EFFECTIVENESS OF POSTHARVEST SOLUTIONS FOR THE CONSERVATION OF CUT *Oncidium varicosum* (ORCHIDACEAE) INFLORESCENCES

Eficácia de soluções para a conservação pós-colheita de inflorescências cortadas de *Oncidium varicosum* (Orchidaceae)

Claudia Fabrino Machado Mattiuz[1], Ben-Hur Mattiuz[2], Teresinha de Jesus Deléo Rodrigues[2], Kelly Magalhães Marques[2], Ramilo Nogueira Martins[3]

ABSTRACT

The orchid *Oncidium varicosum* is a tropical plant with significant commercial value due to the beauty of its yellow inflorescences. Several authors have observed a reduction in the water content of cut flowers, consequently, wilting and senescence of petals are the main reasons for the termination of the decorative life of cut flowers. In this research, we studied the effects of several chemical compounds on the postharvest life of cut inflorescences of *Oncidium varicosum* 'Samurai'. These chemicals are as follows: sucrose (5%) plus 8-hidroxiquinoline citrate (8-HQC) (100 mg L^{-1}) plus silver nitrate ($AgNO_3$) (50 mg L^{-1}); sucrose (5%) plus citric acid (75 mg L^{-1}); quaternary ammonia at 30% (50 mg L^{-1}); and sucrose (5%) plus quaternary ammonia at 30% (50 mg L^{-1}). The highest values for average of relative water content, reducing carbohydrates and soluble sugars were recorded in the flowers treated with the sucrose (5%) plus 8-HQC (100 mg L^{-1}) plus $AgNO_3$ (50 mg L^{-1}) solution. A reduction in color intensity occurred at 12 days postharvest in all treatments and the carotenoid content was reduced to the greatest extent in flowers maintained in distilled water. The lowest numbers of open flowers were observed at 12 and 15 days in the distilled water and quaternary ammonium treatments, being that the others treatments favored the anthesis. The *Oncidium* inflorescences treated with sucrose plus HQC plus $AgNO_3$ demonstrated a higher number of open flowers and reached the longest longevity (22 days).

Index terms: Physiology; orchids; flowers; carbohydrates; carotenoids; relative water content.

RESUMO

A orquídea *Oncidium varicosum* é uma planta tropical com destacada importância comercial, em razão da beleza de suas inflorescências de coloração amarela. A redução do conteúdo de água de flores cortadas tem sido constatada por diversos autores e, como consequência, o murchamento e a senescência das pétalas são as principais razões para a redução da vida útil de flores cortadas. Na presente pesquisa, foi estudado o efeito de diferentes compostos químicos (sacarose (5%) + 8-hidroxiquinolina (8-HQC) (100 mg L^{-1}) + nitrato de prata ($AgNO_3$) (50 mg L^{-1}); sacarose (5%) + ácido cítrico (75 mg L^{-1}); amônia quaternária a 30% (50 mg L^{-1}); sacarose (5%) + amônia quaternária a 30% (50 mg L^{-1}) sobre a vida pós-colheita de inflorescências cortadas de *Oncidium varicosum* 'Samurai'. Os maiores valores médios do conteúdo relativo de água, carboidratos redutores e açúcares solúveis foram registrados nas flores em solução de sacarose 5% + 8-HQC (100 mg L^{-1}) + $AgNO_3$ (50 mg L^{-1}). A redução da intensidade da cor foi mais acentuada, após 12 dias de vida pós-colheita e o conteúdo de carotenoides apresentou maior redução para as flores mantidas em água destilada. Os menores números de flores abertas nas inflorescências de *Oncidium*, aos 12 e 15 dias de vida de vaso foram observados nas hastes mantidas em água destilada e nas duas soluções com amônia quaternária, ou seja os outros tratamentos favoreceram a antese. As flores de *Oncidium* tratadas com sacarose+HQC+$AgNO_3$ obtiveram maior número de flores abertas nas inflorescências, e alcançaram maior longevidade floral (22 dias).

Termos para indexação: Fisiologia; orquídeas; flores; carboidratos; carotenoides; conteúdo relativo de água.

INTRODUCTION

Oncidium is an orchid genus consisting of more than 750 different species. The majority of these species occur in South America, but some are also found in Central America and the Caribbean. *Oncidium varicosum* is a species native to the Atlantic Forest in the state of Rio de Janeiro, and new hybrids of this species are currently being commercialized for cut flowers (Miller; Warren; Miller, 1996). Orchids in the *Oncidium* genus have inflorescences that are erect, large, branched, and present numerous tiny flowers that are generally golden yellow (Allikas; Nash, 2000).

[1]Centro Universitário Moura Lacerda – Unidade II – Campus de Ribeirão Preto – Av. Dr. Oscar de Moura Lacerda, 1520 – 14076-510 – Ribeirão Preto – SP – Brasil – cmattiuz@gmail.com
[2]Universidade Estadual Paulista/UNESP – Faculdade de Ciências Agrárias e Veterinária – Campus de Jaboticabal – Jaboticabal – SP – Brasil
[3]Empresa de Pesquisa Agropecuária de Minas Gerais/EPAMIG – Unidade Regional Epamig Norte de Minas EPAMIG/URENM – Nova Porteirinha – MG – Brasil
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Orchid flowers are very sensitive to ethylene (Halevy; Mayak, 1981), and because ethylene production is an autocatalytic process, larger quantities are produced when flowers are in the presence of senescent flowers. Compounds that can be used to prevent ethylene production in cut flowers include silver thiosulfate, naphthalene acetic acid (Gago; Monteiro, 2012), and 1 methylciclopropene (1-MCP) (Mattiuz et al., 2012a).

Flowers of *Oncidium varicosum* 'Samurai' treated with STS (2 mM) presented a better maintenance of relative water content as well as a higher concentration of carbohydrates and longevity (Mattiuz et al., 2012b). The use of 1-MCP at 1000ppb contributed to higher quality and longer life of inflorescences of *Oncidium varicosum* 'Samurai' up to 20 days (Mattiuz et al., 2012a).

Application of exogenous sugars extends the life of cut flowers. They may serve to improve water relations as they can lower the osmotic potential, maintain respiration and metabolism in case of lack of adequate substrate, and they can reduce ethylene sensitivity (Van Doorn, 2004).

Bactericides are also frequently used in holding solutions (Macnish et al., 2008). The compound 8-HQC is excellent at reducing the physiological occlusion of flower stalks (Nowak et al., 1991); the quaternary ammonium and organic acids inhibit endogenous enzymes related to vascular blockage (Halevy; Mayak, 1981).

The objective of the present research was to evaluate the effects of different chemical compounds on the postharvest physiology of cut inflorescences of *Oncidium varicosum* 'Samurai' in order to extend the vase life of this important Brazilian orchid.

MATERIAL AND METHODS

Inflorescences of *Oncidium varicosum*, 'Samurai', were harvested in the morning in Atibaia-SP, Brazil, when the inflorescences consisted of 30% open or almost open flowers. Each inflorescence was placed in a single plastic tube with micro-perforations, and the flowers were transported in a refrigerated vehicle to the FCAV/UNESP Plant Physiology Laboratory in Jaboticabal-SP, Brazil. At the lab, after selected, the floral stalks were standardized at 0.90m of length, labeled, weighed and subjected to one of the following treatments: 1) distilled water; 2) sucrose (5%) plus 8-HQC (100 mg L^{-1}) plus silver nitrate (50 mg L^{-1} $AgNO_3$); 3) sucrose (5%) plus citric acid (75 mg L^{-1}); 4) quaternary ammonium at 30% (50 mg L^{-1}); or 5) sucrose (5%) plus quaternary ammonium at 30% (50 mg L^{-1}). The inflorescences were maintained in Erlenmeyer flasks containing 0.5 L of the solution and exchanged on each day of evaluation.

The experiment was conducted using a complete randomized design in a factorial scheme comprised of two factors (five postharvest treatments and four evaluation times). Three replications were used for each treatment with three inflorescences, for a total of 180 stalks. The flowers were maintained under conditioned air at a temperature of 23 ºC ± 1.1, and with a photoperiod of 12 hours (4 fluorescent lamps of 40 W each; the ambient room: 4 m x 2.5 m x 2.8 m) and 84% relative humidity.

The relative water content (RWC) of *Oncidium varicosum* 'Samurai' flowers was obtained by collecting ten whole flowers for each replication. The flowers were weighed and immersed in distilled water for four hours. After this period, the flowers were weighed and dried (70 ºC). The RWC calculation (%) was performed according to Kramer (1983).

Carbohydrate extraction of the inflorescences was made in ethanol using 2 g of petals. Soluble carbohydrate contents were quantified using the phenol-sulfuric acid method (Dubois et al., 1956), and reducing sugars were quantified according to the method proposed by Honda et al. (1982). Color evaluation of inflorescences was performed using a MINOLTA CR 200b colorimeter, with the values established as follows: L (100 = white; 0 = black); a* (positive = red; negative = green); and b* (positive = yellow; negative = blue). The hue angle (h°) and the chromaticity were calculated using equations published by Minolta (1994).

In order to determine total carotenoid content, a 1-g flower sample was weighed out for each replicate for each treatment following the methods of Hendry and Price (1993). Each sample was macerated with 80% acetone (v/v) in the presence of $CaCO_3$. The material was then vacuum-filtered, and the final volume was adjusted to 100 mL of 80% acetone per gram of petals and sepals. The absorbance was measured using a spectrophotometer (Beckman-DU-640) at 480, 645 and 663 nm.

The numbers of floral buds and flowers on the orchid stalks were recorded during the evaluations. The vase life days (VLD) were finalized when 50% or more of the flowers in one inflorescence decreased in quality, with wilting, color fading and brightness.

The data obtained were subjected to analysis of variance and the differences between two treatments were larger than the sum of two standard deviations, they were considered significant (Shamaila; Powrie; Skura, 1992).

RESULTS AND DISCUSSION

The RWC of *Oncidium* flowers decreased during the evaluation period in all treatments. The sucrose plus 8-HQC plus $AgNO_3$ solution promoted the turgor maintenance of cut *Oncidium* inflorescences (Figure 1). The loss of fresh mass from cut flowers occurs due to transpiration, and in tropical orchids the transpiration rate is directly related to the floral surface and the size of the flower. In *Dendrobium* and *Aranda* inflorescences, there was a positive correlation between the relative water content and longevity (Hew et al., 1989).

The distilled water treatment at 12 vase life days (VLD) had the lowest RWC value compare to sucrose + 8-HQC + AgNO3 treatment and therefore, a reduced decorative life. This result demonstrated that water alone was not sufficient to guarantee a positive water balance in *Oncidium*. The inflorescences in the holding solution containing sucrose plus 8-HQC plus $AgNO_3$ had a RWC of 85.12% on the fifteenth VLD.

There was reduction in both the soluble carbohydrates and in the reduced sugar contents in the inflorescences after the eighth day of the evaluation period in the majority of treatments (Figure 2). Reducing sugars are described as the main constituents of the sugar pool in the mature petals of several floral species (Halevy; Mayak, 1981). This fact supports the idea that floral tissues are active metabolic centers. In *Cymbidium* flowers, the sugar content in the perianth decreased with the age (Hew; Yong, 2004). Among the treatments, the higher sugar contents were observed in sucrose + HQC + $AgNO_3$ and sucrose + citric acid treatments with the highest values in 8th day of storage. It was found that use of quinoline compounds (8-Hydroxyquinoline sulfate: 8-HQS or 8-Hydroxyquinoline citrate: 8-HQC) in pulsing or holding solution prolonged vase life in gladiolus 'White Prosperity' and rose cut flowers, and sucrose addition had a synergistic effect with germicides (Egilmabi; Ahmed, 2009; Kumar et al., 2012).

The highest reductions were observed in the flowers kept in the quaternary ammonium plus sucrose, followed by solutions containing distilled water and the quaternary ammonium. The reduction of the carbohydrate contents is an indication of the senescence (Figure 2). This occurs because the carbon reserves have been used in respiration and in the repair of cellular damage caused by degradation. Hew and Yong (2004) reported that the positive correlation between water uptake and longevity in *Dendrobium* 'Pompadour' flowers was most likely due to the high sugar levels in the flowers.

The treatment that presented the highest average values for soluble carbohydrates was the sucrose plus 8-HQC plus $AgNO_3$ solution (14.26 % glucose), followed by the sucrose plus citric acid solution (13.17 % glucose).

The use of sucrose in postharvest flower treatments has been recommended by several authors (Halevy; Mayak, 1981; Marissen, 2001). Sucrose delays the degradation of proteins, lipids and nucleic acids, as well as maintains the integrity of membranes and the structure and function of mitochondria. In addition, sucrose inhibits the production and action of ethylene, improves water balance and regulates stomatal closure, thus reducing transpiration (Nowak et al., 1991).

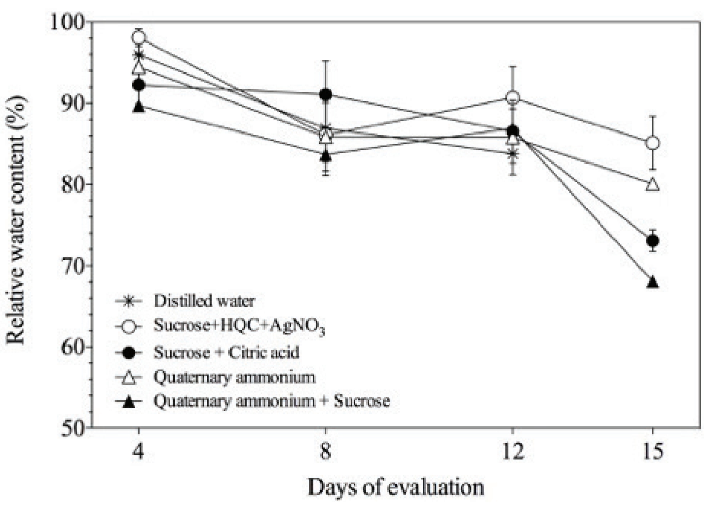

Figure 1: The relative water content of cut *Oncidium varicosum* 'Samurai' inflorescences held in five different holding solutions Data shown are the means ± SD.

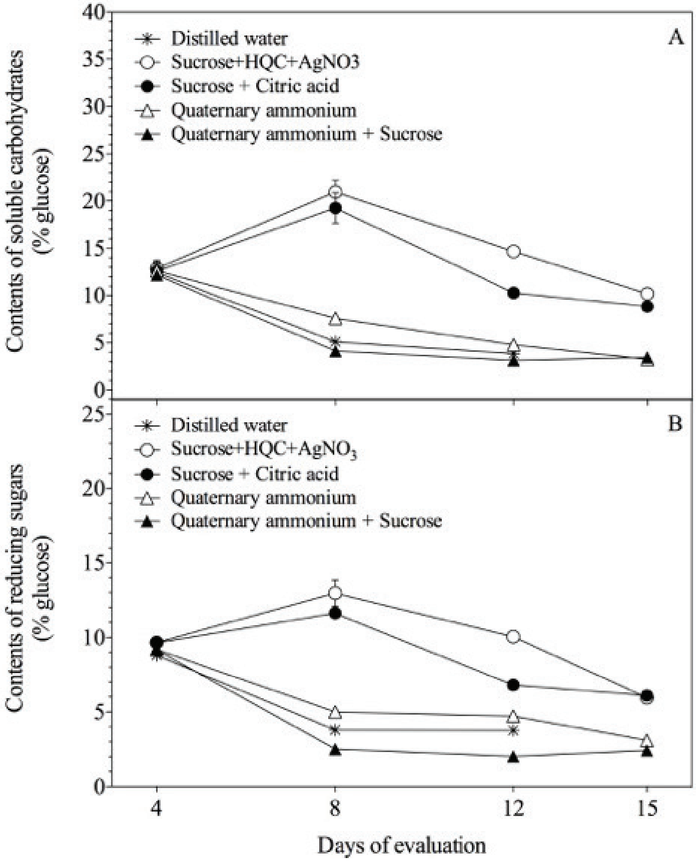

Figure 2: Content of soluble carbohydrates (A) and reducing sugars (B) of cut *Oncidium varicosum* 'Samurai' inflorescences subjected to five different holding solutions. Data shown are mean ± SD.

The use of 8-HQC (50-100 ppm) in addition to sucrose, increased the longevity of several genera of orchids including *Oncidium* 'Goldiana' (Hew, 1985) and *Dendrobium* 'Youppadeewan' (Ketsa; Boonrote, 1990).

The coloration analysis showed a decrease in the luminosity of the inflorescences in all treatments, and showed no difference among the treatments up to the eighth day (Figure 3). The hue angle and chromaticity showed a similar decrease. These analyses indicate that over time, the flowers became darker (luminosity), had a less lively color (hue angle) and were less intense (chromaticity).

The use of the sucrose plus 8-HQC plus $AgNO_3$ solution decreased flower darkening (Figure 3). Flower color is mainly due to the chemical structure of various pigments. *Oncidium* flowers gradually lost their brilliant yellow color. This is in agreement with the results of Nowak and Rudnicki (1990) who reported that floral stalks kept in quality solutions retained a higher intensity of petal coloration. The inflorescences of the sucrose plus HQC plus $AgNO_3$ treatment had the best results, indicating that the composition of this solution was beneficial to color stability. Fading or the darkening of the sepals is described as an indicator of orchid senescence (Harkema; Strijlaart, 1989). The darkening of the flowers may be related to either water stress or to a low level of carbohydrates (Reid, 2002) and is generally caused by phenol oxidation.

Only the inflorescences in the sucrose plus HQC plus $AgNO_3$ solution showed significant reductions in the number of buds and a significant increase in the number of open flowers during the vase life (Figure 4). The sucrose plus citric acid solution produced the next highest number of open flowers at the fifteenth VLD. These results indicate that the maintenance of a higher turgor value (Figure 1) contributed to the anthesis of a larger number of flowers. The distilled water treatment did not differ significantly from the others in evaluations performed at four and eight VLD, but on the twelfth VLD the inflorescences presented 50% senescent flowers (data not shown).

The harvest of orchid flowers at the bud stage is considered commercially attractive because it avoids damage such as the emasculation of flowers and it prevents the autocatalytic synthesis of ethylene (Hew; Yong, 2004). It is important, when harvesting flowers in the bud stage, to treat them with the appropriate solutions to promote flower opening. This research demonstrated that the solution composed of sucrose plus 8-HQC plus $AgNO_3$ promoted excellent anthesis (Figure 4). In studies performed by Hew (1985), sucrose, 8-HQC and silver nitrate also promote the opening of *Oncidium* flowers, promoting 80% of the flowers to open. These results demonstrate that the efficiency of the holding solutions can be improved using the combination of a bactericide and a carbohydrate source.

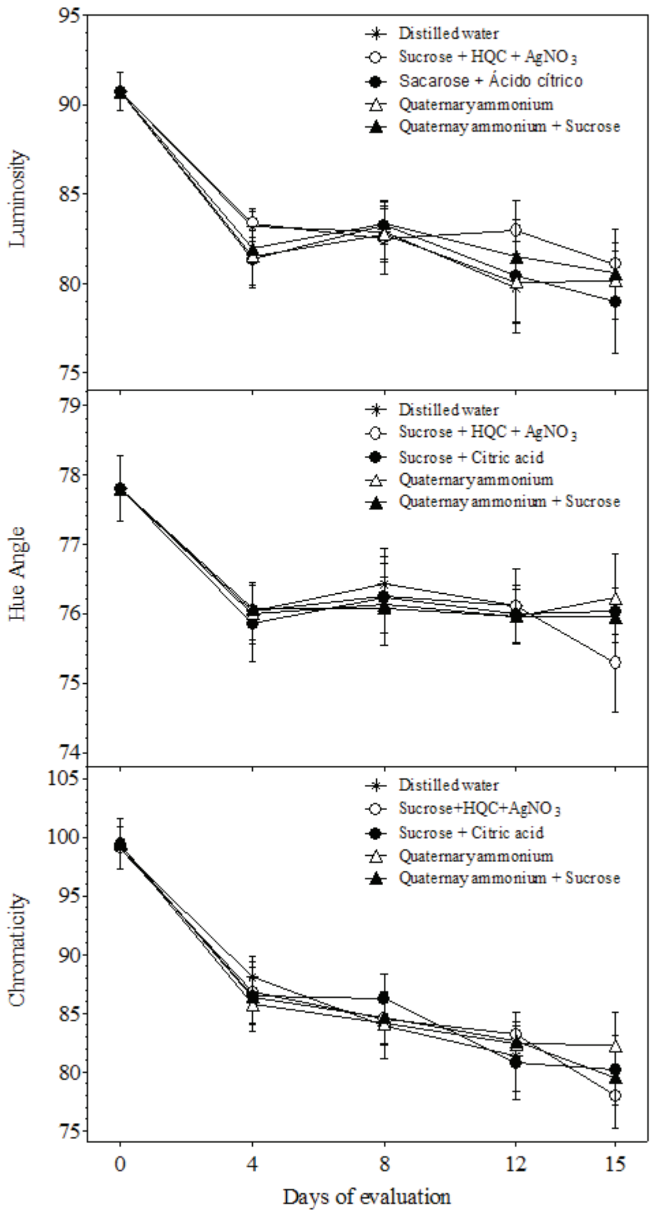

Figure 3: Luminosity, hue angle and chromaticity of cut *Oncidium varicosum* ‘Samurai’ inflorescences subjected to five different holding solutions. Data shown are mean ± SD.

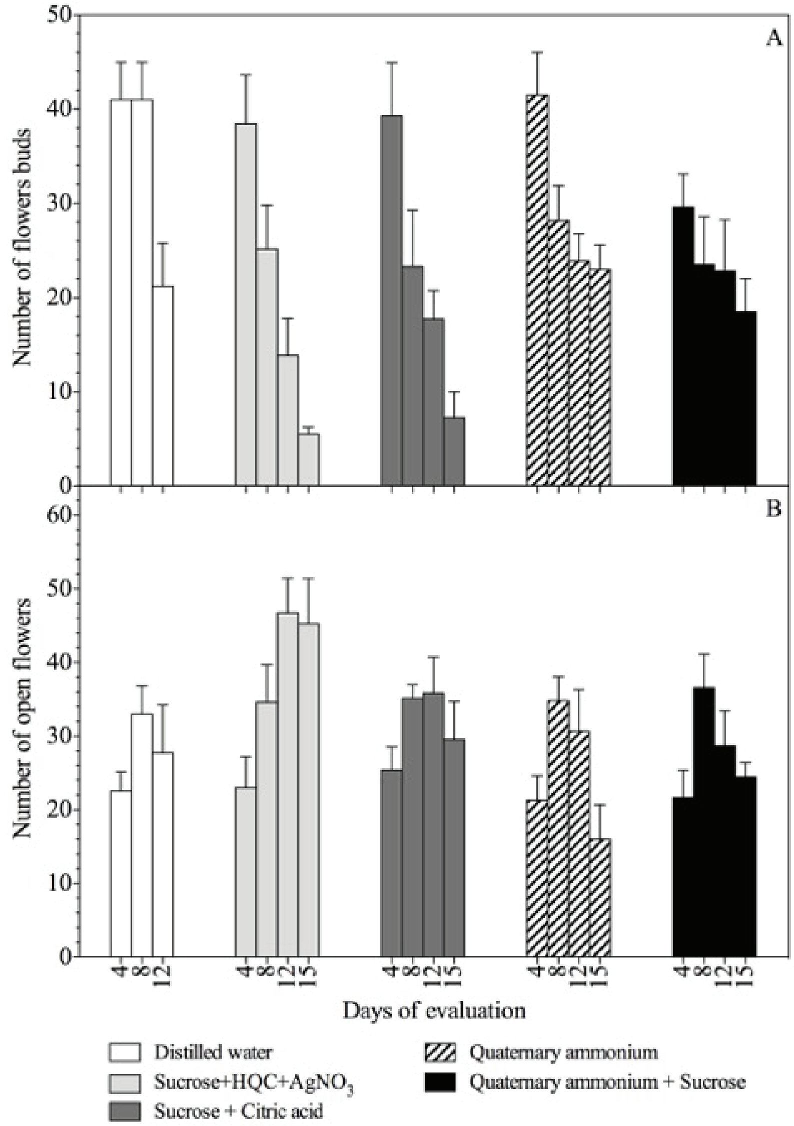

Figure 4: Number of buds (A) and open flowers (B) of cut *Oncidium varicosum* 'Samurai' inflorescences subjected to five different holding solutions. Data shown are mean ± SD.

The flower longevity finished on different days as follows: distilled water (13 days), quaternary ammonium (15 days), quaternary ammonium plus sucrose (15 days), sucrose plus citric acid (16 days), and sucrose plus 8-HQC plus $AgNO_3$ (22 days). The longest life was obtained by the inflorescences held in the sucrose plus 8-HQC plus $AgNO_3$ solution. It is evident, as observed with *Oncidium varicosum* 'Samurai' that quality solutions at the correct concentrations can prolong the postharvest life of cut flowers and contribute to the maintenance of their decorative life.

Wilting and floral senescence are the main reasons for the end of the decorative life of cut flowers (Van Meeteren; Gelder, 1980; Halevy; Mayak 1981). Generally, flower longevity is determined by the senescence of the sepals. This is because the period from the opening of the petals to wilting is shorter than that of other organs (Mayak; Halevy, 1980).

In conclusion, the flowers treated with the sucrose plus HQC plus $AgNO_3$ solution presented a higher average final RWC (85.12%) and the highest content of soluble carbohydrates (10.20% glucose). In all of the holding solutions, the *Oncidium* flowers retained their brilliant yellow color until the twelfth day of postharvest life. The carotenoid content of *Oncidium* flowers kept in distilled water was 17.91 µmol g FW^{-1} (at the twelfth VLD), while the flowers maintained in the sucrose plus HQC plus $AgNO_3$ solution had a carotenoid content of 82.82 µmol g FW^{-1} (at the fifteenth VLD). The *Oncidium* inflorescences treated with sucrose plus HQC plus $AgNO_3$ demonstrated a higher number of open flowers and reached the longest longevity (22 days).

CONCLUSIONS

The highest values for average of relative water content, reducing carbohydrates and soluble sugars were recorded in the flowers treated with the sucrose (5%) plus 8-HQC (100 mg L^{-1}) plus $AgNO_3$ (50 mg L^{-1}) solution.

A reduction in color intensity occurred at 12 days postharvest in all treatments and the carotenoid content was reduced to the greatest extent in flowers maintained in distilled water.

The lowest numbers of open flowers were observed at 12 and 15 days in the distilled water and quaternary ammonium treatments, being that the others treatments favored the anthesis.

The *Oncidium* inflorescences treated with sucrose plus HQC plus $AgNO_3$ demonstrated a higher number of open flowers and reached the longest longevity (22 days).

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