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Response of cut carnation (*Dianthus caryophllus* L.cv. Tempo) to essential oils and antimicrobial compounds

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Abstract

Carnation (*Dianthus caryophyllus* L. cv. Tempo) cut flower is sensitiveto ethylene and bacterial infection on stem end. Bacterial contaminationproducestoxic compoundsand these compounds stimulate the ethylene productionthat ultimately shortens vase life. Cut flowers were kept in vases containing *Artemisia* oil and *Anethum* oil (both at 4, 8 and 12%), 8-hydroxyquinoline sulfate (200, 400 and 600 mg l^{-1}) and aluminum sulfate (100, 200 and 300 mg l^{-1}). Results showed that the 100 mg l^{-1} aluminum sulfate, 200 mg l^{-1} 8-hydroxyquinoline sulfate, 12% *Artemisia* and *Anethum* essential oils induced the maximum vase life (17.9, 16.7, 16.1 and 15.1 days, respectively) of cut flowers.Vase life of control cut flowers was 13 days. Mentioned above treatments stimulate the minimum ethylene production and stem end bacterial colonies and maximum water uptake.

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Introduction

Carnation (*Dianthus caryophllus* L.), family Caryophyllaceae, is native to the Mediterranean region and Central Asia (Khalighi, 2010). Carnation is among the three top cut flowers around the world. The two species, *Dianthus barbatus*and*D. caryophyllus*are cultivated as commercial varieties (Matloubi, 2004; Fahmi andHassan, 2005). Carnation cut flowers are so sensitive to ethylene that causessenescence and vase life reduction (Hashemabadi *et al.*, 2007).Carnation is also susceptibletothe bacterial contamination on stem end thatproducestoxic compoundsandaffects ethylene productionwhich reduces vase life (Lu *et al.*, 2010; Basiri and Zarei, 2011).Given thepublicity of this problem among cutflowers, it seemsto be necessary to find a solution. Essential oilsact asincorporatingenvironmentally friendlyandhighly effectiveon antimicrobial compounds (Edrisi, 2009; Kiamohammady, 2011). Herbal essential oilsare natural compounds thatare knownassecondary metaboliteswhich havepowerful effectonpathogens control and their antimicrobialimpact isprovenas well. These compounds increases thevase life ofcut flowers and their use is becoming widespread recently (Sharififar *et al.*, 2007; Svircev*et al.*, 2007).Artemisia (*Artemisia dracunculus*)and dill (*Anethum graveolens*) have medical properties(Omidbeygi, 2005). Mousavi Bazaz and Tehranifar (2011) investigated the effects of cumin, mint and thyme extracts(50 and 100 mgl^{-1}) and ethanol (4 and 7%) on the vase life of cut Alstroemeria (*Alstroemeria* sp.) and concluded that all treatments had a positive effect on vase life and water uptake and also 50 mgl^{-1} thyme extractextended vase life about 2 days more than the control.Solgi *et al.* (2009) studied on the effect of different herbal essential oils including carvacrol, thyme and zatariya,also silver nanoparticles on the vase life of gerbera (*Gerberajamesonii*cv. Dune), and reported that treatment with 50 and 100 mgl^{-1} carvacrol increased the vase life about 8 days as compared to the control. 8-hydroxyquinolinesulfateorcitrateare usedmainlytoacidification ofthe solutionandcombined withdivalentionssuch as ironand copperto prevent vascularocclusion thatcanprevent enzymatic activities which lead to vascular blockage(Ichimura *et al.*, 1999; Edrisi, 2010).Tarand Hassan(2003) evaluated the effect ofvarious levelsof 8-hydroxyquinolinesulfateon thepostharvest life of*Aster*sp. cut flowerandconcludedthat the use of400mgl^{-1}ofthis compoundincreasedthe vaselife. It is proved that using calcium, aluminum, boron, nickel and zinc salts can extend vase life of cut flowers (Edrisi, 2010).In addition tothe inhibitoryeffect ofaluminum sulfateon microorganism's activity, it reducesthe transpiration of cut flowers. Previous studies showed that the use of aluminum sulfate, especially at high concentrations may cause damage to the leaves of some flowers such as roses (*Rosa hybrida* L.) (Edrisi and Kalayie, 2005). Liao*et al.* (2001) investigated the effect ofaluminum sulfateat different concentrations(50, 100 and 150 mgl^{-1}) on thevase lifeofcut*Eustoma grandiflora* andconcludedthatthe use of 150mgl^{-1}increased vase lifeup to15.4 days. Additionally, aluminum sulfate enhanced water uptake and fresh weight. Hojjati *et al.* (2007) investigated different chemicals like cobalt chloride and aluminum sulfate on *Eustoma grandiflora* vase life and resulted that aluminum sulfate extends vase life of cut flowers.The purpose of the present study was toinvestigate the effect of different concentrations of herbal essential oils and other antimicrobial compounds on the vase life and some other characters of cut carnation (*Dianthus caryophyllus* L. cv. 'Tempo').

Materials and methods

Plant materials

Cut carnation (*Dianthus caryophyllus*L. Cv. 'Tempo') provided from a commercial manufacturer were equalizedat 50 cm height, then they were re-cut from stem end; because of vascular blockage inhibition. Then they immediately transferred to the postharvest laboratory with 12 μMs^{-1}m^{-2} light intensity, 20± 2°C temperature, 12 hours day length and a relative humidity of 60 to 70% to assessment of the traits.The 5 cutflowerswere placed ineachplasticwith 2 l volume vase andthen were treated withspecificconcentrationsofantimicrobial compounds.

Experimental design and treatment

The experiment was carried out based on a completely randomized design with13treatments consisting*Artemisia* and *Anethum*essential oils at 3levels (4, 8and 12%),8-hydroxyquinolinesulfateat3 levels(200, 400and600mgl^{-1}) and aluminum sulfateat3levels (100, 200 and 300mgl^{-1}) alongwith controlplots,in3replicates and39 plots.The pulse treatment completed after 24 hours then flowers were transferred into other vases containing 500 ml3% sucrose + 200mgl^{-1}8-hydroxyquinolinesulfate preservative solution.

Measurement of traits

Themeasured traits were vase life of cut flowers, fresh weight loss,water uptake, ethylene production and bacterialpopulations on the stem end. Vase life is characterized with leaf wilting index or leaf senescence and flowers wilting (Fig. 1) (Nabigol *et al*., 2006). Toevaluate thefresh weight loss, flowers fresh weightwere measuredat the first and the last day of vase life, and also considering the re-cut part weight, their difference were recorded.Due to the preservative solution initial content (500 ml), the absorption was measured according to each day reduction (both evaporation and stem uptake), the solution absorption was calculated andwas divided to the initial flowers weight.To measurethe amountof ethylenereleasedfromeach pot, aflowerwas selected andafter cutto25 cm was weighted and then transferred into the smallerpotscontaining30ml 8-hydroxyquinolinecitrate250 mgl^{-1}and each small pot was placed inside the jars and sealed firmly. In order tosampletheair insidejars, wooden doorsof each jar was equipped with aseptum. Gassamples were taken to Tehran UniversityGas Analysis Laboratory. The released ethyleneproducedwith the flower were measured with C-8 AIT measuring device, Shimadzumodel.Forstem end bacterial population counting, about 2 cm(0.5 g) werecutfromthe stem end 24hours aftertreatment withantimicrobial compounds; also forpreservative solution bacterial population counting, a 2ml sample were isolated from each pot and the evaluation were performed according to Liu *et al.* (2009) method.

Statistical analysis

The experimental design was R.C.B.D. Each experiment was carried out in three replicates and each replicate includes three explants. Analysis of variance (ANOVA) was done using SAS and SPSS statistical software and means were compared using the Least Significant Difference Test (LSD) at 5% probability level.

Results and discussion

Vase life

Analysis of varianceshowed that the effect of different treatments on vase life was statistically significant at 5% level. Mean comparisons revealed that100 mgl^{-1} aluminum sulfate, 200 mgl^{-1} 8-hydroxyquinoline sulfate, 12%Artemisia andTarragon essential oils were the most effective treatments with 17.9, 16.7, 16.1 and 15.1 days vase life, respectively (Table 1, Fig. 2).Vase life control cut flowers was 13 days. Enhancement of vase life can be described with antimicrobial properties of the mentioned above compounds, so that water absorption improved with prevention of vascular blockage and it delays water deficiency related wilting (Di, 2008;Jalili Marandi*et al*., 2011). JaliliMarandi*et al.*(2011) investigated the effects ofsalicylic acid, herbal essential oilsand silver thiosulfate (STS) on thevase lifeof cut rosesandfound that*Carumcopticum*essential oil at the concentrationof 500mgl^{-1}significantlyimproved thevase life as compared to the control.Mousavi Bazaz and Tehranifar (2011) withstudyon*Alstroemeria*and herbal essential oils, ethanol and methanol found that treatmentwith 50and100mgl^{-1}had the best effect on water absorption and vase life.Solgi *et al.* (2009) studiedthe effect of different compounds on cut gerbera cv. Duneand resulted that 50 and 100 mgl^{-1}caused a two-fold increase on vase life compared to the control.Faraji (2005) found that 8-hydroxyquinoline citrate and aluminum sulfate had the best impact on vase life extend, flower diameter, opening percentage and flower quality of cut rose cv. Marosia.Liao *et al.* (2001) examined the effects of aluminum sulfate at concentrations of 50, 100 and 150 mgl^{-1} on cut Lisianthus (*Eustomagrandiflora*) and concluded that 150 mgl^{-1} of that extended vase life up to 15.4 days, additionally aluminum sulfate enhanced water uptake and fresh weight.Investigation of Hojjati*et al.* (2007) with chemicaltreatmentslike cobalt chloride and aluminum sulfate and their effects onvase lifeofcut Lisianthus showed thataluminum sulfate canincrease vase life.Khan *et al.* (2007) studied the effect of aluminum sulfate and sucrose on the properties of tulip (*Tulipahybrida*) and concluded that aluminum sulfate increased the relative water content in leaves and petals 64.5% and 58.7%, respectively.Anju *et al.* (1999) examined the effect of 8-hydroxyquinoline citrate and sucrose on the vase life of cut chrysanthemum (*Chrysanthemummorifolium* L.) and revealedthat these compounds caused an increase in fresh weight and vase life as compared to the control.Tar andHassan (2003) investigated the impact of various levels of 8-hydroxyquinoline sulfate on *Aster* sp. vase life and concluded that the use of 400 mgl^{-1}increased vase life.

Table 1. Effect of antimicrobial compounds on measured traits of cut carnation cv. 'Tempo'**.**

Treatments	Traits				
	Vase life (day)	Water absorption (mlg^{-1} F.W)	Fresh weight loss (g)	Ethylene ($nll^{-1}h^{-1}g^{-1}$ F.W)	Stem end bacterial clonies (Log_{10}CFU ml^{-1})
Control	13.00^{b}	1.39^{c}	7.80^{a}	0.614^{a}	135.50^{a}
Anethum oil 4%	14.8^{b}	1.75^{ab}	6.50^{b}	0.512^{a}	82.00^{b}
Anethum oil 8%	14.75^{b}	1.41^{c}	6.48^{b}	0.501^{a}	32.00^{c}
Anethum oil 12%	15.10^{b}	1.78^{ab}	4.31^{c}	0.313^{c}	30.40^{c}
Artemisia oil 4%	14.50^{b}	1.40^{c}	5.75^{bc}	0.381^{c}	64.00^{b}
Artemisia oil 8%	14.70^{b}	1.45^{c}	6.25^{b}	0.352^{c}	83.00^{b}
Artemisia oil 12%	16.10^{b}	1.80^{ab}	4.40^{c}	0.245^{d}	29.00^{c}
HQS 200 mgl^{-1}	16.70^{a}	1.94^{a}	4.20^{c}	0.214^{d}	25.00^{c}
HQS 400 mgl^{-1}	14.90^{b}	1.52^{b}	6.10^{b}	0.379^{c}	82.00^{b}
HQS 600 mgl^{-1}	13.90^{b}	1.61^{ab}	0.50^{bc}	0.298^{d}	42.10^{b}
$Al_2(SO_4)$ 100 mgl^{-1}	17.90^{a}	1.96^{a}	2.89^{d}	0.201^{d}	14.00^{d}
$Al_2(SO_4)$ 200 mgl^{-1}	13.30^{b}	1.59^{b}	4.80^{c}	0.598^{a}	47.10^{c}
$Al_2(SO_4)$ 300 mgl^{-1}	13.40^{b}	1.47^{c}	6.89^{b}	0.478^{b}	60.00^{b}

*According to LSD test, in each column means with the same letter are not significantly different.

Fresh weight loss

Analysis of variance showed that the effects of different treatments on fresh weight reduction was significant at the 5% level. Mean comparison also revealed that 100 mgl^{-1} aluminum sulfate, 200 mgl^{-1} 8-hydroxyquinoline sulfate and 12% Artemisia and Dill essential oils were the most effective treatments with 2.89, 4.2, 4.4 and 4.3 gloss, respectively (Fig. 3, Table 1).Improvement of water uptake and water relations with antimicrobial compounds prevent fresh weight loss (Farrager*et al.*, 1989; Van Doorn, 1997; Bayat *et al.*, 2011).Liao*et al.* (2001) on their investigation on cut Lisianthusand applying different aluminum sulfate concentrationsfound that aluminum sulfateenhancedfresh weight as compared to the control.Theresearchersalso described this enhancementwith abettercorolla outreach. Hydroxyquinolineenhanced cut roses fresh weight and vase life significantly (Ichimura*et al.*, 1999). These results are in accordance with Elgimabi and Ahmed (2009), Arab *et al.* (2006) and Kim and Li (2002).

Water absorption

Resultsshowedthat amongall treatments, 100 mgl^{-1} aluminum sulfate, 200 mgl^{-1}8–hydroxyquinoline sulfate and 12% Artemisia and Dill essential oils with 1.96, 1.94, 1.80 and 1.78 mlg^{-1} F.W. were the best related to the water absorption(Fig.4, Table 1).Theanalysisof varianceshowed that theeffects of different treatments onwater absorption wassignificantat 5% level. Improving water relations and hydraulic conductivity in cut flowersarise from vascular obstruction prevention which ultimately will improve water absorption (*Figueroaet al.*, 2005).Another reason for superiority of mentioned compounds is microorganism's activity control (bacteria and fungi) that prevent vascular obstruction. Ourresultsare in consistent with JaliliMarandi*et al.* (2011) and Burt(2004). Nabigol *et al.* (2006)showed that antiseptic and anti-ethylene compoundsand also antibiotics increase water absorption, significantly. Anju*et al.* (1999) studied the effectof hydroxyquinolineandsucroseonvaselife ofchrysanthemum(*Chrysanthemum morifolium* L.)andconcludedthat thesecompoundscaused an increasing infresh weightandvase lifeand improvingqualityin comparisonwith the control. Khan*et al.* (2007) investigated the impact ofaluminum sulfateandsucroseon theproperties oftulip(*Tulipa hybrida*)and resulted that aluminum sulfateincreased therelative water contentinleavesandpetals 64.5% and 58.7%, respectively.

Fig. 1. Cut carnation cv. "Tempo" at the last day of vase life.

Bacterial population on stem end

Analysisof varianceshowed that theeffects ofdifferenttreatments onstemend bacterial population wassignificantat 1% level.Mean comparison of the datarevealed thatamongall treatments, 100mgl-1aluminumsulfate, 200 mgl-18-hydroxyquinolinesulfate and 12% Artemisia and Dill essential oils were the most effective treatments containing 14, 25, 29 and 30.4 log10 CFUml-1 population respectively that have a reduction as compared to the control stem ends bacterial contamination (Fig.5, Table 1).The effect ofantimicrobialcompounds used intheseexperimentsis defined by disruptingthe pathogens functionand the respiratorychainwhich prevents pathogens activity and ultimatelycause death(Solgi *et al.*, 2009; Hashemabadi, 2012).

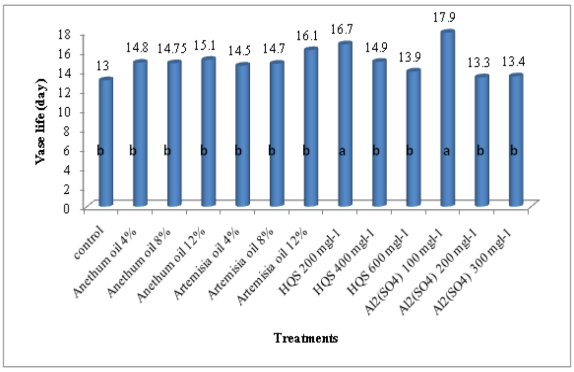

Fig. 2. Effect of different treatments on vase life of cut carnation cv. 'Tempo'.

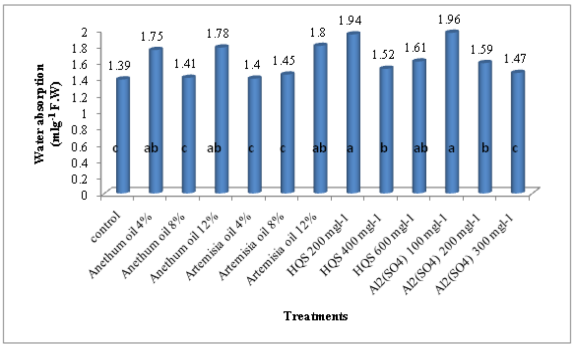

Fig. 3. Effect of different treatments on water absorption of cut carnation cv. 'Tempo'.

Study of Esfandiari*et al.*(2011) on cut lily(*Lilium longiflorum* cv. Shoching)showed thatthe antimicrobial compoundsextend vase life by interfering bacterialcell division. These results are in accordance with Liu *et al.* (2009) and Shanan (2012) about positive impact of antimicrobial compounds and herbal essential oils on pathogenic contamination control and vase life improvement.Kazemi and Ameri (2012) investigated the effects of herbal essential oils, silver nanoparticlesand salicylic acid on bacterial contamination of carnationand found that all treatments significantly reduced bacterial populations much more than the control.Kazemi *et al.*(2011) showed thattheuse of vase lifeextending compoundsat 1.5 and 3 mM decreasedbacterial population of carnation cut flower significantly(about 30-35%).Oraee *et al.* (2011)investigated the effect ofdifferent levels ofsilver nanoparticles andthyme essential oilon vase life and bacterial populations on stem end and in preservative solution of cut gerbera.They found that all these compounds had apositive effect incontrollingbacterial contaminations, so 100 mgl-1thyme oil and 4 mgl-1 silver nanoparticles with two-fold increasein vase life were the most effective treatments.

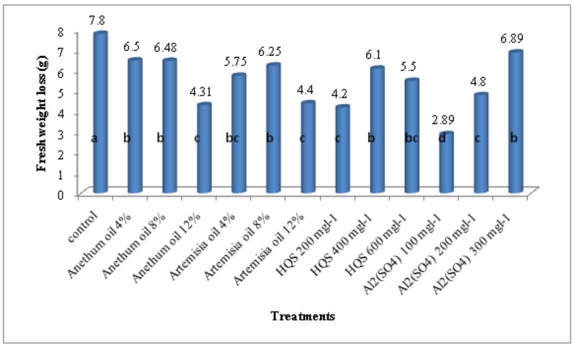

Fig. 5. Effect of different treatments on ethylene production of cut carnation cv. 'Tempo'.

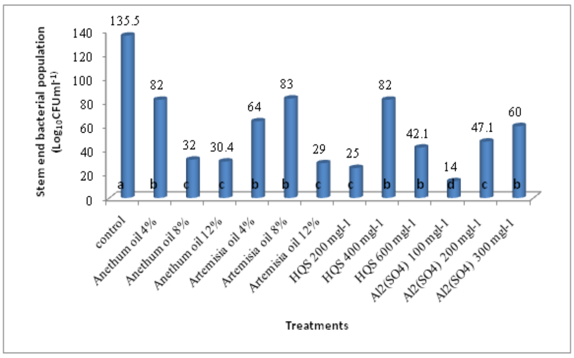

Fig. 6. Effect of different treatments on stem end bacterial population of cut carnation cv. 'Tempo'.

Ethylene production

Mean comparison of the data revealed thatamongall treatments,100mgl-1aluminumsulfateand 200 mgl-1 8-hydroxyquinolinewere the most effective treatments with 0.201 and 0.214 nll-1 per hour per gram fresh weight significantly less ethylene concentration respectively (Fig 6, Table 1).Analysisof varianceshowed that theeffects ofdifferenttreatments onethylene productionwassignificantat 5% level.The impact of these antimicrobial compounds on cut carnation quality enhancement is obvious given the role of antimicrobial compounds on the uptake and transport of nutrients, reduced respiratory rate and reduced the amount of ethylene. Our findings in reducingethylene productionare in consistent with Goszcynska and Rudnicki (1981). Reid *et al.* (1980) found that the use of STS on cut carnation cv."White Seam" in the 1 to 4 M ratio between silver and thiosulfate was satisfactory. Anti-ethylene and antimicrobial compounds due to their stem end bacterial contamination control, can stimulate ethylene production indirectly and can control ethylene production and extending vase life of cut carnation and gerbera (Kim and Lee, 2002; Basiri and Zarei, 2011; Basiri *et al.*, 2011). The results of mentioned studies about ethylene production control is consistent with the results of the current study.

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References

Abbaszadeh M, Elahian H. 2011. Investigation effect of some natural compounds on vase life of cut chrysanthemum cv. Mohandesi Zard. Proceeding of The 7th International Horticultural Science Congress 526-527 P (In Persian).

Anju B, Tripathi SN, Sehgal OP, Bhat A. 1999. Effect of pulsing, packaging and storage treatments on vase life of *Chrysanthemum* cut flowers. Advances in Horticulture and Forestry **6,** 125-131.

Arab M, Khalighi A, Arzani K, Naderi R. 2006. Investigation effect of cold storage, 8-hydroxyquinoline sulphate and sucrose on vase life and keeping quality of cut *Mattiola incana*. Journal of Agricultural Science **37(1),** 83-92 (In Persian).

Basiri Y, Zarei H. 2011. Effects of nano-silver treatments on longevity and some qualitative character of cut flowers of carnation(*Dianthus caryophyllus* cv. 'White Librity'). Proceeding of The

7th International Horticultural Science Congress. 2477-2478 (In Persian).

Basiri Y, Zarei H, Mashayekhi H. 2011. Effects of nano-silver treatments on vase life of cut flowers of carnation(*Dianthus caryophyllus* cv. 'White Librity'). Journal of Advanced Laboratory Research in Biology **2(2),** 49-55.

Bayat H, Azizi M, Shoor M, Vahdati N. 2011. Effect of ethanol and essential oil of medicinal plants on vase life of cut carnation cv. 'Yellow Candy'. Journal of Horticultural Science **25(4),** 384-390 (In Persian).

Burt S. 2004. Essential oils: Their antibacterial properties and potential applications in foods. International Journal of Food Microbiology **94,** 223-253.
http://dx.doi.org/10.1016/j.ijfoodmicro.2004.03.022

Di W. 2008. Effects of antibiotics on the senescence of *Gerbera jamesonii* cut flower. Journal of Anhui Agriculture Sciences (Abstract).Category Index: S682.11.

Edrisi B. 2010. Postharvest physiology of cut flowers. *Payam-e-Digar Publication* 150 p (In Persian).

Edrisi B, Kalayie A. 2005. Investigation effect of chemical treatments on vase life and some quantitative character of cut rose flower. Final Report to Agricultural Research Center and Natural Resource, Markazi Province (In Persian).

Elgimabi MN, Ahmad OK. 2009. Effects of bactericide and sucrose pulsing on vase life of rose cut flowers (*Rosa hybrida* L.). Botany Research International **2(3),** 164-168.

Esfandiari B, Rezaei A, Nemati J, Tehranifar A, Ashrafi J. 2011. Effect of silver nanoparticles on postharvest life of lilium cv. Shocking. Proceeding of the 7th International Horticultural Science Congress 2444-2446 P. (In Persian).

Fahmy AR, Hassan S. 2005. Postharvest studies on some important flower crops.
www.lib.uni-corvinus.hu/Phd/Sadek-Hassan.

Faraji S. 2005. Investigation effects of different chemical treatments on vase life of cut rose cv. Marosia. M.Sc. Thesis, Olum va Tahghighat University, Tehran, Iran 102 p (In Persian).

Farrager RS, Daw ZY, Abo-Raya S. 1989. Influence of some spice essential oils on *Aspergillus parasiticus* growth and production of afflation in a synthetic medium. Journal of Food Science **54,** 74-76.
http://dx.doi.org/10.1111/j.13652621.1989.tb08571.x.

Figueroa I, Colinas MT,Mejia J, Ramirez F. 2005. Postharvest physiological changes in rose of different vase life. Cien Investigation of Agriculture **32,** 167-176.

Goszcynska DM, Rudnicki RM. 1981. Storage of cut flower. Horticulture Review**3,** 59-146.
http://dx.doi.org/10:1002/9781118060834.ch2.

Hashemabadi D. 2012. Comparison effect of silver thiosulphate and silver nanoparticle on vase life of cut carnation cv. "Tempo". Final Report to Islamic Azad University, Rasht Branch, Iran 101 p(In Persian).

Hashemabadi D, Mostofi Y, Kashi A, Memariani M, Shafiei M, Bagheri Moradi G. 2007. Investigation of the effect of 1-MCP (1-Methylcyclopropene) pretreatment in delaying of senescence of carnation (*Dianthus caryophyllus* L. 'Tempo'). Journal of Horticultural Science and Technology **8,** 13-20 (In Persian).

Hojjati Y, Khalighi A, Farrokhzad AR. 2007. Chemical treatments of *Eustoma* cut flower cultivars for enhanced vase life. Journal of Agriculture and Social Science **3(3),** 75-78.

Ichimura K, Kojima K, Goto R. 1999. Effect of temperature, 8-hydroxyquinoline sulphate and sucrose on the vase life of cut roses flowers. Postharvest Biology and Technology **15(1),** 33-40. http://dx.doi.org/10.1016/S0925-5214(98)00063-5

Jalili Marandi R, Hassani A, Abdollahi A, Hanafi S. 2011. Application of *Carum copticum* and *Saturega hortensis* essential oils and salicylic acid and silver thiosulphate in increasing the vase life if cut rose flowers. Journal of Medicinal Plants Research **5(20),** 5034-5038.

Kazemi M, Ameri A. 2012. Response of vase life carnation cut flower to salicylic acid, silver nano-particles, glutamine and essential oil. Asian Journal of Animal Science **6(3),** 122-131. http://dx.doi:10.3923/ajas.2012.122.131

Kazemi M, Hadavi E, Hekmati J. 2011. Role of salicylic acid in decrease of membrane senescence in cut carnation flowers. American Journal of Plant Physiology **6(2),** 106-112. http://dx.doi.org/10.3923/aipp.2011.106.112.

Khalighi A. 2010. Floriculture. Rozbahan Press 392 p (In Persian).

Khan FU, Khan FA, Hayat N, Bhat A. 2007. Influence of certain chemicals on vase life of cut tulip. Indian Journal of Plant Physiology **12,** 127-132.

Kiamohammadi M. 2011. The effects of different floral preservative solutions on vase life of *Lisianthus* cut flowers. Journal of Ornamental and Horticultural Plants **1(2),** 115-122.

Kim Y, Lee JS. 2002. Changes in bent neck, water balance and vase life of cut rose cultivars as affected by preservative solution. Journal of Korean Society for Horticultural Science **43(2),** 201-207.

Liao LJ, Lin YH, Huang KL, Chen WS. 2001. Vase life of *Eustoma grandiflorum* as affected by aluminum sulfate. Botany Bulletin of Academic Science **42,** 35-38.

Liu J, He S, Zhang Z, Cao J, Kv P, He S, Chen G, Joyce DC. 2009. Nano-silver pulse treatments inhibit stem-end bacteria on cut gerbera cv. 'Ruikou' flowers. Postharvest Biology and Technology **54,** 59-62. http://dx.doi.org/10.1016/j.postharvbio.2009.05.004

Lu P, Cao J, He S, Liu J, Li H, Cheng G, Ding Y, Joyce DC. 2010. Nano-silver pulse treatments improve water relations of cut Rosa cv. Movie Star flowers. Postharvest Biology and Technology **57,** 196-202. http://dx.doi.org/10.1016/j.postharvbio.2010.04.003 .

Mousavi Bazaz A, Tehranifar A. 2011. Effects of ethanol, methanol and essential oils as novel agents to improve vase life of *Alstroemeria* flowers. Journal of Biology and Environmental Science **5(14),** 41-46.

Nabigol A, Naderi R, Babalar M, Kafi M. 2006. Effects of some chemical treatment and cold storage on longevity of cut chrysanthemum. Persian Paper Bank. Number of 511 Papers (In Persian).

Omidbeigi R. 2004. Production and processing of medicinal plants. Astan Quds Razavi Publication (In Persian).

Oraee T, Asgharzadeh A, Kiani M, Oraee A. 2011. The role of preservative compounds on number of bacteria on the end of stems and vase solution of cut *Gerbera*. Journal of Ornamental and Horticultural Plants **1(3),** 161-166.

Reid MS, Paul JL, Farhoomand MB, Kofranek AM, Staby GL. 1980. Pulse treatment with silver thiosulphate complex extends the vase life of cut carnation. Journal of the American Society for Horticultural Science **105,** 25-27.

Satoh S, Shibuya K, Waki K, Kosugi Y. 2005. Mechanism of senescence in carnation flowers. Acta Horticulture **669,** 191-198.

Shanan NT. 2012. Application of essential oils to prolong the vase life of rose (*Rosa hybrida* L. cv. 'Grand') cut flowers. Journal of Horticultural Science and Ornamental Plants **4(1),** 66-74.

Sharififar F, Moshafi MH, Mansouri SH, Khodashenas M, Khoshnoodi M. 2007. *In vitro* evaluation of antibacterial and antioxidant activities of the essential oil and methanol extract of endemic (*Zataria multiflora*). Food Control **18,** 800-805. http://dx.doi.org/10.1016/j.foodcont.2006.04.002.

Solgi M, Kafi M, Taghavi TS, Naderi R. 2009. Essential oils and silver nano particles (SNP) as novel agents to extend vase life of gerbera (*Gerbera jamesonii* cv. 'Dune') flowers. Postharvest Biology and Technology **53,** 155-158. http://dx.doi.org/10.1016/j.postharvbio.2009.04.003

Svircev AM, Smith RJ, Zhou T, Hernade M, Liu W, Chid CL. 2007. Effects of thymol fumigation on survival and ultrastructure of *Monilinia fructicola*. Postharvest Biology and Technology **45,** 228-233. http://dx.doi.org/10.1016/j.postharvbio.2006.12.021.

Tar T, Hassan FA. 2003. Evaluating vase life and tissue structure of some compositae (Asteraceae) species. Internal Journal of Horticultural Science **9,** 87-89.

Van Doorn WG. 1997. Water relation of cut flowers. Horticulture Review **18,** 1-85. http://dx.doi.org/10.1002/9780470650608.ch1.