Journal of the Saudi Society of Agricultural Sciences (2012) **11**, 29–35

King Saud University

Journal of the Saudi Society of Agricultural Sciences

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FULL LENGTH ARTICLE

Effects of some preservative solutions on vase life and keeping quality of snapdragon (*Antirrhinum majus* L.) cut flowers

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Received 19 April 2011; accepted 18 June 2011
Available online 7 July 2011

KEYWORDS

Cut flowers;
Snapdragon;
Preservative solution;
Vase life;
Chlorophyll content;
Flower biomass

Abstract The effect of selected chemical agents used as preservative solutions to improve the keeping quality of cut snapdragon (*Antirrhinum majus* L. cv. Yellow Butterfly) flowers had been studied. These preservative solutions (treatments) were: 2% sucrose, 200 ppm 8-hydroxyquinoline sulfate (8-HQS), pulsing treatment with 200 ppm 8-HQS in combination with 2% sucrose for 12 h, pulsing the spikes with 0.2 mM silver thiosulfate (STS) for 1 h, pulsing with 0.2 mM STS for 1 h followed by 2% sucrose solution, or distilled water used as control. The results showed that all treatments had improved the keeping quality and vase life of the cut flowers comparing to control ones. Among all these treatments, the 8-HQS plus 2% sucrose treatment showed best water uptake, water balance, percentage of maximum increase in fresh weight of the cut flower stem and vase life which was extended up to 18 days. Moreover, this keeping solution treatment retarded the degradation of chlorophyll as well as carbohydrate of the cut flowers during their postharvest life. It has been concluded that 200 ppm 8-HQS combined with 2% sucrose solution has the potential to be used as a commercial cut flower preservative solution to delay flower senescence, enhance post-harvest quality and prolong the vase life of cut snapdragon flowers.

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Peer review under responsibility of King Saud University.
doi:10.1016/j.jssas.2011.06.002

Production and hosting by Elsevier

1. Introduction

Antirrhinum majus L. (common name: snapdragon) plants belong to the family of Scrophulariaceae. The species is often planted for landscaping in gardens for its showy flowers. Snapdragon is desirable for cut flowers because of its wide range of petal colors and fragrance. The snapdragon cut flowers are sensitive to ethylene, and their vase lives are relatively short (Wang et al., 1977; Waltering and van Doorn, 1988; Serek et al., 1995).

Adding chemical preservatives to the holding solution is recommended to prolong the vase life of the cut flowers. All holding solutions must contain essentially two components; sugar and germicides. The sugar provides a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the conducting tissues. Among all the different types of sugars, sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers. The exogenous application of the sucrose supplies the cut flowers with much needed substrates for respiration, and enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally (Pun and Ichimura, 2003).

Several methods to increase the vase life of cut flowers and keep their freshness for longer periods have been reported. Cut flowers should be free of any deterioration, as this is one of the principal entry points for decay organisms (Hardenburg, 1968). A major form of deterioration in cut flowers is the blockage of xylem vessels by air and microorganisms that cause xylem occlusion (Hardenburg, 1968). The 8-HQS is a very important germicide in preservatives used in floral industry (Nowak and Rudnicki, 1990), and acts as an antimicrobial agent (Ketsa et al., 1995) which can led to increase water uptake (Reddy et al., 1996). The application with 8-HQS increased the vase life as well as the fresh weight (percentage of initial) of the cut flowers; whereas 8-HQS treatment prevented growth of the microorganisms in xylem vessels of the cut flower stems and maintained water uptake. However, the 8-HQS treatment was more effective when sucrose was coupled with it (Pun and Ichimura, 2003). The concentration of glucose, fructose and sucrose in petals of cut flowers were increased with 8-HQS + 2% sucrose treatment comparing to control ones. Beura et al. (2001) showed that the combination treatment of 8-HQS and sucrose improved the postharvest quality of Gladiolus spikes. In *Dendrobium* cut flowers, holding solutions containing 8-HQS + sucrose extended the vase life and improved flower quality, water consumption, fresh weight, flower freshness, and reduced respiration rate and physiological weight loss (Dineshbabu et al., 2002).

Silver thiosulfate (STS) acts as an ethylene antagonist and reduces ethylene production and respiration (Veen, 1979), and extends flower longevity (Reid et al., 1980). Moreover, Ichimura and Hismatsu (1999) reported that abscission of snapdragon cut flowers was delayed by treatments containing ethylene biosynthesis inhibitors such as methylcyclopropene and silver thiosulfate. However, treatment with STS in combination with sucrose has been found to be more effective in improving vase life than with STS or sucrose alone of some cut flowers such as carnation (Goszynski and Rundnicki, 1982) and *Gypsophila* (Van Doorn and Reid, 1992). Also, the dual application of sugars and antimicrobial agents has increased vase life by up to 22%, and improved spikes quality of two Gladiolus cultivars (Abdulrahman, 2004). Presumably, these disinfectants improve water conductance by preventing bacterial growth (Van Doorn and Perik, 1990; Van Doorn et al., 1991) and the sucrose supplies energy and carbon skeletons needed for bud opening.

The objective of this work was to investigate different keeping solutions and determining the best ones which extend vase life and improve the keeping quality of snapdragon (*A. majus*, L.) cut flowers, especially when used for flower arrangements and interior decorations.

2. Materials and methods

2.1. Experimental site

Seed germination and transplanting of snapdragons (*A. majus*, L. cv. Yellow Butterfly) plants were carried out in a greenhouse under controlled conditions of Plant Production Department, Experiments Station of College of Food and Agricultural Sciences, King Saud University. The temperatures were set at 27/18 °C day/night, and a supplemental light of 750 μmol m^{-2} s^{-1} (at a canopy level) was provided by high-vapor pressure sodium lamps for 14 h day^{-1}. Seeds and seedlings were misted twice daily until transplanted. The flowers were cut to a uniform size of 30 cm from the plant on September 16, 2009.

2.2. Procedure and experimental design

Flower spikes with three open florets were cut from the plants. The flowers were immediately unpacked and the lower 10 cm of the stems were defoliated, and 2 cm from the basal were cut off under water to avoid air embolism. Each treatment consisted of 10 replicates (bottles), and each bottle contained one cut flower stem (one spike). The experiments were carried out in a laboratory of the Plant Production Department, College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia. The laboratory was maintained at 23 °C, 70% relative humidity, and 10 μmol m^{-2} s^{-1} irradiance using cool-white fluorescence lamps for a 12-h photoperiod.

Data were recorded on vase life (days), total water uptake and balance (ml/flower/day) by the spikes, percentage of maximum increase of fresh weight (%), leaf chlorophyll content (mg g^{-1} dry weight), and carbohydrate content (mg g^{-1} dry weight) of petals and stems of snapdragon cut flowers.

To examine the effects of the vase solution components on the keeping quality of snapdragon cut flowers, five different preservative solutions (treatments) were used as follows: (1) 2% sucrose, (2) 200 ppm 8-hydroxyquinoline sulfate (8-HQS), (3) pulsing the spikes with 200 ppm 8-HQS in combination with 2% sucrose for 12 h, (4) pulsing the spikes with 0.2 mM silver thiosulfate (STS) for 1 h, (5) pulsing the spikes with 0.2 mM STS for 1 h followed by 2% sucrose solution, and (6) or distilled water used as a control. The STS was prepared as described by Gorin et al. (1985). The preparation of the STS solution proceeds as follows:

(1) Dissolving 0.079 g $AgNO_3$ in 500 ml deionized water.
(2) Dissolving 0.462 g $Na_2S_2O_3{\cdot}5H_2O$ in 500 ml deionized water.
(3) Pouring $AgNO_3$ solution into $Na_2S_2O_3{\cdot}5H_2O$ solution while stirring.

Pulsing with the STS was done by immersing the lower portion of the cut flower stem in 0.2 mM STS solution ($1AgNO_3{\cdot}4Na_2S_2O_3{\cdot}5H_2O$) for 1 h followed by 2% sucrose solution or distilled water served as a control.

2.3. Vase life

The average vase life of the cut flowers was counted from the day of transferring the spikes to the keeping solutions, and was

assessed to be terminated when flowers lost their ornamental/display value (underwent color change; wilt and loose turgidity). The vase life of the individual snapdragon cut flower stem was terminated when all florets wilted or when they showed bent neck. Florets with unfolded petals on stems which had not bent were counted as an open floret.

2.4. Water relations

2.4.1. Vase solution uptake rate (VSU)

Weights of vases containing vase solutions without the cut spikes were recorded daily during the vase life evaluation period. Average daily VSU rate was calculated by the formula:

$$\text{VSU } [\text{g g}^{-1} \text{ initial fresh weight (IFW)}] = (\text{St}^{-1} - \text{St})/\text{IFW of the stem;}$$

where St is the weight of vase solution (g) at t = day 1, 2, 3, etc., and St^{-1} is the weight of vase solution (g) on previous day (Damunupola, 2009).

2.4.2. Water balance (ml/flower/day)

The following components of water balance of each cut flower stem (a spike) can be distinguished: water uptake, transport, water loss, and the capacity of flower tissue to retain its water (Halevy and Mayak, 1981).

2.5. Maximum increase of fresh weight (%)

Fresh weights of snapdragon pea flowers were measured daily during vase life. The original fresh weight was measured immediately after cutting flowers and before the immersing in keeping solutions. The flowers were weighted every day until the end of the vase life. The fresh weight of each cut flowers was expressed relatively to their initial weights to represent the percentage of weight loss for each cut flower stem (He et al., 2006).

2.6. Chlorophyll determination

Chlorophyll content of snapdragon leaves was extracted by acetone from samples of cut leaf segments (0.59) taken on day 0 (at the beginning of experiment), day 3 and on the day when the vase life of the control flowers was terminated (day 7). The samples were taken from the leaves in the upper part of the flowering stems. The samples were collected separately from each replicate and the average of the three replicates was calculated. Extraction in acetone was repeated until all pigments were extracted. The absorbance of the extracts was determined in by a spectrophotometer (type GBC, UV/VIS 916, Australia). The chlorophyll content was determined according to Moran and Porath (1980). The equations used to determine the concentrations of both chl. a and chl. b were:

$$\text{Chl.a} = 11.24\,A661.6 - 2.04\,A644.8$$
$$\text{Chl.b} = 20.13\,A664.8 - 4.19\,A661.6$$

since A is absorbance.

2.7. Sugars determination

The change in sugar content of snapdragon flowers during vase life were determined on the stems and petals held in de-ionized water (DI) and in a commercial preservative. Samples were taken on days 1, 3, and 5 and separated by a high performance liquid chromatography (HPLC) fitted with differential refractometer to detect fructose, glucose and sucrose in the different sample. Stems and petals were extracted in 2 or 5 ml 80% ethanol depending on the weight of the sample, by shaking for three hours. One milliliter of the extract was then evaporated to dryness in a water bath, redissolved in 1 ml DI, and used directly for HPLC analysis of sugars. Sugars were separated on two 10 cm long Aminex Fast Carbohydrate Columns connected in series, and concentrations determined by refractive index of the peaks and comparison with peak area of an inositol internal standard (Moon-Soo et al., 2001).

2.8. Statistical analysis

The results were interpreted according to Steel and Torrie (1980) and the differences between the means of the treatments were considered significant when they were equal or more than the least significant difference (L.S.D) at the 5% level.

3. Results and discussion

3.1. Vase life

Data presented in (Table 1) showed that the vase life of snapdragon cut flowers was significantly extended as a result of using of 8-HQS, as compared to the control. The vase life was longer in 8-HQS at 200 ppm which resulted in 14 days in comparison with 8 days of the control ones (Table 1). Although, sucrose resulted in lowest vase life comparing to 8-HQS treatment, the longest vase life was attained when sucrose was applied at 2% w/v, where it gave 11.33 days in comparison with 8 days of the control ones. However, the two compounds used significantly extended the vase life of snapdragon cut flowers compared to control. These results may be due to the role of 8-HQS as antimicrobial agent and hence, it might reduce stem plugging. Sugars alone, however, tends to promote microbial growth. However, the combination of sugars and biocides might have extended the vase life of cut flowers (Halevy and Mayak, 1981). Hence, the best treatment was 200 ppm 8-HQS + 2% sucrose, which prolong the vase life up to 18 days comparing to 8 days for the control ones. It may be concluded that the best combination of chemicals in the holding solution should be 200 ppm 8-HQS + 2% sucrose as this treatment recorded the maximum useful vase life.

Table 1 The effects of the different preservative solutions on vase life, water uptake and percentage of the maximum increase in fresh weight of snapdragon cut flowers.

Treatments	Vase life (days)	Water uptake (ml/flower/day)	Maximum increase in fresh weight (%)
Distilled water (control)	8	2.93	29.20
2% Sucrose	11.33	3.25	31.73
200 ppm 8-HQS	14	5.64	39.34
8-HQS + sucrose	18	7.07	55.27
0.2 mM STS	13	3.56	34.91
STS + sucrose	15	5.83	43.56
L.S.D 5%	2.61	2.08	2.52

As for the effects of the STS treatment on vase life of cut snapdragon flowers, the data indicated that STS has been shown to be very effective in extending the vase life of snapdragon. This in agreement with findings obtained on snapdragon (Mor et al., 1984; Ishihara et al., 1991; Sexton et al., 1995). However, combined treatment with STS and sucrose may be preferable for improving the vase life of cut snapdragon flowers (Table 1). Awad et al. (1986) attributed the beneficial effect of STS in the vase-water to the production of Ag^+ ions, which might inhibit the rise of ethylene precursor, thereby enhancing the longevity of cut flowers. In this study, in cut snapdragon flowers, 8-HQS extended the vase life of florets more than STS (Table 1). This indicates that 8-HQS is more effective than STS in increasing vase life. This was similar to the result obtained for *Dendrobium* flowers (Ketsa and Boonrote, 1990). The superiority of 8-HQS over STS may have been due to the relative immobility of STS in the stem (Veen and Van de Geijin, 1978).

Concerning the role of sucrose whether with 8-HQS or STS, the previous results show that adding sucrose extended the vase life and improved the quality of snapdragon cut flowers. Adding a carbohydrates source such sucrose to the holding solution resulted in an extension of vase life if growth of microorganisms was controlled, and the increased flower longevity in the acidic solutions was due to the inhibition of vascular blockage and increased water absorption (Marousky, 1972). Dissolved sugars in cells of petals are osmotically active substances that are drawn into the corolla-cells making the cells turgid with hydrolyzed sugars ready for respiration (Ichimura and Hismatsu, 1999). Similar findings were obtained by Ichimura (1998), Beura et al. (2001), Dineshbabu et al. (2002) and Moneruzzaman et al. (2010).

3.2. Water relations

3.2.1. Water uptake (ml/flower/day)

Relevant data in Table 1 indicated that 8-HQS + 2% sucrose solution was more effective in maintaining water uptake and prolonging vase life (Table 1) than when either 8-HQS, STS was used alone or STS followed by sucrose. The maximum quantity of holding solution was absorbed (Table 1) in the treatment 200 ppm 8-HQS + 2% sucrose, which was (7.07 ml) in comparison to (2.93 ml) for control. This suggests that the synergistic effect of 8-HQS + 2% sucrose on increasing vase life was the result of a suppression of microbial growth (Ketsa et al., 1995), resulting in increased water uptake. The water uptake via the cut flowers placed in a keeping solution resulted in better water balance and flower freshness and reduced early wilting; and thus the vase life of the cut flowers was enhanced. As a consequence, the present investigation revealed that the best holding solution for cut snapdragon would be a combination of both 8-HQS and sucrose would result in better water balance. This might be due to the fact that the 8-HQS present in the holding solution acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues. The blockage of the base of stem due to bacterial plugging results in decrease of water uptake by stem. A very high level of turgidity is necessary for continuation of normal metabolic activities in the cut flowers. Sucrose help to maintaining water balance and also delays turgor loss as the flower senescence (Sven and Jose, 2004). The translocated sugars are accumulated in the flower and increase osmotic concentration and improving their ability to absorb water and maintain their turgidity (Halevy et al., 1978). Hence, addition of sucrose to the holding solution might have lead to increased uptake of the holding solution. This was in conformity with the findings of Rogers (1973). This in agreement with the observation of rose cut flowers, where total water uptake and vase life had increased as well as inhibited flower senescence and bent neck in when using 8-HQS + sucrose in comparison to control (Kim and Lee, 2002; Elgimabi and Ahmed, 2009). Moreover, Beura et al. (2001) showed that the combination treatment of 8-HQS and sucrose improved the postharvest quality of Gladiolus spikes. In *Dendrobium hybrid* flowers, holding solutions containing 8-HQS + sucrose extended the vase life and improved flower quality, water consumption, fresh weight and flower freshness (Dineshbabu et al., 2002).

3.2.2. Water balance (ml/flower/day)

The determination of water balance herein gave a clear view to what happened indigenously inflorescence throughout vase life. The overall water balance in this experiment followed the same trend, but data illustrated in (Fig. 1) revealed that snapdragon flowers which were treated with combination of both 8-HQS and sucrose had been showed better water balance than those with other treatments. Results of the present study may be explained on basis that 8-HQS plays an important role in improving the water balance of snapdragon cut flowers by preventing the growth of microorganism in xylem and thus maintained water uptake by flower stems (Kwon and Kim, 2000). However, the results showed that 8-HQS was positive effect on increasing the water balance of cut snapdragon flowers, especially when combined with other sucrose. Thus, if bacterial growth could be eliminated, sucrose (2%) would result in better water balance of the cut snapdragon flowers. Sucrose plays an important role in improving the water balance of cut flowers by affecting the osmotic potential of the cut flowers and the water holding capacity of the tissues allowing less water to be transpired (Halevy et al., 1978). Moreover, Sucrose is widely used in floral preservatives, which acts as a food source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers (Moon-Soo et al., 2001). In agreement with these results were those obtained by Fahmy (2005), Elgimabi and Ahmed (2009).

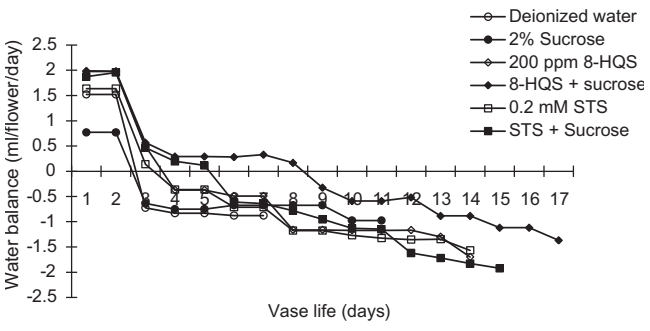

Figure 1 Water balance (ml/flower/day) of snapdragon cut flowers as affected by different holding solutions during vase life.

3.3. Maximum increase of fresh weight (%)

With respect to holding solution effect on maximum increase of fresh weight of snapdragons cut flowers, data presented in (Table 1) showed that, a higher fresh weight was maintained in florets from of spikes placed in 200 ppm 8-HQS + 2% sucrose than those of control. Relevant values for the maximum increase in fresh weight percentage were 55.27%. However, the lowest values of this parameter accompanied the control, which was 29.20% during vase life. The application of 8-HQS increased the vase life as well as fresh weight (% of initial) of cut flowers, where 8-HQS treatment prevented the growth of microorganism in xylem and thus maintained water uptake by flower stems. The major effect of sucrose on the snapdragon flowers is probably may be due to the increase in osmotic concentration of the flowers and by this, to improve water uptake, but the sucrose may also affect the nutrition or energy supply of the flowers. Sucrose may have, also, a beneficial effect on maintaining higher fresh weights in cut flowering stems by inducing stomatal closure in the leaves and thus, reducing water loss (Marousky, 1972). Furthermore, pulsing snapdragon flowers in 8-HQS solution at 200 ppm in vases resulted in higher longevity period, which might indicated that each of 8-HQS and sucrose played a critical role in promoting water absorption and metabolic processes within flower. Moreover, the hydraulic conductance of cut rose stem segments from the control treatment decreased rapidly after harvest, but those for the 8-HQS + 2% sucrose and 8-HQS treatment were maintained near their initial level (Kim and Lee, 2002).

Table 2 The effects of the different preservative solutions on chlorophyll contents (mg g^{-1} dry weight) of leaves of snapdragon cut flowers.

Treatments	1st Day		3rd Day		5th Day	
	Chl. a	Chl. b	Chl. a	Chl. b	Chl. a	Chl. b
Days of determination of chl. a and chl. b						
Distilled water (control)	0.727	0.384	0.940	0.406	0.596	0.070
2% Sucrose	0.733	0.410	1.421	0.743	0.687	0.186
200 ppm 8-HQS	0.674	0.332	1.767	0.599	1.892	0.404
8-HQS + sucrose	0.734	0.410	1.941	1.163	1.765	0.394
0.2 mM STS	0.653	0.324	1.685	0.531	1.734	0.387
STS + sucrose	0.684	0.395	1.873	1.054	1.567	0.352
L.S.D 5%	0.062	0.054	0.088	0.090	1.01	0.030

3.4. Chlorophyll content

Data recorded in Table 2 indicated that a pulse treatment with sucrose + 8-HQS was most effective in retarding chlorophyll degradation compared to control. The concentration of chlorophyll a was higher than chlorophyll b at any point of time throughout the vase life. When cut snapdragon flowers were treated with 200 ppm 8-HQS, chlorophyll content on the 1st day was 0.674, 0.332 mg 1^{-1} weight for chl. a and chl. b, respectively. However, sucrose at 2% was added, chlorophyll content increased. Thus, at the end of the experiment the accumulated chl. 'a' and chl. 'b' were 1.765, 0.394 mg 1^{-1}, respectively. Ewa et al. (2004) showed that a standard preservative solution containing 2% sucrose and 200 mg dm^{-3} citrate or sulfate of hydroxyquinoline (8-HQC or 8-HQS) is often used to prolong the vase life of *Zantedeschia aethiopica* and *Zantedeschia elliottiana* of cut flowers. It has antibacterial properties and provides respirational substrate (Halevy and Mayak, 1981). Sugar treatment also hastened senescence of leaf discs in the model plant *Nicotiana tabacum* and sugar levels were higher in tobacco leaves that were about to senesce as compared to younger leaves (Masclaux et al., 2000). Skutnik et al. (2001) showed that a sugar-containing preservative dramatically reduced vase life and decreases chlorophyll content in the *Z. aethiopica* leaves.

3.5. Changes in sugar content

The data (Tables 3 and 4) showed that fructose, glucose and sucrose were the main soluble carbohydrates in petals and stems of snapdragon cut flowers. Fructose was the major component in petals as well as in stems, and generally it was higher in petals than in stems. Sucrose contents in petals and stems were lower than glucose. The carbohydrate content significantly increased as a result of using 200 ppm 8-HQS + 2% sucrose till the 3rd day, and then sharply decreased on the 5th day at which the vase life of control was terminated. The concentrations of fructose, glucose and sucrose in snapdragon petals were 0.69, 0.17, and 0.25 mg g^{-1} dry weight in controls at the end of the experiments (Table 3). At the same time, values of those sugars in petals of cut flowers placed in 200 ppm 8-HQS, 200 ppm 8-HQS + 2% sucrose or in 2% sucrose alone were1.95, 1.26, and 0.18 mg g^{-1}, respectively (Table 3). While stem contents of the previous sugars increased at the beginning of the experiment, and then decreased towards the end of the experiment comparing to control (Table 4). It is well known that sugar supply, increases the longevity of many cut flowers,

Table 3 The effects of the various preservative solutions on soluble sugars contents (mg g^{-1} dry weight) of snapdragon cut flower petals.

Treatments	1st Day			3rd Day			5th Day		
	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose
Days of determination of soluble sugars contents									
Distilled water (control)	0.91	0.30	0.08	0.13	0.03	0.02	0.69	0.17	0.25
2% Sucrose	1.35	1.97	0.43	2.99	1.95	1.22	0.37	0.88	0.11
200 ppm 8-HQS	2.87	1.97	1.00	2.06	2.99	0.08	1.95	1.26	0.18
8-HQS + sucrose	4.18	3.55	1.23	5.97	4.34	1.99	2.87	1.63	1.01
0.2 mM STS	2.43	1.82	0.89	2.03	2.56	0.05	1.85	1.12	0.08
STS + sucrose	3.65	2.85	1.07	2.99	3.74	1.53	2.41	1.15	0.75
L.S.D 5%	1.78	1.32	0.98	1.88	1.11	0.85	0.75	0.60	0.35

Table 4 The effects of the different preservative solutions on carbohydrate contents (mg g^{-1} dry weight) of snapdragon cut flower stems.

Treatments	1st Day			3rd Day			5th Day		
	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose
Days of determination of carbohydrate content									
Distilled water (control)	0.91	0.30	0.08	0.70	0.60	0.11	0.62	0.43	0.19
2% Sucrose	1.17	1.08	0.32	2.32	2.00	1.23	0.89	0.47	0.09
200 ppm 8-HQS	1.95	1.00	0.16	2.43	2.00	1.45	0.87	1.08	0.69
8-HQS + sucrose	2.21	1.30	1.07	3.53	2.11	1.97	1.51	0.40	0.84
0.2 mM STS	1.82	0.89	0.11	2.31	1.78	1.32	0.63	1.01	0.52
STS + sucrose	2.03	1.12	1.02	3.11	1.92	1.82	1.24	0.29	0.65
L.S.D 5%	1.02	0.88	0.71	1.01	0.79	0.55	0.59	0.41	0.32

since they act as a source of nutrition for tissues approaching carbohydrate starvation (Halevy and Mayak, 1981). The results showed that sucrose + 8-HQS reduced chlorophyll content degradation (Table 2) and preserved carbohydrates content (Tables 3 and 4). This might be inhibiting ethylene action and as a result, the vase life could be increased. This was attributed to the inhibition of ethylene action by 8-HQS (Bartoli et al., 1997; WeiMing et al., 1997). This is in agreement with earlier reports of Hussein (1994), Ichimura et al. (1999), Knee (2002) and Elgimabi and Ahmed (2009). They indicated that glucose, fructose and sucrose in petals of rose cut flowers were increased by the 8-HQS + sucrose treatment compared with control.

4. Conclusion

Based on the results of this study, it could be concluded that all chemicals used in this study have improved the keeping quality of the cut snapdragon flowers. The present study indicates that 200 ppm 8-HQS + 2% sucrose treatment has improved snapdragon cut flower quality by increasing vase life as measured by number of days, water uptake and percentage of maximum increase in fresh weight and chlorophyll content, hence; delaying the onset of leaf senescence and carbohydrate contents of petals and stems. Therefore, 200 ppm 8-HQS + 2% sucrose solution has a potential to be used as a commercial cut flower preservative solution for prolonging vase life and postharvest quality of snapdragon cut flowers.

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