

## SCIENTIFIC ARTICLE

# Post-harvest of safflower flower stems harvested at different times and submitted to different preservative solutions

Janine Farias Menegaes <sup>1\*</sup>, Henrique Fernando Lidório <sup>1</sup>, Rogério Antônio Bellé <sup>1</sup>, Sidinei José Lopes <sup>1</sup>,  
Fernanda Alice Antonello Londero Backes <sup>1</sup>, Ubirajara Russi Nunes <sup>1</sup>

## Abstract

The conservation of the cut flower stems aims to prolong durability, maintain the quality and reduce the losses after harvest, providing a greater period of lifespan and commercialization. Thus, the objective of this work was to evaluate the quality and durability in post-harvest of fresh safflower (*Carthamus tinctorius* L.) flower stems harvested in different times and submitted to different preservative solutions. The experiment was conducted in entirely randomized design and, organized in 4x8 (four preservative solutions and eight harvest seasons) factorial scheme, with four repetitions, and each experimental unit consisting of five floral stems. The cultivation of floral stems of safflower occurred at Floriculture Sector and the harvest seasons of them were carried out in the beginning of flowering from the sowing performed in the first seasonal half: in winter, spring and summer of 2016, autumn, winter, spring and summer of 2017 and autumn of 2018. And, the preservative solutions were: distilled water (control); distilled water + sucrose 2%; distilled water + sodium hypochlorite 2% and distilled water + sucrose 2% + sodium hypochlorite 2%. The floral stems were evaluated in relation to quality notes, dehydration and absorption of preservative solutions. We observed that the floral stems of safflower presented shelf life in average of nine days, with absorption of solution in average of 0.021 mL day<sup>-1</sup> g<sup>-1</sup> of fresh mass and that the use of preservatives was not beneficial to conservation in post-harvest.

**Keywords:** *Carthamus tinctorius* L., cut flower, vase life.

## Resumo

### Pós-colheita de hastes florais de cártamo colhidas em diferentes épocas e submetidas a diferentes soluções conservantes

A conservação das hastes florais cortadas 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. Assim, o objetivo deste trabalho foi avaliar a qualidade e a durabilidade na pós-colheita de hastes florais frescas de cártamo (*Carthamus tinctorius* L.) colhidas em diferentes épocas e submetidas a diferentes soluções conservantes. O experimento foi conduzido em delineamento inteiramente casualizado e, organizado em esquema fatorial 4x8 (quatro soluções conservantes e oito épocas de colheita), com quatro repetições, sendo cada unidade experimental constituída de cinco hastes florais. O cultivo das hastes florais de cártamo ocorreu no Setor de Floricultura e as épocas de colheita das mesmas foram realizadas no início da floração a partir da sementeira realizada na primeira quinzena estacional: no inverno, primavera e verão de 2016, outono, inverno, primavera e verão de 2017 e outono de 2018. E, as soluções conservantes foram: água destilada (testemunha); água destilada + sacarose 2%; água destilada + hipoclorito de sódio 2% e água destilada + sacarose 2% + hipoclorito de sódio 2%. As hastes florais foram avaliadas quanto a notas de qualidade, desidratação e absorção das soluções conservantes. Observou-se que as hastes florais de cártamo apresentaram vida de vaso em média de nove dias, com absorção de solução na média de 0,021 mL dia<sup>-1</sup> g<sup>-1</sup> de massa fresca e que o uso dos conservantes não foi benéfico à conservação em pós-colheita.

**Palavras-chave:** *Carthamus tinctorius* L., flor de corte, vida de vaso.

## Introduction

The Brazilian floriculture cultivates approximately 3000 varieties among cut flowers, potted and ornamental plants, with high demand in visual and phytosanitary quality. However, these products are highly perishable; especially the cut flowers that need management in post-

harvest to maximize their shelf lives (Junqueira and Peetz, 2017).

Among the cut flowers, the safflower inflorescences (*Carthamus tinctorius* L.), belonging to Asteraceae family, originating in Asia, stand out by their beauty, rusticity and versatility, being used as fresh and/or dry cut flowers. In Asia, the floral stems of safflowers are used for

<sup>1</sup> Federal University of Santa Maria (UFSM), Crop Science Department, Santa Maria-RS, Brazil.

\*Corresponding author: [janine\\_rs@hotmail.com](mailto:janine_rs@hotmail.com)

Received December 04, 2018 | Accepted February 22, 2019

Licensed by CC BY 4.0

<http://dx.doi.org/10.14295/oh.v25i1.1989>

ornamentation, mainly, in religious temples in virtue of their durability and, in flower auctions in Holland, since 1990, they are among the 46 most commercialized cut flowers (Coronado, 2010; Emongor and Oagile, 2017).

In Brazil, the culture of safflower was introduced in South region, in the 1990s, as an alternative to the flower producers in virtue of the good adaptability of the culture to the climate conditions; nevertheless, the cultivation of safflower is still incipient (Bellé et al., 2012; Santos and Silva, 2015). Annual and ramified herbaceous species, from 0.6 to 1.5 m of height, each ramification produce from 1 to 5 solitary capitula in the apex of the branch in the colors yellow, orange or red, present scaled floral receptacle and alternating leaves (Kinupp and Lorenzi, 2014).

In relation to the durability of the floral stems of safflowers in post-harvest, we have the register from six to 15 days for fresh material and, in dry material more than two months (Coronado, 2010; Paiva and Almeida, 2014). In fresh material the deterioration starts in the sequence of the harvest, due to the intensification of the natural metabolic processes of the plant, which imply in the loss of quality and commercial value. Thus, the storage period of flowers and foliage, above all, the ones cut is relatively short varying from six to 15 days according to the species, thus, it is necessary the use of preservative techniques for maintenance of quality after their harvest (Wills et al., 1998; Almeida et al., 2011), seeking to extend their durability with commercial value.

Among the post-harvest preservative techniques, the use of preservative solutions seeks to extend and maintain the quality of the cut flowers, delaying their senescence, and they can be used in all the distribution chain, from the producer to the final consumer. Halevy and Mayak (1981) classify four types of preservative solutions for the use in post-harvest, and they are: a) Strengthening or pulsing: used for hydration and immediate replacement after harvest, not going beyond the period of 24 h; b) Conditioning: for use, mainly, during transportation, with solution composed of water added to bactericide and sucrose in low concentrations; c) Floral induction: used with the objective of opening of inflorescences when they are collected in advance, still in immature buds for commercialization and/or sending to long distances; d) Maintenance: for use through long periods, generally, in the commercialization points, containing substances used in an isolated form or as a set, contributing for maintenance of quality of cut stems

Among the preservative solutions, we highlight the use of maintenance solution, which must be simple and of easy manipulation, in which its components enable

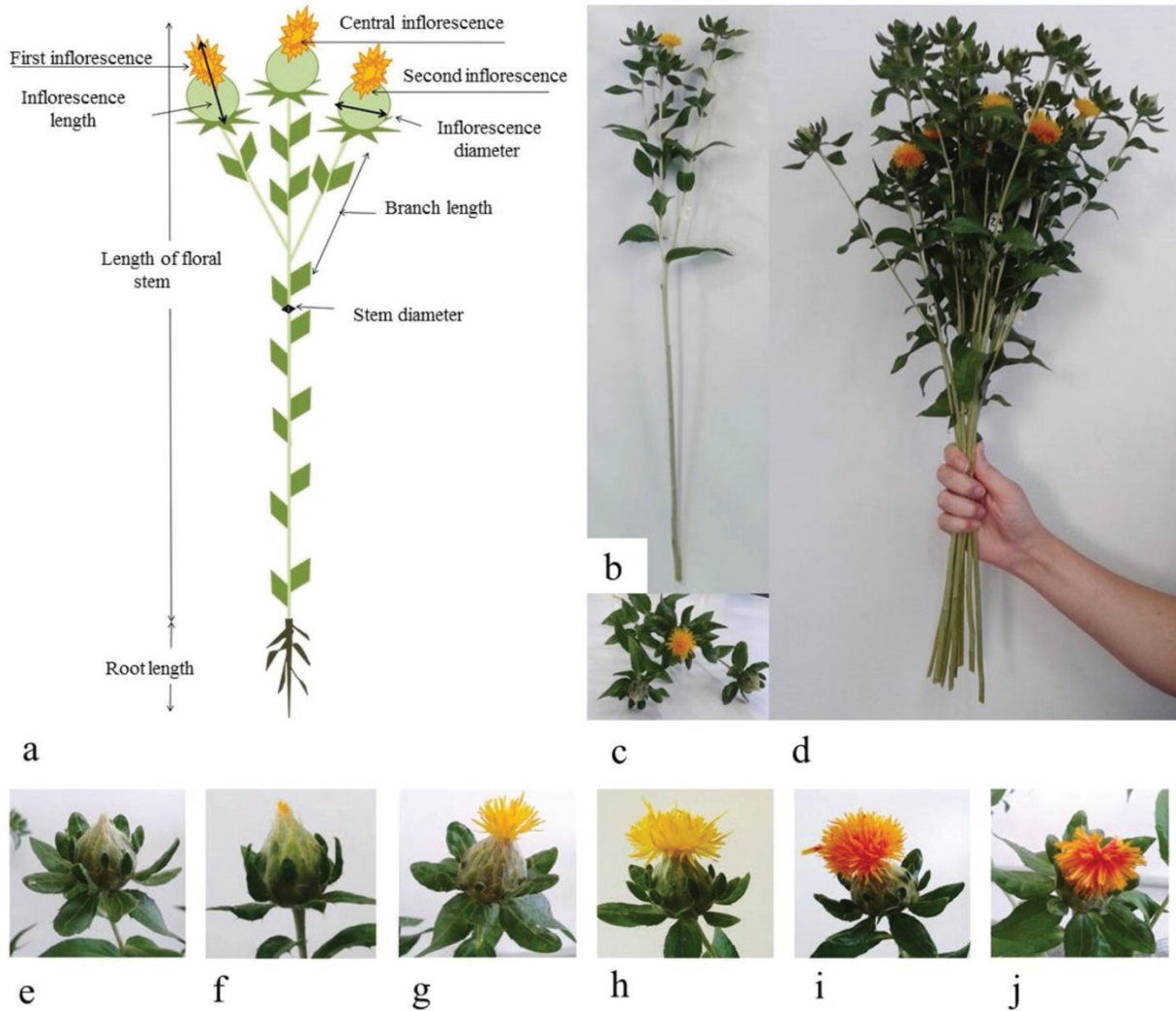
to the floral stems hydration through water, substrate for supplementation of natural sugars, which are quickly used after cutting, in breathing, by means of sucrose and, aseptically by means of sodium hypochlorite that, besides maintaining the water quality, delays the microbial infections in the conducting vessels (Wills et al., 1998; Van Door, 2001; Reid and Jiang, 2012).

Thus, the objective of this work was to evaluate the quality and durability in post-harvest of fresh floral stems of safflower harvested in different times and submitted to different preservative solutions.

## Material and Methods

The experiment was carried out in the period from July, 2016 to October, 2018, in the Floriculture Sector of Phytotechnology Department from Universidade Federal de Santa Maria (UFSM), located in Santa Maria, RS (29°43' S; 53°43' W and altitude of 95m). The climate of the region is humid subtropical (Cfa), according to the classification by Köppen-Geiger, with annual average precipitation accumulated of 1769 mm, annual average temperature near to 19.2° C and air humidity around 78.4% (Mota et al., 1971). The experimental design was conducted entirely randomized and, organized in 4x8 factorial scheme (four preservative solutions and eight harvest seasons), with four repetitions, and each experimental unit was composed of five floral stems of safflower.

The cultivation of floral stems of safflower Lasting Orange cultivar occurred in area of the Floriculture Sector, and the harvest seasons of the same were performed in the beginning of flowering (Figure 1b, 1c, 1g) from the sowing carried out in the first seasonal half of the years from 2016 to 2018, and they were: sowing carried out in the winter of 2016 and harvest of the floral stems 105 days after sowing (DAS); E2: sowing carried out in the spring of 2016 and harvest of floral stems 70 DAS; E3: sowing carried out in the summer of 2016 and harvest of floral stems 61 DAS; E4: sowing carried out in the autumn of 2017 and harvest of floral stems 109 DAS; E5: sowing carried out in the winter of 2017 and harvest of floral stems 95 DAS; E6: sowing carried out in the spring of 2017 and harvest of floral stems 69 DAS; E7: sowing performed in the summer of 2017 and harvest of floral stems 68 DAS; E8: sowing carried out in the autumn of 2018 and harvest of floral stems 120 DAS. And, the preservative solutions were: SC1: distilled water (control); SC2: distilled water + sucrose 2%; SC3: distilled water + sodium hypochlorite 2% and SC4: distilled water + sucrose 2% + sodium hypochlorite 2%.



**Figure 1.** *Carthamus tinctorius* L. Illustration for evaluation of the biometric parameters of the floral stem (a), floral stem standardized with 60 cm (b) and with three inflorescences (c), packet with 10 stems (d). Flowering stages appearance of the color of the buds on the button (e), appearance of visible stamens (f), stamens and ligules partially exposed (g), full bloom (h), end of flowering (i) and senescence of capitulum (j).

The sowing occurred directly in the flower beds, with previous preparation of the soil, on the flower beds we installed the irrigation system by dripping and the plotted tutor displays (12.5 x 10 cm) forming the density of 80 plants m<sup>-2</sup> recommended by Bellé et al. (2012). The harvests of the floral stems occurred when the central inflorescence was partially opened and the others closed (Figure 1b, 1c, 1g), according to the commercialization standards and classification criteria for the safflower in cut flower determined by Veiling Holambra Cooperative (2016). Immediately after the harvest, the floral stems were standardized with cut in bisel maintaining 60 cm in length and three inflorescences (Figure 1b, 1c). In the sequence, the stems were submitted to cooling in cold chamber at 5±2 °C packaged in distilled water, for 24 h (adapted of Sonogo and Brackmann, 1995).

We evaluate the medium diameters of inflorescences and of floral stem (Figure 1a), which were measured by

digital pachymeter (precision of 0.001 mm). To verify the durability of the floral stems of safflower after cooling, these were placed in transparent glass recipients (volume of 1.2 L) containing 300 mL of preservative solutions (with column of water of 7 cm) corresponding to the treatments aforementioned, being renovated each three days, the environmental conditions of the experimental room were maintained with air conditioning to the average temperature of 20 °C and average relative humidity of 65% constant.

The vase life was evaluated in relation to the durability of the floral stems of safflower, which presented healthy and marketable aspect until reach the score three (Table 1). Also, it was evaluated the floral stems quality according to the leaf's characteristics, in relation to withering, yellowing and necrosis and, of the inflorescences in relation to the commercialization point by the score scale presented in Table 1.

**Table 1.** Scale of notes to evaluate the longevity of post-harvest *Carthamus tinctorius* L. floral stems.

NOTE	Inflorescences						Leaves				Healthy and commercial aspect
	Position	Closed	50% open	Open	50% senescent	100% senescent	Coloring	Hydration			
1	Central			x			Green	x	Turgidity	x	Yes
	First	x	x				50% yellow		50% turgid		
	Second	x					Yellow		Dry		
2	Central				x		Green	x	Turgidity	x	Yes
	First			x			50% yellow		50% turgid		
	Monday		x	x			Yellow		Dry		
3	Central				x		Green	x	Turgidity	x	Yes
	First				x		50% yellow	x	50% turgid		
	Second			x			Yellow		Dry		
4	Central					x	Green		Turgidity	x	Yes, with removal
	First					x	50% yellow	x	50% turgid	x	
	Second				x		Yellow		Dry		
5	Central					x	Green		Turgidity		No
	First					x	50% yellow	x	50% turgid	x	
	Second				x	x	Yellow	x	Dry	x	

The relative dry mass (MFR) of floral stems pre and post-storage was calculated according to the methodology by Schmitt et al. (2014) by the formula:

$$MFR_{(\%)} = (M_t \times 100) / M_{t=0} \quad (1)$$

where:  $M_t$  = dry mass of stem (g) no  $t$  = days after harvest;  $M_{t=0}$  = fresh mass of stem (g) in the day of the harvest.

The absorption of preservative solution (ASC) of floral stems in post-storage was calculated with the methodology by Antes et al. (2009) by the formula:

$$ASC \text{ (mL dia}^{-1} \text{ g}^{-1} \text{ of fresh mass)} = (V_{t-1} - V_t) / M_{t=24h} \quad (2)$$

where:  $V_t$  = solution volume (mL) no  $t$ =days after harvest;  $V_{t-1}$ =solution volume (mL) on the previous Day and  $M_{t=24h}$ =fresh mass of stem 24 h after harvest.

The assessment of floral stem mass, absorption of preservative solution and scores were made with interval of three days, at 3, 6, 9, 12, 15, 18 and 21 days of the beginning of the post-harvest process (DPC).

The data expressed in percentage was transformed in arc-sine  $\sqrt{x}/100$ . The analysis of data variance, comparison of qualitative averages by Scott-Knott test and quantitative averages by regression, at the level of 5% of error, were performed with the help of SISVAR program (Ferreira, 2014). Furthermore, we performed the comparison of the progressive averages of the quality scores, absorptions of

preservative solutions and dehydrations of floral stems of *C. tinctorius* in post-harvest, evaluated at 3, 6, 9, 12, 15, 18 and 21 days of the beginning of the post-harvest process (DPC) by regression, at the level of 5% of error.

## Results and Discussion

We verified that the performance of the cooling procedure of the floral stems of safflower in the sequence of harvest helped in the delay of its senescence, presenting benefits for the aesthetic quality of these stems, in relation to the non-use of the cooling compared by preliminary experimentation, mostly, the velocity of floral opening. Paiva and Almeida (2014) recommended to the initial maintenance of floral stems of safflower the temperature of 4 °C to avoid the precocious deterioration of them. Almeida et al. (2011) and Reid and Jiang (2012) point that this procedure is primordial for preserving the plant humidity, thus, removing the heat of the stem arising from the field, besides favoring the reduction of the breathing rate and infection by pathogens.

After collected, we carried out the standardization of floral stems of safflower, in all the harvest seasons, and there was no significant difference for the parameters of initial fresh mass and after 24 h of harvest of floral stem, average diameters of inflorescences and of floral stem (Table 2), meeting the commercial demands established with the commercialization standards and criteria of classification for the safflower in cut flower determined by Veiling Holambra Cooperative (2016).



**Table 2.** Initial fresh mass and after 24 h of the floral stem harvest, mean inflorescence and floral stem diameter, commercial pot life and accumulated absorption of preservative solutions of *C. tinctorius* floral stems harvested at different times and submitted to different solutions.

Harvest seasons	Preservative solutions					Preservative solutions				
	SC1	SC2	SC3	SC4	MD	SC1	SC2	SC3	SC4	MD
	Initial fresh mass of the floral stem (g)					Fresh mass from floral stem after 24 h (g)				
E1	26.3 <sup>ns</sup>	21.0	29.0	28.8	26.3 A	25.8 <sup>ns</sup>	20.6	28.7	28.0	25.8 A
E2	29.3	19.8	29.6	17.8	24.1 A	29.0	19.4	29.3	17.5	23.8 A
E3	20.6	16.4	22.7	22.5	20.5 C	20.2	16.1	22.4	21.9	20.2 B
E4	22.4	15.2	22.7	24.2	21.1 B	22.0	15.0	22.3	24.1	20.9 B
E5	23.7	22.6	31.2	26.6	26.0 A	23.3	22.0	30.2	25.9	25.4 A
E6	18.0	22.6	27.9	21.9	22.6 B	17.5	22.0	27.0	21.4	22.0 B
E7	20.6	14.3	31.2	20.3	21.6 B	20.0	13.9	30.5	20.0	21.1 B
E8	23.3	13.4	23.7	17.7	19.5 C	22.6	13.0	25.6	17.3	19.6 B
MD	23.0 b	18.2 c	27.3 a	22.5 b		22.5 b	17.8 c	27.0 a	22.0 b	
CV	36.14%					35.10%				
	Diameter of the floral stem (mm)					Mean diameter of inflorescences (mm)				
E1	4.6 <sup>ns</sup>	4.4	4.8	5.0	4.7 A	20.1 <sup>ns</sup>	21.7	21.1	19.8	20.7 A
E2	4.0	3.8	4.2	4.3	4.1 B	19.1	19.2	17.7	18.1	18.5 B
E3	4.6	4.2	4.2	4.0	4.2 B	18.4	21.0	15.9	23.0	19.6 A
E4	4.1	4.0	4.0	3.6	3.9 B	17.7	19.6	15.1	20.7	18.3 B
E5	4.7	4.5	4.9	5.1	4.8 A	14.8	17.0	18.9	16.8	16.9 D
E6	4.1	4.5	4.3	4.4	4.3 B	21.0	17.0	15.3	20.9	18.6 B
E7	4.7	4.2	4.2	4.1	4.3 B	19.7	17.8	19.5	16.0	18.2 B
E8	3.8	3.8	4.2	4.3	4.0 B	19.5	16.6	16.0	19.3	17.8 C
MD	4.3 a	4.2 b	4.3 a	4.4 a		18.8 b	18.7 b	17.4 c	19.3 a	
CV	17.83%					8.09%				
	Commercial vase life (days)					Accumulated absorption of preservative solutions (mL g <sup>-1</sup> of fresh mass)				
E1	10.5 Ca*	9.0 Bb	8.3 Dc	10.5 Ba	9.6	0.33 Ca*	0.21 Cb	0.28 Bb	0.28 Bb	0.28
E2	9.0 Db	9.0 Bb	12.0 Ba	11.3 Ba	10.3	0.34 Cc	0.27 Cc	0.41 Ab	0.55 Aa	0.39
E3	9.8 Cb	8.3 Bc	10.5 Ca	9.0 Cb	9.4	0.38 Ca	0.30 Ca	0.34 Ba	0.35 Ba	0.34
E4	14.5 Aa	14.3 Aa	12.0 Bb	11.5 Bb	13.1	0.33 Cb	0.25 Cb	0.40 Aa	0.30 Bb	0.32
E5	12.0 Bc	14.3 Ab	15.0 Aa	15.0 Aa	14.1	0.53 Ba	0.47 Bb	0.45 Ab	0.47 Bb	0.48
E6	12.0 Bb	14.3 Aa	9.0 Cc	10.5 Bc	11.4	0.79 Aa	0.47 Bc	0.48 Ac	0.65 Ab	0.60
E7	8.8 Db	9.0 Bb	10.8 Ca	10.5 Ba	9.8	0.58 Bb	0.65A a	0.42 Ab	0.58 Ab	0.56
E8	9.8 Cb	9.0 Bb	11.3 Ba	11.5 Ba	10.4	0.41 Cc	0.74 Aa	0.53 Ab	0.58 Ab	0.57
MD	10.8	10.9	11.1	11.2		0.46	0.42	0.41	0.47	
CV	16.02%					41.81%				

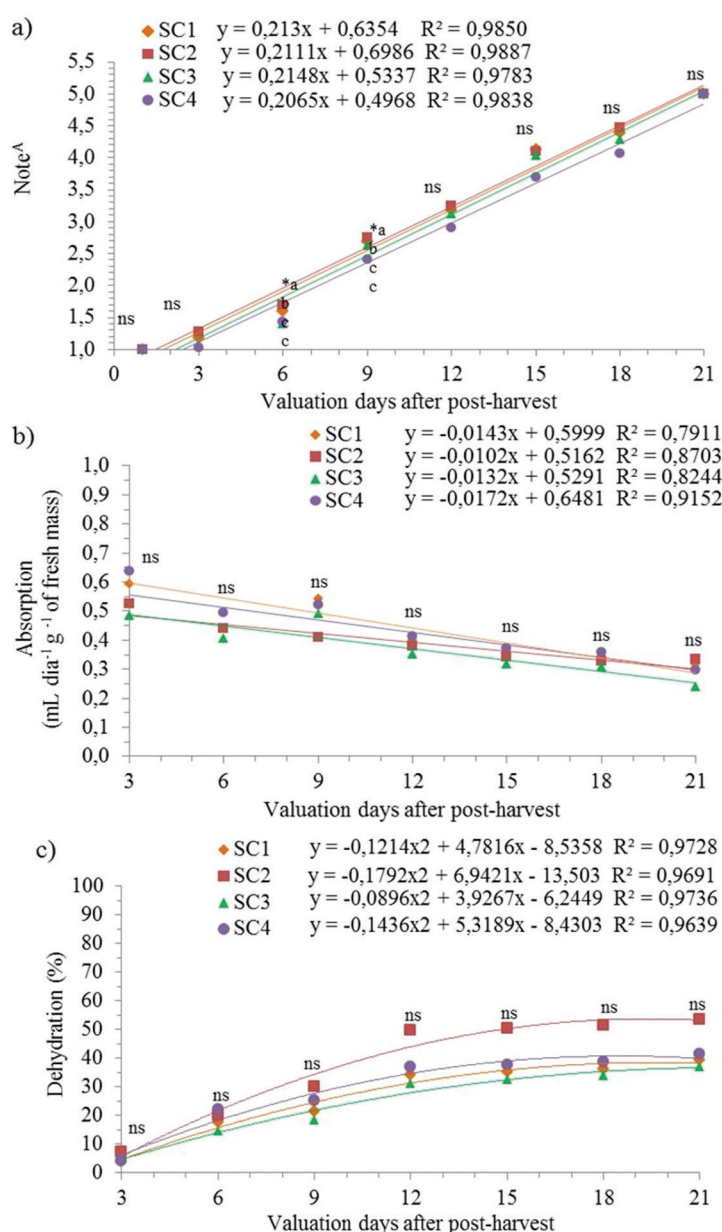
\* Significant interaction and non-significant interaction of factors. Test of averages not followed by the letter, uppercase in the column and lowercase in the row; differ by the Scott-Knott test (5% error). MD: average. CV: coefficient of variation. E1: sowing performed in winter of 2016 and harvesting of flower stems 105 days after sowing (DAS); E2: sowing performed in the spring of 2016 and harvesting of the floral stems 70 DAS; E3: sowing performed in the summer of 2016 and harvesting of the floral stems 61 DAS; E4: sowing performed in autumn 2017 and harvesting of flower stems 109 DAS; E5: sowing performed in the winter of 2017 and harvesting of the floral stems 95 DAS; E6: sowing in the spring of 2017 and harvesting of the floral stems 69 DAS; E7: sowing in the summer of 2017 and harvesting of the floral stems 68 DAS; E8: sowing performed in the autumn of 2018 and harvesting of the floral stems 120 DAS. SC1: distilled water (control); SC2: distilled water + 2% sucrose; SC3: distilled water + 2% sodium hypochlorite and SC4: distilled water + 2% sucrose + 2% sodium hypochlorite.

The commercial vase life of floral stems of safflower with healthy and marketable aspect occurs until the same reach three score (Table 1 and Figure 1), thus, we observed that there was significant interaction of the tested factors, and that the durability of these stems vary from eight and 15 days of vase life (Figure 2a). We verified that in average the preservative solutions vary little in the period of vase life, in relation to the different seasons of harvest, highlighting the season E5 (sowing performed in the winter of 2017 and harvest of the floral stems 95 DAS) with average durability of 15 days, with full opening of all the inflorescences.

Paiva and Almeida (2014) report that the durability of floral stems of safflower varies from 6 to 8 days of vase life in preservative solution. However, the score scale

use for the quality of floral stems of safflower allowed quantifying the minimum period of eight days after harvest, for that these stems can reach the consumer with quality. In post-harvest experiment with floral stems of sunflower (*Helianthus annuus* L.), Curti et al. (2012) point the score scale necessity for qualifying the durability and vase life, corroborating with the results of the present work.

The quality post-harvest of the floral stems of safflower was evaluated until the 21<sup>st</sup> day obtaining score 5, moment of disposal of the same by the final consumer. Considering, in general, that the commercialization of cut flowers occurs until seven days after harvest, this indicates that the preservative solutions used in this work were efficient for extending the vase life of floral stems of safflower with quality, until 15 days after the harvest.



**Figures 2.** Progressive means of the quality notes, the absorptions of the preservative solutions and the dehydration of *C. tinctorius* post-harvest floral stems evaluated at 3, 6, 9, 12, 15, 18 and 21 days after the beginning of the process post-harvest (DPC).

The quality score was also evaluated 24 h after harvest (a DPC). \* significant effect and <sup>ns</sup> non-significant effect of the averages of preservative solutions as a function of post-harvest evaluation days. SC1: distilled water (control); SC2: distilled water + 2% sucrose; SC3: distilled water + 2% sodium hypochlorite and SC4: distilled water + 2% sucrose + 2% sodium hypochlorite.

Castro et al. (2014) and Sanches et al. (2017) point that the longevity of floral stems is directly related to the stage of development of the flowers in the harvest, that is, the opening point, in which the more the flower bud is open, the lower will be its durability in vase, in virtue of the acceleration of metabolic process of breathing, being necessary the use of preservative solutions for maintaining the floral quality by a greater period of time.

We observed that the opening point of central inflorescence partially open (Figure 1b, 1c, 1g) qualifies visually the aesthetics of the floral stem of safflower, allowing its commercialization by a greater period in virtue of the greatest number of inflorescences open with the passage of the days, without damage to the durability of the same, as verified in Table 2.

Bellé et al. (2004) reported that the point of floral opening or of harvest is the stage in which the flower can be completed with its collocation only in water, since that the plant presents good reservations and conditions of adequate temperature, corroborating with the results of this work. Castro et al. (2014) and Cordeiro et al. (2011) verified that calla lily (*Zantedeschia aethiopica* (L.) Spreng.) and rose species (*Rosa x hybrida*), respectively, can be collected precociously, before the full floral opening without prejudice to the durability of vase life.

The average of accumulated absorption of preservative solution was of 0.442 mL g<sup>-1</sup> of fresh mass, corresponding to 0.021 mL day<sup>-1</sup> g<sup>-1</sup> of fresh mass (Table 2). In Figure 2b, we observed that there is a greater absorption of preservative solutions by the floral stems until 9 DPC and from 12 DPC there was reduction of absorption, remaining

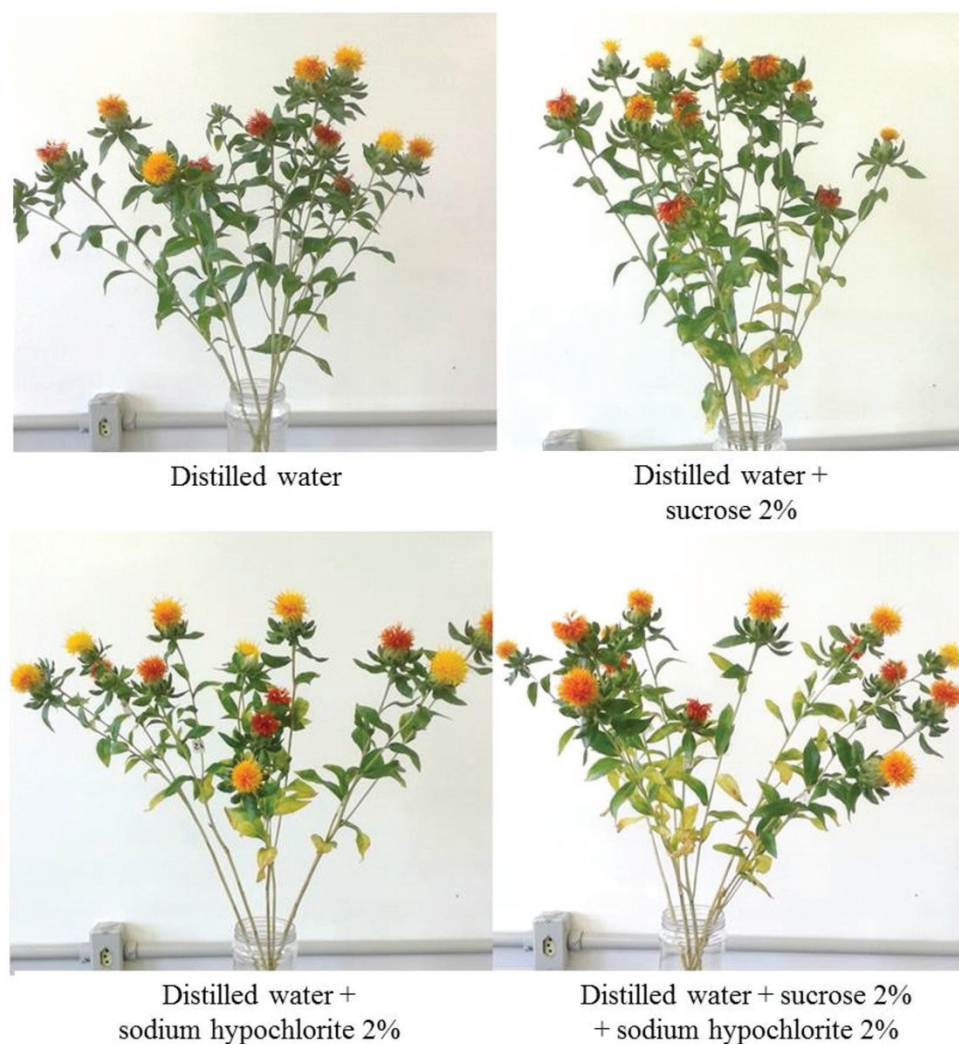
constant until the end of the preservation process in post-harvest (21 DPC).

Similar results to this experiment were verified in the work by Antes et al. (2009) with rose stems, in this case the reduction of absorption of preservative solutions was at 7 DPC. Spricigo et al. (2012) verified absorption decrease of solutions of chrysanthemum stems (*Dendranthema grandiflora* Tzvelev.) from 3 DPC, and durability of stems until 12 DPC. However, Schmitt et al. (2014) studying post-harvest of cut gerberas (*Gerbera jamesonii* Adlam) do not verify difference in absorption of different preservative solutions used.

The Figure 2c, presents the progressive dehydration of floral stems of safflower submitted to the different preservative solutions, and we observed that the fresh mass loss in percentage was increasing with the passage of the period in preservation. We verified a similarity in the dehydration process of the stems in all the tested preservative solutions and also for the different harvest seasons.

The general average of fresh mass loss of the floral stems of safflower after 24 h of cooling was of 2%, being this gradual average loss of 8.8%; 27.9%; 31.5%; 40.9%; 42.9%; 44.9% and 47.7% for all the evaluations on the days 3, 6, 9, 12, 15, 18 and 21 DPC, respectively. We observed that until 12 DPC there was an increasing dehydration of the floral stems of safflower and after this period, a small variation in the fresh mass loss occurred.

The withering and yellowing of the leaves, in general, began after nine days of preservation, and it was accentuated from 15 days, period that also the senescence of the central inflorescences of floral stem of safflower intensified, presenting score three (Figure 3) of quality scale aforementioned. Evidences of senescence similar to the one of this work were verified by Bellé et al. (2004) for chrysanthemum from 10 days of preservation post-harvest in different solutions and, Sanches et al. (2017) verified evidences of senescence of calla lily from 8 days of preservation in solutions for floral opening.



**Figure 3.** Final commercial quality of *C. tinctorius* flower stems preserved in post-harvest in different solutions.

In relation to the efficiency of the preservative solutions, we observed that the mass loss of floral stems of safflower preserved in solution of distilled water + sucrose 2% was the one that obtained the greatest acceleration of deterioration in comparison to the other ones, reaching loss on average of 46% at six days of preservation for all the seasons. Wills et al. (1998) and Reid and Jiang (2012) point that the flowers have high rates of breathing through glycolysis and citric acid cycle, based on translocation of sugar of flowers, requiring sucrose or a source of carbohydrates to continue their vital functions, specially, the breathing, extending the longevity post-harvest of the floral stems, however, each species requires a specific quantity for its preservation. Ciotta and Nunes (2012) did not verify positive effect in durability of stems (*Photinia x fraseri*) for the concentrations of 0, 5%, 10%, 15% and 20% of sucrose.

We observed visual that the solutions having sodium hypochlorite presented yellowing of leaves and whitening of stems anticipated in relation to the solution with only distilled water and with sucrose. This effect was observed in all the harvest seasons, probably, the concentration of

solution with 2% of sodium hypochlorite, is elevated to the maintenance of floral stems of safflower. Almeida et al. (2009) using maintenance solution with 0.2% of sodium hypochlorite for floral stems of roses did not verify benefits in post-harvest. Nevertheless, Wills et al. (1998) indicate the use of sodium hypochlorite because it is a germicide of low cost, inhibiting with efficiency the bacterial infections in the conducting vessels that prevent the absorption of water.

In general, we verified that the individual use or in set of sucrose at 2% and sodium hypochlorite 2%, had the same tendency in preservation of floral stems of safflower preserved only with distilled water (Figure 2a). Wills et al. (1998) and Reid and Jiang (2012) point that the ingredients used in preservative solutions can be beneficial for some species and for the others, they are not. For example, Schmitt et al. (2014) verified that the use of commercial floral preservatives did not benefit the longevity of floral stems of cut gerbera post-harvest.

At 21 days in post-harvest for both the seasons, we verified that the average of mass loss was of 39.3%; 53.6%; 37.1% and 41.5% for the preservative solutions of



SCI (distilled water), SC2 (distilled water + sucrose 2%), SC3 (distilled water + sodium hypochlorite 2%) and SC4 (distilled water + sucrose 2% + sodium hypochlorite 2%), respectively. Almeida et al. (2011) and Sanches et al. (2017) report that the fresh mass loss is a natural metabolic process of the floral stem in virtue of the senescence process and that the progression of dehydration of these stems occurs, also, according to the preservation of its nutritional reservations.

The Figure 3 demonstrates the final commercial quality of floral stems of safflower in different preservative solutions when they presented score three (Table 1). From this score of quality it is not recommended to the commercialization of floral stems in virtue of the beginning of the senescence process of the same, given by the yellowing and withering of leaves.

In relation, the production of floral stems of safflower, we observed the possibility of annual cultivation with ornamental and aesthetic characteristics demanded by the floricultural market. The period of cultivation cycle among the seasons of sowing and harvested are variable, in average of 100 days after sowing (DAS) in winter, 69 DAS in spring, 64 DAS in summer and 114 DAS in autumn. This occurs due to the safflower species be responsive to thermal sum, mainly, in regions where there are the seasons of the year well defined.

## Conclusions

The use of techniques of preservation in post-harvest assisted positively the maintenance of floral stems of safflower (*Carthamus tinctorius* L.), with average vase life of nine days. And, the maintenance of floral stems quality is contemplated only with the use of distilled water, without the necessity of preservatives.

## Author Contribution

JFM<sup>0000-0001-6053-4221</sup>: planning, experiment execution, collection and interpretation of data, statistics and writing. HFL<sup>0000-0002-4522-0408</sup>: experiment execution, collection and interpretation of data. RAB<sup>0000-0001-6704-417X</sup>: planning, statistics and orientation. SJL<sup>0000-0002-7117-541X</sup>: planning and statistics. FAALB<sup>0000-0003-1064-7847</sup>: planning and orientation. URN<sup>0000-0002-7124-9204</sup>: orientation, interpretation of data and writing.

## Acknowledgements

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 University of Santa Maria (UFSM).

## References

ALMEIDA, E.F.A.; PAIVA, P.D.O.; LIMA, L.C.O.; PAIVA, R. Senescência de inflorescências de copo de leite: Influência de diferentes armazenamentos e procedimentos pós-colheita. **Revista Brasileira de Horticultura Ornamental**, v.15, n.1, p.71-76, 2009. DOI: 10.14295/rbho.v15i1.437

ALMEIDA, E.F.A.; PAIVA, P.D.O.; LIMA, L.C.O.; SILVA, F.C.; FONSECA, J.; NOGUEIRA, D.A. Calla lily inflorescences postharvest: pulsing with different sucrose concentrations and storage conditions. **Ciência e Agrotecnologia**, v.35, n.4, p.657-663, 2011. DOI: 10.1590/S1413-70542011000400003

ANTES, R.B.; MONTERO, C.R.S.; RIETH, S.; DUARTE, V.; BENDER, R.J. Bloqueio vascular de hastes de gérbas cv. 'Patrizia'. **Revista Biotemas**, v.22, p.1-7, 2009. DOI: 10.5007/2175-7925.2009v22n2p1

BELLÉ, R.A.; MAINARDICÂMARA, J.C.C.; MELLO, J.B.; ZACHET, D. Abertura floral de *Dendranthema grandiflora* Tzvelev. 'Bronze Repin' após armazenamento a frio seguido de "pulsing". **Ciência Rural**, Santa Maria, v. 34, n. 1, p. 63-70, 2004. DOI: 10.1590/S0103-84782004000100010

BELLÉ, R.A.; ROCHA, E.K.; BACKES, F.A.A.L.; NEUHAUS, M.; SCHWAB, N.T. Safflower grown in different sowing dates and plant densities. **Ciência Rural**, v.42, n.12, p.2145-2152, 2012. DOI: 10.1590/S0103-84782012005000106

CASTRO, M.L.R.; PAIVA, P.D.O.; LANDGRAF, P.R.C.; PEREIRA, M.M.A.; SOUZA, R.R. Estádio de abertura floral e qualidade pós-colheita em armazenamento de copo-de-leite. **Revista Brasileira de Horticultura Ornamental**, v. 20, n. 2, p.131-136, 2014.

CIOTTA, M.N.; NUNES, E.C. Rendimento, qualidade e longevidade de hastes de *Photinia fraseri*. **Revista Brasileira de Horticultura Ornamental**, v.18, n.2, 2012, p.141-146, 2012. DOI:

COOPERATIVA VEILING HOLAMBRA. Padrão de qualidade. **Cartamus de corte**. Holambra: Cooperativa Veiling Holambra, 2016. 4p.

CORDEIRO, C.D.; FINGER, F.L.; SANTOS, J.S.; KARSTEN, J. BARBOSA, J.G. Sensibilidade da rosa 'Osiana' ao etileno. **Bragantia**, v.70, n.3, p.677-681, 2011. DOI: 10.1590/S0006-87052011000300025

CORONADO, L.M. **El cultivo del cártamo (*Carthamus tinctorius* L.) en México**. Ciudad Obregon: SGI, 2010. 96p.

CURTI, G.L.; MARTIN, T.N.; FERRONONATO, M.L.; BENIN, G. Girassol ornamental: caracterização, pós-colheita e escala de senescência. **Revista de Ciências Agrárias**, v.35, n.23, p.240-250, 2012.

EMONGOR, V.; OAGILE, O. **Safflower production**. Botswana: The Regional Universities Forum for Capacity Building in Agriculture – RUFORUM, 2017. 67p.

- FERREIRA, D.F. Sisvar: A guide for its bootstrap procedures in multiple comparisons. **Ciência e Agrotecnologia**, v.38, n.2, p.109-112, 2014. DOI:10.1590/S1413-70542014000200001.
- HALEVY, A.H.; MAYAK, S. Senescence and postharvest physiology of cut flowers. Part 2. **Journal of Horticultural Reviews**, v.3, p.59-143, 1981.
- JUNQUEIRA, A.H.; PEETZ, M.S. Brazilian consumption of flowers and ornamental plants: habits, practices and trends. **Ornamental Horticulture**, v.23, n.2, p.115-120, 2017. DOI: 10.14295/oh.v23i2.1070
- KINUPP, V.F.; LORENZI, H. **Plantas alimentícias não convencionais (PANC) no Brasil** – guia de identificação, aspectos nutricionais e receitas ilustradas. Nova Odessa: Instituto Plantarum, 2014. 768p.
- MOTA, F.S., BEIRSDORF, M.C.I.; GARCEZ, J.R.B. **Zoneamento Agroclimático do Rio Grande do Sul e Santa Catarina**. Pelotas: IPEAS, 1971. 80p.
- PAIVA, P.D.O.; ALMEIDA, E.F.A. **Produção de flores de corte**. Lavras: UFLA, 2014, v.2. 819p.
- REID, M.S.; JIANG, C.Z. Postharvest biology and technology of cut flowers and potted plants. In: JANICK, J. **Horticultural Reviews - volume 40**. New Jersey: Wiley-Blackwell. 2012. 1-54p.
- SANCHES, A.G.; SILVA, M.B.; MOREIRA, E.G.S.; COSTA, J.M.; COSME, S.S. Relação entre o estágio de abertura floral e *pulsing* a vida útil de copo de leite. **Revista de Agricultura Neotropical**, v.4, n.3, p.9-14, 2017. DOI: 10.32404/rean.v4i3.1400
- SANTOS, R.F.; SILVA, M.A. *Carthamus tinctorius* L.: Uma alternativa de cultivo para o Brasil. **Acta Iguazu**, v.4, n.1, p. 26-35, 2015.
- SCHMITT, F.; MILANI, M.; DUARTE, V.; SCHAFER, G. BENDER, R.J. Conservantes florais comerciais nas soluções de manutenção de hastes florais de gébera de corte. **Ciência Rural**, v.44, n.12, p.2124-2128, 2014. DOI: 10.1590/0103-8478cr20120750
- SONEGO, G.; BACKMANN, A. Conservação de pós-colheita de flores. **Ciência Rural**, v. 25, n. 3, p.473-479, 1995. DOI: 10.1590/S0103-84781995000300026
- SPRICIGO, P.C.; FERREIRA, M.D.E; CALBO, A.G. Turgescência de crisântemos após a colheita utilizando o equipamento Wiltmeter®. **Ciência Rural**, v.42, n.2, p.255-260, 2012. DOI: 0.1590/S0103-84782012000200012
- VAN DOOR, W.G. Role of carbohydrates in flower senescence: a survey. **Acta Horticulturae**, v.543, p.179-183, 2001. DOI: 10.17660/ActaHortic.2001.543.21.
- WILLS, R.; LEE, T.; GRAHAM, D. **Postharvest: an introduction to the physiology and handling of fruit, vegetables and ornamentals**. Sydney: UNSW Press, 1998. 262p.