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Postharvest Handling Systems: Ornamental Crops

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Among horticultural crops, cut flowers and other ornamentals have perhaps the highest value and are the most perishable. Their high respiration rates, rapid deterioration, and susceptibility to damage require the utmost care to maintain quality during postharvest handling. Ornamentals are an important part of international commerce in horticultural crops, often being produced many thousands of miles from their intended markets. Marketing ornamentals involves major changes in supply and demand, due to heavy demand for holidays such as St. Valentine's Day and to variable supply, particularly of flowers produced outdoors (fig. 25.1). These considerations also imply the need for optimal postharvest handling of these crops. This chapter first discusses factors affecting the postharvest life of ornamentals, then outlines techniques for their postharvest handling using the postharvest systems employed in California as an example.

FACTORS AFFECTING POSTHARVEST QUALITY OF ORNAMENTALS

Although the factors affecting the postharvest life of ornamentals are largely similar to those for fruits and vegetables, they differ in some important aspects.

FLOWER MATURITY

Minimum harvest maturity for a cut-flower crop is the stage at which harvested buds can be subsequently opened fully and have satisfactory display life after distribution. Many flowers are best cut in the bud stage and opened after storage, transport, or distribution. Although this technique is seldom used, it has many advantages, including reduced growing time for single-harvest crops, increased product packing density, simplified temperature management, reduced susceptibility to mechanical damage, and reduced desiccation. Many flowers are presently harvested when the buds are starting to open (rose, gladiolus); others are normally fully open or nearly so (chrysanthemum, carnation). Flowers for local markets are generally harvested more open than those intended for storage or long-distance transport.

FOOD SUPPLY

The high respiration rate and rapid development of flower buds and flowers indicate the need for a substantial carbohydrate supply to the flowers after harvest. Starch and sugar stored in the stem, leaves, and petals provide much of the food needed for cut-flower opening and maintenance. These carbohydrate levels are highest when plants are grown in high light conditions and with proper cultural management. Carbohydrate levels are generally highest in the late afternoon, after a full day of sunlight. However, flowers are preferably harvested in the early morning, because temperatures are low, plant water content is high, and a whole day is available for processing the cut flowers.

The quality and vase life of many cut flowers can be improved by pulsing them after harvest with a solution containing sugar. The cut flowers are allowed to stand in solution for a short period, usually less than 24 hours, and often at low temperature. The most dramatic example of the effect of added carbohydrate is in spikes of tuberose and gladiolus: flowers open further up the spike, are bigger, and have a longer vase life after overnight treatment with a solution containing 20% sucrose and a biocide to inhibit bacterial growth (fig. 25.2).

Figure 25.1

Variability in the flower market and the effect of holiday periods is shown by the changing wholesale value of red roses and gypsophila through the year.

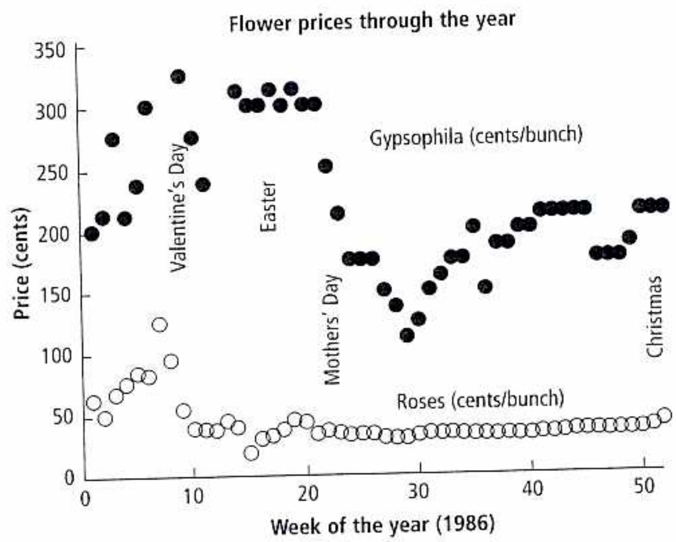
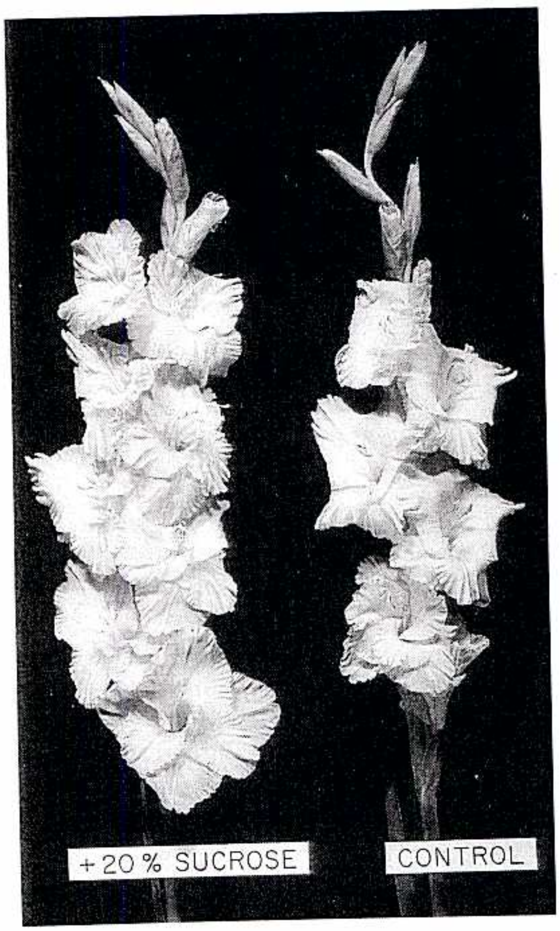


Figure 25.2

Pulsing gladiolus flowers overnight in a cold room with a 20% sucrose solution enhances flower size, opening, and vase life.



Sugar is also an essential part of the solution used to open bud-cut flowers before distribution, and of the vase "preservatives" used at the retail and domestic level. Red roses opened without sugar in the vase solution turn a dark purple (blueing). Blackening of leaves of cut flowers of *Protea nerifolia* can be prevented by maintaining the flowers in high light intensity. The problem is induced by the low carbohydrate status of the harvested inflorescence.

TEMPERATURE

The rapid respiration of cut flowers, an indicator of their rate of growth and senescence, generates heat as a by-product. As in all biological systems, the respiration of cut flowers increases logarithmically with increasing temperature (fig. 25.3). For example, a flower held at 29°C (85°F) is likely to respire up to 45 times faster than a flower held at 2°C (36°F). The rate of senescence can be reduced dramatically by cooling the flowers (fig. 25.4). When cut flowers were stored at a range of temperatures for a five-day transportation simulation, the subsequent vase life of the flowers under standard conditions was directly related to their respiration rate. Since reducing the temperature markedly reduces respiration, rapid cooling and proper temperature maintenance are essential to maintaining quality and satisfactory vase life of cut flowers.

The optimal temperature for storage of most common cut flowers is 0°C (32°F), just above freezing (see fig. 25.4). In contrast, some tropical crops, such as anthurium, bird-of-paradise, some orchids, and ginger, are injured at temperatures below 10°C (50°F). Symptoms of this chilling injury include darkening of the petals (fig. 25.5), watersoaking of the petals (which look transparent), and, in severe cases, collapse and drying of leaves and petals (fig. 25.6).

WATER SUPPLY

Cut flowers, especially those with leafy stems, have a large surface area, so they lose water and wilt rapidly. They should be stored at above 95% RH, particularly during long-term storage. Water loss is dramatically reduced at low temperatures, another reason for prompt cooling.

Even after flowers have lost considerable water (for example, during transportation or

Figure 25.3

Respiration and heat production of cut carnations increases logarithmically with increasing temperature.

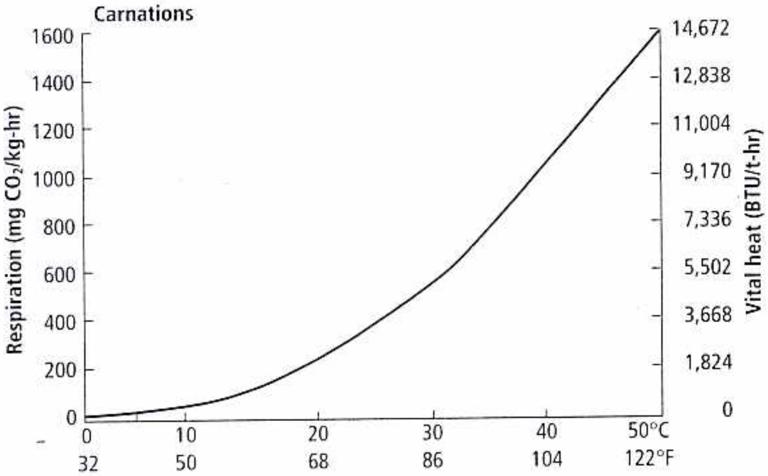


Figure 25.4

Optimal storage temperature for most cut flowers is 0°C (32°F). Flowers kept at 10°C (50°F) deteriorate 3 times faster than those kept at 0°C (32°F).

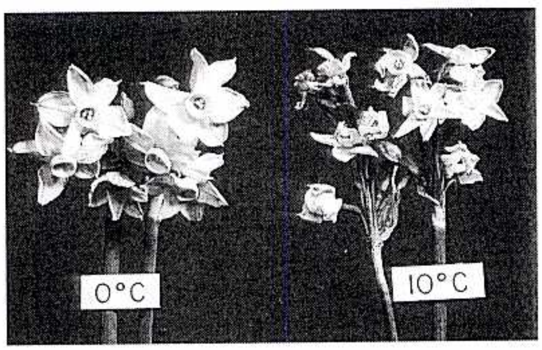


Figure 25.5

Anthurium flowers are sensitive to low temperatures. After storage of 7 days at 0°C (32°F), the flowers show symptoms typical of chilling injury.

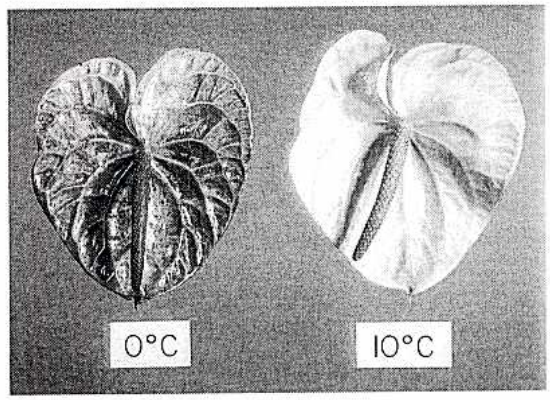


Figure 25.6

Poinsettias, like many other tropical plants, are very sensitive to low-temperature storage. Exposure for 1 week to temperatures below 7°C (45°F) causes complete collapse of the plants.

storage), they can be fully rehydrated using proper techniques. Cut flowers absorb solutions without difficulty, providing there is no obstruction to water flow in the stems. Air embolism, bacterial plugging, and poor water quality can reduce solution uptake.

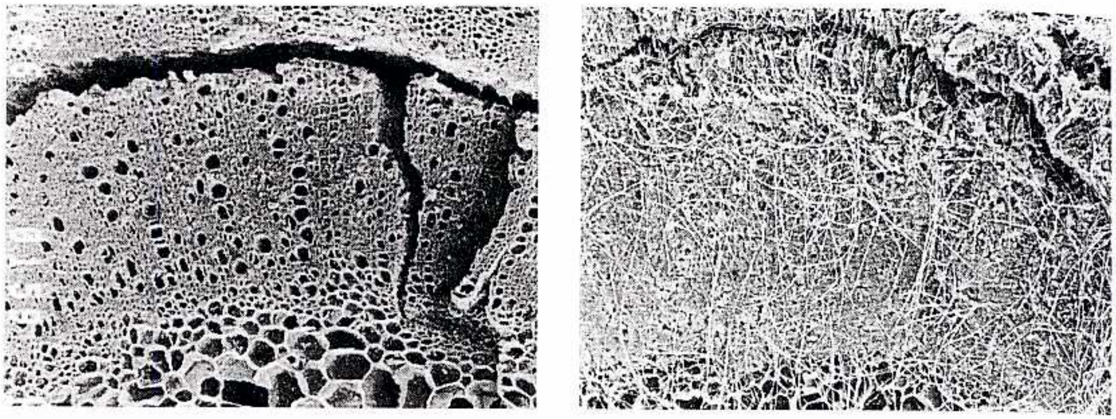
Air embolism. Air embolism occurs when small bubbles of air (emboli) are drawn into the stem at the time of cutting. These bubbles cannot move far up the stem, so the upward movement of solution to the flower is restricted. Emboli can be removed by recutting the stems under water (removing about 2.5 cm or 1 in), by ensuring that the rehydration solution is acid (pH 3 or 4), or by placing the stems in ice water, or in a vase solution heated to 41°C (105°F) (warm, but not hot).

Bacterial plugging. The quality and vase life of flowers are improved by supplying them with sugar after harvest. Sugar can, however, also act as food for the growth of detrimental fungi and bacteria in the water; this growth can be enhanced by organic materials from the cut stem. Substances produced by the bacteria and the bacteria themselves can plug the water-conducting system (fig. 25.7). For this reason, buckets should be cleaned and disinfected regularly, and flower-holding solutions should contain germicides to prevent the growth of microorganisms. Acidic vase solutions not only improve water flow by overcoming embolism but also inhibit bacterial growth.

Water quality. Hard water contains minerals that make the water alkaline. Alkaline

Figure 25.7

Scanning electron micrograph of a cross-section of the stem of the rose flower ([A] before; [B] after) held for 3 days in deionized water. The fine tubes conducting water to the flower have become plugged with bacterial slime and fungal hyphae.

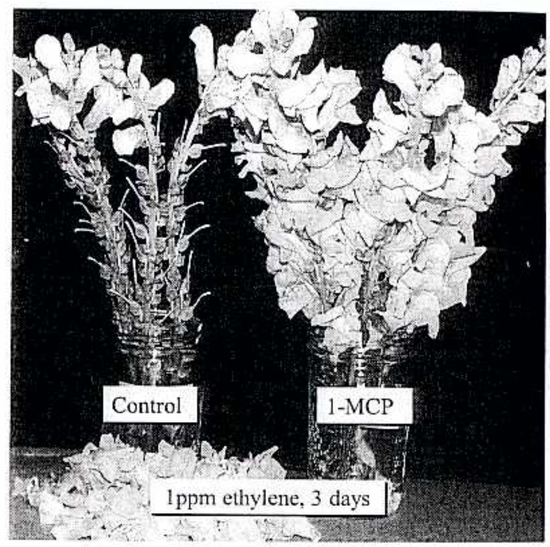


water does not move readily through stems and can substantially reduce vase life. Such water can be treated by removing the minerals using a deionizer or by making the water acidic. Commercial flower preservatives may not contain enough acid to acidify some very alkaline waters; in that case, more acid should be added. Recent studies have explained why the presence of low salt concentrations in the water may improve flow in cut flower stems.

Certain ions found in tap water are toxic to some cut flowers. Sodium (Na^+), present in high concentrations in soft water, is, for example, toxic to carnations and roses. Fluoride (F^-) is very toxic to gerbera, gladiolus, freesia, and some rose varieties; fluoridated drinking water contains enough F^- (about 1 to 2 ppm) to damage these cut flowers.

Figure 25.8

Effect of ethylene and MCP on flower loss in snapdragon.



ETHYLENE

Some flowers, especially carnations and some rose cultivars, perish rapidly if exposed to minute concentrations of ethylene. In carnations and sweet peas, ethylene produced by the flower induces the normal processes of senescence. In many compound flowers, such as snapdragon and delphinium, ethylene causes flower abscission, or shattering (fig. 25.8). Ethylene is produced in large quantities by some ripening fruits and during combustion of organic materials (e.g., gasoline, firewood, tobacco). Levels of ethylene in the air above 0.1 ppm in the vicinity of many cut flowers can cause damage. Storage and handling areas should be designed not only to minimize contamination with ethylene but to have enough ventilation to remove any ethylene that does occur. Treatment with the anionic thiosulfate complex of silver (STS) reduces the effects of ethylene (exogenous or endogenous) in some flowers (fig. 25.9); 1-methylcyclopropene (1-MCP), another inhibitor of ethylene action, provides similar protection. Finally, refrigeration greatly reduces ethylene production and the sensitivity of the product to ethylene.

GROWTH TROPISMS

Certain responses of cut flowers to environmental stimuli (tropisms) can result in quality loss. Most important are geotropism (bending away from gravity) and phototropism

Figure 25.9

Effect of STS pretreatment on opening of cut Lovely Girl roses.

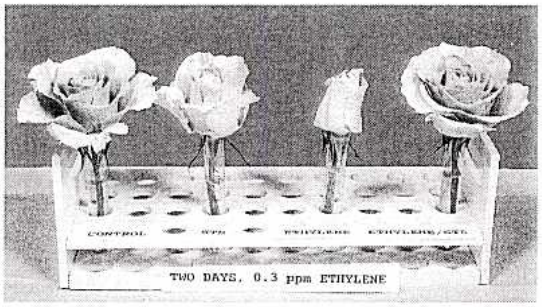
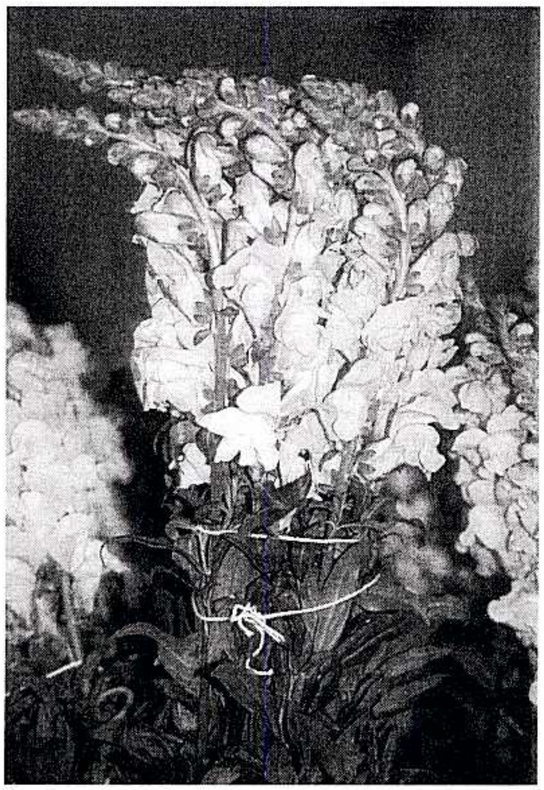


Figure 25.10

Laying snapdragons on the bench results in unsightly curvature.



(bending toward light). Geotropism often reduces quality in spike-flower crops like gladiolus and snapdragon, because the flowers and spike bend upward when stored horizontally (fig. 25.10). These flowers should be handled upright whenever possible, although proper storage temperatures will greatly reduce bending.

MECHANICAL DAMAGE

Bruising and breakage of cut flowers should be avoided. Flowers with torn petals, broken stems, or other obvious injuries are undesirable for aesthetic reasons. Disease organisms can more easily infect plants through injured areas. In fact, most diseases are caused by infection of injured areas. Finally, respiration and ethylene evolution are generally higher in injured plants, further reducing storage and vase life.

DISEASE

Flowers are susceptible to disease, not only because their petals are fragile, but also because the sugar solution secreted by their nectaries is an excellent nutrient supply for even mild pathogens. To make matters worse, transfer from cold storage to warmer handling areas can result in condensation of water on the harvested flowers. The ubiquitous spores of gray mold (*Botrytis cinerea*) can germinate wherever free moisture is present. In the humid environment of the flower head, it can even grow (albeit more slowly) at temperatures near freezing. Proper greenhouse hygiene, temperature control, and minimizing condensation on flowers all reduce losses caused by gray mold. Some fungicides, such as vinclozolin, iprodione, and a copper complex (Phyton-27) have been approved for use on cut flowers and are effective against gray mold.

POSTHARVEST MANAGEMENT TECHNIQUES USED FOR CUT FLOWERS

Systems for harvesting and marketing cut flowers vary according to individual crops, growers, production areas, and marketing systems. All involve a series of steps—harvesting, grading, bunching, sleeving, storage, packing, precooling, transportation, and retail marketing, not necessarily in that order. Management systems should be selected that maximize postharvest life of the flowers, a goal that usually requires prompt precooling and proper temperature management throughout the marketing chain. Increasingly, producers are trying to reduce the number of steps in the postharvest handling system. For example, some field flower growers cut, grade, bunch, and pack their product in the field (fig. 25.11). The packed boxes are then taken directly to the precooler. Such systems, where appropriate, reduce damage to the flowers and may decrease labor costs.

Figure 25.11

Harvesting, grading, bunching, and packing are all carried out under shade in this chrysanthemum bouquet operation.

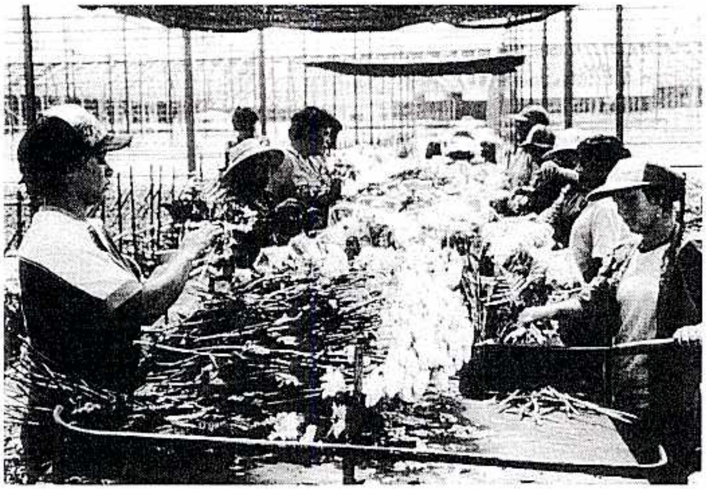
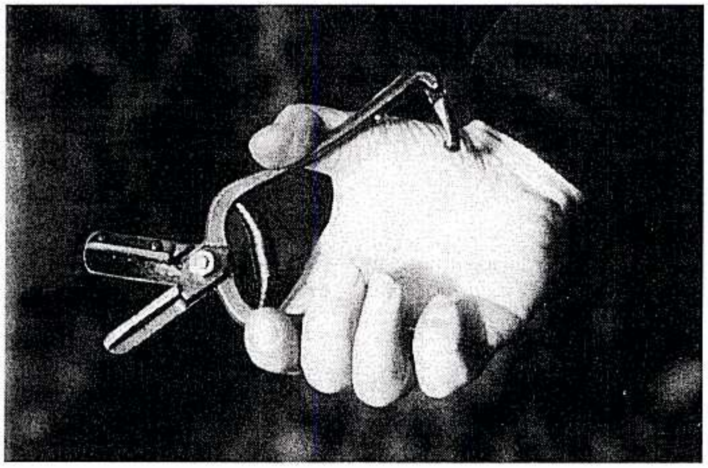


Figure 25.12

These specialized shears hold a rose stem after it has been cut, simplifying the task of harvesting.



HARVESTING

Harvesting is normally done by hand, using shears or a sharp knife. Simple mechanical aids are used for some crops; examples are the hook-shaped comma that permits chrysanthemum harvest without stooping and rose shears that grip the flower stem after it has been cut, allowing it to be withdrawn single-handedly from the bush (fig. 25.12). At no time should harvested flowers be placed on the ground, where they may become contaminated with disease organisms. Ideally, harvesting, grading, and packing should all be done dry, without the use of chemical solutions or water. If this is not possible, clean buckets containing clean water and a biocide should be used. With hard water and for difficult-to-rehydrate flowers, clean water containing sufficient citric acid to bring the pH to 3.5 and an appropriate biocide should be used instead.

GRADING

The designation of grade standards for cut flowers is controversial. There are no U.S. federal or state standards for cut flowers or other ornamentals. Large producers, wholesalers, or retailers may have internal grade standards, but they are highly variable. The Society of American Florists has promulgated "recommended" grade standards for some major crops, but they cannot be enforced. Stem length, still the major quality standard for many flowers, may bear little relationship to flower quality, vase life, or usefulness. Straightness of stems, stem strength, flower size, vase life, freedom from defects, maturity, uniformity, and foliage quality are among the factors that should also be used in cut flower grading. Bunch weight, proposed 60 years ago as a grade standard for New York flower producers, is now being applied by the Holland flower auction for certain field flowers. Mechanical grading systems, including semiautomatic systems using vision technology to determine stem length and bud maturity, should be carefully designed to ensure efficiency and avoid damaging flowers.

BUNCHING

Flowers are normally bunched, except for standard chrysanthemums, anthuriums, orchids, and some other specialty flowers. The number of flowers in the bunch varies according to growing area, market, and species. Groups of 5, 10, 12, and 25 are common for single-stemmed flowers. Spray-type flowers are bunched by the number of open flowers, by weight, or by bunch size.

Bunches are held together by string, paper-covered wire, or elastic bands and are frequently sleeved soon after harvest (fig. 25.13) to separate them, protect the flower heads, prevent tangling, and identify the grower or shipper. Materials used for sleeving include paper (waxed or unwaxed) and polyethylene (perforated, unperforated, and blister). Sleeves can be preformed (although variable bunch size can be a problem), or they can be formed around each bunch, using tape, heat sealing (polyethylene), or staples.

Figure 25.13

Thin plastic sleeves are pulled over the flower bunches to provide protection and keep flowers separate in the box.

Damage through multiple handlings can be reduced if grading, sizing, and even bunching are done in the field or greenhouse. Flowers should be graded and bunched before being treated with chemicals or being placed in storage. When the flowers are badly wilted, or when labor is not available for grading and bunching, flowers should be rehydrated under refrigeration until these operations can be carried out.

CHEMICAL SOLUTIONS

The diverse solutions in which flowers may be placed after harvest have specific purposes.

Rehydration. Wilted flowers should be rehydrated in a cooler, using deionized water containing a germicide. Wetting agents (0.01 to 0.1%) can be added, and the water should be acidified with citric acid, hydroxyquinoline citrate (HQC), or aluminum sulfate to a pH near 3.5. No sugar should be added to the solution. The solution should contain a biocide.

Pulsing. The term *pulsing* means placing freshly harvested flowers for a short time in a solution formulated to extend their storage and vase life. Sucrose is the main ingredient of pulsing solutions, and the proper concentration ranges from 2 to 20%, depending on the crop. Some cut flowers are also fumigated with 1-MCP or pulsed with STS to reduce the adverse effects of ethylene. Flowers can be pulsed with STS for short periods at warm temperatures (e.g., 10 minutes at 21°C [70°F]) or long periods at cool temperatures (e.g., 20 hours at 2°C [36°F]). Short pulses (10 seconds) in solutions of silver nitrate are valuable for some crops. Chinese asters and maidenhair fern respond well to solutions containing 1,000 ppm silver nitrate. Other flowers (e.g., gerberas) respond well to 100 to 200 ppm. The function of the silver nitrate is not fully understood. In some cases it seems to function strictly as a germicide (e.g., chrysanthemums). The residual silver nitrate solution should be rinsed from the stems before packing.

Bud opening. Bud-cut flowers are opened in bud-opening solutions before they are sold. These solutions contain a germicide and sugar. Foliage of some flowers (especially roses) can be damaged if the sugar concentration is too high. Buds should be opened at relatively warm temperatures (21° to 27°C [70° to 80°F]), moderate humidities (60 to 80% RH), and reasonably high light intensities (100 to 200 foot-candles).

Tinting. Artificial coloration of flowers (tinting) is done in two ways: through the stem (for carnations) and by dipping the flower heads (for other flowers, principally daisies). In tinting carnations, proprietary dye solutions (combinations of food-type dyes with adjuvants designed to increase uptake of the solution) are mixed in a bucket and warmed to about 41°C (105°F). The carnations to be tinted (usually White Sim) are allowed to dry somewhat (overnight in the packing shed at 18°C [65°F]) to increase their rate of solution uptake. Dyeing is stopped before the flowers reach the desired color, because dye still in the stem is flushed into the flower by the vase solution. Tinting by dipping is done with proprietary tinting solutions containing aniline dyes dissolved in organic solvents such as rubbing alcohol (isopropanol). The heads of the flowers are dipped in a vat of the dye, shaken to remove surplus solution, and placed on a rack to dry before storage or packing.

PACKING

Most boxes for cut flowers are long and flat (fig. 25.14). This design restricts the depth of the flowers in the box, which may in turn reduce physical damage. Flower heads can be placed at both ends of the container for better use of space. Layers of whole sheets of newspaper have traditionally been used to prevent the layers of flowers from injuring each other, but using small pieces of newspaper to protect only the flower heads allows for more efficient cooling of flowers after packing.

Figure 25.14

Boxes commonly used in California for packing cut flowers are long and flat. From left: a regular fiberboard box designed for a bottom air delivery trailer, a box constructed from polyurethane-sprayed fiberboard, and a polystyrene "casket."

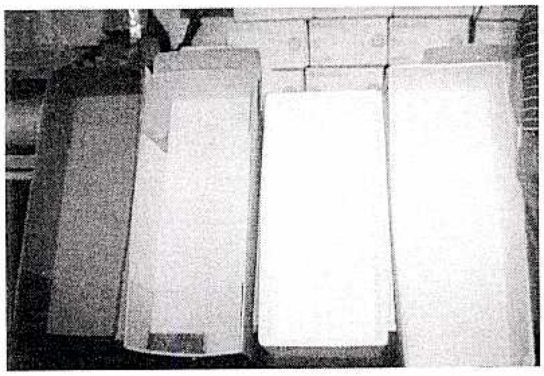
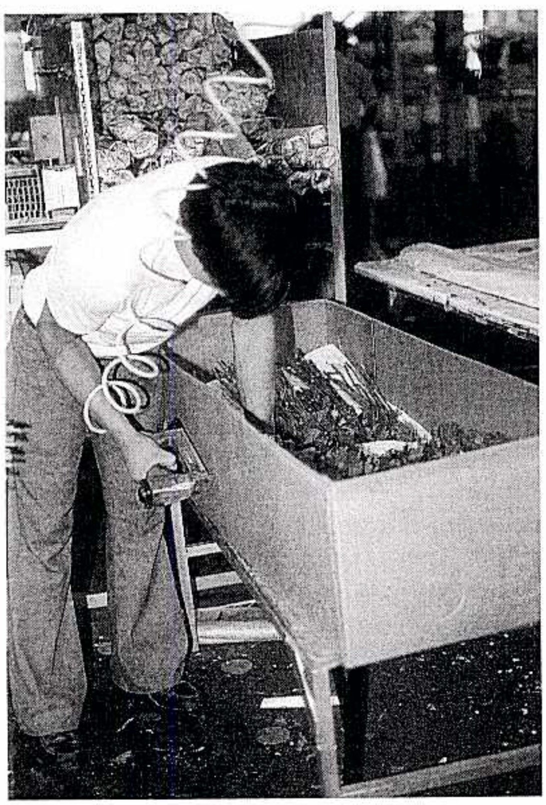


Figure 25.15

Cleats (padded with newspaper and foam) to hold the product are stapled to each side of the box.



It is critical that boxes be packed in ways that minimize transport damage. Most packers anchor the product by filling the box so that the contents are firmly held. To avoid longitudinal movement, packers use one or more "cleats," normally foam- or newspaper-covered wood pieces that are placed over the product, pushed down, and stapled into each side of the box (fig. 25.15). Padded metal straps, high-density polyethylene blocks, and cardboard tubes can also be used as cleats. To ensure that the flowers do not move, it is useful to place a bottom cleat in the box, so that the bottom of the box cannot bulge and allow movement. The heads of the flowers are normally placed 7 to 12 cm (3 to 5 in) from the end of the box to eliminate the danger of petal bruising should the contents of the box shift, and to provide a plenum to distribute precooling air to the contents of the box. With some flowers, a staggered arrangement of the bunches anchors with the product.

Gladioli, snapdragons, and some other species are often packed in vertical hampers to prevent unsightly geotropic curvature. Cubic hampers are used for upright storage of daisies and other flowers. Specialty flowers such as anthurium, orchids, ginger, and bird-of-paradise are packed in various ways to minimize friction damage during transport (fig. 25.16). Flower heads may be individually protected by paper or polyethylene sleeves. Cushioning materials, such as shredded paper, paper wool, or wood wool may be distributed between the packed flowers to further reduce damage. For some tropical flowers (anthurium, heliconia) these materials may be moistened to reduce water loss. The bases of high-value flowers, such as orchids, may be sealed in small vials containing water or a preservative solution to ensure that they do not dehydrate during transportation. This is particularly useful for chilling-sensitive flowers, because the higher handling temperatures that they require are apt to accelerate desiccation.

COOLING

By far the most important part of maintaining the quality of harvested flowers is cooling them as soon as possible after harvest

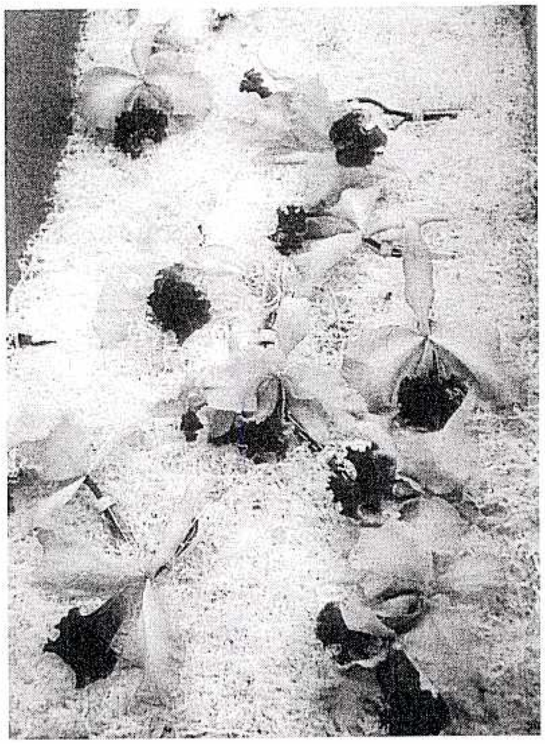


Figure 25.16

High-value flowers are often specially packed. Here, cattleya orchids with individual tubes containing floral preservative are separated and cushioned from vibration with shredded newsprint.

and maintaining optimal temperatures during marketing. Most flowers should be held at 0 to 2°C (32 to 36°F). Chilling-sensitive flowers (anthurium, bird-of-paradise, ginger, tropical orchids) should be held at temperatures above 10°C (50°F).

Individually, flowers cool (and warm) rather rapidly (half-cooling times of a few minutes). Individual flowers brought out of cool storage into a warmer packing area warm quickly and develop condensation before packing. The simplest way to keep packed flowers adequately cooled and dry is to pack them in the cool room. Although this method is not always popular with packers and may slow packing somewhat, it ensures a cooled, dry product.

Packed boxes of cut flowers do not cool well if they are merely placed in a refrigerated room. The rapid respiration of the flowers and the insulating properties of a packed box result in heat buildup in packed flower boxes unless steps are taken to ensure temperature reduction. Forced-air cooling of boxes with end holes or closable flaps is the most common and effective method for cooling cut

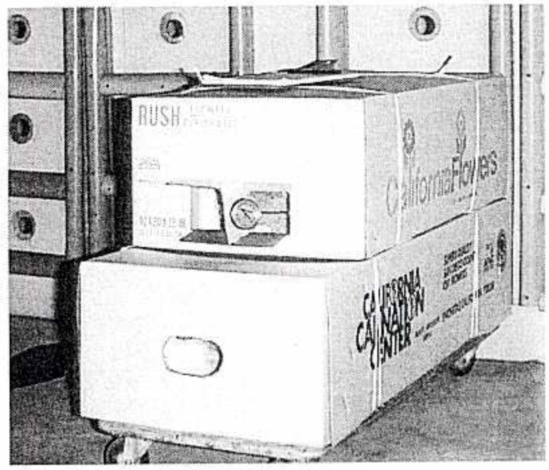


Figure 25.17

In forced-air precooling of flowers, cool air is sucked or blown through the packed boxes.

flowers. Cool air is sucked or blown through the boxes (fig. 25.17). Care must be taken to pack in such a way that air can flow through the box and not be blocked by the packing material (fig. 25.18). In general, packers use less paper when packing flowers for precooling. The half-cooling time for forced-air cooling ranges from 10 to 40 minutes, depending on product and packaging.

If the packages are to remain in a cool environment after precooling, vents may be left open to assist removal of the heat of respiration. Flowers that are to be transported at ambient temperatures can be packed in polyethylene caskets, foam-sprayed boxes, or boxes with the vents resealed. Using ice in the box is only effective if it is placed so that it intercepts heat entering the carton (i.e., it must surround the product), and care must be taken to ensure that the ice does not melt onto the flowers or cause freezing damage.

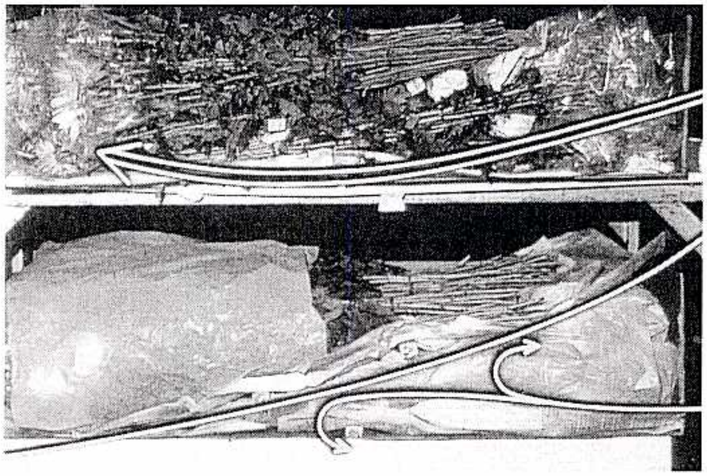
Tropical flowers shipped in a mixed load need special care. The flowers should be packed in plenty of insulating material (an insulated box packed with shredded newsprint, for example). These flowers should not be cooled. If they are to be shipped by truck, they should be placed in the middle of the load, away from direct exposure to cooling air.

STORAGE

Although it would be advantageous to store cut flowers for short periods (up to a month), few cut flowers maintain their quality during cool storage. With the exception of bud-cut

Figure 25.18

Proper precooling of cut flowers requires that the flowers be packed so that airflow through the box is not impeded (as shown by the arrows). Upper box is correctly packed; in the lower box, paper protection prevents satisfactory airflow.



carnations, which can be stored for several months, flowers should not be stored for more than 2 to 3 weeks.

The factors limiting storage life of flowers are not fully understood, but development of *Botrytis* is commonly observed. Flowers intended for storage should be of premium quality and should be pretreated appropriately (STS, 1-MCP, sugar, growth regulators), depending on the species. Flowers to be stored for any length of time should be held dry (packed, and preferably wrapped, after cooling, in polyethylene sheet to minimize water loss). Flowers can be stored for a few days with their bases in preservative solution, but vase life is reduced if the storage period is longer. The storage room should be at 0°C (32°F) for most cut flowers, and the temperature should vary from this by no more than 0.2°C (0.5°F). To avoid larger temperature fluctuations, which are likely to cause condensation on the flowers and consequent growth of *Botrytis* and other pathogens, access to the storage room should be limited. The RH in the room should be at least 95%, and ethylene-producing commodities (especially fruits) should be rigorously excluded.

In general, controlled or modified atmosphere storage has not proved to be useful with cut flowers. Carnations last well in CA conditions, but they also last well in regular storage. The vase life of daffodils falls less rapidly during storage in a nitrogen atmosphere, and some flowers (lily) can withstand high CO_2 concentrations in storage, which may be useful for inhibiting pathogen growth. After storage, flowers should be rehydrated in the cool room, using water containing a biocide, and preferably at pH 3.5.

RETAIL HANDLING

To ensure maximum quality and satisfaction to the customer, it is vital that retail florists handle flowers properly on receipt. On arrival, packed boxes should be unpacked or placed immediately in a cool room. After unpacking, flower bunches should be recut and placed in a cool room (in a warmed rehydration solution) for at least a few hours. If flowers are to remain in the store for several days, they should be displayed in a clean bucket or vase containing a vase preservative.

The florist's cool room should be held at 0° to 2°C (32° to 36°F). Chilling-sensitive flowers (anthurium, bird-of-paradise, ginger, tropical orchids) should be held at temperatures above 10°C (50°F). Cut flowers that are held during storage with their bases in water (wet storage) are usually kept only 1 to 3 days, while those stored dry are often kept for longer periods.

Vase solutions. Vase solutions normally contain a low concentration of sugar (0.5 to 2.0%), a chemical to keep the pH of the solution low, and a germicide. Flowers are kept in this solution indefinitely. This treatment is usually provided by the retail seller or the customer. Preservatives are supplied to the trade in bulk or may be purchased in individual sachets intended for 1 quart (0.9 L) of solution. A typical solution contains 1 to 2% sugar, a biocide (HQC or a mixture of quaternary ammonium compounds) and 300 ppm citric acid. Various other chemicals are sometimes incorporated, including aluminum sulfate (which forms flocculent aluminum hydroxide to trap particles in the water and also lowers the pH), slow-release chlorine compounds (good biocides, but sometimes toxic) and 6-benzyl adenine (a plant growth regulator that increases the vase life of some flowers). These chemicals should be used at recommended strengths.

Flowers in the supermarket. Flowers intended for supermarket sales require special care throughout the distribution chain. First, only flowers that have adequate vase life to remain saleable for the intended period of time should be used; thus some short-lived flowers such as iris, tulip, and narcissus should be avoided. Flowers with common postharvest problems (roses, gypsophila) are a danger, too. It is particularly important that ethylene-sensitive flowers (notably carnations, some rose cultivars, and gypsophila) be treated with STS or 1-MCP if they are to be marketed through produce stores.

DRYING

A number of cut flower crops are sold in both fresh and dried forms. For some, such as statice and strawflower, the drying process can be as simple as hanging bunches upside down (to keep the stems straight) in a warm, dry location. Others, such as gypsophila and silver-dollar eucalyptus, which become too brittle if dried this way, are placed in a freshly prepared solution of 30% glycerol. The glycerol moves through the plant in the course of a day or so. Dye can be added to the glycerol to color the dried foliage or flowers. After the glycerol treatment, the plants are hung upside down in a warm dry environment to dry. Materials dried in this way remain supple for years. Improved methods of drying and preservation are still being developed. Plastic impregnation of whole plants and freeze-drying cut flowers are two such techniques.

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