

## EVALUATION OF SEVERAL AG<sup>+</sup> SOURCES AND SOME ESSENTIAL OILS FOR PROLONGING VASE LIFE OF GERBERA CUT FLOWERS CV. "JULIA"

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### **Abstract**

This study was conducted at Sahl El-Husseinieh Research Station, Agricultural Research Center, Egypt at 2016 and 2017 seasons. This study conducted to evaluate the effect of different Ag<sup>+</sup> sources i.e silver nanoparticles, silver nitrate and silver thiosulphate and some essential oils i.e. thyme, rosemary and lavender on postharvest quality of the cut *Gerbera jamesonii* cv. "Julia" flowers. The holding solutions containing thyme or rosemary or lavender + sucrose as antimicrobial agents were more effective than 8-HQS + sucrose. The maximum solution uptake and vase-life were recorded by holding solution of SNP at 9 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose compared to essential oils or 8-HQS + sucrose solutions. SNP concentrations were used as pulsing solutions surpassed significantly in most postharvest parameters compared to all AgNO<sub>3</sub> treatments. All SNP treatments had a sharp increase in fresh weight on the 2<sup>nd</sup> day and they reached their maximum fresh weight on the 4<sup>th</sup> days than other treatments. There were no differences between AgNO<sub>3</sub> and STS as dipping solution in prolonged vase life, enhancing water relation and fresh weight. AgNO<sub>3</sub> treatments were significantly reduced bacteria growth in vase solutions more than STS treatments. However, the stem flowers dipped in STS for 20 min then held in 8-HQS + sucrose proved more effective an increasing the level of lignin and anthocyanin. It was noted that, the increase of anthocyanin in radial flowers was accompanied with increased life span of flowers in the façade. Microscopic viewing of vessels showed that SNP prevented the growth of bacteria at the end of the stem flower resulting that an improved water absorption and flower vase extended life.

**Key words:** Antimicrobial agents, Essential oil, Gerbera, Silver nanoparticles, SNA, Vase life.

### **INTRODUCTION**

*Gerbera (Gerbera jamesonii, Bolus Ex Hook)* commonly known as Transvaal Daisy, belongs to family Asteraceae. It is one of the most important commercial flowers in the world. *Gerbera* flowers are almost insensitive flowers to ethylene, susceptible to grey mold and scape-bending. The period of dipping or pulsing end of stem flower in the solution containing sugar + germicides ranged from several minutes to several hours. This treatment's used by growers, wholesalers or retail florists in order to increase the flower's vase life during handling. Sugars support the

operations fundamental for extending the shelf life of flowers, such as keeping mitochondrial structure and functions, enhancing water balance by transpiration regulating, and water uptake increasing. Microorganisms can block vessels and decrease water uptake. It is needed to use antimicrobials, such as 8-hydroxyquinoline sulfate (8-HQS) which, it is a very important germicide commonly applied in floral preservatives. Silver nitrate ( $AgNO_3$ ) is one of the most silver salts commonly used in commercial flower preservative solutions. Silver thiosulphate (STS) is an inhibitor of ethylene production and a bactericide. Jiang *et al.*, (2004) showed that silver nanoparticles (SNP) are more effective on inhibiting growth bacteria than various silver oxides ( $Ag^0$ ,  $Ag^+$ ,  $Ag^{+2}$ ,  $Ag^{+3}$ ). SNP have efficacy against a large numeral of bacterial types, safe for human and non-toxic to plant cells neither they damage the environment. SNP is blocs of silver atoms that scope in diameter from 1 to 100 nm and are enticing interest as antimicroorganisms (Chaloupka *et al.*, 2010). The action of silver on the microbes is remains unknown. But the possible mechanism of work of metallic silver, silver ions and SNP may be due to the morphological and structural changes in the bacterial cells (Rai *et al.*, 2009). The action of SNP is due to a very large surface area of SNP, which supplies better contact with microorganisms, associated the membrane cell and bacterial intervention (Morones *et al.*, 2005). SNP as antibacterial agent prevented bacteria in stem end and vase solution, maintained water relation and fresh weight these is due to enhance vase life of Gerbera (Abadi *et al.*, 2013)

Most studies pointed out the importance of essential oils for floriculture as a good alternative to silver and other chemical compounds in flower preservatives because of their antimicrobial activities and their environmental friendly nature. Bassole and Juliani (2012) mentioned that essential oils are natural plant extracts comprising a large number of components and have multiple antimicroorganism properties. The most role of essential oils as antimicrobial to originate from oxygenated terpenoids, particularly phenolic terpenes, phenylpropanoids and alcohols. The compounds include phenolic groups are usually the most effective. The hydrophobicity of essential oils can break the lipids of the cell membrane and mitochondria, performance them permeable and lead to leakage of cell components. Thyme essential oil can be increased vase life and keeping quality of gerbera flowers (Jafarpour *et al.*, 2015). Babarabie *et al.*, (2016) showed that essential oils of rosemary and peppermint reduced the number of microorganisms in vase solution and enhanced quality of Alstroemeria cut flowers. Banjaw (2017) mentioned that the thyme essential oil was a positive response on vase life of Lisianthus, Gerbera, Narcissus, Chrysanthemum, Alstroemeria, and carnation cut flowers. He suggested

that rosemary essential oils extended vase life of Alstroemeria and carnation cut flowers.

The present study was carried to evaluate the effect of different Ag<sup>+</sup> sources i.e SNP, silver nitrate, silver thiosulphate and some essential oils i.e. thyme, rosemary, lavender on postharvest longevity of the cut *Gerbera jamesonii* cv. "Julia" flowers.

## MATERIALS AND METHODS

This study was conducted in Sahl El-Husseinih Research Station, Agriculture Research Center, Egypt at at 2016 and 2017 seasons.

### Plant material:

Uniform Gerbera flowers were harvested at opening of ray flowers in the early morning from a commercial farm and transported with ice gel bags inside ice box to the lab during 4hr. The experiments began the same day. The flower stem was re-cut under distilled water to 50 cm length.

### Experimental design:

Three experiments were conducted a completely randomized block design. Each experiment was duplicated twice. The treatment was nine flowers with three replicates. The lab conditions: 24hr. light with white fluorescent lamps at 1500 Lux, 20°C± 2°C and RH of 65% ±5.

### First experiment: Comparison between 8- hydroxyquinoline sulfate, essential oils and silver nanoparticles as holding solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:

Stem flowers were held in different vase solutions to complete their vase life:

- 8- hydroxyquinoline sulfate ( 8-HQS) at 200mg<sup>-1</sup>+30 g<sup>-1</sup>sucrose (control).
- Thyme (*Thymus vulgaris*) at 100 or 200 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose.
- Rosemary (*Rosmarinus officinalis*) at 100 or 200 mg<sup>-1</sup> +30 g<sup>-1</sup> sucrose.
- Lavender (*Lavandula officinalis*) at 100 or 200 mg<sup>-1</sup>+30g<sup>-1</sup> sucrose.
- Silver nanoparticles (SNP) at 3, 6 or 9 mg<sup>-1</sup> + 30 g<sup>-1</sup>sucrose. SNP a diameter of 8-20 nm was prepared according to Hebeish *et al.*, (2013).

### Second experiment: Comparison between silver nanoparticles and silver nitrate as pulsing solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:

Stem flowers were pulsed in:-

- SNP at 10, 20 and 30 mg<sup>-1</sup> for 24 hr.
- Silver nitrate (AgNO<sub>3</sub>) at 200 and 300 mg<sup>-1</sup> for 24 hr.
- Distilled water (D.W) for 24 hr.

After that, flowers placed in vase solution containing 8-HQS at 200 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose to complete their vase life.

**Third experiment: Comparison between silver nitrate and silver thiosulphate as dipping solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:**

Stem flowers were dipped in:-

- Silver nitrate (AgNO<sub>3</sub>) at 500 mg<sup>-1</sup> for 5 and 10 min.
- Silver thiosulphate (STS) at 1:4mμ for 10 and 20 min.
- Distilled water (D.W)

After that flowers were held in vase solution containing 8-HQS at 200 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose to complete their vase life .

**The following data were recorded:**

- Vase life (days): ending the inflorescence life when the beginning of wilting of ray flowers.
- Maximum increase in inflorescence fresh weight (%).
- Total water uptake (g /flower).
- The relative fresh weight (% of the initial) was recorded every two days during the vase life period.
- The water balance (g/flower/2days) was calculated by deducting the total transpiration loss from water uptake was recorded every two days during the vase life period.
- Bacteria No. Log<sup>10</sup> (CFU/ml) in vase solution were recorded on 8<sup>th</sup> day of treatment, as described by De Witte and Van Doorn (1988).
- Lignin (%) in stem was estimated according to the method described by A.O.A.C. (2000).
- Anthocyanin (mg/g100 Fw) at the 8<sup>th</sup> day in ray flowers was determined according to Meng and Wang (2004).
- Total and reducing sugars in head florescence (%) at the 8<sup>th</sup> day were determined according to James (1995).
- Anatomical study: The cross sections were taken at the 8<sup>th</sup> day of treatment from the stems base for examination of xylem occlusion by light microscopic and photography, as described by Willey (1971).

**Statistical analysis:**

The data were subjected to statistical analysis of variance according to Steel and Torrie (1980). The means were compared by Duncan's multiple range test at  $P \leq 0.05$

## RESULTS

### **First experiment: Comparison between 8- hydroxyquinoline sulfate, essential oils and silver nanoparticules as holding solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:**

It is observed from Table (1) that there were non-significant differences in vase life, maximum increase in fresh weight and total water uptake between 8-HQS at 200 mg<sup>-1</sup> +sucrose at 30 g<sup>-1</sup> as control treatment and the different holding solutions in essential oils (thyme at 100 or 200 mg<sup>-1</sup>, rosemary at 100 or 200 mg<sup>-1</sup> and lavender at 100 or 200 mg<sup>-1</sup>) + sucrose at 30 g<sup>-1</sup>. All essential oils + sucrose at 30 g<sup>-1</sup> treatments had more effective on reduction of bacteria numbers compared to 8-HQS + sucrose in both seasons. However, SNP treatments ( 3 , 6, 9 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose) significantly surpassed of essential oils and 8-HQS as preservative holding solutions treatment in extending vase life, maximum increase in fresh weight, total water uptake and reduced bacterial growth in vase solution, in both seasons.

As shown in Fig. (1), the relative fresh weight (%) during the shelf life periods of Gerbera flowers were gradually increased up to 2<sup>nd</sup> day with essential oils and 4<sup>th</sup> day with 8-HQS and SNP treatments. After the 6<sup>th</sup> day the essential oils treatments had severe shortage in fresh weight, however, other treatments gradually decreased slightly the relative fresh weight % in both seasons. The SNP treatments then 8-HQS treatments recorded significant enhancement in flowers the relative fresh weight % compared to essential oil treatments.

Illustrated in Fig.(2) indicated that all treatments showed a similar trend for water balance mentioned above in fresh weight change. SNP treatments showed the least negative effect on the water balance during the vase life periods.

Concerning the number of bacteria, lignin in stem, anthocyanin in ray flowers and total and reducing sugars in head inflorescence, data in Table (2) showed that bacteria No. in the preservative holding solution a significantly decreased by increasing SNP concentration. All holding solutions treatments i.e essential oils + sucrose and SNP + sucrose treatments significantly enhanced the level of lignin, anthocyanin, total sugars and reducing sugars more than those holding in 8-HQS + sucrose. However, most SNP treatments gained best than essential oils treatments. SNP at 9 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose as a holding solution treatment was most effective on enhancing the postharvest keeping quality of Gerbera cv. " Julia" cut flowers.

Table 1: Effect of 8-HQS, essential oils and SNP as holding solutions on the keeping postharvest quality of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

Holding solutions	Vase life (day)		Maximum increase in fresh weigh (%)		Total water uptake (g/flower)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
8 HQS + Sug (Control)	10.00 b	10.67 b	20.97bcd	22.31 bc	57.54 b	66.09 c
Thyme at 100 mg <sup>-L</sup> +Sug	10.67 b	11.33 b	18.25 d	19.32 cd	53.79 b	60.13 c
Thyme at 200 mg <sup>-L</sup> + Sug	11.00 b	11.67 b	19.19 cd	19.82 cd	59.14 b	63.86 c
Rosemary at 100mg <sup>-L</sup> +Sug	10.89 b	11.67 b	16.42 d	17.26 cd	52.27 b	56.82 c
Rosemary at 200 mg <sup>-L</sup> +Sug	10.78 b	11.33 b	15.12 d	16.17 d	50.44 b	54.72 c
Lavender at 100 mg <sup>-L</sup> +Sug	10.67 b	11.00 b	15.07 d	15.47 d	49.04 b	56.14 c
Lavender at 200 mg <sup>-L</sup> +Sug	10.67 b	11.33 b	17.76 d	18.63 cd	49.28 b	56.62 c
SNP at 3 mg <sup>-L</sup> + Sug	15.67 a	16.11 a	24.72 abc	25.55 ab	101.11 a	95.73 b
SNP at 6 mg <sup>-L</sup> + Sug	16.00 a	17.00 a	26.51 ab	27.70 a	105.71 a	113.90 a
SNP at 9 mg <sup>-L</sup> + Sug	16.67 a	17.67 a	26.68 a	27.96 a	111.96 a	127.94 a

Mean value followed by different letters (a,b,c,...)are significantly different , according to the Duncan's multiple Test at P ≤ 0.05.

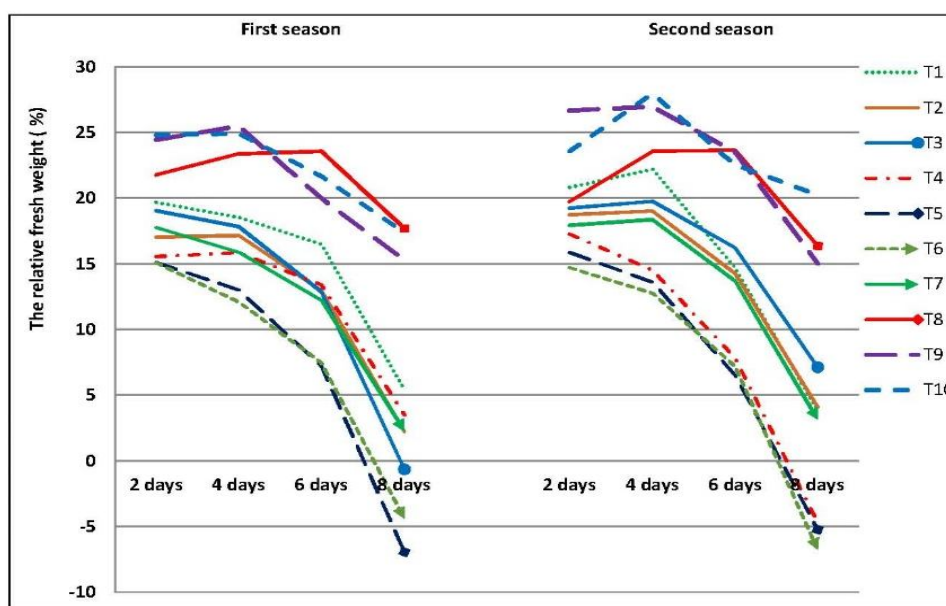


Fig.1: Effect of 8-HQS, essential oils and SNP as holding solutions on the relative fresh weight (%) every 2 days during the vase life period of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

T1: 8HQS at 200 mg<sup>-L</sup> + Sug

T2: Thyme at 100 mg<sup>-L</sup> + Sug

T3: Thyme at 200 mg<sup>-L</sup> + Sug

T4: Rosemary at 100 mg<sup>-L</sup> + Sug

T5: Rosemary at 200 mg<sup>-L</sup> + Sug

T6: Lavender at 100 mg<sup>-L</sup> + Sug

T7: Lavender at 200 mg<sup>-L</sup> + Sug

T8: SNP at 3 mg<sup>-L</sup> + Sug

T9: SNP at 6 mg<sup>-L</sup> + Sug

T10: SNP at 9 mg<sup>-L</sup> +Sug

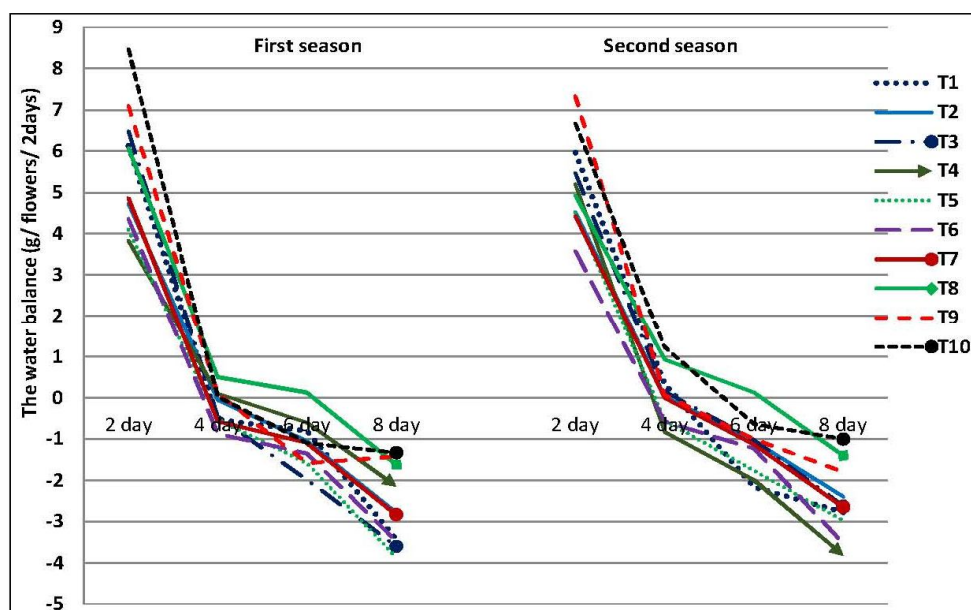


Fig.2: Effect of 8-HQS, essential oils and SNP as holding solutions on the water balance (g/flower/2days) during the vase life period of *Gerbera jamesonii* cv.. "Julia" cut flowers in the two seasons.

T1: 8HQS at 200 mg<sup>-1</sup> + Sug

T2: Thyme at 100 mg<sup>-1</sup> + Sug

T3: Thyme at 200 mg<sup>-1</sup> + Sug

T4: Rosemary at 100 mg<sup>-1</sup> + Sug

T5: Rosemary at 200 mg<sup>-1</sup> + Sug

T6: Lavender at 100 mg<sup>-1</sup> + Sug

T7: Lavender at 200 mg<sup>-1</sup> + Sug

T8: SNP at 3 mg<sup>-1</sup> + Sug

T9: SNP at 6 mg<sup>-1</sup> + Sug

T10: SNP at 9 mg<sup>-1</sup> +Sug

Table 2. Effect of 8-HQS, essential oils and SNP as holding solutions on the No. of bacteria in vase solution and Chemical computation of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

Holding solutions	Bacteria No. Log <sup>10</sup> (CFU/ml)	Lignin (%)	Anthocyanin (mg/100g fw)	Total sugars(%)	Reducing sugars (%)
8 HQS + Sug (Control)	8.90 a	1.75 j	29.62 g	4.75 j	1.66 j
Thyme at 100 mg <sup>-1</sup> + Sug	7.63 d	2.51 f	38.32 d	5.19 f	2.57 f
Thyme at 200 mg <sup>-1</sup> + Sug	7.61 d	2.39 g	40.47 b	5.42 d	2.73 d
Rosemary at 100 mg <sup>-1</sup> + Sug	7.49 e	2.58 e	34.20 e	5.10 g	2.48 g
Rosemary at 200 mg <sup>-1</sup> + Sug	7.85 b	2.66 d	39.46 c	5.31 e	2.64 e
Lavender at 100 mg <sup>-1</sup> + Sug	7.86 b	2.30 h	29.77 fg	4.98 h	2.43 h
Lavender at 200 mg <sup>-1</sup> + Sug	7.72 c	2.21 i	29.84 f	4.86 i	2.35 i
SNP at 3 mg <sup>-1</sup> + Sug	6.15 f	2.94 c	38.42 d	6.14 c	3.82 c
SNP at 6 mg <sup>-1</sup> + Sug	5.95 g	3.26 b	42.82 a	6.69 a	4.64 a
SNP at 9 mg <sup>-1</sup> + Sug	5.85 h	3.37 a	42.90 a	6.56 b	4.25 b

Mean values followed by different letters (a,b,c,..) are significantly different t, according to the Duncan Multiple Range Test  $P \leq 0.05$ .

**Second experiment: Comparison between silver nanoparticles and silver nitrate as pulsing solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:**

The flowers were pulsed in SNP at 10, 20 and 30 mg<sup>-1</sup> and AgNO<sub>3</sub> at 200 and 300 mg<sup>-1</sup> for 24 hours then held in 8-HQS + sucrose to complete their shelf life period. Data shown in Table (3 & 4) indicated that all pulsing solutions treatments significantly improved translation quality traits compared to control. SNP at 10, 20 and 30 mg<sup>-1</sup> as pulsing solutions surpassed significantly most parameters compared to AgNO<sub>3</sub> at 200 and 300 mg<sup>-1</sup> treatment. The longest vase life (15.67&16.67 days) was obtained with SNP at 20 mg<sup>-1</sup> treatment than others different SNP concentrations in the two seasons respectively. Also, it was more effective in improving other quality characteristics except for anthocyanin in ray flowers.

The maximum increase in the relative fresh weight % during shelf life periods was observed on 4<sup>th</sup> day from experiment beginning in different concentrations of SNP and AgNO<sub>3</sub> respectively. The increased the relative fresh weight % was gradually decreased after that day. The control treatment recorded more negative effect in increasing the relative fresh weight %. Flowers were pulsed in SNP at 20 mg<sup>-1</sup> for 24hr. then held in 8-HQS + sucrose showed more enhancing of increased the relative fresh weight % (Fig., 3).

Data Illustrated in Fig. (4), showed that the increased water balance was gradually decreased after 4<sup>th</sup> day with different SNP and AgNO<sub>3</sub> concentrations, respectively. Flowers were pulsed in SNP at 20 mg<sup>-1</sup> for 24hr. then held in 8-HQS + sucrose maintained more favorable water balance than other treatments in *Gerbera* cv. "Julia" cut flowers. The control treatment was deficit water balance in flowers.

**Third experiment: Comparison between silver nitrate and silver thiosulphate as dipping solutions on the keeping quality of *Gerbera jamesonii* cv. "Julia" cut flowers:**

Data presented in Tables (5 & 6) showed that all treatments had positive effects on increasing longer vase-life, maximum increase in fresh weight, total water uptake, level of lignin, anthocyanin, total sugars and reducing sugars and inhibited bacterial growth in vase solutions more than control treatment. No significant differences were found among various concentrations of AgNO<sub>3</sub> and STS treatments in most cases. On the other hand, 8-HQS + sucrose treatment recorded a less values than AgNO<sub>3</sub> and STS treatments. The longest vase-life and increased total sugars% and reducing sugars% were obtained by AgNO<sub>3</sub> at 500<sup>-1</sup> for 10 min. then held in 8-HQS + sucrose. However, the stem flowers dipped in STS for 20 min then holding in 8-HQS + sucrose more effective on improving level of lignin and anthocyanin.



Regarding the relative fresh weight (%) and water balance during the shelf life period of *Gerbera* cv. "Julia" cut flowers data illustrated in Figs. (5 & 6) that, the high level increase in the relative fresh weight % and water balance were observed on 4<sup>th</sup> day from experiment beginning with 8-HQS, AgNO<sub>3</sub> and STS treatments compared to control treatment. The increased fresh weight % and water balance gradually decreased after that day. STS for 10 min and AgNO<sub>3</sub> at 500 mg-1 for 10 min then holding in 8-HQS + sucrose treatments, respectively had better in enhancing the relative fresh weight % and water balance during the vase life duration compared to other treatments. The control treatment had rapid degradation of flowers relative fresh weight and water balance.

Table 3. Effect of SNP and AgNO<sub>3</sub> as pulsing solutions on the keeping postharvest quality of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

Pulsing solutions	Vase life (day)		Maximum increase in fresh weight (%)		Total water uptake (g/flower)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
DW	8.33 c	9.00 c	13.71 b	12.84 b	42.93 c	39.34 d
SNP at 10 mg <sup>-L</sup>	14.33 ab	15.67 a	22.82 a	24.24 a	86.21 a	94.72abc
SNP at 20 mg <sup>-L</sup>	15.67 a	16.67 a	25.59 a	26.09 a	91.71 a	109.08 a
SNP at 30 mg <sup>-L</sup>	15.33 a	16.00 a	24.29 a	25.10 a	93.48 a	104.75ab
AgNO <sub>3</sub> at 200 mg <sup>-L</sup>	11.67 b	12.00 b	22.07 a	23.32 a	68.89 b	79.65 c
AgNO <sub>3</sub> at 300 mg <sup>-L</sup>	12.00 b	13.33 b	21.14 a	22.29 a	79.44 b	89.03 bc

Mean values followed by different letters (a,b,c,...) are significantly different, according to the Duncan's Multiple Range Test at  $P \leq 0.5$ .

Table 4. Effect of SNP and AgNO<sub>3</sub> as pulsing solution on the bacteria No. in vase solution and chemical composition of *Gerbera jamesonii* cv."Julia" cut flowers in the two seasons.

Pulsing solutions	Bacteria No. Log <sup>10</sup> (CFU/ml)	Lignin (%)	Anthocyanin (mg/100g fw)	Total sugars(%)	Reducing sugars (%)
DW	10.90 a	1.66 f	22.03 f	2.09 f	0.73f
SNP at 10 mg <sup>-L</sup>	7.38 d	3.02 c	38.14 c	6.02 c	3.61 c
SNP at 20 mg <sup>-L</sup>	7.30 e	3.15 a	40.82 b	6.43 a	3.93 a
SNP at 30 mg <sup>-L</sup>	7.23 e	3.10 b	41.14 a	6.27 b	3.89 b
AgNO <sub>3</sub> at 200 mg <sup>-L</sup>	8.82 b	2.13 d	37.78 d	5.93 d	3.59 d
AgNO <sub>3</sub> at 300 mg <sup>-L</sup>	8.48 c	2.02 e	36.82 e	5.63 e	3.21 e

Mean values followed by different letters (a,b,c,...) are significantly different, according to the Duncan's Multiple Range Test at  $P \leq 0.05$ .

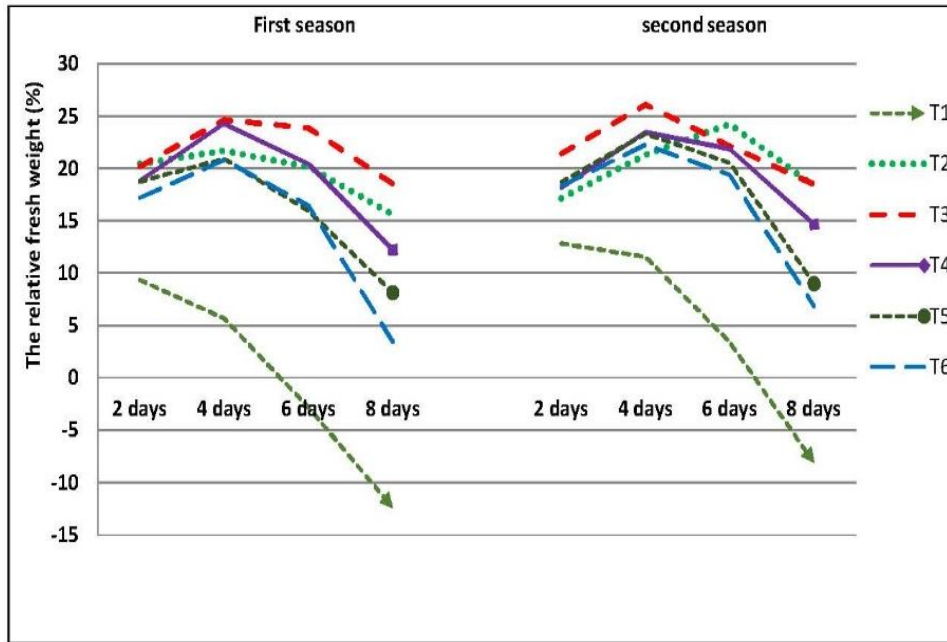


Fig.3. Effect of SNP and  $AgNO_3$  as pulsing solutions on the relative fresh weight (%) every 2days during the vase life period of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

T1: DW                      T2: SNP at  $10\text{ mg}^{-L}$                       T3: SNP at  $20\text{ mg}^{-L}$   
 T4: SNP at  $30\text{ mg}^{-L}$                       T5:  $AgNO_3$  at  $200\text{ mg}^{-L}$                       T6:  $AgNO_3$  at  $300\text{ mg}^{-L}$

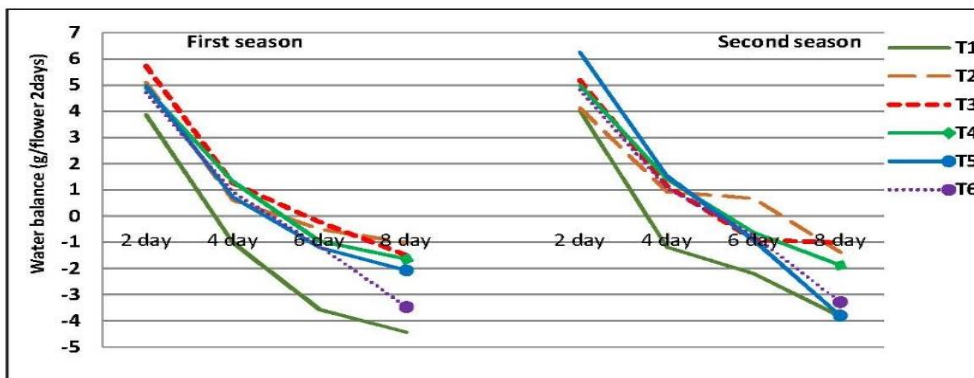


Fig.4. Effect of SNP and  $AgNO_3$  as pulsing solutions on the water balance (g/flower/ 2 day) during the vase life period of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

T1: DW                      T2: SNP at  $10\text{ mg}^{-L}$                       T3: SNP at  $20\text{ mg}^{-L}$   
 T4: SNP at  $30\text{ mg}^{-L}$                       T5:  $AgNO_3$  at  $200\text{ mg}^{-L}$                       T6:  $AgNO_3$  at  $300\text{ mg}^{-L}$

Table 5. Effect of AgNO<sub>3</sub> and STS as dipping solutions on the keeping postharvest quality of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.

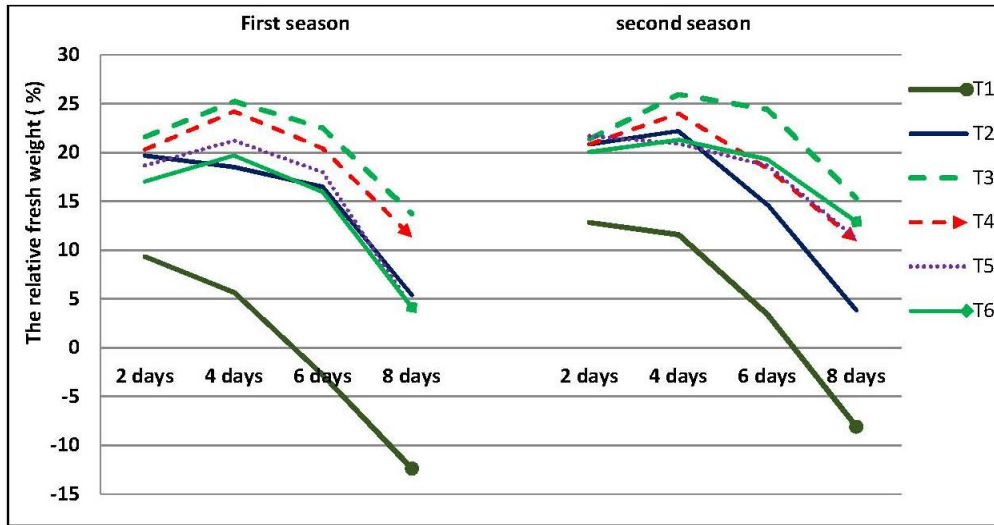
Dipping solutions	Vase life (day)		Maximum increase in fresh weight (%)		Total water uptake (g/flower)	
	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season	1 <sup>st</sup> season	2 <sup>nd</sup> season
Dw	8.33 c	9.00 b	13.71 b	12.84 b	42.93 b	39.34 b
8 HQS + Sug	10.00 b	10.67 a	20.97 a	22.31 a	57.54 ab	66.09 ab
AgNO <sub>3</sub> for 5 min	12.67 a	13.67 a	25.49 a	25.95 a	83.24 a	91.94 a
AgNO <sub>3</sub> for 10min	13.00 a	14.00 a	24.21 a	24.66 a	83.63 a	92.73 a
STS for 10 min	12.00 a	13.00 a	22.39 a	23.59 a	73.49 a	85.32 a
STS for 20 min	12.56 a	13.56 a	21.14 a	22.20 a	77.40 a	87.23 a

Mean values followed by different letters (a,b,c,..) are significantly different, according to the Duncan's Multiple Range Test at P≤0.05

Table 6. Effect of AgNO<sub>3</sub> and STS as dipping solution treatments on the No. of bacteria in vase solution and chemical composition of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons .

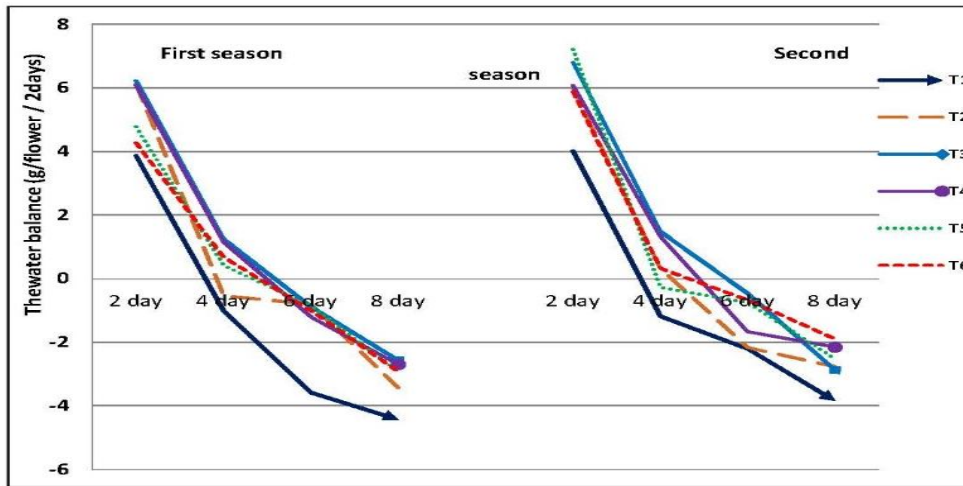
Dipping solutions	Bacteria No. Log <sup>10</sup> (CFU/ml)	Lignin (%)	Anthocyanin (mg/100g fw)	Total sugars (%)	Reducing sugars (%)
Dw	10.90 a	1.66 f	22.03 f	2.09 f	0.73 f
8HQ5 + Sug	8.90 b	1.75 e	29.62 e	4.75 e	1.66 e
AgNO <sub>3</sub> for 5 min	8.85 b	1.83 d	36.28 b	5.82 a	3.45 a
AgNO <sub>3</sub> for 10 min	8.85 b	1.94 c	33.81 c	5.71 b	3.31 b
STS for 10 min	8.46 c	2.75 b	32.05 d	5.39 d	2.91 d
STS for 20 min	8.46 c	2.83 a	39.07 a	5.51 c	3.18 c

Mean values followed by different letters (a,b,c,..) are significantly different, according to the Duncan's Multiple Range Test at P≤0.05.



**Fig.5. Effect of AgNO<sub>3</sub> and STS as dipping solutions on the relative fresh weight (%) every 2 days during the vase life period of *Gerbera jamesonii* cv. "Julia" cut flowers in the two seasons.**

**T1: DW                      T2: 8HQS + Sug              T3: AgNO<sub>3</sub> for 5 min.  
 T4: AgNO<sub>3</sub> for 10 min.    T5: STS for 10 min.    T6: STS for 20 min.**

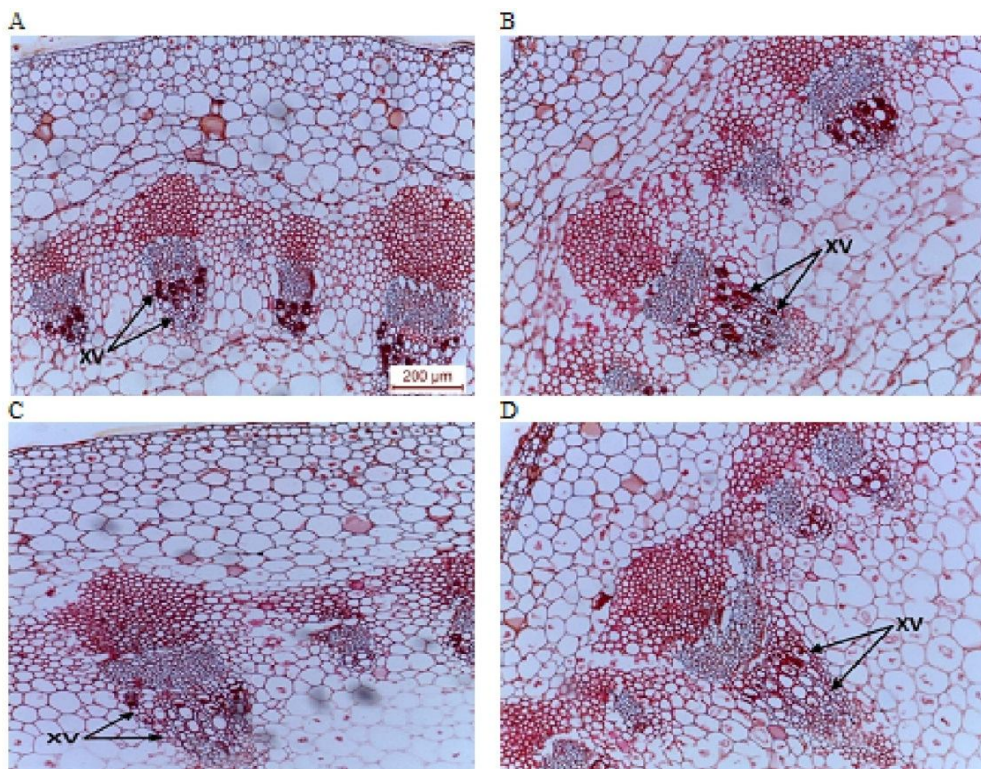


**Fig.6: Effect of 8-HQS, AgNO<sub>3</sub> and STS as dipping solutions on the water balance (g/flower/2days) during the vase life period of *Gerbera jamesonii* cv."Julia" cut flowers in the two seasons.**

**T1: DW                      T2: 8HQS + Sug              T3: AgNO<sub>3</sub> for 5 min.  
 T4: AgNO<sub>3</sub> for 10 min.    T5: STS for 10 min.    T6: STS for 20 min.**

### Anatomical study by light microscopy:

The cross sections were taken at the 8<sup>th</sup> day of treatment from the stems bases for examination of xylem occlusion by light microscopic. It was observed from Fig. (7) that the xylem vessels of cut *Gerbera jamesonii* stems bases dipped in SNP at 20 mg<sup>-1</sup> for 24hr. then placed in 8-HQS + sucrose solution were cleaned and opened for solution uptake. In SNP at 9 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose treatment, most of the xylem vessels were cleaned and opened. The opposite, treatment of 8-HQS at 200 mg<sup>-1</sup> + 30 g<sup>-1</sup> sucrose alone showed that most of the xylem vessels were low hygiene and blocked by microorganisms. Moreover, the control treatment (DW) was closed and filled with microorganisms and debris.



**Fig. 7. The cross section of the stems bases of *Gerbera jamesonii* cv. "Julia" cut**

**flowers treated with:**

**(A) Control (distilled water),**

**(B) Holding in 8-HQS +sucrose,**

**(C) Holding in SNP at 9 mg<sup>-1</sup> + sucrose and**

**(D) Pulsing in SNP at 20 mg<sup>-1</sup> for 24hr. then holding in 8-HQS + sucrose treatments at the 8<sup>th</sup> day from the beginning of experiment.**

**\* magnification at 200μm**

**xv : xylem vessels**

## DISCUSSION

Many investigators pointed out that, the water relationship is the main reason for short vase life in cut flowers, which, it is mostly the growth of bacteria in the vase solution and clogging of vessels resulting in reduced absorption of the solution. Moreover, wilting of cut flower occurs when transpiration rate surpasses water uptake. Lower water uptake usually occurs due to the bacteria blocking the xylem vessels, resulting in the lack of water reaching the upper part (Je Drzejuk *et al.*, 2016). The results under discussion pointed out that all treatments of cut Gerbera flowers showed a clear improvement in water absorption rate and reduction of bacterial growth in vase solutions. Enhancing water uptake maintains water balance and flower freshness for extending vase life period and keeping quality of Gerbera cut flower.

The results under discussion showed that application of different essential oils (thyme at 100 or 200  $mg^{-1}$ , rosemary at 100 or 200  $mg^{-1}$  or lavender at 100 or 200  $mg^{-1}$ ) + sucrose at 30  $g^{-1}$  in vase solution were very effective as antimicrobial agents compared to 8-HQS+30  $g^{-1}$  sucrose, which inhibited bacterial growth and prevented plugging of water conducting tissues. This is due to separate the lipid composition of the bacterial cell membrane and mitochondria, binding to membrane proteins and releasing lipopolysaccharides (LPS), which results in disturbing cell wall structures (Braga *et al.*, 2008).

In the present experiment, it was observed that the maximum solution uptake and vase life were got by holding solutions containing SNP at 9  $mg^{-1}$  + 30  $g^{-1}$  sucrose compared to the different essential oils and 8-HQS treatments in Gerbera cv. "Julia" cut flowers. However, Meman and Dabhi (2006) showed that maximum solution absorption and vase-life of Gerbera by preservative solution containing 4% sucrose plus 250  $mg^{-1}$  8-HQC.

The data under study show that the flowers were pulsed in SNP at 20  $mg^{-1}$  for 24hr. then held in 8-HQS + sucrose extended vase life, enhanced total water uptake and water balance and reduced bacteria growth in vase solution and at cut stem ends. These are an agreement with Rafi and Ramezani (2013) on rose cvs. "Avalanche" and "Fiesta". Our data pointed out that the different SNP concentrations used as pulsing solutions surpassed significantly most parameters under this study compared to all  $AgNO_3$  treatments. SNP seemed to be more effective by enhancing postharvest quality than  $AgNO_3$  treatments. SNP may positively affect water uptake in a second way besides its anti-bacterial effect. However, Ahmad *et al.* (2016) on gladiolus cut flowers mentioned that silver nitrate was the best source of silver ion compared to SNP and STS.

Our data showed that SNP treatments had a sharp increase in the relative fresh weight % the 2<sup>nd</sup> day and reached their maximum fresh weight on 4<sup>th</sup> day than others treatments. Similar results on cut flower rose cv. "Movie Star" was obtained by Lú *et al.* (2010) showed that 10 mg<sup>-1</sup> nano-silver +5% sucrose treatment increased fresh weight until 3<sup>th</sup> day then decreased after that. Perhaps the reason for the relatively fresh weight increase is to the increase energy supply of sucrose and regulate of water absorption by SNP.

The results under discussion showed that, there were non- differences between AgNO<sub>3</sub> and STS treatments in prolonged vase life, enhancing water relation and fresh weight and reduced bacteria growth in vase solutions. However, the dipping of the stem flowers in STS for 10 min then holding in 8-HQS + sucrose improved the level of lignin, anthocyanin , total sugars and reducing sugars. Similar result was obtained on Gerbera cut flowers by El-Saka (2002). This is due to that STS plays an important role as an antimicrobial and inhibitor of ethylene.

Our results showed that with extending shelf life period, anthocyanin in ray flowers was measured in Gerbera cv. " Julia" cut flowers increased leading to the intensification of color in flowers with age development.

The intense colors of flowers were the results of flavoniod pigments and closely related compounds. The flavoniods found both in the cytosol and vacuoles. Most flavoniods pigments exist in live plant tissues as glycosides where one or more of their hydroxyl groups are joined to a sugar. Also, SNP improved anthocyanin on carnation flowers (Moradi *et al.*, 2012).

The results explained that total and reducing sugar content was higher in the cut flowers treated with preservatives containing sucrose this may be due to the hydrolysis of external sugar.. The availability of exogenous sugar resulted in higher content of metabolically utilizable reducing and non-reducing sugars for longer period, thus prolonging vase life. Also, adding sucrose to vase solution reduced water loss by increasing the water holding capacity of petals and /or stomata closure.

## **CONCLUSION**

From the previous results, it can be summarized that SNP at 9 ppm plus 30g<sup>-1</sup> sucrose in the vase solution enhanced the postharvest quality of *Gerbera jamesonii* cv. " Julia" cut flowers. It recommend that adding SNP to the holding solution as a strong inhibitor of growth bacterial in the preservative solutions of cut flowers.

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## تقييم مصادر مختلفة لأيون الفضة والزيوت الطبيعية لإطالة حياة الفازة لأزهار الجربيرا صنف "جوليا"

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أجريت هذه الدراسة بمحطة بحوث سهل الحسينية - مركز البحوث الزراعية - مصر في موسمي 2016 و 2017. لدراسة تقييم تأثير مصادر مختلفة لأيون الفضة مثل نانو فضة و نترات الفضة و ثيوسلفات الفضة وبعض الزيوت الأساسية مثل الزعتر و حصالبان واللافندر على جودة ما بعد الحصاد لأزهار الجربيرا المقطوفة صنف "جوليا".

كان محلول الفازة المكون من الزيوت الأساسية [الزعتر ( 100 أو 200 ملجم/لتر) أو حصالبان ( 100 أو 200 ملجم/لتر) أو اللافندر ( 100 أو 200 ملجم/لتر)] + 30 جم/لتر للسكروز كعوامل مضادة للميكروبات أكثر فاعلية بالمقارنة بال 8- هيدروكسي كينولين سلفات + 30 جم/لتر للسكروز. سجل محلول الفازة المكون من 9 ملجم/لتر من الفضة النانوية + 30 جم/لتر سكروز أقصى معدل لامتصاص المحلول و عمر الأزهار في الفازة مقارنة بالزيوت الأساسية أو 8- هيدروكسي كينولين سلفات مع السكروز.

أدت معاملة نقع الأزهار في الفضة النانوية بتركيز 20 ملجم/لتر لمدة 24 ساعة ثم النقل لمحلول الفازة (8- هيدروكسي كينولين سلفات + السكروز) إلى أطالة عمر الأزهار في الفازة وزيادة أمتصاص الماء وتحسن الإتران المائي والحد من نمو البكتريا في محلول الفازة و قاعدة الساق الزهرية و زيادة الوزن الطازج بالمقارنة بالمعاملات الأخرى. تفوقت الفضة النانوية كمحالييل نقع معنويا في معظم القياسات مقارنة بمعاملات نترات الفضة.

لم يوجد فرق معنوي بين معاملات الغمس في نترات الفضة و ثيوسلفات الفضة ثم النقل لمحلول الفازة على إطالة عمر الأزهار في الفازة وتحسين العلاقات المائية و الوزن الطازج وتقليل نمو البكتريا في محلول الفازة. لكن كان غمس الأزهار في ثيوسلفات الفضة لمدة 10 دقائق ثم النقل لمحلول الفازة أكثر فاعلية في تحسين مستوي اللجنين والأنثوسيانين والسكريات الكلية والمختزلة. من الملاحظ زيادة الأنثوسيانين في الأزهار الشعاعية مع زيادة فترة حياة الأزهار في الفازة.

أظهرت الدراسة المجهرية للأوعية أن الفضة النانوية ثبطت نمو الكائنات الحية الدقيقة في

قاعدة الساق الزهرية مما أدى لتحسن أمتصاص الماء وإطالة فترة حياة الأزهار في الفازة.