Research Journal of Agriculture and Biological Sciences, 8(2): 261-271, 2012
ISSN 1816-1561
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Effect of some Postharvest Treatments on Vase Life and Quality of Chrysanthemum (*Dendranthema Grandiflorum Kitam*) Cut Flowers.

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ABSTRACT

The present study was conducted at the laboratory of Horticulture Department, Faculty of Agriculture, Benha University during the two seasons of 2010-2011, 2011-2012. to evaluate the effects of five preservative solutions as pulsing applications, four cold storage periods and three holding solution treatments as well as their interactions on vase life and quality of chrysanthemum(*Dendranthema grandiflorum* Kitam.) cv. "White Zambla" cut flowers. Pulsing solution treatments were 1- Distilled water (dw) for 24 h as control, 2- silver thiosulphate (STS) at 0.4mM for 30minutes then 10ppm Benzyladenine (BA) for 24 hours. 3- STS at 0.4mM for 30minutes then 20ppm gibberellic acid (GA_3) for 24 hours 4- Aminooxy acetic acid (AOA) at 4mM + GA_3 at 20ppm for 24 hours. 5- STS at 0.4mM for 30minutes then pulsed in BA at 10ppm + GA_3at 20ppm + AOA at 4mM for 24 hours. Cut flowers were subjected to pulsing treatments just before cold storage. The four tested cold storage periods were without cold storage (control), storage for 7, 14 or 21-days at 2±1°C and 65-80% relative humidity .After subjecting flowers to pulsing and storage treatments, treated cut flowers were subjected to three holding solution treatments i.e., 1- Distilled water (dw) as control, 2- Sucrose (S) at 2% + citric acid (CA) at 100ppm + silver nitrate ($AgNO_3$) at 25 ppm and 3- Sucrose at 2% + 8-hydroxy-quinoline sulphate at 100ppm + citric acid at 100ppm to record the effects on vase life and quality of chrysanthemum cut flowers. All tested pulsing solutions significantly increased vase life, florets opening % and change percentage in fresh weight of cut flowers, decreased contamination in vase solution, improved water balance for cut flowers, and increased total sugars content in florets. Pulsing treatment of STS at 0.4mM for 30minutes then pulsed in BA at 10ppm + GA_3 at 20ppm + AOA at 4mM for 24 hours had the most favorable effect in this respect. Also, all tested holding solution treatments increased vase life, florets opening % and change percentage in fresh weight of cut flower spike, decreased contamination in vase solution, improved water balance for cut flower spikes, and increased total sugars content in florets, with superiority for the treatment of sucrose at 2% + 8-hydroxy-quinoline sulphate at 100ppm + citric acid at 100ppm. As the cold storage period was increased from zero-time to 21-days, the above mentioned characters of cut flower longevity and quality were decreased. When pulsing applications interacted with cold storage periods then subjected to holding solution treatments, the highest quality and the longest vase life of chrysanthemum cut flowers were obtained under the interaction treatments of pulsing in STS at 0.4mM for 30minutes then pulsed in BA at 10ppm + GA_3 at 20ppm + AOA at 4mM for 24 hours without cold storage or with storage for 7-days at 2±1°C and treated with holding solution containing sucrose at 2% + 8-hydroxy quinoline sulphate at 100ppm + citric acid at 100ppm as compared to control and the other interaction treatments in both seasons of this study.

Key words: pulsing solution, storage periods, holding solution, vase life, and quality of chrysanthemum cut flowers.

Introduction

Nowadays, cut flowers occupy an important position in the local and foreign markets because of their importance as a source of national income. Chrysanthemum (*Dendranthema grandiflorum* Kitam.) cv. "White Zambla" belongs to Family: Compositae (Asteraceae) is commonly know as Autumn Queen. It is highly attractive and charming short day plant, which behaves both as an annual as well as perennial flowering herb (Arora, 1990). Chrysanthemum is one of the most common cut flowers and of the highest economic importance in the floriculture industry for decoration and adornment .Cut flowers of chrysanthemum are widely used in two types namely, standard (one flower on the stem) and spray (multiple flowers on the stem such as cv. "White Zambla" .The vase life is differing among various species and cultivars of chrysanthemum, which is one of the most valuable characteristics determining its quality, satisfying consumer preferences and the commercial value .Short postharvest vase life is one of the most important problems of the cut flowers. However, longevity of vase life is an important factor for consumer preference (Kader, 2003). Senescence of cut flowers is induced by

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several factors, e.g., water stress (Sankat and Mujaffar, 1994), micro-organisms (Van Doorn and Witte, 1997) and ethylene effects (Han and Miller, 2003).

The preservative materials used as pulsing or holding solutions seemed to prolong flower longevity. In this study, some chemical preservatives treatments, i.e benzylademine (BA) + silverthiosulphate (STS), gibberellic acid (GA_3) + STS, GA_3 + aminooxyacetic acid (AOA) and (BA + STS + GA_3 + AOA) are using as pulsing solutions, sucrose (S) + citric acid (CA) + 8.hydroxy quinoline sulphate (8.HQS) and S + CA + silver nitrate ($AgNO_3$) as holding solutions were used for prolonging vase span. In this respect, benzyladenine (BA) delayed senescence by its effects on ethylene synthesis processes in the tissue of flowers and decreases the ethylene production within the carnation flowers (Bosse and Van Staden, 1989) and decreasing of protein hydrolytic enzymes activity lipooxygenase (Leshem *et. al*., 1979). Gibberellic acid prevented leaf chlorosis, which was the major postharvest disorder in many cut flowers such as Santonia cv. Golden light flowers (Eason *et. al.*, 2001). Aminooxy acetic acid (AOA) proved to be beneficial in prolonging vase life; inhibited or slow ethylene formation,(Nowak and Rudnicki, 1990) and delaying senescence,(Lawton *et al.,* 1989). Moreover, silver thiosulphate (STS) inhibited the action of ethylene and lending to a decrease in lipoxygenase (Lox) as well as served as an antibacterial component. Sucrose inhibited ethylene synthesis as well as promoting flower bud opening and inhibiting flower senescence of cut snapdragon flowers (Ichimura and Hisamatsu, 1999). Also, citric acid (CA) improved water balance and reduced stem plugging of bride of paradise cut flowers (Halevy *et al.,* 1978), in addition applying citric acid (CA) at (0, 100, 200ppm) increased vase life, petal water content (%), initial fresh weight (%), marketability and significantly of chrysanthemum cut flowers (Vahdati Mashhadian *et. al.,* 2012).Silver nitrate ($AgNO_3$) increased total soluble sugars content in petals and consequently increased vase life of rose cv. Raktagandha (Bhattacharjee and De, 1998). Furthermore, 8-HQS delayed senescence and eliminated bacterial growth which was the principal reason for reducing water uptake and transport of gerbera flower, (Abdel Kader, 1987).

Cold storage of cut flowers harvesting is essential in several species of cut flowers. The cut flowers should be exposed to low temperature during the different handling processes (immediately after cutting, during the grading, storage and transportation). Storage of cut flowers at the optimum temperatures, in addition to high percentages of relative humidity in the storage conditions, delays senescence and maintains the quality (Song *et al.*, 1992), Mohamed (2009) on tuberose and bird of paradise cut flower spikes, El-Bouhy (2010) on bird of paradise cut flower spikes and Gendy and Hamad (2011) on *Strelitzia reginae* cut flowers.

Therefore, the aim of this study was prolong the vase life of chrysanthemum cv. "White Zambla" and to keep their freshness for long periods by using pulsing solutions before cold storage and holding solutions as well as their interaction treatments to improve postharvest characters, water relations, averages of bacterial counts in vase solutions and some chemical constituents of chrysanthemum cut flowers.

Materials and Methods

The present study was conducted at the laboratory of Horticultural Department, Faculty of Agriculture, Benha University during the two seasons of (2010-2011, 2011-2012).

Chrysanthemum cv. "White Zambla" cut flowers were obtained from private Ornamental Farm at Namol, Kalubia Governorate. The cut flowers were harvested in the early morning, (at outer petals fully open but before disk flowers start to elongated). The flowers were warped in tissue paper (craft paper) in groups and transported to the laboratory quickly, under dry condition. After that, chrysanthemum cut flowers were recut (10cm) before pre-cooling were preformed by placing them in cold water for one hour to remove field heat. Uniform cut flowers (about 70-80cm long and 0.9cm diameter with 18-20 leaves) per spike were used.

The experiment started on the 1st November in the two successive seasons of (2010-2011, 2011-2012). The present work aimed to study the effects of three factors viz., pulsing solutions, storage period and holding solutions as well as their interaction treatments on vase life and quality of chrysanthemum cut flowers.

The present work treatments could be explained under the following factors:

1. Pulsing solutions: All flowers were divided to equal and similar five groups and were pulsing in various chemical solutions before cold storage periods at 2± 1°C at different periods.

1.1. First group was pulsed in distilled water (D.W) for 24 hours (control treatment).

1.2. Second group was pulsed in silver thiosulphate (STS) at 0.4mM for 30minutes then 10ppm benzyladenine (BA) for 24 hours.

1.3. Third group was pulsed in silver thiosulphate (STS) at 0.4mM for 30minutes then 20ppm gibberellic acid (GA_3) for 24 hours.

1.4. Fourth group was pulsed in aminooxy acetic acid (AOA) at 4mM + (GA_3) at 20ppm) for 24 hours.

1.5. Fifth group was pulsed in silver thiosulphate (STS) at 0.4mM for 30minutes then pulsed in [(BA) at 10ppm + (GA_3) at 20ppm + (AOA) at 4mM] for 24 hours.

Preparation of silver thiosulphate (STS) solutions: Silver nitrate ($AgNO_3$) (0.1M) stock solution and of sodium thiosulphate ($Na_2S_2O_5$, $5H_2O$) (0.1M) were stored in the dark as described by Reid *et al.,* (1980). Silver thiosulphate (STS) was prepared freshly by combining calculated volumes of these solution with distilled water.

STS was prepared according to Gorin *et al.,* (1985) as follows:

Dissolving of 0.079g ($AgNO_3$) in 500ml distilled water (solution 1). Dissolving of 0.462g ($Na_2S_2O_5$, $5H_2O$) in 500ml distilled water (solution 2). Solution 1 was poured into solution 2 with stirring. The end concentration of silver was 0.463mM.

The pH pulsing solutions were determined as shown in Table (A).

Table A: The pH of pulsing solutions treatments at initial and final treatments.

Composition of the solution	Initial pH	Final pH
1- Distilled water (D.W.) control	6.77	7.04
2- STS at 0.4mM then BA at 10ppm	4.20 then 4.43	4.20 then 4.65
3- STS at 0.4mM then GA_3 at 20ppm	4.20 then 4.50	4.20 then 4.70
4- GA_3 at 20ppm + AOA at 4mM	4.73	5.14
5- STS 0.4mM then (BA at 10ppm + GA_3 at 20ppm + AOA 4mM)	4.20 then 4.30	4.20 then 4.55

2- Storage period treatment:

Subjected chrysanthemum cut flowers to the above-mentioned pulsing treatments were divided into four groups to study the effect of different tested storage periods, then were packaged (nine flowers were warped by tissue paper) in polyethylene sleeves (30 micron thickness, (70 X 100 cm) and butter paper (50 micron thickness, 70 X 100 cm). After that, flower bags were packed in carton boxes (120 X 50 X 30 cm) and were stored at 2±1°C and relative humidity of 65 – 80 % to examined the following storage periods:

2.1- Zero –time: (without storage)chrysanthemum cut flowers were held till the end of the experiment in holding solutions under lab condition (fluorescent light about 1000 lux), temperature of 20°C ± 2 and relative humidity between 60-70%) (control). 2.2- 7-days: chrysanthemum cut flowers were stored at 2±1°C for 7 days. 2.3- 14-days: chrysanthemum cut flowers were stored at 2±1°C for 14 days.2.4- 21-days: chrysanthemum cut flowers were stored at 2±1°C for 21 days.

3- Holding solutions treatments:

After the end of storage periods, chrysanthemum cut flowers of each group were divided into three parts. Each part was held till the end of the experiment in holding solutions (500ml/glss container) under lab condition (fluorescent light about 1000 lux), temperature of 20°C ± 2 and relative humidity between 60-70%) as follows:

3.1- Control: placing chrysanthemum cut flowers bases in a distilled water (D.W.). 3.2- Sucrose (S) 2% + citric acid (CA) at 100ppm + silver nitrate ($AgNO_3$) at 25 ppm: placing chrysanthemum cut flowers bases at 2% (S) + 100ppm (CA) + 25ppm ($AgNO_3$). 3.3- Sucrose (S) at 2% + 8-hydroxy-quinoline sulphate (8-HQS) at 100ppm + citric acid (CA) at 100ppm: placing chrysanthemum cut flowers bases at 2% (S) + 100ppm (8-HQS) + 100ppm (CA).

The pH of holding solutions was determined as shown in Table (B)

Table B: The pH of holding solution treatments at initial and final treatments.

Composition of the solution	Initial pH	Final pH
1- Distilled water (D.W.) (Control)	6.77	7.04
2- 2% (S) + 100ppm (CA) + 25ppm ($AgNO_3$)	3.88	4.12
3- 2% (S) + 100ppm (8-HQS)+ 100ppm (CA)	3.51	3.77

Experiment layout:

The design of the experiment was a split-split plot design with 60 treatments (5 pulsing solution treatments x 4 storage periods x 3 holding solution treatments) replicated 3 times (each replicate consisted of 10glass containers with five flowers/glass containers). The pulsing solution treatments assigned to the main plots, where the storage periods treatments were employed to the sub plot, while the holding solution treatments were devoted to the sub-sub plots.

The following data were recorded:

1. Postharvest characters:

1.1. The longevity of chrysanthemum cut flower spikes (days) was determined when the wilted florets reach 75% from the number of total florets on the spike.

1.2. Floret opening percentage was calculated as a percentage of opened florets from all the florets on the cut spike at the end of longevity (36 days).

1.3. Change percentage in fresh weight of cut flower spike after 18 days from the treatment, (based on the beginning fresh weight of cut flowers).

2. Water relations:

Water uptake and water loss per chrysanthemum cut flowers were determined by weighting the jars with and without flower spikes and correcting for the evaporation. Water balance per chrysanthemum cut flowers was calculated (g /spike) as the difference between water uptake and water loss at 18 days vase life.

3. Averages of bacteria counts (Colonies/ml):

Bacterial contamination was determined in the keeping solution incubated for 48 h. The samples of the preservative solutions were taken (1 ml of each) and diluted using sterilized distilled water. One ml of each diluted solution was streaked on nutrient agar into Petri dishes. Cultures were incubated 2-3 days at 28°C and the colonies appearing on the plates were counted as described by Marousky (1968). This experiment was carried out after 20 days from the treatment at the laboratory of Microbiology Department, Faculty of Agriculture, Benha University.

4. Chemical constituents determinations:

Chemical constituents were determined after 15 days from the treatment (when control flowers were started to show wilting symptoms).

4.1. Total sugars percentage: total sugars percentage were determined in the fresh petals of florets samples calorimetrically according to the method described by Smith *et al.,* (1956).

Statistical analysis:

All data obtained during both seasons of study were subjected to analysis of variance as a factorial experiments in split-split plot design. L.S.D. method was used to compare between means according to Snedecor and Cochran (1980).

Results and Discussion

Effect of some postharvest treatments on quality of chrysanthemum (Dendranthema grandiflorum kitam) cut flowers.

1. Effect of pulsing solution treatments:

1.1. Postharvest characteristics and water relations:

Data in Table (1) show that all tested pulsing solution treatments scored highly significant increments in postharvest characters (vase life, floret opening percentage and change percentage in fresh weight of cut flowers) and water relations (water balance) of chrysanthemum cut flowers as compared with control in both season. However, the treatment of BA + STS + GA_3 + AOA statistically induced the highest values of vase life (days), floret opening percentage, change percentage in fresh weight of cut flowers and water balance, followed in descending order by the treatment of BA + STS in both seasons. On contrary, the lowest values of these parameters were recorded by control treatment in both seasons.

1.2. Bacterial counts (colonies/ml):

Data in Table (1) indicate that subjecting chrysanthemum cut flowers to all studied pulsing solution treatments resulted progressively decreases in bacterial counts epresent as (colonies/ml vase solution), especially the treatment of BA + STS + GA_3 + AOA which scored the lowest number of colonies/ml vase solution as compared with the other studied treatments in both seasons. Also, the treatment of BA + STS gave high reduction in the number of colonies/ml vase solution in both seasons.

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1.3. Chemical determination:

Total sugars percentage in the florets of chrysanthemum cut flowers registered high significant increment as a result of exposing to all tested pulsing solution treatments when compared with control (Table, 1). In general, pulsing cut flowers base in the treatment of BA + STS + GA_3 + AOA showed to be the most effective treatment for inducing the highest value in this parameter, followed by the treatment of BA + STS in both seasons. These results were coincided with those obtained by Zagory and Reid (1986) on many cut flowers , El-Saka (1992) on bird of paradise, Van Doorn (1997) on cut rose flowers, Anju *et al*., (1999) on chrysanthemum , Kwon *et al*., (2000) on freesia, Gendy (2000) on gladiolus cut flower spikes, El-Bouhy (2002) on tuberose cut flower spikes ,Mohamed (2009) on tuberose and bird of paradise cut flower spikes, El-Bouhy(2010) on bird of paradise cut flower spikes and Gendy and Hamad (2011) on *Strelitzia reginae* cut flowers.

Table 1: Effect of pulsing solutions treatments on vase life (days), floret opening percentage , change percentage in fresh weight of cut flowers, water balance (g)/flower , bacterial counts (colonies/ ml) and total sugars percentage of *Dendranthema grandiflorum* kitam. cut flowers during the two seasons of 2010-2011/2011-2012.

Treatments		Vase life (days)	Floret opening percentage	Change percentage in fresh weight of cut flower	Water balance (g)/flower	Bacterial count (colonies/ ml)	Total sugars percentage
Pulsing solutions		1st season					
Control (D.W.)		26.75	84.13	1.95	3.80	260.22	2.73
STS + BA		30.04	89.33	11.03	7.57	164.69	3.34
STS + GA_3		28.61	86.47	5.21	2.94	206.69	3.03
GA_3 +AOA		29.73	87.81	7.51	4.06	187.39	3.21
STS + BA + GA_3 +AOA		31.25	90.50	12.91	10.63	159.61	3.48
L.S.D at	5%	0.554	0.195	0.398	0.686	0.904	0.005
	1%	0.719	0.257	0.526	0.908	1.195	0.006
2nd season							
Control (D.W.)		25.59	81.20	1.89	4.41	272.06	2.77
STS + BA		30.32	87.07	9.60	9.11	174.39	3.40
STS + GA_3		28.95	84.44	4.97	5.56	214.33	3.10
GA_3 +AOA		29.57	85.36	8.35	7.00	196.50	3.17
STS + BA + GA_3 +AOA		31.98	88.29	11.47	12.68	169.50	3.50
L.S.D at	5%	0.401	0.173	0.446	0.585	0.793	0.005
	1%	0.531	0.228	0.590	0.773	1.049	0.006

Distilled water (DW) - Silver thiosulphate (STS) - Benzyl adenine (BA) - Gibberellic acid (GA_3)- Aminooxy acetic acid (AOA)

The above-mentioned results of chrysanthemum cut flowers caused by the tested pulsing solution treatments might be attributed to that benzyladenine (BA) delayed senescence by its effect on ethylene synthesis processes in the tissues of flowers (Cook *et al.,*1985). Also, STS had inhibited effect on ethylene production which leads to a decrease in lipoxygenase activity and served as an antibacterial component. In addition, gibberellin (GA_3) prevented leaf chlorosis , which was the major postharvest disorder in many cut flowers such as Santonia cv. Golden light flowers (Eason *et al.,* 2001). Gibberellin is very important in the controlling of petal growth, (Jeffcoat and Harris, 1972) and the growth and development of flower, (Goszczynska and Reid, 1985). Furthermore, aminooxy acetic acid (AOA) proved to be beneficial in prolonging vase life; inhibited or slow ethylene formation and delaying senescence (Nowak and Rudnicki, 1990).

2. Effect of cold storage period treatments:

2.1. Postharvest characteristics and water relations:

Data in Table (2) reveal that there are gradual decrease in postharvest parameters (vase life, floret opening percentage and change percentage in fresh weight of cutflowers) and water balance of chrysanthemum cut flowers with prolonging the cold storage period. So, stored cut flowers for 21 days scored the lowest values of these parameters in most cases as compared with other different storage periods in both seasons. While, cut flowers stored for zero or seven days scored highly significant increments in vase life (days), floret opening percentage, change percentage in fresh weight of cut flowers and water balance as compared to the long storage period of 21- days in both seasons.

2.2. Bacterial counts (colonies/ml):

The number of bacterial colonies/ml vase solution was progressively increased as the cold storage period was increased from zero up to 21 days (Table, 2). However, stored cut flowers for 21 days scored the highest number of bacterial colonies/ml vase solution as compared with storage periods for zero or 7 days in both

seasons. The remained storage period (14 days) occupied an intermediate position between the above-mentioned treatments in both seasons.

However, increase of bacterial count in vase solution because increasing cold storage period may be due to the harmful effects of cold conditions. Since, cold temperatures may cause damages to cell walls of cut flowers, which facilitate microorganisms' growth (Wouter *et al.*, 1991)**.**

Table 2: Effect of storage periods (days) treatments on vase life (days) , floret opening percentage , change percentage in fresh weight of cut flowers, water balance (g)/flower , bacterial counts (colonies/ ml) and total sugars percentage of *Dendranthema grandiflorum* kitam. cut flowers during the two seasons of 2010-2011/2011-2012.

Treatments		Vase life (days)	Floret opening percentage	Change percentage in fresh weight of cut flowers	Water balance (g)/flower	Bacterial count (colonies/ ml)	Total sugars percentage
Storage periods (days)		1st season					
0		32.74	96.92	12.93	11.14	52.44	3.70
7		31.58	97.36	13.35	9.85	102.96	3.47
14		28.6	88.00	6.00	4.35	248.58	2.89
21		24.62	81.97	-1.41	-2.13	378.91	2.59
L.S.D at	5%	0.487	0.174	0.356	0.614	0.809	0.004
	1%	0.644	0.230	0.470	0.812	0.1.07	0.005
2nd season							
0		33.02	94.88	12.93	15.77	56.66	3.61
7		32.57	94.59	15.58	14.74	110.76	3.47
14		28.49	86.82	3.78	4.58	259.13	3.02
21		23.03	78.90	-2.72	-4.08	394.87	2.65
L.S.D at	5%	0.359	0.155	0.399	0.523	0.710	0.004
	1%	0.475	0.204	0.528	0.691	0.938	0.005

2.3. Chemical determination:

It was interested to note from data in Table (2) that there was a negative relationship between total sugar percentage in the florets of chrysanthemum cut flowers and storage periods. Hence, as the storage period increased, the values of total sugar percentage decreased to reach for the maximum decreasing at the highest storage period (21 days). This trend was true in both seasons. These results are in harmony with those obtained by Song *et al.*, (1992) on gladiolus cut flower spikes, Reid *et al.*, (2001) on tuberose cut flower spikes, Vinod *et al.*, (2003) on tuberose cut flower spikes , Abd El-Sadek (2005) on gypsophila cut flowers, Hettiarachchi and Balas (2005) *Kniphofia uvaria* flowers, Mohamed (2009) on tuberose and bird of paradise cut flower spikes and El- Bouhy (2010) on *Strelitzia reginae* cut flowers.

3. Effect of holding solution treatments:

3.1. Postharvest characteristics and water relations:

Data presented in Table (3) declare that all tested holding solution succeeded in increasing the values of vase life (days), floret opening percentage, change percentage in fresh weight of cut flowers and water balance, with superiority for the treatment of S + CA + 8-HQS as compared with the treatments of S + CA + $AgNO_3$ and control in both seasons.

3.2. Bacterial counts (colonies/ml):

Data in Table (3) clear that the number of bacterial colonies/ml vase solution was greatly increased by using all studied holding solution treatment, particularly the treatment of S + CA + 8-HQS as compared with control in both seasons.

3.3. Chemical determination:

Data presented in Table (3) demonstrates that the treatment of S + CA + 8-HQS showed to be the most effective one for inducing the highest florets total sugar contents as compared with control in both seasons.

These results are in agreement with those obtained by El- Saka (1992) on bird of paradise, Anju *et al*., (1999) on chrysanthemum, Kwon *et al.*, (2000) on freesia, Gendy (2000) on gladiolus cut flower spikes, El-Bouhy (2002) on tuberose cut flower spikes, Hettiarachchi and Balas (2005) on *Kniphofia uvaria* flowers, Mohamed (2009) on tuberose and bird of paradise cut flower spikes ,El- Bouhy (2010) on *Strelitzia reginae* cut

flowers, Gendy and Hamad (2011) on *Strelitzia reginae* cut flowers and Vahdati Mashhadian *et. al.*, (2012) on chrysanthemum cut flowers.

The previous results of the tested holding solution treatments might be due to the effect of sucrose that inhibited ethylene synthesis as well as promoting flower bud opening and inhibiting flower senescence of cut flowers (Ichimura and Hisamatsu, 1999). Moreover, sucrose was the main source of nutrition and the energy necessary for maintaining all biochemical and physiological processes after flower separation from mother plant (Nowak and Rudincki 1990).

Table 3: Effect of holding solution treatments on vase life (days), floret opening percentage, change percentage in fresh weight of cut flowers, water balance (g)/flower, bacterial counts (colonies/ ml) and total sugars percentage of *Dendranthema grandiflorum* kitam. cut flowersduring the two seasons of 2010-2011/2011-2012.

Treatments		Vase life (days)	Floret opening percentage	Change percentage in fresh weight of cut flowers	Water balance (g)/flower	Bacterial count (colonies/ ml)	Total sugars percentage
Holding solution		1st season					
Control (D.W.)		22.11	76.06	-9.39	-2.18	320.22	1.99
S+CA+$AgNo_3$		32.34	93.05	15.77	9.29	136.38	3.49
S+CA+ 8-HQS		33.38	93.83	16.79	10.30	130.57	4.00
L.S.D at	5%	0.422	0.151	0.308	0.532	0.700	0.004
	1%	0.557	0.199	0.407	0.703	0.926	0.005
2nd season							
Control (D.W.)		21.87	73.73	-7.77	-0.97	332.17	2.00
S+CA+$AgNo_3$		32.64	90.66	14.56	11.56	144.20	3.55
S+CA+ 8-HQS		33.33	91.43	14.98	12.65	139.70	4.02
L.S.D at	5%	0.311	0.134	0.346	0.453	0.615	0.004
	1%	0.411	0.177	0.457	0.599	0.813	0.005

Distilled water (DW) - Sucrose (S) -Citric acid (CA) - Silver nitrate (AgNO3) - 8-hydroxy quinolene sulphate (8-HQS)

Moreover, citric acid (CA) as it widely used to decrease the PH of water, improved water balance and reduced stem plugging of cut flowers (Halevy *et al.*, 1978). Also, silver nitrate (AgNO3) increased total soluble sugars content in petals and consequently increased the vase life of cut flowers (Bhattacharjee and De, 1998). Additionally, 8-hydroxy quinolene sulphate (8-HQS) delayed senescence and eliminated bacterial growth which was the principal reason for reducing water uptake and transport of gerbera flower (Abdel Kader, 1987).

Table 4: Effect of the interaction between pulsing solutions , storage periods (days) and holding solutions treatments on vase life (days) and floret opening percentage of *Dendranthema grandiflorum kitam.* cut flowers during the two seasons of 2010-2011 / 2011-2012.

Treatments		Vase life (days)			Floret opening percentage			Vase life (days)			Floret opening percentage		
		1st season						2nd season					
		Holding Solutions											
Storage periods (days)	Pulsing solutions	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS
0	Control (D.W.)	23.50	33.73	34.30	85.68	99.81	100	23.20	31.80	32.60	83.33	95.93	96.67
	STS + BA	26.80	36.70	37.30	91.18	100	100	26.90	37.30	38.10	89.26	98.33	98.89
	STS + GA_3	25.50	35.30	35.90	89.81	100	100	25.60	35.70	36.50	87.41	98.15	97.96
	GA_3 +AOA	26.10	35.11	35.30	91.18	100	100	26.10	36.11	37.20	89.45	97.59	98.89
	STS + BA + GA_3 +AOA	27.90	38.20	39.17	93.14	100	100	27.50	40.30	40.60	92.22	99.63	99.45
7	Control (D.W.)	23.30	30.10	33.80	88.24	99.22	100	23.60	29.60	30.10	83.33	95.01	97.04
	STS + BA	25.60	35.30	35.90	93.53	100	100	26.30	37.10	38.70	89.45	97.96	99.82
	STS + GA_3	23.90	34.73	35.11	89.81	100	100	25.10	35.40	36.70	86.67	98.33	97.96
	GA_3 +AOA	25.40	34.50	35.30	93.33	100	99.81	25.60	35.90	36.70	87.96	96.29	97.04
	STS + BA + GA_3 +AOA	26.90	36.10	37.90	94.51	100	100	27.10	40.60	40.30	91.29	100	100
14	Control (D.W.)	17.30	28.80	29.30	72.35	91.17	93.14	17.10	28.30	29.10	69.82	89.26	91.48
	STS + BA	21.50	33.50	34.10	77.06	94.51	94.51	21.20	33.10	33.80	75.56	94.07	94.63
	STS + GA_3	20.50	29.60	32.20	74.51	93.14	94.12	20.40	31.80	33.10	72.22	91.67	93.15
	GA_3 +AOA	21.30	29.90	32.60	75.49	94.12	94.71	21.20	33.30	33.80	74.26	94.63	94.26
	STS + BA + GA_3 +AOA	22.40	34.40	35.10	78.24	95.88	97.06	21.90	34.50	34.90	77.04	94.63	95.56
21	Control (D.W.)	17.73	23.90	25.30	64.91	82.75	85.69	14.40	23.50	23.90	62.78	80.37	81.29
	STS + BA	17.11	28.10	28.80	70.98	88.82	90.19	16.10	27.30	28.10	68.33	86.11	86.85
	STS + GA_3	15.80	27.10	27.80	67.84	87.26	88.24	15.10	26.11	26.20	67.22	83.52	83.89
	GA_3 +AOA	16.30	32.50	32.40	69.61	87.84	88.84	15.80	26.50	26.80	67.59	83.89	84.07
	STS + BA + GA_3 +AOA	17.40	29.30	29.90	71.56	92.35	92.75	17.50	29.12	29.50	69.63	88.89	89.07
L.S.D at	5 %	**1.886**			**0.675**			**1.390**			**0.599**		
	1 %	**2.493**			**0.892**			**1.838**			**0.791**		

4. Effect of interaction treatments between pulsing solution, storage period and holding solution:

4.1. Postharvest characteristics and water relations:

Data in Tables (4 & 5) indicate that all resulted combinations between pulsing solution, storage periods and holding solutions treatments succeeded in increasing the values of vase life (days), floret opening percentage, change percentage in fresh weight of cut flowers and water balance (g)/ flower as compared with control in both seasons. However, the best results of these parameters were obtained by using all combinations of BA + STS + GA_3 + AOA treatment, especially those interacted with S + CA + 8-HQS under cold storage for zero or seven days as compared with the other combined treatments in both seasons. On the reverse, the lowest values of these parameters were recorded by the combinations of control, especially those stored under cold storage for 21 days in both seasons. The rest treatments came in-between the above-mentioned treatments in both seasons.

4.2. Bacterial counts (colonies/ml):

Data in Table (6) reveal that all tested pulsing solutions interacted with zero or seven days cold storage periods, especially those treated with the holding solution containing S + CA + 8-HQS resulted in high significant reduction in the number of bacterial colonies/ml vase solution as compared to the other combinations in both seasons. Gradual increases in the number of bacterial colonies in vase solution were noticed with extending storage period from zero-time to 21 days.

Table 5: Effect of the interaction between pulsing solutions, storage periods (days) and holding solutions treatments on change percentage in fresh weight of cut flowers and water balance (g)/flower of *Dendranthema grandiflorum* kitam.cut flowers during the two seasons of 2010-2011 / 2011-2012.

Treatments		Change percentage in fresh weight of cut flowers			Water balance (g)/flower			Change percentage in fresh weight of cut flowers			Water balance (g)/flower		
		1st season						2nd season					
		Holding Solutions											
Storage periods (days)	Pulsing solutions	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS
0	Control (D.W.)	-7.82	15.32	16.14	-1.52	17.66	13.47	-7.54	14.94	14.83	4.86	15.42	15.84
	STS + BA	-4.15	25.21	25.92	2.04	19.74	19.64	-3.65	24.28	24.07	4.18	21.98	24.26
	STS + GA_3	-6.86	20.57	20.98	1.24	13.10	12.48	-6.31	19.34	20.24	5.90	18.16	20.50
	GA_3 +AOA	-6.18	21.75	22.86	-1.45	13.68	16.20	-4.49	20.57	21.35	2.24	20.04	19.65
	STS + BA + GA_3 +AOA	-2.32	25.92	26.67	2.36	17.40	22.32	-1.33	24.99	24.56	3.28	29.05	31.04
7	Control (D.W.)	-10.07	16.3	17.67	-2.98	13.32	10.94	-5.19	16.32	16.98	5.20	13.54	16.70
	STS + BA	-6.91	26.77	26.79	2.67	15.80	17.84	-0.91	23.97	24.99	3.16	19.74	22.37
	STS + GA_3	-5.31	20.8	22.02	1.20	8.96	9.02	-2.94	21.43	21.23	5.76	12.12	17.10
	GA_3 +AOA	-6.67	22.61	23.46	0.84	12.25	12.83	-3.76	21.82	22.51	5.12	18.30	20.22
	STS + BA + GA_3 +AOA	-1.36	26.62	27.56	5.82	18.78	20.44	0.51	25.83	26.57	6.34	27.32	27.84
14	Control (D.W.)	-14.62	6.39	9.37	-4.60	5.64	8.00	-14.42	5.78	6.14	-4.76	4.87	3.62
	STS + BA	-9.29	18.17	20.43	-3.44	8.10	9.70	-9.88	13.61	14.88	-4.52	10.68	12.50
	STS + GA_3	-12.01	10.08	11.77	-3.90	3.62	6.40	-13.09	8.31	9.33	-5.89	6.94	6.81
	GA_3 +AOA	-10.06	11.77	13.22	-3.58	6.61	7.56	-11.04	10.29	10.11	-1.70	7.64	8.70
	STS + BA + GA_3 +AOA	-7.28	20.43	21.75	-1.70	13.02	13.91	-7.74	16.88	17.57	-3.27	13.28	13.62
21	Control (D.W.)	-19.83	-3.29	-2.17	-9.82	-2.16	-2.33	-20.01	-3.08	-2.08	-10.64	-4.82	-6.82
	STS + BA	-11.61	10.01	11.02	-8.09	2.26	4.47	-16.84	9.99	10.75	-6.94	0.27	1.66
	STS + GA_3	-17.98	0.23	-1.84	-6.76	-4.93	-3.94	-18.28	0.57	-0.15	-10.80	-6.14	-4.10
	GA_3 +AOA	-17.47	6.47	8.41	-7.72	-4.98	-2.73	-17.64	2.71	3.48	-10.70	-1.89	-3.61
	STS + BA + GA_3 +AOA	-9.96	13.19	13.71	-3.04	8.58	9.76	-15.07	12.59	12.25	-6.60	4.85	5.06
L.S.D at	5 %	**1.378**			**2.379**			**1.546**			**2.025**		
	1 %	**1.821**			**3.145**			**2.044**			**2.678**		

4.3. Chemical determinations:

Data in Table (6) show that total sugars (%) was greatly increased by using all resulted combinations between pulsing solution, storage period and holding solution treatments in both seasons. However, the highest value of this parameter was gained in florets of cut flowers pulsed in BA + STS + GA_3 + AOA then stored under cold storage for zero or seven days and hold in solution containing S + CA + 8-HQS in both seasons. These results are in agreement with those of Kushal *et al.,* (2000) and Waithaka *et al.,* (2001) on tuberose cut flower spikes as well as Kushal *et al.,* (2002) on gladiolus cut flower spikes, Abd El Sadek (2005) on gypsophila cut flowers, Belynskaya and Kondrat (1990), on tulip cut flower, Reid *et al.,* (2001) on cut tuberose spikes, Mohamed (2009) on tuberose and bird of paradise cut flowers, El- Bouhy (2010) on bird of paradise cut flowers and Gendy and Hamad (2011) reported that subjecting bird of paradise cut flower spikes to pulsing treatment in silver thiosulphate solution at 1: 4 mM for 30 minutes, then in solution containing 20% sucrose + 200 ppm 8-hydroxy quinolene sulphate for 12 hours before cold storage for five days at cold storage at 6±1°C and 80 – 90 % relative humidity (as handling period). Since, this treatment decreased contamination of vase solution and improved water relations of flower spikes, so increased vase life and florets opening percentage, as well as, maintained anthocyanin content in petals.

Table 6: Effect of the interaction between pulsing solutions , storage periods (days) and holding solutions treatments on bacterial counts (colonies/ml) and total sugars percentage of *Dendranthema grandiflorum* kitam. cut flowers during the two seasons of 2010-2011 / 2011-2012.

Treatments		Bacterial count (colonies/ ml)			Total sugars percentage			Bacterial count (colonies/ ml)			Total sugars percentage		
		1st season						2nd season					
		Holding Solutions											
Storage periods (days)	Pulsing solutions	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS	Control (D.W.)	S+CA+ AgNo3	S+ CA+ 8-HQS
0	Control (D.W.)	190.67	56.67	52.33	2.18	3.61	3.91	197.67	59.66	56.33	1.94	3.66	3.81
	STS + BA	48.12	19.33	16.67	2.81	4.19	4.65	54.10	28.33	25.33	2.71	3.91	4.72
	STS + GA_3	94.67	39.67	37.10	2.31	3.96	4.49	86.12	44.33	41.66	3.21	3.75	4.22
	GA_3 +AOA	72.33	39.66	34.67	2.71	4.13	4.46	80.13	43.66	37.10	2.51	3.69	4.21
	STS + BA + GA_3 +AOA	47.33	20.33	17.33	2.91	4.33	4.91	51.66	22.33	22.10	2.71	4.15	4.89
7	Control (D.W.)	370.66	79.10	75.33	1.91	3.54	3.65	394.67	83.67	82.33	1.72	3.62	3.71
	STS + BA	123.33	43.10	39.66	2.38	3.93	4.72	133.33	50.1	46.33	2.62	4.15	4.61
	STS + GA_3	212.67	63.33	59.66	2.11	3.85	3.91	222.67	68.33	64.66	1.91	3.79	3.88
	GA_3 +AOA	161.33	62.32	54.67	2.33	3.82	4.61	168.65	66.66	61.33	2.12	3.89	4.51
	STS + BA + GA_3 +AOA	124.10	40.11	35.33	2.39	4.18	4.72	131.33	44.64	42.65	2.51	4.25	4.81
14	Control (D.W.)	533.00	201.31	193.34	1.31	2.91	3.16	542.67	208.12	204.10	1.42	3.16	3.33
	STS + BA	383.33	139.32	133.10	1.81	3.43	4.11	394.33	146.13	142.10	1.91	3.55	4.21
	STS + GA_3	437.67	174.12	170.10	1.51	2.97	3.57	451.33	186.67	182.65	1.67	3.34	3.62
	GA_3 +AOA	412.67	155.00	150.66	1.71	3.24	3.89	425.33	170.67	163.10	1.89	3.45	3.91
	STS + BA + GA_3 +AOA	381.13	138.11	126.33	1.91	3.55	4.21	390.66	143.34	136.33	1.95	3.64	4.31
21	Control (D.W.)	677.31	351.34	341.64	1.12	2.61	2.87	723.11	360.66	352.10	1.22	2.72	2.92
	STS + BA	512.66	263.32	254.66	1.62	2.93	3.61	531.12	273.33	268.67	1.56	3.18	3.71
	STS + GA_3	583.00	307.66	301.12	1.41	2.82	3.43	598.66	317.66	307.33	1.35	2.91	3.54
	GA_3 +AOA	541.66	288.66	275.11	1.55	2.75	3.39	553.10	296.65	292.10	1.41	2.89	3.62
	STS + BA + GA_3 +AOA	497.10	245.66	243.13	1.72	3.15	3.81	513.33	269.30	266.34	1.66	3.22	3.91
L.S.D at	5 %	**3.132**			**0.016**			**2.748**			**0.016**		
	1 %	**4.141**			**0.021**			**3.633**			**0.021**		

Conclusively, it could be recommended that subjecting chrysanthemum cut flowers to pulsing treatment (BA + STS + GA_3 + AOA) before cold storage for period not exceed seven days at 2±1°C and 65-80% relative humidity, then hold in solution containing (S + CA + 8-HQS) to reduce the contamination of vase solution and improved water balance of flowers, so increased vase life and florets opening percentage.

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