

EFFECT OF ESSENTIAL OILS AND GERMICIDES ON THE VASE LIFE OF CARNATION (*DIANTHUS CARYOPHYLLUS* L.) CUT FLOWERS

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ABSTRACT: Natural preservatives such as herbal essential oils have the ability to extend the life of fresh-cut flower pots after harvest. The effect of clove oil, lavender oil and thyme oil, especially when combined with antimicrobial agents such as 8-hydroxyquinoline sulfate and silver nitrate, on vase life and post-harvest value of carnations picked after harvest, was studied. The results showed that the use of different preservative solutions consisting of clove, lavender and thyme oils mixed with silver nitrate and 8-hydroxyquinoline sulfate has a significant effect on the characteristics of cloves. The study confirmed that the effect between clove essential oil and silver nitrate was significant for most of the traits. The highest percentage of those studied traits were when carnation flowers were treated with 200 mg l⁻¹ clove essential oil and 30 mg l⁻¹ of silver nitrate.

Key words: carnation, *Dianthus caryophyllus* L., AgNO₃, 8-HQS, essential oils, clove oil, lavender oil, thyme oil.

INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) belongs to the Caryophyllaceae Family (Ghasemi Ghahsareh and Kafi, 2009) is one of most important and popular cut flowers for producers and consumers due to its high ability to maintain quality, its portability to far distances and its remarkable ability to absorb water after prolonged transportation (Khalighi and Shafie, 2000). The carnation cut flowers often show wilting symptoms as well as bending of the stem just below the flower probably due to a low water potential, which causes vascular occlusion (Burt, 2004; Gilbert *et al.*, 2001; Huang *et al.*, 2002). There are several reports of the damage of flowers induced by ethylene such as premature senescence and wilting of the corolla. Ethylene has an important role in the regulation of flowers senescence and its production rate is increased with senescence of flowers (Ketsa and Rugkong, 2000). In addition, carnation is very sensitive to

accumulation of bacteria at the stem end or in the vase solution that can cause the vascular obstruction and reduction of vase life (Van Doorn *et al.*, 1991).

Extension of the vase life and keeping quality are important parameters for evaluation of cut flower, for both domestic and export markets.

Vase life termination for many cut flowers is characterized by wilting which is due to loss of water from the cells (He *et al.*, 2006). Many agents have been used in vase solutions of the cut flowers which extend vase life by improving water uptake. These include silver nitrate (Fujino *et al.*, 1983).

Silver nitrate (AgNO₃) is the wide antimicrobial effect as well-known, since Ag⁺ ion replaces the hydrogen cations (H⁺) on surface proteins in cell membranes of bacteria, which leads to loss of membrane integrity and causing cell death (Feng *et al.*, 2000). It is more effective as a biocide (Jiang

et al., 2004). In contrast, AgNO₃ (12.5 and 25.0 mg l⁻¹) reduced number of bacteria in the petiole to zero.

8-hydroxyquinoline sulfate (8-HQS) may act as an inhibitor and the disinfecting effect on preventing the growth of bacteria in the vase solution and increased the vase life (van Doorn, 1998).

Kuiper *et al.* (1995) believed 8-hydroxyquinoline is a bactericide substance and an environment-acidifying agent that in addition to prevent the growth of bacteria and reduce the environment pH, it also prevents vessel closure in cutting cross caused by sedimentation of various chemical materials.

Essential oils (Eos), organic natural substances, are safe and environmentally friendly that have strong antimicrobial properties against some pathogens. Edible, medicinal and herbal plants and spices such as oregano, rosemary, thyme, sage, basil, turmeric, ginger, garlic, nutmeg, clove, mace, savory and fennel have been successfully used either alone or in combination with other preservation methods (Tajkarimi *et al.*, 2010), these antibacterial properties are attributed to the high levels of phenolic compounds such as carvacrol, thymol and eugenol (Lambert *et al.*, 2001). Solgi *et al.* (2009) and Amini *et al.* (2016) reported that thyme, summer savory and ajwain Eos are used in preserving solution for extending the vase-life of gerbera (*Gerbera jamesonii* 'Dune') and *Dianthus caryophyllus* 'Yellow Candy' cut flowers. Mihajilov *et al.* (2010) showed that the use of thyme essential oil with a concentration of 200 ppm increased longevity in Sensi cultivar by 2.34 days.

Thyme (*Thymus vulgaris*) is a member of the Family Lamiaceae. Its oil mainly contains thymol, borneol, and carvacrol (Jakiemiu *et al.*, 2010). It has antioxidative, antibacterial, and antimycotic properties (Imelouane *et al.*, 2009). Solgi *et al.* (2009) reported that thyme oil is used in the vase solution for prolonging the shelf life of gerbera (*Gerbera jasmeson* 'Dune') cut

flowers. Lavender essential oil is extracted from the plant *Lavandula angustifolia*. Lavender is purported to have antifungal, antibacterial, and antimicrobial properties (Silva *et al.*, 2015). Clove (*Syzygium aromaticum*) belongs to the family Myrtaceae and has many medicinal properties such as antimicrobial and antiviral activities (Osman *et al.*, 2020);

The aim of this study was to distinguish the effect of adding different extractions of essential oils of clove, thyme and lavender, dill with 8-HQS and AgNO₃ to control the population of bacteria and extend the vase life of cut flowers of carnation.

MATERIALS AND METHODS

The present study was done at Antoniadis Research Branch, Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Alexandria, Egypt, during the two successive seasons of 2019 and 2020.

Source of the cut flowers:

Flowers were obtained from a well-known commercial nursery in Alexandria. The variety used in this experiment is carnation (*Dianthus caryophyllus* L. 'Cinderella').

Source of essential oils (Eos):

The Eos used in this experiment was obtained from the National Research Centre (NRC), Dokki, Egypt.

Cut flowers preparations:

Flowers were harvested at paint-brush stage and were quickly transferred to postharvest laboratory under dry conditions, they were recut before treatments to the length of 50 cm.

The following treatment were applied:

Stems of flowers were placed in a glass bottles (500 ml) containing 400 ml of one of the following holding solutions at different levels:

1. Distilled water (control).

2. 8-HQS at 200 mg l⁻¹ + clove oil 100 mg l⁻¹.
3. 8-HQS at 200 mg l⁻¹ + clove oil 200 mg l⁻¹.
4. 8-HQS at 200 mg l⁻¹ + lavender oil 100 mg l⁻¹.
5. 8-HQS at 200 mg l⁻¹ + lavender oil 200 mg l⁻¹.
6. 8-HQS at 200 mg l⁻¹ + thyme oil 100 mg l⁻¹.
7. 8-HQS at 200 mg l⁻¹ + thyme oil 200 mg l⁻¹.
8. AgNO₃ at 30 mg l⁻¹ + clove oil 100 mg l⁻¹.
9. AgNO₃ at 30 mg l⁻¹ + clove oil 200 mg l⁻¹.
10. AgNO₃ at 30 mg l⁻¹ + lavender oil 100 mg l⁻¹.
11. AgNO₃ at 30 mg l⁻¹ + lavender oil 200 mg l⁻¹.
12. AgNO₃ at 30 mg l⁻¹ + thyme oil 100 mg l⁻¹.
13. AgNO₃ at 30 mg l⁻¹ + thyme oil 200 mg l⁻¹.

After that, each bottle was covered at its mouth with cellophane wrap to prevent evaporation. All the treated cut flowers were kept at the average temperature of (18.6-19 °C), average humidity (63%-65%) and under continuous fluorescent light at 24 hours' at about 450- 500 lux.

Experimental layout and statistical analysis:

The experimental layout was a completely randomized design (CRD). It consists of thirteen treatments with three replicates, each replicate contained three flowers. The means between treatments were compared by L.S.D. test at 5% level of probability. Data were statistically analyzed according to the method described by Snedecor and Cochran (1989).

Data recorded:

Data were recorded as the following:

Postharvest characters:

1. Vase life (days):

It was determined as the number of days from starting the experiment to the fading

stage. The fading stage was set at the wilting of 50% of petals wilted or browning or inward rolling (Karimian Fariman and Tehranifar, 2011; Pun *et al.*, 2014).

2. Loss of flower fresh weight percentage (LFFW%):

It was determined at the fading stage as the following formula:

$$\text{LFFW (\%)} = \frac{\text{Initial fresh weight} - \text{final fresh weight}}{\text{Initial fresh weight}} \times 100$$

3. Final water uptake (g):

It was calculated at the end of the experiment using the following formula:

Water uptake (g) = The amount of solution at the beginning of the experiment - the amount of the solution remaining at the end of the experiment.

4. Flower fresh weight/flower dry weight ratio (FWR):

At the fading stage the cut flowers were oven dried at 75 °C for 48 hours to get the dry weight (F.D.W.). The fresh weight was divided by the dry weight as below:

$$\text{FWR} = \frac{\text{Fresh weight/flower (g)}}{\text{Dry weight/flower (g)}}$$

5. Relative fresh weight (RFW):

Fresh weight of the flowers was determined just before the immersion of the flowers into the solutions and collected every two days until the vase life of the flowers was terminated. The fresh weight of each flower was expressed relative to the initial weight to represent the water status of the flower.

$$\text{Relative fresh weight (RFW) (\%)} = \frac{W_t}{W_0} \times 100$$

Where W_t is the weight of flower (g) at (2, 4 and 6 days), W₀ is the initial fresh weight of the same flower (g).

6. Vase solution uptake rate:

The VSU rate was measured according to the formula below:

$$\text{VSU rate} = \frac{(\text{St}-1)-\text{St}}{\text{IFW of stem}} \times 100$$

Where (St) is weight of vase solution (g) at (2, 4 and 6 days), (St-1) is the weight of the vase solution (g) on the previous day and (IFW) is the initial fresh weight (g).

Chemical analysis:

1. Chlorophyll a and b contents (mg g⁻¹ fresh weight) was determined in leaves according to Moran (1982) in the upper part of flowering stems at the end of vase life of control plant.
2. Reducing sugars content (mg g⁻¹ dry weight) was determined at the end of the experiment in the flower spike according to Miller (1959).
3. Anthocyanin content (mg g⁻¹ fresh weight) was measured according to Bariola *et al.* (1999) method, in this regard 0.1 g of fresh petal was weighed and pulverized in a mortar for extracting methanol and 1% HCl was added in to every sample. Samples were put in the falcon and maintain in 4°C for one night. Finally, the absorption was read in 530 and 657 nm and calculated using the following formula:

$$\text{Anthocyanin} = D_{530} - 0.24 D_{657}$$

Average bacterial counts (C.F.U/ml):

Solutions (0.1 ml) were spread on general medium (nutrient agar), incubated for 24 h at 29 °C and were evaluated by serial dilutions. Number of colonies per petri dish was counted accurately. All bacteria counting was replicated three times (Balestra *et al.*, 2005).

RESULTS

Postharvest characters:

1. Vase life (days):

Data presented in Table (1) exhibit the different responses of carnation plants on

vase life as influenced by two biocides (8-HQS and AgNO₃) and three different essential oils, (clove, lavender and thyme), and their concentrations (100 and 200 mg l⁻¹) of the dose of application. Table (1) show that holding the flowers in all preservative solutions for two seasons significantly improved vase life compared to hold the flowers in a distilled water (control).

Furthermore, the highest significant values of flower vase life were reported for flowers deposited in mixed preservative solution (AgNO₃ at 30 mg l⁻¹ combined with clove oil at 200 mg l⁻¹) which were 16.16 and 16.53 days in both seasons, respectively. This was followed by the treatment of 8-HQS at 200 mg l⁻¹ with clove Eos at 200 mg l⁻¹ was record 15.16 and 15.22 days in 2019 and 2020, whereas the lowest vase life (11.18 and 11.52days) was obtained by thyme oil (100 mg l⁻¹) with silver nitrate in both seasons, respectively compared with untreated treatment (control (distilled water)).

Furthermore, the highest significant values of flower vase life were reported for flowers deposited in an AgNO₃ solution at 30 mg l⁻¹ combined with clove oil which were 14.45 and 15.31 in both seasons, respectively. This was followed by the treatment of 8-HQS at 200 mg l⁻¹ with clove Eo at 100 mg l⁻¹ was record 14.12 and 14.55 days in 2019 and 2020, whereas the lowest vase life (11.18 and 11.51days) was obtained by thyme oil (100 mg l⁻¹) with silver nitrate in both seasons, respectively.

2. Loss of flowers fresh weight percentage (LFFW%):

Results exhibited in Table (1) proved that the interactions between biocides and essential oils were significant in the two seasons. It shows that the lowest significant decrees in LFFW ratio was obtained after AgNO₃ mg l⁻¹ with clove essential oil 200 mg l⁻¹ (11.72 and 11.99) in both seasons. On the other hand, the highest increase in LFFW was obtained after application with silver nitrate with thyme oil (100 mg l⁻¹) which

Table 1. Effect of pulsing with biocides and essential oils on vase life, loss of flowers fresh weight percentage (LFFW), final water uptake (FWU) and flower fresh/dry weight ratio in cut flowers of carnation ‘Cinderella’ in 2019 and 2020.

Treatments	Vase life (days)		LFFW (%)		FWU (g/plant)		FWR	
	2019	2020	2019	2020	2019	2020	2019	2020
Control (distilled water)	7.69	8.40	48.12	47.52	66.82	66.82	2.69	2.75
8-HQS + CL at 100 mg l ⁻¹	13.79	13.86	19.19	16.69	104.33	105.87	6.25	6.16
8-HQS + CL at 200 mg l ⁻¹	15.16	15.22	12.81	12.03	110.40	109.77	7.29	7.13
8-HQS + LA at 100 mg l ⁻¹	11.98	12.92	24.43	21.58	92.19	94.94	5.07	5.80
8-HQS + LA at 200 mg l ⁻¹	12.89	12.89	20.52	20.16	96.43	95.77	6.28	5.74
8-HQS + TH at 100 mg l ⁻¹	12.22	12.46	17.36	21.89	90.71	91.38	5.71	5.89
8-HQS + TH at 200 mg l ⁻¹	12.86	12.11	19.09	16.91	93.40	92.07	5.75	5.92
AgNO ₃ + CL at 100 mg l ⁻¹	14.98	14.47	16.74	14.78	106.76	107.42	7.26	7.00
AgNO ₃ + CL at 200 mg l ⁻¹	16.16	16.53	11.72	11.99	115.14	115.80	8.29	8.10
AgNO ₃ + LA at 100 mg l ⁻¹	12.10	11.85	22.53	20.13	87.80	88.47	5.68	6.02
AgNO ₃ + LA at 200 mg l ⁻¹	11.64	12.64	22.61	19.90	87.21	86.88	5.74	6.04
AgNO ₃ + TH at 100 mg l ⁻¹	11.18	11.52	26.63	25.17	78.37	78.37	4.67	5.68
AgNO ₃ + TH at 200 mg l ⁻¹	12.19	12.59	24.05	24.44	83.36	83.36	4.96	5.75
LSD (5%)	0.73	1.14	4.82	3.93	3.64	6.62	0.73	0.65

CL: clove, LA: lavender, TH: thyme.

recorded 26.63 and 25.17 in both seasons, respectively less than the initial fresh weight compared with control (distilled water).

3. Final water uptake (g/plant)

Table (1) confirmed that the mixed solutions (biocides, Eos, and their concentrations) showed highly significant effects in both seasons of 2019 and 2020.

It was shown that the largest raise (115.14 and 115.80 g) in the 1st and 2nd seasons was observed with uses of holding solution AgNO₃ at 30 mg l⁻¹ and clove essential oil at (200 mg l⁻¹). This was followed by application with 8-HQS and clove essential oil at 200 mg l⁻¹ which recorded 110.40 and 109.77g. The same table also found that the smallest amount of consumption of water uptake in the first and second seasons was measured after treated on silver nitrate with thyme at (100 mg l⁻¹) recorded 78.37 and 78.37 g in 1st and 2nd seasons, respectively.

4. Flower fresh weight/ flower dry weight ratio (FWR):

Application of the biocides with different essential oils was recorded in Table (1). Applying the 8-HQS dose as biocides with clove oil (200 mg l⁻¹) gave the largest increase in FWR with values of 8.29 and 8.10 g in the two seasons. On the contrary, the flowers treated with silver nitrate and thyme at 100 mg l⁻¹ gave the smallest flower fresh weight / flower dry weight ratio (4.67 and 5.68 g) during both seasons.

5. Relative fresh weight (RFW) %:

The RFW value is shown in Table (2) after the second, fourth, and sixth days of the experiment. According to the Table, incorporating AgNO₃ + Clove at 200 led to significant increase in RFW values of 2, 4, and 6 days after testing started (106.20, 97.04, 88.08 and 107.48, 96.69, 88.73) among both years, with the same amount of significance. Amidst this, using AgNO₃ and thyme oil at 100 ppm dropped to the lowest

Table 2. Effect of pulsing with biocides and essential oils on vase solution uptake and relative fresh weight in cut flowers of carnation ‘Cinderella’ in 2019 and 2020.

Treatments	VSU% (2 days)		VSU% (4 days)		VSU% (6 days)		RFW% (2 days)		RFW% (4 days)		RFW% (6 days)	
	2019	2020	019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control (distilled water)	30.08	0.80	4.73	26.00	16.21	7.44	84.34	87.47	61.69	1.15	1.88	52.57
8-HQS + CL at 100 mg l ⁻¹	37.83	0.72	5.83	39.37	22.91	23.19	102.18	103.63	92.39	2.70	2.14	83.66
8-HQS + CL at 200 mg l ⁻¹	42.63	5.35	0.21	43.50	25.83	26.22	103.56	105.61	95.35	95.53	6.08	87.20
8-HQS + LA at 100 mg l ⁻¹	34.21	5.97	2.69	33.54	19.65	0.49	94.48	97.82	83.43	86.44	5.95	78.00
8-HQS + LA at 200 mg l ⁻¹	38.63	7.10	5.48	34.78	20.22	1.37	100.76	98.95	84.31	87.08	7.04	78.98
8-HQS + TH at 100 mg l ⁻¹	36.18	8.13	5.89	35.42	20.82	1.57	98.25	99.82	86.30	89.18	7.96	80.11
8-HQS + TH at 200 mg l ⁻¹	36.81	9.61	6.77	35.99	23.87	21.81	100.66	101.01	88.23	9.64	8.86	80.33
AgNO ₃ + CL at 100 mg l ⁻¹	42.16	2.30	9.81	42.65	23.26	24.78	103.12	104.39	94.42	3.02	4.39	85.69
AgNO ₃ + CL at 200 mg l ⁻¹	45.95	7.85	4.46	46.07	27.38	33.40	106.20	107.48	97.04	6.69	8.08	88.73
AgNO ₃ + LA at 100 mg l ⁻¹	37.27	1.84	5.71	37.24	21.43	2.58	96.42	102.28	89.06	0.68	9.97	81.44
AgNO ₃ + LA at 200 mg l ⁻¹	41.22	2.72	9.10	39.14	22.14	3.93	96.68	103.06	89.70	91.96	0.24	81.83
AgNO ₃ + TH at 100 mg l ⁻¹	30.09	2.13	7.83	31.81	18.08	8.35	89.52	95.87	77.69	82.07	1.78	74.69
AgNO ₃ + TH at 200 mg l ⁻¹	31.97	33.86	30.36	32.44	19.17	19.38	93.22	96.63	80.69	85.48	5.15	76.86
LSD (5%)	2.10	3.20	3.14	4.03	1.74	1.50	3.80	2.34	2.28	2.28	2.30	1.94

CL: clove, LA: lavender, TH: thyme.

RFW after 2, 4, and 6 days (89.52, 77.69, 71.78 and 95.87, 82.07, 74.69) after the study started. The RFW was lowest in the untreated plants. The RFW value of all treatments started to decline as the vase life of the untreated plants began to shorten.

6. Vase solution uptake (VSU) (%):

As shown in the Table (2) control plants had the lowest VSU value in both seasons compared to other treatments. Furthermore, the vase life of the untreated plants ended on the sixth day of the experiment on the second report, after six days of the experiment. The VSU value as a result of all treatments was higher than the value observed on the second day of the experiment. In comparison, the other treatments reported directives in the VSUR value relative to the prior value recorded on the second day of the experiment. The VSU values of all treatments significantly decreased after six days of the experiment.

Chemical characters

1. Chlorophyll a, b (mg g⁻¹ fresh weight):

Table (3) shows a major difference in chlorophyll a and chlorophyll b content after various treatments. Clove oil at 200 mg l⁻¹ concentration had the highest chlorophyll a and b content after AgNO₃ and 8-HQS were placed. During both seasons, untreated plants had the poorest chlorophyll a and chlorophyll b amount.

2. Anthocyanin content (mg g⁻¹ fresh weight):

The highest level of anthocyanin was associated with the AgNO₃ treatment + clove essential oil (200 mg l⁻¹) (0.59 and 0.61) and the minimal amount was found in the control treatment (0.12 and 0.12). (Table 3) in both seasons.

3. Reducing sugars content (mg g⁻¹ dry weight):

Table (3) demonstrated that there was a substantial difference in reducing-sugar after various interventions treatments used. Using

AgNO₃ with clove oil at 200 mg l⁻¹ resulted in significantly higher reducing sugar content (12.26 and 13.37) in both seasons. In contrast, the lowest reducing sugar content was reported after using AgNO₃ with thyme oil at 100 mg l⁻¹ in both seasons (7.37 and 6.92). Furthermore, data showed that untreated flowers had the lowest significant reducing sugars content. In terms of biocides and essential oils, using 8-HQS and clove oil at 200 mg l⁻¹ resulted in a significant increase in reducing sugar content (11.87 and 11.12) in both seasons.

Number of bacterial colonies (x10⁵ CFU/ml):

Data presented in Table (3) showed significantly different number of bacterial colonies after various treatments. The majority of bacterial colonies were discovered in the control treatment. All of the treatments resulted in a substantial decrease in the number. The mixture of AgNO₃ and clove oil at 200 mg l⁻¹ recorded 1.12 and 1.27 CFU/ml in both seasons, and the worst treatment of bacterial colonies was AgNO₃ + thyme oil at 100 ppm (6.80 and 6.77 CFU/ml) for both seasons, respectively, achieved a highly important reduction in the number of bacterial colonies. The effect of different treatments on vase solution bacterial colonies, as shown in Table (3), significantly reduces the number. The results showed that the amount of bacterial colonies in the vase solution was highest in the control procedure, and the lowest number of bacterial colonies were found in the treatment of clove at 200 mg l⁻¹ for both applications with AgNO₃ and 8-HQS. Treatments with 8-HQS and AgNO₃ in combination with essential oils, on the other hand, showed a highly significant difference (Fig.1).

DISCUSSION

The duration of a flower vase has an economic effect. A shorter vase life could be caused by a number of factors, including climacteric ethylene synthesis (Halevy and

Table 3. Effect of pulsing with biocides and essential oils on chlorophyll a and b contents, anthocyanin, reducing sugars and bacterial colonies in cut flowers of carnation ‘Cinderella’ in 2019 and 2020.

Treatments	Chlor. a (mg g ⁻¹ f.w.)		Chlor. b (mg g ⁻¹ f.w.)		Antho. (mg g ⁻¹ f.w.)		R. sugar (mg g ⁻¹ d.w.)		Bact. Coln. (x105 CFU/ml)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control (distilled water)	8.32	8.65	2.40	2.26	0.12	0.12	6.33	5.59	21.89	22.14
8-HQS + CL at 100 mg l ⁻¹	14.92	13.24	6.26	5.23	0.55	0.57	9.30	9.14	1.68	1.66
8-HQS + CL at 200 mg l ⁻¹	17.37	15.75	7.26	6.81	0.59	0.60	11.87	11.12	1.29	1.33
8-HQS + LA at 100 mg l ⁻¹	12.85	13.61	4.83	4.23	0.26	0.38	8.23	8.08	2.30	2.28
8-HQS + LA at 200 mg l ⁻¹	14.83	13.78	4.86	5.04	0.31	0.45	9.18	8.16	3.08	3.07
8-HQS + TH at 100 mg l ⁻¹	11.65	12.33	5.43	4.89	0.36	0.32	8.60	8.21	3.31	3.30
8-HQS + TH at 200 mg l ⁻¹	11.71	12.84	5.83	4.91	0.37	0.37	8.75	8.30	3.09	3.08
AgNO ₃ + CL at 100 mg l ⁻¹	15.93	14.37	6.95	6.02	0.56	0.58	10.35	10.36	1.58	1.41
AgNO ₃ + CL at 200 mg l ⁻¹	19.57	18.88	8.04	7.29	0.59	0.61	12.26	13.37	1.12	1.27
AgNO ₃ + LA at 100 mg l ⁻¹	13.01	12.12	4.93	4.84	0.44	0.53	8.35	8.73	3.65	2.50
AgNO ₃ + LA at 200 mg l ⁻¹	15.76	12.12	5.36	5.12	0.51	0.56	9.02	8.87	3.10	2.27
AgNO ₃ + TH at 100 mg l ⁻¹	9.60	11.24	3.76	3.17	0.15	0.15	7.37	6.92	6.80	6.77
AgNO ₃ + TH at 200 mg l ⁻¹	10.83	11.45	4.32	3.58	0.24	0.27	7.86	7.55	5.43	5.47
LSD (5%)	1.31	1.53	0.94	0.87	0.02	0.03	0.54	0.62	1.59	1.04

CL: clove, LA: lavender, TH: thyme.

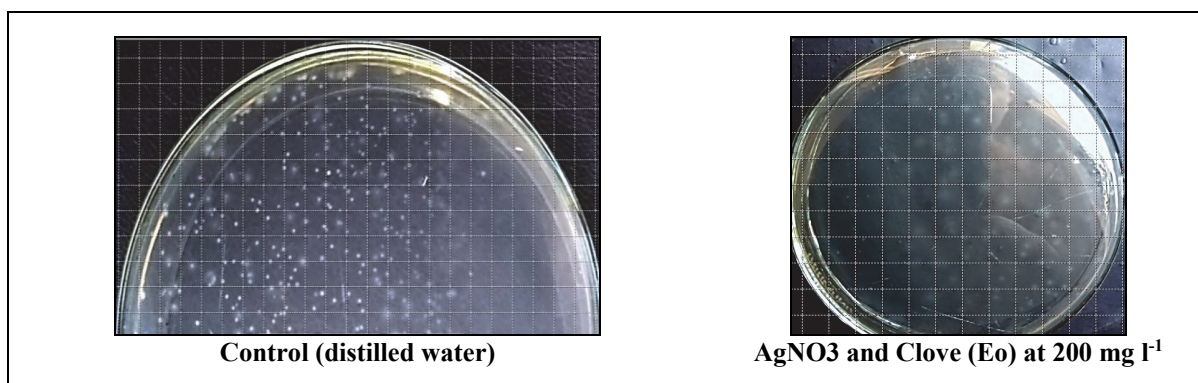


Fig. 1. Pattern of bacterial abundance in vase solution on NA media treated with pulsing in AgNO₃ and clove (Eo) at 200 mg l⁻¹ compared to the control (distilled water).

Mayak, 1981) and/or bacterial and degradation product blockage of stem xylem vessels. Some of the chemicals examined for vase longevity are ethylene synthesis inhibitors, such as silver (Ag⁺) (Veen and Van de Geijn, 1978), and antimicrobials, such as hydroxyquinoline (VanDoorn, 1998). These chemicals are known to inhibit microbial activity and are commonly used in this sense (VanDoorn *et al.*, 1991).

A major issue after flower harvesting is the production of bacteria in preservative

solutions, which causes the vascular system of stems and flowers to become blocked.

Previously, antimicrobial substances such as silver nitrate and sulphate Hydroxy quinolin citrat was used to extend the vase life of flowers or extending longevity and maintaining quality; however, due to environmental contamination, the use of natural products has become more common in recent years. (Mehrddad B. *et al.* 2016).

The AgNO₃ factor substantially increased vase life, flower fresh weight loss, final water absorption, flower fresh weight/

flower dry weight ratio, chlorophyll a and b, anthocyanin content, reducing sugars, and reducing bacterial colonization in carnation flowers.

The results of this survey were in agreement with these of Van Doorn *et al* (1991) who noted that AgNO₃ should be present in the vase solution in order to prolong vase life, and AgNO₃ at 12.5 and 25.0 mg l⁻¹ reduced the number of bacteria in the petiole to zero. (Petridou *et al.*,1999).

A study on the mechanism of inhibitory action of Ag⁺ on microorganisms revealed that the expression of cellular proteins and enzymes that are necessary for ATP production was inactivated with Ag⁺ (Yamanaka *et al.*, 2005).

Preservative solution containing silver nitrate mg l⁻¹ adding with clove oil (200 mg l⁻¹) had the longest vase life of 16.16 days, followed by holding in preservative solutions containing 8-HQS mg l⁻¹ and clove oil (200 mg l⁻¹) which for both had a subsequent vase life of 15.16 days. Applying these treatments, carnation increased vase life significantly in comparison with control treatment.

The plant hormone, ethylene, is responsible for early senescence in many flowers such as orchids, roses etc. (Leiv and Hans 2005). Vase life of cut flowers can be improved by delaying senescence using ethylene synthesis and receptor inhibitors such silver complex (Jafar Abbasi, 2011).

Microbial occlusion of xylem vessels of cut flowers reduces solution absorption by stems, and it is well known that essential oils have antimicrobial properties. Essential oils inhibit oxygen absorption and oxidative phosphorylation of pathogens, causing disruption in the cytoplasmic membrane, disrupting proton motive power, active coagulation of cell contents, and therefore energy depletion, which enhances water uptake (Oliveira *et al.*, 2007 and Conner *et al.*, 1993).

The findings revealed that essential oils, due to the antimicrobial and antioxidant

properties of their phenolic compounds, improve water correlation in the vessel, fresh weight loss, and prevention of chlorophyll degradation by reducing microorganism growth and preventing vascular obstruction, and were able to extend the life of carnation cut flowers by eliminating free radicals. Extracts and essential oils of fennel, geranium, lavender and basil in the vase solution reduced the amount of obstruction of xylem vessels and cinnamon essential oils reduced the microbial population (Shanan, 2012).

The use of essential oils in preservative solution of Rose cv. "Grand" cut flowers increased fresh weight by improving water relations (Shanan, 2012) Phenolic compounds in essential oils are able to control ethylene production to some extent. (Rad, 2018).

According to Jafar Abbasi (2011) the increased reducing sugars in the floret and stem of tuberose cut spikes may increase the osmotic capacity of the stem and petals, enhancing their nutrient absorption and maintain turgidity and explaining the increase in flower longevity observed in the different treatments.

The findings of this study are consistent with the findings of Irfan Gani *et al.* (2018), who discovered that various combinations of essential oils damage the cell wall and cell membrane of microbes, increasing ion leakage and permeability, and causing the damaged cells to die, which likely aids in increasing water uptake and improving water balance., improved water balance which in turn helps in increasing fresh weight.

The results of this study are consistent with a current research results that the effect of rosemary extract on Chrysanthemum cut flowers it was found that 25% of rosemary extract protect the chlorophyll. (Basiri *et al.* 2011).

CONCLUSION

In the present study, stems of carnation plants were treated in application of 8-HQS

(200 mg l⁻¹) and AgNO₃ (30 mg l⁻¹) as a preservative holding solution placed in moved to continuously one of the vase solutions of clove, lavender and thyme oils all at two concentrations 100 and 200 mg l⁻¹ for extending longevity and maintaining quality. The treatment containing the combination of 200 mg l⁻¹ clove oil with 30 mg l⁻¹ AgNO₃ resulted in the significantly longest vase life, largest vase solution uptake, more values on RFW and the highest amount on uptake of preservative vase solution.

Based on the results of this research, it can be stated that essential oils as eco-friendly is useful alternative to chemical compounds and can be considered to increase the life of carnation cut flowers.

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تأثير الزيوت العطرية ومبيدات الميكروبات على فترة بقاء ازهار القرنفل المقطوفة

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المواد الحافظة الطبيعية مثل الزيوت العطرية العشبية لها القدرة على إطالة فترة بقاء الأزهار المقطوفة حديثاً بعد الحصاد في الفازة. تمت دراسة تأثير زيت القرنفل وزيت اللافندر وزيت الزعتر، خاصة عندما يقترن بمضادات الميكروبات مثل ٨-هيدروكسي كينولين سلفات وبنترات الفضة، على فترة بقاء الأزهار في الفازة وقيمة الزهرة بعد الحصاد. أظهرت النتائج أن استخدام المحاليل الحافظة المختلفة المكونة من زيوت القرنفل واللافندر والزعتر الممزوج ببنترات الفضة و ٨ هيدروكسي كينولين سلفات له تأثير كبير على جميع صفات القرنفل. أكدت الدراسة أن التأثير بين زيت القرنفل وبنترات الفضة كان معنوياً لمعظم الصفات. كانت أعلى نسبة من الصفات المدروسة عند معاملة أزهار القرنفل بـ ٢٠٠ مجم/لتر من زيت القرنفل و ٣٠ مجم/لتر من بنترات الفضة.