Heliconia 'Golden Torch' postharvest: stem ends cutting and renewing vase water benefits[1]

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ABSTRACT

The postharvest longevity is one of the main aspects that should be considered in the production of cut flowers and is a pre-requisite for product quality and marketing success. However, cut flowers are highly perishable products that need to be treated and stored to maintain its quality and value. This study aimed to assess *Heliconia psittacorum* 'Golden Torch' inflorescences postharvest longevity, submitted to periodic stem ends cutting and vase water renewal. The experimental design was a completely randomized 3x2 factorial, corresponding to the stem ends cuts (1,0 cm; without cutting; cutting at 24 hours; cutting at 48 hours) and water renewal (with and without renewal), with four repetitions. The assessed variables were: water uptake by flower stems (WUFS); loss of fresh stem mass (LFSM); dry matter of flower stems (DMFS) and postharvest longevity (PHL). The stem cut significantly influenced WUFS and LFSM. However, the water renewal factors affected all variables, while the interaction between factors (stem cuts x water renewal) only influenced PHL. The cuts at the stem base of *Heliconia* 'Golden Torch' procedures enable the restoration of water potential and this practice, associated with water renewal during storage allows greater tissues hydration, maintaining the postharvest quality.

Keywords: Cut flowers, vessels obstruction, postharvest quality.

RESUMO

Pós-colheita de helicônia 'Golden Torch': benefícios do corte na base da haste e renovação da água de vaso

A longevidade pós-colheita é um dos aspectos mais relevantes da produção de flores de corte e é pré-requisito para qualidade do produto e o sucesso na comercialização. No entanto, as flores de corte são produtos altamente perecíveis que necessitam serem tratadas e armazenadas de forma a manter sua qualidade e valor. O objetivo deste estudo foi avaliar a durabilidade pós-colheita de inflorescências de *Heliconia psittacorum* 'Golden Torch' submetidas a cortes periódicos na base das hastes e renovação da água de vaso. O delineamento foi o inteiramente casualizado, arranjado em esquema fatorial (3 x 2), correspondentes aos cortes (1,0 cm) na base das hastes (sem corte; corte a 24h; corte a 48h) e renovação de água (com e sem renovação), com quatro repetições. As variáveis avaliadas foram: absorção de água pelas hastes florais (WUFS); perda de massa fresca das hastes florais (LFSM); massa seca das hastes florais (DMFS) e longevidade pós-colheita (PHL). Os cortes realizados na base das hastes florais influenciaram significativamente na AAHF e PMFHF. No entanto, o fator renovação de água apresentou efeito sobre todas as variáveis analisadas, enquanto que a interação entre os fatores (cortes na base x renovação de água) influenciaram apenas a POSC. A utilização de cortes na base das hastes florais de helicônia 'Golden Torch' possibilitou o restabelecimento do potencial hídrico e essa prática associada à renovação da água durante o armazenamento permite maior hidratação dos tecidos, mantendo a qualidade de vida pós-colheita.

Palavras-chave: floricultura de corte, obstrução de vasos, qualidade pós-colheita.

1. INTRODUCTION

Floriculture is one of the most important economic activities in the Brazilian agribusiness. In this sector, the marketing of flowers and cut foliage ranks second, increasing its percentage rate of approximately 31.4% in 2008, to 34.3% in 2013 (UNEMOTO et al., 2012). This improvement reflects a good market acceptance, along with ideal growing conditions in Brazil, which enable the production of flowers and ornamental plants of excellent quality, representing a good opportunity for Brazil to expand its agricultural frontiers, increasing the capacity to generate employment and income in rural areas (JUNQUEIRA and PEETZ, 2014; ALBUQUERQUE et al., 2014).

Heliconia are cut flowers with exotic beauty, diversity of colors and shapes, resistance to handling and transport, and long postharvest life (RODRIGUEZ, 2013; SOUZA et al., 2016). Among them, the hybrid *Heliconia psittacorum* L. x *Heliconia spathocircinata* Arist. 'Golden Torch' are highlighted because of their high productivity, year-round production, and high marketing potential worldwide (CASTRO et al., 2007; COSTA et al., 2007). However, it

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is important to observe that postharvest longevity is among the most important aspects in the production of cut flowers, since it is directly related to quality and success of the crop marketing (CASTRO et al., 2007).

Cut flowers are highly perishable products that need to be properly handled and stored in order to maintain their value and quality. Quality can be naturally lost through senescence, chlorosis, stem bending, excessive desiccation and transpiration. Therefore, in order to extend the flower postharvest life and delay senescence, proper storage methods should be followed. A humid storage environment is widely used, since the product will not need to be packaged to maintain tissue turgor and reduce desiccation. On the other hand, the storage of stems in a humid environment increase the chances of contamination and xylem vessels blocking, caused by microbial contamination, and the formation of air bubbles (embolism). Vessel blocking develops a negative potential equilibrium, where in water absorption is lower than the loss, causing water stress and reducing postharvest life (AHMAD et al., 2012).

Stem of various species of *Heliconia* showed water imbalance in transportation due to reduced water consumption, causing premature folding of leaves and bracts discoloration resulting from vascular occlusions of unknown nature (VAN DOORN, 1999; GUIMARÃES et al., 2010). One of the techniques used to mitigate the effects of water stress is to recut the stem ends into floral preservative solutions, restoring stems normal water potential and allowing greater tissue hydration (BROSCHAT and DONSELMANN, 1988; AHMAD et al., 2012; VIEIRA et al., 2013). However, no information about maintaining postharvest quality of *Heliconia* related to this type of intervention is available. On the other hand, there are several studies with this species submitted to different postharvest treatments (CASTRO et al., 2007; RIBEIRO et al., 2010; COSTA et al., 2011; GUIMARÃES et al., 2014; AMARAL et al., 2015; SOUZA et al., 2016).

There is an increase interest regarding postharvest surveys on cut flowers. Moreover, according to Junqueira and Peetz (2014), the professionalization in the postharvest area stands out among the main challenges for Brazilian floriculture growers. In this context, this study aimed to evaluate the *Heliconia psittacorum* 'Golden Torch' inflorescences postharvest longevity, with cutting of stem ends and vase water renewal.

2. MATERIAL AND METHODS

Flower stems of *Heliconia* 'Golden Torch' were harvested in January 2013 at an experimental production area located in the municipality of Bom Jesus-PI, Brazil (latitude 09º04'28'' S, longitude 44º21'31'' W and altitude 277 m). Harvest was realized during the early hours of the day, aiming the maintenance of stem hydration and avoiding exposure to excessive heat (LOGES et al., 2005). The harvest stage was determined when inflorescences contained two open bracts.

After harvest, the stems were immediately taken to the Laboratory of Plant Growth Analysis on Campus Professora Cinobelina Elvas (CPCE) of Universidade Federal do Piauí (UFPI), where they were washed, standardized (35 cm long, without considering the inflorescences, by cutting the basal portion). The stems were then tagged, weighed and randomly packed into vessels containing 500 mL water, considering the maintenance solution (pH 6.54 and EC 0.02 dS m^{-1}) and sealed with PVC film around the stems to prevent water evaporation, being submitted to different treatments: stem end cut (each cut with 1 cm) -without cutting, cutting every 24 hours and cutting every 48 hours - and renewal of maintenance water [with renewal (water measured, discarded and renewed every two days) and without renewal (water measured and supplemented when necessary, every two days)].

The stems were kept in a room under controlled temperature conditions (25 ± 2 °C) and with average relative humidity of approximately 60%, with lighting provided for 24 hours by cold fluorescent lamps (General Electric F400 Extralife, 40W).

During the experiment, the following parameters were evaluated: **1) Water uptake by flower stems (WUFS):** determined by weighing the containers with the maintenance solution, not considering the flower stems; **2) Loss of fresh stem mass (LFSM):** the stems were always weighed at the same time and kept out of the vase water for the shortest period of time (20-40s) possible. The initial fresh mass of inflorescences was obtained and, subsequently, new weight measurements were carried out every two days to obtain the fresh matter reduction of flower stems at the end of the experiment. All cutted material (each cut = 1 cm) was weighed in a scale with 0.001 g of precision (Bioprecisa®) and added at the end of evaluations; **3) Dry matter of flower stems (DMFS):** the evaluation was made after the evaluation of postharvest longevity, by drying the material in an oven at 70 °C until constant weight. The samples were weighed in a scale with 0.001g of precision (Bioprecisa®); **4) Postharvest longevity (PHL):** daily assessment, obtained by the average number of days until it achieved the score two. The scores were based on standards set by Castro et al. (2007), where: Score 0 (zero) = assigned to excellent general appearance (newly harvested); Score 1 (one) = assigned to good general appearance (signs of senescence little characteristic, with brightness loss) and Score 2 (two) = assigned to regular general appearance (beginning of wilting or discreet bract browning).

The experimental design was completely randomized and the treatments were arranged in a factorial scheme 3 x 2 (cuts at the base x water renewal), with four repetitions and three stems per experimental plot. The data were submitted to variance analysis for diagnosis of significant effects by the "F" test and, and when significant, the treatment means were compared by Tukey's test ($P < 0.05$). Analyses were performed with the aid of the SISVAR software (FERREIRA, 2014).

3. RESULTS AND DISCUSSION

The use of periodic cuts at the stem base of 'Golden Torch' significantly influenced both WUFS and LFSM variables. However, the water renewal factor (with and without renewal) showed significant effect on all variables, while the interaction between factors (cuts at the base x water renewal) only influenced PHL (Table 1).

Table 1. Water uptake by flower stems (WUFS), loss of fresh stem mass (LFSM), dry matter of flower stems (DMFS) and postharvest longevity (PHL) of *Heliconia psittacorum* x *H. spathocircinata* 'Golden Torch' inflorescences, as a function of cuts stem ends and vase water renewal.

Source of variation	***WUFS mL***	***LFSM mg***	***DMFS mg***	***PHL days***
Stem base cuts	5.15*	22.3**	0.60 ns	0.97 ns
Water renewal	53.3**	11.1**	0.0**	29.2**
Cutting x Water renewal	1.42 ns	3.0 ns	0.36 ns	12.0**
CV %	6.2	24.0	14.7	5.3

* Significant ($p \leq 0.05$); ** Significant ($p \leq 0.01$); ns - not significant according to F test.

Water renewal showed the best results. Flower stems submitted to water renewal showed higher WUFS (331.3 mL), with lower LFSM (9.77 mg), resulting in an increase of DMFS and, consequently, higher PHL (14.1 days), while the stems that remained in the same solution without water renewal presented lower WUFS (274.8 mL), with a higher LFSM (13.6 mg) and lower values of DMFS and PHL (12.5 days) (Table 2).

Table 2. Water uptake by flower stems (WUFS), loss of fresh stem mass (LFSM), dry matter of flower stems (DMFS) and postharvest longevity (PHL) of *Heliconia psittacorum* x *H. spathocircinata* 'Golden Torch' inflorescences, as a function of vase water renewal.

Renewal water	***WUFS mL***	***LFSM mg***	***DMFS mg***	***PHL days***
Without renewal	274.8 b	13.6 a	10.0 b	12.5 b
Renewal	331.3 a	9.77 b	11.4 a	14.1 a
DMS	16.2	2.41	1.2	0.6

Means followed by the same letter in the column do not differ by Tukey's test ($p \leq 0.05$).

These results are in agreement with those obtained by Amaral et al. (2015), who aimed to evaluate the postharvest performance of 'Golden Torch' submitted to the supply of water as a maintenance solution, with and without water renewal, and obtained the best results with water renewal.

Water supply for flower stems is apparently a simple task, since the solution establishes a direct contact with the vessels, without the need to overcome root tissues (REID and JIANG, 2012). However, in practice, absorption is frequently interrupted by cavitation and obstructions caused by the accumulation of substances or the presence of microorganisms (WANG et al., 2014). The results obtained in this study indicated that the practice of water renewal of the maintenance solution, provided a higher postharvest longevity of 'Golden Torch' stems, interrupting the development cycle of possible microorganisms presented in the water used (tap water), since no substance with germicide action was added to the solution.

Periodic cuts at the stem base, considered in isolation, caused a reduction of up to 10% in WUFS (Figure 1A). It was also observed that the lower water absorption, associated with the cut at the stem base, resulted in approximately 200% of fresh matter loss (Figure 1B). Therefore, the results obtained in this study indicated that the cut at the stem base decreases water absorption and, consequently, increases fresh matter loss. Fresh matter loss is usually related to an imbalance between absorption and water loss which, in turn, are responsible for maintaining turgidity in plant tissues (FINGER et al., 2008).

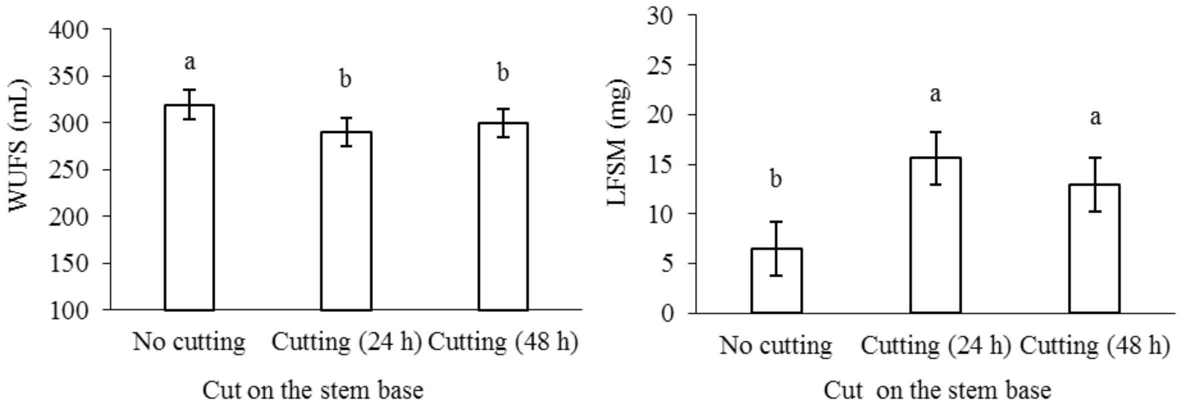

Figure 1. Water uptake by floral stems (A) and loss of fresh stem matter (B) of *Heliconia psittacorum* x *H. spathocircinata* 'Golden Torch', as a function of cutting. Means followed by the same letter do not differ by Tukey's test ($p \leq 0.05$) and vertical bars represent means standard errors.

Performing cuts at the stem base has been mentioned in several studies as a method effective to remove embolism and blockages, preventing cavitation (VIEIRA, 2013). However, it is not always feasible for some species, since cutting can trigger a cascade of physiological events associated with the wound which, in turn, induce ethylene synthesis and activation of enzymes involved in the biosynthesis of lignin and other substances that are accumulated in the vessel cell wall, causing their obstruction and, therefore, water absorption is strongly affected (SILVA et al., 2009; WANG et al., 2014). Thus, the obtained results suggest that performing periodic cuts, analyzed in isolation, in the postharvest of 'Golden Torch' flower stems, causes a decrease in water absorption, with consequent fresh matter loss, associated with its postharvest longevity.

Regarding the interaction between the factors cuts at the stem base and water supply, there was a significant effect only for PHL, indicating the existence of a dependent relationship between the two factors (Figure 2). The water supply method (with renewal and without renewal) had no effect when the stems were not submitted to cuts at the base (every 24 and 48 hours). However, postharvest longevity was higher for treatments corresponding to water renewal associated with periodic cuts (24 and 48 hours) at the stem base.

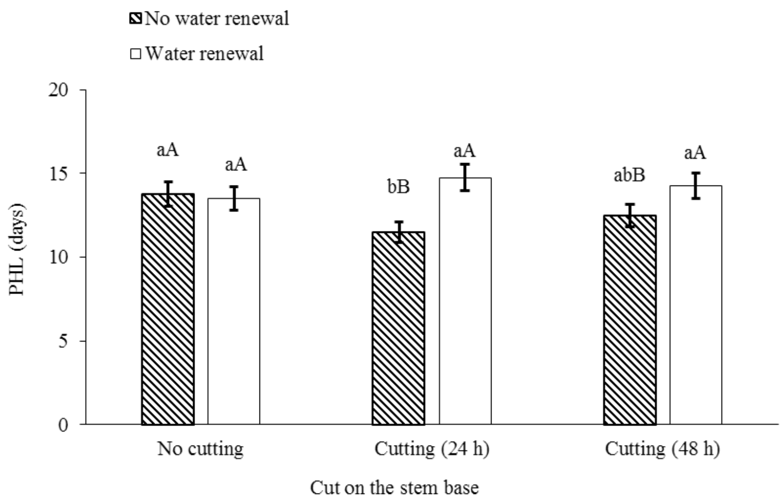

Figure 2. Postharvest longevity of *Heliconia psittacorum* x *H. spathocircinata* 'Golden Torch' inflorescences as a function of stem base cuts and water supply. Means followed by the same uppercase letter do not differ according to Tukey's test ($p \leq 0.05$) in the treatments with cuttings at the stem base, while means followed by the same lowercase letter do not differ in the treatments with and without water renewal. Vertical bars represent means standard errors.

This result may be related to the obstruction of xylem vessels caused by microbial contamination or accumulation of substances induced by cutting. Once the obstruction of xylem vessels occurs, water balance in the stems is impaired; under these conditions, transpiration continues and water absorption is limited, causing water stress which, in turn, causes premature loss of turgor in organs and, consequently, a reduction in the postharvest life of stems. On the other hand, the removal of obstructed areas, performed by periodic cuts at the base of stems submerged in water, may alleviate or even reverse the water status of the stems, restoring their normal water potential (AHMAD et al., 2012; VIEIRA et al., 2013).

Therefore, water renewal during storage of 'Golden Torch' flower stems, associated with periodic cuts at the stem base, may increase PHL, since water renewal interrupts the cycle of microorganisms, and the removal of the occluded area provided by periodic cuts, restores the normal water potential of the stems, allowing greater water absorption for the maintenance of metabolic activities and turgor pressure in the tissues, which will extend their postharvest life.

It is observed that the rehydration of flower stems after harvest is an important practice, since it restores tissue turgor and performing periodic cuts at the stem base does not always enable the maintenance of postharvest quality. However, by the results obtained in this study, it is clear that the use of cuts at the stem base of 'Golden Torch', enables the water potential restoration and this practice, associated with water renewal during storage can lead to more tissue hydration, maintaining postharvest quality.

4. CONCLUSIONS

Water renewal during storage is efficient to maintain the postharvest quality of *H. psittacorum* 'Golden Torch' flower stems.

Periodic cuts, every 24 hours, associated with water renewal during storage of *H. psittacorum* 'Golden Torch' flower stems, provides greater postharvest longevity.

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