC	0	65–70	6–8 months	Sprouting
Garlic	RC	0	65–70	6–7 months	Sprouting

RC, *room cooling.*

TABLE 3.12 Characteristics for Some Subtropical Fruits

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Avocado	FC	4–13	85–90	2–4 weeks	CI
Orange	RC, FC	3–8	90	3–12 weeks	CI
Grapefruit	RC	10–15	85–90	6–8 weeks	CI
Lemon	RC	10–13	85–90	1–6 months	CI
Lime	RC	9–10	85–90	6–8 weeks	CI
Pomegranate	HC, FC	5°C	90	2–3 months	CI
Persimmon	FC	−1°C	90	3–4 weeks	
Lychee	FC	1.5	90–95	3–5 weeks	Desiccation
Fig	FC	0	85–90	7–10 days	
Date	RC	−15 to 0	≤75	6–12 months	
Olive	RC	5–10	85–90	4–6 weeks	CI
Kiwifruit	FC	0	85	4–7 weeks	

HC, *hydrocooling;* FC, *forced-air cooling;* RC, *room cooling;* CI, *chilling injury.*

3.4.1 Temperate Fruits

Temperate fruits are those adapted to the temperate zone climates in the middle latitudes. Some examples of these include apple, pear, peach, plum, grape, and strawberry. These fruits are also classified in other forms: apple and pear appear as pome fruits, peach and plum as stone fruits, and grape and strawberry as small fruits.

3.4.2 Subtropical Fruits

Examples of these are fig, loquat, cherimoya, olive, lychee, and persimmon. (Table 3.12) Some of these fruits are not very perishable, such as citrus, date, carob, jujube, and kiwifruit. Some subtropical fruits are sensitive to chilling injury. Table 3.12 shows some characteristics of some of these fruits.

3.4.3 Tropical Fruits

Some examples of these fruits include bananas, plantains, mangos, papayas, and guava (Table 3.13). All tropical fruits are sensitive to chilling injury, and therefore they should be maintained at a relatively high temperatures ranging from 4 to 13°C depending on the commodity, which contributes to their short postharvest life. Almost all tropical fruits are climacteric, and produce relatively high amounts of ethylene. Banana is among the most popular tropical fruits, which is commonly ripened after harvest or after reaching the destination market with ethylene. Some tropical fruits such as mango and papaya are heat treated

TABLE 3.13 Characteristics of Some Tropical Fruits

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life (Weeks)	Sensitivity
Banana	FC, RC	13–15	90–95	1–4	CI
Plantain	FC, RC	13–15	90–95	1–5	CI
Mango	FC	10–13	85–90	2–4	CI
Papaya	FC	7–13	85–90	1–3	CI
Guava	FC	5–10	85–90	2–3	CI

FC, *forced-air cooling;* RC, *room cooling.*

(commonly with hot water treatment, but also with hot air) for insect or disease control. Some tropical fruits, such as mango and papaya, can also be irradiated for quarantine purposes. Almost all tropical fruits are well adapted to forced-air precooling.

3.4.4 Small Fruits

Examples of small fruits include grape, strawberry, blackberry, blueberry, cranberry, and raspberry (Table 3.14). The limiting factor of postharvest life of these fruits is their latent infection with diseases, especially with *Botrytis cinerea*. Small fruits are insensitive to chilling injury, and therefore they can be best maintained at the lowest possible temperature above freezing (0°C). Unfortunately, this temperature is not enough to completely stop the growth of Botrytis, and therefore some complimentary treatments are used. Berries such as strawberries, blueberries, and blackberries are resistant to exposure to high levels of CO_2, and therefore this treatment is commonly used, especially for strawberries, at about 20 kPa during fruit shipment. Grapes are among the very few fruits that tolerate the exposure to SO_2 gas, and therefore this treatment is very commonly used to delay the growth of Botrytis. All these fruits are very well adapted to forced-air precooling. However, most are characterized by a short postharvest life.

TABLE 3.14 Characteristics of Some Small Fruits

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life
Grape	FC	−1 to 0	90–95	1–6 months
Strawberry	FC	−1 to 0	90–95	5–7 days
Blackberry	FC	−1 to 0	90–95	2–3 days
Blueberry	FC	−1 to 0	90–95	2 weeks
Cranberry	FC	−1 to 0	90–95	2–4 months
Gooseberry	FC	−1 to 0	90–95	2–4 weeks
Raspberry	FC	−1 to 0	90–95	2–3 days

FC, *forced-air cooling.*

TABLE 3.15 Characteristics of Some Pome Fruits

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life	Sensitivity
Apple	FC, HC	0–4	85–90	2–9 months	Brown core in McIntosh
Pear	FC, HC	−0.5 to 0.5	90–95	2–6 months	
Quince	VC	0.1	95	2–3 months	

VC, *vacuum cooling;* HC, *hydrocooling;* FC, *forced-air cooling;* RC, *room cooling.*

3.4.5 Pome Fruits

Examples of pome fruits include apples, pears, and quince (Table 3.15). These fruits are of temperate origin and resist chilling temperatures, therefore they are best maintained at low temperatures (around 0°C). Very few apple cultivars are slightly susceptible to chilling at temperatures lower than 3–4°C. All these fruits are climacteric, produce relatively high amounts of ethylene, and adapt very well (especially apples and pears) to storage in controlled atmospheres; therefore they usually have a relatively long storage life.

3.4.6 Stone Fruits

Examples of stone fruits include peach, nectarine, plum, and apricot (Table 3.16). Stone fruits are very well adapted to be stored at 0°C. Some of them, such as peaches, may present cold damage at 5°C. They all require high relative humidity of 90%–95%. All stone fruits are climacteric, and some may adapt to short durations of controlled atmosphere storage.

3.4.7 Nuts

Examples of some important nuts include almond, macadamia, pecan, pistachio, and walnut (Table 3.17). This group of commodities are all characterized by very low metabolic activity and low water content and activity, and therefore they are very well adapted to be maintained at very low temperatures (0°C or lower), and relatively low (65%–70%) relative humidity, for a long period of time (several months to more than one year). Nuts are very resistant to low levels of oxygen and very high levels of CO_2, and therefore modified and controlled atmospheres at extreme gas composition (very low O_2 and/or very high CO_2) can be used for these commodities to control insects and diseases to avoid oxidation.

TABLE 3.16 Characteristics of Some Stone Fruits

Produce	Precooling	Temperature (°C)	% RH	Postharvest Life (Weeks)
Peach	HC, FC	0	90–95	2–4
Nectarine	HC, FC	0	90–95	2–4
Plum	FC, RC	0	90–95	4–5
Apricot	FC, RC	0	90–95	1–2

HC, *hydro-cooling;* FC, *forced-air cooling;* RC, *room cooling.*

TABLE 3.17 Characteristics of Some Nuts

Produce	Postharvest Life (Months)
Pecan	12–18
Walnut	10–20
Almond	15–20
Macadamia	12–24
Pistachio	12

3.5 ORNAMENTALS

Ornamentals are a very big and hugely diverse group of whole plants or parts of plants that are grown usually for decorative purposes. Ornamentals can be grouped as cut flowers, florist greens (decorative foliage) bulbs, corms, rhizomes, tubers and roots, cuttings and scions, and nursery stocks. These commodities have diverse origins and characteristics, and therefore also very diverse postharvest handling requirements. Many of these commodities are chilling sensitive, sensitive to water loss and to exposure to ethylene. Therefore, they mostly need to be precooled very fast (mostly by using forced-air cooling), maintained under high humidity atmosphere, and protected from exposure to ethylene gas. Several of these commodities respond very well to treatments with ethylene antagonists, such silver thiosulfate (STS) and 1-methylecyclopropene (1-MCP).

3.6 RESPIRATION, CLIMACTERIC, AND ETHYLENE

Fruit growth and development start with a fruit set and ends with senescence and death; different commodities are picked at different stages, depending on the purpose of the use of such commodity. All commodities are characterized by the highest rate of metabolic activity (highest respiration rate) immediately after fruit initiation (after fruit set), and the metabolic activity decreases as the development of the fruit advances, until it reaches a minimum when the fruit is commonly physiologically mature. At this stage some commodities continue their respiration rate with no significant changes until senescence and death of the tissue. These commodities are known as nonclimacteric commodities. Other distinct groups of commodities are characterized by a sudden increase in respiration rate known as the climacteric. Table 3.18 list examples of climacteric and nonclimacteric commodities.

The classification of horticultural commodities into climacteric and nonclimacteric is very helpful in facilitating their postharvest handling. For example, climacteric commodities can be ripened off the plant if harvested after reaching their physiological maturity (at any point at or after the sudden increase of the respiratory climacteric), but nonclimacteric commodities will not ripen off the tree. Therefore this fact is commonly used in practice, where all nonclimacteric commodities have to be picked when they reach their optimum ripening

and consumption stage, while nonclimacteric commodities can be (and many of them are commonly) harvested before they reach their final ripening and consumption stage (but after they reach their physiological maturity)..This way, they tolerate postharvest handling and shipping, can reach distant markets, and can be stored for longer periods of time.

The climacteric respiration process (the sudden increase in respiration rate) is also accompanied by a sudden increase in ethylene production, which is not seen in nonclimacteric commodities. This fact is also important for the commercial handling of climacteric and nonclimacteric commodities. Climacteric commodities are generally characterized by higher ethylene production than those nonclimacteric. Climacteric commodities also respond differently to ethylene exposure compared to nonclimacteric commodities. Ethylene has a much more pronounced effect on climacteric commodities. Some climacteric commodities (such as bananas, tomatoes, avocado, and mangoes) are ripened after harvest using ethylene. Some citrus (nonclimacteric) fruits are treated with ethylene after harvest to change their color, although this treatment will not affect their reopening stage.

TABLE 3.18 Examples of Climacteric and Nonclimacteric Commodities

Climacteric Fruits	Nonclimacteric Fruits
Avocado	Cashew
Apricot	Citrus fruit
Cantaloupe	Potato
Cherimoya	Chili pepper
Plum	Lychee
Peach	Grape
Feijoa	Pineapple
Breadfruit	Olive
Guava	Winter squash
Fig	Summer squash
Persimmon	Strawberry
Kiwifruit	Tamarillo
Mamey	Eggplant
Mango	Loquat
Apple	Jujube
Passion fruit	Pomegranate
Papaya	Cucumber
Pear	Cherry

Continued

TABLE 3.18 Examples of Climacteric and Nonclimacteric Commodities—cont'd

Climacteric Fruits	Nonclimacteric Fruits
Banana	Blueberry
Watermelon	Cactus pear
Soursop	
Tomato	
Sapodilla	
Melon	

3.7 RESPIRATION RATE AND ETHYLENE PRODUCTION AND SENSITIVITY

Horticultural commodities (climacteric and nonclimacteric) are also grouped according to their respiration rate (Table 3.19) and ethylene production (Table 3.20) rates. These grouping systems are very helpful for the postharvest handling of fresh horticultural commodities. For example, commodities with low metabolic activity (very low respiration rate) such as dates, dried fruits and vegetables, and nuts are characterized by very long postharvest life, while those with very high metabolic activity such as asparagus, mushrooms, parsley, peas, spinach, and sweet corn, are commonly characterized by very short postharvest life. Commodities with intermediate metabolic activity are characterized by intermediate postharvest life.

TABLE 3.19 Some Horticultural Commodities Classified According to Their Respiration Rates

Class	Range at 20°C ($mg\,CO_2/kg\,h$)	Commodities
Very low	<5	Dates, dried fruits and vegetables, nuts
Low	5–10	Apple, beet, celery, citrus fruits, cranberry, garlic, grape, honeydew melon, kiwifruit, onion, papaya, persimmon, pineapple, pomegranate, potato, pumpkin, sweet potato, water melon, winter squash
Moderate	10–20	Apricot, banana, blueberry, cabbage, cantaloupe, carrot (topped), celeriac, cherry, cucumber, fig, gooseberry, lettuce (head), mango, nectarine, olive, peach, pear, plum, potato (immature), radish (topped), summer squash, tomato
High	20–40	Avocado, blackberry, carrot (with tops), cauliflower, leek, lettuce (leaf), lima bean, radish (with tops), raspberry, strawberry
Very high	40–60	Artichoke, bean sprouts, broccoli, Brussels sprout, cherimoya, cut flowers, endive green onions, kale, okra, passion fruit, snap bean, watercress
Extremely high	>60	Asparagus, mushroom, parsley, peas, spinach, sweet corn

TABLE 3.20 Classification of Some Horticultural Commodities According to Their Ethylene (C_2H_4) Production

Class	Range at 20°C (μL C_2H_4/kg h)	Commodities
Very low	<0.1	Artichoke, asparagus, cauliflower, cherry, citrus fruits, grape, jujube, strawberry, pomegranate, leafy vegetables, root vegetables, potato, most cut flowers
Low	0.1–1.0	Blackberry, blueberry, casaba melon, cranberry, cucumber, eggplant, okra, olive, pepper (sweet and chili), persimmon, pineapple, pumpkin, raspberry, tamarillo, watermelon
Moderate	1.0–10.0	Banana, fig, guava, honeydew melon, lychee, mango, plantain, tomato
High	10.0–100.0	Apple, apricot, avocado, cantaloupe, feijoa, kiwifruit (ripe), nectarine, papaya, peach, pear, plum
Very high	>100.0	Cherimoya, mammey apple, passion fruit, sapote

TABLE 3.21 Ethylene Highly Produced and Ethylene Sensitive Horticultural Commodities

Ethylene Highly Produced Commodities	Ethylene Sensitive Commodities
Apples, apricots, avocados, banana (ripening), cantaloupe, cherimoya, figs, guava, honeydew melons, ripe kiwifruit, mamey, mangoes, mangosteen, nectarines, papayas, passion fruit, peaches, pears, persimmons, plantains, plums, prunes, quinces, rambutan, tomatoes	Banana (unripe), Belgian endive, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, chard, cucumbers, cut flowers, eggplant, florist greens, green beans, kiwifruit (unripe), leafy greens, lettuce, okra, parsley, peas, peppers, potted plants, spinach, squash, sweet potatoes, watercress, watermelon, yams

The grouping of fresh horticultural commodities according to their ethylene production (Table 3.20) is also of great benefit for the postharvest handling of these commodities. For example, commodities that produce high amounts of ethylene (e.g., apple, cantaloupe, and cherimoya) should not be mixed during storage, transport, or displays with commodities very sensitive to ethylene (Table 3.21).

3.8 CHILLING AND NONCHILLING SENSITIVE COMMODITIES

Horticultural commodities are commonly grouped into chilling and nonchilling sensitive or resistant commodities (Tables 3.22 and 3.23). This classification is very important and helpful in avoiding this injury and to avoid holding sensitive commodities at lower than their safe temperature.

TABLE 3.22 Classification of Some Fruits According to Their Sensitivity to Chilling Injury

Class	Fruits
Nonchilling sensitive fruits	Apple, apricot, blackberry, blueberry, cherry, current, date, fig, grape, kiwifruit, loquat, nectarine, peach, pear, persimmon, plum, prune, raspberry, strawberry
Chilling sensitive fruits	Avocado, banana, breadfruit, carambola, cherimoya, citrus, cranberry, durian, feijoa, guava, jackfruit, jujube, longan, lychee, mango, mangosteen, olive, papaya, passion fruit, pepino, pineapple, plantain, pomegranate, prickly pear, rambutan, sapodilla, sapote, tamarillo

TABLE 3.23 Classification of Some Vegetables According to Their Sensitivity to Chilling Injury

Class	Fruits
Nonchilling sensitive vegetables	Artichoke, asparagus, lima bean, beet, broccoli, Brussels sprouts, Cabbage, carrot, cauliflower, celery, sweet corn, endive, garlic, lettuce, mushrooms, onion, parsley, parsnip, peas, radish, spinach, turnip
Chilling sensitive vegetables	Snap beans, cassava, cucumber, eggplant, ginger, muskmelon, okra, peppers, potato, pumpkin, squash, sweet potato, taro, tomato, watermelon, yam

3.9 CLASSIFICATION OF HORTICULTURAL COMMODITIES ACCORDING TO THEIR RECOMMENDED PRECOOLING METHODS

Precooling or fast cooling (the fast elimination of field heat) is an essential postharvest treatment for almost all fresh horticultural commodities. Different precooling methods are available and are commonly used according to the properties and characteristics of the different horticultural commodities. These methods include room cooling, forced-air cooling, hydrocooling, vacuum cooling, and icing. The proper precooling method(s) for some important horticultural commodities are listed in Table 3.24.

TABLE 3.24 Recommended Precooling Methods for Some Horticultural Commodities

Commodity	Proper Precooling Method(s)
Apples	R, F, H
Artichoke	H, I
Asparagus	H, I
Avocados	F
Beans, snap	R, F, H
Beans, butter	R, F, H
Beets, topped	R
Berries	F
Blueberries	R, F
Brambles	R, F
Broccoli	I
Cabbage	R, F
Cantaloupe	H, I
Cucumbers	F, H
Cut flowers	F, R
Eggplant	R, F

TABLE 3.24 Recommended Precooling Methods for Some Horticultural Commodities—cont'd

Commodity	Proper Precooling Method(s)
Grapes	F
Green onions	H, I
Leafy greens	H, I
Lettuce	V
Mangoes	F
Mushrooms	F
Okra	R, F
Papayas	F, R
Peaches	F, H
Peas	F, H
Peas, field	F, H
Peppers	R, F
Potatoes	R, F
Potted plants	R
Squash	R, F
Strawberries	R, F
Sweet corn	H, I
Tomatoes	R, F
Turnips	R
Watermelons	R

R, *room cooling;* F, *forced-air cooling;* H, *hydrocooling;* V, *vacuum cooling;* I, *icing.*

3.10 TOLERANCE TO ATMOSPHERIC GASES

The grouping of fresh horticultural commodities according to their tolerance to atmospheric gases, especially oxygen (Table 3.25) and carbon dioxide (Table 3.26), is of great benefit for the handling of these commodities for different reasons. This grouping indicates the optimum levels of gases that can be used when some of these commodities are either transported or stored in modified or controlled atmospheres. On the other hand, this grouping system is beneficial as those that commodities exposed to oxygen levels lower than their tolerance or carbon dioxide levels higher than their tolerance can cause severe injury. In addition, this grouping system indicate those commodities that can tolerate very low levels of oxygen and/or very high levels of carbon dioxide, as these atmospheres can be used as potential treatments for the control of diseases and insects.

TABLE 3.25 Classification of Some Fruits and Vegetables According to Their Tolerance to Low O_2 Atmospheres

Minimum O_2 Pressures Tolerated (kPa)	Commodities
0.5	Tree nuts, dried fruits, and vegetables
1.0	Some cultivars of apples and pears, broccoli, mushroom, garlic, onion, most cut or sliced (minimally processed) fruits and vegetables
2.0	Most cultivars of apples and pears, kiwifruit, apricot, cherry, nectarine, peach, plum, strawberry, papaya, pineapple, olive, cantaloupe, sweet corn, green bean, celery, lettuce, cabbage, cauliflower, Brussels sprouts
3.0	Avocado, persimmon, tomato, pepper, cucumber, artichoke
5.0	Citrus fruits, green pea, asparagus, potato, sweet potato

3.11 RELATIVE PERISHABILITY

According to several classification and grouping systems, such as metabolic activity (respiration rate), ethylene production and sensitivity, and chilling sensitivity, among others, fresh horticultural commodities can be classified according to their relative perishability (Table 3.27). For example, commodities with very high metabolic activity (e.g., berries) and/or those with very high sensitivity to chilling injury and therefore need to maintained at relatively high temperatures (e.g., banana) are characterized by high perishability. Commodities with very low metabolic activities (e.g., nuts, dry fruits, and vegetables) and/or those that can be maintained at very low temperatures (e.g., onions and potatoes, and/or those that can be held in controlled atmospheres (e.g., apples) are characterized by low perishability.

TABLE 3.26 Classification of Some Fruits and Vegetables According to Their Tolerance to Elevated CO_2 Atmospheres

Maximum CO_2 Pressures Tolerated (kPa)	Commodities
2	Apple (Golden Delicious), Asian pear, European pear, apricot, grape, olive, tomato, pepper (sweet), lettuce, endive, Chinese cabbage, celery, artichoke, sweet potato
5	Apple (most cultivars), peach, nectarine, plum, orange, avocado, banana, mango, papaya, kiwifruit, cranberry, pea, pepper (chili), eggplant, cauliflower, cabbage, Brussels sprouts, radish, carrot
10	Grapefruit, lemon, lime, persimmon, pineapple, cucumber, summer squash, snap bean, okra, asparagus, broccoli, parsley, leek, green onion, dry onion, garlic, potato
15	Strawberry, raspberry, blackberry, blueberry, cherry, fig, cantaloupe, sweet corn, mushroom, spinach, kale, Swiss chard

TABLE 3.27 Classification of Fresh Horticultural Commodities According to Relative Perishability and Potential Postharvest Life at Optimal Temperature and Relative Humidity

Relative Perishability	Potential Storage Life (Weeks)	Commodities
Very high	<2	Apricot, blackberry, blueberry, cherry, fig, raspberry, asparagus, bean sprouts, broccoli, cauliflower, cantaloupe, green onion, leaf lettuce, mushroom, pea, spinach, sweet corn, tomato (ripe), most cut flowers and foliage, fresh-cut (minimally processed) fruits and vegetables
High	2–4	Avocado, banana, grape (without SO_2 treatment), guava, loquat, mandarin, mango, melons (honeydew, crenshaw, pershian), nectarine, papaya, peach, pepino, plum, artichoke, green beans, Brussels sprouts, cabbage, celery, eggplant, head lettuce, okra, pepper, summer squash, tomato (partially ripe)
Moderate	4–8	Apple and pear (some cultivars), grapes (SO_2 treated), orange, grapefruit, lime, kiwifruit, persimmon, pomegranate, pummel, table beet, carrot, radish, potato (immature)
Low	8–16	Apple and pear (some cultivars), lemon, potato (mature), dry onion, garlic, pumpkin, winter squash, sweet potato, taro, yam, bulbs and other propagules of ornamental plants
Very low	>16	Tree nuts, dry fruits, and vegetables

3.12 CLASSIFICATION ACCORDING TO COMPATIBILITY

Horticultural commodities are commonly stored and transported together in "mixed loads." However, it is very important that only compatible commodities be maintained together. Compatibility of horticultural commodities are based on several bases, including: (1) temperature requirement, (2) relative humidity requirement, (3) ethylene production, (4) ethylene sensitivity, (5) tolerance to low oxygen atmospheres and high CO_2 atmospheres during modified and controlled atmosphere storage and shipment, (6) sensitivity, (7) tolerance to sulfur dioxide fumigation. Table 3.28 lists the different compatible groups of horticultural commodities that can be stored or transported together in mixed loads.

TABLE 3.28 Grouping of Compatible Horticultural Commodities

Group	Commodities
Group 1. Fruits and vegetables, 0–2°C, 90%–95% relative humidity. Several are ethylene producers	Apples, apricots, Asian pears, Barbados cherry, beets (topped), berries (except cranberries), caimito, cashew apple, cherries, coconuts, currants, cut fruits, dates, figs (not with apples), gooseberry, grapes (without sulfur dioxide), horseradish, kohlrabi, leeks, longan, loquat, lychee, mushrooms, nectarines, parsnips, peaches, pears, persimmons, plums, pomegranates, prunes, quinces, radishes, raspberry, strawberry, rutabagas, turnips

Continued

TABLE 3.28 Grouping of Compatible Horticultural Commodities—cont'd

Group	Commodities
Group 2. Fruits and vegetables, 0–2°C, 90%–100% relative humidity. Many products of this group are sensitive to ethylene	Alfalfa sprouts, amaranth, anise, artichokes, arugula, asparagus, bean sprouts, beets, Belgian endive, berries (except cranberries), bok choy, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celeriac, celery, chard, cherries, sweet corn, cut vegetables, daikon, endive, escarole, grapes (without sulfur dioxide), horseradish, Jerusalem artichoke, kailon, kale, kiwifruit, kohlrabi, leafy greens, leeks (not with figs or grapes), lettuce, lo bok, mint, mustard greens, green onions (not with figs, grapes, mushrooms, rhubarb, or corn), parsley, parsnips, peas, pomegranates, radicchio, rhubarb, rutabagas, salsify, scorzonera, shallot, snow peas, spinach, turnips, water chestnut, watercress
Group 3. Fruits and vegetables, 0–2°C, 65%–75% relative humidity	Dry onion, garlic
Group 4. Fruits and vegetables, 5°C, 90%–95% relative humidity	Cactus leaves, cactus (prickly) pears, caimito, cantaloupes, clementine, cranberries, lemons, lychees, kumquat, mandarin, oranges, pepino, tamarillo, tangelos, tangerines, ugli fruit, yucca root
Group 5. Fruits and vegetables, 7–10°C, 85%–90% relative humidity, sensitive to chilling injury, many are sensitive to ethylene	Babaco, basil, beans, cactus stems (nopales), cactus pears, caimito, calamondin, chayote, cowpea, cranberry, cucumber, custard apple, durian, eggplant, feijoa, granadilla, grapefruit, guava, kiwano, kumquat, lemon, lime, long bean, malanga, mandarin, okra, olive, orange, passion fruit, pepino, peppers, pineapple, potatoes, pummelo, sugar apple, summer squash (soft shell), tamarind, tangelo, tangerine, taro root, tomatillo, ugli fruit, watermelon, winged bean
Group 6. Fruits and vegetables, 13–15°C, 85%–90% relative humidity, chilling sensitive, many produce high concentration of ethylene	Atemoya, avocados (certain cultivars), babaco, bananas, bitter melon, black sapote, boniato, breadfruit, canistel, carambola, cassava, cherimoya, coconuts, feijoa, ginger root, granadilla, grapefruit, guava, jaboticaba, jackfruit, langsat, lemons, limes, mamey, mangoes, mangosteen, melons (except cantaloupes), papayas, passion fruit, pineapple, plantain, pumpkin, rambutan, santol, sapodilla, sapote, soursop, sugar apple, winter squash, tomatillos, ripe tomatoes, yam
Group 7. Fruits and vegetables, 18–21°C, 85%–90% relative humidity	Jicama, sweet potatoes, mature green tomatoes, watermelon, white sapote, yams
Group 8. Flowers and florist greens, 0–2°C, 90%–95% relative humidity	Aadiantum, allium, aster (China), bouvardia, carnation, cedar, chrysanthemum, crocus, cymbidium orchid, dagger and wood, ferns, freesia, galax, gardenia, ground pine, hyacinth, ilex (holy), iris (bulbous), juniper, lily, lily-of-the-valley, mistletoe, mountain-laurel, narcissus, peony (tight buds), ranunculus, rhododendron, rose, salal (lemon leaf), squill, sweet pea, tulip, vaccinium (huckleberry), woodwardia fern

TABLE 3.28 Grouping of Compatible Horticultural Commodities—cont'd

Group	Commodities
Group 9. Flowers and florist greens, 4.5°C, 90%–95% relative humidity	Acacia, adiantum (maidenhair), alstroemeria, anemone, aster (China), asparagus (plumosa, sprenger), buddleia, buxus (boxwood), calendula, calla, candytuft, camellia, clarkia, colombina, coreopsis, cornflower, cosmos, croton, dahlia, daisies, delphinium, dracaena, eucalyptus, feverfew, forgot-me-not, foxglove, gaillardia, gerbera, gladiolus, gloriosa, gypsophila, heather, hedera, luine, magnolia, marigolds, mignonette, philodendron, phlox, pittosporum, poppy, pothos, primrose, protea, ranunculus, scotch-broomern, snapdragon, snowdrop, statice, stephanotis, stevia, stock, strawflower, violet, woodwardia fern, zinnia
Group 10. Flowers and florist greens, 7–10°C, 90%–95% relative humidity	Anemone, bird-of-paradise, camellia, chamaedorea, eucharis, gloriosa, godetia, palm, podocarpus, sweet William
Group 11. Flowers and florist greens, 13–15°C, 90%–95% relative humidity	Anthurium, ginger, dieffenbachia, heliconia, staghorn fern, poinsettia

3.13 CLASSIFICATION ACCORDING TO ODOR PRODUCTION AND ABSORPTION

Some horticultural commodities produce different odors, and some food commodities are capable of absorbing these odors (Table 3.29). It is very important to consider these characteristics when storing or transporting horticultural commodities together, especially for a long period of time.

TABLE 3.29 Horticultural Commodities That Produce Odors and Those That Absorb Odors

Odor Produced By	Absorbed By
Apples	Cabbage, carrots, celery, figs, onions, meat, eggs, dairy products
Avocados	Pineapples
Carrots	Celery
Citrus fruit	Meat, eggs, dairy products
Ginger roots	Eggplants
Grapes, SO_2 treated	Almost all other fruits and vegetables
Leeks	Figs, grapes
Onions, dry	Apples, celery, pears
Onions, green	Corn, figs, grapes, mushrooms, rhubarb
Pears	Cabbage, carrots, celery, onions, potatoes
Potatoes	Apples, pears
Peppers, green	Pineapples
Strongly scented vegetables	Citrus fruit

3.14 CONCLUSIONS

Horticultural commodities have very diverse characteristics (e.g., anatomical, morphological, physiological, biochemical, shapes, forms, sizes, colors, etc.), and therefore their postharvest handling requirements are also extremely diverse. The grouping of horticultural commodities according to different characteristics is very helpful in facilitating their postharvest handling as groups rather than individually. The bases of grouping these communities are also very diverse, as indicated in this chapter.

Further Reading

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