RESEARCH PAPER

Role of flower preservative solutions during postharvest of *Hydrangea macrophylla* cv. Bela

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Abstract

D. Aros, C. Silva, C. Char, L. Prat, and V. Escalona. 2016. Role of flower preservative solutions during postharvest of *Hydrangea macrophylla* cv. Bela. Cien. Inv. Agr. 43(3):418-428. *Hydrangea macrophylla* (hydrangea) is widely used as an ornamental plant and cut flower due to its inflorescence, which is composed of colored bracts. As cut flowers, hydrangeas show a postharvest life of up to 1 month at 2 °C, but little is known about their postharvest life during air shipment. This study was aimed at evaluating the effect of Triton X-100 (surfactant) and ClO_2 (biocide) during an air shipment simulation of hydrangea harvested at two floral stages of development: fresh and antique. Vase life, fresh weight loss (FWL) and solution uptake were evaluated after an air shipment simulation. Furthermore, bacterial counts and microscopic observation of the bracts were performed in order to understand the water relations of hydrangea during vase life. The longest vase life was observed in antique hydrangeas, and the control (deionized water) was the best treatment, reaching up to 32.7 days in this floral stage. FWL was faster when using Triton X-100 (3.83 days to lose 20% of FW) compared to deionized water (8.75 days). However, this flower preservative was efficient at promoting solution uptake (31.96 mL). Bacterial plugging did not appear to occur considering that the high presence of microorganisms counted did not affect solution uptake or vase life. The presence of stomata on the bracts seems to be crucial for the dehydration of the inflorescence, a problem that was not solved by the higher water uptake promoted by Triton X-100. Thus, deionized water was the best treatment, and the effect of flower preservatives in order to extend vase life of hydrangea cut flowers was insignificant.

Key words: ClO_2, hydrangea, Triton X-100, vase life

Introduction

Hydrangea macrophylla (hydrangea) is a deciduous shrub native to eastern Asia widely used as an ornamental plant in gardens and as cut flow-

ers (Sacco *et al*., 2012). Hydrangeas are popular for their colorful, sphere-shaped inflorescence, which is highly demanded at Christmas and Mother's Day, mostly by the European and North American markets (van Gelderen and van Gelderen, 2004). *H. macrophylla* inflorescences are composed of several partial inflorescences, which are composed of small fertile florets and sterile

florets with large colored bracts. The decorative value of hydrangeas comes from these colored bracts, which probably arose as a mutation or arrest of certain genes involved in floral organ morphogenesis. As cut flowers, hydrangeas are harvested at three different stages according to the development of the color of the bracts: fresh, transition and antique (Schiappacasse *et al.*, 2014). Hydrangea cut flowers show a postharvest life of up to 1 month at 2 °C, but this period is shorter if hydrangeas are stored or transported at higher and variable temperatures (Dole and Wilkins, 1999).

The postharvest life of cut flowers depends on several biotic and abiotic factors that induce the senescence of different plant organs. Thus, control of temperature, relative humidity, light, ethylene, microorganisms, water quality, and others factors are all important to maintaining the quality of cut flowers during their postharvest life. Temperature is the most important factor since high temperature triggers an increase in the respiration rate, causing rapid senescence of the flower (Kader, 2007). Relative humidity (RH) is also important because it plays a key role in the dehydration of cut flowers, one of the main deteriorating symptoms observed during postharvest.

Flower preservative solutions, with both surfactant and antimicrobial effects, are usually used to prolong the vase life of cut flowers, particularly in cases where flowers cannot be kept at low temperatures during storage and transportation. Surfactants help to quickly rehydrate flowers because a reduction of the surface tension of water improves water uptake (Seyed *et al.*, 2012). Chemical preservatives with surfactant effects include 8-hydroxyquinoline citrate, 8-hydroxyquinoline sulfate, alkylethoxylate (van Doorn *et al.*, 2001), Tween-20, Tween-80, Agral-LN (van Doorn *et al.*, 2001), and Triton X-100 (Jones *et al*, 1993), among others. Those with biocidal effects help to prevent occlusions from occurring mainly at the basal stem end of cut flowers, which strongly decrease water uptake from the vase, and many products have been used in cut flowers for this

purpose such as sodium hypochlorite (Macnish *et al.*, 2010), silver nitrate (Figueroa *et al.*, 2005), Physan 20, 8-hydroxyquinoline (Cruz *et al.*, 2006), silver thiosulfate (Figueroa *et al.*, 2005) and chlorine dioxide (Macnish *et al.*, 2008). Despite the benefits described for these flower preservatives, their effects depend on the dosage and duration of exposure (Chao *et al.*, 2010; Macnish *et al.*, 2008), since in certain species, high doses or long exposure may provoke toxicity and thereby reduce vase life by dehydration, browning (van Doorn *et al.*, 2001), leaf chlorosis and premature flower drop (Macnish *et al.*, 2008).

Studies focused on hydrangea postharvest have shown that this species lasts for 7 to 9 days after storage for 20 days at 0.5 °C (Schiappacasse *et al.*, 2014). Moreover, vase solution with an electrical conductivity (EC) between 2.0 and 2.5 dS m^{-1} and a pH of 3.2 has been described as optimal to extend the vase life of hydrangea (Ahmad *et al.*, 2013). However, the effect of flower preservatives during hydrangea postharvest has not been studied. Furthermore, studies focused on evaluating the postharvest of this species after the variable conditions occurring during air shipment, the main transportation mode for this species, have not been considered. Hence, this study was aimed at evaluating the effect of the biocide chlorine dioxide (ClO$_2$) and the surfactant octyl phenol ethoxylate (Triton X-100) on the postharvest life of cut flowers of hydrangea, simulating air shipment conditions from harvest to final market.

Materials and methods

Plant material

Flowers of *H. macrophylla* cv. Bela were harvested from 3-year-old plants grown under open-air conditions covered only by a shading net. Stems were cut 30 cm in length in order to obtain uniform quality, and bunches were arranged according to the treatments described below. The blades used to harvest were surface sterilized in 95% (v/v)

ethanol prior to use. Harvesting was performed during the morning in the middle of February at a farm located in Pirque, Region Metropolitana, Chile. Harvested stems were placed for 20 h at 22 °C for rehydration. To assess the effect of floral development at harvest time during postharvest of hydrangea, two floral stages were evaluated: fresh and antique.

Treatments

Floral preservative solutions were used both during air shipment simulation experiments and during the vase life evaluations. The treatments were as follows: deionized water, Triton X-100, ClO_2 and ClO_2 + Triton X-100 for each floral stage. To simulate the air shipment conditions normally used by Chilean export companies to send cut flowers overseas, each floral stem was put into a 20 mL Aquapick® tube containing the preservative solution, and different storage conditions were used at each of the five stages of the export process: 0. Harvest and ground transport to the airport; 1. Waiting for inspection and shipment at the airport (20 h); 2. Loading of the flowers into the airplane (3 h); 3. Storage of the flowers during the flight from Santiago in Chile to Miami in the USA (10 h); and, 4. Storage at destination before customer consumption (64 h) (Table 1).

Flower preservative solutions

The biocide chlorine dioxide (ClO_2) (Difem Pharma, Santiago, Chile) was used at a concentration of 2 $\mu L \times L^{-1}$ with or without the addition of 0.1 $mL \times L^{-1}$ of the surfactant octyl phenol ethoxylate (Triton X-100) (Calbiochem, USA). Deionized water was used to make the preservative solutions.

Vase life evaluation

After the air shipment simulation, the flowers were placed in 1.5 L–plastic vases at ambient conditions (20 °C ± 2 °C, 60 ± 5% relative humidity and a 12 h photoperiod). Each vase, containing 3 floral stems, was filled with 1 L of preservative solution. The open end of the vase was sealed around the stems with Parafilm. Vase life was evaluated daily according to a sensorial scale considering the quality of bracts (dehydration and inward rolling) and inflorescences (browning). The scale was developed based on previous studies, and scores ranged from 1 to 5 (Table 2). The end of vase life was considered the day when the average score of the treatment was ≤ 3. Additionally, photographs of each treatment were recorded using a Nikon D3000 10 Mpx Black (Nikon Co., Tokyo, Japan). The daily amount of vase solution taken by the hydrangeas was estimated by weighing the vases and floral stems separately every day, and the results were subtracted and expressed in mL. To monitor the fresh weight evolution of the floral stems, they were weighed daily and individually, and the values were expressed as a percentage of the initial fresh weight. Considering that all the treatments showed different vase life (days), this parameter was evaluated as the number of days when floral stems reached 20% of fresh weight loss, which is considered critical for some cut flowers (Kader, 2007).

Microbiological analyses

Microbial counts in the preservative solution at the end of the flight simulation period were performed by collecting a sample from the Aquapick® tube and during vase life by collecting a sample from the vase solution. In both cases, a 6-mL sample composed of 2 mL from each of the replicates of each treatment was evaluated. Samples were placed into sterile bags for blending in a Stomacher® 400 Circulator (Seward, Worthing, UK) for 1 min. Each sample was diluted in 54 mL of peptone water and then placed in a Masticator Classic (IUL Instruments, Barcelona, Spain) for homogenization for 1 min. Serial dilutions from 10^{-1} to 10^{-8} were prepared and plated on Plate Count Agar for 48 h at 37 °C. Additionally, a

Table 1. Simulation of the export conditions of cut hydrangea flowers from Santiago (Chile) to Miami (USA), according to information provided by Chilfresh Ltda. (flower exporter).

Stage	Duration (h)	External		Internal	
		T (°C)	RH (%)	T (°C)	RH (%)
0	28	22.0	60.7	22.5	59.1
1	20	13.6	75.2	16.1	72.6
2	3	31.1	46.7	22.2	78.8
3	10	13.3	86.6	15.4	75.0
4	64	5.2	93.3	5.8	83.7

Table 2. Sensorial scale for vase life evolution of *Hydrangea macrophylla* cv. cut flowers based on parameters related to bracts and inflorescences.

Score	Parameter	
	Characteristics of bracts	Browning of inflorescences (%)
5	100 to 95% turgid bracts 0 to 5% bract in-rolling	0 to 2
4	95 to 70% turgid bracts 5 to 15% bract in-rolling	2 to 4
3	70 to 50% turgid bracts 15 to 50% bract in-rolling	4 to 6
2	50 to 10% turgid bracts 50 to 80% bract in-rolling	6 to 8
1	10 to 0% turgid bracts 80 to 100% bract in-rolling	8 a 10

10 g sample from the base of the stem was also collected to count the microbes accumulated in the plant tissue. The samples were placed into sterile bags with 100 mL of peptone water for homogenization for 1 min. Serial dilutions and plates were performed under the same conditions previously described.

Microscopic observation of bracts

Stomata counts on the bracts of the flowers were performed by direct observation of the epidermis under a CX21FS1 Olympus stereoscopic microscope (Olympus, Tokyo, Japan). Epidermal tissue was obtained by directly stripping off the epidermal layer from both sides (abaxial and adaxial) of the bracts using tweezers. Fresh epidermal tissue was stained with toluylene red and observed using 40X magnification. Stomatal density was expressed as the number of stomata per mm^{-2} of epidermal tissue.

Experimental design and statistical analyses

A completely randomized design with factorial arrangement was used. Data on flower fresh weight loss, vase life and preservative solution uptake from the vase were subjected to an analysis of variance (ANOVA) using INFOSTAT software (Infostat, 2002). Means were compared using Tukey's HSD (honestly significant difference) test for multiple pairwise comparisons with a 5% significance level.

Results

Vase life evaluation

The vase life of hydrangea flowers was assessed according to the quality of bracts and inflorescences. Statistical analysis showed no interaction between 'floral stage' and 'vase solution', therefore they were independently analyzed using ANOVA. Surprisingly, the longest vase life was reached by using deionized water, showing significant differences from the rest of the treatments in the antique stage (32.7 days). For the fresh stage, deionized water alone or combined with ClO_2 reached the longest vase life (17.7 days), which was significantly longer than the rest of the treatments (Figure 1; Table 3).

Fresh weight loss and solution uptake of cut hydrangea flowers

Weight loss was measured during vase life and expressed as the number of days to lose 20% of

Table 3. Vase life (days) of *Hydrangea macrophylla* cv. Bela cut flowers at 20 °C and 50% RH after a flight trip simulation period using flower preservative solutions based on combinations of deionized water, ClO_2 and Triton X-100.

Floral stage	Flower preservative solution			
	Deionized water	ClO_2	Triton X-100	Triton X-100 + ClO_2
Fresh	A[1] 17.67 a[2]	A 17.67 a	B 8.33 a	B 8.00 a
Antique	A 32.70 b	B 23.33 b	C 14.00 b	D 9.33 b

[1]Different capital letters in a row indicate significant differences according to Tukey's test ($P \leq 0.05$).
[2]Different small letters in a column indicate significant differences according to Tukey's test ($P \leq 0.05$).

Figure 1. Development of *Hydrangea macrophylla* cv. Bela cut flowers from the beginning until the end of vase life, using flower preservative solutions based on combinations of deionized water, ClO_2 and Triton X-100.

the cut flower fresh weight. All treatments showed significant fresh weight loss (FWL) until day five when, due to vase solution uptake, all the flowers recovered their initial fresh weight. The slowest FWL was observed in the treatment using deionized water with an average of 8.75 days, and it was significantly different from the treatment using Triton X-100, which lost 20% of fresh weight at day 3.83. Although not significantly different from deionized water, ClO_2 and Triton X-100 + ClO_2 reached 20% flower FWL faster, with 7.50 and 6.83 days, respectively (Table 4).

Solution uptake was evaluated daily, and a comparison among treatments was performed on the day when the flowers reached 20% FWL. The highest solution uptake was observed using Triton X-100 (31.96 mL), and it was significantly different from the control. The treatments using ClO_2 and Triton X-100 + ClO_2 were not different from the control, taking up 26.56 and 26.44 mL, respectively (Table 4).

Bacterial count

Treatments using both chlorine dioxide and Triton X–100 were more effective at delaying microbial growth, showing the lowest count of bacteria in the Aquapick (4.3 log CFU mL^{-1}) and at the base of the stems (5.1 log CFU g^{-1}). Aquapick showed the lowest count of bacteria (between 4.3 and 6.1 log CFU mL^{-1}), probably due to the shorter period of time (5.2 days) that the flowers were kept under this condition (Table 1) compared to the vase solution (ranging between 5.9 and 7.0 log CFU mL^{-1}), where the flowers were kept for more than 8 days during the vase life (Figure 2).

Discussion

Vase life is affected by both floral stage and vase solution

The antique floral stage showed the longest vase life, significantly longer than that of fresh for all the flower preservative solution treatments applied (Table 3). van Doorn and Han (2011) observed longer vase life in lilies harvested at more mature stages, suggesting that postharvest is related to the accumulation of carbohydrates in the tepals. Thus, the hydrangeas in the antique stage may have higher levels of carbohydrates to redistribute and extend the vase life of this species.

Regarding the use of deionized water, van Meeteren and van Gelder (1999) observed better results using tap water during the vase life of chrysanthemum, suggesting that low concentrations of several ions present in this water positively affect the water balance of this species. The treatment using ClO_2 and Triton X-100 together showed the shortest vase life, and the main factor determining the end of vase life observed was browning of inflorescences, suggesting signs of toxicity provoked by the absorption of these preservative solutions (Figure 1).

Although previous studies have reported good results using surfactants in rose and sunflower for vase life (Jones *et al.*, 1993), they are sometimes associated with negative effects, such as leaf yellowing, pedicel bending and chlorosis, particularly with concentrations higher than 300 mg L^{-1} (van Doorn *et al.*, 2002). Furthermore, Hajizadeh *et al.* (2012) found lower levels of anthocyanin in roses treated with the surfactants 8-HQC and silver nitrate during postharvest. Anthocyanins are responsible for the color in hydrangeas, and their degradation, which was observed in fresh hydrangeas (Figure 1), could have been accelerated by the effect of the surfactants applied.

Chlorine dioxide produces an oxidizing effect on organic molecules of the cell, causing disruption of various cellular processes, and it has been described to have low toxicity in comparison with other biocides (Koermer and Wldman, 2002). On the other hand, Macnish *et al.* (2008) recommended 2 μL L^{-1} of ClO_2 to control bacterial growth during the postharvest life of *Gerbera*, *Gypsophila* and *Matthiola*. However, the same

Table 4. Fresh weight loss and solution uptake of *Hydrangea macrophylla* cv. Bela cut flowers kept at 20 °C and 50% RH after a flight trip simulation period using two flower preservative solutions. Evaluation was performed considering the number of days to reach 20% fresh weight loss.

Flower preservative solution	Fresh weight loss (days)	Solution uptake (mL)
Deionized water	8.75 a[1]	23.96 b
ClO_2	7.50 ab	26.56 ab
Triton X-100	3.83 b	31.96 a
Triton X-100 + ClO_2	6.83 ab	26.44 ab

[1]Different letters in a row indicate significant differences according to Tukey's test ($P \leq 0.05$).
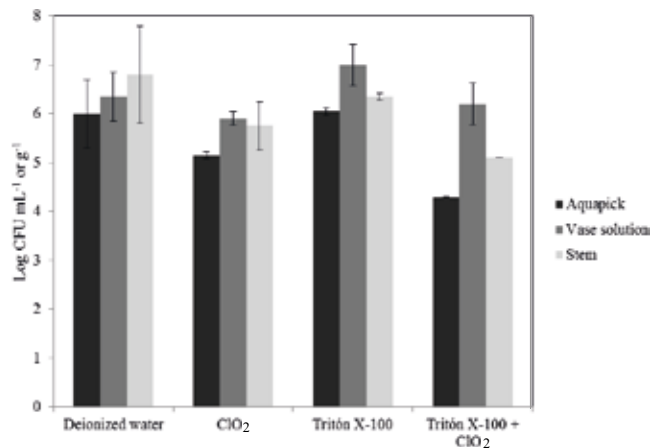
Figure 2. Number of bacteria accumulated in the Aquapick, the vase solution (log UFC mL^{-1}) and the base of the stems (log UFC g^{-1}) of *Hydrangea macrophylla* cv. Bela cut flowers evaluated at the end of vase life.

study observed leaf yellowing and premature flower drop at the concentration of 50 µL L^{-1} applied to others species, such as *Alstroemeria* and *Lilium*. Another study described signs of toxicity (brown discoloration at the base) in cut flowers of *Oncidium* when the stalks were dipped for 5 days into a preservative solution containing ClO_2 at a concentration of 50 mg L^{-1} or higher (Chao *et al*., 2010). Negative effects have also been observed during the vase life of cut flowers using other biocides, such as aluminum sulfate, sodium benzoate, hydroxyquinoline citrate (HQC), Isocil and Physan-20 (Knee, 2000).

The effect of ethylene on the vase life of hydrangea flower stems has been previously reported only in the fresh stage and has been described to produce bract abscission (Schiappacasse *et*

al., 2014). Considering that this symptom was not observed in this study, the effect of ethylene during postharvest of hydrangea flower stems was negligible.

Preservative solutions negatively affect fresh weight loss but facilitate solution uptake

Triton X-100 is a nonionic detergent used as a surfactant to enhance permeabilization of the cell membrane (Koley and Bard, 2010), suggesting its positive effect on solution uptake observed during postharvest of hydrangea cut flowers (Table 4). Floral stage, among others factors, has been described to influence the effect of flower preservatives in order to obtain a satisfactory water balance (Ahmad *et al*., 2013). However, the two

floral stages evaluated in this study showed no statistically significant differences in terms of solution uptake or FWL.

Jowkar *et al*. (2012) suggested that maximum weight gain and solution uptake are correlated, and subsequently, both are correlated with longer vase life of cut flowers. The present study, however, showed that the slowest fresh weight loss (deionized water) was not related to the highest solution uptake, and vice versa (Table 4). Thus, hydrangeas lost fresh weight slower in deionized water and showed the longest vase life compared to the other treatments. Moreover, dehydration of the bracts was one of the most common symptoms observed during the evaluation of hydrangea, and in many cases, it triggered the end of vase life.

Chlorine dioxide did not show significant differences from the control or from Triton X-100 in terms of solution uptake. A similar observation was suggested by Knee (2000), who observed that some biocides do not increase fresh weight gain, but a number of them actually inhibit it.

ClO_2 partially controls bacteria

Although lower levels of bacteria were counted in the solutions containing ClO_2, this substance did not provide very effective control, particularly in the vase solution. van Doorn (1997) described poor efficacy of ClO_2 due to its inability to control all vegetative and sporulating bacteria.

Reduction of solution uptake rate due to microbial contamination has been described, suggesting that levels of approximately 5 to 8 log CFU mL^{-1} in the vase solution cause water uptake reduction in various flower species (van Doorn, 1997). Moreover, bacteria levels of 11 log CFU mL^{-1} significantly reduce water uptake in 'Charlotte' roses (Macnish *et al*., 2008). In this study, the high presence of bacteria in the vase solution of all the treatments evaluated seemed not to affect solution uptake (Table 3) since no relation between this parameter

and the accumulation of bacteria was observed.

Bacterial plugging is usually observed in the base of the stems of cut flowers, affecting water uptake and vase life (Ratnayakea *et al*., 2012). According to the results described in this study, this phenomenon was not observed; despite the high presence of bacteria detected, particularly in the vase solution and the base of the stem by the end of the vase life, water uptake was not reduced. Furthermore, the higher water uptake using Triton X-100 also showed higher bacterial counts (Figure 2). This could be explained by the vascular size of the stem, which is one of the main factors controlling water uptake and vase life in cut flowers (van Doorn, 1997). Thus, previous studies have described that occlusion of xylem is not observed in *Hydrangea macrophylla* due to protrusions emanating from axial parenchyma cells into xylem vessels through pits (Schweingruber *et al*., 2011).

Anatomy of Hydrangea macrophylla would explain solution uptake and water loss results

The aesthetic value of the genus *Hydrangea* comes from its colored bracts, which are foliar organs, as well as petals, but less modified (Esau, 1977). Microscopic observations have confirmed that hydrangea bracts show a high number of stomata, more similar to leaves than petals, which could explain the severe fresh weight loss despite the high solution uptake observed, (Table 4) since the balance between transpiration and water uptake is crucial during the vase life of cut flowers (van Doorn, 1997). Thus, although no stomata were observed on the adaxial surface, abundant stomata were observed on the abaxial side of the bracts (Figure 3), reaching values of 37 ($\pm$ SE=4.9; n=5) and 27 ($\pm$ SE=2.2; n=4) stomata per mm^{-2} in the fresh and antique stages, respectively. The density of stomata is related to the loss of water by transpiration (Bergmann 2004), as observed by Schroeder and Stimart (2005), who described transpiration through stomata during *Antirrhinum majus* postharvest, finding between 100 to 200 stomata mm^{-2} on the abaxial surface of the leaves, ignoring transpiration through

the petals. The same authors concluded that stomatal density is related not only to transpiration but also to the total number of stomata per flower. Considering the characteristics of the inflorescence of hydrangea, with a high number of bracts per flower stalk, stomata located on the surface of these bracts would allow a high rate of transpiration that correlated with the high water loss observed. Furthermore, Triton-100 has been described as beneficial to maintaining stomatal opening (Jones *et al*., 1993), therefore, its effect on hydrangea could explain the higher fresh weight loss observed in flowers preserved with this substance (Table 2).

Despite the fact that ClO_2 (biocide) partially controlled the presence of microorganisms, and Triton X-100 (surfactant) enhanced solution uptake during postharvest of hydrangea cut flowers, these flower preservatives were not effective at extending vase life after air shipment simulation of this species. Furthermore, due to the large size of the xylem vessels in hydrangea stems, bacterial plugging is not observed during postharvest. On the other hand, the presence of stomata on the bracts seems to be crucial for the dehydration of the inflorescences of hydrangea, a problem that was not solved by the higher solution uptake promoted by Triton X-100.

Acknowledgements
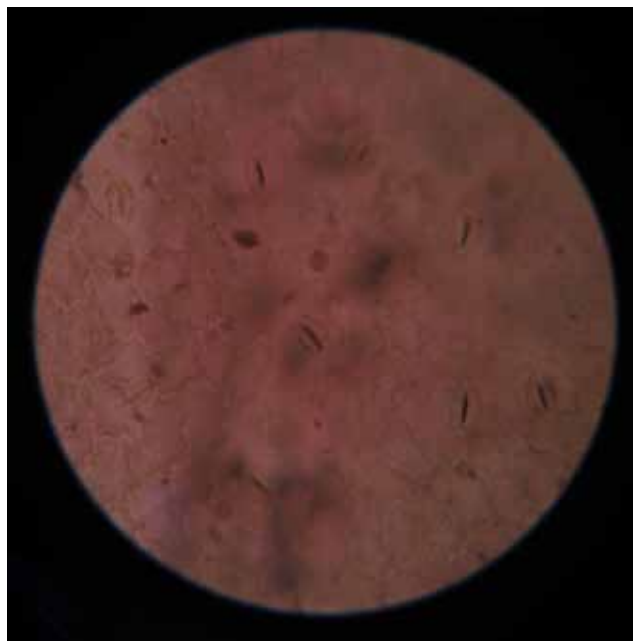
Figure 3. Photograph of stomata observed on the epidermis of the abaxial side of the bracts of *Hydrangea macrophylla* cv. Bela using a CX21FS1 Olympus stereoscopic microscope at 40X.

Resumen

D. Aros, C. Silva, C. Char, L. Prat y V. Escalona. 2016. Rol de las soluciones preservantes de flores durante la postcosecha de *Hydrangea macrophylla* cv. Bela. **Cien. Inv. Agr. 43(3):418-428.** *Hydrangea macrophylla* (hortensia) es ampliamente utilizada como planta ornamental y flor de corte debido a su inflorescencia compuesta por brácteas coloreadas. Como flor de corte, las hortensias presentan una vida en postcosecha de hasta un mes a 2°C pero poco se conoce sobre su postcosecha durante un envío aéreo. Este estudio tuvo como objetivo evaluar el efecto de Triton X-100 (surfactante) y ClO_2 (biocida) durante una simulación de envío aéreo de hortensias cosechadas en dos estados de desarrollo floral: 'fresh' y 'antique'. Durante esta simulación aérea se evaluó vida en florero, pérdida de peso fresco y captura de solución. Además, se realizó un conteo de bacterias y observaciones microscópicas de las brácteas para entender las relaciones hídricas durante la vida en florero. La vida en florero más prolongada se observó en hortensias 'antique' y el control (agua deionizada) fue el mejor tratamiento alcanzando hasta 32,7 días en este estado floral. La pérdida de peso fresco fue más rápida cuando se utilizó Triton X-100 (3,83 días para perder 20% of peso fresco) en comparación con el agua deionizada (8,75 días). Sin embargo, este preservante floral fue eficiente en promover la captura de solución (31,96 mL). El taponamiento por bacteria no fue sugerido para esta especie considerando que la alta presencia de microorganismos contabilizados no afectó la captura de solución y la vida en florero. La presencia de estomas en las brácteas parece ser crucial para la deshidratación de la inflorescencia, problema que no fue resuelto por la mayor captura de solución promovido por el Triton X-100. Agua deionizada fue el mejor tratamiento y el efecto de preservantes florales fue insignificante para extender la vida en florero de flores de hortensia.

Palabras clave: ClO_2, hortensia, Triton X-100, vida en florero.

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