Postharvest Handling of Cut Kniphofia (*Kniphofia uvaria* Oken 'Flamenco') Flowers

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Abstract

Cold storage and floral preservative treatments were evaluated in cut *Kniphofia uvaria* Oken 'Flamenco' flowering stems. Geotropic bending of the stems was strongly affected by the storage method. Stems wrapped in wet newspapers and polythene stored at 4 ºC showed better postharvest performances than 'dry' stored stems. Cut stems were placed in floral solutions (Standard vase solution (SVS), commercial floral preservatives (Chrysal, Flora, Flower fresh), A biocide (8-HQS), a biological extract (Biovin) or in tap water as a control. Fresh weight, vase life, flower colour, soluble solid concentration, osmotic potential and water uptake were noted during the vase period. Stems treated with Flora or Flower fresh produced the longest vase life (6.90 or 6.51 d respectively). No significant differences were observed for vase life of flowers placed in 8-HQS (4.86 d) and tap water (5.25 d) vases. Flowers in SVS, Biovin and tap water increased fresh weight up to day 3 and then it decreased throughout the remaining period. In contrast, flowers in Flora, Flower fresh and 8-HQS showed continuous increase in fresh weight until senescence. However, the differences between flowers in control (tap water) and floral preservatives for fresh weight were small and nonsignificant. Results suggest that stem osmotic potential, colour and flower soluble solid concentration are important factors in determining the vase life of *Kniphofia* flowers. For cold storage, flower stems wrapped in wet newspapers was the better option, as it reduced geotropic bending during the storage period and maintained good flower quality during the vase period.

INTRODUCTION

The cut flower industry worldwide is constantly researching postharvest flower quality in storage and in the vase period to organize market chain. Maintenance of optimum flower quality that will command premium prices on world floricultural markets can be varied according to environmental conditions and postharvest handling methods. *Kniphofia* is one of the specialty cut flowers, which have been growing in popularity with the floriculture industry and consumers for last several years.

Kniphofia uvaria is little known and there are apparently no published reports of its flower quality variation with various treatments. To meet consumer demand at export markets, it is necessary to study the postharvest quality of these flowers. Storing cut *Kniphofia* stems in coolers benefits the grower, wholesaler, and florists by extending the production season, allowing storage of excess production, improving production efficiency, and enabling shipment (Goszczynska and Rudnicki, 1988). Cut *Kniphofia* flowers are subjected to geotropic bending and should be shipped in a vertical position. This paper describes a series of experiments that investigate the cold storage to reduce geotropic bending and vase life evaluation with introducing flower preservative solutions under normal environmental conditions.

MATERIALS AND METHODS

The research was carried out in the experimental station field, cold storage unit and Institute of Fruit Growing and Horticulture laboratory of the University of Natural

Resources and Applied life Sciences, Vienna, Austria. At the University Experimental Station, flowers were harvested from cultivated plants in the field, placed immediately in buckets of water, and transported to the institute laboratory. Stems were recut under water to a length of 30 cm and were immediately placed in buckets with water before introducing vase solution treatments or cold storage.

Experiment 1 - Cold Storage

The effects of storage temperatures at 4 and 13 ºC on *Kniphofia* quality and longevity were studied. Cut flower stems were stored 'dry' (stems enclosed in polythene bags), wrapped in wet newspapers and then enclosed in polythene bags, or 'wet' (tap water containers) for 5 days at 4 and 13 ºC. In the wet storage method, the flowers were not packed in polythene bags. After cold storage, racemes were unwrapped, weighed, recut under water and placed in vases filled with tap water. Three stems per treatment, replicated three times were used for each treatment.

Experiment 2 - Vase Water Additives

Preparation of vase solutions was done according to the instructions on the commercial products and published recommendations using deionised water (van Meeteren et al. 2000). Vase solutions of Standard Vase Solution (SVS-$NaHCO_3$ 125 mg/l, $CaCl_2.2H_2O$ 99 mg/l, $CuSO_4.5H_2O$ 1.2 mg/l; van Meeteren et al. 2000), Chrysal (10 g/l) Flora (1 ml/l), Flower fresh (9 g/l), Biovin (1 ml/l) and 8-HQS (200 mg/l) were prepared using deionised water under room temperature. Laboratory tap water was used as a control treatment. A plastic vase (1000 ml capacity) was used to place cut flower stems, was filled with 500 ml of the desired vase water solution. Three freshly harvested flower racemes were taken as the experimental unit for a vase and three replicates were used for each treatment.

Vases were transferred to benches in a room at 20 ± 2 ºC, with a light level approximately 20 - 50 µmol $m^{-2}s^{-1}$ provided by cool white fluorescent tubes, and a 12 h photoperiod. Relative humidity varied from 45 to 55 % during the experimental period. Each vase had to be re-filled with the desired vase solution according to water consumption rate of flowers.

Assessments

In experiment 1, the percentage weight change and percentage bent stems during the storage period and vase life were measured. The end of vase life was defined as the time when flowers wilted, browned, had abscised, or had severely bent stems. Fresh weight, water uptake, transpiration, osmotic potential, soluble solid concentration and flower colour were assessed for treatments of experiment 2. The fresh weight of flower stems was measured daily until senescence. Average daily water uptake rate was calculated from daily measurements of the weight of the vases without flowers. Values were corrected for direct evaporation from the vases by substracting the volume of water evaporated from a vase of the same volume without flowers. Average daily transpiration rate was calculated from the combined weights of the flower and the vase. Soluble solid concentration (ºBrix) was determined, using extracts of crushed defrosted flowers in a mortar, using a hand-type refractometer (Atago, Japan). A Vapour Pressure Osmometer (Wescor, USA) was used to measure osmotic potential of defrosted samples at senescence.

The CIE *L*a*b** colour system (McGuire, 1992) was used to assess the colour of flowers with a Chroma meter CR-200b (Minolta, GmbH Ahrensburg, Germany, 1988). In all experiments, treatments were arranged according to a randomised complete block design. The data were analysed by GLM (SPSS, 11,0 version). Data were presented as means ± SE. Significant differences were assessed with the Tukey's HSD and correlation was determined by Pearson method at $P = 0.05$.

RESULTS

Experiment 1 - Cold Storage

The cut stems that were wrapped in wet newspapers and polythene and stored at 4 ºC showed significantly longer vase life (6.5 d) than the other treatments. Stems stored at 4 and 13 ºC either 'wet' or 'dry' method had no difference in vase life (Table 1). The vase life decreased with increasing temperature. Stem bending was least at 4 ºC. During storage, the weight loss was greater in flowers stored 'dry' compared to those stored 'wet'. Flowers wrapped with wet newspapers had a better visual appearance than those stored 'wet' or 'dry' (in polythene bags). Floral abscission was higher in flowers stored 'dry' (polythene bags), compared to the other treatments.

Experiment 2 - Vase Water Additives

1. Fresh Weight and Vase Life. The fresh weight of cut *Kniphofia* racemes increased substantially up to day 3 and then it declined up to senescence. The differences in FW of stems of the various treatments were not significant. Of all vase water additives, Flora and Flower fresh resulted in a longer vase life (6.9 and 6.5 d respectively; Table 2) compared to the other treatments. FW showed a high positive correlation (r = 0.71) with flower osmotic potential at 0.05 level (data not presented).

2. Osmotic Potential and ºBrix Value. Osmotic potential of stems and flowers increased in Flora and Flower fresh (Table 2). Vase life was positively correlated (r = 0.47) with stem osmotic potential at 0.05 level. ºBrix of stems did not show significant differences between treatments, although lower values occurred in stems placed in Flora and Flower fresh compared to freshly harvested flowers. Flower ºbrix value showed a negative correlation (r = -0.55) with the length of vase life.

3. Transpiration and Water Uptake. Initial transpiration rate did not show significant differences among treatments. Transpiration rates and uptake rates of stems placed in Chrysal, Flora and Flower fresh remained higher until senescence, compared with the other treatments (Table 3). Vase life was positively correlated (r = 0.47) with the rate of water uptake at the end of the experiment (0.05 level; data not shown).

4. Flower Colour. Flower stems placed in SVS, Flora and Flower fresh showed higher leaf lightness (*L**) at senescence than other treatments. *L** value of stems in Flora markedly increased at the end of vase life, indicating a bright flower colour until the end of the test (Fig. 1A). Stems in tap water also maintained their leaf lightness throughout the vase period. Flowers of stems placed in SVS, Flora, Flower fresh, tap water and 8-HQS were able to maintain *L** at a higher value even at senescence, compared with freshly harvested flowers. Flower *a** of all treatments slightly increased at senescence except in Chrysal. Stems placed in tap water had a lower *a** than other treatments (Fig. 1B). Treatments with Flower fresh and Biovin vase solutions had a higher *a** value at the end of vase life. They showed opposite patterns for flower *b** at senescence (Fig. 1C). Among the floral solutions, flower stems kept in SVS and Flora showed a small increase of *b** value during the vase period.

DISCUSSION

Experiment 1 - Cold Storage

In the current trials, we investigated the effect of cold storage on *Kniphofia* flower quality and on geotropic stem bending, which is a major problem. Stems wrapped with wet newspapers and enclosed in polythene bags stored at 4 ºC had better postharvest performance (longer vase life and a minimum of stem bending) compared with 'dry'-stored stems. According to our previous experiments, the best storage temperature for cut *Kniphofia* racemes was 4 ºC (data not shown). Even then, cut *Kniphofia* flowers have a relatively short vase life.

Dry stored flowers were covered by perforated polythene bags to minimise water loss during the vase period. However, it showed more detrimental effects than 'wet' or

stems wrapped in wet newspapers, showing weight loss of racemes stored at both 4 and 13 ºC temperatures. Wet storage was carried out in buckets containing water and therefore they occupied more space in the storage room, compared to dry storage. During wet storage at higher temperatures (13 ºC), carbohydrate breakdown occurs at higher rates than for flowers stored dry (Halevy and Mayak, 1981). During wet storage at 13 ºC, bud development and senescence of flowers occur more rapidly compared to the flowers kept dry. Mor (1989) similarly recommended 'dry' over 'wet' storage for roses since flowers with lower water content performed better than flowers with higher water content.

Dry storage is the more commonly used method for long term storage of cut flowers (Nowak and Rudnicki, 1990). Mor (1989) suggested that 'wet' stored rose flowers had higher respiration rates than the 'dry' stored flowers, resulting in poor quality performances after cold storage. However, storage method and temperature vary with the cut flower species/cultivars. Rudnicki et al. (1989) recommended 'wet' storage for carnations. We advise to wrap with wet newspapers and keep in polythene bags at 4 ºC for cut *Kniphofia* racemes to maintain vase life and to reduce 'bent stem' problems in storage period.

Experiment 2 - Vase Water Additives

Use of floral preservatives is the most economical and practical method for extending the postharvest life of cut flowers (Salunkhe et al., 1990; Nowak and Rudnicki, 1990). Vase life is one of the most important post-storage criteria for cut flowers. Addition of 8-HQS, SVS or floral preservatives did not significantly extend the vase life of *Kniphofia* stems. We found that vase water additives had no negative influence on stem bending.

Flower preservative solutions are composed of a mixture of chemicals that enhance the postharvest quality and longevity of cut stems. The solutions may contain carbohydrates (sucrose or glucose), biocides (8-HQS or 8-HQC), plant growth regulators (Gibberellins, Cytokynins), anti ethylene compounds (silver thiosulphate), or chemicals known to aid water uptake and to reduce water tension. Here we have shown that commercial floral preservatives do not improve the vase life of *K. uvaria*. However, results of water uptake and transpiration show that cut racemes kept in Flora, Chrysal and Flower fresh had higher values than other treatments.

When flowers are detached from the plant, water loss from these continues through transpiration. The ideal floral preservative is that which allows water absorption in flower tissues (Salunkhe et al., 1990). Water absorption from the preservative solution maintains water balance and flower freshness (Reddy and Singh, 1996). Therefore, it will delay wilting of flowers, thereby maintaining vase life. The SVS showed lower transpiration and uptake rates, suggesting that it is not suitable for *Kniphofia* cut flowers.

The behaviour of the flower in a vase at the consumer's place is one of the important quality aspects of cut flowers. Vase life is determined by changes in water relations, carbohydrate balance and development process in the vase period. Burge et al. (1996) concluded that flower senescence in *Leptospermum* was determined primarily by water balance. Similarly vase life of *Kniphofia* was terminated by wilting and shedding of flowers. Biocides can inhibit microorganisms and their plant cell break down by-products from blocking the vascular system, thereby reducing the decline in water uptake (Halevy and Mayak, 1981; van Doorn, 1997). However, in our trials, 8-HQS did not improve vase life or water uptake, and water uptake gradually declined during the experimental period. Development of petal colour during vase period has been observed, thereby increasing L^*, a^* and b^* values of flower stems placed in floral preservatives. In considering above factors, we suggest using a floral preservative solution for kniphofia flowers to maintain flower quality during vase period.

CONCLUSIONS

Vase water additives and tap water caused significant differences in the vase life of freshly cut flowers. Vase life is positively influenced by cold storage. The data

presented here advise keeping cut kniphofia racemes wrapped with wet newspapers and polythene storage at 4 ºC to reduce stem bending and to maintain keeping quality of flowers. The ornamental value of cut *Kniphofia* flower stems is determined by visual parameters such as appearance of flowers and stem and stem length. Colour components (*L**, *a** and *b**) are positively affected by vase solutions with commercial floral preservatives, thereby suggesting the use of appropriate floral preservatives to maintain flower colour during the vase period.

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Tables

Table 1. Effect of storage temperature on vase life, geotropic bending and fresh weight changes during cold storage of *K. uvaria*. Values are means of 12 stems ± SE

Storage treatment	% weight change in storage	% Geotropic bent stems	Vase life (d)
4 ºC Wrapped with wet news papers & in a polythene bag	-1.1 ab	19.6 a	6.5 c
4 ºC 'Dry' storage	-5.7 a	35.8 b	4.7 b
4 ºC 'Wet' storage	46.8 c	52.2 c	3.6 a
13 ºC Wrapped with wet news papers & in a polythene bag	6.4 b	37.0 b	4.5 ab
13 ºC 'Dry' storage	-8.3 a	40.7 bc	3.5 a
13 ºC 'Wet' storage	7.5 b	69.4 d	3.8 a

Means separation across columns; means followed by the same letter are not significantly different by Tukey HSD test at $P = 0.05$.

Table 2. Effects of vase solutions on vase life (d), osmotic potential (mmol/kg) and total soluble solids (ºBrix) at the end of vase life of *K. uvaria* Oken 'Flamenco' cut stems. Each column shows means of three replicate stems ± SE.

Vase solution	Osmotic potential		ºBrix		Vase life (d)
	Stem	Flower	Stem	Flower	
SVS	-6.0 ± 0.2	-9.9 ± 0.3	2.9 ± 0.2	6.6 ± 0.3	5.4 ± 0.6
Chrysal	-5.7 ± 0.2	-6.9 ± 0.5	3.0 ± 0.1	5.3 ± 0.1	5.5 ± 0.5
Flora	-4.8 ± 0.5	-6.81± 0.4	2.0 ± 0.3	4.5 ± 0.2	6.9 ± 0.9
Flower fresh	-5.4 ± 0.6	-6.9 ± 0.4	2.3 ± 0.2	4.6 ± 0.3	6.5 ± 0.6
Biovin	-5.9 ± 0.2	-7.7 ± 0.9	2.6 ± 0.1	6.2 ± 0.2	5.5 ± 0.1
Tap water	-4.9 ± 0.3	-10.6 ± 0.4	2.8 ± 0.2	7.4 ± 0.2	5.3 ± 0.3
8-HQS	-9.4 ± 0.3	-9.4 ± 0.3	3.1 ± 0.2	6.2 ± 0.1	4.9 ± 0.3
Fresh flowers	-7.9 ± 0.1	-6.4 ± 0.1	2.3 ± 0.1	6.0 ± 0.1	

Table 3. Effect of vase solutions on transpiration and water uptake rates on day 1, 3 and end of vase life of *Kniphofia* cut stems. Each column shows means of three replicate stems. Means within column with different letters are significantly different at $P < 0.05$

Vase solution	Transpiration (g/d.stem)			Uptake (g/d.stem)		
	Day 1	Day 3	End of vase	Day 1	Day 3	End of vase
SVS	11.5 a	7.5 a	7.5 a	12.3 a	4.8 a	3.9 a
Chrysal	12.6 a	12.5 b	14.4 d	12.1 a	13.4 b	13.0 c
Flora	12.7 a	12.6 b	13.5 cd	12.8 a	12.9 b	12.1 c
Flower fresh	13.0 a	13.3 b	15.4 d	12.2 a	14.1 b	14.4 c
Biovin	12.0 a	9.1 a	9.1 ab	12.1 a	5.9 a	5.7 ab
Tap water	11.8 a	7.2 a	7.3 a	12.0 a	4.6 a	4.0 a
8-HQS	12.0 a	12.3 b	11.3 bc	13.0 a	11. 9 b	7.6 b

Figures

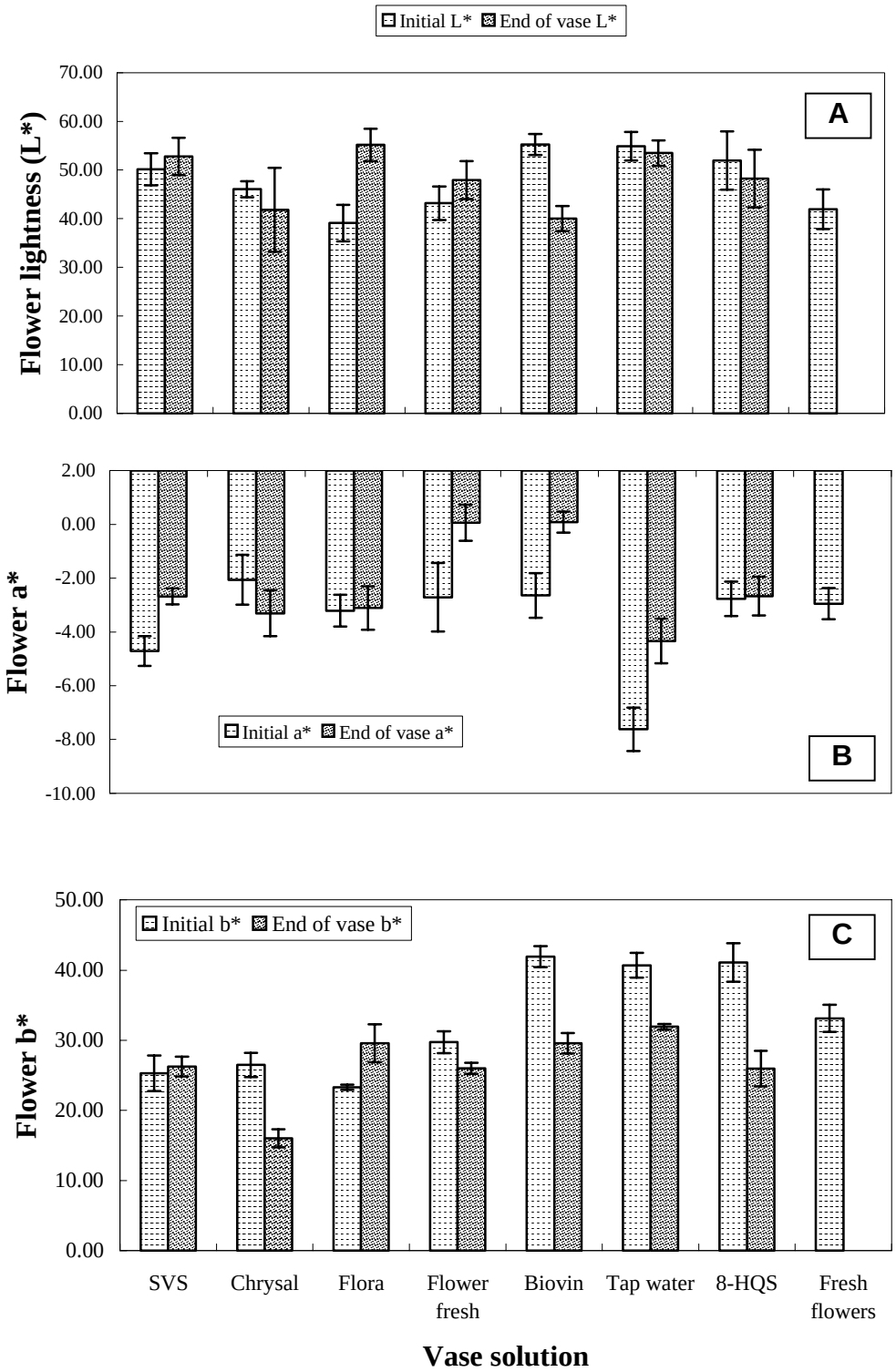

Fig. 1. Effects of vase solutions on *Kniphofia uvaria* Oken 'Flamenco' flower colour components (A) *L** - flower lightness, (B) *a** and (C) *b** in vase period. Bars indicate standard errors of means.