Postharvest Quality of Cut Anthurium Flowers (*Anthurium andraeanum* L.) after Long-Distance Shipment

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Abstract

Flower quality parameters (FW, vase life, colour, osmotic potential, water uptake, transpiration rate and total soluble solids) were measured to examine the effects of treatments on postharvest quality of anthurium (*Anthurium andraeanum* L. 'Tropical'), after long-distance shipment. With a vase life of about 16 d the effects of a 'heat treatment' (60ºC, 15 s) and 'ultrasonic treatment' (1 min) differed significantly from the non-treated control (11.9 d). However, the differences between stem-end treatments (heat and ultrasonic) for vase life were small and non-significant. Non-treated control flowers showed lower FW and earlier spathe blueing than heat-treated and ultrasonic-treated flowers. Spathe chroma value of flowers placed in Biovin, tap water, and 8-HQS was improved during vase life whereas spathe red hue was positively influenced only in flowers placed in Flora. In contrast, spadix chroma showed no significant difference with respect to controls. Results indicated that floral preservatives and stem-end treatments have a positive affect on keeping quality. The data also indicate the importance of maintaining a good water balance during commercial handling and transport of *Anthurium.*

INTRODUCTION

Air transportation is used to deliver flower boxes from Sri Lanka to Europe. However, it takes usually five or more days to deliver boxes from the harvesting gate to the final destination. This research aimed to use stem-end treatments and floral additives to control senescence of *Anthurium* and to examine quality parameters after long-distance transportation. An understanding of changing patterns in weight, colour, shelf life, ºbrix and osmotic potential will assist in developing commercial postharvest handling procedures to extend postharvest life and maintain flower quality throughout the postharvest chain.

Water deficits in any cut flower occur when the rate at which water is lost through transpiration exceeds the rate at which water is absorbed and transported through the stem. Previous researchers observed an association of termination of vase life with developing water deficit. While storage temperature (Sankat and Mujaffar, 1994), water balance (Mayak et al., 1974) and senescence symptoms (Paull, 1982) have already been evaluated in previous studies, to our knowledge no one has tested stem end treatments to maintain postharvest quality of *Anthurium* cut flowers.

MATERIALS AND METHODS

Cut anthurium (*Anthurium andraeanum* L. 'Tropical') flowers grown in shade houses in Colombo, Sri Lanka, were obtained from a commercial grower, for conducting laboratory experiments in Austria. Immediately after arrival at Vienna airport, boxes were delivered to the institute laboratory. The boxes were kept in a cold room at 12 ºC (2 h) before starting the experiment. Flower stems were cut to maintain 30 cm stem length and were placed in buckets with tap water.

Preparation of vase solutions was made according to the instructions given on the label of the commercial products and published recommendations, using deionised water. Standard Vase Solution (SVS - $NaHCO_3$ 125 mg/l, $CaCl_2.2H_2O$ 99 mg/l, $CuSO_4.5H_2O$

1.2 mg/l) introduced by van Meeteren et al. (2000), Flora (1 ml/l), Biovin (1 ml/l) and 8-HQS (200 mg/l) were selected as vase solutions and tap water was the control. A plastic vase (1000 ml capacity) containing 750 ml of the desired vase water solution was used for placing the cut flower stems. Three replicates consisting of three flowers per vase were used for each treatment. During the vase period, each vase had to be topped up to the original level with the respective vase solution according to the water consumption rate of the flowers on day 7 and 14 during vase period. Stems were re-cut on day 14. The experiment was repeated twice.

A heated shaking water bath (model 1086, Burgwedel, Germany) filled to 60 mm water level was used to provide the heat treatment, which involved dipping, stem-ends (60 ºC for 15 s). Ultrasonic water bath (Transonic 780, Germany) was used to give the ultrasonic treatment, keeping the stem-ends inside the water bath for 1 min. After subjecting the flowers to different treatments, vases were kept in a room with an ambient air temperature (20 ± 2ºC) and under artificial light (12 h/d) from cool-white fluorescent tubes. The measurement of water uptake and transpiration was done according to Sankat and Mujaffar (1994). Colour on both spathe and spadix was measured with a chroma meter (Model CR220b, Minolta GmbH Ahrensburg, Germany, 1988). Results are expressed as lightness ($L*$), $a*$, $b*$, chroma ($C*$) and hue angle (h^o), all of which relate to visual perception (McGuire, 1992). A vapour pressure osmometer (Wescor, Inc., Utah, USA) was used to measure spathe osmotic potential. Soluble solid content of *Anthurium* was determined by refractometer (PR 101, Atago, Japan) as ºBrix % on defrosted juice.

Statistical analysis was undertaken using SPSS version 11 (Chicago, USA, 1996). Data were presented as mean ± SD. Where appropriate a post hoc test was undertaken to rank the means. The Pearson method was used to calculate correlation among variables at a significance level of 0.05.

RESULTS AND DISCUSSION

Effect of Vase Life and Fresh Weight

Non-treated flowers (controls) were kept in tap water showed the shortest vase life (11.86 d). The vase life of *Anthurium* cut flowers was significantly increased by interaction of vase solutions and stem-end treatments as compared with controls (Fig. 1A). However, there was no significant difference for vase life of heat-treated and ultrasonic-treated flowers placed in SVS, a commercial floral preservative (Flora), 8-HQS or tap water. It proved that adding floral preservatives and applying stem-end treatments prolonged *Anthurium* vase life.

Commercially prepared floral preservatives usually contain a sugar, an acidifier and a biocide they have therefore the ability to supply food to the cut stem, to improve water uptake, to prevent microbial growth (which reduces vascular occlusion of flower stems) and to increase flower weight. Effectiveness of 8-HQS could be partially due to inhibition of bacterial proliferation since it is a germicide (Marousky, 1971). Moreover, 8-HQS inhibits the occurrence of bent neck in cut rose flowers and improves water-use efficiency by inhibiting vascular blockage and reducing transpiration (Halevy and Mayak, 1981). However, our preliminary experiments showed that some commercial floral preservatives negatively affected *Anthurium* flower keeping quality by showing early petal blueing symptom and by creating negative water balance (unpublished data).

Petal blueing was shown earliest in the controls, and next in Biovin and tap water vases. We observed slight contamination of vase water in Biovin and in tap water treatments after 10 days of the experiment. Contamination of the vase solution is a major problem for most cut flowers, causing early wilting of flowers for various reasons (Nowak and Rudniki, 1975). One reason for early wilting is bacterial plugging of the xylem. Previous studies (Nowak and Rudniki, 1975; Song et al., 1996) showed the beneficial effects of using 8-HQS in preventing bacterial development in stock flowers. According to our experimental results, 8-HQS showed no significant effect on vase life as compared with other treatments, but vase life was better than that of non-treated controls.

As shown in Fig. 1B, lowest dry weight percentage at senescence was observed heat-treated flowers in SVS and ultrasonic-treated flowers kept in tap water. Interestingly, higher dry weights were seen of ultrasonic-treated flowers placed in Biovin than other treatments at termination; however, this was not significantly different from other treatments. The controls showed lower fresh weight throughout the vase period; it was however, not significantly different from other treatments (data not shown). We observed continuous reduction of fresh weight of flowers even placed in floral preservatives, indicating a deterioration of their water status. That may be related to long distance shipment for several days, i.e. affecting flower physiological and metabolic activity.

Biovin is a biological fertilizer prepared from grape residues. We wanted to examine the possibility of using it as an organic flower preservative, since it is an environmentaly friendly product that can be used throughout the postharvest chain in future. The benefits of using Biovin as a floral preservative for *Anthurium* were proved by its showing approximately the same vase life and fresh weight with other commercial floral preservatives.

Water Uptake and Transpiration during Vase Period

The highest water uptake (4.09 g/d.stem) was observed in ultrasonic-treated flowers placed in 8-HQS and the lowest uptake (2.60 g/d.stem) in heat-treated flowers in tap water on day 2. The water uptake rate was decreased from the first day of vase life for all vase solutions until recutting of stems and topping up of vases on day 14. A significant effect of stem-end treatment and vase water on water uptake rate was observed on day 7 and at the end of vase life (Table 1). Uptake rates of flowers placed in Flora (ultrasonic-treated), Biovin (heat-treated) and tap water (heat- and ultrasonic-treated) declined up to day 7. Uptake rates were slightly increased after topping up of vase solutions, resulted a higher uptake rate at termination.

Cutting the flower stem after transport is a common practice to facilitate water uptake into stems after dry storage, which is a priority for obtaining successful vase life. In our experiments, changes in transpiration rate were not related to uptake rates. High transpiration rate was observed at the beginning of the vase life and it continuously reduced (Table 1). Slight positive changes were observed after recutting stems and topping up of vases after 14 days; however, the differences were not significant. Loss of water by transpiration exceeded that of uptake; indicating a loss in flower fresh weight (Fig. 2), giving to reduce flower turgidity and inducing wilting. The balance between the rate of water uptake and the rate of transpiration is directly related to *Anthurium* flower turgidity and flower keeping quality (Sankat and Mujaffar, 1994). Paull and Goo (1985) investigated blockage in *Anthurium* flowers to an ethylene stimulated vascular occlusion near the cut end of the stem. This proved that long-distance transportation in dry storage drastically affects the physiological state of flowers, resulting in decreased water uptake, coupled with continuous transpiration in the vase period.

Osmolality and ºBrix Values

There were significant differences between the osmotic potential of ultrasonic-treated stem of the cut flowers placed in flower preservative (Flora) and non-treated controls and other treatments at senescence. No significant differences were observed for the osmotic potential of spathe tip, middle or basal parts for either different floral solutions or different stem-end treatments. However, higher osmotic potential values were shown on stem and leaf basal parts of *Anthurium* at termination (data not shown). The osmotic potentials of spathe tip, middle, base, and of the stem of non-treated controls gave comparatively higher values than treated samples. Stem treated flowers kept in tap water and 8-HQS vases did not show osmotic potential variation for different flower parts. There was no significant difference in ºBrix value due to treatments. Spathe osmotic potential showed positive correlations with vase water treatments ($r^2 = 0.29$, $P = 0.05$) and stem-end treatments ($r^2 = 0.27$, $P = 0.05$); however, the differences were not significant. In contrast, spadix osmotic potential correlated significantly ($r^2 = 0.46$, $P =$

0.01) with vase-water treatments.

Flower Colour

Our results showed that colour components were positively affected by stem-end treatments and vase-water solutions. Changes in colour have been very frequently utilized (Parups and Chan, 1973) as postharvest evaluation criteria. Significant colour differences between treated and control flowers were observed, but there were no significant differences between stem-end treated flowers. Spathe *L** was reduced along the vase period and it was slightly increased by topping up of vases and recutting of stems in all treatments except stem treated flowers in SVS vases ((Fig. 2A). Ultrasonic-treated flowers placed in Biovin, Flora and SVS vases, and heat-treated flowers in Flora and SVS vases were able to maintain higher *L** values even at senescence. We observed an increasing spathe *a** on day 5 of vase life of heat-treated SVS, tap water and 8-HQS vases, and ultrasonic-treated Flora vases. The value of *a** was also affected positively by refilling vases and recutting of stems during the vase period (Fig. 2B). Compared with other treatments, the value *a** of non-treated flowers rapidly declined throughout the vase period. Lower spathe *b** value was associated with petal blueing. Lower *b** at termination of vase life was observed in flowers on control, heat-treated SVS and ultrasonic-treated 8-HQS vases (Fig. 2C). Treatments were able to maintain a higher *b** until day 10 of the vase life, after which it rapidly declined to a very low value, resulting in petal blueing at senescence. We found that spathe *a** (r^2 = 0.30, P = 0.05), *b** (r^2 = 0.37, P = 0.05), chroma (r^2 = 0.51, P = 0.01) and hue (r^2 = 0.43, P = 0.01) were significantly correlated with vase water treatments.

Less intensively coloured spathes (lower chroma values) were observed in flowers placed in control vases. However, they were not significantly different from stem-treated flowers placed in floral solutions. Higher chroma values were observed in all treatments until day 10 (Table 2), after which they substantially reduced to senescence. Heat-treated flowers kept in tap water and SVS were able to maintain initial chroma values up to day 10 of vase life. Heat-treated flowers in tap water vases had the lowest chroma (19.38 ± 2.63) at the end of vase life.

Compared with spathe chroma, spadix chroma of all treatments had lower values at the beginning of the vase life. Colour intensities of heat-treated flowers in Flora, Biovin, SVS, tap water and non-treated controls continuously increased up to day 10, and after which values reduced slightly (data not shown). They did not show any significant differences throughout out the vase period.

There were no significant differences for stem-end treatments for spathe red hue during the vase period (Table 2). However, the spadix yellow hue showed significant differences in the non-treated controls. Non-treated flowers placed in tap water showed the lowest values after day 5 of the vase life. No significant differences were observed among flowers of both stem end treatments. Both heat- and ultrasonic-treated flowers showed a higher value of yellow hue in spadix at termination than at initial (data not shown), while the spathe red hue showed decreased values at senescence. Positive correlations were observed for spathe hue (r^2 = 0.43, P = 0.01) and spadix hue (r^2 = 0.46, P = 0.01) for all vase solutions at the end of vase life.

CONCLUSIONS

Anthurium flowers have a better ability to tolerate water stress and to maintain acceptable quality during transportation than many other cut flowers (Paull, 1987). Reduced water availability during shipment affects water uptake and postharvest performances in vase period. We observed that the vase life of floral preservative treated flowers was very similar to that of flowers placed in tap water. Data indicated that addition of floral preservatives give results that are indistinguishable from tap-water-treated flowers, and suggest that there is little to be gained in adding nutrients during vase life. It proved that nutrients gained in the preharvest stage were the ones critical in the postharvest stage. It is necessary to conduct further experiments to test further stem-end treatments to find optimum levels. However, it was evident that use of tap water as a vase solution for field grown *Anthurium* was as effective as using floral preservatives. In our experiments, flower colour (both spathe and spadix) was positively correlated with use of vase solutions. It is necessary to use an appropriate vase solution to maintain flower colour after a long-distance shipment.

Water uptake during vase period is greatly affected by long-distance transportation, resulting negative water accumulation (water loss) and substantial fresh weight reduction even in the initial stage of the vase life. We would suggest using wet cotton plugs or other similar material to cover stem-ends and to maintain higher relative humidity inside boxes before long-distance shipment. Minimization of water loss and respiration rates are considered to be important factors in maintaining *Anthurium* flower keeping quality throughout the postharvest chain.

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Tables

Table 1. Effects of floral preservatives and stem-end treatments on water uptake and transpiration rates of *Anthurium* flowers. Each column shows mean ± SD of three replicate flowers.

Treatment	Water uptake (ml/d per stem)				Transpiration (ml/d per stem)			
	Initial		End of vase life		Initial		End of vase life	
	Heat	Ultra	Heat	Ultra	Heat	Ultra	Heat	Ultra
SVS	3.3 ± 0.6	3.6 ± 0.2	1.9 ± 0.1	2.2 ± 0.7	3.3 ± 0.3	3.9 ± 0.1	3.0 ± 0.2	2.6 ± 0.1
Flora	2.9 ± 0.5	3.0 ± 0.4	2.2 ± 0.3	2.6 ± 0.5	4.5 ± 0.6	4.0 ± 0.0	2.4 ± 0.3	2.5 ± 0.1
Biovin	3.0 ± 1.1	2.6 ± 0.6	3.0 ± 0.4	2.1 ± 0.2	4.6 ± 0.1	4.3 ± 0.3	2.7 ± 0.1	2.7 ± 0.2
Tap water	2.6 ± 0.5	3.4 ± 0.8	2.6 ± 0.3	2.7 ± 0.2	4.0 ± 0.1	3.7 ± 0.3	2.7 ± 0.1	2.8 ± 0.3
8-HQS	3.2 ± 0.4	4.1 ± 0.5	2.4 ± 0.4	2.5 ± 0.2	5.1 ± 0.1	4.7 ± 0.2	2.7 ± 0.4	2.6 ± 0.1
Control	2.6 ± 0.3		1.5 ± 0.1		4.9 ± 0.9		2.7 ± 0.6	

Table 2. Effects of floral preservatives and stem-end treatments on spathe chroma and hue angle of *Anthurium* spathes. Each column shows mean ± SD of three replicate flowers.

Treatment	Spathe chroma				Spathe ºhue			
	Initial		End of vase life		Initial		End of vase life	
	Heat	Ultra	Heat	Ultra	Heat	Ultra	Heat	Ultra
SVS	33.6 ± 0.3	34.7 ± 2.8	24.0 ± 2.1	22.2 ± 1.5	0.5 ± 0.03	0.4 ± 0.01	0.2 ± 0.06	0.3 ± 0.11
Flora	36.6 ± 4.8	35.4 ± 0.6	26.4 ± 1.3	21.3 ± 2.5	0.4 ± 0.01	0.4 ± 0.01	0.3 ± 0.06	0.2 ± 0.12
Biovin	38.0 ± 3.5	36.5 ± 3.0	21.2 ± 2.0	23.4 ± 2.0	0.4 ± 0.02	0.4 ± 0.03	0.3 ± 0.11	0.3 ± 0.08
Tap water	32.8 ± 0.8	37.7 ± 3.7	19.4 ± 2.6	24.0 ± 1.4	0.4 ± 0.02	0.4 ± 0.02	0.2 ± 0.11	0.3 ± 0.06
8-HQS	32.8 ± 1.6	34.6 ± 1.4	20.5 ± 2.8	20.3 ± 1.4	0.4 ± 0.02	0.4 ± 0.03	0.4 ± 0.06	0.4 ± 0.10
Control	37.3 ± 2.5		24.6 ± 2.4		0.4 ± 0.01		0.3 ± 0.15	

Figures

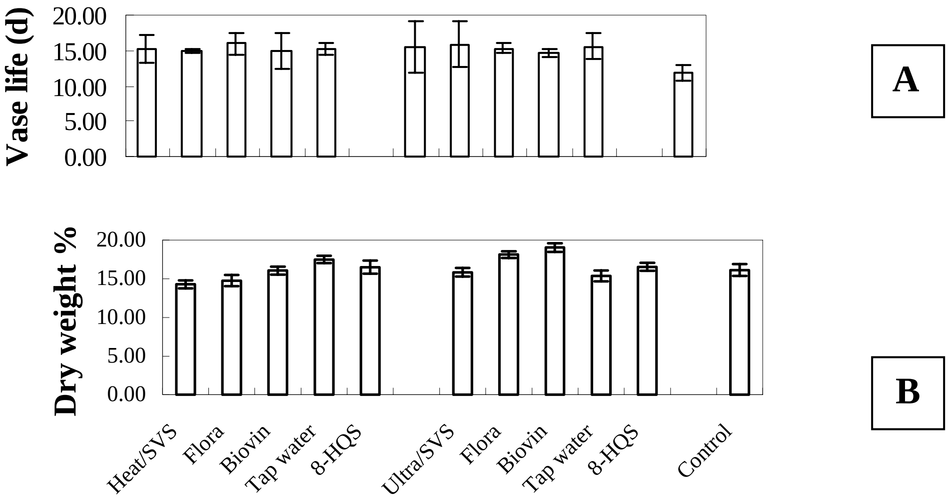

Fig. 1. Vase life (**A**) and % dry weight (**B**) of stem treated *Anthurium* flowers placed in vase solutions. Vertical bars indicate SD of 3 represent replicates of flowers.

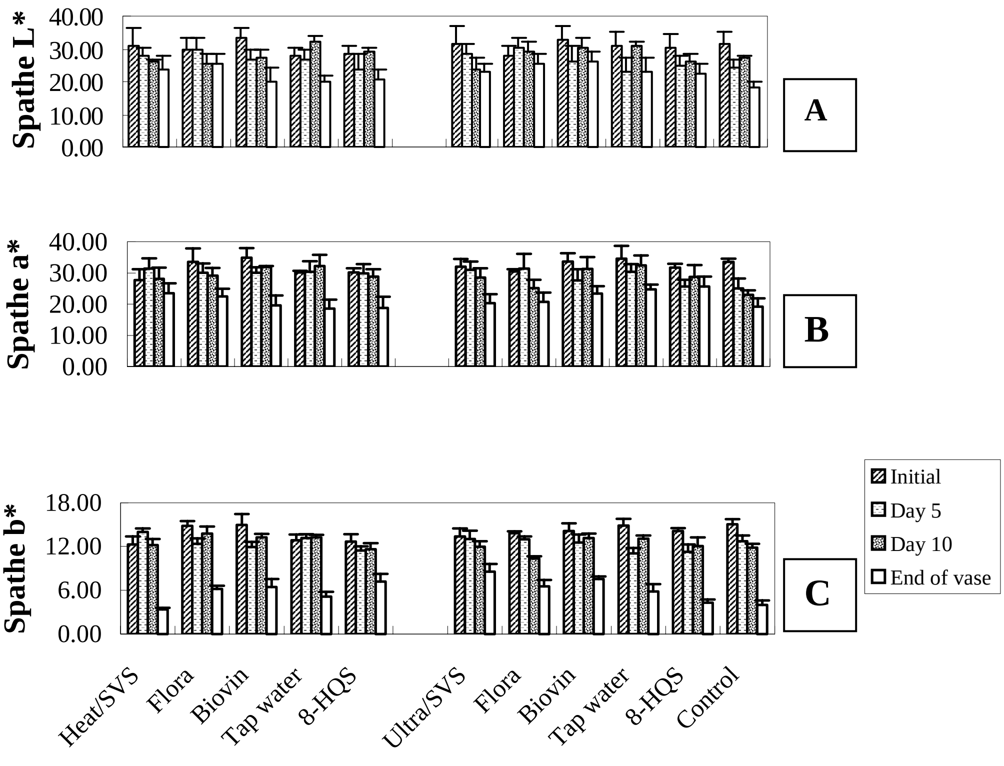

Fig. 2. Spathe L* (**A**), a* (**B**) and b* (**C**) of stem treated *Anthurium* flowers placed in vase solutions. Vertical bars indicate SD of 3 replicates of flowers.