FACTSHEET 01/20

a revision of 24/05 and 02/06

Guidelines for the post-harvest handling of cut flowers and foliage

Figure 1. Harvesting protected cut flower column stocks

Action points

- Understand all the physical, microbiological and chemical factors that can lead to loss of quality in the production and processing of cut flowers and foliage, and determine how these can be minimised
- Map out the post-harvest handling process on the nursery or farm, use the principles of the hazard analysis and critical control point (HACCP) system to identify the key stages which impact product quality and implement the necessary control or preventative measures to maintain quality
- Minimise the potential for any physical damage and stress to the product post-harvest
- Maintain good levels of site hygiene in the cold store and packing areas
- Ensure that cut flowers and foliage are stored at the correct temperature and humidity, and that refrigeration equipment in the cold store is well maintained
- Choose the correct post-harvest treatment for the cut flowers and foliage being processed and ensure that any waste solution is disposed as per the manufacturer's instructions

Background

Cut flower and foliage quality is at its optimum at harvest and quickly deteriorates thereafter unless product is handled correctly. It is therefore important to manage the rate of product deterioration and preserve quality for as long as possible after harvesting.

As the majority of retailers now provide a stated vase life for product after purchase, it is also important to ensure that the vase life potential is enhanced at all stages of the post-harvest process.

The production of UK-grown cut flowers and foliage provides growers with the principal advantage over their overseas competitors of being able to deliver product in a relatively short lead in time without the additional transport costs associated with imported products.

In the UK, product is grown both indoors, under glass (Figure 1) and polythene structures, and outdoors. Outdoor-grown cut flowers, in particular, are subject to changeable weather conditions, they are highly perishable and require significant post-harvest handling to maintain quality throughout the supply chain.

During the process of post-harvest handling, it is therefore important to be aware of all the factors that can lead to loss of product quality and determine how to minimise these.

Post-harvest handling process

It is important to establish and understand exactly the post-harvest handling process on the nursery or farm (Figure 2). Keep it simple – start by looking at the general process of harvesting and post-harvest handling rather than crop-specific detail. Essentially, there are four necessary steps in order to fully understand the post-harvest process.

Figure 2. Management of field-grown cut sunflowers

1. Creating a process flow chart

A process flow chart is invaluable in helping to identify the key activities from harvesting through to product dispatch. The product may leave as a raw material to be assembled into a final product by the customer or the product may be finished on site.

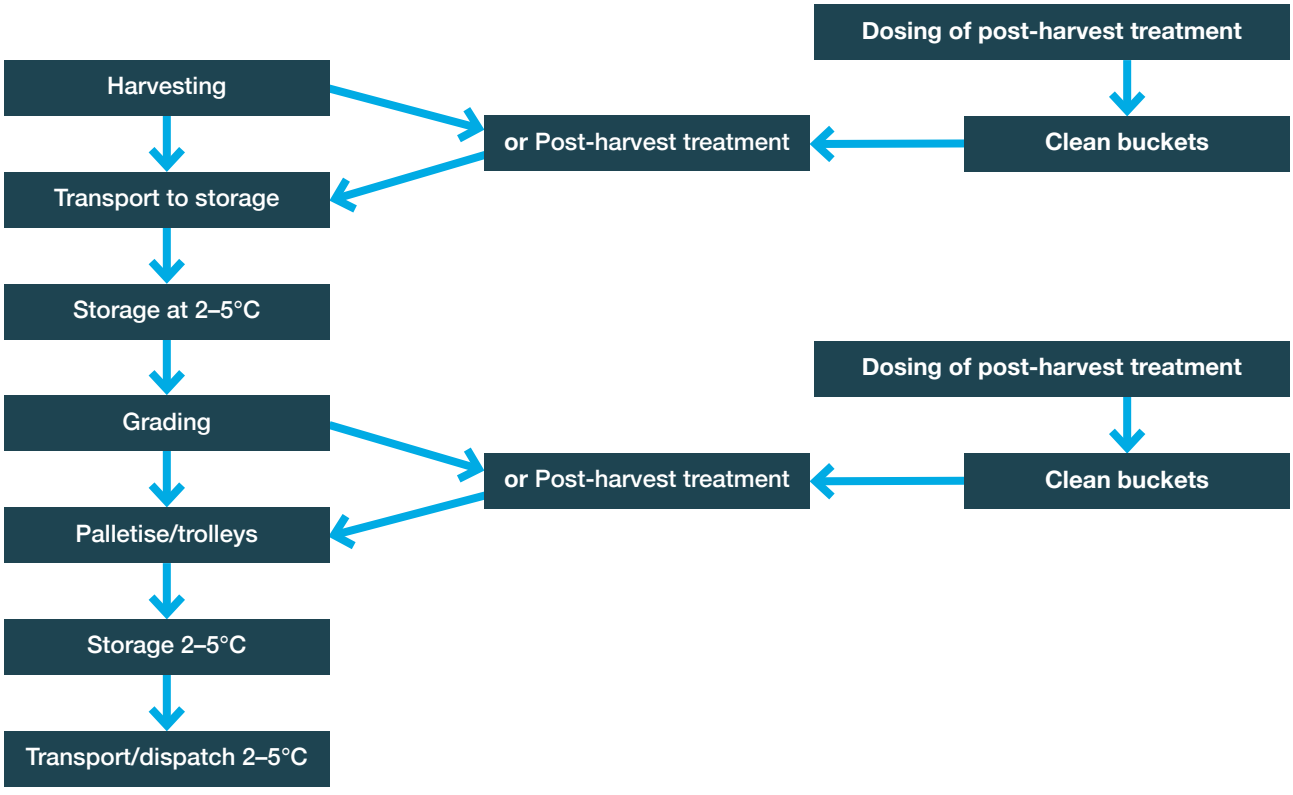

Figure 3. Example of a process flow chart for cut flowers and foliage (raw material to packer)

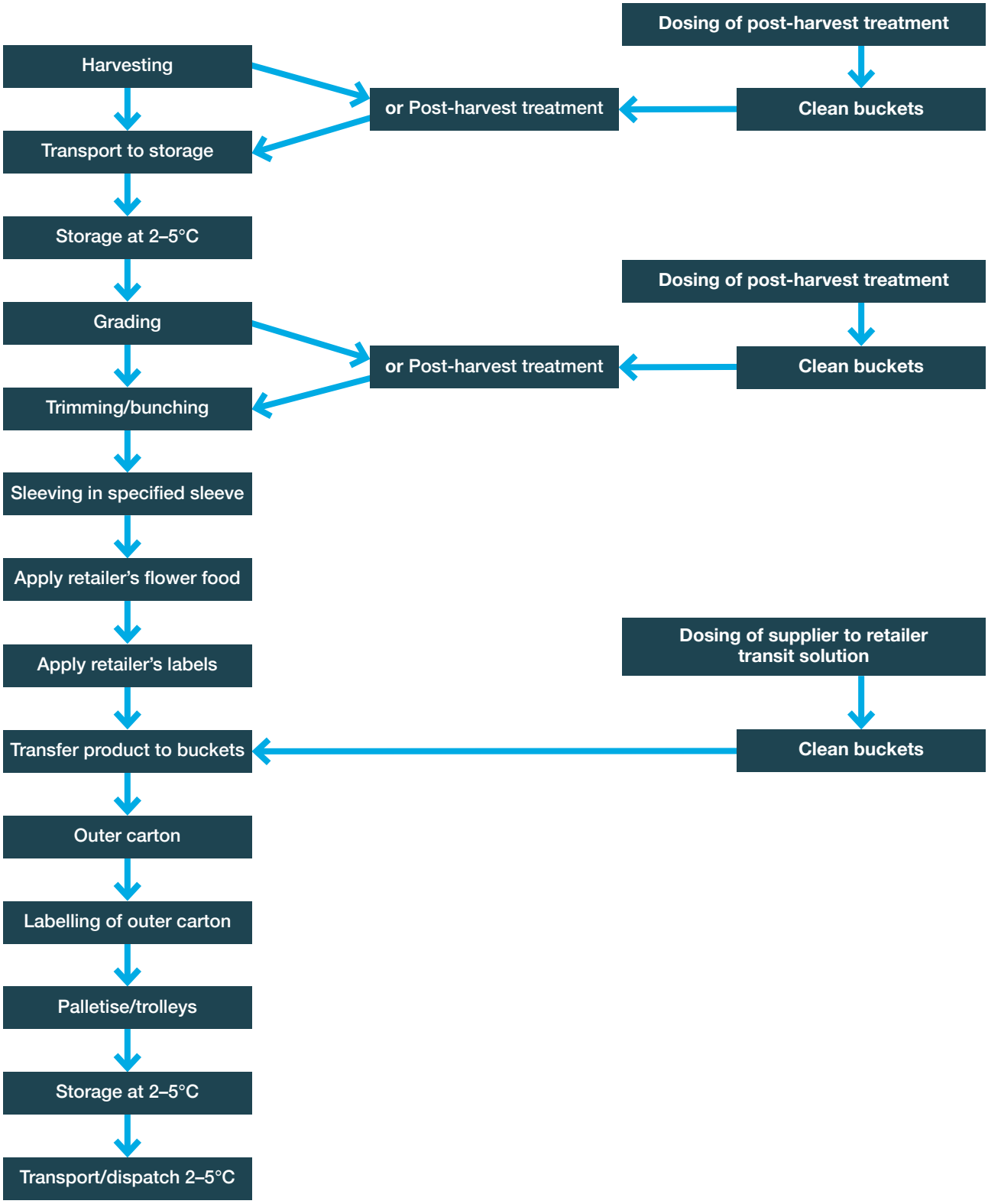

Figure 3a. Example of a process flow chart for cut flowers and foliage (including sleeving and packing)

Examples of process flow charts capturing the main post-harvest activities can be seen in Figures 3 and 3a. Figure 3 presents the simpler process for handling cut flowers and foliage, where a grower is simply harvesting, grading and supplying the raw material to a packer. Figure 3a illustrates a flow chart covering the more detailed process for handling material where the grower is also sleeving and packing the product. Depending on the types of crop being grown, the process flows may vary between, for example, indoor-grown and outdoor-grown cut flowers.

2. Identifying the potential factors which impact quality

The next step is to identify the factors that impact quality in the post-harvest process. These are normally physical, microbiological, chemical and/or quality assurance issues.

Physical

- Look at how the cut flowers and foliage are harvested, are the stems cut and moved from the growing beds in such a way as to minimise damage?

Figure 4. Debris from harvested product should be regularly disposed of

- Bruising or other mechanical damage leads to poor appearance but also provides potential sites for disease infection (e.g. botrytis). Mechanical damage can also result in increased water loss from the cut stem. All of these issues potentially lead to a reduction in post-harvest quality
- Is there unnecessary double handling of the cut stems?
- Does harvest occur at the correct flower stage? The more advanced the flowers, the higher the risk of damage and the shorter their post-harvest life
- How do the staff ensure that the harvested product is not contaminated by a foreign body, such as a harvesting knife?
- How is the harvested product transported from the glasshouse or field to the storage area? Can it be improved?
- How is the grading process managed? Are there measures in place to minimise physical damage?
- Is the correct harvesting container used for the product?
- How is the temperature of the harvested product managed?

Microbiological

- Are the harvesting tools and containers clean and have they been disinfected?
- Is the process of cleaning and disinfecting the harvesting tools and containers, and any other equipment that comes into contact with the freshly harvested flowers, effective enough?
- Are there preventative measures in place to minimise physical damage and therefore reduce the risk of microbial infection?
- Does the harvesting process include a step to ensure debris from harvested product is disposed of promptly to prevent the potential spread of pest and disease (Figure 4)?
- Is the water used in the harvesting containers clean and free from microorganisms? Mains water is best
- Do the harvesting containers contain the correct concentration of post-harvest treatments to reduce microbial growth?

Chemical

- Are the post-harvest treatments measured out and handled correctly?
- Is the dosing equipment calibrated correctly?
- Is the concentration of the post-harvest treatments measured correctly?

Quality assurance

- Are the stems trimmed to the correct specified length, and is the correct amount of lower stem foliage being removed? Some foliage is mechanically harvested, which means that all of the stems on the plant are cut in one operation. When this is the case, it is very important that the product is thoroughly graded in order to ensure that customer specifications are maintained
- Are the stems bunched to the correct specified number and/or weight?
- Is the correct specified label, sleeve, bucket and outer carton used?
- Are the outer cartons labelled and stacked correctly on pallets for dispatch?

The above list is not exhaustive and each individual nursery or farm will have to consider some or all of these examples, together with additional factors, depending on the nature of the business and the logistics employed.

Having established the potential factors that impact quality, the next step is to decide whether each is critical to the quality of the cut flower product and how it can be managed.

3. Identifying critical control points

A useful tool for identifying which factors are hazardous, the risk associated with each, and whether they are critical within the post-harvest process is the critical control point decision tree.

Defining hazards and risks

A hazard is anything with the potential to cause harm. A risk is the likelihood that a hazard will cause harm.

A critical control point (CCP) is a point, step or procedure at which control can be implemented resulting in the hazard and associated risk being eliminated, prevented or reduced to an acceptable level. Each potential hazard needs to be identified and the decision tree used to determine the level of risk associated with it (Figure 5). This process will also help to establish any additional steps required in the post-harvest process flow that may have not been considered initially. It may also identify potential crop-specific hazards that need to be considered outside of the general process flow chart.

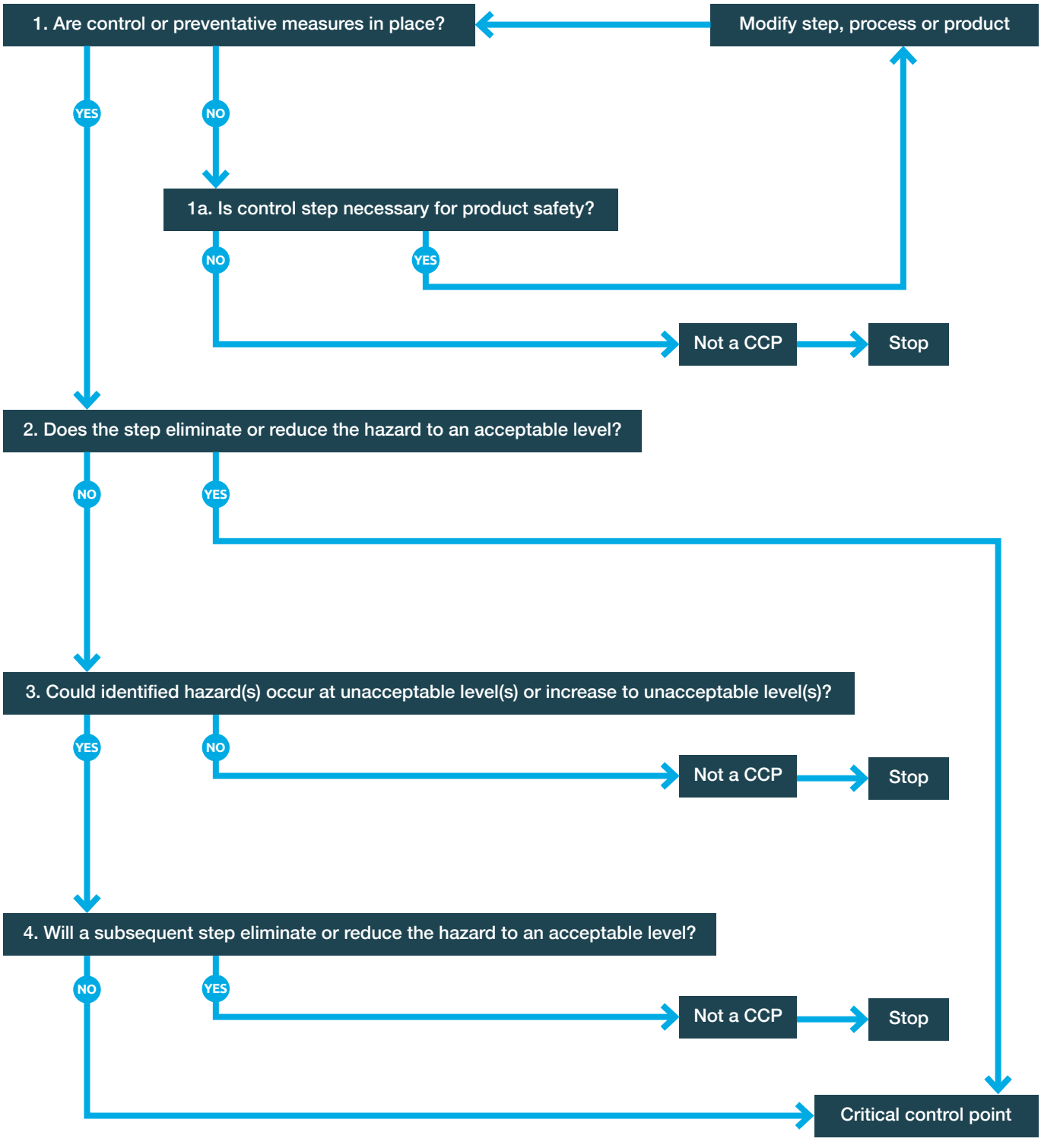

Figure 5. Critical control point decision tree for each identified hazard in the post-harvest process

4. Managing critical control points

Once the hazards have been identified, it is important to decide what control or preventative measures can be put in place to eliminate or reduce occurrence to an acceptable level.

A table is useful in helping to establish: the control measures required for each CCP; the critical limits that determine what is acceptable or unacceptable; how the process is maintained; what corrective action is required and how each procedure is verified. Table 1 shows a potential format and provides examples of hazards for consideration.

In summary, the process described is based on the principles underpinning the hazard analysis and critical control point (HACCP) system. HACCP is a systematic approach used throughout the food industry to manage product safety. However, it can easily be adapted for the ornamental horticulture industry and is a very effective quality-management tool.

Using the principles of HACCP as a management tool is recommended and satisfies the requirements of certification schemes and retail customers.

Once a general process for the post-harvest handling of cut flowers has been agreed, it can then be adapted to be more crop-specific, if required.

The HACCP process also helps to identify any documentation and record keeping that may be required on the nursery or farm to monitor the critical control points and the management of them.

It is important to keep the process simple. It is also very beneficial, when carrying out the analysis of the process flow and deciding upon the critical control points, to include all relevant members of staff, particularly those involved in the day-to-day activities. They invariably have valuable information and knowledge as to how a procedure is carried out, the issues that arise and how they can be resolved.

For additional information on the HACCP system, refer to the ‘Further information’ section at the end of the factsheet.

CCPs during the post-harvest handling of cut flowers and foliage

The following key areas are considered as CCPs during the process of post-harvest handling of cut flowers and foliage:

- Physical handling
- Temperature control and product management
- Water loss
- Post-harvest treatments
- Process hygiene management

Physical handling

It is important to consider how the cut flowers and foliage are harvested, and steps should be taken to minimise any potential physical damage.

- Many types of cut flower are delicate and therefore very susceptible to damage. The overall harvesting process should therefore try to involve the minimum amount of double handling as possible

Table 1. Example format to establish and record the control measures required for CCPs

Processing step	Possible hazard and risk	Control or preventative measure	CCP number (example)	CCP critical limits	Monitoring procedure	Corrective action	Verification procedure
Harvesting of the cut flowers	Harvest knives Risk of sharp harvest knives left in the product	Formal knife control procedure, with knives individually identified and signed in and out by staff	CCP 1	No knives in the product	Printed form managed by the harvesting supervisor, with numbered knives signed in and out	If a knife goes missing, stop harvesting and locate knife. If knife cannot be located, inform manager and grading shed/packhouse. Consider disposing of batch. Record actions taken	Regular internal audit checks
Post-harvest treatment of ethylene-sensitive flowers	Post-harvest chemical treatments Under- or overdosing of treatment due to length of time cut flowers are in the post-harvest chemical treatment	Clearly label cut flower batch with date and time placed in treatment, e.g. 17.05.19 10:00am	CCP 8	Minimum 4 hours, maximum 72 hours	Formal procedure that clearly identifies process and person responsible for checking the product and removing it from the post-harvest treatment	If less than minimum specified time, replace cut flowers in post-harvest treatment. If more than maximum time, dispose of batch	Regular internal audit checks

- The method of harvesting should ensure that the process is efficient while at the same time not causing damage
- When harvesting cut foliage, the method of bunching and collecting the foliage from the field should be carefully considered to prevent the inclusion of field debris among the harvested stems
- The best, most appropriate container should be used for harvested product, particularly to transport the cut stems from the growing location to the grading and cold-storage areas
- Containers used should be clean and free of plant debris (Figure 6)
- The harvested product needs to be protected from the elements during the transport process
- The method of packing and transport from the grower to the customer should also be considered to prevent damage

Figure 6.Containers should be clean and free of plant debris before use

Temperature control and product management

Good temperature management is fundamental in the post-harvest handling of cut flowers and foliage and is one of the most important CCPs. The following guidelines should be considered.

- Where possible, harvest in the coolest part of the day
- Cool the cut flowers as rapidly as possible, but not too quickly as 'chilling injury' may result
- Temperatures from ambient to chill need to be managed carefully (Figure 7)
- Consider pre-cooling to take the field heat out of product before exposing it to final cold store temperatures of 2–5°C, particularly product that has been harvested in higher than normal temperatures, both indoor- and outdoor-grown product
- If pre-cooling is not feasible, consider other methods of taking field heat out of the cut flowers. For example, using shading to protect the cropped stems immediately after harvesting prior to transit back to the storage areas
- Try and combine the pre-cooling period with the application of any post-harvest treatments
- Store the cut flowers away from other external sources of ethylene (such as bulbs and vegetables)
- Identify the product post-harvest using traceability tickets, which include harvest date, this will help to ensure good stock rotation in the cold stores
- Handle the chilled cut flowers as little as possible in and out of the cold store. Alternating warm and cold temperatures may cause condensation and can lead to deterioration of quality

Figure 7. Cooling cut flower tulips in an insulated cold store

Water loss

Water loss is a major cause of deterioration of cut flowers and foliage post-harvest and should be managed.

- Minimise the water loss from the harvested stems. Rapid water loss will lead to stress and wilting
- Breezy harvesting conditions will increase water loss – take this into account when handling outdoor-grown cut flowers and foliage
- Most importantly, harvest the flower directly into clean, fresh water or a post-harvest treatment
- Refrigeration units in cold stores not only cool product, they also remove moisture from the air. A higher relative humidity in storage can reduce water loss and prolong product life. The ideal relative humidity for cut flowers in storage is 85–95%. Humidities higher than this will lead to problems, in particular disease issues such as botrytis and associated flower spotting

Post-harvest treatments

The correct use of post-harvest treatments prolongs the life of cut flowers. The majority of cut flowers and foliage will benefit from a post-harvest treatment.

- The best treatment for each different flower genera should be used to maximise its post-harvest life. Tables 2 and 3 list the available post-harvest treatments and the main cut flower and foliage genera and species grown in the UK they can be used with
- Any post-harvest treatment used must be registered for use in the country of application and any destination country
- Post-harvest treatments must be dosed correctly
- The most common method of dosing liquid products is via a proportional dilutor, but other products come in other forms, such as tablets
- Proportional dilutors must be regularly calibrated and maintained to ensure accuracy
- Do not mix old solution with freshly prepared solution
- Staff members who are responsible for handling post-harvest treatments must be appropriately qualified (see box opposite)
- Health and safety issues must be considered when handling and storing the products being used. Any member of staff handling post-harvest treatments should wear gloves at all times. An eyewash station should be in the vicinity of the dosing area
- Always follow the manufacturer's guidelines
- Any unused post-harvest treatments must be disposed of correctly and the manufacturer's guidelines followed

Operator qualification requirements when handling post-harvest treatment products

Products containing silver thiosulphate

City and Guilds NPTC PA1 and PA10 qualifications are required if the solution is mixed manually into a trough/bucket by an operator and then batches of cut flowers are placed into the trough/bucket (this is categorised as a batch treatment). If the solution is put through an automated dosing system (such as a proportional dilutor), then PA1 and PA (SC) qualifications are required (this is categorised as an automated system).

Products containing 1-methylcyclopropene (1-MCP)

PA1 and PA9 qualifications are required to use these products.

Products containing 6-benzyladenine + gibberellins or ethephon

PA1 and PA10 qualifications are required if the solution is mixed manually. PA1 and PA (SC) are required when applying products through an automated application system.

Management of products containing silver thiosulphate

All waste solution must be disposed of as chemical waste – no other disposal method is now permitted. To minimise the amount of waste solution generated, volumes of 'ready to use' solution should closely match what is required to treat the batch of flowers (by stem uptake). Neutralisation kits are no longer supplied. In order to minimise the amount of waste solution, consider the following:

- For optimal treatment, one stem needs on average 2.5 ml 'ready to use' solution
- The treatment should be the first one made to the cut stems
- Make a clean cut, ensuring that all stems are cut level
- In cold store, an overnight treatment is recommended
- In cold store, the solution can be (re)used for up to three to five days

Treatment dose measuring devices

A fluorometer can be used to accurately determine the dosing of products containing silver thiosulphate and hormone-based products.

Chlorine indicator solution will confirm the presence, but not the concentration, of chlorine-based products.

A glucometer can be used to determine and record dosing accuracy when using rehydrating products, or a pH strip will confirm the required pH.

Table 2. Cut flower post-harvest treatments for use in the UK (excluding transport and display treatments)

Product name(s)	Active ingredient	Registration number	Mode of action	Application method	Dose rate	Comments
Chrysal AVB	Silver thiosulphate	19041	Prevents ethylene from binding to its receptor	Manual application and dosing system	0.5 ml and 1 ml/L, depending on the flower genera	Treatment must occur on the nursery, minimum of four hours treatment and maximum of 72 hours, and, once completed, the flowers must be removed from the solution and placed in a suitable transit solution before being transported to the customer
Florissant 100	Silver thiosulphate	19158	Prevents ethylene from binding to its receptor	Manual application and dosing system	0.5 ml and 1 ml/L, depending on the flower genera	Treatment must occur on the nursery, minimum of four hours treatment and maximum of 72 hours, and, once completed, the flowers must be removed from the solution and placed in a suitable transit solution before being transported to the customer
Chrysal Ethylene Buster	1-MCP (1-methylcyclopropene)	16222	Prevents ethylene from binding to its receptor	Apply in an airtight space, e.g. individual flower boxes	One tablet per 10 m^3 of treated space	Chrysal Ethylene Buster is supplied in the form of tablets and the 1-MCP gas is produced by adding the tablets to an activating solution Once 1-MCP has been activated, the box or container that has been treated should remain closed during storage or shipping for a minimum of four hours
Floralife EthylBloc	1-MCP (1-methylcyclopropene)	18288	Prevents ethylene from binding to its receptor	Apply in an airtight space, e.g. individual flower boxes	One sachet per 0.04 m^3 treated space	Floralife EthylBloc is supplied in 2.5 g sachets that are activated by dipping them into clean water for 1 to 2 seconds Once 1-MCP has been activated, the box or container that has been treated should remain closed during storage or shipping for a minimum of four hours
Chrysal CVBN	Slow-release chlorine	N/A	Bacterial suppressant	Automatic or manually dispensed pills	One pill per 2–3 L of water	For maximum effect, should be used as soon as possible after cutting and throughout the whole supply chain
Florissant 500N	Slow-release chlorine	N/A	Bacterial suppressant	Automatic or manually dispensed pills	One tablet per 2.2 L of water	For maximum effect, should be used as soon as possible after cutting and throughout the whole supply chain
Chrysal RVB Clear Intensive	Biocide and rehydrating agent	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	1 ml/L of water	Chrysal RVB Clear is a rehydrating product, balancing pH levels while stimulating water uptake
Chrysal Clear Professional 3	Biocide, rehydrating agent and sugars	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	10 ml/L of water	Chrysal Clear Professional 3 is a flower food used for bud development and forcing flowers

Table 2. Cut flower post-harvest treatments for use in the UK (excluding transport and display treatments) (continued)

Floralife Express Clear 100	Biocide and rehydrating agent	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	5 ml/L of water	Floralife Express products provide rehydration (and nutrition as appropriate) to flowers without the need to recut stems. However, hard-to-rehydrate subjects, such as hydrangea, may require the stems to be recut in order to provide the best results. Other Floralife products are available for use during storage and transit
Floralife Express Clear Ultra 200	Biocide, rehydrating agent and sugars	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	5 ml/L of water	Floralife Express products provide rehydration (and nutrition as appropriate) to flowers without the need to recut stems. However, hard-to-rehydrate subjects, such as hydrangea, may require the stems to be recut in order to provide the best results. Other Floralife products are available for use during storage and transit
Florissant 810	Biocide, rehydrating agent and sugars	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	1 ml/L of water	The main difference between the two Florissant products is the differing level of sugars
Florissant 820	Biocide, rehydrating agent and sugars	N/A	Rehydration of flower stems and bacterial suppressant	Manual application and dosing system	5 ml/L of water	The main difference between the two Florissant products is the differing level of sugars
Chrysal BVB	6-benzyladenine and gibberellins	17780	Maintains leaf colour and aids bud opening	Manual application and dosing system	0.15–2 ml/L of water	Chrysal BVB has a recommendation for use either straight, with alstroemeria, anemone, iris, lily and nerine, or mixed with Chrysal Plus, for use with tulip
Floralife Bulb 100	6-benzyladenine and gibberellins	17995	Maintains leaf colour and aids bud opening	Manual application and dosing system	0.15–5 ml/L of water	Floralife Bulb 100 has a recommendation for use either straight, with alstroemeria, iris and lily, or mixed with Floralife Bulb 100, for use with tulip
Chrysal Plus	Ethephon	17874	Prevents stem stretch in tulips	Manual application and dosing system	See Comments box	1 L of BVB should be mixed with 2 x 15 ml bottles of Chrysal Plus and then diluted at 1–2 ml/L of water to achieve the final usable solution. Chrysal Plus is not recommended for use individually
Floralife Tulipa	Ethephon	17966	Prevents stem stretch in tulips	Manual application and dosing system	See Comments box	5 L of Floralife Bulb 100 should be mixed with a 150 ml bottle of Floralife Tulipa (a mixture known as Floralife Tulipa 100) and then diluted at 2 ml/L of water to achieve the final usable solution. Floralife Tulipa is not recommended for use individually

Table 3. Available post-harvest treatments for the main cut flower and foliage genera and species grown in the UK, by mode of action

Product/ Plant genera	Ethylene-blocking products				Bactericidal products		Biocidal, rehydration and nutritional products						Other products (to maintain leaf colour and prevent stem stretch)			
	Chrysal AVB	Chrysal Ethylene Buster	Floralife Ethylbloc	Florissant 100	Chrysal CVBN	Florissant 500N	Chrysal RVB Clear Intensive	Chrysal Clear Professional 3	Floralife Express Clear 100	Floralife Express Clear Ultra 200	Florissant 810	Florissant 820	Chrysal BVB	Chrysal BVB and Chrysal Plus	Floralife Bulb 100	Floralife Tulipa 100
Agapanthus	X	X		X	X				X	X						
Alstroemeria				X					X	X			X		X	
Antirrhinum	X	X		X	X		X		X	X						
Aster					X		X		X	X	X					
Brodiaea (triteleia)	X	X			X		X		X	X						
Brassica					X	X					X					
Bupleurum					X	X	X				X					
Campanula	X	X			X	X	X		X	X	X					
Carthamus tinctorius							X				X					
Chrysanthemum							X		X	X	X					
Dahlia	X	X			X	X	X				X					
Delphinium	X	X	X	X	X		X		X	X						
Dianthus	X	X		X	X		X									
Dianthus barbatus (sweet william)					X		X		X	X						
Eustoma (lisianthus)								X	X	X						
Gladiolus									X	X						
Godetia					X		X		X	X						
Grasses					X	X	X				X					
Gypsophila	X	X		X			X	X	X	X	X					
Helianthus (sunflower)					X	X		X	X	X	X					
Hydrangea							X		X	X	X					
Hypericum					X		X		X	X	X					
Iris													X		X	
Lathyrus (sweet pea)	X	X	X	X	X		X		X	X						
Lilium (Asiatic + LA hybrids)	X	X							X	X			X		X	
Lilium (oriental + longiflorum)									X	X			X		X	
Matthiola (column stocks)					X	X			X	X	X					
Paeonia	X	X			X	X	X		X	X	X	X				
Phlox	X	X		X	X		X		X	X						
Ranunculus					X	X	X				X		X			
Scabiosa	X	X		X	X		X		X	X						
Scilla					X											
Sedum					X	X	X				X					
Solidago					X		X		X	X	X					
Tulipa														X		X
Zinnia					X	X	X		X	X	X					

Tables 2 and 3 have been collated using information from current product labels, technical leaflets and in direct conversation with the manufacturers. Information may have changed since the publication of this factsheet, therefore check with the manufacturers, suppliers or BASIS-qualified consultant for the most up-to-date information on product availability and use.

Process hygiene management

Good site hygiene control throughout the post-harvest handling process is very important. Each stage in the process should be considered, and a hygiene management plan adopted to maintain good hygiene practices. The following areas should be considered.

- Debris should be promptly removed to reduce the risk of pest and disease contamination of unharvested product
- Harvesting equipment should be routinely disinfected, while containers should ideally be cleaned between each use, ensuring that dirt and plant tissue are removed. A mild chlorine bleach solution or approved horticultural disinfectant that contains a biocide can be used. Clean containers should be stored appropriately to prevent recontamination
- Water used in the post-harvest process should be potable and, ideally, mains in origin. If other water sources are used, they should be analysed regularly to ensure microbial contaminants do not enter the post-harvest process
- A daily routine to sweep away dirt and debris in the cold store should be in place and it is good practice, both pre- and post-season, to fully disinfect the store, walls and floors, with an approved horticultural disinfectant
- A formal programme of vermin control should be in place, set up internally by a trained member of staff or managed by an external pest control contractor. Bait boxes should be sited at key locations and inspected regularly

Automation of post-harvest activities

Most cut flowers and foliage crops produced in the UK are still harvested by hand, although specialist harvesting equipment has been developed for some crops, such as berried foliage.

In order to reduce costs, once stems are harvested, many businesses have some form of post-harvest mechanisation, ranging from simple conveyer belt systems to fully automated bunching machines (Figure 8).

Figure 8. Post-harvest mechanisation of cut flower tulip

However, in recent years, the cost and availability of seasonal labour has led to some businesses investing in sophisticated handling, packing and grading systems. Such systems also need to be carefully managed to maintain product quality.

The level of automation adopted post-harvest is determined by the plant genera/species and volume of stems being processed, the investment capital available and the size of the packing facility.

Mode of action of post-harvest treatments

In order to maximise the vase life of cut flowers, especially to ensure retailer stated time periods, the use of the correct post-harvest treatment is essential. Post-harvest products are generally based on a number of active ingredients in varying concentrations. Active ingredients include:

- Sugars
- Rehydrating agents
- Biocides
- Acidifiers
- Ethylene blockers and plant growth hormones

Product nutrition

Sugars are the primary active ingredient as a source of nutrition to complete flower development, bud opening and maintain flower colour. Biocides, acidifiers and rehydrating agents provide the optimum environment to enable the sugars to give a prolonged effect on cut flower quality and ultimate post-harvest life.

Product rehydration

After cutting, harvested stems still respire and, as a result, lose water through evaporation. Where possible, stems should be placed straight into a post-harvest treatment solution after harvesting. A solution containing a rehydrating product will aid water uptake as it contains a wetting agent. This is especially important with woody-stemmed species, such as hydrangea and a range of hardy cut foliage, including hypericum and snowberry.

A rehydrating agent will help where there has been a loss in stem, leaf and flower turgidity. Stems that have been stored dry should be trimmed before being placed into the rehydrating solution. Bear in mind that some cut flower species are actually best kept dry once harvested, to prevent early opening of the flower buds.

Reducing microbial growth

Biocides are used to slow down and reduce the growth of microorganisms in the post-harvest treatment solutions. Some treatments have a slow-release action to manage the microbial growth over a period of time.

Cut flowers and foliage take up water via the xylem vessels in the stem. If the xylem vessels become blocked, then water uptake is reduced or prevented completely. The vessels can become blocked in a number of ways.

- A build-up of microbial organisms – moulds, yeasts and bacteria will multiply rapidly in the water that the harvested stems are placed into. They also grow on the cut wound surface and on exposed xylem vessels (Figure 9)

- The bioload on the cut stem – each harvested stem will already have its own microorganisms, known as the bioload. Cut flowers that have hairy and/or soft stems, such as column stocks, tend to have higher bioloads
- Physical blockages – when harvested, cut flowers are still respiring and losing water and therefore try to draw water up the stems to replace the lost water. If the stem is not placed into water immediately after harvesting, the stem will draw up air rather than water and this in turn creates an air bubble which blocks the stem
- Poor hygiene management – this can occur as a result of dirty harvesting containers and water

Therefore, poor hygiene, high levels of microbial growth, leaving cut flower stems to dry for extended time periods and high temperatures will all increase the likelihood of stem blockages and should be avoided.

Figure 9. Microbial growth developing on the ends of cut flower stems

Water pH control

Acidifiers, such as citric acid, are included in many post-harvest treatments as they aid both the water uptake process and help to maintain the pH of the solution, therefore helping to prevent the growth of many microorganisms.

Minimising the impact of ethylene and other plant growth hormones

A number of cut flower species, including alstroemeria, delphinium, dianthus and sweet pea are particularly susceptible to damage from ethylene (Figure 10). Ethylene is required by plants to enable buds to develop but, once harvested, too much is detrimental and can result in buds not opening properly, buds shrivelling and extensive flower bud drop. Various ethylene-blocking ingredients act to nullify the effect of ethylene.

Ethylene can originate from both the internal metabolism of the cut stem or from external biological sources, such as ripening fruit. Whenever practical, cut flowers should be kept away from other sources of ethylene while indoors, such as gas-powered forklifts. Ethylene dissipates quickly in well-ventilated areas but can be harmful in enclosed areas.

Figure 10. Petal drop with ethylene-sensitive species

Another issue is flower stem elongation after cutting. This is a particular issue with cut flower tulips, especially bunches of mixed flower colours, where the rate of stem extension varies between flower colours/varieties. Specialist post-harvest treatments, containing plant growth hormones, have been developed to overcome this problem.

Application and disposal of post-harvest treatments

It is important to use any post-harvest treatment at the correct concentration. Underdosing can result in increased microbial growth, stem discolouration, poor bud and flower development, reduced water uptake, increased leaf yellowing and bud and petal drop. Conversely, overdosing can give rise to stem discolouration and leaf damage.

It is always important to ensure that any treatments used are handled in line with the manufacturer's recommendations. All products should be accompanied by a product safety data sheet, compiled and supplied by the post-harvest treatment manufacturer.

Health and safety issues need to be taken into consideration when storing and handling the products being used. It is important that all staff are aware of the potential hazards and that those dosing the products have undertaken formal training to ensure that they are sufficiently qualified to handle the products. Proportional dilutors are the most common and accurate method of applying liquid post-harvest treatments. Other products, in the form of tablets, labels and T-bags are easy to dose, usually one per bucket.

To maintain correct dosage when using a proportional dilutor, it is important to regularly flush the unit through. Some manufacturers supply acidic cleaning solutions specifically for this purpose. In hard-water areas, cleaning may be required more frequently as there is a risk that the dosing unit will contain more sedimentation deposits.

It is important to ensure that the manufacturer's guidelines for disposal are followed correctly. Information will be contained within the product safety data sheet, product label and technical information. If in doubt, contact the manufacturer.

Further information

HACCP-related

Codex Alimentarius –
http://www.fao.org/fao-who-codexalimentarius/en/

Codex Alimentarius – Food Hygiene Basic Texts.
Fifth Edition 2016. ISBN 9251076510

Post-harvest treatment manufacturers

Chrysal UK Ltd
Tel: 0113 307 4050
www.chrysal.co.uk

Floralife and Oasis Grower Solutions
Tel: 07718 106809
www.floralife.com

Florissant (UFO Supplies)
Tel: +31 297 343 603
www.ufosupplies.nl

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