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INFLUENCE OF SOME PRESERVATIVE SOLUTIONS ON VASE LIFE AND POSTHARVEST QUALITIES OF LIMONIUM CUT FLOWERS

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ABSTRACT: The present study was conducted at the Postharvest Lab. of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt in March of 2016 and 2017 seasons, to examine the effect of some pulsing solutions on improving the quality of limonium cut flowers. Limonium cut flowers were pulsed in silver thiosulfate (STS) at 500 mg/l for 1/4 and 1/2 h, silver nitrate ($AgNO_3$) at 500 mg/l for 1/4 and 1/2 h, $AgNO_3$ at one g/l for 1/4 and 1/2 h, sodium benzoate at 250 mg/l for 12 and 24 h, sodium benzoate at 500 mg/l for 12 and 24 h, daminozide at 25 mg/l for 12 and 24 h and daminozide at 50 mg/l for 12 and 24 h followed by transferring to a holding solution 8-hydroxyqunoline sulphate (HQS) at 200 mg/l + sucrose (20 g/l). Distilled water was used as a control treatment. The obtained results indicated that treatment of *Limonium sinuatum* cv. Girlie Wings cut flowers treated by STS at 500 mg/l for 1/2 h enhanced water uptake, relative fresh weight, dry weight percentage of cut flowers, floret opening percentage, pigments content, total carbohydrate percentage and total phenols as well as inhibiting growth of all isolated microorganisms and improved quality of flowers, followed by cut flowers treated with STS at 500 mg/l for 1/4 h then $AgNO_3$ 500 mg/l for 1/2 h.

Key words: *Limonium sinuatum*, silver thiosulfate (STS), silver nitrate ($AgNO_3$), sodium benzoate, daminozide, sucrose, 8-hydroxyqunoline sulphate (8-HQS).

INTRODUCTION

Limonium is a genus of ornamental plants belongs to the family Plumbaginaceae. It has a sub-cosmopolitan appropriation in Europe, Asia, Africa, Australia, North America, Canary Islands and the Mediterranean. There are various shades of flowers, for example, white, blue, rose, red, coral, light yellow, purple and mauve. *Limonium sinuatum*, usually known as static, ocean lavender, indent leaf bog rosemary, ocean pink, wavy leaf and ocean lavender, it is herbaceous enduring and channel molded flowers in summer (Wikipedia, 2017). Phenomenal as a crisp cut flower and useful for dried bloom plans. The plant is garden employments of blended fringes, shake gardens, cut bloom gardens, glades and cutting patio nurseries.

The life span of the cut blossom is an essential issue today. Additionally, the most vital compounding factor in cut flowers is ethylene creation and blockage of xylem vessels via air and microorganism (Elgimabi and Ahamed, 2009 and Elgimabi, 2011). Hashemabadi *et al.* (2015) found that microorganisms and microbes that develop in the vase arrangement, hinder the stem end and decrease water take-up by the blooms, in addition, the generation of synthetic aggravates that lead to vascular blockage and

along these lines diminish the vase life of cut flowers.

Distinctive substances can be utilized as an additive in the answer for delaying the vase life of cut flowers, lessen microbial proliferation and vascular blockage, increase water take-up of the stem and stop the hurtful impact of ethylene.

Hydroxyqunoline combination with sucrose improved the postharvest quality of gladiolus spikes (Beura *et al*., 2001). Pun and Ichimura (2003) showed that 8-HQS treatment was more effective when sucrose was coupled with it. Vigna *et al*. (1999) mentioned that 2.5% sucrose + 150 mg/l 8-HQS increased keeping quality in *Limonium sinuatum*. In Dendrobium cut flowers, holding solutions containing 8-HQS + sucrose extended the vase life and increased flower quality, water consumption, fresh weight, flower freshness, and reduced respiration rate and physiological weight loss (Dineshbabu *et al*., 2002). Yann *et al*. (2000) showed that 10% sucrose + 200 ppm 8-HQS prolonged vase life and increases ornamental value of Limonium. Also, sucrose with 8-HQS maximized vase life for flowers and maintained stem fresh weight of waxflower (Dung *et al*., 2017). The preservative composed of 8-HQC and sucrose markedly improved flower longevity of clematis flowers (Rabiza *et al*., 2017). Hydroxyqunoline prevents the growth of microorganisms in xylem vessels, maintaining water uptake and extending flower vase life (Asrar, 2012). Abdul-Wasea (2012) found that 200 ppm 8-HQS combined with 2% sucrose solution have 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.

The use of ethylene antagonist silver thiosulfate solution (STS) will therefore allow for a better adjustment of flowers supply to the requirements of the market. Asrar (2012) showed that pulsing the spikes with 0.2 mM silver thiosulfate (STS) for 1 h treatments had improved the keeping quality and vase life of the cut flowers comparing to control ones of cut snapdragon flowers. Gul and Inayatullah (2013) found that in *Narcissus pseudonarcissus* flowers pulse treatment of spikes with STS (0.5 mM, 1 h) increased solution uptake, maintained high fresh and dry mass of flowers. Suong *et al*. (2017) revealed that STS was the most effective pretreatment solution, significantly extending the vase life from 11.8 days (control) to 19.9 days, retaining the initial fresh weight and a positive water balance for longer and inhibiting microbial growth in the vase. STS also enhanced the water uptake rate, and maintained the high chlorophyll and soluble sucrose contents in the leaves of cut rose flowers. Bang *et al*. (1999) found that pulseding with STS (0.5 mM) for 45 minutes of 'Raktagandha' roses was found to be best for improving post harvest life and quality. Sodium benzoate as an antifungal compound reduces microorganisms' activity and bacterial contamination in vase solution. Ketsa and Sribunma (1985) showed that pulsing treatment with sodium benzoate at 300 mg l^{-1} concentration for 24 h gave maximum vase life of cut rose cv. 'Christian Dior' flower. Davood *et al*. (2012) revealed that 250 mg l^{-1} of sodium benzoate was the most effective on vase life of rose cut flowers and reduced ethylene production.

Silver nitrate ($AgNO_3$) is one of the most common forms of silver salts used in commercial flower preservative solutions and mostly used as ethylene binding inhibitor. Darras and Pompodakis (2010) reported that pulsing with 20 or 40 mg l^{-1} $AgNO_3$ for 24 h extended vase life by 1.6 and 1.9 days, respectively, compared to the control. Pulsing cut roses for 10-20 mint with $AgNO_3$ improved the vase life up to 6.0 and 5.3 days, respectively (Reddy and Raju, 1988). Mohy Eldeen (2012) found that significant improvement in vase life of rose cut flowers occurred when pulsed with 30 ppm ($AgNO_3$). Pulsing with ($AgNO_3$) strikingly enhanced vase life and solution uptake in rose cut flowers (Singh and Tiwari, 2002). Amit *et al.* (2013) stated that $AgNO_3$

(25 ppm) was the best preservatives in diameter of florets and fresh weight of gladiolus flower.

Daminozide (B-9) is a plant growth retardant, can hinder plant tissues gibberellins biosynthesis, thereby inhibiting the growth of cut flower plants and extend the life of cut flowers after the cutting. Kahar (2008) found that single application of B-9 at 2500 ppm in chrysanthemum delayed the time of flowering and improved the synchrony of flowering and double the vase life. Application of daminozide at 2500 ppm improved vase life (Jeyakumar *et al.,* 2016).

In this study endeavors have been made to broaden the vase life of limonium flowers by the utilization of various chemical compounds at different concentrations, and by utilizing synthetic substances effectively accessible in the nearby market.

MATERIALS AND METHODS

The experimental trial research was carried out at Ornamental Plants and Landscape Gardening Research Dept., Hort. Res. Inst. ARC, Giza, Egypt in throughout two successive seasons 2016 and 2017.

Plant material:

Limonium sinuatum cv. Girlie Wings cut flowers were purchased from the local commercial green-houses of Floramix Farm (El-Mansouria, Giza). The flowering stems were cut in the early morning with the stem length of 80 cm, at basal florets opening and directly wrapped in groups and transported to the laboratory within nearly 2 hours. Flowers were precooled by placing in ice cold water for one hour to remove the effect of high field heat. 3 cm of stem bases were recut under water to avoid air embolism before treatment.

First experiment:

The cut flowers were divided into four groups. The first group was pulsed in preservative solution containing silver thiosulfate (STS)**,** the second group in silver nitrate ($AgNO_3$), the third group in sodium benzoate and the fourth one in daminozide. These four groups were held in a preservative solution consisting of 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) in addition to distilled water (control)**.**

The treatments were evaluated as follows:

T1= Distilled water (control).

T2= Pulsing in STS at 500 mg/l for 1/4 hour.

T3= Pulsing in STS at 500 mg/l for1/2 hour.

T4= Pulsing in $AgNO_3$ 500 mg/l for 1/4 hour.

T5= Pulsing in $AgNO_3$ 500 mg/l for 1/2 hour.

T6= Pulsing in $AgNO_3$ 500 mg/l for 1/4 hour.

T7= Pulsed in $AgNO_3$ g/l four 1/2 hour.

T8= Pulsing in sodium benzoate at 250 mg/l for 12 hours.

T9= Pulsed in sodium benzoate at 250 mg/l for 24 hours.

T10= Pulsing in sodium benzoate at 500 mg/l for 12 hours.

T11= Pulsing in sodium benzoate at 500 mg/l for 24 hours.

T12= Pulsing in daminozide at 25 mg/l for 12 hours.

T13= Pulsing in daminozide 25 mg/l for 24 hours.

T14= Pulsing in daminozide 50 mg/l for 12 hours.

T15= Pulsing in daminozide 50 mg/l for 24 hours.

The cut flowers were placed in a flask or bottle (1000 ml) containing 450 ml of holding preservative solution (3 flower heads/flask). Each flask was covered at its surface with cellophane wrap to prevent evaporation during the vase life period and till the end of experiment under the room temperature. The following traits were studied:

- Vase life (longevity): Vase life was determined as the number of days to wilting of flowers.

- Water uptake and water loss (g/inflorescence): accumulative water uptake and loss were recorded for the entire period of vase life of the inflorescence stem.
- Floret opening percentage was calculated as a percentage of opened florets from all the florets on the cut cluster spike (inflorescence) at the end of longevity.
- Relative fresh weight (%): Relative fresh weight of stems was calculated using the following formula (He *et al*., 2006):

$$RFW\ (\%) = \frac{\text{Fresh weight of stem in mentioned day} \times 100}{\text{Fresh weight of stems in zero days}}$$

- Dry matter: Dry matter percentage of cut flowers was calculated by the following equation: DM (%) = dry weight/fresh weight × 100 (Hashemabadi *et al*., 2015).

Chemical analyses: Chlorophyll a, chlorophyll b and carotenoids (mg/100 g f.w.) were determined in the fresh leaf samples at the end of longevity and measured according to Lichtenthaler and Wellburn (1985). Total carbohydrates (%) content were determined according to A.O.A.C. (1995).

Anthocyanin content (%) in flowers was determined colorimetrically according to Fuleki and Francis (1968).

Phenols content in the leaves: mg/100 g f.w. according to A.O.A.C. (1990). Indoles content in the leaves: mg/100 g f.w. as recorded by Larsen *et al.* (1962) and Salim *et al.* (1978) and the concentration were calculated as mg indole acetic acid/100 g fresh weight.

Statistical analysis:

The layout of the experiment was completely randomized design. Analysis was carried out using MSTAT-C statistical software (1985) and the means were compared by Duncan's Multiple Rang Test at $p \leq 0.05$ % as described by Waller and Duncan (1969) to verify differences among means of various treatment.

Second experiment:

I. Isolation, purification and identification of the microorganisms:

The plant samples were thoroughly washed with tap water, cut into small pieces and surface sterilized with sodium hypochlorite (3%) for 3 minutes, washed several times with sterilized water and dried between sterilized filter paper. The sterilized pieces were aseptically transferred to Petri dishes of PDA medium or nutrient agar medium and incubated at 25 °C for 7 days.

The growing fungi or bacteria were purified using single, hyphal tip techniques or dilution method for bacteria (Dhingra and Sinclair, 1995) and identified according to Booth (1971); Domasch *et al.* (1980); Plaats-Niterink and Van Der (1981).

The identification was kindly confirmed by Mycol. Res. and Survey Dep., PI. Pathol. Res. Inst. ARC, Giza, Egypt.

II. Effect of the tested treatments on the isolated microorganisms under lab conditions:

The treatments at two concentrations were tested to study their inhibitory effect on growth of the isolated microorganisms. Tested treatments were added to conical flasks containing sterilized PDA medium to obtain the proposed concentration, then rotated gently and dispensed in sterilized petri plates (10 cm diameter). Plates were individually inoculated at the center with equal disks (5 mm diameter) of 7 days old culture or streak bacteria spores. Five plates were used as replicates for each particular treatment. Inoculated plates were incubated at 27 °C. The average growth of microorganisms tested was calculated after 10 days of incubation.

RESULTS AND DISCUSSION

Longevity (days to wilting):

Our results showed that the various antiseptic preservative solutions were effective in extending vase life period of

Limonium sinuatum cut inflorescences in compared to the control, as documented in Table (1). The significantly highest value was obtained with STS at 500 mg/l for 1/2 h followed by 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) which recorded 31.3 and 33.9 days in the first and second seasons, respectively. The treatments of $AgNO_3$ at 500 mg/l for 1/2 h and $AgNO_3$ 1 g/l for 1/2 h followed by 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) were found to induce a negative effect on vase life of the cut inflorescences. The vase life decreased to 21.7, and 22.5 days in response to daminozide at 25 mg/l for 24 h in the first and second seasons, respectively. However the treatment of sodium benzoate at 500 mg/l for 24 h recorded the lowest values (20.0 and 22.1 days in both seasons respectively.

Concerning the effect of pulsing solutions treatments on longevity, data presented in Table (1) showed that all treatment gave significantly higher values of vase life in the two seasons than control treatment. These results are in agreement with those of Gul and Inayatullah (2013). They found that pulse treatment of spikes of *Narcissus pseudonarcissus* flowers with STS (0.5 mM, 1 h) increased solution uptake and STS was the most effective pretreatment solution, significantly extending the vase life and inhibiting microbial growth in the vase (Suong *et al.,* 2017). Bakhsh *et al.* (1999) found that vase life of tuberose cut flowers increased by pulsing solution containing 200 ppm silver nitrate ($AgNO_3$) and 4 mM silver thiosulfate (STS). Arshad *et al.* (2010) reported that STS applied significantly extended vase life of cut lisianthus flowers as mentioned by Gul and Inayatullah (2013) on *Narcissus pseudonarcissus* at pulse treatment of spikes STS (0.5 mM, 1 h). Mohy Eldeen (2012) found that significant improvement in vase life of rose cut flowers occurred when pulsed in 30 ppm ($AgNO_3$). Pulsing with ($AgNO_3$) strikingly enhanced vase life and solution uptake in rose cut flowers. Silver ions present in STS have been found effective ethylene blockers. STS has been shown to inhibit the increase in climacteric respiration and ethylene production of flowers (Finger *et al.,* 2004).

Water uptake:

The importance of enhancing water uptake as a method for prolonging the vas life of *Limonium sinuatum* cv. Girlie Wings cut flowers has long been recognized and there are substantial studies of the factors affecting water relations of various species of cut flowers. Regarding the pulsing solutions, solutions of STS at 500 mg/l for 1/2 h and $AgNO_3$ 500 mg/l for 1/2 h had the best impact (133.5, 121.1 and 141.9, 135.4 g/inflorescence/day, in the two seasons, respectively) on increasing value of water uptake by *Limonium* cut flowers, contrary with the impact of daminozide 50 mg/l for 24 h (69.4 and 73.2 g/inflorescence/day in both seasons, respectively). Water uptake as shown in Table (1) indicated that all preservative treatments improved water uptake for both seasons in comparison with control.

These findings are in accordance with those attained by Mohammadi and Mosirat (2011) and Al-Humaid *et al.* (2004) who found that STS reduces bacterial count in the basal parts of gladiolus and rose stems. On *Narcissus pseudonarcissus* pulse treatment of spikes STS (0.5 mM, 1 h) increased solution uptake (Gul and Inayatullah, 2013). Madhavi (2016) exhibited that pulsing with $AgNO_3$ has given good results in improving water relations of gerbera cut flowers.

Water loss:

End of vase life of cut flowers is characterized by wilting associated with an imbalance developing between water uptake through xylem conduits in stems and water loss through stomata and other structures on leaves and other organs. To better understand the onset of adverse postharvest water relations, cut flower researchers seek to acquire data on rates of water uptake and water loss. These indices are usually monitored by weighing stems and vases daily or thereabout with a single analytical

Table 1. Effect of pulsing solution treatments on longevity (days), water uptake and water loss (g/inflorescence/day) of *Limonium sinuatum* cv. Girlie Wings cut inflorescences during the vase life period in 2016 and 2017 seasons.

Pulsing treatments	1st Season			2nd Season		
	Longevity	Water uptake	Water loss	Longevity	Water uptake	Water loss
Distilled water (control)	16.7i	38.9 i	50.7 h	18.1i	42.9 j	52.9 k
STS at 500 mg/l for 1/4 h	27.4bc	120.4bc	118.6 bc	30.3b	123.4 cd	121.2d e
STS at 500 mg/l for 1/2 h	31.3 a	133.5a	130.9 a	33.1 a	141.9 a	135.8 a
$AgNO_3$ 500 mg/l for 1/4 h	25.2 c-e	112.2d	107.4 d	26.0 de	116.9 e	116.3e
$AgNO_3$ 500 mg/l for 1/2 h	28.3 b	121.1b	120.6 b	29.5 bc	135.4 b	131.8 ab
$AgNO_3$1 g/l for 1/4 h	24.4 df	114.8d	116.3c	24.6 e-g	126.3 c	125.0 cd
$AgNO_3$1 g/l for 1/2 h	26.8 b-d	115.1cd	118.0 bc	27.7 cd	120.2 de	120.8 de
Sodium benzoate at 250 mg/l for 12 h	23.6 e-g	110..5d	121.4 b	25.3 ef	123.6 cd	127.9 bc
Sodium benzoate at 250 mg/l for 24 h	22.1 f-h	80.2f	91.8 e	23.2 gh	82.9 g	89.8 gh
Sodium benzoate at 500 mg/l for 12 h	21.5 gh	74.0gh	74.9 g	22.8 gh	78.9 gh	80.7ij
Sodium benzoate at 500 mg/l for 24 h	20.0 h	70.2h	75.8 g	22.1 h	76.0 hi	79.3j
Daminozide at 25 mg/l for 12 h	23.3 e-g	93.7e	108.5 d	25.5 e	98.4f	100..5f
Daminozide 25 mg/l for 24 h	21.7 gh	71.8h	77.6 g	22.5 h	75.8 e-i	91.7g
Daminozide 50 mg/l for 12 h	22.2 f-h	78.3fg	82.9 f	23.6 f-h	75.8i	85.5hi
Daminozide 50 mg/l for 24 h	21.9 f-h	69.4h	78.6 g	23.7 h	73.2i	81.3ij

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

balance. (Lü *et al*., 2009 and Macnich *et al.*, 2008).

Data presented in Table (1) show that water loss of *Limonium sinuatum* cv. Girlie Wings cut flowers which were pulsed in STS at 500 mg/l for 1/2 h increased more than the other treatments in the both seasons. Beside, the control (distilled water) was the lowest value between each treatment in both seasons. However, there were no significant differences between the pulsing in sodium benzoate at 500 mg/l for 12 h, sodium benzoate at 500 mg/l for 24 h, daminozide 25 mg/l for 24 h and daminozide 50 mg/l for 24 h in the first season.

Relative fresh weight%:

Data presented in Table (2) clearly indicated that during the vase life (seven days after putting flowers in the holding solution) the most effective pulsing solutions in preserving relative fresh weight of cut flowers were in STS at 250 mg/l for 1/2 h followed by 8-HQS (200 mg/l) + sucrose (20 g/l) with significant differences, compared to the control (Distilled water) in two seasons, as they enhanced the relative fresh weight. These findings agreed with those of Gul and Inayatullah (2013) who revealed that the ion leakage of the petal discs was lowered in the STS pulsed spikes particularly in 8-HQS + scu., suggesting increased membrane permeability: treatment with STS increase fresh and dry weight up to 8 days of the treatment on *Narcissus pseudonarcissus.* Arshad, *et al.* 2010 stated that STS treated flowers maintained a higher relative fresh weight (RFW) in cut lisianthus flowers. In reference to the second period (14 days of the presence of flowers in solutions) the heights values recorded resulted by STS at 500 mg/l for 1/2 h and $AgNO_3$ at 500 mg/l for 1/4h and 1/2 h (109.7, 107.4, 107.3 and 110, 108.2, 107.8, respectively) in both

Table 2. Effect of pulsing solution treatments on relative fresh weight % of *Limonium sinuatum* cv. Girlie Wings cut inflorescences in the vase life period during 2016 and 2017 seasons.

Pulsing treatments	1st Season			2nd Season		
	After 7 day	After 14 days	After 21 days	After 7 days	After 14 days	After 21 days
Distilled water (control)	65.2g	72.2h	----	60.6 i	71.3i	----
STS at 500 mg/l for 1/4 h	100.3b	100.4d	56.1e	103.1a	102.2c	57.4ef
STS at 500 mg/l for 1/2 h	103.8a	109.7a	72.8a	105.4a	110.0a	74.3a
$AgNO_3$ 500 mg/l for 1/4 h	102.3a	107.4ab	55.7ef	100.3b	108.2ab	58.2de
$AgNO_3$ 500 mg/l for 1/2 h	100.6b	107.3ab	66.9b	103.0a	107.8ab	68.6b
$AgNO_3$1 g/l for 1/4 h	95.3c	104.5bc	59.6c	95.9b	106.1b	59.7cd
$AgNO_3$1 g/l for 1/2 h	87.8d	103.9c	58.1cd	90.1c	105.6bc	60.0cd
Sodium benzoate at 250 mg/l for 12 h	60.7hg	83.3fg	59.2c	63.8h	87.0e-g	61.2c
Sodium benzoate at 250 mg/l for 24 h	74.3e	94.2e	53.8fg	74.7d	96.1d	55.5f
Sodium benzoate at 500 mg/l for 12 h	70.8f	84.4f	50.5hi	72.4de	87.9ef	52.6g
Sodium benzoate at 500 mg/l for 24 h	56.6j	83.1fg	46.7k	57.8j	86.4e-h	26.2i
Daminozide at 25 mg/l for 12 h	68.3f	83.8fg	47.4k	69.6ef	84.0gh	50.2hi
Daminozide 25 mg/l for 24 h	65.3g	80.8g	51.8gh	67.5fg	83.3h	52.8g
Daminozide 50 mg/l for 12 h	57.9ij	83.5fg	49ij	66.7g	84.8f-h	51.1gh
Daminozide 50 mg/l for 24 h	56.3j	84.6f	47.5k	58.1j	83.5h	50.3hi

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

seasons. Effect of pulsing with $AgNO_3$ and STS on cut rose, showed the highest gain in fresh weight (Singh and Bhattacharjee, 2000 and Suong *et al.,* 2017).

Floret opening percentage:

Data presented in Table (3) significantly indicated that all pulsing solutions and holding solution (sucrose 2% + 8-hydroxy-quinoline sulphate 200 mg/l) mostly increased floret opening percentage. In this concern, pulsing in STS at 500 mg/l for 1/4 h effect on floret opening percentage was not significantly different from pulsing in solution of STS at 500 mg/l for 1/2 h in the two seasons. Regarding the solutions effect of pulsing, $AgNO_3$ at 500 mg/l for 1/2 h and daminozide 25 mg/l for 24 h significantly increased floret opening percentage (87.5, 87.3 and 92.8, 88.4, respectively in both seasons). On the contrary, the shortest percentage of floret opening was observed with the sodium benzoate at 500 mg/l for 12 h by 31.4 and 35.6 %, respectively in both seasons. This results are in harmony with those of Saichol *et al.* (1995) who stated that $AgNO_3$ was more effective in controlling microbial growth and in maximizing bud opening of *Dendrobium*'Pompadour'.

Dry weight:

Data exhibited in Table (3) cleared that cut *Limonium* inflorescences pulsed in the solution of STS at 500 mg/l for 1/2 h, STS at 500 mg/l for 1/4 h , $AgNO_3$ 500 mg/l for 1/2 h and daminozide 25 mg/l for 24 h significantly increased dry weight compared to those pulsed in the solution of sodium benzoate at 250 mg/l for 24 h in the two seasons. Cut inflorescences held in distilled water (control) gave the lowest dry weight. This may be to that the function of sucrose in offering the desired energy for the survival of flower and affects the structure of the

Table 3. Effect of pulsing solution treatments on floret opening % and dry weight percentage %, of *Limonium sinuatum* cv. Girlie Wings cut inflorescences during the vase life period in 2016 and 2017 seasons.

Pulsing treatments	1st Season		2nd Season	
	Floret opening %	D.W. %	Floret opening %	D.W. %
Distilled water (control)	25.4 k	56.6 g	30.2 i	54.2 h
STS at 500 mg/l for 1/4 h	90.3 ab	80.3 bc	94.5 a	80.5 bc
STS at 500 mg/l for 1/2 h	92.6 a	84.1 a	95.6 a	85.6 a
$AgNO_3$ 500 mg/l for 1/4 h	85.2 c	80.1 bc	89.3 bc	80.7 bc
$AgNO_3$ 500 mg/l for 1/2 h	87.5 bc	83.0 ab	92.8 ab	82.0 ab
$AgNO_3$1 g/l for 1/4 h	80.3 d	61.8 f	86.1 c	56.7 gh
$AgNO_3$1 g/l for 1/2 h	57.0 f	71.3 d	61.8 e	71.0 d
Sodium benzoate at 250 mg/l for 12 h	35.4 i	62.0 f	38.9 gh	59.3 fg
Sodium benzoate at 250 mg/l for 24 h	28.3 jk	55.5 gh	34.4 hi	63.6 e
Sodium benzoate at 500 mg/l for 12 h	31.4 i	68.0 de	35.6 h	70.5 d
Sodium benzoate at 500 mg/l for 24 h	76.7 e	66.4 e	80.7 d	65.5 e
Daminozide at 25 mg/l for 12 h	48.2 g	79.6 c	53.4 f	78.6 c
Daminozide 25 mg/l for 24 h	87.3 bc	80.2b c	88.4 bc	82.0 ab
Daminozide 50 mg/l for 12 h	38.8 g	65.6 e	40.7 g	62.4 ef
Daminozide 50 mg/l for 24 h	59.3 e	78.5 c	60.5 e	77.9 c

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

flower cell walls and delays getting older tissues, and increased the dry weight and water retention. Compounds extending the vase life of cut flower on the prevention of dry weight loss with the aid of preventing the degradation of carbohydrates (Dashtbany and Hashemabadi, 2015). Gul and Inayatullah (2013) revealed that pulse treatment of spikes with STS (0.5 mM, 1 h) increased dry mass of *Narcissus pseudonarcissus* flowers.

Chemical composition:

Using STS as a pulse preservation solution had a positive effect on Limonium cut inflorescences as presented in Table (4) which cleared that treating cut inflorescences with STS at 500 mg/l for 1/4 h and STS at 500 mg/l for 1/2 h enhanced chlorophyll a, b and carotenoid contents compared to the control, in both seasons. On the other hand, daminozide pulsing solution retarded the degradation of chlorophyll a and chlorophyll b, which were at least values. It can be concluded that *Limonium sinuatum* cut inflorescences treated by $AgNO_3$ gave significantly the highest means of the leaves content of chlorophyll a and chlorophyll b as compared to the control. This might be due to inhibiting ethylene action. Suong *et al.* (2017) revealed that STS was the most effective on increasing chlorophyll content in the leaves of the cut rose flowers.

Anthocyanin content (mg/100 g f.w.):

Data presented in Table (5) showed that in both seasons, the significantly highest contents of anthocyanin were recorded with petals of flowers pulsed with STS at 500 mg/l for 1/2 h compared to the other solutions. However, the best results were gained by STS at 500 mg/l for 1/4 h and sodium benzoate at 250 mg/l for 12 h pulsing solution, which gave the highest

Table 4. Effect of pulsing solution treatments on chlorophyll a, b and carotenoids (mg/100 g f.w.) of *Limonium sinuatum* cv. Girlie Wings cut inflorescences during the vase life period in 2016 and 2017 seasons.

Pulsing treatments	1st Season			2nd Season		
	Chl. a	Chl. b	Caro.	Chl. a	Chl. b	Caro.
Distilled water (control)	0.39 j	0.22 g	0.27 e	0.35 j	0.28 ef	0.35 c-e
STS at 500 mg/l for 1/4 h	0.93 a	0.46 a	0.43 ab	1.03 b	0.47 a	0.44 a
STS at 500 mg/l for 1/2 h	0.98 a	0.50 a	0.45 a	1.12 a	0.49 a	0.45 a
$AgNO_3$ 500 mg/l for 1/4 h	0.82 b	0.37 b	0.43 ab	0.85 c	0.36 bc	0.37 b-c
$AgNO_3$ 500 mg/l for 1/2 h	0.80 bc	0.34 b-d	0.32 de	0.83 c	0.39 b	0.28 f
$AgNO_3$1 g/l for 1/4 h	0.75 c	0.35 bc	0.29 e	0.77 d	0.36 bc	0.30 ef
$AgNO_3$1 g/l for 1/2 h	0.79 bc	0.34 b-d	0.30 de	0.80 cd	0.35 b-d	0.32 d-f
Sodium benzoate at 250 mg/l for 12 h	0.63 de	0.29 d-f	0.40 a-c	0.67 e	0.32 c-d	0.42 ab
Sodium benzoate at 250 mg/l for 24 h	0.65 de	0.28 ef	35.0 cd	0.68 e	0.30 d-f	0.32 d-f
Sodium benzoate at 500 mg/l for 12 h	0.60 ef	0.26 fg	0.40 a-c	0.65 ef	0.29 ef	0.43 a
Sodium benzoate at 500 mg/l for 24 h	0.67 d	0.30 c-f	0.38 bc	0.69 e	0.33 c-e	0.40 a-c
Daminozide at 25 mg/l for 12 h	0.55 fg	0.25 fg	0.30 de	0.60 fg	0.26 f	0.31 ef
Daminozide 25 mg/l for 24 h	0.50 gh	0.29 d-f	0.39 bc	0.55 g	0.30 d-f	0.44 a
Daminozide 50 mg/l for 12 h	0.40 ij	0.33 b-e	0.40 a-c	0.43 i	0.37 bc	0.42 ab
Daminozide 50 mg/l for 24 h	0.45 hi	0.35 bc	0.38 bc	0.49 h	0.40 b	0.43 a

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

Table 5. Effect of pulsing solution treatments on anthocyanine (mg/100 g f.w.) and total carbohydrate % of *Limonium sinuatum* cv. Girlie Wings cut flowers during the vase life period in 2016 and 2017 seasons.

Pulsing treatments	1st Season		2nd Season	
	Anthocyanine	Carbohydrate	Anthocyanine	Carbohydrate
Distilled water (control)	0.50d e	23.8 j	0.52 ef	24.1 i
STS at 500 mg/l for 1/4 h	1.05 ab	60.2 b	1.14 b	61.4 a
STS at 500 mg/l for 1/2 h	1.26 a	65.1 a	1.29 a	63.8 a
$AgNO_3$ 500 mg/l for 1/4 h	0.57 cd	49.5 c	0.62 d	50.3 b
$AgNO_3$ 500 mg/l for 1/2 h	0.39 d-f	45.3 e	0.43 f	47.5 cd
$AgNO_3$1 g/l for 1/4 h	0.13 g	47.8 cd	0.15 h	49.6 bc
$AgNO_3$1 g/l for 1/2 h	0.29 e-g	46.3 de	0.29 g	49.9 d
Sodium benzoate at 250 mg/l for 12 h	1.02 ab	54.3 c	1.05 b	55.2 c
Sodium benzoate at 250 mg/l for 24 h	0.81 bc	36.2 fg	0.84 c	37.5 ef
Sodium benzoate at 500 mg/l for 12 h	0.15 fg	30.5 h	0.15 h	31.1 h
Sodium benzoate at 500 mg/l for 24 h	0.14 fg	31.7 h	0.18 h	33.9 g
Daminozide at 25 mg/l for 12 h	0.61 cd	25.5 ij	0.61 de	26.3 i
Daminozide 25 mg/l for 24 h	0.60 cd	38.4 f	0.63 d	29.5 e
Daminozide 50 mg/l for 12 h	0.12 g	37.8 f	0.15 h	38.6 e
Daminozide 50 mg/l for 24 h	0.40 d-f	27.5 i	0.14 h	29.4 h

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

records in the two seasons. Khalid (2012) reported that concentrations of anthocyanin in the petals were higher in with STS pulsing treatments in cut sweet pea flowers.

Total carbohydrate percentage %:

According to results shown in Table (5), pulsing *Limonium sinuatum* cv. Girlie Wings cut flowers with STS at 500 mg/l for 1/2 h and STS at 500 mg/l for 1/4 h then holding in solution containing 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) produced the maximum amount of carbohydrates% compared to the control during the two seasons. The percentage of total carbohydrates decreased in *Limonium* flowers pulsed in daminozide solution at 25 mg/l for 12 h then holding in solution containing 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) (25.5 and 26.3 % in both seasons, respectively) and pulsing in daminozide solution 50 mg/l for 24 h (27.5 and 29.4% in both seasons, respectively) compared to all treatments. Results of the present study are in line with the findings attained by Suong *et al.* (2017) who revealed that STS inhibits microbial growth in the vase. STS also maintained the high soluble sucrose contents in the leaves of cut rose flowers. This was also stated by Khalid (2012) on cut sweet pea flowers. He found that anthocyanin concentrations increased by treatments with STS followed by sucrose during the postharvest life.

Total phenols and total indoles:

As shown in Table (6) it can be concluded that the highest amount of total phenols and total indoles (mg/100 g f.w.) were found in flowers treated with STS at 500 mg/l for 1/2 h compared to the other treatments, in both seasons. Using AgNO3 at 500 mg/l for 1/4 h and $AgNO_3$ at 500 mg/l for 1/2 h gave a high value, and there was no significant differences among them in total phenol, in two seasons. Higher phenolic content in spikes pulsed with STS of extended the vase life, particularly in 8-HQS + suc vase solution. The higher content of total phenols has been shown to be associated with longer vase life in cut rose petals *Hemerocallis* (Mwangi *et al*., 2003 and Gulzar *et al*., 2005).

Second experiment:

Isolation, purification and identification of the microorganisms:

Data presented in Table (7) illustrated the frequency of the isolated microorganisms from the samples. *Mucor* sp. (31.30), *Aspergillus niger* (23.4) and *Penecillium* sp. (17.5) recorded the highest percentages, while, *A. alternate* (0.2.3) was the least ones in this respect.

Data presented in Table (8) show that STS was the most effective treatments, whereas it completely inhibited growth of all isolated microoraganisms by 100% on the other hand, daminozide was the least one in this respect.

Conclusion:

Regarding the obtained results, it is able to be concluded that pulsing in STS at 500 mg/l for 1/2 h followed by transfer to 8-hydroxyqunoline sulphate (200 mg/l) + sucrose (20 g/l) prolonged vase life and delayed senescence as compared to other treatments. It preserves the execution of flowers according to various measurements taken as water uptake, relative fresh weight, dry weight percentage of cut flowers, floret opening percentage, pigments content, inhibited growth of all isolated microorganisms and enhancing postharvest evolution of *Limonium sinuatum* cv. Girlie Wings cut flowers.

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Table 6. Effect of pulsing solution treatments on total phenols and total indoles (mg/100 g f.w.) of *Limonium sinuatum* cv. Girlie Wings cut flowers in the vase life period in 2016 and 2017 seasons.

Pulsing treatments	1st Season		2nd Season	
	Total phenols	Total indoles	Total phenols	Total indoles
Distilled water (control)	0.59 ij	0.40 cd	0.62 gh	0.42 g
STS at 500 mg/l for 1/4 h	3.43 b	1.10 b	3.60 b	1.20 b
STS at 500 mg/l for 1/2 h	3.99 a	1.50 a	4.00 a	1.61 a
$AgNO_3$ 500 mg/l for 1/4 h	2.20 d	0.41 cd	2.40 c	0.45 ef
$AgNO_3$ 500 mg/l for 1/2 h	2.415 c	0.32 c-e	2.50 c	0.36 hf
$AgNO_3$1 g/l for 1/4 h	0.76 hi	0.33 cd	0.90 fg	0.37 h
$AgNO_3$1 g/l for 1/2 h	0.87 h	0.30 c-e	0.950 fg	0.34 i
Sodium benzoate at 250 mg/l for 12 h	1.12 g	0.22 de	1.23 ef	0.25 j
Sodium benzoate at 250 mg/l for 24 h	1.11 g	0.50 c	1.33 ef	0.53 d
Sodium benzoate at 500 mg/l for 12 h	1.47 f	0.11 e	1.60 de	0.16 k
Sodium benzoate at 500 mg/l for 24 h	1.82 e	0.51 c	1.90 d	0.56 c
Daminozide at 25 mg/l for 12 h	1.23 gh	0.30 c-e	1.40 e	0.35 hi
Daminozide 25 mg/l for 24 h	0.49 g	0.43 cd	0.50 h	0.47 e
Daminozide 50 mg/l for 12 h	2.21 j	0.25 de	2.30 c	0.26 j
Daminozide 50 mg/l for 24 h	0.68 i	0.41 cd	0.69 gh	0.44 fg

Means within a column having the same letter/letters are not significantly different according to Duncan's multiple Range Test at 5% level.

Table 7. Occurrence percentages of the fungi isolated from samples.

Fungi	Frequency (%)
Alternaria alternata Nees. (A)	02.3
Aspergillus niger (B)	23.4
F. moniliforme J. Scheld. (C)	2.70
Pythium ultimum Braun (D)	11.2
Penecillium sp. (E)	17.5
Bacillus subtilis (F)	10.2
Mucor sp. (G)	31.3

Table 8. Effect of the tested treatments on the isolated microorganisms under lab. conditions.

Treatment	Conc.	A	B	C	D	E	F Inhibition zone	G
Daminozide	25 mg/l	3.2	4.1	5.2	1.0	3.6	2.4	3.7
Daminozide	50 mg/l	1.0	2.4	3.2	00	1.2	9.0	1.7
STS	500 mg/l	0.0	0.0	0.0	0.0	0.0	9.0	0.0
Sodium benzoate	250 mg/l	0.0	1.1	2.7	3.1	1.5	5.6	2.4
Sodium benzoate	500 mg/l	0.0	0.5	2.2	1.3	1.1	3.1	1.5
Ag NO3	500 mg/l	0.0	0.0	0.0	0.9	0.0	6.5	0.8
Ag NO3	1 g/l	0.0	0.0	1.3	0.7	0.0	6.5	0.7

***Alternaria alternate* Nees.(A), *Aspergillus niger* (B), *F. moniliforme* J. Scheld. (C), *Pythium ultimum*, Braun (D), *Penecillium sp.* (E), *Bacillus subtilis* (F), *Mucor sp.* (G).**

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تأثير محاليل الحفظ على عمر وجودة أزهار الليمونيم

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أجريت هذه الدراسة في معمل معاملات ما بعد الحصاد بقسم بحوث نباتات الزينة وتنسيق الحدائق، معهد بحوث البساتين، مركز البحوث الزراعية جيزة، مصر أثناء موسمي ٢٠١٦ و ٢٠١٧ و ذلك للوقوف على تأثير بعض محاليل الحفظ لتحسين جودة الأزهار المقطوفة. تم نقع أزهار الليمونيوم المقطوفة فى محلول ثيوسلفات الفضة ٥٠٠ ملجم/لتر لمدة ربع ونصف ساعة، نترات الفضة ٥٠٠ ملجم/لتر لمدة ربع ونصف ساعة، نترات الفضة ١ جم/لتر لمدة ربع ونصف

ساعة، بنزوات صوديوم ٢٥٠ ملجم/لتر لمدة ١٢ و٢٤ ساعة، بنزوات صوديوم ٥٠٠ ملجم/لتر لمدة ١٢ و٢٤ ساعة، داي أمينوزويد ٢٥ملجم/لتر لمدة ١٢و ٢٤ ساعة و داي أمينوزويد ٥٠ملجم/لتر لمدة ١٢ و ٢٤ ساعة، تلى ذلك نقل الازهار الى محلول حفظ ٨- هيدروكسي كينولين سلفات ٢٠٠ملجم/لتر + سكروز ٢٠ جم/لتر و تم إستخدام الماء المقطر كمعاملة كنترول. تشير النتائج المتحصل عليها إلى أن معاملة أزهار الليمونيوم المقطوفة صنف "جيرلى وينجز" بمحلول ثيوسلفات الفضة عند ٥٠٠ مجم / لتر لمدة ٢/١ ساعة أدى إلى تحسين إمتصاص الماء، النسبة المئوية للوزن الطازج، النسبة المئوية للوزن الجاف للزهور المقطوعة، نسبة تفتح الأزهار، محتوى الصبغات، النسبة المئوية للكربوهيدرات الكلية، الفينولات الكلية والاندولات الكلية، كما ثبطت النمو لجميع الكائنات الدقيقة المعزولة وأدت إلى تحسين جودة الأزهار المقطوفة، تليها الأزهار المقطوفة المعاملة بثيوسلفات الفضة عند ٥٠٠ مجم / لتر لمدة ٤/١ ساعة ثم نترات الفضة ٥٠٠ ملجم/لتر لمدة ٢/١ ساعة، مقارنة بمحاليل الحفظ الأخري.