Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online

POST-HARVESTING OF CUT FLOWERS AND ORNAMENTAL PLANTS

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SAP 21261 Received: 07/12/2018 Accepted: 31/05/2019
Sci. Agrar. Parana., Marechal Cândido Rondon, v. 18, n. 4, oct./dec., p. 313-323, 2019

ABSTRACT - The preservation of floral stems aims to prolong durability, maintain quality and reduce losses after harvesting, leading to a longer shelf life and commercialization of these products. In that there is a storage period, especially, of cut plants relatively short between seven and 15 days, this being one of the most important stages of the floricultural sector, ensuring the maintenance of the balance of the distribution market to the final consumer. The high perishability of the floral stems requires specific pre- and postharvest handling contributing positively to its conservation. In cut plants, such as the floral stems, there is an intensification of the physiological processes to maintain its metabolism right after harvest, when the plant leaves the plant and discontinues the supply of water and nutrients, resulting in the acceleration of its senescence. Thus, the understanding of the metabolism of the conservation of the floral stems gives the producer and the consumer products without changes in their aesthetic and qualitative aspect. Thus, the objective of the present study was to carry out a review of the post-harvest literature on cut flowers and ornamental plants, including pre- and post-harvest factors, solutions and preservative components.
Keywords: storage, compounds preservatives, floriculture, conservation solutions.

PÓS-COLHEITA DE HASTES FLORAIS E PLANTAS ORNAMENTAIS CORTADAS

RESUMO - A conservação das hastes florais tem como finalidade prolongar a durabilidade, manter a qualidade e reduzir as perdas após a colheita propiciando um período maior de vida útil e comercialização destes produtos. Em que se tem um período de armazenamento, sobretudo, de plantas cortadas relativamente curto entre sete e 15 dias, sendo este uma das etapas mais importantes do setor florícola, garantindo a manutenção do equilíbrio do mercado distribuidor até o consumidor final. A alta perecibilidade das hastes florais requer manejos específicos de pré e pós-colheita contribuindo positivamente para a sua conservação. Em plantas cortadas, como, as hastes florais há intensificação dos processos fisiológicos para manutenção do seu metabolismo logo na sequência da colheita, momento que ocorre o desligamento da planta-matriz e a interrupção do suprimento de água e nutrientes, resultando na aceleração sua senescência. Assim, o entendimento do metabolismo da conservação das hastes florais propicia ao produtor e ao consumidor produtos sem alterações em seu aspecto estético e qualitativo. Deste modo, o objetivo do presente trabalho foi realizar uma revisão de literatura sobre pós-colheita de flores e plantas ornamentais cortadas, englobando os fatores de pré e pós-colheita, as soluções e componentes conservantes.
Palavras-chave: armazenamento, compostos conservantes, floricultura, soluções de conservação.

INTRODUCTION

The products of the flower-growing sector present high ornamental quality, mainly, in relation to the visual aesthetics quality, that is, products without damages and harm. Nevertheless, the ornamental flowers and plants present high perishability, due to the natural metabolic processes, such as loss of turgidity, yellowing of the leaves, incidence of phytopathogens, among others, when these processes are added implies in the precocious loss of quality and commercial value, when they are not treated post-harvest.

Although the flower-growing sector presents high technification in the productive management, such as substrate, environments of cultivation, propagation, among others, many losses of products occur after the step of harvest in the processing (selection, classification, packaging and others) in the storage, in transportation and in distribution, because of lack of correct applications of the techniques after harvest. These losses are quantified in Brazil between 30 and 50% and, in Europe, this value is in the maximum 25%, because the period between the harvest and the acquisition by the final consumer must be the sooner possible, guaranteeing, thus, to the consumer greater period of use of these products (ALMEIDA et al., 2009; SILVA and SILVA, 2010).

In this context, the post-harvest characterizes itself by a set of management techniques carried out on plants seeking to extend their durability and maintain the commercial quality, and it can be used in several products such as, vegetables, fruits and flower-growing, especially, in cut flowers and foliage. Among these parts of cut plants, as, floral stems, after the separation of mother-plant, the intensification of the metabolic processes begins quickly, due to the rupture of the flow of water and nutrients,

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resulting in the acceleration of their senescence (LOGES et al. 2005; YAMANE, 2015).

Seeking to delay these processes as much as possible throughout the years several components and preservative solutions have been tested in the post-harvest process of ornamental flowers and foliage, in the most different phases of the chain, ranging from the processing of the floral stems in the sequence of harvest, in transport guarantying the turgidity of stems, in the retail commercialization points (floricultures, self-service, among others) for the maintenance of quality and by the final consumer.

The first measure to be taken for the maintenance of quality of cut floral stems is the partial immersion in water or in preservative solution, to maintain the same hydrated in the sequence of harvest, guarantying their longevity. The preservative solutions are known globally and, composed basically by water, sucrose, germicides (DIAS, 2016; LIM et al., 2017; GUPTA and DUBEY, 2018).

Thus, the objective of this work was to carry out a literature review about post-harvest of cut ornamental flowers and plants, encompassing the factors of pre and post-harvest, preservative solutions and components.

DEVELOPMENT

Factors that affect the quality of conservation pre and post-harvest

The factors of pre and post-harvest determine the longevity after harvest, together with the genetic and morphophysiological characteristics of each species, which accordingly to how they are managed, affect the quality of floral stems and foliage. As factors of pre-harvest we have the physiologic maturation stage (point of opening of flowers, florets and buds), climate conditions (light, temperature and relative humidity), turgidity and sanitary quality; and, as post-harvest factors we can quote transport (logistic), hydration and conditioning, storage (temperature and relative humidity) and packaging (LOGES et al., 2005; SILVA et al., 2008; GUPTA and DUBEY, 2018).

The pre-harvest factors for the preservation and durability of floral stems and foliage refer to the ornamental and aesthetic quality, being individualized for each species. The development stage of flowers in harvest influences their durability in vase life. The point of harvest of flowers is, generally, indicated by the point of floral opening, which has to consider also, the formation of petals degree of pigmentation and definite coloration, number of buds or florets, number of leaves, size and diameter of stems, etc.

The point of harvest is the stage in which one flower can be submitted to the preservative solution containing only in water, since that the plant presents good reservation and conditions of adequate temperature (BELLÉ et al., 2004). Some species can be collected precociously, before the total floral opening, for example, arum lily (*Zantedeschia aethiopica* (L.) Spreng.) (CASTRO et al., 2014), consolida ajacis (*Consolida ajacis* Nieuwl.) (FINGER et al., 2004), gladiolus (*Gladiolus* x *hortulanus*) (SILVA et al., 2008), lily (*Lilium longiflorum* Thunb.) (BARBOSA et al., 2006) and rose (*Rosa* x *hybrida*) (CORDEIRO et al., 2011), among others.

The harvest of the flowers/inflorescences anticipated, that is, precocious stage of development with floral opening beginning or still incomplete, depending on the species, presents greater vase life than the species collected next to the stage of total opening. In which these floral stems will have less durability of vase life, due to the respiratory metabolism that accelerates their senescence (TAIZ and ZEIGER, 2009; ALMEIDA and PAIVA, 2012).

The climate conditions of harvest interfere, directly, in the turgidity of floral stems. Because of that, we recommend the harvest in mild temperature and time, such as the beginning of the morning or the end of the afternoon, for that the transport until the processing be fast, avoiding the floral stems to be exposed for a long period to the excessive hot after the cut causing their dehydration (LOGES et al., 2005; REID and JIANG, 2012).

The stage of processing of floral stems guarantees their quality due to the selection procedure, of classification (in relation to the size and diameter of floral stems; number of leaves, buds, florets and leaves; mechanical damage and by phytopathogens, etc), cleaning, hydration, packaging, among others. All this process must result in commercial lots of floral stems with a minimum of 95% of uniformity of their qualitative and quantitative aspects, being different for each species, obeying the recommendation of the standard and criteria of quality of commercialization established by IBRAFLOR and by the Veiling Holambra Cooperative for Brazil, based on the international standards of commercialization of ornamental flowers and plants.

The post-harvest factors that affect the preservation of floral stems and foliage are in the management related to the form of transport between the field/greenhouse for the processing and, as these products will be distributed until the florists or final consumer. In this last one the efficiency in the logistic guarantees a prolongation of vase life for the consumer, because the average of durability of cut flowers and foliage can reach 21 days when correctly managed. This period is equivalent since the harvest until the disposal of the products by the final consumer (Figure 1) (ANEFALOS and CAIXETA FILHO, 2005; GUPTA and DUBEY, 2018).

The conditioning and hydration of floral stems occur with the use of preservative solutions, which seek to extend and maintain the quality of cut flowers, delaying their senescence, and can be used in all the distribution chain, from the producer to the final consumer. Due to the variation among the species, the control of senescence requires the optimization of hydric relations, reduction of abscission or withering of petals and flowers, the growth control of micro-organisms and, in many cases, the provision of respiratory substrate (NOWAK et al., 1991; FINGER et al., 2004).

Thus, the preservative solutions must be simple and of easy manipulation, in which their components allow hydration to the floral stems by means of water, substrate for the supplementation of the natural sugars, which are quickly used after the cut by respiration; and asepsis for the maintenance of water quality, delaying the microbial infections in the conducting veins, guaranteeing the phytosanitary quality (VAN DOOR, 2001; ALMEIDA et al., 2007).

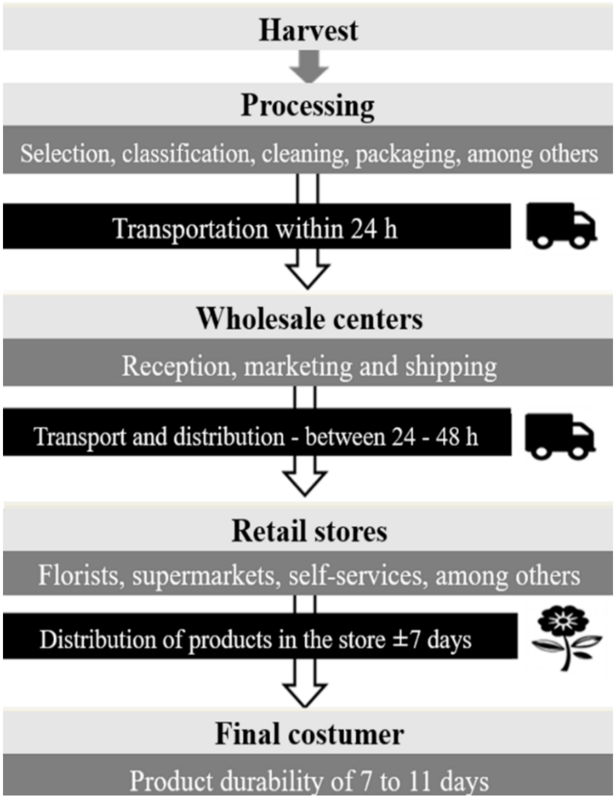

FIGURE 1 - Flowchart of the logistics between the harvest to the final consumer of the flower stems. Source: MENEGAES, J. F. (2019).

Together to the management of preservative solutions, the low temperatures seek to mitigate the respiration, reducing the production of ethylene and consequently, the delay of degradation of the reservation of sugars or other substrates, prolonging the durability of flowers and foliage in environments of conservation (ALMEIDA et al., 2009; VIEIRA and SOUZA, 2009). Generally, we use the cooling by 24h after the harvest with the finality of reducing the metabolic activity, being recommended between 5 to 7ºC in cold chamber for the management in the property or research, between 7 to 10ºC in cold chamber for the storage before the transportation and, between 7 to 15ºC in cold chamber for flowers of temperate climate and between 15 to 20ºC in cold chamber for flowers of tropical climate both for the points of retail sales (NOWAK et al., 1991; SONEGO and BRACKMANN, 1995; LOGES et al., 2005; ALMEIDA and PAIVA, 2012).

Finally, the packaging also ensure the quality of floral stems in post-harvest. The material used for packaging must be firm and rigid, in a way to accommodate the stems, pack of inflorescence or bouquet without damaging them and without letting them loose inside the boxes of rigid cardboard box for export and/or in plastic boxes for the terrestrial distribution in national level (LOGES et al. 2005). In Brazil, the number of stems and weight by box depends on the species, generally, it is used the ones recommended by IBRAFLOR and by the Veiling Holambra Cooperative

However, we can conclude that there are many factors that affect positive or negatively the quality of conservation of floral stems and other parts of plants, because of that, a set of management techniques is advisable to minimize the losses in post-harvest guaranteeing as much as possible the quality of these products.

Post-harvest life durability

The post-harvest life duration of floral stems and foliage varies from species to species (Table 1), according to the conditions in which they are exposed following the harvest and how they are stored, by the pre and post-harvest factors, as well as the genetic and anatomical characteristics of each species and among cultivars. For example, the tropical flowers have greater period of durability between 15 to 60 days, according to the treatment of conservation to be submitted; yet, species of temperate climate have maximum durability of 21 days (NOWAK and RUDNICKI, 1990; DIAS-

TAGLIACOZZO et al., 2006; DIAS-TAGLIACOZZO et al., 2006).

Conditions of storage

The atmosphere during the storage has as finality to maintain as much as possible the quality of floral stems and foliage, thus it is necessary the refrigerated storage. With the purpose of reducing metabolic processes, mainly the respiratory rates (enzyme degradation), ethylene production (senescence delay) and transpiration (water loss), besides inhibiting the microbial growth (DIAS-TAGLIACOZZO et al., 2006). The packaging can be by humid or dry via, being this last one, generally, used for transport for long periods (DIAS-TAGLIACOZZO; MOSCA, 2007; DIAS et al., 2016).

TABLE 1 - Pot life of the main floral stems and foliage sold in the country.

Stems	Ornamental species	Vase life (days)	Authors
Floral stems	Alstroemeria (*Alstroemeria aurantiaca* L.)	10 - 17	MATAK et al., 2017
	Antrurium (*Anthurium andraeanum* Lind.)	21 - 48	NOMURA et al., 2014
	Arum lily (*Zantedeschia aethiopica* (L.) Spreng.)	7 - 9	CASTRO et al., 2014
	Chrysanthemums (*Dendranthema grandiflora* Tzevelv)	9 - 17	SILVA and SILVA, 2010; SPRICIGO et al., 2010
	Gerbera (*Gerbera jamesonii* Adlam)	9 - 12	DURIGAN et al., 2013; SCHMITT et al., 2014
	Gladiolus (*Gladiolus* x *hortulanus*)	6 and 10	SILVA et al., 2008
	Lily (*Lilium pumilum* DC.)	6 and 10	SANTOS et al., 2018
	Rose (*Rosa* x *hybrida*)	7 and 14	DIAS et al., 2016; LIM et al., 2017
Floral stems as a complement	Aster (*Symphyotrichum tradecantii* (L.) G.L.Nesom)	10 - 15	ZAGO et al., 2015
	Gipsofila (*Gypsophila paniculata* L.)		
	Solidaster (*Solidago canadenses* L.)	5 - 6	PERINA et al., 2016
Leafy stems	Asclepia (*Asclepias curassavica* L.)	10 - 21	ZAGO et al., 2019
	Aspargus (*Asparagus densiflorus* Sprengeri)		
	Dietes (*Dietes* spp.)		
	Pitosporum *(Pittosporum tobira* Thunb.*)*		
	Butcher's broom (*Ruscus aculeatu* L.)		
	Boston fern (*Nephrolepis exaltata* (L.) Schott.)		

In humid storage the floral stems and foliage are packaged in preservative solutions with relative humidity of air is recommended between 60 to 65%, yet for the storage in dry atmosphere, the relative humidity of air must be around 90-92%, because the floral stems and foliage do not enter in contact with the aqueous means (NOVAK et al., 1991; GUPTA and DUBEY, 2018). Nevertheless, in environments of storage of high humidity the proliferation of fungal and bacterial diseases in floral stems and foliage are common. And, in environments of low humidity can occur the precocious darkening of the leaf edge and the rolling of thin leaves by dryness of the tissues (NOWAK and RUDNICKI, 1990; DIAS-TAGLIACOZZO et al., 2006).

Gupta and Dubey (2018) point average temperature for humid storage around 4ºC and for dry storage between 0 to 2ºC for the species of carnation (*Dianthus* spp.), chrysanthemums (*Dendranthema* spp.) and rose (*Rosa* spp.). However, there are species that can be packaged with temperature equal to both forms of storage, for example, the floral stems of gladiolus (*Gladiolus* spp.) with temperature of 4ºC, for both forms. The tropical species, by virtue of the sensibility of these species to the cold, the temperature of storage must be above 14ºC and the relative humidity of 90 to 95%, for example, for the species of alpinia (*Alpinia* spp.), anthurium (*Anthurium* spp.), strelitzia (*Strelitzia* spp.) and heliconia (*Heliconia* spp.) (NOWAK and RUDNICKI, 1990; LAMAS, 2002).

The luminosity is essential for the photosynthetic processes that generate accumulation of carbohydrates which will be used for the maintenance of floral stems life and foliage during all the post-harvest process. Generally, a 12-hour photoperiod of light is used, because the total darkness can cause discoloration in the petals, intensifying the floral senescence, which is typical occurrence for the floral stems of cut roses and gerberas (*Gerbera* spp.) (DIAS-TAGLIACOZZO et al., 2006; GUPTA and DUBEY, 2018; LIM et al., 2017).

Preservative solutions

The preservative solutions aim to provide to the cut floral stems, and can be considered as hydrating substrate (water), energetic (sucrose) and phytosanitary (fungicide and bactericide). There is also the use of other ingredients for the formulation of solutions, for example, mineral ions, ethylene inhibitors, growth regulators, antioxidants, among others. Its composition must provide energy to the floral stems, preventing the microbial development or the ethylene synthesis (SILVA and SILVA, 2010; REID and JIANG, 2012; NOMURA et al., 2014). However, the ingredients used in preservative solutions can be beneficial for some species or not for others. For example, Schimitt et al. (2014) verified that the use of floral commercial preservative did not benefit the longevity of floral stems of cut gerberas (*Gerbera jamesonii* Adlam) in post-harvest.

The deterioration of flowers and foliage begins in the sequence of harvest by virtue of intensification of natural metabolic processes of the plant, which imply in the loss of quality and commercial value. This way, the post-harvest of flowers and foliage aims to prolong the durability, maintain the quality and reduce the losses, especially, of inflorescences, after harvest, providing a greater period of useful life and commercialization of these products, and techniques and managements for the durability, the quality and commercial value.

The preservative solutions must be used since the processing of floral stems in the sequence of the harvest in the transport, guaranteeing the turgidity of stems in the retail commercialization points (floricultures, self-service, among others), for the maintenance of quality, and by the final consumer, avoiding the senescence symptoms of floral stems precociously, for example, with the withering, yellowing and rolling of leaves, fading of petals, abscission of flowers or buds, darkening and curvature of inflorescence, among others.

Normally, it is used four types of preservative solutions routinely in the post-harvest process, distinct in relation to the finality of using and classified as: a) strengthening or pulsing, b) conditioning, c) maintenance and d) floral induction (HALEVY; MAYAK, 1981).

a) Strengthening solution or pulsing: used for hydration and nutrition of tissues in the sequence of harvest. This procedure is considered a fast treatment before the transportation or storage of floral stems or of cut foliage, prolonging the vase life of the same. The basis of stems can remain in this solution for some minutes or until 24h. The composition of solution can be only clean and fresh water and/or added sucrose, products of sanitary control, among others. The immediate reposition of carbohydrates provides to the floral stems and foliage the reduction in transpiration, the osmotic regulation of tissues and the stomachic closing (HALEVY and MAYAK, 1981; NOWAK et al., 1991; ALMEIDA et al., 2011).

In the pulsing solution, the basis of sucrose has been demonstrating positive results in post-harvest conservation for the species torch ginger (*Etlingera elatior* (Jack) R. M. Sm.) (CARNEIRO et al., 2014), arum lily (*Zantedeschia aethiopica* (L.) Spreng) (ALMEIDA et al., 2011), carnation (*Dianthus caryophyllus* L.) (ADUGNA et al., 2012), statice (*Limonium sinuatum* L.) (CIOTTA e NUNES, 2011), lily (*Lilium longiflorum* Thunb.) (BARBOSA et al., 2006), oncidium (*Oncidium baueri* Lindley) (FAVETTA et al., 2016) and rose (*Rosa* x *hybrida*) (YAGIA et al., 2014). Nevertheless, the concentration of ingredients and the time of exposition of floral stems varies for each species.

b) Conditioning solution: used for restoration of turgidity right after the harvest, in transportation and in storage, with use of water plus bactericide and sucrose in low concentrations. Many cut flowers present precocious dehydration immediately after the harvest, being necessary the instantaneous hydration of these flowers, conditioning solutions act positively in these situations (ALMEIDA et al., 2009; NOMURA et al., 2014).

In the conditioning solution the basis of sucrose and germicide has demonstrated positive results in conservation in post-harvest for the alpinia (*Alpinia purpurata* Vieill. Schum.) (DIAS-TAGLIACOZZO et al., 2003), anthurium (*Anthurium andraeanum* André) (NOMURA et al., 2014), consolida ajacis (*Consolida ajacis* Nieuwl.) (FINGER et al., 2004) and lily (*Lilium longiflorum* Thunb.) (DIAS-TAGLIACOZZO et al., 2005). However, the concentration of ingredients and time of exposure of floral stems vary for each species.

Henschke et al. (2016) working with ornamental grasses in post-harvest verified positive effect of solution of conditioning in the basis of gibberellin and 8-HQS for the species *Alopecurus pratensis* L. ‘ureovariegatus’, *Chasmanthium latifolium* Michx., *Glyceria maxima* Hartm. ‘variegata’, *Miscanthus sinensis* Thunb. ‘Silberspinne’, *Miscanthus sinensis* Thunb. ‘Zebrinus’, *Pennisetum alopecuroides* L., *Phalaris arundinacea* L. ‘Picta’ and *Spartina pectinata* Link. ‘Aureomarginata’.

c) Maintenance solution: used for long periods, usually, in commercialization points. The maintenance solutions, also known as vase solutions, can have substances used isolated or in conjunction and that contribute for the maintenance of the quality of cut floral stems. There is a great diversity of ingredients available for the formulation of the preservative solutions, such as sucrose, germicides, ethylene inhibitors, organic acids, antioxidants, plant regulators and essential oils (NOWAK et al., 1991; DURIGAN et al., 2013; BASTOS et al., 2016).

The maintenance solution composed by the most diverse ingredients (sucrose, citric acid, hypochlorite of sodium, 8-hydroxyquinoline, 1-methylcyclopropene, among others) has demonstrated positive results in conservation in post-harvest for the species of alpinia (*Alpinia purpurata* (Vieill) K. Schum) (MATTIUZ et al., 2005), gerbera (*Gerbera jamesonii* Adlam) (DURIGAN et al., 2013), heliconia (*Heliconia* x *rauliana*) (RIBEIRO et al., 2010), rose (*Rosa* x *hybrida*) (BASTOS et al., 2016), beehive ginger (*Zingiber spectabile* Griff.) (MOSCA et al., 2009) and Canadian goldenrod (*Sodidalgo canadensis* L.) (FONSECA et al., 2017; PERINA et al., 2016). Nevertheless, the concentration of the ingredients and the exposure time of floral stems vary for each species.

d) Solution of floral induction: used with the objective of opening of inflorescences when these ones are collected in advance, still in immature buds for commercialization and sending to long distances. This solution is similar to pulsing solution, however, the concentration of the ingredients is lower and the period of exposure is greater, because the floral stems remain in solution by several days, preferable in places with control of relative humidity of air and average temperature of 20º C (HALEVY and MAYAK, 1981; SONEGO and BRACKMANN, 1995).

The floral induction solution in basis of sucrose has demonstrated positive results in conservation in post-harvest for the species arum lily (*Zantedeschia aethiopica* (L.) Spreng) (SANCHES et al., 2017), lily (*Lilium longiflorum* Thunb.) (HAN, 2003), rose (*Rosa* x *hybrida*) (CORDEIRO et al., 2011) and beehive ginger (*Zingiber spectabile* Griff.) (COELHO et al., 2012). Nevertheless, the concentration of ingredient and exposure time of floral stems vary for each species.

Preservative compounds

The treatments of formulation of preservative solutions vary between the species and finality of use, concentrations and combinations among different products. The most used ingredients are: a) sucrose, b) germicides [b1) hypochlorite of sodium, b2) 8-hydroxyquinoline and b3) citric acid], c) ethylene inhibitors [c1) silver ions (silver nitrate and silver thiosulphate), c2) 1-methylcyclopropene (1-MCP), d) plant regulators [d1) cytokinin d2) gibberellins], e) essential oils and f) methanol and ethanol, among others (DURIGAN et al., 2013; BASTOS et al., 2016). There are also commercial preservatives, such as Crystal Clear®, Original Floralife®, Flower®, Floralife®, Florissant®, Roselife®, among others.

a) Sucrose: the energetic substrate most used; its concentration varies from 0.5 to 20%, generally from 0.5 to 2.0 for maintenance solutions and 2.0 to 20% for pulsing solutions. Nevertheless, in some cases, the sucrose can cause adverse effect to the one desired, that is, each species tolerates a concentration of sucrose (HALEVY and MAYAK, 1981; HASTENREITE et al., 2006).

As energy source, the exogenous sucrose restores again the carbohydrates depleted in the respiratory process, and, also, acts in the degradation delay of proteins, lipids and ribonucleic acids. Thus, maintaining the integrity of the membrane, improving the hydric balance and regulating the stomata closing, reducing the transpiration and, consequently, delaying the production and action of ethylene (NOWAK et al., 1991; SONEGO and BRACKMANN, 1995).

The flowers, generally, have high respiration rates through the glycolysis and the Krebs cycle, based on the translocation of sugar of leaves. The vegetable tissue requires sucrose or a source of carbohydrates to continue its vital functions, especially, the respiration and extending the longevity of post-harvest of floral stems, mainly, in conservation (MONTEIRO et al., 2002; TAIZ and ZEIGER, 2009).

Brackmann et al. (1998) verified that the floral stems of zinnia (*Zinnia elegans* Jacq.) submitted to conditioning solutions for 3 h with 1% of sucrose prolonged the longevity and decreased the percentage of flowers with dark spots in sepals and in leaves. Ribeiro et al. (2010) conferred that the inflorescences of heliconia (*Heliconia* x *rauliana* Barreiros) submitted in maintenance solution of sucrose at 20% presented greater lifespan in post-harvest in relation to the treatment without sucrose.

Silva and Silva (2010) verified that the maintenance solution with sucrose at 10% kept the lifespan of floral stems of chrysanthemums (*Dendranthema grandiflora* Tzevelv) Calabria cultivar for 17 days in post-harvest, providing lower percentage of flowers with dark spots and lower danger to the sepals and leaves in comparison to the treatment with sucrose at 15%. Spricigo et al. (2010) observed that the use of sucrose in maintenance solutions of floral stems of chrysanthemums, Dragon variety, prolonged the durability of stems in relation to the other treatments.

However, Hastenreite et al. (2006) did not determine positive effect in durability of floral stems of oncidium (*Oncidium varicosum*) treated in post-harvest with sucrose between the concentrations between zero to 15% with pulsing of 24 h. Ciotta and Nunes (2012), did not verify either positive effect in durability of stems of photinia (*Photinia* x *fraseri*) for the concentrations of 0, 5, 10, 15 and 20% of sucrose, with pulsing of 24 h.

b) Germicides: ingredients used as phytosanitary substrate for the preservative solutions, with the objective of keeping the water of the solution clean and inhibit the proliferation of microorganisms in solution, in recipient and, mainly, in the surface of floral stems, thus, promoting the sanity and durability of vase life of these flowers (NOWAK et al., 1991; DIAS, 2016). The germicides most used are:

b1) Hypochlorite of sodium: one of the germicides very used, generally, in concentrations from 1 to 5%. With bactericide action, it acts purifying the water and inhibiting bacterial infections in the conducting vessels that prevent the water absorption. Nowak and Rudnicki (1990) recommended the use of hypochlorite of sodium to conservation of rose (*Rosa* x *hybrida*) with positive results in durability in post-harvest. Almeida et al. (2009) did not verify benefit in conservation of roses cultivars Grand Gala, Tineke, Osiana and Texas, with use of hypochlorite of sodium at 0.2% in maintenance solution. Almeida et al. (2007) did not determine response to the use of hypochlorite of sodium in maintenance solution of arum lily (*Zantedeschia aethiopica* (L.) Spreng). Coelho et al. (2012) did not verify either beneficial effect for the stems of beehive ginger (*Zingiber spectabile* Griff.) in maintenance solution with hypochlorite of sodium at 5%.

b2) 8- hydroxyquinoline (8-HQ): acts as bactericide and fungicide, besides reducing the vascular block of stems helping in hydric balance, being usual in two forms of citrate and sulfate of 8- hydroxyquinoline (8-HQC and 8-HQS). However, we should be careful in the manipulation of these products, because Faragher et al. (2002) reported harmful effect of this product to human health, in virtue of presenting mutagenic characteristics.

Spricigo et al. (2010) observed that the floral stems of chrysanthemums (*Dendranthema grandiflora* Tzevelv), Dragon variety, in maintenance solutions composed by 8-HQC at 200 mg L^{-1} + sucrose at 50 g L^{-1}, favored the opening of buds and the turgidity of ligules, prolonging the quality of floral stems. Bellé et al. (2004) verified that the use of 8-HQ in dose of 100 mg L^{-1} + 2% of sucrose provided positive effect in vase life of chrysanthemums (*Dendranthema grandiflora* Tzevelv), Bronze Repin cultivar in pulsing solution, after storage at 2ºC.

b3) Citric acid: used as bactericide, but, also works as antioxidant, preventing the damage caused by the oxygen entry in the vascular system, helps in pH reduction of water. Generally, it is associated to sucrose, cytokinin, gibberellic acid, among others, in pulsing solutions. Dias-Tagliacozzo et al. (2005) verified positive effect of floral stems quality of lily (*Lilium longiflorum* Thunb.) in conditioning solution containing 4% of sucrose + 200 mg L^{-1} of citric acid for 24 h. Dias-Tagliacozzo and Castro (2002) observed positive effect of citric acid in pulsing solution for chrysanthemums (*Dendranthema grandiflora* Tzevelv), carnation (*Dianthus caryophyllus Linn*), gladiolus (*Gladiolus* x *hortulanus*) and rose (*Rosa* x *hybrida*), in concentration between 200 and 300 mg L^{-1}.

c) Ethylene inhibitors: the ethylene is a plant hormone associated to natural senescence of flowers. In search of prolonging the life in post-harvest of floral stems, between the treatments the inhibition of ethylene action becomes necessary (FINGER et al., 2004; TAIZ and ZEIGER; 2009).

Woltering and Van Door (1988) listed three forms of response of floral stems to ethylene: the flowers with precocious dryness and withering, such as orchids (Orchidaceae) and petunia (*Petunia* x hybrida); the flowers with abscission of petals without visible sign of withered, as in roses (*Rosa* x *hybrida*) and geraniums (*Pelargonium* x *hortorum*); and flowers insensitive to ethylene, such as iris (*Iris* spp.) and lilies (*Lilium* spp.). The ethylene inhibitors most used are:

c1) Silver ions: silver nitrate and silver thiosulphate. They present, besides the germicide action, inhibitor action of ethylene biosynthesis, because compete by the same active binding site of ethylene. In this case, the silver ions benefit the longevity of floral stems, being the formulations most used the silver nitrate ($AgNO_3$) and silver thiosulphate (STS). However, these ions can provoke phytotoxicity of flowers, according to their dosage, motive why in some countries the use of silver for the post-harvest process is prohibited (SONEGO and BRACKMANN, 1995; MATTIUZ et al., 2005).

Santos et al. (2008) verified that the treatment with $AgNO_3$ in stems of beehive ginger (*Zingiber spectabile* Griff.) was the most efficient in maintenance of vase life, however, the same authors, indicated the disposal of this component due to its toxicity. Bellé et al. (2004) verified that the use of silver thiosulphate in the dose of 11 mg L^{-1} provided positive effect in the vase life of chrysanthemums (*Dendranthema grandiflora* Tzevelv), Bronze Repin cultivar, in pulsing solution after the storage at 2ºC.

c2) 1-methylcyclopropene (1-MCP) is a derivative of cyclopropene used as a regulator of synthetic plant growth. It is a volatile and non-toxic gas, being used for inhibiting the ethylene biosynthesis. Commercially, the 1-MCP reduce the cracks in fruits and helps in maintenance of floral stems freshness. The application of 1-MCP on the floral stems of consolida ajacis (*Consolida ajacis* Nieuwl.) (SANTOS et al., 2005), geranium (*Pelargonium* x *hortorum*) (JONES et al., 2001) and ornamental peppers (*Capsicum annuum* L.) (FINGER et al., 2015), was efficient, avoiding the deleterious effects of ethylene, with the delay of senescence and extending the longevity of the same in post-harvest.

d) Plant regulators: plant hormones involved in the growth and development of plants, the main ones are: auxins, gibberellins, cytokinins, ethylene and abscisic acid. Some of these applied exogenously in preservative solutions seek to prolong the floral stems of post-harvest, generally, are applied individually or associated with other substances. The application of cytokinins and/or gibberellins interferes in the senescence of leaves and flowers, delaying the chlorosis and depletion of reverse due to the respiration process (NOWAK and RUDNICKI, 1990; BRACKMANN et al., 2005; TAIZ and ZEIGER, 2009; GUPTA and DUBEY, 2018). The plant regulators most used are:

d1) Cytokinins: directly linked to the factors of cellular division and delay of senescence, associated to the reduction of loss rate of proteins and RNA. The application of cytokinins inhibits partially the senescence process, delaying the expression of determined genes involved in the process. Favero et al. (2015) verified that with the aspersion of cytokinins [6-benzylaminopurine (6-BAP)] in floral stems of anthurium (*Anthurium andraeanum* André), Apalai cultivar, in conditioning solution, there was average gain of 4.1 days in vase life maintaining the freshness of stems. Dias-Tagliacozzo et al. (2003) verified positive effect of the cytokinin use (6-BAP) on the floral stems of alpinia (*Alpinia purpurata* Vieill. Schum.).

d2) Gibberellins: used in the form of gibberellic acid (GA_3) in preservative solutions, especially, of pulsing. This regulator contributes to delay the yellowing of leaves in cut floral stems, inhibiting the degradation of chlorophyll. Dias-Tagliacozzo et al. (2005) verified that the addition of 50 mg L^{-1} of gibberellin in conditioning solution for floral stems of lily (*Lilium longiflorum* Thunb.) delayed the leaf yellowing. Brackmann et al. (2005) verified that the application of gibberellin in preservative solution in post-harvest accelerated the senescence of flowers and leaves of chrysanthemums (*Dendranthema grandiflora* Tzevelv) Bronze, Recital and Repim Flippo cultivars. Favero et al. (2017) observed that the formulation containing gibberellin and benzyladenine had a positive effect in maintenance of fresh biomass of turmeric stems (*Curcuma alismatifolia* Gagnep.).

e) Essential oils: natural and volatile compounds, limpid, rarely, colored, characterized by strong odor and produced as secondary metabolites by aromatic plants, and can be extracted from all the organs of the plant. With germicide, fungicide and insecticide action, it can be used in preservative solutions, because they are natural compounds that do not affect the environment (BAKKALI et al., 2008; YAMANE, 2015).

Manfredini et al. (2017) working with essential oils in post-harvest of roses (*Rosa* x *hybrida*) Avalanche cultivar, tested several oils, as eucalyptus (*Eucalyptus citriodora* (Hook.) L. H. Bailey), cinnamon (*Cinnamomum zeylanicum* J. Presl), lemongrass (*Cymbopogon citratus* (DC) Stapf.) and peppermint (*Mentha* x *piperita*) all of them with concentration of 1% and, clove (*Syzygium aromaticum* (L.) Merrill & Perry.), with concentration of 0.1%, pulverized on the floral stems, besides the control with distilled water. With this study, they verified that the post-harvest with essential oil of peppermint and eucalyptus at 1% enable greater durability and quality of roses, in relation to the other treatments. Bastos et al. (2016) working with essential oils of rosemary (*Rosmarinus officinalis* L.) in dose of 100 $\mu L\ L^{-1}$ and ginger (*Zingiber officinale* L.), in concentration of 100 $\mu L\ L^{-1}$, in post-harvest of rose (*Rosa* x *hybrida*) Carola cultivar, verified satisfactory results in maintenance of floral stems quality in relation to the other treatments, with sucrose at 2% and hypochlorite of sodium at 5%.

f) Ethanol and methanol: alcohols that aim at promoting the reduction of cellular respiration senescence of flowers, with beneficial effects on the control of rot fungi, promoting a situation of asepsis in the post-harvest system (KAUR and MUKHERJEE, 2013). The same authors verified durability of post-harvest in cut stems of marigold (*Calendula officinalis* L.) with use of ethanol and methanol at 2%, with gain of 4 days in relation to the control treatment.

CONCLUSIONS

The post-harvest treatments, generally, are a mix of traditional treatments and already consolidated, as the use of preservative solutions composed by sucrose and hypochlorite of sodium, by the ease of manipulation and acquisition of these ingredients. We can observe on the scientific literature about this theme that the technique post-harvest is being enhanced in relation to the use of traditional ingredients with the commercial formulations, with specificities for each species of agro-economical interest.

According to the abovementioned there are a lot of chemical products and preservative solutions that can be applied, individual or in conjunction, aiming at the maintenance of post-harvest of floral stems seeking to prolong their vase life and commercial value.

Concluding, it is clear the importance of post-harvest techniques, which is still deficient in some aspects, as form of use and applicability of products. Thus, making it easy to the producer, distributor, florist and even to the final consumer, the continuous use of solutions elaborated for each situation seeking the maintenance of floral quality of flowers and ornamental plants.

ACKNOLEDGEMENTS

To Coordination for the Improvement of Higher Education Personnel (CAPES) by the incentive and financing of this work and to Postgraduate Program in Agronomy from Federal.

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