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Review

Effect of refrigeration on post-harvest flowers

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Cut flowers have a very limited life after they have been cut off from the mother plant, as survival on their own reserves is generally low due to the special morphological and physiological characteristics of their tissues. The use of refrigeration for storage of flower cuttings is very important because it reduces water loss, senescence, infections caused by bacteria and fungi, thus extending the shelf-life of flowers during the storage period. Therefore, the aim of the present work is to show differences between requirements of various species of flowers during refrigerated storage.

Key words: Cooling, post-harvest, conservation, flowers, cold injury.

INTRODUCTION

When harvested, cut flowers have a temperature of 5°C higher than the field ambient temperature. The correct procedure would be to remove as soon as possible that temperature. One of the techniques used for the removal of the "field heat" is to subject the flowers to the cooling process, also known as "pre-cooling", widely used for fruit and vegetables (Pellegrini and Belle, 2008).

There are two types of cooling: wet, in which the rods are stored with their basal portion and dry, in which cut flowers with early distension and that are quickly handled are placed in boxes in coldroom (Rudnicki et al., 1991; Castro and Honorius, 1992; Mapeli, 2009). In the literature we found only the work on storage of dry floral scape like *Strelitzia reginae* (Moraes et al., 1999; Jaroenkit and Paull, 2003; Finger et al., 2003).

COOLING

The most important effect of cooling is related to the immediate decrease of the whole metabolism of the flower which favors the extension of shelf life, maintaining its quality and reducing expenditures in the subsequent cold storage (Pellegrini and Belle, 2008).

The use of low temperature during storage is important for the conservation of the flowers, because in addition to inhibiting bacterial and fungal infections, it reduces degradation of certain enzymes and ethylene production; it reduces sweating, breathing and slows the various processes related to growth and senescence (Nowak and Rudnick, 1990; Ashrae, 1994; Sanino, 2004). Among the tested temperatures for chrysanthemum Ono ', 1.5°C best preserved flowers (Vieira and Brigida, 2009). While Vieira and Lima (2009) found that there was no increase in longevity of chrysanthemum Faroe when stored at 10°C for 48 h. Belle et al. (2004) ascertained that storage at low temperatures delayed the onset of symptoms of senescence in *Dendranthema grandiflora* subjected to 2°C. Kelley et al. (2003), working with edible flowers, found that *Viola tricolor* L. cv. Mount Helen, *Viola* x *wittrockiana* L. cv. Accord Clear Mixture and *Tropaeolum majus* L. cv. Jewel Mix can be stored at 0 and 2.5°C for two weeks with perfect visual quality. For this same period, flowers of *Borago offcinalis* L. can be stored at -2.5°C with acceptable quality. Delaporte et al. (2000) found that regardless of time of storage at 3°C (0.7 or

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14 days), the vase life of *Eucalyptus* sp. was 11 days. The optimal range of 0.5°C as its longevity was inversely proportional to the storage time and temperature (Waithaka et al., 2001). Flowers of *Narcissus tazetta* L. cv. White Paper and *Narcissus pseudonarcissus* L. cv. Potted Geranium had twice the post-production longevity when stored at 0°C compared to flowers held at 12.5°C (Cevallos and Reid, 2000), indicating an inverse correlation between respiratory rate and the vase life of these flowers. Storing flowers of *Leucocoryne coquimbensis* at 2°C for 3 to 7 days, Elgar et al. (2003) reported that the longevity was 8 to 9 days, but when kept at 12 or 20°C for 3 days showed longevity of only 5 to 7 days. In *Gerbera jamesonii* cv. Vesuvio and *Helianthus annuus* L., Celikel and Reid (2002) noted that it is possible to store them at temperatures near freezing. However, temperatures below the minimum safety can cause disorders in some species, which makes the plant very susceptible to damage caused by cold (Couey, 1982; Reid, 1991; Jaroenkit and Paull, 2003; Lucangeli et al., 2004).

Some terms are used to express the results of the symptoms caused by cold, such as chilling injury, injuries due to low temperatures and disorders (Morris, 1982; Chitarra and Chitarra, 2005). Chilling injury is a physiological disorder that appears in culture of tropical and subtropical origin (Skog, 1998), resulting in reduction in quality. It is caused by exposure to low temperatures (Parkin et al., 1989; Lucangeli et al. 2004).

Chilling injury differs from that injury caused by freezing damage, which is the result of crystal ice formed gradually in tissues stored at temperatures below the freezing point (Skog, 1998), depending on the cultivar and growing conditions (Chitarra and Chitarra, 2005).

Detecting and diagnosing chilling injury is often difficult, because the products often have no visible damage immediately after being removed from low temperature. The symptoms may occur when the product is transferred from the condition of low temperature to room temperature, which may occur in a few hours or days after removing (Skog, 1998). Symptoms of injury include, among others, discoloration of flowers, petals and necrotic lesions on leaves, delayed development of buttons (Nowak and Rudnicki, 1990; Joyce et al., 2001) and dehydration (Dias-Tagliacozzo and Castro, 2005).

Many species of tropical origin are injured when exposed to cold temperatures between 0 to 12°C (Nowak and Rudnicki, 1990, Reid, 1991; Brackmann et al., 2000). Cut flowers, for example, rods *Anthurium* can be stored in minimum temperature exceeding 13°C (Paull, 1987; Lamas, 2004). This fact has been ascertained by Reid and Dodge (2001), who reported that storage below 10°C induced discoloration and necrosis of the spathe and spadix. In *Heliconia*, storage temperature greater than 10°C is recommended (Broschat and Donselman, 1983; Jaroenkit and Paull, 2003). Cavalcante et al. (2005) observed that stems of *Heliconia chartaceae* "Sexy Scarlet ", when stored at 15°C showed no chilling injury. In other tropical species, Dias Tagliacozzo and Castro (2005) found that stems of *Zingiber spectabilis* when stored at 10, 13 and 18°C showed the best result at 18°C. In the Emperor stick the temperature below 10°C induced the appearance of chilling injuries, characterized by shallow depressions and increased incidence of diseases (Leitão, 2001). Dias and Castro (2002) recommend Alpinia, after packaging the temperature between 12 to 18°C.

In addition to tropical flowers, the sensitivity of the panicles temperature during storage has been demonstrated in some studies. Joyce and Shorter (2000) found that the temperature range of security for the storage of *Anigozanthos* spp., cvs. H1 and Bush Dawn is between 2 and 5°C, for when kept at 0°C showed chilling injury, whose symptoms were wilting and discoloration of the petals. It also reduced the pot life of the flowers of *Campanula medium*, stored at 2°C, by increasing the storage time from one to three weeks (Bosma and Dole, 2002). In *Curcuma alismatifolia* (turmeric, siam tulip or tulip), Bunya-Atichart et al. (2004) observed dryness and discoloration of the bracts of pink to dark purple, yellow green bracts, deformation of buttons and flowers, and lack of openness of buttons to 7.5°C. Flowers of *Phaseolus coccineus* L. cv. Dwarf Bees do not exhibit satisfactory quality for two weeks storage in any of the temperatures studied (-2.5, 0, 2.5, 5, 10 and 20°C), showing necrosis, mold and tissue breakdown (Kelly et al., 2003). Moraes (2003) reported a reduction in the lifetime of *Epidendrum ibaguense* rods stored at 10°C as the storage time was increased (seven, fourteen and twenty one days).

In the case of tropical plants, Jaroenkit and Paull (2003) state that in Bird of Paradise (*Strelitzia reginae* Banks ex Aiton) flowers, the critical temperature for the development of chilling injury is 10 to 13°C. Finger et al. (2003) observed symptoms of chilling injury in *Strelitzia reginae* when they were stored dry (RH 90%) for seven days at 10°C and exhibited life of 8.3 days. However, Moraes et al. (1999) also studied *S. reginae* storage at 10°C for a period of seven, fourteen, twenty-one and twenty eight days and reported the prolongation of the conservation of the flowers dry-stored. But, there was a demonstration of chilling injury from 28 days. These results are considered controversial, according to Reid (2004), stating that the best temperature range for long term storage of *S. reginae* is 6 to 7°C; and Nowak and Rudnicki (1990) stated 8°C for a period of 4 weeks. The useful life of scapes floral *S. reginae* is 10 to 15 days (Jaroenkit et al., 2008) and according to Bayogan et al. (2008), 6-16 days.

The degree of chilling injury suffered by a plant or its organs depends on temperature, duration of its exposure and the different sensitivity of each species (Kays, 1991; Chitarra and Chitarrra, 2005). However, the mechanisms of tolerance to chilling injury are complex. They may act

Table 1. Storage temperature of the main flowers.

Name	Storage temperature (ºC)	Maximium storage period (weeks)
Alpinia	12-18	3
Anthurium	13	4
Cravo	0-1	16-24
Chrysanthemum	1-1,5	3
Cyclamen	0-1	3
Gladíolus	4	4
Heliconia	10-13	3
Lilium	1	6
Rose	0,5-3	2
Strelitzia	6-13	4
Tulipa	0-1	8
Zingiber spectabilis	10-18	3

Sources: Broschat and Donselman, 1983; Paull, 1987; Nowak and Rudnick, 1990; Moraes et al. (1999); Dias and Castro, 2002; Finger et al. (2003); Jaroenkit and Paull, 2003; Reid, 2004; Cavalcante et al., 2005; Dias Tagliacozzo and Castro, 2005; Vieira and Souza, 2009.

together with other biochemical and physiological mechanisms to maintain normal physiological functions under stressful condition promoted by chilling injury (Pennycooke et al., 2005).

Relatively, low temperatures may also cause other adverse effects on the longevity of flowers, as will the stimulus synthesis of ethylene (Kader 2002). Some authors attributed accelerated aging step and stimulation of ethylene production peak to lower temperature (Faragher and Mayak, 1984; Paulin et al., 1985). The response and sensitivity to ethylene is dependent on the stage of development, variety and perception of the plant organ (Ciardi and Klee, 2001; Jones et al., 2001).

Flowers can be classified as insensitive, sensitive or highly sensitive to ethylene (Santos et al., 2005). Flowers that are highly sensitive to ethylene have their senescence triggered by the presence of small quantities of the regulator, such as Carnation, Orchid, *Petunia*, *Alstroemeria*, *Delphinium* and *Gypsophila* (Borochov et al., 1997; Kenza et al., 2000). According to Müller and Stummann (2003), receptor expression is increased when ethylene sensitive flowers suffer stress in advance leading to senescence. In some plants, the ethylene response is accompanied by an autocatalytic induction of enzymes involved in this synthesis gas (Altvorst and Bovy, 1995). Many flowers are less sensitive or insensitive such as *S. reginae* (Nowak and Rudnicki, 1990). The following table shows the storage temperature of the main flowers marketed (Table 1).

CONCLUSION

Post-harvest loss of flowers occurs due to improper harvesting, transportation, storage and distribution. Post-harvest life of flowers is governed by water content, respiratory rate, ethylene production, endogenous plant hormones and exogenous factors such as microbial growth, temperature, relative humidity and atmospheric compositions. Post-harvest loss of flowers can be considerably minimized and their storage life can be greatly increased by careful manipulation of these factors.

REFERENCES

Altvorst ACV, Bovy AG (1995). The role ethylene in the senescence of carnation flowers, a review. Plant Growth Regul. 16:43-53.
Ashrae (1994). Commodity Storage Requirements. Refrigeration Systems and Applications Handbook. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
Bayogan ERV, Jaroenkit T, Paull RE (2008). Postharvest life of Bird-of-Paradise inflorescences. Postharvest Biol. Technol. 48(2):259-263.
Belle R, Mainardi JCCT, Mello JB, Zachet D (2004). Abertura floral de *Dendranthema grandiflora* Tzvelev. ´Bronze Repin´ após armazenamento a frio seguido de “pulsing”. Ciência Rural 34:63-70.
Borochov A, Spiegelstein H, Philosoph HS (1997). Ethylene and flower petal senescence interrelationship with membrane lipid catabolism. Physiol. Plantarum 100:606-612.
Bosma T, Dole JM (2002). Postharvest handling of cut *Campanula medium* flowers. Hortic. Sci. 37:954-958.
Brackmann A, Bellé AR, Vizzoto M, Lunardi, R (2000). Armazenamento de crisântemos *Dedranthema grandiflora* cv. Red refocus em diferentes temperaturas e soluções conservantes. Rev Bras Agrociênc. 6(1):65-69.
Broschat TK, Donselman HM (1983). Heliconias: a promising new cut flower crop. Hortic. Sci. 18(2):1-2.
Bunya-Atichart K, Ketsa S, Doorn WG (2004). Postharvest physiology of Curcuma alismatifolia flowers. Postharvest Biol. Technol. 34:219-226.
Castro CEF, Honório SL (1992). Colheita e conservação de flores. In: Castro CEF (coord.). Manual de Floricultura. Maringá. Editora da Universidade Estadual de Maringá. pp. 37-43.
Cavalcante RA, Mosca JL, Maciel VT, Paiva W (2005). O. Armazenamento refrigerado de Heliconia chartaceae Lane ex Barreiros cv. Sexy Scarlet colhidas em diferentes pontos de abertura. Hortic Bras. 2(23):563-569.
Celikel FG, Dodge LL, Reid MS (2002). Efficacy of 1-MCP (1-

methylcyclopropene) and promalin for extending the post-harvest life of Oriental lilies (*Lilium* x '*Mona Lisa*' and '*Stargazer*'). Sci Hortic. 2(93):149-155.

Cevallos JC, Reid MS (2000). Effects of temperature on the respiration and vase life of Narcissus flowers. Acta Hortic. 517:335-341.

Chitarra MLF, Chitarra AB (2005). Pós-colheita de frutas e hortaliças fisiologia e manuseio. Lavras: Editora UFLA, p. 785.

Ciardi J, Klee H (2001). Regulation of ethylene-mediated responses at the level of the receptor. Ann. Bot. 88:813-822.

Couey HM (1982). Chilling injury of crops of tropical and subtropical origin: an overview. Hortic. Sci. 2(17):158-162.

Delaporte KL, Klieber A, Sedgley M (2000). Postharvest vase life two flowering *Eucalyptus* species. Postharv. Biol. Technol. 19:181-186.

Dias-Tagliacozzo GM, Castro CEF (2002). Fisiologia da pós-colheita de especies ornamentais. In: WACHOWICZ CM, CARVALHO RI N. Fisiologia vegetal: produção e pós-colheita. Curitiba: Champagnat 1:359-382.

Dias-Tagliacozzo GM, Castro CEF (2005). Manutenção da qualidade pós-colheita de Zingiber spectabilis Griff. Hortic Bras. 2(23):563- 568.

Elgar HJ, Fulton TA, Walton EF (2003). Effect of harvest stage, storage and ethylene on the vase life of Leucocoryne. Postharvest Biol. Technol. 27:213-217.

Faragher JD, Mayak S (1984). Physiological responses of cut rose flowers to exposure to low temperature: change in membrane permeability and ethylene production. J. Exp. Bot. 156(35):956-974.

Finger FL, Moraes PJ, Barbosa JG, Grossi JAS (2003). Vase life of bird-of-paradise flowers influenced by pulsing and term of cold storage. Acta Hortic 628:863-867.

Jaroenkit T, Chen JN, Paull RR (2008). Nectar secretion, mucilage production and mold growth on bird-of-paradise inflorescences. Postharvest Biol. Technol. 3(49):431-435.

Jaroenkit T, Paull RE (2003). Reviews postharvest handling of heliconia, red ginger, and bird-of-paradise. Hortic. Technol. 2(13):259-266.

Jones ML, Kim E-S, Newman SE (2001). Role of ethylene and 1-MCP in flower development and petal abscission in zonal geraniums. Hort. Sci. 7(36):1305-1309.

Joyce DC, Meara SA, Hetherington SE, Jones P (2001). Effects of cold storage on cut Grevillea 'Sylvia' inflorescences. Postharvest Biol. Technol. 18:49-56.

Joyce DC, Shorter AJ (2000). Long term, low temperature storage injures kangaroo paw cut flowers. Postharvest Biol. Technol. 20:203-206.

Kader AA (2002). Postharvest technology of horticultural products. 3nd ed. Los Angeles: University of California, Division of Agriculture and Natural Resources. p. 535. (Publication, 3311).

Kays SJ (1991). Postharvest physiology of perishable plant products. New York, p.532.

Kelly KM, Cameron AC, Bierbaum JA, Poff KL (2003). Effect of storage temperature on the quality of edible flowers. Postharvest Biol. Technol. 27:341-344.

Kenza M, Umiel N, Borochov A (2000). The involvement of ethylene in the senescence of Ranunculus cut flowers. Postharvrst Biol. Technol. 19:287-290.

Lamas AM (2004). Flores: produção, pós-colheita e mercado. In: Semana Internacional DA Fruticultura, Floricultura E Agroindustria, 11. Fortaleza, CE. Fortaleza: Instituto Frutal. p. 109.

Leitão APS (2001). Produção de Flores Tropicais. Frutal, Fortaleza, 1 CD-ROM.

Lucangeli C, Polenta G, Budde C (2004). Daño por frio em tomates cherry almacenados a 14ºC y 2ºC después de recibir pretatamientos de estrés térmico. INTA – EEA San Pedro; Buenos Aires – Argentina. Disponível em: http://www.inta.gov.ar/sanpedro/info/doc/pos/gpoo6.htm. Acesso em: 17/11/2007.

Mapeli AM (2009). Influência de substâncias preservativas, antietilênicas e da refrigeração na conservação pós-colheita de flores de *Epidendrum ibaguence* Kunt (Orchidaceae). Tese (Doutorado em Fisiologia Vegetal) - Universidade Federal de Viçosa, Viçosa p. 117.

Moraes PJ (2003). Crescimento, caracterização da abertura floral e manejo pós-colheita de flores de *Epidendrum ibaguence* Kuth. (Doutorado em Fitotecnia) – Universidade Federal de Viçosa p. 110.

Moraes PJ, Cecon PB, Finger FL (1999). Efeito da refrigeração e do condicionamento em sacarose sobre a longevidade de inflorescências de *Strelitzia reginae* Ait. Rev Bras Hortic Ornam. 2(5):151-156.

Morris LL (1982). Chilling injury of horticultural crops: an overview. Hortic. Sci. 2(17):161-162.

Müller R, Stummann BM (2003). Genetic regulation of ethylene perception and signal transduction related to flower senescence. J. Food Agric. Environ. 1:87-94.

Nowak J, Rudnicki RM (1990). Postharvest handling and storage of cut flowers, florist greens and potted plant. Portland: Timber Press p. 210.

Parking KL, Maragoni A, Jackman RL (1989). Chilling injury. A review of possible mechanism. J. Food Biochem. 13:127-132.

Paulin A, Kerhardy F, Maestri B (1985). Effect of drought and prolonged refrigeration on senescence in cut carnation (*Dianthus caryophyllus*). Physiol. Plant 64:535-540.

Paull RF (1987). Effect of storage duration and temperature on cut *anthurium* flowers. Hortic. Sci. 3(22):459-460.

Pellegrini MBQ, Bellé RA (2008). O que você precisa saber sobre pós-colheita de flores. Revista Campos Negócios p. 69.

Pennycooke JC, Cox S, Stushnoff C (2005). Relationship of cold acclimation, total phenolic content and antioxidant capacity with chilling tolerance in petunia (Petunia x hybrid). Environ. Exp. Bot. 53:225-232.

Reid MS (1991). Effects of low temperatures on ornamental plants. Acta Hortic. 298:215.

Reid MS, Dodge L (2001). Anthurium: Recommendations for maintaining postharvest quality. Department of Environmental Horticulture, University of California p. 234.

Reid SM (2004). Products facts. Bird of paradise. Recommendations for maintaining postharvest quality. Disponível em: http://postharvest.ucdavis.edu/files/77194.pdf.

Rudnicki RM, Nowak J, Goszczynska DM (1991). Cold storage and transpiration conditions for cut flowers, cutting and potted plants. Acta Hortic. 298:225-231.

Sanino A (2004). Conservação de tomate (*Lycopersicum esculentum*) 'Debora', submetido a diferentes condições de resfriamento e aquecimento intermitente. Dissertação (Mestrado), Universidade Estadual de Campinas. p. 63.

Santos VR, Finger FL, Barbosa JG, Barros SR (2005). Influência do etileno e do 1-MCP na senescência e longevidade das inflorescências de esporinha. Bragantia 1(64):33-38.

Skog LJ (2008). Chilling injury of horticultural crops. Horticultural Research Institute of Ontario. University of Guelp Factsheet. 1998. Disponível em: http://www.omafra.gov.on.ca/english/crops/facts/98-021.htm#Figure%203.

Vieira MRS, Brigida S (2009). Storage of cut chrysanthemums at different cutting temperatures. Pesqui. Agropecu. Trop. 4(39):356-359.

Vieira MRS, Lima GPP (2009). Shelf life of stems chrysanthemum faroe followed cold storage. Magistra 4(21):360-363.

Waithaka K, Reid MS, Dodge LL (2001). Cold storage and flowers keeping quality of cut tuberose (*Polianthes tuberosa* L.) J. Hortic. Sci. Biotechnol. 76:271-275.