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POST-HARVEST CHARACTERISTCS OF GERBERA CUT FLOWERS AS INFLUENCED BY PRESERVATIVE SOLUTIONS AND COLD STORAGE PERIODS TREATMENTS

Amal M.M. El-Ghazouly*, M.A.I. Abdelkader, A.E. Awad and G.A. Bishr

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

ABSTRACT

The present work was carried out at the laboratories of Hort. Dept., Agric. Fac., Zagazig University, Egypt during 2014 and 2015 seasons to improve keeping quality of gerbera *cv.* Rosamine cut flowers by using of pulsing, holding solutions and cold storage for several durations as well as their combination treatments. Besides, studying these treatments affects on post harvest characters and water relation characters as well as some chemical constituents in gerbera cut flowers. Pulsing solution treatments used were control distilled water (D.W.), sucrose (S) at 5 % plus 8-hydroxy quinolene sulphate (8-HQS) at 200 ppm for 18 hours, benzyladenine (BA) at 10 ppm + 5% S + 200 ppm 8-HQS for 18 hours, silver thiosulphate (STS) 1:4 mM for 20 minutes then placed in 5% S + 200 ppm 8-HQS for 18 hours, STS 1:4 mM for 20 minutes then placed in BA at 25 ppm + 5% S + 200 ppm 8-HQS for 18 hours and sodium nitroprusside (SNP) 250 ppm for 1 hour then placed in BA at 25 ppm + 5% S + 200 ppm 8-HQS for 18 hours. Furthermore, gerbera cut flowers were stored at 4±1°C for 0, 5 or 10 days. Whereas, holding solutions treatments used after storage period treatment were control distilled water (D.W.) and sucrose (S) 2.5% + 8-hydroxyquroline sulphate (8-HQS) at 200 ppm + citric acid (CA) at 150 ppm, besides to the combination treatments between them. The following data were recorded, post harvest characters (vase life), water relations (water balance) and chemical constituents (anthocyanin content, total sugars, total nitrogen and protein percentages) as well as correlation coefficient among these characters as affected by the combination between pulsing solution, storage periods and holding solution treatments used. The obtained results came to the conclusion that, the longest vase life of gerbera and the highest quality cv. Rosamine cut flowers were obtained by using the combination treatments between STS + S + 8-HQS for 18 hours as pulsing solution and storage at 4±1°C for 0-time and 5 days and holding solution tretments contained sucrose (2.5%) + 8-hydrox quinolene sulphat (200 ppm) + citric acid (150 ppm) compared to the other ones under study.

Key words: Gerbera, preservative solutions, cold storage, vase life, water relations and chemical constituents.

INTRODUCTION

Nowadays, cut flowers occupy an important position in the local and foreign markets because of their importance as a source of Egypt national income. Gerbera (*Gerbera jamesonii* L.) is an important ornamental flower and is commonly used as a cutting flower belonging to Asteraceae family, classified as a flowering plant and is one of ten popular cut flowers in the world which occupies the forth place according to the global trends in floriculture Choudhary and Prasad (2000).

Keeping quality is an important parameter for evaluation of cut flower quality, for both domestic and export markets. Addition of chemical preservatives to the pulsing and holding solution is recommended to prolong the vase-life of cut flowers. In this regards, some chemical preservatives, *i.e.* sucrose + 8-hydroxy quinolene sulphate (8-HQS) in combination with benzyladenine (BA), silver thiosulphate (STS)

* **Corresponding author: Tel. :** +201001311230
E-mail address: amal.mmm@gmail.com

or sodum nitro proceed (SNP) used as pulsing solutions and sucrose, 8-hydroxy quinolone sulphate (8-HQS) and cirtic acid as holding solutions were used to prolong vase extension . Sucrose antagonizes the effect of ABA, which promotes senescence (Halevy and Mayak, 1979). Application of 8-hydroxy quinolone salts (8-HQS) reduced vascular blockages in rose cut flowers (Marousky, 1971). As well, sucrose alone has not been usually used, because sugar treatment without germicides promotes bacterial proliferation, leading to shortening vase life. 8-HQS increased vase life, dry weight, wet weight, flower diameter, mean absorbed preservative solution, and quality score. 8-HQS also decreased the stem curvature in gerbera cut flowers. (Banaee *et al*, 2013). Sugars contribute to the osmotic potential of tissues and maintain the respiration rate and membrane integrity (Halevy and Mayak, 1979 and 1981). (Reddy and Singh, 1996) reported that increase in water uptake by sucrose pulsing treated tuberose spikes might be due to, translocated sugars accumulated in flowers increased the osmotic potential and improved the ability of spikes to absorb water. (De *et al.,* 1996) studied post-harvest life of pulsed gladiolus spikes as affected by different chemicals in cv. Highstyle and reported that sucrose 4% + 8 – HQC (250 ppm) was found most beneficial in improving vase life. In addition, Benzyladenine (BA) is effective in maintaining flower quality and longevity in carnations (Staden *et al.*,1990). Also (BA) delayed senescence by its effect on ethylene synthesis processes in the tissue of carnation flowers (Cook *et al.,* 1985), however, sliver thiosulphate (STS) having the effects of inhibiting ethylene production, reducing the rate of ethylene formation and delaying senescence have also been corroborated (Nowak and Rudnicki, 1990). Sodium nitroprusside (Nitric oxide) NO donor is effective in increasing the post-harvest life of rose, sunflower, lisianthus cut flowers. It regulates the internal ethylene activity (Nazirimoghaddam *et al.,* 2014). Citric acid is maintaining water balance and because of bactericide action it reduces the stem plugging (Meetern, 1979).

Cold storage of gerbera cut flowers after harvesting is essential. (Palanikumar *et al.,* 2000) recorded that dry packed flowers were stored at 4°C at 70 – 75% RH for 4 and 5 days storage enhanced post-harvest life and quality of cut roses. (Abd El- Sadek, 2005) observed that gypsophila cut flowers stored at 5°C for (0–5) days recorded significant increase in flowers longevity, floret opening percentage, improvement in water balance compared to storage at 5°C for 15 days treatment. (Hettiarachchi and Balas, 2004) stated that cold storage at 4°C for 7days has the potential to be used for delaying inflorescence senescence, prolonging vase life and post-harvest quality of *Gloriosa superb* (Glory lily) cut flowers.

Therefore, the main purpose of the current study was to evaluate the effectiveness of some pulsing, holding solution treatments, cold storage periods as simulate cool truck conditions transport in order to minimize transport costs as well as their combination treatments for prolonging longevity and keeping quality of *Gerbera jamesonii* L. cv. Rosamine cut flowers.

MATERIALS AND METHODS

The present work was carried out at the laboratory of Horticulture department, Faculty of Agriculture, Zagazig University in January and February during the two seasons of 2014 and 2015. The most important and popular cut flowers in world gerbera (*Gerbera jasmonaii* cv. Rosamine) belongs to family Asteraceae were chosen to be under our investigation.

The cut gerberas for the experiment were brought from Floramix Farm which is located at Kafrhakim, Imbaba, Giza Governorate, Egypt. The variety used in the investigation was pink colure flower with medium size and attractive appearance.

The desired flowers of uniform size 12 cm diameter, 60 cm flower stalk length with pink colure, free from pests and diseases were selected and harvested using sideward push near the base of the flower stem, by holding the clump. The flowers were harvested when the ray florets are completely elongated. Immediately after harvest the flowers were brought to the laboratory (light fluorescent about 500 lux, temperature 22-24°C and 60-70% relative humidity) for imposing the treatments.

This work was aimed to study the effects of three factors *viz*., pulsing solution, storage period, and holding solution as well as their combination treatments on *Gerbera jasmonaii* cut flowers post-harvest characters, water relations and some chemical constituents.

The gerbera cut flowers were subjected to the following treatments:

Pulsing Solutions

All flowers were divided to equal and similar sex groups and recuted to be (50 cm) which were pulsed in various chemical solutions before storage periods at 4±1°C at different periods (as simulate transport).

1. First group was pulsed in distilled water (D.W) for 18 hours (as a control treatment).
2. Second group was pulsed in sucrose (S) at 5% + 8-hydroxy quinolenesulphate (200 ppm 8-HQS) for 18 hours.
3. Third group was placed in benzyladenine (10 ppm BA) + 5% S + 200 ppm 8-HQS for 18 hours
4. Fourth group was pulsed in silver thiosulphate (1: 4 mM STS) for 20 minutes then 5% S + 200 ppm 8-HQS for 18 hours.
5. Fifth group was pulsed in silver thiosulphate (1: 4 mM STS) for 20 minutes then placed in 25 ppm BA + 5% S + 200 ppm 8-HQS for 18 hours.
6. Sixth group was pulsed in sodium nitroprusside (250 ppm SNP) for 1 hour then placed in 25 ppm BA + 5% S + 200 ppm 8-HQS for 18 hours.

Preparation of silver thiosulphate (STS) solution:

Silver thiosulphate (STS) was prepared as needed on the day of the experiment by combining calculated volumes of those solutions and distilled water STS was prepared according to (Gorin *et al.*, 1985) as follows:

1. Dissolving 0.079 g. ($AgNO_3$) in 500 ml distilled water [solution 1].
2. Dissolving 0.462 g. ($Na_2\ S_2O_3.\ 5H_2O$) in 500 ml distilled water [solution 2].
3. Solution 1 was poured into solution 2 with stirring. The final concentration of silver was 0.463 mM.

Storage periods as simulate transport

All groups mentioned above packing; every nine stems were warped by tissue paper and packed in carton boxes, then were moved to room storage at 4±1°C and relative humidity between 90-95% for several durations as follows:

1. 0-days gerbera cut flowers were hold till the end of the first experiment in holding solution and distilled water to study the effect of the pulsing treatments on the post-harvest characters, water relations, longevity and chemical constituents.
2. 5-days gerbera cut flowers were stored at 4±1°C for 5 days
3. 10- days gerbera cut flowers were stored at 4±1°C for 10 days in order to simulate transport.

At the end of storage period, gerbera cut flowers were hold till the end of experimental in the holding solutions and distilled water under laboratory condition.

Holding solutions (H.S):

After the end of storage period, cut flowers hold in glass containers with two different vase solutions as following:

1. D.W (control treatment).
2. H.S (25 g/l S + 200 mg/l 8-HQS + 150 mg / l citric acid).

Combination treatments between pulsing solutions, storage periods and holding solutions

Each treatment of pulsing solutions was combined with one of treatment of both storage periods and holding solutions to consist 36 combination treatments.

The treatments of the present work were arranged in factorial experiment in complete randomized block design with three replicates. Each replicate consisted of one Jar. Three cut flowers helded in the Jar (500 ml capacity) containing 250 ml solution.

Data Recorded

Post harvest characteristics

The longevity of cut flowers (days) was determined when the wilted flowers reach 75% from the total number of flowers.

Water relations

Water balance (g/flower) was calculated as the difference between water uptake and water loss after 3, 6 and 9 days from the treatment and at the end of longevity 12 days where:

1. Water uptake (absorbed solution) as g/ flower was determined after 3, 6, and 9 days from the treatment and at the end of the longevity 12days.
2. Water loss (g/flower) was calculated as the difference between the beginning fresh weight of cut flower pluse the beginning weight of the solution and fresh weight of cut flowers besides the weight of solution after 3, 6, and9 days from the treatments and at the end of longevity12 days.

Chemical constituents

Chemical constituents were determined when control treatment started to show wilting symptoms after 7 days of the beginning of experiment.

Total sugars

Total sugars were determined in the dried ray flowers samples, calorimetrically according to the method described by (Forsee, 1938).

Nitrogen and Protein percentages

Nitrogen (%) will be determined in dried sample of ray flowers calorimetrically according to that reported by (Chapman and Pratt, 1978) and were multiplied by 6.25 to calculate protein (%).

Anthocyanin content

Anthocyanin content (mg/100g) in ray flowers: a sample of air dried weighted ray flowers was determined cholorimertrically according to the method described by (Abou-Arab *et al.,* 2011).

Correlation coefficient

Simple correlation coefficients between some post-harvest characters and chemical constituents of gerbera cut flowers under the effects of combinations between pulsing solutions, storage periods and holding solutions were done according to (Guler *et al.,* 2001).

Statistical Analysis

All collected data were subjected to analysis of variance and means of treatments were compared with the least significant difference (LSD) test at $P \leq 0.05$. The statistical calculations were performed with statistix software version 9 (Analytical Software, 2008).

RESULTS AND DISCUSSION

Effect of Pulsing Solution Treatments

Data recorded in Table 1 illustrate that, all pulsing solution treatments recorded significant increase in vase life and water balance of gerbera cut flowers comparing to control in the two tested seasons. However, the treatment of silver thiosulphate (STS) at 1:4 mM for 20 minutes then placed in 5% S + 200 ppm 8-HQS for 18 hours (STS + S + 8-HQS) showed significant increase in vase life and water balance comparing to control and the all other treatments during the two seasons. These results are in accordance with those reported by (Kwon *et al.,* 2000) on freesia using STS + S + 8-HQS for vase life; (Chamani *et al.,* 2005) on rose cv. First Red reported that STS complex with application of sucrose gave promising results in prolonged vase life and enhanced flower vase quality; (Hayat *et al.,* 2012) on rose using combination between STS with sucrose regarding longevity as well as (Asrar, 2012) on snapdragon and (Elshereef, 2015) on carnation and solidago cut flowers using 8-HQS + sucrose regarding vase life and water balance, whereas, the increase in water balance due to STS treatment was also found by (El- Saka, 1992) on bird of paradise, (Gendy, 2000) on gladiolus cut flower spikes and (El-Bouhy, 2002) on tuberose cut flower spikes.

Such increase in gerbera cut flowers vase life caused by STS + S + 8-HQS treatment might be attributed to STS inhibition effect on ethylene production which leads to a decrease in lipoxygenase activity and served as an antibacterial component. Sucrose reduced the initial water uptake due to the decrease in osmotic potential of sucrose solution (Chamani *et al.,* 2005). Furthermore, 8-HQS salts delayed

Table 1. Effect of pulsing solutions on vase life (days) water balance (g/flower) and some chemical constituents of gerbera cut flowers during 2014 and 2015 seasons

Pulsing solution	Vase life (day)	Water balance (g/flower)				Chemical constituents			
		Shelf life period (day)				Anthocyanin (mg/100g)	Total Sugars	Nitrogen (%)	Protein (%)
		3	6	9	12				
				First season (2014)					
Control (DW)	15.05	-0.42	-0.87	-2.21	-5.31	2.12	6.77	1.93	12.05
S+8HQS	17.55	0.25	-0.12	-1.41	-3.01	2.00	5.37	2.12	13.28
BA+S+8HQS	17.61	0.09	-0.18	-2.09	-4.37	2.29	5.33	2.30	14.39
STS+S+8HQS	20.84	0.57	0.65	-0.36	-2.22	1.97	5.64	1.79	11.24
STS+BA+S+8HQS	19.67	0.05	0.01	-1.59	-3.69	1.96	8.64	2.03	12.69
SNP+BA+S+8HQS	16.77	-0.44	-0.81	-2.23	-4.78	2.32	3.89	1.88	11.76
LSD at 5%	0.26	0.22	0.26	0.51	0.63	0.15	0.14	0.11	0.69
				Second season (2015)					
Control (DW)	15.48	-0.51	-1.08	-2.66	-5.26	2.11	7.29	1.75	10.96
S+8HQS	16.65	0.18	-0.26	-1.83	-3.86	2.08	4.84	2.09	13.09
BA+S+8HQS	17.01	-0.07	-0.06	-1.24	-4.88	2.13	5.75	2.10	13.14
STS+S+8HQS	20.83	0.52	0.65	-0.39	-1.94	2.03	5.91	2.07	12.93
STS+BA+S+8HQS	19.52	0.07	0.08	-1.34	-2.87	2.11	7.95	1.69	10.57
SNP+BA+S+8HQS	17.09	-0.28	-0.53	-2.03	-5.15	2.13	4.27	1.72	10.74
LSD at 5%	0.17	0.13	0.2	0.28	0.45	0.10	0.12	0.10	0.63

DW distilled water, S sucrose, 8HQS 8-hydroxy quinolenesulphate, BA benzyladenine, STS silver thiosulphate, SNP sodium nitroprusside.

senescence and eliminated bacterial growth, which was the principal reason for reduction water uptake and transport of gerbera flower (Abdel Kader, 1987).

Data presented in Table 1 show that, in most cases, anthocyanin content in flowers (mg/ 100 g dry weight) and nitrogen as well as protein percentages in flowers of *Gerbera jamesonii* L. recorded significant increases as a result of exposing to pulsing solution treatment of STS + S + 8-HQS comparing to control treatment. However, pulsing cut flowers bases in STS + BA + S + 8-HQS recorded significant increase respecting total sugars percentage as compared to control and other treatments under study. (Yamane *et al.*,2005) on gladiolus using sucrose, (El-Bouhy, 2002) on tuberose using kinetin and (Abd El-Sadek, 2005) on gypsophila using STS regarding total soluble sugars percentage as well as (Almasi *et al.*, 2012) on *Dendrobium* using sucrose + 8-HQC regarding anthocyanin content, also had reported similar results.

Effect of Storage Periods Treatments

Data listed in Table 2 suggest that, in most cases, there are gradual decrease in post-harvest characters (vase life) and water balance of gerbera cut flowers with extending the cold storage period. Stored cut flowers for 10 days recorded significant decrease in vase life as compared to other different storage periods in the

Table 2. Effect of storage period on vase life (day), water balance (g/flower) and some chemical constituents of gerbera cut flowers during 2014 and 2015 seasons

Storage period (day)	Vase life (day)	Water balance (g/flower)				Chemical constituents			
		Shelf life period (day)				Anthocyanin (mg/100g)	Total Sugars	Nitrogen (%)	Protein (%)
		3	6	9	12				
					First season (2014)				
0 time	21.16	0.31	0.37	-0.06	-0.98	1.80	3.67	2.49	15.57
5 days	16.25	-0.09	-0.51	-2.50	-5.85	2.31	7.23	1.75	10.94
10 days	16.33	-0.17	-0.52	-2.38	-4.86	2.22	6.93	1.79	11.21
LSD at 5%	0.02	0.05	0.25	0.35	0.54	0.12	0.18	0.08	0.47
					Second season (2015)				
0 time	20.62	0.53	0.45	-0.09	-1.20	1.93	3.57	2.49	15.57
5 days	16.39	-0.29	-0.46	-1.97	-5.49	2.21	7.29	1.48	9.26
10 days	16.28	-0.29	-0.59	-2.69	-5.29	2.15	7.14	1.74	10.89
LSD at 5%	0.11	0.09	0.21	0.40	0.49	0.15	0.12	0.15	0.93

two seasons. While, cut flowers stored for zero and 5 days recorded an increase in vase life and water balance as compared to the long storage period of 10 days in both seasons.

These results are in line with those obtained by (Reid *et al.*, 2001) on tuberose cut flower spikes and (Abd El-Sadek, 2005) on gypsophila cut flowers. (Hettiarachchi and Balas, 2005) stated that cold storage at 4 °C maintained good flower quality during the vase of cut *Kniphofia uvaria* flowers. However, a sharp decrease in vase life was observed at 4 °C after 10 days of cold storage (Hettiarachchi and Balas, 2004) on *Gloriosa superba* L.

The obtained data in Table 2 demonstrate that, cut flowers stored for 5 days 4±1°C recorded an increase in anthocyanin content and total sugars as compared to the start (0-time) and the long storage period of 10 days in both seasons. Moreover, anthocyanin content and total sugars of gerbera cut flowers were significantly increased when stored to 5 or 10 days compared to control (0-time). Since, (Gul *et al.*, 2007) attributed this increase to enhanced influx of water and osmolytes into cells. While, there are a significant decrease in nitrogen and protein percentages in gerbera cut flowers with extending storage periods at 4±1°C for different days (5 and 10 days) compared to start point (0-time).

In addition, (Ahmad *et al.*, 2013) reported that, cold storage treatment before transfer to holding solutions improved iris species floral diameter, membrane integrity and maintained higher fresh and dry mass of flowers, sugar content, and soluble proteins.

Effect of Holding Solution Treatments

The data illustrated in Table 3 indicate that, holding solution contained 5% sucrose + 200 mg/l 8-HQS + 150 mg/l citric acid significantly increased the vase life and water balance of gerbera cut flowers in comparison with control (D.W treatment) in the two seasons. In the same time, water balance increased as they advanced in age to be the maximum after 6 days from the treatment then decreased after 9 days from the treatment till the end of shelf life period (12 days) to record its minimum with the two seasons. In addition, the treatment of holding

Table 3. Effect of holding solution on vase life (day), water balance (g/flower) and chemical constituents of gerbera cut flowers during 2014 and 2015 seasons

Holding solution	Vase life (day)	Water balance (g/flower)				Chemical constituents			
		Shelf life period (day)				Anthocyanin (mg/100g)	Total Sugars	Nitrogen (%)	Protein (%)
		3	6	9	12				
				First season (2014)					
Control (DW)	16.87	-0.57	-1.47	-3.42	-5.91	2.19	6.41	2.20	13.77
S+8HQS+CA	18.96	0.61	1.03	0.12	-1.88	2.03	5.47	1.82	11.38
LSD at 5%	0.10	0.12	0.19	0.22	0.39	0.06	0.09	0.07	0.44
				Second season (2015)					
Control (DW)	17.04	-0.73	-1.57	-3.45	-6.27	2.17	6.43	1.96	12.23
S+8HQS+CA	18.49	0.70	1.17	0.28	-1.72	2.02	5.57	1.85	11.58
LSD at 5%	0.12	0.07	0.13	0.15	0.21	0.06	0.08	0.07	0.44

DW distilled water, S sucrose, 8HQS 8-hydroxy quinolenesulphate, CA citric acid.

solution contained S + 8-HQS + CA significantly increased water balance (g /flower) compared to the control in the two seasons after 3, 6, and 9 days from the treatment and at the end of shelf life (after 12 days).

Generally, there were similar results mentioned by (El-Zohairy, 1999) on rose, and Khenizy (2000) on carnation by using S + 8-HQS + CA as well as (Cho *et al.*, 2001) on *Eustoma grandiflorum* (Raff.) Shinn by using sucrose. In addition, 8-hydroxy quinolene salts (8-HQS) treatment might be delayed senescence and increased vase life of gerbera cut flowers. Such effect could be attributed to that 8-HQ salts treatment prevented vascular blockage by reducing the number of bacteria in the stem, (Halevy and Mayak, 1981). Moreover, citric acid might be increased vase life by decreasing the pH of holding solution consequently the increase of water uptake as mentioned by Phavaphutanon and Ketsa (1989) on cut roses cv. Christian Dior. Also, Patel and Mankad (2016) on *Tithonia rotundifolia* reported that sucrose solution increase the capacity of water uptake while combination of citric acid at 100 ppm, was proved best to maintain water balance in flowers. It is also an osmotically active molecule leading to the promotion of subsequent water relation. So by application of these chemicals, blockage of vessels is prevented and ethylene levels retain resulting in prolonged fresh vase life.

Table 3 pointed out that the treatment of S + 8HQS+ CA as holding solution recorded significant decrease in anthocyanin content (mg/100g), total sugars, nitrogen (%) and protein (%) of gerbera cut flowers comparing to control (distilled water). Such results hold true in both seasons. These results are in similar with those stated by Gendy (2000) on gladiolus cut flower spikes.

Effect of Combination Treatments Among Pulsing Solutions, Storage Periods and Holding Solutions

It is evident from the results in Table 4 that, in mostly, under the combination treatments among pulsing, storage periods and holding solutions, there were gradual decrease in vase life as well as water balance (g / flower) of gerbera cut flowers with extending storage periods at 4±1°C for different days (0 time, 5 and 10 days). However, treatments of combination among storage periods at 4±1°C (0-time), pulsing solution of STS + S + 8-HQS and holding solution of S + 8-HQS + CA significantly increased the vase life and water balance of *Gerbera jamesonii* L. cut flowers compared to control in the two seasons. Pulsing

Table 4. Effect of the combination among storage periods, pulsing solutions and holding solutions on vase life (day) and water balance (g/ flower) of gerbera cut flowers during 2014 and 2015 seasons

Storage period	Pulsing solution	Holding solution	Vase life (day)		Water balance (g/ flower)							
					Shelf life period (day)							
					First season(2014)				Second season(2015)			
			1st	2nd	3	6	9	12	3	6	9	12
0-time (start)	**Control (DW)**	**DW**	15.40	17.72	-0.29	-1.83	-2.72	-3.65	0.07	-0.99	-1.97	-3.40
		HS	20.70	20.02	0.44	1.51	1.83	1.46	0.51	1.71	2.45	2.11
	S+8HQS	**DW**	19.95	18.53	0.03	-1.00	-1.99	-3.92	-0.06	-1.11	-2.06	-3.11
		HS	23.65	21.38	1.44	2.11	2.18	1.39	1.94	2.19	1.62	1.00
	BA+S+8HQS	**DW**	21.55	18.82	-0.97	-0.69	-2.36	-4.16	-0.17	-0.29	-2.17	-3.79
		HS	20.80	20.25	0.64	1.74	1.77	1.18	1.04	1.80	1.76	1.21
	STS+S+8HQS	**DW**	23.05	24.40	0.33	0.05	-0.63	-1.83	0.74	-0.12	-1.56	-2.86
		HS	28.30	27.14	1.74	2.79	3.215	2.95	1.32	2.57	3.39	3.18
	STS+BA+S+8HQS	**DW**	21.40	20.11	0.01	-1.13	-2.15	-3.05	0.07	-2.15	-3.36	-4.52
		HS	21.82	21.27	0.61	1.81	2.00	1.74	0.38	1.78	1.98	1.68
	SNP+S+BA+8HQS	**DW**	18.45	18.90	-0.10	-1.34	-2.63	-3.95	-0.46	-1.37	-2.59	-3.67
		HS	18.90	18.90	-0.17	0.44	0.73	0.07	0.93	1.37	1.48	-2.29
5-days	**Control (DW)**	**DW**	12.75	13.55	-1.50	-2.45	-5.21	-10.53	-2.00	-4.08	-6.25	-12.53
		HS	14.35	14.00	-0.44	-0.82	-1.84	-7.41	-0.33	-0.33	-1.48	-4.35
	S+8HQS	**DW**	14.25	14.50	-1.60	-2.82	-4.77	-5.68	-2.09	-3.05	-5.25	-7.16
		HS	16.80	15.23	1.31	1.66	0.24	-3.04	1.69	1.78	0.69	-3.24
	BA+S+8HQS	**DW**	14.35	16.57	-0.62	-2.12	-4.75	-8.29	-0.83	-1.49	-0.89	-8.56
		HS	16.80	15.67	0.75	0.69	-2.29	-4.74	0.69	0.95	-0.25	-2.52
	STS+S+8HQS	**DW**	17.90	17.85	-0.27	-0.88	-3.07	-5.42	-1.18	-0.50	-2.53	-4.86
		HS	18.95	18.85	1.66	2.22	1.18	-0.67	1.48	1.98	1.03	-0.53
	STS+BA+S+8HQS	**DW**	17.70	17.67	-1.95	-1.49	-3.44	-6.58	-1.50	-1.23	-3.38	-5.78
		HS	19.47	20.43	1.23	1.59	-0.27	-3.16	1.17	1.52	-0.14	-2.72
	SNP+S+BA+8HQS	**DW**	14.45	14.53	-1.95	-3.17	-5.66	-11.80	-1.82	-2.78	-5.43	-11.39
		HS	17.20	17.85	1.07	1.49	-0.11	-2.88	1.25	1.69	0.23	-2.26
10-days	**Control (DW)**	**DW**	12.73	13.57	-0.82	-2.26	-4.82	-8.28	-1.54	-3.41	-6.96	-8.98
		HS	14.35	14.00	0.11	0.63	-0.48	-3.47	0.20	0.64	-1.76	-4.42
	S+8HQS	**DW**	14.27	14.50	-0.45	-1.24	-3.73	-5.14	-0.81	-1.76	-4.75	-5.76
		HS	16.30	15.77	0.78	0.59	-0.39	-1.65	0.43	0.41	-1.26	-4.91
	BA+S+8HQS	**DW**	15.37	15.33	0.13	-0.81	-3.54	-6.93	-1.02	-1.26	-4.39	-10.42
		HS	16.80	15.40	0.59	0.09	-1.42	-3.29	-0.16	-0.08	-1.52	-5.16
	STS+S+8HQS	**DW**	17.90	17.87	0.07	-0.43	-2.21	-4.62	-0.02	-1.04	-2.38	-4.72
		HS	18.97	18.87	-0.13	0.18	-0.64	-3.73	0.77	0.98	-0.27	-1.86
	STS+BA+S+8HQS	**DW**	17.70	17.70	-0.59	-1.01	-3.81	-7.18	0.35	0.27	-1.91	-3.27
		HS	19.95	19.93	-0.25	0.31	-1.85	-3.90	-0.02	0.30	-1.24	-2.62
	SNP+S+BA+8HQS	**DW**	14.45	14.53	-1.03	-1.88	-4.0	-5.34	-0.95	-1.87	-4.17	-8.10
		HS	17.20	17.86	-0.45	-0.42	-1.67	-4.78	-0.66	-0.25	-1.68	-3.21
LSD at 5%			0.52	0.47	0.52	0.75	1.09	1.63	0.29	0.52	0.71	1.03

Pulsing solution: DW distilled water, S sucrose, 8HQS 8-hydroxy quinolenesulphate, BA benzyladenine, STS silver thiosulphate, SNP sodium nitroprusside. Holding solution (H.S) S sucrose, 8HQS 8-hydroxy quinolenesulphate, CA citric acid.

solution of STS + BA + S + 8-HQS was more effective in increasing vase life especially when flowers were stored at 4±1°C for 0-time after those flowers were held in holding solution containing S + 8-HQS + CA as compared to the other treatments.

Similar results were found by Anju *et al.* (1999) on chrysanthemum cut flowers, Abd El-Sadek (2005) on gypsophila cut flowers and Gendy (2007) on gladiolus cut flower spikes.

Such increase in gerbera cut flowers longevity due to the combination treatments among pulsing solutions, storage periods (0, 5 and 10 days at 4±1°C) and holding solution (S + 8-HQS + CA) might be attributed to that, each pulsing solution used alone or storage periods or holding treatments recorded a promotive effect in this connection as mentioned and attributed just before. Consequently, their combinations together might maximize their effects in this regard.

Data in Table 5 shows that, in most cases, the treatment of combination among SNP + BA + S + 8-HQS or STS + S + 8-HQS as pulsing solution, storage at 4±1°C for 5 days and holding solution of DW recorded significant increase in anthocyanin content as compared to the other treatments under study in the first and second seasons, respectively. Furthermore, anthocyanin content significantly increased with all combination treatments between pulsing solution, storage periods and holding solution compared with control DW of pulsing solution and 0 time of storage and DW of holding solution during both seasons, in most cases. These results coincided with those found by Gendy (2007) on gladiolus cut flower spikes. Furthermore, the treatment of combination among distilled water or BA + S + 8-HQS as pulsing solution, storage at 4±1°C for 5 or 10 days and holding solution of S+8-HQS+CA or distilled water significantly increased total sugars as compared to the other combination treatments and control in most cases. These results are in harmony with those reported by Abd El-Sadek (2005) on gypsophila cut flowers.

Generally, nitrogen and protein percentages of gerbera cut flowers were significantly increased by combination treatment among S + 8-HQS or STS + BA + S + 8-HQS as pulsing solution, storage at 4±1°C for 0-time and holding solution of distilled water compared to the other combination treatments and control, in the first and second seasons, respectively in most cases.

Effect of Combination among Pulsing Solution, Storage Periods and Holding Solution on Correlation Coefficients Between Gerbera Cut Flowers Characters

The results of simple correlation coefficients between some characters of post-harvest, water relation and some chemical constituents of gerbera cut flowers under the effects of the combination between pulsing solution, storage periods and holding solution treatments are presented in Table 6.

It is evident from the obtained data in Table 6 that gerbera cut flowers longevity exhibited positive and average relationship with each of water balance after 3, 6, 9, and 12 days of shelf life, which, indicated that the increase in water balance was accompanied by increasing vase life of gerbera cut flowers under the effect of combination treatment of pulsing solution, storage periods and holding solution. In contrast, there was weak and negative relationship with anthocyanin content, as well as weak and negative or positive relationships with nitrogen, protein and total sugars percentages in the first and second season, respectively.

Moreover, total sugars showed positive relationships with both water balance and vase life in most cases. Furthermore, nitrogen and protein percentages of gerbera cut flowers exhibited negative interrelationships with total sugars percentage. Finally, anthocyanin content in gerbera cut flowers negatively showed relationship with vase life and water balance in the two seasons. However, these results are in agreement with those stated by Gendy (2007) on gladiolus and Diab *et al.* (2015) on sweet pea.

Table 5. Effect of the combination among storage periods, pulsing solution and holding solutions anthocyanin (mg/100g), nitrogen, protein percentage and total sugars of gerbera cut flowers during 2014 and 2015 seasons

Storage period	Pulsing solution	Holding solution	Anthocyanin (mg/100g)		Total Sugars		Nitrogen (%)		Protein (%)	
			I	II	I	II	I	II	I	II
0-time (start)	**Control (DW)**	**DW**	1.34	2.12	7.07	6.94	2.41	2.41	15.07	15.07
		HS	1.90	1.81	4.23	2.57	2.44	2.44	15.30	15.30
	S+8HQS	**DW**	1.54	1.70	2.32	1.57	3.92	3.92	24.52	24.52
		HS	1.61	1.59	0.83	0.76	2.48	2.48	15.50	15.50
	BA+S+8HQS	**DW**	2.35	2.25	5.36	5.47	1.87	1.87	11.71	11.71
		HS	1.77	2.05	1.43	0.95	2.56	2.56	16.00	16.00
	STS+S+8HQS	**DW**	1.43	1.53	1.74	2.28	2.77	2.77	17.33	17.33
		HS	1.66	2.23	4.64	4.23	1.43	1.42	8.91	8.90
	STS+BA+S+8HQS	**DW**	1.69	1.40	6.26	5.31	3.15	3.15	19.68	19.68
		HS	1.72	2.36	3.76	3.56	2.26	2.26	14.13	14.13
	SNP+BA+S+8HQS	**DW**	2.34	2.32	2.77	2.87	2.36	2.36	14.73	14.73
		HS	2.25	1.77	3.56	6.28	2.23	2.23	13.91	13.91
5-days	**Control (DW)**	**DW**	2.50	2.28	2.82	2.89	2.26	0.83	14.13	5.22
		HS	2.22	2.08	17.57	20.68	1.46	1.61	9.11	10.04
	S+8HQS	**DW**	2.20	2.43	3.32	2.64	1.39	1.53	8.74	9.54
		HS	2.08	2.25	9.55	9.27	1.23	1.27	7.67	7.93
	BA+S+8HQS	**DW**	2.89	2.29	0.77	0.74	1.86	1.37	11.62	8.55
		HS	2.55	2.46	4.35	3.63	2.26	2.40	14.13	15.00
	STS+S+8HQS	**DW**	2.55	2.67	4.57	4.46	1.24	2.28	7.74	14.23
		HS	2.19	1.57	11.32	13.37	1.61	1.58	10.04	9.85
	STS+BA+S+8HQS	**DW**	2.37	2.42	4.34	3.75	2.49	0.86	15.55	5.36
		HS	1.56	1.83	13.25	11.66	1.29	1.27	8.09	7.92
	SNP+BA+S+8HQS	**DW**	2.63	2.37	6.58	6.14	2.35	1.17	14.69	7.32
		HS	2.02	1.85	8.31	8.25	1.56	1.62	9.73	10.16
10-days	**Control (DW)**	**DW**	2.49	2.21	6.59	8.13	1.78	1.83	11.15	11.43
		HS	2.27	2.14	2.33	2.49	1.21	1.39	7.55	8.67
	S+8HQS	**DW**	2.25	2.22	13.72	12.28	1.61	1.26	10.04	7.89
		HS	2.32	2.24	2.49	2.49	2.11	2.11	13.20	13.20
	BA+S+8HQS	**DW**	2.27	1.86	16.63	19.52	3.59	2.84	22.49	17.75
		HS	1.97	1.86	3.43	4.17	1.67	1.58	10.41	9.85
	STS+S+8HQS	**DW**	2.19	2.31	8.46	8.57	1.46	1.94	9.11	12.14
		HS	1.84	1.87	3.10	2.57	2.29	2.42	14.31	15.12
	STS+BA+S+8HQS	**DW**	2.21	2.42	20.59	20.61	1.72	1.35	10.78	8.43
		HS	2.19	2.24	3.60	2.79	1.27	1.27	7.96	7.93
	SNP+BA+S+8HQS	**DW**	2.33	2.22	1.52	1.51	1.39	1.49	8.71	9.29
		HS	2.35	2.23	0.64	0.56	1.41	1.44	8.80	9.00
LSD at 5%			0.31	0.28	0.38	0.32	0.28	0.29	1.77	1.89

Pulsing solution: DW distilled water, S sucrose, 8HQS 8-hydroxy quinolenesulphate, BA benzyladenine, STS silver thiosulphate, SNP sodium nitroprusside. Holding solution (H.S) S sucrose, 8HQS 8-hydroxy quinolenesulphate, CA citric acid.

Table 6. Simple correlation coefficients between some post-harvest characters, water relations and some chemical constituents of gerbera cut flowers under the effect of combination between storage periods, pulsing solution and holding solutions during 2014 and 2015 seasons

Characters	1	2	3	4	5	6	7	8
					First season(2014)			
Y. Vase life (day)	0.474**	0.609**	0.557**	0.520**	- 0.490**	- 0.125	- 0.125	- 0.001
Water balance (3days)		0.892**	0.806**	0.717**	- 0.449**	- 0.034	- 0.034	0.283
Water balance (6 days)			0.937**	0.783**	- 0.523**	- 0.172	- 0.172	0.124
Water balance (9 days)				0.837**	- 0.545**	- 0.222	- 0.222	- 0.029
Water balance (12 days)					- 0.510**	- 0.298*	- 0.297*	- 0.043
Anthocyanin content						0.123	0.123	-0.224
Nitrogen percentage							1.000**	0.373*
Protien percentage								0.373*
Total sugars								
					Second season(2015)			
Y. Vase life (day)	0.493**	0.574**	0.617**	0.658**	- 0.126	0.040	0.040	0.026
Water balance (3days)		0.919**	0.869**	0.786**	- 0.381*	0.132	0.132	0.239
Water balance (6 days)			0.940**	0.848**	- 0.335*	0.141	0.141	0.065
Water balance (9 days)				0.825**	- 0.272	0.078	0.078	- 0.042
Water balance (12 days)					-0.139	-0.005	-0.005	0.112
Anthocyanin content						-0.193	-0.193	-0.216
Nitrogen percentage							1.000**	-0.074
Protien percentage								-0.074
Total sugars								

The values were significant at least differences at 5% (0,296) and highly significant at 1% (0.409).

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تأثير معاملات محاليل الحفظ وفترات التخزين البارد على صفات ما بعد الحصاد لأزهار الجربيرا المقطوفة

أمل محمد مختار الغزولي - محمد أحمد إبراهيم عبد القادر – عبد الرحمن العريان عوض – جمال عطا بشر
قسم البساتين - كلية الزراعة - جامعة الزقازيق - مصر

تم إجراء هذا العمل في معامل قسم البساتين كلية الزراعة جامعة الزقازيق في مصر خلال شهرى يناير و فبراير من العامين ٢٠١٤ و ٢٠١٥ بهدف تحسين جودة الحفظ لأزهار الجربيرا المقطوفة صنف روزامين باستخدام معاملات محاليل الحفظ المؤقتة والمستديمة وفترات التخزين البارد ومعاملات التداخل بينهم، بالإضافة إلى دراسة تأثيرات هذه المعاملات على صفات ما بعد الحصاد والعلاقات المائية والمحتوي الكيميائي لأزهار الجربيرا المقطوفة، كانت معاملات محاليل الحفظ المؤقتة المستخدمة هي الماء المقطر، و٥ % سكروز + ٢٠٠ جزء في المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة، و٢٥ جزء في المليون بنزيل أدينين + ٥ % سكروز + ٢٠٠ جزء في المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة، وثيوسلفات الفضة بتركيز ٤:١ ملليمول لمدة ٢٠ دقيقة ثم وضعت في ٥ % سكروز + ٢٠٠ جزء في المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة، وثيوسلفات الفضة بتركيز ٤:١ ملليمول لمدة ٢٠ دقيقة + ٢٥ جزء في المليون بنزيل أدينين + ٥ % سكروز + ٢٠٠ جزء في المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة، والصوديوم نيترو بروسيد ٢٥٠ جزء في المليون لمدة ساعة واحدة + ٢٥ جزء في المليون بنزيل أدينين + ٥% سكروز + ٢٠٠ جزء في المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة، كذلك، معاملات فترات التخزين حيث تم تخزين أزهار الجربيرا المقطوفة على ٤± °م لمده صفر، ٥ ، ١٠ يوم، بينما، كانت معاملات محاليل الحفظ الدائم المستخدمة بعد معاملات التخزين هي ماء مقطر، ٢٥ جرام / لتر سكروز + ٢٠٠ مليجرام/ لتر سلفات هيدروكسى كينولين سلفات + ١٥٠ مليجرام / لتر حمض الستريك. وكانت البيانات المسجلة هى صفات ما بعد الحصاد (عمر الأزهار)، والعلاقات المائية (الاتزان المائي)، وبعض المحتويات الكيماوية (المحتوي من الأنثوسيانين)، وكذلك تم تقدير النسب المئوية لكل من السكريات الكلية والنيتروجين والبروتين الكلى) وكذلك تم دراسة معاملات الارتباط بين تلك الصفات وذلك تحت تأثير التداخل بين معاملات محاليل الحفظ المؤقتة، وفترات التخزين ومحاليل الحفظ الدائمة. يمكن التوصية من خلال النتائج المتحصل عليها بأنه يمكن الحصول على أعلى جودة وأطول عمر لأزهار الجربيرا المقطوفة صنف روزامين باستخدام معاملات التداخل بين محلول الحفظ المؤقت ثيوسلفات الفضة بتركيز ٤:١ ملليمول لمدة ٢٠ دقيقة ثم تنقل لمحلول يحتوى على ٥% سكروز + ٢٠٠ جزء فى المليون ٨-هيدروكسى كينولين سلفات لمدة ١٨ ساعة وفترات التخزين على درجة ٤±١ °م لمدة صفر - ٥ يوم ومحلول الحفظ الدائم المتكون من ٢.٥% سكروز + ٢٠٠ جزء في المليون من ٨-هيدروكسى كينولين سلفات + ١٥٠ مليجرام / لتر حمض الستريك) مقارنة بالمعاملات الأخرى تحت هذه الدراسة.

المحكمـــــون:
١- أ.د. صفاء مصطفى محمد مصطفى أستاذ الزينة – كلية الزراعة بمشتهر– جامعة بنها.
٢- د. أحمد شــــــاكر حسين الجنــدي أستاذ الزينة المساعد – كلية الزراعة – جامعة الزقازيق.