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Postharvest quality of red gerberas depending on the storage temperature

Qualidade pós-colheita de gérberas vermelhas em função da temperatura de armazenamento

Ana Carolina Corrêa Muniz[I] Vanessa Cury Galati[I] Kelly Magalhães Marques[I] Claudia Fabrino Machado Mattiuz[II] Ben-Hur Mattiuz[I*]

ABSTRACT

This study aimed to verify the best storage temperature in the postharvest quality conservation of inflorescences of gerberas cv. 'Intenza'. Inflorescences were kept in distilled water and stored at the temperatures of 22ºC (control); 12ºC; 8ºC and 4ºC. The experiment was conducted in a completely randomized design in split plot with two factors: 4 treatments (temperatures) X 4 evaluation dates (0, 3, 6 and 9 days). It was used three replicates, with three inflorescences each. It were evaluated the variation of fresh mass, relative water content, soluble and reducing sugars content and longevity. Results were submitted to analysis of variance and means compared by Tukey test at 5% of probability. The inflorescences of gerbera maintained at 4ºC, 8ºC and 12ºC showed a greater postharvest life compared with the inflorescences of the control, highlighting those kept at 4ºC which presented less loss of mass and higher soluble sugar content; thus, maintaining the quality of gerberas for a longer period, with vase life of approximately 15 days.

Key words: ***Gerbera jamesonii*** *L., cut flowers, carbohydrates, floral longevity.*

RESUMO

O presente trabalho teve como objetivo verificar a melhor temperatura de armazenamento na conservação da qualidade pós-colheita de inflorescências de gérberas cv. 'Intenza'. As inflorescências foram mantidas em água destilada e armazenadas nas temperaturas de 22ºC (controle); 12ºC; 8ºC e 4ºC. O experimento foi conduzido em delineamento inteiramente casualizado, em parcelas subdivididas no tempo com dois fatores: 4 tratamentos (temperaturas) X 4 períodos de avaliação (0, 3, 6 e 9 dias). Foram utilizados três repetições, com três inflorescências cada. Foi avaliado a variação da massa fresca, o conteúdo relativo de água, o teor de açúcares solúveis e redutores das lígulas e a longevidade. Os resultados foram submetidos à análise de variância e as médias comparadas pelo teste de Tukey a 5% de probabilidade. As inflorescências de gérbera mantidas a 4°C, 8ºC e 12ºC apresentaram maior vida pós-colheita em comparação com as inflorescências do tratamento controle, com destaque para àquelas mantidas à 4ºC as quais apresentaram menor perda de massa e maior teor de açúcares solúveis, mantendo assim, a qualidade das gérberas por um período mais longo, com vida de útil de aproximadamente 15 dias.

Palavras-chave: ***Gerbera jamesonii*** *L., flores de corte, carboidratos, longevidade floral.*

INTRODUCTION

Cut flowers occupy a major role in the global horticulture. Maintain good quality and extend the vase life of these flowers is essential for good acceptance of these products on the market (SARDOEI et al., 2014). One of the most important species in the trade of cut flowers is the gerbera that is very popular in the market due mainly to its wide variety of colors and shapes, however, most varieties has a very short vase life. As a result, many studies have been performed to extend the vase life of these flowers (ANTES et al., 2009; PERIK et al., 2012; DANAEE et al., 2013; SCHMITT et al., 2014; MUNIZ et al., 2015). Despite the emergence of new conservation techniques, the low temperature is still the main one, and it is considered one of the

[I]Departamento de Tecnologia, Faculdade de Ciências Agrárias e Veterinárias (FCAV), Universidade Estadual Paulista (UNESP), Campus de Jaboticabal, Via de Acesso Prof. Paulo Donato Castellane, s/n, 14884-900, Jaboticabal, SP, Brasil. E-mail: benhur@fcav.unesp.br. *Corresponding author.
[II]Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo (USP), Piracicaba, SP, Brasil.

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most important factors in determining the extent of vegetables postharvest life.

The critical role of temperature on the life of cut flowers has been mentioned in the literature for a long time (CARROW, 1978; NOWAK & RUDNICKI, 1990; JONES & MEGAN, 1993). Low temperatures retard the senescence and the deterioration of flowers tissues, because they reduce some important processes in the postharvest, as the exhaustion of reserves, mainly carbohydrates, the growth of bacteria and fungi, the production of ethylene and the excessive water loss (HARDENBURG et al., 1986; NOWAK et al., 1991; REID, 1991; CORBINEAU, 1992), being effective for the preservation of several species, such as gerberas (DURIGAN, 2009) and alstroemerias (GALATI et al., 2015).

LIU et al. (2009) reported that low temperatures decreased water loss and inhibit microbial growth in lilies, which consequently resulted in a lower obstruction of xylem and increased water absorption and vase life. DURIGAN & MATTIUZ (2009) observed that gerberas 'Suzanne' stored at 2ºC, 4ºC and 6ºC showed vase life higher than those stored at 20ºC, being these temperatures effective in the maintenance of the appearance and decorative quality of the inflorescences. BELLÉ et al. (2004) stated that the storage at 2ºC delayed the symptoms of senescence in chrysanthemums. Temperature of 4ºC showed a positive and significant effect on the increasing of the vase life of daffodils, delaying the senescence of these flowers (SARDOEI et al., 2014).

Given the above and due to the lack of studies specifically related to this cultivar of gerbera, the aim of this study was to evaluate the best storage temperature in the quality maintenance and in the prolongation of vase life of cut gerberas cv. 'Intenza'.

MATERIALS AND METHODS

It were used inflorescences of ***Gerbera jamesonii*** cv. 'Intenza' of red coloring obtained from commercial producer in the city of Andradas, Minas Gerais (22º4'19 "S and 46º34'20" W), Brazil. Inflorescences were harvested on October 29th, 2014 when the stem had 5 to 6mm of diameter and when there was one to three floral circles (male flowers) visibly open. On property, the inflorescences were subjected to an immersion treatment in chlorine 100mg L^{-1} for 4 hours and then were placed in cardboard boxes and transported in vehicle with cooling for about 4 hours to the Laboratory of Post-Harvest Technology in the Technology Department of the FCAV/UNESP, Jaboticabal, SP.

In the laboratory, the inflorescences were standardized, discarding the damaged ones or the ones that did not have the harvest time specified. Then, they were cut to 40cm in length, making up the cut on the base of the stems inside a container with tap water. After this standardization, nine inflorescences were randomly taken to an initial evaluation and the remaining inflorescences were randomly distributed in flasks containing 500ml of distilled water and placed in different temperatures.

The experiment was conducted in a completely randomized design in split plot with two factors: four storage temperatures (22±3ºC and 65±4% RH; 12±2ºC and 63±5% RH; 8±2ºC and 62±4 % RH and 4±2ºC and 60±5% RH) and four evaluation times (0, 3, 6 and 9 days). Three replicates, with three inflorescences each were used. Inflorescences were maintained in a room with continuous illumination for 24 hours, as recommended by VAN MEETEREN (1978) for 9 days (except for inflorescences of the longevity lot, which was maintained until the end of their decorative life). Every three days were evaluated the following qualitative parameters:

Variation of fresh mass: Inflorescences were weighed in balance accurate to 0.01g, where the negative values indicated gain of mass and the positive values indicated loss of mass of inflorescences. The variation was calculated as a percentage, according to the following equation: Variation of fresh mass (%) = $FM_1 - FM_2$ X $100/FM_1$; where: FM_1 = fresh mass from the previous assessment day; FM_2 = fresh mass of the day.

Relative water content of ligules (RWC): was evaluated in nine ligules of each replicate, three of each inflorescence. In each treatment, the ligules were weighed, immersed in distilled water and kept under hidratation for 4 hours. After this period, they were superficially dried with a towel paper, reweighed (turgid weight) and taken to an oven with forced air circulation at 70ºC for drying and a new weighing (dry weight). This allowed us to calculate the relative water content, expressed as a percentage, using the following equation (KRAMER, 1983): RWC (%) = FW – DW X 100/TW – DW; where FW = fresh weight, DW = dry weight; TW = turgid weight.

Soluble and reducer sugars content in the ligules: assessed as MATTIUZ et al. (2010), being the results expressed as g glucose $100g^{-1}$ of fresh weight.

Floral longevity: This analysis was performed on a separate batch of inflorescences exclusively to evaluate the qualitative parameters required for commercialization. It was visually evaluated using a grading scale from 1 to 4 used by producers and by Veilling Holambra, where: Note 4

= brightly colored, ligules turgid and spotless, stems erect and turgid, less than 1/3 of floral discs visibly open, great marketing conditions; Note 3 = brightly colored, ligules turgid and with no or few spots, stems slightly curved, maximum half of floral discs visibly open and good conditions for floral arrangements, but without marketing conditions; Note 2 = ligules faded and/or darkened with patches and/or diseases, slightly withered, bent stem, with more than half of floral discs visibly open and unused condition; Note 1 = ligules faded and/or darkened, presence of stains and/or diseases, wilted, very bent or fallen stem, with more than half of floral discs visibly open, and unused condition. Completion of this evaluation was when the inflorescences presented score below 3. Even getting grades lower than 3, the inflorescences were still in analysis condition, but did not have more marketing condition, which is the reason to evaluate the longevity in a separate batch of inflorescences.

Results were submitted to analysis of variance (ANOVA) and the effect of treatments, while significant, was compared by F test. Significant differences among the results were compared by Tukey test at 5% probability.

RESULTS AND DISCUSSION

In all treatments, the inflorescences of gerbera gained mass (indicated by the negative values showed in the table) until the 3rd day of storage, especially the treatment at 4ºC which was the only one that differed from the control treatment. On the 9th day, there was mass loss (indicated by the positive values showed in the table) for all treatments (Table 1), probably due to the senescence of inflorescences, because during this process occur physical changes, such as water loss (MAYAK, 1987).

Only the inflorescences stored at the lowest temperature (4ºC) gained mass until the 6th day of storage (Table 1). This was due to the positive water balance, i.e., the inflorescences maintained at this temperature absorbed more water than they lost, once the low temperature probably reduced the transpiration rate thereby reducing the water loss (VILAS BOAS, 2000).

When the absorption and transpiration are unbalanced, the absorption becomes limited occurring loss of water balance, which will lead to an irreversible condition and a reduced vase life (VAN MEETEREN et al., 2001). Storage time and transpiration result in loss of mass of the vegetables, which limits their useful life (VILAS BOAS, 2000). This loss is related to loss of water, the main cause of deterioration, which in addition to the quantitative loss, also harm the appearance (wilting) and the nutritional quality of vegetables (CARVALHO, 2000), which may explain the behavior of gerberas stored at 22ºC, where the mass loss was higher.

The highest averages for the relative water content (RWC) were obtained at the lowest temperatures (4ºC, 8ºC and 12ºC), highlighting the treatment at 8ºC, which was the only one that differed from the control treatment (22ºC). It was also possible to observe that, during the storage, there was a decrease in the RWC as a natural process of loss of turgor of the cells due to the senescence (Table 2). These results are in agreement with the findings of DURIGAN & MATTIUZ (2009), MATTIUZ et al. (2010) and PIETRO et al. (2012), whose species of gerbera, orchid and rose, respectively, stored at 22ºC showed a decrease in the RWC during the storage.

Inadequate storage temperatures, adverse humidity and high levels of ethylene are some of the factors that contributed to the activation of chemical oxidation and other physical processes, which can cause changes in pigments and dehydration, respectively. These processes usually lead to abscission, bending of stems and browning and discoloration of petals (REID, 1997; SEREK & REID, 2000; VAN DER MEULEN-MUISERS et al., 2001). In the present research the inflorescences kept at 22ºC showed early stem bending, what decreased their

Table 1 - Variation of fresh mass (%) of inflorescences of gerberas 'Intenza' held for 9 days at different temperatures.

Treatments	Evaluation day					
	3		6		9	
22ºC (Control)	-0.90	aC	3.35	abB	13.00	aA
12ºC	-3.63	aC	1.22	bB	8.97	bA
8ºC	-5.77	aB	5.82	aA	6.56	bcA
4ºC	-15.32	bC	-2.87	cB	4.80	cA

*Means followed by at least one common letter, lowercase in the column and uppercase in the line, did not differ significantly by Tukey test (P>0.05). Negative values indicate gain of mass and positive values indicate loss of mass.

Table 2 - Average of the relative water content (RWC) (%) and average content of reducer and soluble carbohydrates (g glucose $100g^{-1}$ of fresh mass) in ligules of inflorescences of gerberas 'Intenza' held for 9 days at different temperatures.

Treatments	----------RWC----------		Reducer	Soluble
22ºC (Control)	84.71	b	0.77 a	0.47 b
12ºC	89.00	ab	0.83 a	0.49 ab
8ºC	91.51	a	0.87 a	0.52 ab
4ºC	90.29	ab	0.86 a	0.53 a
----------Evaluation day----------				
0	94.34	a	0.87 a	0.57 a
3	88.13	b	0.84 a	0.53 b
6	88.30	b	0.82 a	0.48 c
9	84.74	b	0.80 a	0.42 d

*Means followed by at least one common letter do not differ significantly, by Tukey test ($P>0.05$).

postharvest life. Conversely, the inflorescences kept at 4ºC, 8ºC and 12ºC had stem bending only from the 9th day of storage, showing the efficiency of low temperatures to conservation of gerberas, once the stem bending is one of the most important problems that limited the postharvest life of the gerberas.

GALATI et al. (2015) observed that Alstroemeria stems kept at 22ºC showed a decrease in the RWC from the 6th day of storage and for those stored at 8ºC and 12ºC this remained constant, differing from those under 4ºC, which RWC remained constant from the 6th day after storage.

Concerning the content of reducer carbohydrates of the inflorescences it wasn't reported significant differences among the treatments. However, the inflorescences stored at 4ºC showed higher levels of soluble carbohydrates, differing significantly from the control. Regarding the evaluation days, it was observed a gradual decrease in the content of soluble carbohydrates during the storage (Table 2).

Carbohydrates are an important source of energy and structural components, besides being metabolism regulatory molecules (KUMAR et al., 2008). Decrease in the content of soluble and reducer carbohydrates during the storage period is due to the senescence process of the inflorescences, as these use the carbohydrates as breath substrate, which are depleted over time. The demand for sugar during the development and opening of flowers may also explain the reduction in carbohydrates content during storage (TRUSTY & MILLER, 1991; DURIGAN, 2009).

The application of the lowest temperatures (4ºC, 8ºC and 12ºC) significantly increased the vase life of gerberas, highlighting the inflorescences kept at 4ºC that had a shelf life three times higher than those maintained at 22ºC (14.8 days vs. 5.0 days) (Table 3). Inflorescences that remained at the temperatures of 4ºC, 8ºC e 12ºC entered more slowly in the senescence process, when compared with those stored at 22ºC. These results are explained by the retardation of the physiological processes at low temperatures. According to BOTTCHER et al. (2003) and ICHIMURA & UEYAMA (1998) vegetables generally have a reduced shelf life, straight or exponentially with the increasing of the temperature.

Regarding the notes of quality for the parameter floral longevity, there was a significant difference among the control treatment and the others treatments from the 3rd day of storage. The averages notes of the treatments at 4ºC, 8ºC and 12ºC were close to the highest one (4.00) until the 9th day of storage, while the average note for the control treatment was below the acceptable since the 6th day of storage. In all treatments there was a decrease of the notes throughout the experimental period, showing that the inflorescences entered in the senescence process (Figure 1).

Table 3 - Average longevity, in days, of inflorescences of gerberas 'Intenza' kept at different temperatures.

Treatments	Longevity (days)
22ºC (Control)	5.0 c
12ºC	11.4 b
8ºC	10.9 b
4ºC	14.8 a

*Means followed by at least one common letter do not differ significantly, by Tukey test ($P>0.05$).

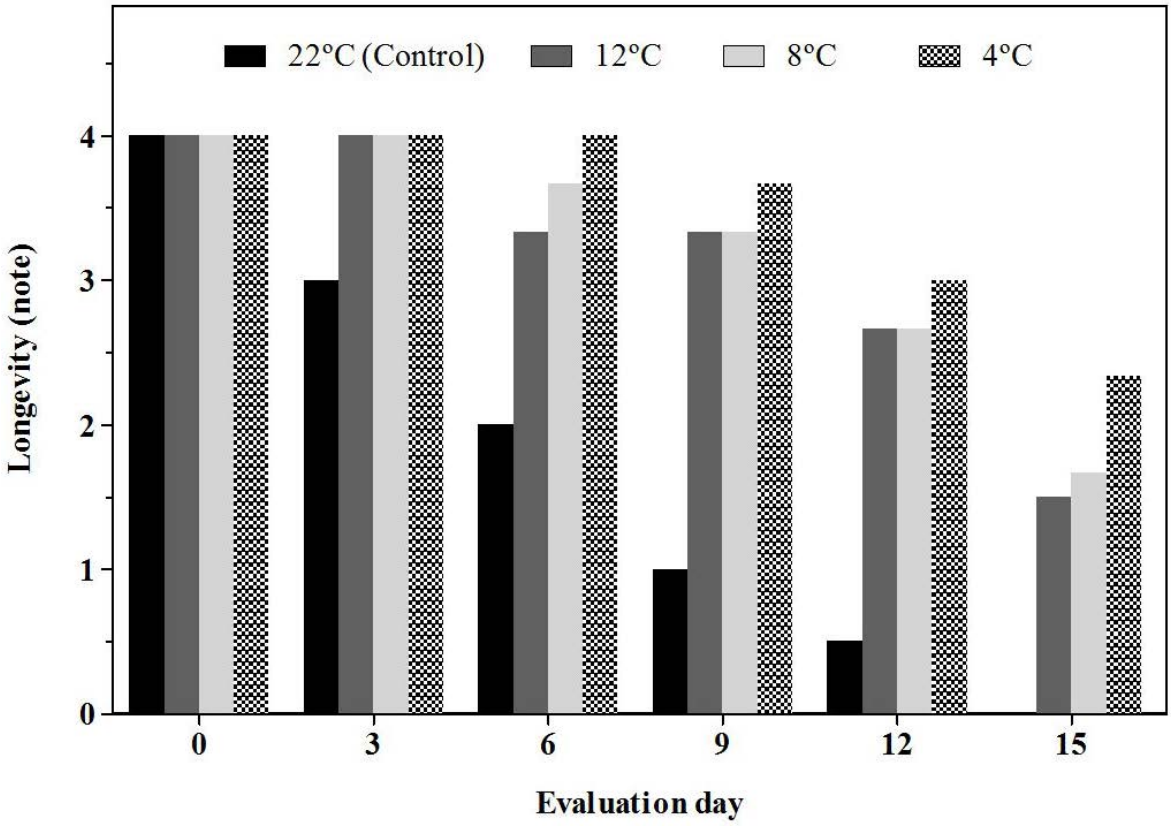

Figure 1 - Average of notes of quality in the evaluation of the longevity of gerberas 'Intenza' kept at different temperatures. Note 4 = spotless ligules, erect and turgid stems, less than 1/3 of the floral discs visibly opened; Note 3 = turgid ligules and with no or few spots, stems slightly curved, with a maximum of half of the floral discs visibly opened; Note 2 = ligules with stains and/or diseases, slightly withered, bent stems, with more than half of the floral discs visibly opened; Note 1 = ligules with stains and/or diseases, wilted, very bent or fallen stems, with more than half of the floral discs visibly open.

In the inflorescences stored at 22ºC occurred the development of powdery mildew from the 4th day of storage, affecting the appearance of the inflorescences and hence its longevity.

CONCLUSION

The temperatures of 4ºC, 8ºC and 12ºC prolonged the postharvest life of the inflorescences of gerbera comparing with the inflorescences kept at 22ºC. However, the temperature of 4ºC is the better one, because it maintained the quality of gerberas for a longer time, with vase life of approximately 15 days. During this period, the stems remained erect and the inflorescences turgid, with the desirable characteristics for commercialization.

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