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IMPROVING THE SHELF LIFE AND QUALITY OF CUT GLADIOLUS CV. "WHITE PROSPERITY" SPIKES BY ETHYLENE INHIBITOR, COLD STORAGE AND THEIR INTERACTIONS

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ABSTRACT: *The study was conducted at the Postharvest Lab. of Floriculture Res. Dept., Hort. Res. Inst., Giza, Egypt during 2012 and 2013 seasons to explore the effect of silver thiosulphate solution (STS) applied as foliar spray or as immersing solution for 10, 20 and 30 minutes (control spikes were immersed in distilled water), cold storage at 5 ℃, vertically or horizontally for 2 or 4 days, beside control treatment in which spikes were kept at room temperature and their interactions on water relations, longevity and quality of Gladiolus hybridus cv. "White Prosperity" cut spikes. After each treatment, the bases of spike stems were held in 10 % sucrose solution till the end of the experiment.*

The obtained results showed that STS pulsing treatments caused a significant increment in the amount of water uptaken by cut Gladiolus spikes, and significantly decreased, the amount of water loss compared to control in most cases of the two seasons. These treatments were also improved floret diameter, vase life, spike fresh and dry weights, dry weight %, opening %, leaf content of chlorophyll a, b and reducing sugars % in the leaves petals, and decreased wilting %, and carotenoids content in the leaves and total sugars % in the leaves and petals. However, the prevalence was for immersing in STS solution for 10 min treatment, which gave the best values in most previous characters with few exceptions in both seasons. Storage at room temperature or at 5℃, vertically or horizontally for 2 or 4 days alternated improving means of previous characters with the mastery of horizontal cold storage treatment for 2 days, which recorded the best results in most cases. The interaction treatments also induced a marked improvement in most measurements, but the dominance was for the combining between immersing in STS solution for 10 min. and horizontal cold storage for 2 days, as this combination gave the best water relations, the longest vase life and the highest quality compared to the other individual and combined treatments.

Accordingly, it is recommended to immerse the cut spikes of Gladiolus cv. "White Prosperity" in STS solution for 10 min and then holding them in 10 % sucrose solution at room temperature for local marketing or storage them after immersing in STS solution, horizontally for at least 2 days at 5 ℃ for shipment abroad.

Key words: *Gladiolus, shelf life, STS, cold storage, Postharvest treatments.*

INTRODUCTION

Gladiolus L., Corn flag or Sword lily that belongs to Fam. Iridaceae is one of the four famous commercial cut flowers in the world (Bai *et al*., 2009). However, the smaller flowered cultivars are used for the herbaceous border. It is a tender and perennial herb with tunicate corms. Native to Europe, Mediterranean region, the Near East, but chiefly to tropic and South Africa. Flowers are showy, sometimes fragrant, in 1-sided spikes. Propagated mainly by corms and cormels (Bailey, 1976).

The longevity of gladiolus cut flowers is very short. The typical vase life of individual florets is just 4 to 6 days (Yamada *et al*., 2003). Therefore, many efforts were done to increase the longevity of this important cut flower, such as those elicited by Rekha and Shankaraiah (2002) who found that an increase in vase life and fresh weight of cut gladiolus spikes was significantly more with spikes held in PM + 3 % sucrose + 200 ppm 8-HQS solution for 22 days at cold storage (5 °C) conditions. Sashikalal and Ranvir (2003) noticed that both cellophane and

butter paper packed flowers stored at 4 °C for 2 days, in cellophane or butter paper for 4 days and in butter paper for 6 days proved to be the best to increase the postharvest life of Gladiolus cv. Her Majesty cut spikes. On gladiolus cut spikes cv. Peater Pears, Singh *et al*., (2007) reported that cold storage at 6-10 °C for 10 days with polypropylene (60 µ) film packaging maintained good keeping quality with improved floret opening, floret size and petal colour.

Similar observations were also detected on gladiolus cut spikes by Beura *et al*., (2001), Hassan (2005), Singh *et al*., (2009), Marandi *et al*., (2011) and Shimizu-Yumoto and Ichimura (2015) whom noted that pretreatment with STS improved bud opening and longevity of cut gladiolus "Princess Summer Yellow" spikes after suboptimal temperature storage for 6 days.

On other cut flowers, several reports were also recorded by Hutchinson *et al*., (2003) on tuberose, Jul *et al*., (2007) on amaryllis, Solgi *et al*., (2009) on gerbera, Gendy and Hamad (2011) on *Strelitzia reginae*, Shahri *et al*., (2011) on cut spikes of *Consolida ajacis* cv. Violet Blue, Bayleyegn *et al*., (2012) on rose, Santos *et al*., (2012) on *Epidendrum ibaguense*, Abdel-Moniem *et al*., (2012) on *Rosa hybrida* cvs. Anna, Gold Strike and Spot and Abd-Allah *et al*., (2013) on Asiatic hybrid lily cv. Orange Tycoon.

Regarding the effect of storage method, Muchiri (2005) mentioned that horizontal packaging of *Eustoma grandiflorum* cut flowers at 2 °C caused geotropic bending of flower pedicels. Cut inflorescences stored horizontally in boxes had their flower pedicels remaining bent not less than 15° throughout the display period, whereas those stored vertically in boxes had no detectable geotropic curvature. Longer periods of horizontal packaging progressively increased geotropic curvature of flower pedicles and this in effect reduced the overall postharvest quality of cut flowers. Moreover, Celikel *et al*., (2010) pointed out that when cut spikes of snapdragon were placed horizontally at 20°C, growth became negatively gravitropic within 20 min. Bending was significantly higher than control (stored vertically) in all flowers stored horizontally at temperatures above 5 °C.

Analogous results were also explored by Philosoph-Hodas *et al*., (1996) on snapdragon, Han (2001) on lilies and Celikel and Reid (2002) and Watkins and Miller (2005) on gerbera and sunflower and indicated that the best storage temperature for gladiolus spikes (as buds) ranged between 4-6 °C for 5-8 days proved keeping them in vertical position.

The purpose of this trial is to explore the most suitable pulsing treatment and storage method reliable for increasing longevity and freshness of cut gladiolus spikes cv. White Prosperity.

MATERIALS AND METHODS

The current work was carried out at the Postharvest Lab of Floriculture Res. Dept., Hort. Res. Inst., Giza, Egypt during the two consecutive seasons of 2012 and 2013 to examine the effect of silver thiosulphate, cold storage and their interactions on longevity, water relations and quality of one of the commercial cultivar of gladiolus.

Fresh cut spikes of *Gladiolus hybridus* cv. "White Prosperity" were obtained on January, 16th for each season from a local commercial farm (Floramax, El-Mansouria, Giza), picked in the early morning when the first flower bud showed the full colour (export stage) at similar lengths of 60 cm and were directly divided into groups and wrapped inside kraft paper and transported as quick as possible to the laboratory. Once in the Lab., the cut spikes were firstly precooled by immersion in a cool water (about 7 °C) for 30 min. to remove the field heat. Subsequently, stem bases were recut under water by removing about 1 cm and the cut spikes were divided into similar and equal five groups, as each one of them received one of the following treatments:

1. The treatment with silver thiosulphate (STS) solution, prepared by dissolving 0.34 g $AgNO_3$ in 125 ml distilled water (solution A) and 0.632 g sodium thiosulphate in 125 ml distilled water (solution B). Solution A was slowly added to solution B with shaking to get 250 ml of STS solution (Reid *et al*., 1980 b).

The solution of STS was used as: spray on the foliage of the cut spikes, and as pulsing solution where the bases of spike stems were immersed in it for 10, 20 or 30 min., beside control treatment in which the stem bases were immersed in distilled water. This group was kept at room conditions (as the temperature, RH and light intensity during the course of study ranged between; 18 ± 2 °C, 45 ± 5 % and 900-1000 lux, respectively) and referred to as pulsing or Lab treatments.

2. Each one of the remained 4 groups was subjected to the previously mentioned lab treatments plus cold storage at 5 °C, vertically or horizontally for either 2 or 4 days to form the following 4 cold storage treatments:
   - Storage for 2 days, vertically.
   - Storage for 2 days, horizontally.
   - Storage for 4 days, vertically.
   - Storage for 4 days, horizontally.

3. The interaction treatments: each treatment of pulsing (lab) treatments was combined with each one of cold storage treatments to create 25 interaction treatments.

At the end of as each one of the aforenamed treatments, the bases of spike stems were hold in clear glass jars (3 spikes/jar) containing about 200 ml of 10 % sucrose solution till the end of the experiment. A drop of xylene was added on the surface of sucrose solution to prevent evaporation during the vase life period. The jars with spikes inside were kept at room temperature (18 ± 2 °C) under normal daylight and natural ventilation. The lay out of the experiment in the two seasons was a complete randomized blocks in factorial experimental type, replicated thrice as each replicate included 3 spikes (Mead *et al*., 1993).

Data were recorded as follows: water uptake and water loss (g/spike) were evaluated during the shelf period once every 3 days and recorded in the tables as the mean for the whole shelf period. Water balance was calculated by subtracting water loss mean from water uptake mean, floret diameter (cm), vase life (day), spike fresh and dry weights (g), dry weight % using the equation of: DW % = dry weight/fresh weight x 100, as well as opening and wilting percentages. In ethanolic extracts, the content of chlorophyll a, b and carotenoids (mg/g f.w.) in fresh leaf samples, total and reducing sugars percentages in fresh leaf and petal samples were determined according to the methods of Moran (1982) and Dubois *et al*., (1966), respectively.

Data were then tabulated and statistically analysed using SAS Institute Program (1994). Differences among treatments were compared by Duncan's New Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Effect of silver thiosulphate, cold storage treatments and their interactions on:

1- Water relations of cut spikes.

It is obvious from data averaged in Table (1) that amount of water uptake by gladiolus cut spikes increased significantly by STS spraying or pulsing treatments compared to control treatment (D.W.) in the two seasons. The opposite was the right concerning amount of water loss, which decreased significantly by the same treatments relative to control treatment in both seasons. However, the highest amount of water uptake coupled with the least one of water loss was achieved in the two seasons by pulsing in STS solution for 10 min. It could be said that, the best water balance was achieved in the two seasons by this treatment which raised such parameter to 33.47 and 30.58 g in the first and second seasons, respectively.

Table (1): Effect of silver thiosulphate, cold storage and their interaction on water relations of cut *Gladiolus hybridus* Hort. cv. White Prosperity spikes during 2012 and 2013 seasons.

Pulsing treatments	Water uptake (g)						Water loss (g)						Water balance					
	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean
		V.	H	V.	H			V.	H	V.	H			V.	H	V.	H	
First season: 2012																		
Distilled water (cont.)	42.12m	22.40q	62.01fg	34.39o	65.20d	45.22E	56.93b	38.74hi	53.45c	45.38f	52.28c	49.36A	-14.81m	-16.34m	8.56ij	-10.99lm	12.92h	-4.132E
STS spraying	42.54m	27.45p	62.64e-g	64.03d-f	51.87j	49.71D	35.44j	47.10e	30.30k	53.40c	43.52g	41.95C	7.10j	-19.65f	32.34c	10.63i	8.35ij	7.754CD
STS pul. For 10 min	92.41a	49.44k	51.50jk	85.60b	61.03g	68.00A	24.53m	35.36j	27.41l	37.36i	47.96de	34.52D	67.88a	14.08gh	24.09d	48.24b	13.07gh	33.472A
STS pul. For 20 min	44.60l	45.38l	49.58k	57.20h	64.56de	52.26C	42.94g	45.30f	30.10k	49.12d	52.38c	43.97B	1.66k	0.08k	19.48e	8.08ij	12.18h	8.30C
STS pul. For 30 min	54.82i	45.19l	71.29c	40.00n	63.07d-g	54.87B	38.22i	44.64fg	63.58a	30.26k	40.35h	43.41B	16.60fg	0.55k	7.71j	9.74i	22.72e	11.46B
Mean	55.30D	37.97E	59.40B	56.24C	61.15A		42.45C	39.39D	53.39A	36.70E	45.28B		15.69B	-4.26E	18.44A	13.14D	13.85C	
Second season: 2013																		
Distilled water (cont.)	42.08m	29.14n	61.87f	29.76n	64.82d	45.53D	57.31d	38.20j	62.45b	50.64f	54.56e	52.63A	-15.23l	-9.06k	-0.58ij	-20.88m	10.26fg	-7.10E
STS spraying	53.19g	28.10n	63.07d-f	63.01d-f	52.23gh	51.92C	34.66k	42.02i	60.31c	64.94a	49.96f	50.38B	18.53ef	-13.92	2.76h	-1.93j	2.27h	1.54D
STS pul. For 10 min	91.03a	48.89jk	51.18hi	62.69ef	85.02b	67.76A	25.91l	45.70g	25.78g	49.74f	38.78j	37.18E	65.12a	3.19h	25.40c	12.95f	46.24b	30.58A
STS pul. For 20 min	48.46k	45.30l	51.01hi	64.20de	63.95de	54.58B	49.78f	42.70i	43.88g-i	38.07j	54.02e	45.69C	-1.32ij	2.60h	7.13g	26.13c	9.93fg	8.89C
STS pul. For 30 min	42.45m	46.20l	70.84c	50.23ij	62.05f	54.35B	39.07j	44.78gh	50.78f	43.00hi	38.63j	43.25D	3.38h	1.42i	20.06e	7.23g	23.42d	11.10B
Mean	55.44D	39.53E	59.59B	53.98C	65.61A		41.35E	42.68D	48.64AB	49.28A	47.19C		14.10B	-3.15E	10.95C	4.70D	18.42A	

Cont. = Control, V = Vertical, H = Horizontal and STS = silver thiosulphate.
Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5 % level.

As for the effect of storage treatments, it was noticed that cold storage for 4 days increased water uptake to the highest amount when spikes were kept horizontally compared with the other treatments in both seasons, while the least amount of water loss was attained in the first season by storing the spikes vertically for 4 days treatment, followed by vertical storage treatment for only 2 days. In the second season, that was attained by the control treatment (storage at room temperature), which reduced water loss value to 41.35 g and followed by vertical storage treatment for only 2 days, that decreased the mean of such parameter to 42.68 g, compared to the other treatments.

On the other hand, the interaction treatments caused variable effects on water relations of gladiolus cut spikes. The best water relations registered in the two seasons was attributed to the combining between pulsing spikes in STS solution for 10 min. and keeping them at the room temperature, as this combination raised water uptake to the highest value, decreased the water loss to the minimal value. Consequently the best water balance means (67.88 g in the 1st season and 65.12 g in the 2nd one) with highly significant differences over all the other combinations in the two seasons. This may be attributed to that STS inhibited the action of ethylene and lead to a decrease in lip oxygenase (Lox) activity, as well as served as an antibacterial component, beside that all vital processes, including photosynthesis are well carried out under room temperature, and this finally will maintain the water balance of spikes by regulating the water flux into the xylem vessels and controlling transpiration (Han, 2001).

These results are in accordance with those revealed by Beura *et al*., (2001), Hassan (2005), Singh *et al*., (2009) and Shimizu-Yumoto and Ichimura (2015) on gladiolus. In this connection, Marandi *et al*., (2011) claimed that STS treatment at 150 ppm had positive effect on water uptake by gladiolus cut spikes. Gendy and Hamad (2011) found that pulsing Bird-of-Paradise cut flowers in STS solution (1 : 4 mM) for 30 min., then in solution containing 20 % SUC + 200 ppm 8-HQS for 12 h significantly improved water balance and maintained flower quality. When the previous pulsing treatment interacted with cold storage for 5 days at 6 ± 1° C, the highest water balance and quality were obtained. Abd-Allah *et al*., (2013) stated that storage under room temperature recorded the highest amount of water uptaken by lily flowering stems compared with cold storage treatments. Storage at 2 ° C gave the least means in this parameter. The inflorescences rapidly wilted after the ninth day from cut. This may be due to increasing petal sensitivity after cold storage, depletion of carbohydrate reserves and oxidative stress caused by cold storage.

2- Floret diameter and vase life:

Data in Table (2) clear that floret diameter and vase life increased significantly in response to the different pulsing treatments used in this trial. However, the superiority was for pulsing in STS solution for 10 min. treatment which gave the highest records in both seasons over the control and other pulsing treatments. This may indicate the role of STS as ethylene binding inhibitor and as a biocide, so improves the vase life of cut flowers by delaying its senescence (Abdel-Moniem *et al*., 2012). On the other side, storage at room temperature greatly improved floret diameter in the two seasons, whereas cold horizontal storage for 4 days significantly improved this character in the second season only. Vase life, however extended markedly by storage at room temperature and cold horizontal storage for 2 days treatments in the 1st season, while in the 2nd one, the longest vase life was established by cold horizontal storage for 2 days and cold vertical storage for 4 days treatments. This may be reasonable because all vital processes, including

Table (2): Effect of silver thiosulphate, cold storage and their interaction on floret diameter and vase life of cut *Gladiolus hybridus* Hort. cv. White Prosperity spikes during 2012 and 2013 seasons.

Pulsing treatments	Floret diameter (cm.)						Vase life (day)					
	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean
		V.	H	V.	H			V.	H	V.	H	
	First season: 2012											
Distilled water (cont.)	5.04e-g	3.11m	3.97k	3.22m	3.68l	3.80D	18.00c	18.00c	18.00c	18.00c	18.00c	18.00C
STS spraying	5.87b	4.23j	4.91g	4.50i	4.93g	4.89B	21.00a	18.00c	20.00ab	19.00bc	18.00c	19.20AB
STS pul. For 10 min.	5.80bc	5.22e	6.08a	3.91k	4.64hi	5.13A	21.00a	20.00ab	21.00a	19.00bc	19.00bc	20.00A
STS pul. For 20 min.	5.21ef	3.67l	4.11jk	5.16ef	5.68bc	4.77C	19.00bc	20.00ab	19.00bc	18.00c	18.00c	18.80BC
STS pul. For 30 min.	5.60cd	4.83gh	4.03jk	5.45d	4.99fg	4.98B	18.00c	20.00ab	20.00ab	20.00ab	18.00c	19.20AB
Mean	5.50A	4.21D	4.62BC	4.57C	4.78B		19.40A	19.20AB	19.60A	18.80B	18.20C	
	Second season: 2013											
Distilled water (cont.)	5.51ef	4.59i	4.27j	3.88k	5.83b-e	4.82B	19.00f	19.00f	19.00f	19.00f	19.00f	19.00C
STS spraying	5.76b-e	5.52d-f	5.53c-f	5.27fg	6.10ab	5.64A	19.67ef	19.66ef	21.00a-d	21.00a-d	20.33c-e	20.33B
STS pul. For 10 min.	5.78b-e	5.47ef	6.20a	5.67c-e	5.47ef	5.72A	20.00d-f	19.67ef	22.00a	21.67ab	20.33c-e	20.73A
STS pul. For 20 min.	5.88a-d	5.78b-e	4.94h	5.58c-f	5.54c-f	5.54A	20.66b-e	20.00d-f	20.00d-f	21.67ab	21.00a-d	20.67A
STS pul. For 30 min.	5.72c-e	5.71c-e	5.11gh	5.89a-c	5.82b-e	5.65A	21.00a-d	20.32d-f	21.00a-d	21.33a-c	19.00f	20.53AB
Mean	5.73A	5.41B	5.21C	5.26C	5.75A		20.07B	19.73B	20.60A	20.93A	19.93B	

Cont. = Control, V = Vertical, H = Horizontal and STS = silver thisoulphate.

Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5 % level

photosynthesis were still continuous under storage at room temperature, so cut flowers were supplied with energy-produced metabolites necessary for their freshness, while cold storage prevents depletion of such materials by decreasing the rate of respiration (Celikel and Reid, 2002). In this regard, Shahri *et al*., (2011) observed that pulsing spikes of *Consolida ajacis* cv. Violet Blue in 0.5 mM STS solution prior to 72 h wet storage at 5 °C and transferring them to holding solution containing Sucrose + HQS significantly improved the postharvest performance of this cut flower.

The interaction treatments also improved the means of these two traits with various significant differences compared to control, but the prevalence in the two seasons was for connecting between pulsing in STS solution for 10 min. and cold horizontal storage for 2 days as this combined treatment elevated the means of such two parameters to the utmost high values in both seasons. This may be ascribed to lumping the beneficial effects of both silver thiosulphate and cold storage as mentioned before.

The previous findings were documented by Hutchinson *et al*., (2003) who suggested that STS and sucrose can improve tuberose vase life and floret opening through improvement of the water balance. Furthermore, Santos *et al*., (2012) declared that vase life of *Epidendrum ibaguense* spikes was increased to 6.5 days when pulsed with 2 mM STS for 30 min. The STS applied before cold storage reduced the rate of flower abscission and improved the ratio between transpiration and water uptake. On the same line, were those results gained by Sashikalal and Ranvir (2003), Singh *et al*., (2007), Macnish *et al*., (2008) and Singh *et al*., (2009) on gladiolus.

3- Fresh and dry weight of spikes and dry weight percentage:

According to data illustrated in Table (3), it can be concluded that all pulsing treatments induced a significant increment in spike fresh and dry weights compared to the control in both seasons. The mastery in the first season was for pulsing in STS solution for 10 min. treatment, while in the second one was for either pulsing in the same solution for the same time or spraying with it on the foliage, as these two latter treatments gave closely near values with non-significant differences between them in the two seasons.

Regarding the effect of storage treatments on such two parameters, it fluctuated in both seasons. The interactions, on the other hand, in proved the means of these two traits in most cases of the two seasons. The heaviest fresh and dry weights of spikes were achieved in both seasons by joining between pulsing in STS solution for 10 min. and cold storage, horizontally for 2 days, as this combined treatment increased spike fresh weight to 18.05 and 19.15 g and spike dry weight to 9.87 and 8.46 g in the 1st and 2nd seasons, respectively.

The percent of dry weight was also affected by the used treatments, as it reached the maximal value in the 1st season by pulsing in STS solution for either 10 or 30 min., while in the 2nd one, STS spraying treatment gave the highest dry weight %. The cold storage, horizontally for 4 days scored in the two seasons the highest dry weight % compared to the other storage treatments. Vertical cold storage treatment for 4 days interacted with pulsing in STS solution for 30 min. surpassed all the other sole and combined treatments giving in the 1st season the utmost high dry weight % at all (61.06 %), while in the 2nd one, that was achieved by combining between the horizontal cold storage for 4 days and spraying with STS solution (52.96 %).

The aforestated results may be interpretted and discussed as previously mentioned in case of water relations, floret diameter and vase life criteria. However, simillar observations were also detected by Rekha and Shankaraiah (2002) on gladiolus, Jul *et al*., (2007) on amaryllis, Solgi *et al*.,

Table (3): Effect of silver thiosulphate, cold storage and their interaction on fresh and dry weight and dry weight percentage of cut *Gladiolus hybridus* Hort. cv. White Prosperity spikes during 2012 and 2013 seasons.

Pulsing treatments	Spike fresh weight (g)						Spike dry weight (g)						Dry weight (%)					
	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean
		V.	H	V.	H			V.	H	V.	H			V.	H	V.	H	
	First season: 2012																	
Distilled water (cont.)	11.57m	13.35lj	12.97jk	12.95jk	12.19lm	12.61D	5.07fg	3.11j	3.43j	5.14fg	5.82ef	4.51D	43.82f	23.30l	26.45j	39.69h	47.74d	36.20C
STS spraying	12.81j-l	14.58e-g	14.11g-i	15.05de	15.43cd	14.40B	6.44de	3.08j	3.61lj	8.07b	8.37b	5.91B	50.27c	21.12n	25.58jk	53.62bc	54.24b	40.97B
STS pul. For 10 min	14.29f-h	15.39cd	18.05a	16.55b	15.37cd	15.93A	6.55de	3.92h-j	9.87a	6.61de	6.37de	6.66A	45.84e	25.47k	54.68b	39.94h	41.44g	41.47A
STS pul. For 20 min	14.95d-f	8.65n	15.23c-e	12.70j-l	14.15g-i	13.14C	5.14fg	4.37g-l	5.23fg	4.97fg	6.24de	5.19C	34.38l	50.52c	34.34l	39.13hl	44.10e	40.49B
STS pul. For 30 min	15.12de	15.89c	13.76hl	12.48kl	14.88d-f	14.43B	6.46de	3.56lj	4.73g-i	7.62bc	6.97cd	5.87B	42.72fg	22.40lm	34.38l	61.06a	46.84de	41.48A
Mean	13.75BC	13.57C	14.82A	13.95B	14.40A		5.93B	3.61D	5.37C	6.48A	6.75A		43.41B	28.56D	35.09C	45.69A	45.87A	
	Second season: 2013																	
Distilled water (cont.)	15.83g-k	15.77g-k	15.36l-l	14.70lm	14.99kl	15.33C	4.49h-j	3.48k	4.30lj	4.06jk	4.96g-l	4.26D	28.36hl	22.07l	27.99l	27.62l	33.09fg	27.83E
STS spraying	17.83bc	16.46e-h	15.30j-l	16.97d-f	16.24f-l	16.56A	7.65b	4.68g-j	4.24lj	7.62b	8.60a	6.56A	42.91c	28.43hl	27.71l	44.90b	52.96a	39.38A
STS pul. For 10 min	16.03g-j	17.45b-d	19.15a	16.67d-g	15.03kl	16.87A	7.05bc	4.29lj	8.46a	7.14bc	5.74ef	6.54A	43.98bc	24.58jk	44.18b	42.83c	38.19de	38.75B
STS pul. For 20 min	18.10b	15.87g-k	15.49l-l	16.63d-g	15.69h-k	16.36AB	4.82g-l	5.04g-i	4.52g-j	6.08de	6.22de	5.34C	26.63j	31.76g	29.18h	36.56ef	39.54d	32.75D
STS pul. For 30 min	17.17c-e	15.54h-l	16.43e-h	14.08m	15.18j-l	15.68B	5.88de	3.98jk	5.22fg	6.50cd	7.73b	5.86B	34.25f	25.61jk	31.77g	46.16b	50.92a	37.74C
Mean	16.99A	16.22B	16.35B	15.81C	15.43D		5.96C	4.29E	5.35D	6.28B	6.65A		35.22C	26.49E	32.17D	39.62B	42.96A	

Cont. = Control, V = Vertical, H = Horizontal and STS = silver thisoulphate.

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

(2009) on gerbera and Hassan and Ali (2014) whom indicated that 1- MCP or STS treatments significantly extended the vase life and minimized the weight loss of gladiolus spikes compared with the control. Both treatments minimized also ethylene production and retained membrane stability. On Asiatic hybrid lily "Orange Tycoon" cut flowering stems, Abd-Allah *et al*., (2013) noticed that pulsing in STS solution at 1 : 4 mM for 30 min improved the change % in fresh weight of inflorescences.

4- Opening and wilting percentage:

Data in Table (4) exhibit that flower bud opening % significantly increased in response to the various pulsing treatments employed in this work. However, the highest percent of opening was obtained by pulsing in the STS solution for 10 min. in both seasons. The opposite was right regarding the wilting %, which decreased significantly by pulsing treatments, with few exceptions in the two seasons. On the other side, opening % was the maximum in the first season when spikes were kept at room temperature (control), whereas in the second one, that occurred by cold storage treatments, either horizontally for 2 days or vertically for 4 days. Generally, cold storage treatments raised wilting % with significant difference compared to keeping at room temperature (conted treatment) that reduces the means of such measurement to the least values in the two seasons.

A marked effect on these two parameters was also noticed by the interaction treatments which elevated the percent of opening to the highest averages by combining pulsing in STS solution for 10 min. and cold, horizontal storage for 2 days in both seasons, and diminished the percentage of wilting to the minimal values in the two seasons by combining between pulsing in STS solution for 10 min. and keeping the spikes at room temperature.

This may indicate the role of STS in improving floret opening. In this connection, Serek *et al*., (1994) affirmed that a climacteric pattern of ethylene production by the youngest buds on the spike of gladiolus (which never opened) was stimulated by cool storage , and was not affected by holding the spikes in a preservative solution containing sucrose. Pulsing the spikes in STS solution improved floret opening but not the life of individual florets. Sucrose and STS had similar but not synergistic effects on floret opening, suggesting that STS improves flower opening in gladiolus by overcoming the effects of carbohydrates depletion. These results, are in harmony with these of Shimizu-Yumoto and Ichimura (2015) on gladiolus cv. "Princess Summer Yellow", Gendy and Hamad (2011) on *Strelitzia reginae* and Abd-Allah *et al*., (2013) whom reported that pulsing in STS solution (1:4 mM) improved flower opening of Asiatic hybrid lily cv. "Orange Tycoon".

5- Leaf and petal chemical composition:

As shown in Table (5), data reveal that pulsing treatments caused a marked increment in the leaf content of chlorophyll a and b (mg/g f.w.), as well as reducing sugars % in the leaves and petals with the superiority of pulsing for 10 min. treatment, which recorded the highest means of the aforenamed constituents relative to control (distilled water) and other pulsing treatments. The opposite was right concerning carotenoids content in the leaves and total sugars % in the leaves and petals, as they decreased as a result of applying different pulsing treatments except of pulsing for 20 min and for 30 min treatments that slightly increased total sugars content in the leaves and petals over control to 2.03 and 2.67 %, respectively.

It was also noticed that content of chlorophyll a and carotenoids in the leaves increased, while that of chlorophyll b declined by cold storage treatments, with the

Table (4): Effect of silver thiosulphate, cold storage and their interaction on opening and wilting of cut *Gladiolus hybridus* Hort. cv. White Prosperity spikes during 2012 and 2013 srasons.

Pulsing treatments	Opening (%)						Wilting (%)					
	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean	Without storage (Cont.)	Storage for 2 days		Storage for 4 days		Mean
		V.	H	V.	H			V.	H	V.	H	
	First season: 2012											
Distilled water (cont.)	57.63gh	53.58ij	57.29h	54.92i	53.40ij	55.36D	30.63hi	35.65e	46.97b	31.81gh	28.62ij	34.74A
STS spraying	62.90cd	57.39gh	59.73e-g	60.43ef	60.18ef	60.13B	21.93l	35.68e	26.17k	32.89fg	41.28c	31.59B
STS pul. For 10 min.	66.22b	60.48ef	68.50a	51.59j	64.08bc	62.17A	17.29m	32.83fg	32.32gh	26.08i	29.14i	27.53C
STS pul. For 20 min.	59.43f-h	53.45ij	61.95c-e	54.43i	57.80gh	57.41C	39.04d	43.06c	34.54ef	25.54k	30.56hi	34.55A
STS pul. For 30 min.	61.27d-f	57.80ij	47.09k	65.65b	57.17h	57.80C	27.03jk	50.60a	22.90l	28.85ij	45.95b	35.07A
Mean	61.49A	56.54D	58.91B	57.40C	58.53B		27.18E	39.56A	32.58C	29.04D	35.11B	
	Second season: 2013											
Distilled water (cont.)	65.02jk	64.71k	72.28de	60.48l	62.32a	64.96D	41.20i	52.78d	48.42f	50.73e	40.67i	46.76B
STS spraying	67.09h-k	68.14g-i	70.01e-g	75.89c	74.06cd	71.04B	29.43m	46.08g	36.86jk	34.33l	35.26kl	36.39E
STS pul. For 10 min.	75.54c	70.37e-g	83.94a	65.71i-k	67.39h-j	72.59A	24.13o	30.88m	48.90ef	41.02i	37.37j	39.97D
STS pul. For 20 min.	67.21h-j	72.36de	73.95cd	70.82ef	66.46i-k	70.16C	43.72h	61.72c	50.01ef	43.66h	30.56m	45.93C
STS pul. For 30 min.	72.24de	64.98jk	55.45m	80.14b	69.36f-h	68.43C	27.02n	67.40a	35.41kl	46.07g	64.13b	48.01A
Mean	69.42B	68.11C	71.13A	70.61A	67.92D		33.10D	51.77A	43.92B	43.16B	41.60C	

Cont. = Control, V = Vertical, H = Horizontal and STS = silver thisoulphate.
Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5 % level

superiority of horizontal storage for 2 days which gave the best pigments content. The percent of total and reducing sugars in the leaves fluctuated, but in petals, data indicated that total sugars % increased, while reducing sugars % decreased by the various cold storage treatments compared to storage at room temperature. However, combining between pulsing in STS solution for 10 min. and vertical cold storage for 2 days gave the highest content in most constituents mentioned above.

Table (5): Effect of silver thiosulphate, cold storage and their interaction on leaf and petal chemical composition of cut *Gladiolus hybridus* Hort. cv. White Prosperity spikes during 2013 season.

Cold storage treatments		Under the room conditions (in the Lab)	Pigments content (mg/g f.w.)			Total sugars (%)		Reducing sugars (%)	
			Chlorophyll a	Chlorophyll b	Carotenoids	Leaves	Petals	Leaves	Petals
Without storage (cont.)		Distilled water (cont.)	0.84	0.50	0.44	1.47	0.33	1.04	1.99
		STS spraying	2.78	1.93	1.13	1.52	0.56	1.57	2.03
		STS pul. For 10 min.	3.23	3.35	1.17	1.82	2.71	1.70	2.54
		STS pul. For 20 min.	2.84	2.23	0.73	1.47	3.35	1.04	2.29
		STS pul. For 30 min.	2.08	2.93	0.60	1.55	2.61	0.99	2.35
Mean			2.35	2.19	0.81	1.57	1.37	1.27	2.24
Storage for 2 days	V	Distilled water (cont.)	1.35	0.05	0.59	1.34	1.23	1.12	1.07
		STS spraying	2.64	2.73	0.71	1.31	1.66	1.21	1.56
		STS pul. For 10 min.	2.27	2.83	3.61	2.46	3.82	2.36	3.61
		STS pul. For 20 min.	1.92	1.01	2.31	1.86	0.56	1.34	1.41
		STS pul. For 30 min.	1.69	1.44	0.52	1.23	1.97	0.97	1.94
	Mean		1.97	1.61	1.55	1.64	1.85	1.40	1.92
	H.	Distilled water (cont.)	0.91	1.87	1.60	0.88	0.94	0.45	1.73
		STS spraying	4.98	2.25	1.93	1.78	3.06	0.58	0.94
		STS pul. For 10 min.	5.26	4.07	3.21	2.36	2.23	1.81	3.00
		STS pul. For 20 min.	1.86	1.88	1.82	1.04	1.08	0.58	0.98
		STS pul. For 30 min.	1.60	1.88	2.03	1.48	1.93	0.72	1.91
	Mean		2.92	2.39	2.12	1.51	1.85	0.83	1.71
Storage for 4 days	V	Distilled water (cont.)	2.25	0.74	1.13	1.06	0.85	0.45	0.34
		STS spraying	2.61	1.27	2.54	1.22	3.12	0.60	2.24
		STS pul. For 10 min.	2.37	2.46	3.94	1.73	1.38	1.17	1.58
		STS pul. For 20 min.	3.05	2.45	1.38	1.16	2.02	2.22	1.26
		STS pul. For 30 min.	3.65	1.45	1.53	1.17	1.80	0.86	1.33
	Mean		2.79	1.67	2.10	1.27	1.83	1.06	1.35
	H	Distilled water (cont.)	1.64	1.41	0.33	1.06	0.65	1.62	1.24
		STS spraying	1.41	1.33	1.21	1.91	1.57	1.77	1.39
		STS pul. For 10 min.	7.49	2.30	1.26	2.45	2.81	1.89	2.59
		STS pul. For 20 min.	1.44	1.06	0.45	2.60	2.20	1.85	1.96
		STS pul. For 30 min.	4.43	1.10	2.00	1.77	3.20	1.75	3.04
	Mean		3.28	1.44	1.05	1.96	2.09	1.78	2.04
Mean		Distilled water (cont.)	1.40	0.91	0.82	1.16	0.80	0.94	1.27
		STS spraying	2.88	1.90	1.50	1.55	1.99	1.15	1.63
		STS pul. For 10 min.	4.12	3.00	2.64	2.16	2.59	1.79	2.66
		STS pul. For 20 min.	2.22	1.73	1.34	1.63	1.84	1.41	1.58
		STS pul. For 30 min.	2.69	1.76	1.34	1.44	2.30	1.06	2.11

Cont. = Control, V = Vertical, H = Horizontal and STS = silver thisoulphate.

This may indicate the role of both STS and cold storage in the presence of sucrose in preventing depletion of active constituents in spike tissues. In this regard, Hassan and Ali (2014) found that silver thiosulphate at 0.2 or 0.4 mM for 6h. enhanced the relative water content in gladiolus spikes and maintained chlorophyll and carbohydrates contents compared with the control spikes which were kept in distilled water. On Bird-of-Paradise, Gendy and Hamad (2011) pointed out that pulsing treatment of STS at 1: 4 mM for 30 min maintained anthocyanin content in petals. The present results confirm the previous reports mentioned by Singh *et al*., (2007) and Marandi *et al*., (2011) on gladiolus and Bayleyegn *et al*., (2012) who postulated that passive refrigeration system and pulse with mixtures of STS, chrysal clear solution and 8-HQS maintained a fresh-like quality of rose flowers and TSS contents of petals.

From the previous findings, it can be advised to pulse the cut spikes of gladiolus cv. "White Prosperity" with STS solution for 10 min. and then preserving them in 10 % sucrose solution at room temperature for local marketing, or storage them after pulsing, horizontally for at least 2 days at 5 °C for shipping abroad.

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تحسين عمر وجودة نورات الجلاديولس المقطوفة (صنف بروسبرتى الأبيض) بمثبط الإيثلين، التخزين البارد والحفظ فى محلول سكروز

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الملخص العربى

أجريت هذه الدراسة بمعمل معاملات ما بعد القطف بقسم بحوث الزينة، معهد بحوث البساتين، الجيزة، مصر خلال موسمى 2012، 2013 لدراسة تأثير محلول ثيوسلفات الفضة عند إضافتها رشاً على الأوراق أو غمس النورات فيه لمدة 10، 20، 30 دقيقة (غمست نورات المقارنة فى ماء مقطر)، التخزين البارد على درجة 5 °م، رأسيا أو أفقياً لمدة يومين أو أربعة أيام (بجانب معاملة المقارنة والتى حفظت فيها النورات على درجة حرارة الغرفة العادية) وكذلك التفاعلات بينهما على العلاقات المائية، عمر وجودة نورات الجلاديولس (صنف بروسبرتى الأبيض) بعد القطف. عقب تطبيق كل معاملة من المعاملات السابقة حفظت قواعد النورات فى محلول سكروز (10 %).

أوضحت النتائج المتحصل عليها أن معاملات ثيوسلفات الفضة أحدثت زيادة معنوية فى كمية الماء الممتصة بواسطة نورات الجلاديولس، لكنها على النقيض قللت كمية المياه المفقودة من هذه النورات مقارنة بالكنترول فى معظم الحالات بكلا الموسمين. أدت هذه المعاملات أيضاً إلى تحسين قطر الزهيرات، عمر النورات فى الفازة، الوزن الطازج والجاف للنورات، النسبة المئوية لوزن النورات الجاف، النسبة المئوية للتفتح، محتوى الأوراق من كلورفيللى أ، ب وكذلك محتوى الأوراق والبتلات من السكريات المختزلة، بينما قللت نسبة الذبول، محتوى الأوراق من الكاروتينويدات ومحتوى الأوراق والبتلات من السكريات الكلية. إلا أن السيادة فى جميع هذه القياسات كانت لمعاملة الغمس فى محلول ثيوسلفات الفضة لمدة (10 دقائق) والتى أعطت أفضل القيم مع بعض الاستثناءات البسيطة بكلا الموسمين. ولقد تبادلت معاملات التخزين على درجة حرارة الغرفة أو التخزين البارد على درجة 5 °م، رأسياً أو أفقياً لمدة يومين أو أربعة أيام تحسين متوسطات الصفات السابقة، مع تفوق معاملة التخزين البارد أفقياً لمدة يومين والتى سجلت فى معظم الأحيان أفضل النتائج. أيضاً أحدثت التفاعلات المشتركة تحسناً واضحاً فى معظم القياسات، لكن السيادة كانت لمعاملة الجمع بين الغمس فى محلول ثيوسلفات الفضة لمدة 10 دقائق والتخزين البارد أفقياً لمدة يومين، حيث أعطت هذه التوليفة أفضل علاقات مائية للنورات المقطوفة، أطول عمر فى الفازة واعلى جودة مقارنة بالمعاملات الفردية والمشتركة الأخرى.

وعليه، يمكن التوصية بغمس نورات الجلاديولس المقطوفة (صنف بروسبرتى الأبيض) فى محلول ثيوسلفات الفضة لمدة (10 دقائق)، ثم تحفظ بعد ذلك فى محلول سكروز (10 %) عند استهلاكها محلياً أو تخزن لمدة يومين على الأقل أفقياً على درجة (5 °م) عند شحنها للخارج.

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