

Wholesale Distribution Center Storage

James F. Thompson and Adel A. Kader

Thompson is with the Biological and Agricultural Engineering Department, University of California, Davis, CA. He is now retired. Kader is with the Department of Pomology, University of California, Davis, CA. He is now retired.

Most produce is shipped from the point of production to regional or local distributors, such as terminal markets, independent wholesalers, or chain store distribution centers. Produce orders are assembled at these sites and then shipped to retail stores, restaurants, or institutions such as schools or hospitals. Produce and floral items lose quality during these marketing steps, and the amount of quality loss accumulates at each step. The consumer will receive quality produce only if each operation in the handling chain minimizes abuse caused by mechanical damage, improper temperature and RH, moisture loss, ethylene damage, odor contamination, and excessive storage time.

Large wholesale distribution facilities, whether independently owned or integrated with a retail chain, strive to receive only the amount of produce that can be shipped the following day. A few fruits such as mature green avocados, bananas, mangos, and tomatoes are ripened before shipment to retail stores and may be held in special ripening rooms for several days.

Products should be received at their proper long-term storage temperature and then stored at that temperature. Fruits and vegetables can be divided into three categories or groups according to their optimum temperature requirements (table 1). The RH of the storage atmosphere should be 85 to 95%; however, for vegetables stored at low temperatures, it should be 90 to 98%. The lowest temperature range of 0 to 2 °C (32 to 36 °F) should be used for the majority of the green, nonfruit vegetables and temperate fruits and melons. If there is enough capacity in the facility, the fruits should be stored separately from the vegetables. This allows installing equipment to maintain higher RH (90 to 98%) for the vegetables as many of them are quite susceptible to water loss and wilting. Table 2 shows cut flowers and nursery items divided into the recommended three categories or groups. If handled with produce, the floral items in group 1 should be in the group 1A vegetable room to minimize exposure to ethylene produced by many fruits.

Table 1. Compatible fresh fruits and vegetables during 7-day storage*

	Groups 1A and 1B		Group 2	Group 3	
	0-2 °C; group 1A: 90-98% RH; group 1B: 85-95% RH		7-10 °C; 85-95% RH	13-18 °C; 85-95% RH	
	Group 1A				
Vegetables	Alfalfa sprouts	Chinese cabbage [†]	Mint [†]	Basil [†]	Bitter melon
	Amaranth [†]	Chinese turnip	Mushroom	Beans, snap, green, wax	Boniato [†]
	Anise [†]	Collard [†]	Mustard greens [†]	Cactus leaves (nopales) [†]	Cassava
	Artichoke	Corn, sweet, baby	Parsley [†]	Calabaza	Dry onion
	Arugula [†]	Cut vegetables	Parsnip	Chayote [†]	Ginger
	Asparagus [†]	Daikon [†]	Radicchio	Cowpea (Southern pea)	Jicama
	Beans, fava, lima	Endive [†] -chicory	Radish	Cucumber [†]	Potato
	Bean sprouts	Escarole [†]	Rutabaga	Eggplant [†]	Pumpkin
	Beet	Fennel [†]	Rhubarb	Kiwano (horned melon)	Squash, winter (hard rind) [†]
	Belgian endive [†]	Garlic	Salsify	Long bean	Sweet potato [†]
	Bok choy [†]	Green onion [†]	Scorzoneria	Malanga [†]	Taro (dasheen)
	Broccoli [†]	Herbs [†] (not basil)	Shallot [†]	Okra [†]	Tomato, ripe, partially ripe, & mature green
	Broccoflower [†]	Horseradish	Snow pea [†]	Pepper, bell, chili	Yam [†]
	Brussels sprouts [†]	Jerusalem artichoke	Spinach [†]	Squash, summer (soft rind) [†]	
	Cabbage [†]	Kailon [†]	Sweet pea [†]	Tomatillo	
	Carrot [†]	Kale [†]	Swiss chard [†]	Winged bean	
	Cauliflower [†]	Kohlrabi	Turnip		
	Celeriac	Leek [†]	Turnip greens [†]		
	Celery [†]	Lettuce [†]	Water chestnut		
	Chard [†]		Watercress [†]		

	Group 1B						
Fruits and melons	Apple [‡]	Elderberry	Prune [†]	Avocado, unripe [‡]	Lime [†]	Atemoya [‡]	Sapodilla [‡]
	Apricot [‡]	Fig	Quince [†]	Babaco	Limequat	Banana [‡]	Sapote [‡]
	Avocado, ripe [‡]	Gooseberry	Raspberry	Cactus pear, tuna	Mandarin	Breadfruit [‡]	Soursop [‡]
	Barbados cherry	Grape	Strawberry	Calamondin	Mango, ripe [‡]	Canistel [‡]	Watermelon
	Blackberry	Kiwifruit ^{†‡}		Carambola	Olive	Casaba melon	
	Blueberry	Loganberry		Cranberry	Orange	Cherimoya [‡]	
	Boysenberry	Longan		Custard apple [‡]	Passion fruit	Crenshaw melon [‡]	
	Caimito	Loquat		Durian, ripe [‡]	Pepino	Honeydew melon [‡]	
	Cantaloup [‡]	Lychee		Feijoa	Pineapple	Jaboticaba	
	Cashew apple	Nectarine		Granadilla [‡]	Pummelo	Jackfruit [‡]	
	Cherry	Peach		Grapefruit [†]	Sugar apple	Mamey [‡]	
	Coconut	Pear (Asian & European)		Guava [‡]	Tamarillo	Mangosteen [‡]	
	Currant	Persimmon [†]		Juan canary melon [‡]	Tamarind	Papaya [‡]	
	Fresh-cut fruits [‡]	Plum, ripe [†]		Kumquat	Tangelo	Persian melon [‡]	
	Date	Plumcot, ripe [†]		Lemon [†]	Tangerine	Plantain [‡]	
	Dewberry	Pomegranate			Ugli fruit	Rambutan	

Source: Thompson et al. 1996

*Ethylene should be kept below 1 $\mu\text{L L}^{-1}$ (1 ppm) in the storage area.

[†]Sensitive to ethylene damage.

[‡]Produces significant ethylene.

Table 2. Compatible flowers, florist's foliage, and nursery items during 7-day storage[†]

Flowers	Group 1*			Group 2		Group 3
	0-2 °C; 85-95% RH			7-10 °C; 85-95% RH		13-18°C; 85-95% RH
	Acacia	Gaillardia	Protea	Anemone		African violet
	Alstroemeria	Gardenia	Rannunculas	Bird of paradise		Anthurium
	Allium	Gerbera	Rose	Camellia		Ginger
	Aster	Gladiolus	Snapdragon	Eucharis		Heliconia
	Bouvardia	Gypsophlia	Snowdrop	Gloriosa		Orchid, cattleya, vandal
	Buddleia	Heather	Squill	Godetia		Poinsettia
	Calendula	Hyacinth	Statice	Sweet-william		Bulbs, corms, rhizomes, tubers, & roots
	Candytuft	Iris	Stephanotis			Nursery stock
	Carnation	Laceflower	Stevia			
	Chrysanthemum	Lilac	Stock			
	Clarkia	Lily	Strawflower			
	Columbine	Lily-of-the-valley	Sweet pea			
	Coreopsis	Lupine	Tulip			
	Cornflower	Marigolds	Violet			
	Cosmos	Mignonette	Zinnia			
	Crocus	Narcissus	Cuttings & scions			
	Dahlia	Orchid, cymbidium				
	Daisy, English, Marguerite, Shasta	Ornithogalum				
	Delphinium	Poppy				
	Feverfew	Peony				
	Forget-me-not	Phlox				
	Foxglove	Primrose				
	Freesia					
Florist's foliage (greens)	Adiantum (maidenhair)	Gallax	Pittosporum	Chamaedorea		Dieffenbachia
	Asparagus (plumose)	Ground pine	Rhododendron	Cordyline		Staghorn fern

Buxus (boxwood)	Hedera	Salal (lemon leaf)	Palm
Camellia	Ilex (holly)	Scotch-broom	Podocarpus
Cedar	Juniper	Smilax	
Croton	Leatherleaf	Vaccinium (huckleberry)	
Dracaena	Leucothoe	Woodwardia fern	
Fern, dagger, wood	Magnolia		
Eucalyptus	Mistletoe		
	Mountain-laurel		
	Myrtus (myrtle)		
	Philodendron		

*Can be stored with group 1A vegetables in a mixed produce storage.

† Ethylene should be kept below $1 \mu\text{L L}^{-1}$ (1 ppm) in the storage area.

The two warmer temperature ranges in tables 1 and 2 are for chilling-sensitive produce (groups 2 and 3). The highest-temperature room can also be used to ripen fruit that only require a warm environment to ripen. If refrigerated space is limited, low-temperature fruits, vegetables, and flowers can be mixed in a room; air-conditioned space at 20 to 25 °C (68 to 77 °F) can be used for highest-temperature products (group 3).

Many green vegetables and most floral products are quite sensitive to ethylene damage. Ethylene must be kept away from these products. Minimize ethylene from nearby banana-ripening rooms by—

- using ethylene levels of 100 $\mu\text{L L}^{-1}$ in the ripening rooms instead of the higher levels often used in commercial operations,
- venting ripening rooms to the outside after the exposure period is complete and before rooms are opened,
- ventilating the area around ripening rooms at least once a day or install an ethylene scrubber, and
- using battery-powered forklifts instead of internal combustion-driven units (for example, propane-powered units).

Floral products are particularly sensitive to ethylene. Some distribution facilities have found that the previously described precautions are inadequate in preventing damage to flowers. They have chosen to handle flowers with dairy or meat products, where ethylene is low, or they require that all floral products be chemically treated to resist ethylene damage.

Weak fiberboard containers are usually the cause of mechanical damage to produce between packing and retail display. If products arrive at the distribution facility in crushed boxes, store buyers must work with suppliers to use stronger boxes or ensure that packed boxes are correctly stacked and palletized.

The distribution center assembles pallets of mixed products to be shipped to retail outlets. Products can easily be damaged when boxes with different footprints are stacked and heavy bags of product are placed on weak boxes. Placing only strong containers on the bottom layers of a pallet load can minimize some of this damage. Plastic foam and returnable plastic containers are often stronger than typical fiberboard boxes and can reduce mechanical damage.

Most distribution facilities have special ripening rooms or areas reserved for fruit ripening. Ripening rooms are used extensively for bananas and may also be used to ripen avocados, kiwifruit, mangoes, tomatoes, nectarines, peaches, plums, and European pears. Pressurized or forced-air ripening rooms allow better control of ripening compared with older methods of space-stacking boxes in a warm room. The new designs force temperature-controlled air through the boxes to maintain fairly uniform product temperature. Ethylene gas (100 to 150 $\mu\text{L L}^{-1}$) is added to the atmosphere on a schedule appropriate for each product, and CO₂ levels are kept below 1% by ventilating the rooms with outside air. Ripening is done with air temperature in the range of 15 to 25 °C (59 to 77 °F), and water vapor is added to the air to keep RH above 85 to 95% in order to reduce moisture loss. The ripening of some products, like stone fruit and pears that were treated with ethylene at the packing operation, can be promoted by warming them to 13

to 18 °C (55 to 64 °F).

References

Thompson, J., A.A. Kader, and K. Sylva. 1996. Compatibility chart for fruits and vegetables in short-term transport and storage. Nat. Res. Pub. no. 21560, University of California, Division of Agriculture and Natural Resources, Oakland, CA.