

POSTHARVEST HANDLING OF FRESH CUT FLOWERS AND PLANT MATERIAL



Whether you grow fresh flowers for the local farmers' market and retail florist or have a large operation that sells truckloads to the national wholesales market, you need to move your product from the field to your consumers in a manner that ensures a high quality product. Below are the top 10 reasons why flowers do not last.

1. Food depletion
2. Attacked by bacteria and fungi
3. Normal maturation and aging
4. Wilting—water stress and xylem blockage
5. Bruising and crushing
6. Fluctuating temperatures during storage and transit
7. Color change—bluing
8. Accumulation of ethylene
9. Poor water quality
10. Suboptimal cultural practices or conditions

As a grower, you need to be aware of these problems and how to solve them with good post-harvest care. Cold storage and proper attention to maintaining optimum cold storage temperatures will slow normal maturation and aging, attack by bacteria and fungi and bluing of flowers, besides solving any improper temperature control problems. Consistent use of floral preservatives, careful handling and good sanitation practices will solve food depletion, poor water quality, bruising and crushing, wilting, and bacterial and fungal attack problems. Ethylene accumulation can be handled by using Silver Thiosulfate, by having good

sanitation practices and good ventilation. Lastly, suboptimal cultural practices and conditions can only produce substandard flowers. You cannot improve the quality of flowers after harvest.

Postharvest handling of cut flowers includes both harvest and handling. Harvest includes the decision of when, how and where to cut and the actual act of cutting the flower. Handling is everything else involved in preparing the flowers for market. Exactly how these steps are done depends on the crop, the market and the operation size.

Harvest

The most important factors for harvest are when, how and where—"when" the plant material will reach the optimum stage of development and "when" during the day to harvest. Each plant material has its own best harvest stage and this can vary depending on the use of, and market for, the plant material. Materials for preserving usually are harvested more mature than those for fresh, wholesale markets. Some general rules of thumb for when to harvest are: spike type flowers—harvest when one-fourth to one-half of the individual florets are open; daisy type flowers—harvest when flowers are fully open. Table 1 lists the specific optimum harvest stage for a variety of plant materials. These are for a national wholesale market. For local markets, the material can be more mature.

The other "when" is, when is the best time of day for harvesting flowers. The best time is the coolest part of the day and when there is no surface water from dew or rain on the plants. Also,

Table 1. Optimal Stage of Development for Harvest of Fresh Cut Flowers

Common Name	Species	Stage of Development
African Marigold	<i>Tagetes erecta</i>	fully open flowers
Allium, Ornamental Onion	<i>Allium</i>	one-fourth to one-third florets open
Annual Gaillardia, Blanket Flower, Indian Blanket Flower	<i>Gaillardia pulchella</i>	fully open flowers
Astilbe	<i>Astilbe</i> hybrids	one-half florets open
Bachelor's Button	<i>Centaurea</i> spp.	flowers beginning to open
Bearded Iris	<i>Iris</i> Bearded cvs.	colored buds
Bee-Balm, Fragrant Balm, Oswego Tea	<i>Monarda didyma</i>	almost open flowers
Black-eyed Susan, Yellow Oxeye Daisy, English Bulls-eye	<i>Rudbeckia</i> spp.	fully open flowers
Calendula, Pot Marigold	<i>Calendula officinalis</i>	fully open flowers
Canterbury Bells	<i>Campanula</i> spp.	one-half florets open
China Aster, Annual Aster	<i>Callistephus chinensis</i>	fully open flowers
Clarkia, Farwell to Spring	<i>Clarkia unquiculata</i>	one-half florets open
Climbing Lily, Glory Lily	<i>Gloriosa superba</i>	almost fully open flowers
Cockscomb	<i>Celosia argentea</i> <i>var. cristata</i>	one-half florets open
Columbine	<i>Aquilegia</i> hybrids	one-half florets open
Columbine Meadow Rue	<i>Thalictrum aguilegiifolium</i>	one-half florets open
Common Grape Hyacinth	<i>Muscari botryoides</i>	one-half florets open
Common Mignonette	<i>Reseda odorata</i>	one-half florets open
Common Stock	<i>Matthiola incana</i>	one-half florets open
Common Garden, Late Tulips	<i>Tulipa</i> cvs.	half-colored buds
Common Foxglove, Finger Flower, Purple Foxglove	<i>Digitalis purpurea</i>	one-half florets open
Common Sunflower	<i>Helianthus annuus</i>	fully open flowers
Coreopsis, Tickseed, Lance Coreopsis	<i>Coreopsis grandiflora</i>	fully open flowers
Daffodil, Narcissus, Jonquil	<i>Narcissus</i> cvs.	“Goose neck” stage
Dahlia	<i>Dahlia</i> cvs.	fully open flowers
Daylily	<i>Hemerocallis</i> cvs.	half-open flowers
Delphinium	<i>Delphinium</i> spp.	one-half florets open
Dutch Iris	<i>Iris x hollandica</i>	colored buds
English Daisy, True Daisy	<i>Bellis perennis</i>	fully open flowers
Fleabane	<i>Erigeron</i> hybrids	fully open flowers
Freesia	<i>Freesia</i> hybrids	first bud beginning to open
Garden Forget-me-Not, Woodland Forget-me-Not	<i>Myosotis sylvatica</i>	one-half florets open
Glads	<i>Gladiolus</i> cultivars	1 to 5 buds showing color
Globe Thistle	<i>Echinops ritro</i>	half-open flowers
Goldenrod	<i>Solidago</i> spp.	one-half florets open

Table 1. Optimal Stage of Development for Harvest of Fresh Cut Flowers, continued

Common Name	Species	Stage of Development
Joseph's Coat, Amaranth Fountain Plant, Tampala	<i>Amaranthus tricolor</i>	one-half florets open
Kaffir, Lily, Clivia	<i>Clivia miniata</i>	one-fourth florets open
Larkspur, Annual Delphinium	<i>Consolida ambigua</i>	2 to 5 florets open
Lily-of-the-Valley	<i>Convallaria majalis</i>	one-half florets open
Lisianthus	<i>Eustoma grandiflorum</i>	5 to 6 open flowers
Love-in-a-Mist	<i>Nigella damascena</i>	open flowers
Lupine	<i>Lupinus</i> cvs. Russell	one-half florets open
Montebretia	<i>Crococsmia x crocosmiiflora</i>	one-half florets open
Nasturtium	<i>Tropaeolum majus</i>	fully open flowers
Nerine	<i>Nerine bowdenii</i>	oldest buds almost open
Pansy	<i>Viola x wittrockiana</i>	almost open flowers
Peony	<i>Paeonia</i> cvs.	colored buds
Perennial Gaillardia, Blanket	<i>Gaillardia x grandiflora</i>	fully open flowers
Perennial & Annual Baby's Breath	<i>Gypsophila</i> spp.	flowers open but not overly mature
Pincushion Flower	<i>Scabiosa</i> spp.	half-open flowers
Poppy Anemone	<i>Anemone coronaria</i>	buds beginning to open
Ranunculus	<i>Ranunculus asiaticus</i>	buds beginning to open
Sea Holly	<i>Eryngium</i> spp.	fully open flowers
Showy Stonecrop Sedum, Live-forever	<i>Sedum</i> spp.	fully open flowers
Siberian Squill, Blue Squill	<i>Scilla siberica</i>	half-open flowers
Snapdragon	<i>Antirrhinum majus</i>	one-third florets open
Speedwell	<i>Veronica</i> spp.	one-half florets open
Statice, Sea-lavendar	<i>Limonium</i> spp.	almost fully open flowers
Summer Phlox, Garden Phlox, Fall Phlox	<i>Phlox paniculata</i>	one-half florets open
Sunflower Heliopsis, Hardy Zinnia, Orange Sunflower, False Sunflower	<i>Heliopsis helianthoides</i>	fully open flowers
Sweet Pea	<i>Lathyrus odoratus</i>	one-half florets open
Sweet William	<i>Dianthus barbatus</i>	one-half florets open
Sweet Violet, English Violet, Garden Violet, Florists Violet	<i>Viola odorata</i>	almost open flowers
Tall Gayfeather, Blazing Star, Button Snakeroot	<i>Liatris spicata</i>	one-half florets open
Tiger, Asiatic, Oriental lilies	<i>Lilium</i> spp.	colored buds
Torch-Lily, Common Poker Plant, Flame Flower	<i>Kniphofia uvaria</i>	almost all florets are showing color
True Monkshood	<i>Aconitum napellus</i>	one-half florets open
Tuberose	<i>Polianthes tuberosa</i>	majority of florets open
Yarrow	<i>Achillea filipendulina</i>	fully open flowers
Zinnia	<i>Zinnia elegans</i>	fully open flowers

Information in this table gathered from various sources listed at the end of this publication.

harvesters need enough light to see what they are harvesting. This usually is in the cool of the morning after the dew has dried. Late afternoon or evening also has possibilities because the plants have stored carbohydrates from the day which will provide a food reserve for the plant material. In Kansas, though, late summer afternoons are quite warm.

“How” and “where” go together. Besides knowing at what stage of development to harvest, where and how to cut the flower on the plant also is important. This is most important on plants that produce multiple flowers/crops per season. You want to harvest the longest stem possible without sacrificing future production. You should leave at least two to five nodes (growing points) below your cut to ensure new growth. Very vigorous plants can be cut back to less nodes, while less vigorous plants should have more nodes left. Most stems should be at least 15 to 18 inches long. Longer lengths usually are better.

It does not matter if the cut is slanted or squared, but it does matter that you use sharp, clean cutting utensils. Sharp cutting utensils will not crush the xylem and block the flow of water up the stem. Clean utensils will not introduce harmful microbes to the cut stems. Some shears are designed to hold the flower after it is cut. Inexperienced harvesters may find shears less dangerous than knives. Cutting utensils should be cleaned daily with disinfectant—a 1:10 solution of chlorine bleach in water works well.

Flowers with sticky sap require special treatment immediately after harvest. To prevent the flow of the sticky sap, which can block the xylem, dip the cut ends in boiling water for 10 seconds or sear with a flame, immediately after harvest. Poppies, mignonette and poinsettia are examples of flowers with sticky sap.

Handling

Once harvested, there are a series of steps or tasks done to prepare the flowers for market. These are collectively called handling. These handling steps include

1. Grading
2. Leaf Removal
3. Bunching
4. Recutting
5. Hydration

6. Special Treatments
7. Packing
8. Precooling
9. Cold Storage
10. Delivery to Market

Not all of these are done to all flowers, and whether they are used or not depends on the market the flowers are going to be sold to. Where and how the steps are done depends on the market and the facilities of the operation. Flowers can have all the handling steps performed in the field, only some done in the field with the rest in the packing shed, or have all handling steps done in the packing shed.

Field handling usually is limited to leaf removal, grading, bunching, hydrating, and packing with immediate transport to market or cold storage for brief holding. Flowers for local retail markets often are packed this way since they are marketed immediately after harvest. Flowers also can have these steps performed in the field and then be transported to a packing shed where recutting, special treatments, precooling and dry packing can be performed.

All the handling steps can be done in a packing shed, too. It often makes for a better flow of activities if they are all done in the same place. Some of the steps can only be feasibly done in the packing shed, such as special treatments, precooling, cold storage and recutting. These extra steps usually are done for flowers going to wholesale markets.

The packing shed may be an ultra modern air conditioned building or an open air covered porch. The handling space should:

- be shaded or covered to keep temperatures lower and prevent direct sunlight on the flowers.
- be well lit so you can see well when grading the flowers.
- have a clean water source for preparing harvest, treatment and holding solutions, and for use in cleaning the area.
- have ample space so all handling activities can be performed smoothly, such that workers are not crossing over each other.
- have a cold storage or at least a cooler, shaded place to store the flowers until they are ready for market.
- have a place to prepare for harvest activities.



Although not previously listed, the first step after cutting the stem, whether you are going to handle them in the field or in the packing shed, should be to place them in water or a harvest solution. This solution may be acidified (pH 3.5), tepid water, citric acid works well, or a floral preservative. The harvest containers should be clean and disinfected after each use. Flowers should never be laid on the bare ground. After the harvest container is full of flowers, place them in a cool place until they can be handled or taken to market. The cool place can be a shady area in the field or a refrigerated cold storage. Do not over fill the containers. This will bruise your flowers and cause some to tangle with each other.

Leaves should be stripped from the stem. If the flowers are being field handled this can be done before they are placed in the harvest containers or before they are bunched into marketable bouquets. Usually, leaves are stripped from the bottom one-third of the stem, or at least the ones that would be in any holding solution.

Grading starts with deciding which flowers to harvest. Only marketable flowers should be harvested. Marketable flowers are free of blemishes, including both leaves and petals. The flowers can be grouped or graded by stem length if there are differences and also by developmental stage. More mature ones should be sold as soon as possible, while others can be held in cold storage for later sales.



How the flowers are bunched and packaged depends on the market you are using. If you are selling in a local retail market you have a lot of flexibility, but your customers will let you know what sells the best. Mixed bunches and single type bunches are both popular. Larger flowers such as lilies, gladiolus and sunflowers often are sold as single stems. Sleeving or wrapping the bunches helps prevent the different bunches and flowers from becoming tangled. Columbine, larkspur, delphinium, baby primrose, forget-me-nots and buddleia are flowers that should be wrapped or sleeved prior to marketing to prevent tangling.

Wholesale markets have a set of guidelines for the methods of bunching and packaging flowers. Most are bunched by 10's or 5's. Some, like roses and carnations, are bunched by 25's. Lilies-of-the-Valley are bunched in 25's and Sweet Violets are bunched in 100's with a collar of leaves underneath the flowers. Large, expensive to grow flowers can be sold by single stems. As stated before, some should be wrapped to prevent tangling. Most are boxed and shipped dry.

Proper pre-shipping handling is important in order to get flowers to the market in good shape. The flowers should be well hydrated but not wet when packed. Most spike flowers like snapdragons and gladiolus need to be packed upright to prevent the tips from curving. Special boxes or hampers are made for these type of flowers.

Once bunched, flowers should be hydrated, placed in water for awhile before they are packed dry. The hydrating step should include a step where, after the flowers are bunched, the stems are recut under water to eliminate any air bubbles in the xylem that can block the uptake of water. These



air bubbles can occur when the flowers were harvested. Once recut, the flower can be placed in a general holding solution used to hydrate the flowers or receive a special treatment such as silver thiosulfate.

Flowers usually are not packed dry into boxes in the field but are in the packing shed for distant wholesale markets. When flowers are packed into boxes, the bunches are sleeved or wrapped and then packed tightly so the bunches do not move or vibrate in transit (causes bruising). The standard flower box is 12 × 12 × 48 inches. There are smaller sizes, too, called half or quarter boxes that are 6 × 12 × 48 inches and 6 × 6 × 48 inches, respectively.

Precooling is a step that rapidly brings the temperature of the flowers down from the field temperature to a proper storage temperature. A low temperature slows the respiration rate of the flowers which in turn helps them last longer. Forced-air cooling is the best method for flowers—cool air is actively forced with fans through the bunched flower. This can be done when the flowers are in a bucket or when they are packed dry into boxes. The precooling of flowers is a very important step for individuals selling to a large wholesale market, distant markets and if their crop is to be stored for a long time such as peonies. Individuals who sell at a local retail market usually do not need to worry about this step since their flowers will be in the customers home the day they are picked.

Cold storage is recommended for all flowers that will not be in the market immediately and any flowers sold wholesale. As stated before, low temperatures slow the respiration rate of the flowers and prolong the vase life of the flowers. In general, temperatures should be 32 to 40°F and have a relative humidity of 85 to 90 percent, for most flowers. Table 2 list several species with their optimum temperature and their cold storage life. Flowers should never be stored with fruits and vegetables. Some fruits and vegetables produce ethylene that can dramatically shorten the life of the flowers. Once flowers are bunched into marketable units they should be placed in cold storage. As a new grower using local retail markets, a refrigerated cold storage may not be available or affordable. Since most of their flowers will be sold within hours a cool place such as an air conditioned room, cellar or basement could be used. More in-depth information on cold storage for fresh cut flowers and plant material is contained in K-State Research

Table 2. Storage Temperature Recommendations, and Approximate Storage Life and Vaselife for Fresh Cut Flowers and Florist Greens

	Storage Temperature		Approximate Period	
	C	F	Storage Life	Vaselife
Cut Flowers				
Allium	0 to 2	32 to 35	2 weeks, dry 4 weeks, wet	10 to 14 days -----
Anemone	4 to 7	40 to 45	2 days	4 to 8 days
Aster, China	0 to 4	32 to 40	1 to 3 weeks	5 to 10 days
Buddleja	4	40	1 to 2 days	1 to 2 days
Calendula	4	40	3 to 6 days	-----
Candytuft	4	40	3 days	-----
Clarkia	4	40	3 days	5 to 10 days
Columbine	4	40	2 days	-----
Coreopsis	4	40	3 to 4 days	-----
Cornflower	4	40	3 days	6 to 10 days
Cosmos	4	40	3 to 4 days	4 to 6 days
Dahlia	4	40	3 to 5 days	7 to 14 days
Daisy, English	4	40	3 days	-----
Daisy, Marguerite	2	36	1 to 2 weeks	4 to 7 days
Daisy, Shasta	4	40	7 to 8 days	-----
Delphinium	4	40	1 to 2 days	4 to 12 days
Feverfew	4	40	3 days	-----
Forget-me-not	4	40	1 to 2 days	-----
Foxglove	4	40	1 to 2 days	-----
Freesia	0 to 0.5	32 to 33	10 to 14 days	4 to 12 days
Gaillardia	4	40	3 days	-----
Gladiolus	2 to 5	35 to 42	5 to 8 days	6 to 10 days
Godetia	10	50	1 week	-----
Gypsophila	4	40	1 to 3 weeks	5 to 10 days
Iris, bulbous	-0.5 to 0	31 to 32	1 to 2 weeks	3 to 6 days
Lilac, forced	4	40	4 to 6 days	7 to 10 days
Lily	0 to 1	32 to 34	2 to 3 weeks	7 to 10 days
Lily-of-the-valley	-0.5 to 0	31 to 32	2 to 3 weeks	4 to 11 days
Lupine	4	40	3 days	-----
Marigolds	4	40	1 to 2 weeks	-----
Mignonette	4	40	3 to 5 days	-----
Narcissus	0 to 0.5	32 to 33	1 to 3 weeks	4 to 8 days
Poppy	4	40	3 to 5 days	-----
Peony, tight buds	0 to 1	32 to 34	2 to 6 weeks	2 to 7 days
Phlox	4	40	1 to 3 days	2 to 7 days
Ranunculus	0 to 5	32 to 41	7 to 10 days	5 to 7 days
Snapdragon	4	40	1 to 2 weeks	5 to 7 days
Snowdrop	4	40	2 to 4 days	-----
Squill	0 to 0.5	32 to 33	2 weeks	-----
Statice	2 to 4	35 to 40	3 to 4 weeks	4 to 8 days
Stock	4	40	3 to 5 days	5 to 8 days
Strawflower, fresh	2 to 4	35 to 40	3 to 4 weeks	7 to 10 days
Sweet pea	-0.5 to 0	31 to 32	2 weeks	3 to 7 days
Sweet william	7	45	3 to 4 days	5 to 9 days

Table 2. Storage Temperature Recommendations, and Approximate Storage Life and Vaselife for Fresh Cut Flowers and Florist Greens, continued

	Storage Temperature		Approximate Period	
	C	F	Storage Life	Vaselife
Cut Flowers, con't.				
Tulip	-0.5 to 0	31 to 32	2 to 3 weeks	3 to 6 days
Violet	1 to 5	34 to 41	3 to 7 days	-----
Zinnia	4	40	5 to 7 days	6 to 10 days
Florist greens				
Asparagus(plumosa)	2 to 4	35 to 40	2 to 3 weeks	6 to 14 days
Asparagus(sprenger)	2 to 4	35 to 40	2 to 3 weeks	6 to 14 days
Dagger and wood ferns	0	32	2 to 3 weeks	-----
Hedera	2 to 4	35 to 40	2 to 3 weeks	-----
Ilex (holly)	0 to 4	32 to 40	3 to 5 weeks	5 to 14 days
Juniper	0	32	1 to 2 months	-----
Leatherleaf (baker fern)	1 to 4	34 to 40	1 to 2 months	7 to 15 days
Magnolia	2 to 4	35 to 40	2 to 4 weeks	-----
Mistletoe	0	32	3 to 4 weeks	-----

Information in this table gathered from various sources listed at the end of this publication

and Extension Bulletin MF-1174, *Commercial Specialty Cut Flower Production: Cold Storage for Specialty Cut Flowers and Plant Material*.

Flower storage life and vaselife are considered to be two different things. The customer wants to know the vaselife—how long will the flowers last in my home—while the grower needs to know both—to determine how long flowers can be kept in cold storage and to be able to tell customers how long the flowers will last. Table 2 lists several species of common cut flowers and their vaselives. If flowers have to be stored before marketing, a cool place (preferably a refrigerated cold storage, especially for flowers) should be used.

There are many flowers that are not commonly found in the wholesale market because they do not store well, ship well or last long. These should only be used for local markets. These include foxglove, garden phlox, lupine, clarkia, stevia, common stocks, candytuft, cornflower, feverfew, blue laceflower, English daisy, calendula, pot marigold, sweet violets and gaillardia.

Fresh flower preservatives are chemicals added to water to make flowers last longer. They contain a germicide, a food source, a pH adjuster, water, and sometimes surfactants and hormones.

Germicides are used to control bacteria, yeasts and molds. These microorganisms harm flowers by producing ethylene, blocking the xylem, producing toxins and increasing sensitivity to low

temperatures. Bacterial counts of 10 to 100 million per 1 milliliter impairs uptake, while counts of 3 billion per 1 milliliter causes wilting. Some common germicides are listed on the following page. 8-HQC is the most common one used in commercial floral preservatives.

Sucrose is the most common food source used in floral preservatives. It provides energy to sustain flowers longer and to open flowers in the bud stage. One to 2 percent sucrose is the standard amount in preservatives. Never use sucrose without a germicide, as it is the primary food source for microorganisms, too.

Acids or acid salts are added to adjust the pH of the water to 3.5 to 5.0. At this pH, less microbes can grow and water is taken up by the flowers more easily. Surfactants and wetting agents reduce water tension so water is taken up more easily, also. Tween 20 and Triton are examples of surfactants.

Water is the most important component of floral preservatives. We take water and its quality for granted. We expect it to be pure and healthy for our flowers, but that is not always the case. Water is what keeps flowers turgid or firm. There are some properties or characteristics of water that should be understood because of their effect on flowers. They are pH, temperature, soluble salts, alkalinity and hardness.

As stated before, acidic water, pH 3.5 to 5.0, is best. Water with a low pH is taken up by the

Germicide Types	Common Name	Recommended Concentration
8-hydroxyquinoline sulphate	8-HQS	200–600 ppm
8-hydroxyquinoline citrate	8-HQC	200–600 ppm
Silver Nitrate	AgNO ₃	10–200 ppm
Silver Thiosulfate	STS	0.2–4 ppm
Thiobendazole	TBZ	5–300 ppm
Quarternary ammonium salts	QAS	5–300 ppm
Slow-release chlorine compounds	50–400 ppm of Cl	
Aluminum sulphate	Al ₂ (SO ₄) ₃	200–300 ppm

flowers quicker and more easily. The lower pH inhibits the growth of xylem blocking microbes. Neutral is 7, acidic is <7, and basic is >7. Well water in Kansas is usually pH 8 to 9. Municipal water supplies usually are treated to increase the pH to 8 to 9 also to prevent corrosion of pipes. Citric acid, an organic acid, usually is used to acidify water.

The best temperature is warm—100°F. Warm water has less dissolved gases in it—dissolved gas bubbles can cause blockages in the xylem just like microbes.

Unless water is pure, it will have dissolved mineral salts in it; these will affect the pH and contribute to the salinity, hardness and alkalinity of the water. When water is tested, the results will usually show a total soluble salts or total dissolved salts number. This usually is expressed as ppm or mg/liter or microsiemens. These are not interchangeable.

$$1 \text{ ppm} = 1 \text{ mg/liter} = 700 \text{ } \mu\text{siemens}$$

The total soluble salts is made up of alkalinity or hardness and salinity. Low soluble salt content is best. They can interfere with water uptake because they change the osmotic potential of the water. They can burn leaves and petals because they can accumulate in the tips.

Alkalinity is the measure of water's ability to neutralize acid or buffering capacity. It is a measure of the negative ion salts in the water. It is measured as mg/liter Calcium Carbonate, CaCO₃ equivalents or ppm Calcium Carbonate, CaCO₃. The active ions are bicarbonate, HCO₃⁻; carbonate, CO₃⁼; and hydroxide, OH⁼. Water with less than 100 mg/liter CaCO₃ equivalents is best. If it is higher, the pH of the water may not be able to be adjusted with a floral preservative; and will make the floral preservatives ineffective since the acidifiers in them may be completely "buffered out" by the alkalinity of the water. To make the floral preservative more effective, an acid such as

Toxic Soluble Salt Concentrations for Selected Species

Species	Sensitivity Concentration
Glads	700 ppm
Roses	200 ppm
Mums	200 ppm
Carnations	200 ppm

citric acid will need to be added instead of adding more floral preservative.

Hardness often is used interchangeably with alkalinity but it measures the positive ion salts in the water. These are usually magnesium, Mg⁺⁺ and calcium, Ca⁺⁺. The standard practice to decrease hardness in water is to soften it by exchanging the magnesium and calcium ions with sodium ions. Sodium ions, though, can be toxic to the flowers at high levels. This method of decreasing water hardness should not be used for cut flowers.

Fluoride is one specific ion that causes many problems. It is commonly added to municipal water supplies to prevent tooth decay in humans. Flowers in the lily family and other monocots are more sensitive to fluoride than others. Fluoride toxicity is more of a problem at a lower pH, which

Fluoride Sensitivity for Select Species

Species	Sensitivity Concentration
Freesias	1 ppm
Gladiolus	1 ppm
Gerberas	1 ppm
Mums	5 ppm
Snapdragon	5 ppm
Roses	5 ppm

is best for holding flowers. Species that are more sensitive to fluoride are listed on page 9.

Floral preservatives are designed to deal with less than optimum water. The pH adjusters are

designed to lower the pH to the optimum. Some have more acid to deal with “hard” water. Other times the soluble salt content, fluoride levels and alkalinity are so bad a reverse osmosis, deionizing or distillation water system will be needed to purify the water. Pure water has no contaminants, no soluble salts, no fluoride, and no buffering effect so preservative pH adjustors work well. Water should be tested to determine what the problem is and to determine the best remedy.

Commercial Fresh Cut Flower

Preservative Sources

Floralife—Floralife, 120 Tower Dr., Burr Ridge, IL 60521, 800-323-3689

Rogard/Silgard—Gard Environmental Group, 250 Williams Roas, Carpentersville, IL 60110, 800-433-4273, 847-836-7700, FAX 847-836-7711,

Chrystal—Pokon & Chrystal USA, 3063 NW 107th, Miami, FL 33172, 800-247-9725

Prolong—Robert Koch Industries, Inc. Rt.1 Box 4HH, Bennett, CO 80102, 303-644-3763

Oasis—Smithers Oasis, P.O. Box 118, Kent, OH 44240, 330-673-5831

Vita Flora—P.O. Box 565, Chandler, AZ 85244, 800-874-1452, FAX 602-813-8156

Besides the standard floral preservative solutions for holding flowers there are some specific solutions and treatments that serve different needs.

- A harvesting solution often will simply be water acidified with citric acid to a pH of 3.5 to 5.0.
- A conditioning, hardening, or hydrating solution is used to restore the turgor of wilted flowers and dry packed flowers. It usually is warm water with a germicide, acidified to pH 3.5 to 5.0 with citric acid and a wetting agent, i.e. Tween 20 0.01 to 0.1 percent.
- Impregnation is a treatment that protects stems against the blockage of water vessels by microbes. Stems are dipped in 1000 ppm silver nitrate solution for 10 minutes. The stems should not be recut after treatment.
- Pulsing or loading is a type of treatment used to extend the vase life of flowers held in water, stored wet or dry for long periods or shipped long distances. It is called a pulse because it is only done for a short period of time, or called

loading because the flowers are loaded up with food for a long storage period. Stems are placed in solutions with germicide and a higher concentration of sugar for specific treatment periods depending on the species. Because the higher concentration of sugar can act like a soluble salt causing petal and leaf injury, the treatment is only a few hours or a day. The temperature should be 65 to 75°F and light intensity should be 2000 lux.

- Bud opening solutions are used to open flowers harvested in a tight bud stage. Flowers harvested in the tight bud stage will keep longer in storage and will ship better. Stems are placed in solutions containing higher concentrations of sugar, plus a germicide and hormonal compounds that facilitate bud growth and development. High light and humidity, and room temperatures are used. The high sugar content can injure the flowers and leaves.

Ethylene, called the ripening, senescence and wound hormone, is a naturally occurring plant hormone. It is important in the reproductive cycle of plants. It triggers the ripening and senescence of flowers and fruit and is also produced when plants are wounded. Many decay and disease organisms also produce ethylene. Ethylene damages some cut flower species by causing flowers to drop prematurely, flower buds to not open, and flower petals to close. There are three strategies to prevent ethylene damage: (1) keep ethylene from flowers by preventing ethylene pollution; (2) remove ethylene from the atmosphere; and (3) inhibit the effect of ethylene on flowers. Some specific measures to prevent ethylene damage on flowers are:

1. Make sure CO₂ generators in greenhouses and oil or gas heaters in greenhouses and handling areas are working properly and well vented.
2. Protect plants against pest and diseases.
3. Prevent pollination of flowers.
4. Harvest flowers at optimum stage.
5. Avoid physical injury to flowers during handling.
6. Cool flowers as soon as possible after harvest.
7. Keep storage and handling facilities clean, and remove diseased and dying plant material.

8. Do not use internal combustion engines in any handling work or production areas.
9. Have good air circulation and ventilation in handling and storage areas.
10. No smoking in handling and storage areas.
11. Do not store flowers with ethylene producing fruits and vegetables.
12. Do not store newly harvested flowers in bud stages with fully open flowers.
13. Use ethylene scrubbers in cold storage area.
14. Use STS treatment on sensitive species.
15. Use other chemical treatments in floral preservatives.

There are various chemicals that can inhibit the effect of ethylene. The most common is the metal ion silver. It usually is applied to flowers in the form silver thiosulfate, STS. It acts on both ethylene receptors and production sites in the flower. This protects the flowers from ethylene in the environment and it stops the flower from producing ethylene itself. Other chemicals are MCP (1-methylcyclopropane) a gas which acts only on receptors, but is not available commercially, and EVB (Pokon & Chrystal), and Vita Flora which act on the flower's ethylene production sites.

To treat or pulse flowers with STS, stems are placed in STS solution for 20 minutes at 65°F. To make the solution, follow these directions or buy pre-made solutions. Floralife sells a two-part solution that make STS.

STS Solution

Ethylene Sensitive Species

Snapdragons	Dutch Iris
Sweet Peas	Freesia
Larkspur	Baby's Breath
Delphinium	Alstroemeria

1. Dissolve 0.079 g AgNO₃ in 500 ml of deionized water.
2. Dissolve 0.462 g Na₂S₂O₃X 5H₂O in 500 ml deionized water.
3. Pour AgNO₃ solution into Na₂S₂O₃X 5H₂O solution while stirring. The concentration of silver is 0.463 mM (463 ppm).
4. The STS solution is now ready to use. If not used immediately, the solution may be kept in a dark glass or plastic container at 65 to 75°F, in total darkness for up to four days.

Lastly, sanitation is of utmost importance in handling fresh cut flowers. The handling area and cold storage should be cleaned and sanitized after each use. Equipment, cutting utensils, containers and handling surfaces should be cleaned and disinfected with a 1:10 bleach solution. Unmarketable flowers should be disposed of after each harvest. Dirty harvest and holding containers and cutting utensils spread disease. Dying plant material is a reservoir for plant disease organisms and produces ethylene. All shorten the storage and vase life of flowers.

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