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Investigation of the Impact of Benzyladenine and Several Natural Compounds on the Vase Life and Some Qualitative Traits of Tuberose Cut Flowers

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Abstract

Tuberose (*Polianthes tuberosa*) is one of the most important cut flowers with fragrant buds. To prolong vase life of tuberose, proper preservative solution applying is necessary. For this purpose, two types of chemical and natural treatments were used. Applied treatments were benzyladenine (50, 100, and 150 mg l^{-1}), the extracts of rosemary and Eucalyptus (12, 25 and 50%) and sour orange fruit extract (3, 4, 5 and 6 ml l^{-1}). Sucrose 4% was used in all solutions. Measured characteristics included the vase life, the percentage of opening of the buds, the relative fresh weight, the solution absorption, the total soluble solids, chlorophyll a, b and total chlorophyll. The results showed that the maximum vase life was obtained in benzyladenine treatment of 50 mg l^{-1} (11.66 days) and the minimum vase life was obtained in the control treatment and rosemary extract of 50% (6.33 days). The highest percentage of buds opening was related to the benzyladenine treatment of 150 mg l^{-1}. The maximum relative fresh weight and solution absorption were obtained in the benzyladenine treatments of 100 and 50 mg l^{-1}, respectively and the maximum amount of total soluble solids was obtained in *Eucalyptus* extract treatment of 12 %. In addition, the maximum amount of chlorophyll a, b and total was related to the treatment of sour orange fruit extract of 4.5 mg l^{-1}. In general, the results showed that benzyladenine had the maximum vase life but, natural compounds especially the extracts of Eucalyptus and sour orange had the significant effect on the vase life and the other traits of tuberose cut flowers and they can be used as simple, healthy and cheap compounds.

Keywords: Benzyladenine, Natural compounds, Tuberose, Vase life.

INTRODUCTION

Tuberose (*Polianthes tuberosa*) has been used by humans since 400 years ago as one of the important cut flowers (Joz-Ghasemi *et al*., 2013). This flower is one of the most important cut flowers with very fragrant buds (Ebtehaj *et al.*, 2012). Senescence after harvesting the cut flowers is the limiting factor in the marketability of this species and many efforts has been done to increase the longevity of postharvest flowers by using various chemical treatments (Bowyer *et al*., 2003). Therefore, it is necessary to use the proper preservative solution. The inability of the buds for developing and opening, buds falling (Joz-Ghasemi *et al*., 2010), and the few vase life are the important and usual problems after harvesting the cut flowers of tuberose.

Gibberellins and cytokinins are recommended for delaying the senescence of the cut flowers. Among cytokinins, artificial cytokinins are usually the most effective in delaying the aging and its probable reason is greater stability of these compounds (Davis, 1998). Effects of gibberellic acid and benzyladenine in the reduction of the oxidizing enzyme activity of Hosta leaves have been proven (Robiza Swider *et al.*, 2004). Dipping the head of flower in a solution of benzyladenine for a few minutes has been recommended to increase the vase life of gerbera (Dole and Wilkins, 1999).

In recent years, using natural compounds such as extracts of some fruits, essential oils and extracts of medicinal plants has been studied (Golshadi Ghaleh-Shahi *et al*., 2015). Researches have well demonstrated the fact that natural compounds can be proper alternatives for the artificial chemicals (Solgi *et al.,* 2009; Golshadi Ghaleh-Shahi *et al.*, 2015).

Many investigations have clearly shown the disadvantages of using chemical compounds. For example, silver salts have many uses as antimicrobial compounds in the preservative solution of cut flowers although it is a heavy metal that pollutes the drinking water. Moreover, its absorption by the body may damage the nervous system (Mayers *et al.*, 1997). Therefore, it is important to replace dangerous compounds with essential oils and extracts of herbs and fruits. However, the use of herbal essential oils has been studied more than herbal and fruit extracts. Basiri *et al*. (2011) reported that the application of rosemary extract increased the vase life of carnation. Samiee *et al*. (2013) reported that the use of *Artemisia* essential oil in the preservative solution of the cut flower of chrysanthemum delays the reduction of petal protein and leaf chlorophyll. The use of the *Eucalyptus* and lavender essential oils caused a reduction in bending of inflorescence of the *Gerbera* cut flowers (Ikani *et al.*, 2013).

Babarabie *et al*. (2014) stated that apple fruit extract apparently is a suitable solution for the vase solution of *Alstroemeria* because of containing some compounds such as malic acid, citric acid and fructose and that the application of 45 ml l^{-1} apple extract increased the total soluble solids of petal and the vase life of *Alstroemeria* cut flowers. Mehraj *et al*. (2013) showed that the application of lemon extract with sucrose improved the vase life of snowball cut flowers.

The purpose of this experiment was to investigate the effect of rosemary, eucalyptus and sour orange fruit extract and benzyladenine on the vase life and some physiological traits of tuberose cut flowers.

MATERIALS AND METHODS

This study was conducted in 2014 in a completely randomized design with three replications in the laboratory of Horticultural Sciences Department, Gorgan University of Agricultural Sciences and Natural Resources of Gorgan at temperature of 20 ± 2 °C, humidity of 60 ± 5%, the light of 600 lux with 12-hour lighting period. Tuberose cut flowers were prepared from a greenhouse at the Pakdasht city and were transferred to Gorgan after packaging in suitable condition. The applied treatments included plant extracts of rosemary and Eucalyptus (12.5, 25 and 50%), sour orange fruit extract (3, 4.5 and 6 ml l^{-1}) and BA (50, 100 and 150 mg l^{-1}). 4% sucrose was used in all treatments. Distilled water and 4% sucrose were used as the control. To produce herbal extracts, 1:10 ratio of plant material to water with distillers device was used. To use the sour orange fruit extract, several sour oranges were harvested from sour orange trees at the Campus of Agricultural Sciences

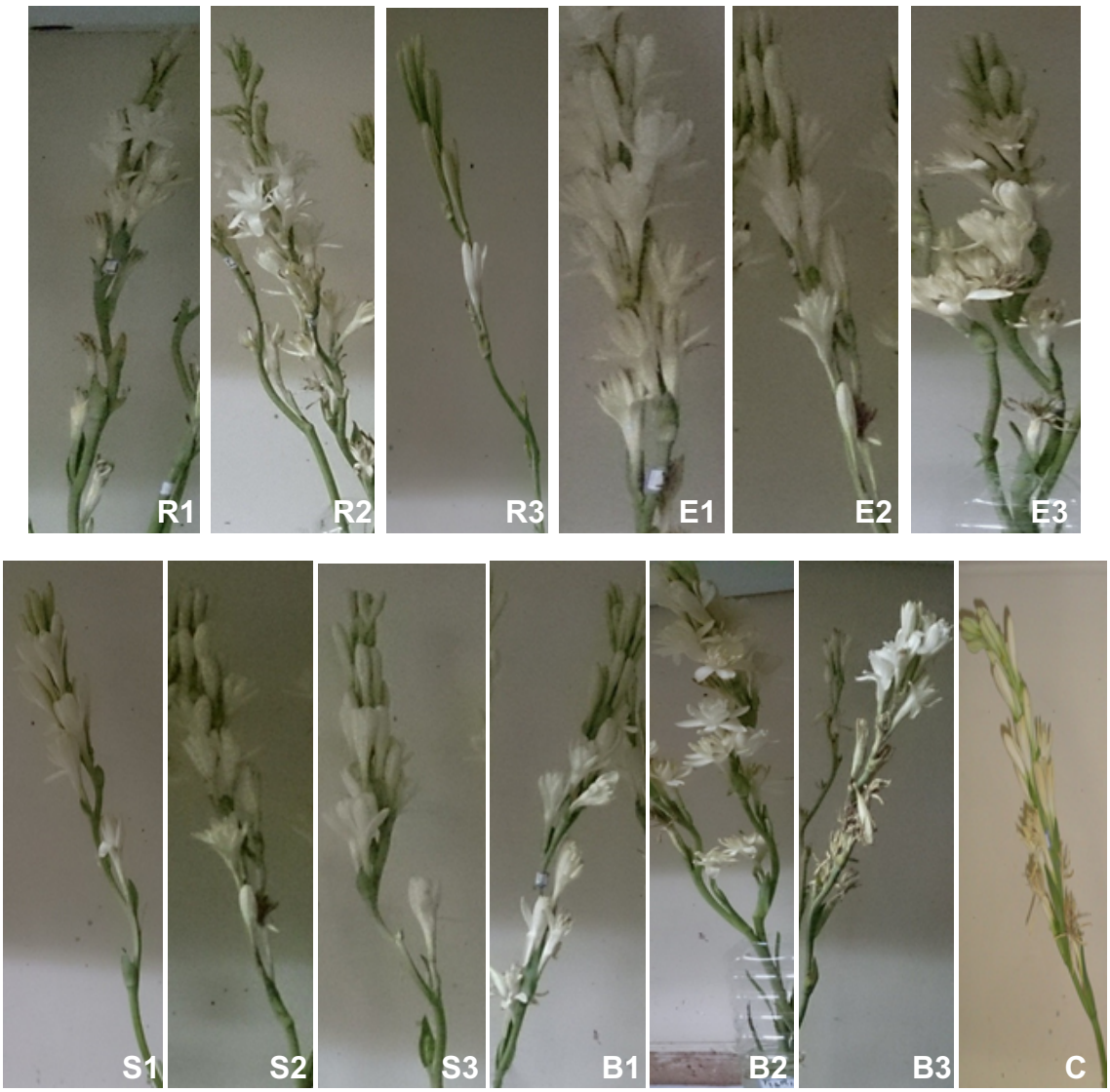

Fig. 1. Flower treated by preservative solutions on 7th day of experiment.

R1: Rosemary extract (12%)
R2: Rosemary extract (25%)
R3: Rosemary extract (50%)
C: Control
E1: *Eucalyptus* extract (12%)
E2: *Eucalyptus* extract (25%)
E3: *Eucalyptus* extract (50%)
S1: Sour orange fruit extract (3 ml l^{-1})
S2: Sour orange fruit extract (4.5 ml l^{-1})
S3: Sour orange fruit extract (6 ml l^{-1})
B1: Benzyladenine (50 mg l^{-1})
B2: Benzyladenine (100 mg l^{-1})
B3: Benzyladenine (150 mg l^{-1})

and Natural Resources of Gorgan University, and their extract was taken out with a hand juicer. Then, the concentration of the extracts was determined by a pH meter. For this purpose, pHs were considered 4, 5 and 6 that finally, concentrations of 3, 4.5, 6 ml l^{-1} were obtained for pH 6, 5 and 4, respectively.

Measured characteristics included vase life, opening of florets, relative fresh weight, absorption of solution, total soluble solids, chlorophyll a, chlorophyll b and total chlorophyll. Vase life was evaluated by Reid (1996)'s method in which the changes in flower color, falling of florets, and the opening of flowers are considered. Apparent quality was measured by the Amerin scoring method (Amerin *et al*., 1965). Characteristics such as the change in the color of petals and leaves, the wilting of the petals and the opening of buds were investigated. To measure this trait, a cut flower was selected in each replication. On the first day of experiment, score of 100% was considered for the all due to the same relative quality of flowers. On subsequent days, over time the scores were deducted due to the loss of flower quality. For example, the difference in apparent quality of flowers on the seventh day of experiment is shown in Fig. 1.

The percentage of flower opening was determined by counting the total number of florets

on the first day and daily counting of the open florets until the last days of each flower.

Relative fresh weight was measured by using a digital scale and was calculated by the following formula.

$w_t/w_{t=0} \times 100$= relative percentage of fresh weight (RFW)

W_t: Stem fresh weight in the same day and days 3, 6, ...

$W_{t=0}$ = Weight of the stem in day zero

Water absorption was measured by using a graduated cylinder and was calculated by the following formula.

$WA= (S_{t-1})-S_t /w_{t=0}$

WA: The amount of absorbed solution

S_t: Solution weight (g) in days zero, 3 and …

S_{t-1}: Solution weight (g) in the previous day

$W_{t=0}$: Stem fresh weight in day zero

For the measurement of soluble solids of petals, 0.5 g of petals was separated and pulverized in a mortar, and its extract was obtained after it was crushed. The Brix degrees of the obtained extract were read by using a manual refractometer device.

Arnon (1967)'s method was used to measure chlorophyll. Finally, the data were analyzed by SAS Software Package and the means were compared by using LSD test.

RESULTS

The results of analysis of variance of data showed that the effect of treatment, time and interaction between treatment were significant for all studied characters ($p<0.01$) (Table 1, 2 and 3).

Table 1. ANOVA of the effect of the treatment on vase life and florets opening of tuberose cut flowers.

S.O.V.	df	Vase life	Florets opening
Treatment	12	11.36**	783.58**
Error	24	0.083	1.3
CV (%)	-	3.27	2.08

Table 2. ANOVA of the effect of treatment and time on apparent quality of tuberose cut flowers.

S.O.V.	df	Apparent quality
Treatment	12	3090.06**
Time	11	19941.41**
Treatment × Time	132	92.55**
Error	312	48.29
CV (%)	-	10.27

Table 3. ANOVA of the effect of treatment and time on measured characteristics of tuberose cut flowers.

S.O.V.	df	Relative fresh weight	Solution absorption	TSS	Chlorophyll a	Chlorophyll b	Total chlorophyll
Treatment	12	1450.07**	0.113**	29.09**	0.017**	0.021**	.0038**
Time	3	27220.92**	0.723**	115.36**	0.481**	0.407**	0.889**
Treatment × Time	36	889.59**	0.003**	12.2**	0.007**	0.006**	0.013**
Error	104	263.05	0.324	0.0005	0.0003	0.00005	0.00006
CV (%)	-	18.41	12.09	0.47	10.23	4.61	2.59

**: Significant 1%

Vase life

The results showed that the maximum vase life (11.66 days) was obtained under the treatment of benzyladenine at the rate of 50 mg l^{-1} and that control treatment had the vase life of 6.33 days (Fig. 2).

Percentage of florets opening

The results showed that the highest and lowest florets opening was obtained in treatments of 150 mg l^{-1} benzyladenine and 50% rosemary extract, respectively (Table 4). In addition, among the natural compounds, the treatments of 25% *Eucalyptus* extract and 4.5 ml l^{-1} sour orange extract had a significant impact on the rate of florets opening (Table 4).

The relative fresh weight

The results showed that the maximum relative fresh weight was related to the treatment of 50 mg l^{-1} benzyladenine (Table 4). Nonetheless, this treatment resulted in no significant difference in relative

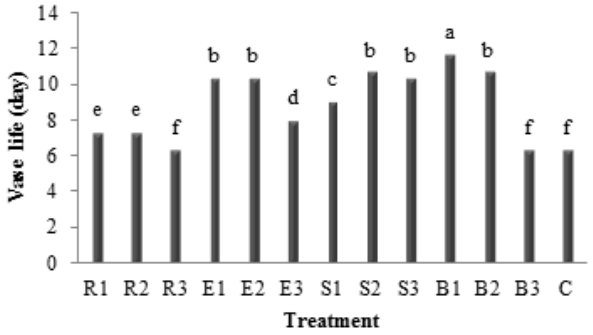

Fig. 2. The effect of preservative solutions on vase life of tuberose cut flowers.

R1: Rosemary extract (12%) E1: *Eucalyptus* extract (12%) S1: Sour orange fruit extract (3 ml l^{-1}) B1: Benzyladenine (50 mg l^{-1})
R2: Rosemary extract (25%) E2: *Eucalyptus* extract (25%) S2: Sour orange fruit extract (4.5 ml l^{-1}) B2: Benzyladenine (100 mg l^{-1})
R3: Rosemary extract (50%) E3: *Eucalyptus* extract (50%) S3: Sour orange fruit extract (6 ml l^{-1}) B3: Benzyladenine (150 mgl^{-1})
C: Control

Table 4. The effect of preservative solutions on measured characteristics of tuberose cut flowers.

Treatment	Bud opening (%)	Relative fresh weight (%)	Solution absorption (ml g^{-1} F W)	TSS (%)	Chlorophyll a (mg g^{-1} FW)	Chlorophyll b (mg g^{-1} FW)	Total chlorophyll (mg g^{-1} FW)	Apparent quality (%)
R1	46.83^{f}	86.97^{ab}	0.36^{ef}	3.47^{j}	0.13^{d}	0.12^{g}	0.22^{h}	62.22^{h}
R2	41.16^{g}	80.73^{bc}	0.39^{e}	3.71^{i}	0.17^{c}	0.15^{e}	0.29^{f}	64.72^{gh}
R3	26.52^{i}	75.29^{bc}	0.33^{fg}	2.85^{l}	0.12^{ef}	0.08^{h}	0.17^{i}	53.05^{i}
E1	68.46^{c}	96.19^{a}	0.51^{bc}	6.90^{a}	0.13^{d}	0.19^{c}	0.32^{e}	73.88^{cd}
E2	75.53^{b}	97.47^{a}	0.54^{b}	6.75^{b}	0.16^{c}	0.20^{b}	0.36^{c}	66.66^{fg}
E3	64.83^{d}	94.98^{a}	0.47^{d}	3.80^{h}	0.16^{c}	0.14^{f}	0.29^{f}	71.11^{de}
S1	59.90^{e}	96.58^{a}	0.48^{cd}	5.45^{f}	0.20^{b}	0.16^{d}	0.34^{d}	69.44^{ef}
S2	62.95^{d}	95.25^{a}	0.52^{bc}	5.85^{e}	0.22^{a}	0.21^{a}	0.43^{a}	77.50^{ab}
S3	36.76^{h}	86.90^{ab}	0.53^{b}	5.07^{g}	0.21^{b}	0.20^{b}	0.39^{b}	74.16^{cd}
B1	46.73^{f}	97.59^{a}	0.62^{a}	6.42^{c}	0.20^{b}	0.16^{d}	0.36^{c}	80.55^{a}
B2	63.80^{d}	98.54^{a}	0.51^{bc}	6.20^{d}	0.21^{b}	0.16^{d}	0.36^{c}	76.38^{bc}
B3	79.03^{a}	69.28^{c}	0.38^{e}	3.17^{k}	0.16^{c}	0.12^{g}	0.24^{g}	54.72^{i}
C	40.06^{g}	69.33^{c}	0.30^{g}	2.72^{m}	0.10^{f}	0.08^{i}	0.15^{i}	54.44^{i}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

R1: Rosemary extract (12%) E1: *Eucalyptus* extract (12%) S1: Sour orange fruit extract (3 ml l^{-1}) B1: Benzyladenine (50 mg l^{-1})
R2: Rosemary extract (25%) E2: *Eucalyptus* extract (25%) S2: Sour orange fruit extract (4.5 ml l^{-1}) B2: Benzyladenine (100 mg l^{-1})
R3: Rosemary extract (50%) E3: *Eucalyptus* extract (50%) S3: Sour orange fruit extract (6 ml l^{-1}) B3: Benzyladenine (150 mg l^{-1}
C: Control

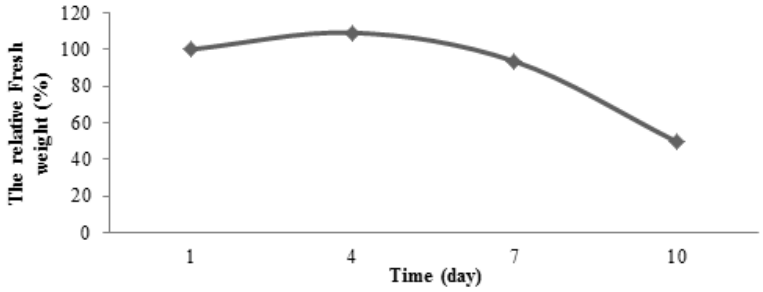

Fig. 3. The effect of postharvest time on the relative fresh weight of tuberose cut flowers.

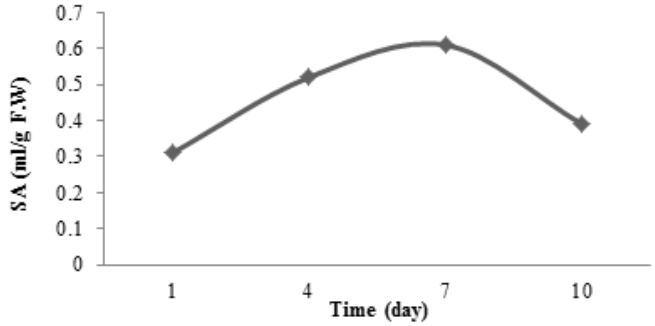

Fig. 4. The effect of postharvest time on solution absorption (SA) of tuberose cut flowers.

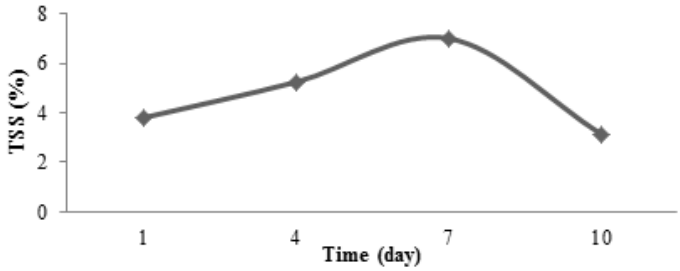

Fig. 5. The effect of postharvest time on total soluble solids (TSS) of tuberose cut flowers.

fresh weight as compared to treatments of *Eucalyptus* extract and sour orange extract. In addition, the minimum amount of relative fresh weight was related to 150 mg l^{-1} benzyladenine and control. The relative fresh weight of flowers was increased until the fifth day and after that it started to decreased (Fig. 3).

Solution absorption

The results showed that the highest solution absorption was obtained from the treatment of 50 mg l^{-1} benzyladenine. Extracts of rosemary, eucalyptus and sour orange resulted in significant differences as compared to control (Table 4). The solution absorption by flowers was increased until seventh day and after that it started to decrease (Fig. 4).

Total soluble solids

The results showed that the highest and the lowest levels of total soluble solids were obtained in the 12% eucalyptus extract treatment and in the control, respectively (Table 4). The amount of total soluble solids was increased until seventh day and then it was decreased (Fig. 5).

Chlorophyll a, chlorophyll b, total chlorophyll

Results showed that the maximum amount of chlorophyll a, b and total were obtained in 4.5 ml l^{-1} of sour orange extract treatment. Moreover, the results showed that all used treatments had significant difference in terms of the amount of chlorophyll of leaves compared to the control

Table 5. The interaction between treatment and time for relative fresh weight (g) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	100^{c}	100^{b}	100^{b}	100^{b}	100^{c}	100^{b}	100^{b}	100^{b}	100^{c}	100^{b}	100^{c}	100^{b}	100^{a}
4	116.09^{a}	107.34^{a}	107.75^{a}	107.6^{a}	103.63^{b}	112.14^{a}	117.55^{a}	106.19^{a}	109.99^{a}	112.19^{a}	111.04^{a}	113.02^{a}	94.68^{b}
7	103.34^{b}	92.97^{c}	73.31^{c}	91.49^{c}	118.61^{a}	94.64^{c}	87.1^{c}	85.74^{c}	102.31^{b}	98.57^{c}	101.32^{b}	45.02^{c}	60.56^{c}
10	28.46^{d}	22.63^{d}	20.1^{d}	85.67^{d}	67.66^{d}	73.15^{d}	81.69^{d}	55.67^{d}	68.71^{d}	79.61^{d}	81.79^{d}	19.1^{d}	22.1^{d}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

Table 6. The interaction between treatment and time for solution absorption (ml g^{-1} FW) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	0.31c	0.31c	0.31c	0.31d	0.31d	0.31d	0.31d	0.31d	0.31c	0.31d	0.31d	0.31c	0.31c
4	0.57a	0.49a	0.65a	0.6b	0.54b	0.34c	0.36c	0.42c	0.4b	0.87b	0.66a	0.45b	0.4a
7	0.36b	0.37b	0.49b	0.78a	0.6a	1.03a	0.69a	0.88a	0.72a	0.94a	0.63b	0.66a	0.39b
10	0.2d	0.15d	0.1d	0.36c	0.42c	0.47b	0.58b	0.49b	0.72a	0.36c	0.46c	0.1d	0.1d

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

Table 7. The interaction between treatment and time for total soluble solids (%) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	3.8^{b}	3.8^{c}	3.8^{a}	3.8^{d}	3.8^{c}	3.8^{d}	3.8^{c}	3.8^{d}	3.8^{c}	3.8^{d}	3.8^{d}	3.8^{b}	3.8^{b}
4	5.8^{a}	5.46^{a}	3.7^{b}	6.1^{c}	4.9^{b}	4.8^{c}	3.9^{b}	5.6^{c}	5.5^{b}	6.4^{c}	6.06^{b}	5.8^{a}	4.1^{a}
7	3.2^{c}	4.4^{b}	2.9^{c}	10.4^{a}	5.2^{a}	10.3^{a}	11.1^{a}	8.3^{a}	8.9^{a}	8.1^{a}	10.53^{a}	2.1^{c}	2.1^{c}
10	1.1^{d}	1.2^{d}	1^{d}	7.3^{b}	1.3^{d}	8.1^{b}	3^{d}	5.7^{b}	2.1^{d}	7.4^{b}	4.4^{c}	^{1}d	0.9^{d}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

R1: Rosemary extract (12%)
R2: Rosemary extract (25%)
R3: Rosemary extract (50%)
C: Control

E1: *Eucalyptus* extract (12%)
E2: *Eucalyptus* extract (25%)
E3: *Eucalyptus* extract (50%)

S1: Sour orange fruit extract (3 ml l^{-1})
S2: Sour orange fruit extract (4.5 ml l^{-1})
S3: Sour orange fruit extract (6 ml l^{-1})

B1: Benzyladenine (50 mg l^{-1})
B2: Benzyladenine (100 mg l^{-1})
B3: Benzyladenine (150 mg l^{-1})

Table. 8. The interaction between treatment and time on chlorophyll a (mg g^{-1} FW) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}	0.054^{d}
4	0.117^{b}	0.217^{b}	0.116^{b}	0.217^{a}	0.242^{b}	0.224^{b}	0.221^{b}	0.275^{b}	0.253^{b}	0.23^{b}	0.266^{b}	0.259^{a}	0.134^{b}
7	0.275^{a}	0.338^{a}	0.219^{a}	0.203^{b}	0.274^{a}	0.265^{a}	0.442^{a}	0.468^{a}	0.411^{a}	0.367^{a}	0.328^{a}	0.25^{b}	0.148^{a}
10	0.1^{c}	0.1^{c}	0.1^{c}	0.076^{c}	0.1^{c}	0.11^{c}	0.086^{c}	0.113^{c}	0.13^{c}	0.179^{c}	0.198^{c}	0.1^{c}	0.1^{c}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

Table. 9. The interaction between treatment and time on chlorophyll b (mg g^{-1} FW) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}	0.038^{d}
4	0.109^{b}	0.122^{b}	0.06^{c}	0.127^{c}	0.138^{b}	0.138^{c}	0.124^{c}	0.156^{c}	0.158^{c}	0.135^{c}	0.143^{c}	0.154^{b}	0.078^{c}
7	0.231^{a}	0.35^{a}	0.158^{a}	0.36^{a}	0.288^{a}	0.356^{a}	0.341^{a}	0.374^{a}	0.389^{a}	0.248^{a}	0.285^{a}	0.206^{a}	0.114^{a}
10	0.1^{c}	0.1^{c}	0.1^{b}	0.235^{b}	0.1^{c}	0.28^{b}	0.147^{b}	0.282^{b}	0.214^{b}	0.217^{b}	0.194^{b}	0.1^{c}	0.1^{b}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

Table 10. The interaction between treatment and time on the total chlorophyll (mg g^{-1} FW) of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}	0.093^{d}
4	0.227^{b}	0.339^{b}	0.177^{c}	0.344^{b}	0.38^{b}	0.362^{c}	0.345^{b}	0.431^{b}	0.411^{b}	0.365^{c}	0.409^{b}	0.413^{b}	0.213^{b}
7	0.506^{a}	0.688^{a}	0.377^{a}	0.564^{a}	0.562^{a}	0.621^{a}	0.783^{a}	0.842^{a}	0.8^{a}	0.615^{a}	0.613^{a}	0.456^{a}	0.262^{a}
10	0.2^{c}	0.2^{c}	0.2^{b}	0.311^{c}	0.2^{c}	0.39^{b}	0.233^{c}	0.395^{c}	0.344^{c}	0.396^{b}	0.392^{c}	0.2^{c}	0.2^{c}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

R1: Rosemary extract (12%)
R2: Rosemary extract (25%)
R3: Rosemary extract (50%)
C: Control

E1: *Eucalyptus* extract (12%)
E2: *Eucalyptus* extract (25%)
E3: *Eucalyptus* extract (50%)

S1: Sour orange fruit extract (3 ml l^{-1})
S2: Sour orange fruit extract (4.5 ml l^{-1})
S3: Sour orange fruit extract (6 ml l^{-1})

B1: Benzyladenine (50 mg l^{-1})
B2: Benzyladenine (100 mg l^{-1})
B3: Benzyladenine (150 mg l^{-1})

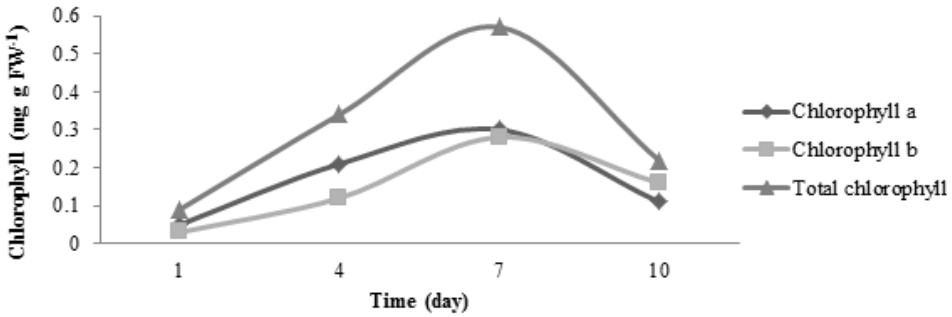

Fig. 6. The effect of postharvest time on chlorophyll of tuberose cut flowers.

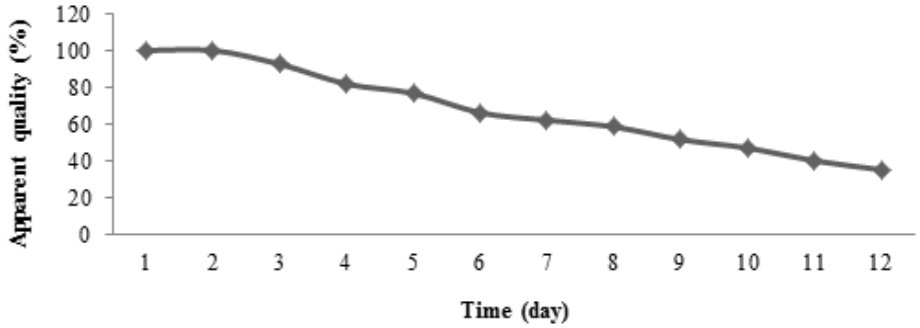

Fig. 7. The effect of postharvest time on the apparent quality of tuberose cut flowers.

(Table 4). Amount of leaf chlorophyll was increased until seventh day of experiment and after that it was decreased (Fig. 6).

Apparent quality

The results showed that the highest and lowest the apparent quality was obtained from the treatment of benzyladenine at 50 mg l^{-1} and the control, respectively (Table 4). The apparent quality of flowers was reduced from the second day (Fig. 7). The results of the means comparison of the traits related to apparent quality of flowers showed that there was a significant interaction between treatment and time (Table 11).

Table 11. The interaction between treatment and time for the apparent quality of tuberose cut flowers.

Time (day)	R1	R2	R3	E1	E2	E3	S1	S2	S3	B1	B2	B3	C
1	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}
2	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}
3	86.66^{b}	86.66^{b}	80^{b}	100^{a}	93.33^{b}	100^{a}	93.33^{b}	100^{a}	100^{a}	100^{a}	100^{a}	83.33^{b}	80^{b}
4	73.33^{c}	73.33^{c}	70^{c}	86.66^{b}	76.66^{c}	86.66^{b}	83.33^{c}	93.33^{b}	86.66^{b}	100^{a}	93.33^{b}	70^{c}	70^{c}
5	70^{d}	70^{d}	63.33^{d}	80^{c}	73.33^{d}	80^{c}	80^{d}	90^{c}	86.66^{b}	93.33^{b}	86.66^{c}	60^{d}	63.33^{d}
6	60^{e}	60^{e}	53.33^{e}	73.33^{d}	63.33^{e}	73.33^{d}	66.66^{e}	73.33^{d}	73.33^{c}	80^{c}	76.66^{d}	53.33^{e}	53.33^{e}
7	53.33^{f}	53.33^{f}	50^{f}	70^{e}	56.66^{f}	70^{e}	63.33^{f}	73.33^{d}	66.66^{d}	76.66^{d}	70^{e}	53.33^{e}	48.33^{f}
8	53.33^{f}	53.33^{f}	40^{g}	63.33^{f}	56.66^{f}	63.33^{f}	60^{g}	70^{e}	66.66^{d}	76.66^{d}	70^{e}	43.33^{f}	43.33^{g}
9	50^{g}	50^{g}	30^{h}	60^{g}	50^{g}	60^{g}	56.66^{h}	63.33^{f}	56.66^{e}	66.66^{e}	60^{f}	33.33^{g}	33.33^{h}
10	40^{h}	50^{g}	20^{i}	53.33^{h}	50^{g}	50^{h}	53.33^{i}	63.33^{f}	56.66^{e}	66.66^{e}	60^{f}	23.33^{h}	23.33^{i}
11	30^{i}	40^{h}	20^{i}	50^{i}	40^{h}	40^{i}	43.33^{j}	53.33^{g}	53.33^{f}	56.66^{f}	53.33^{g}	20^{i}	20^{j}
12	30^{i}	40^{h}	10^{j}	50^{i}	40^{h}	30^{j}	33.33^{k}	50^{h}	43.33^{g}	50g	46.66^{h}	16.66^{j}	16.66^{k}

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD test.

R1: Rosemary extract (12%) E1: *Eucalyptus* extract (12%) S1: Sour orange fruit extract (3 ml l^{-1}) B1: Benzyladenine (50 mg l^{-1})
R2: Rosemary extract (25%) E2: *Eucalyptus* extract (25%) S2: Sour orange fruit extract (4.5 ml l^{-1}) B2: Benzyladenine (100 mg l^{-1})
R3: Rosemary extract (50%) E3: *Eucalyptus* extract (50%) S3: Sour orange fruit extract (6 ml l^{-1}) B3: Benzyladenine (150 mg l^{-1})
C: Control

DISCUSSION

Cytokinin especially benzyladenine prevents the activities of ethylene, which is a harmful gas for cut flowers, and this compound is the most vital factor for delaying the petals and leaves of *Dianthus*, tuberose and *Matthiola incana* (Serek *et al*., 1995; Yang and Hoffman, 1984). It seems that benzyladenine increases the vase life as compared to the control by delaying the aging of tuberose cut flowers. Moreover, in this study, extracts of rosemary, eucalyptus and sour orange fruits increased the vase life. Germicidal and fungicidal compounds should be used in the vase solution of cut flowers to prevent the growth of microorganisms. The increase in the tuberose life with herbal and sour orange extracts may be due to their antimicrobial effect. Antibacterial and antifungal effect of many herbal extracts has been demonstrated (Wilson *et al*., 1997).

As mentioned, one of the major problems in tuberose cut flower is its disability in developing the florets. The growth of petals corresponding with the flowers opening is the result of the development of cells (Knee, 2000) and cell development requires the flow of water and osmolyte compounds such as carbohydrates into petal cells (Evans and Reid, 1988). Thus, sucrose can be used to provide the necessary carbohydrates. Hoseini Darvishani and Chamani (2013) reported that extracts of rosemary and thyme improved the development of rose flower buds. The results of Kushal and Arosa (2000) showed that benzyladenine solution increased the florets opening of tuberose cut flowers, which is consistent with our results.

Water use by flower petals delays the cell death. Danaei *et al.* (2011) reported that the treatment of 50 mg l^{-1} of benzyladenine increased the amount of relative fresh weight and solution absorption of gerbera cut flowers that is in agreement with the results of the present study. The positive effect of herbal extracts and essential oils on preservation of the relative fresh weight of cut flowers have been reported in some studies. Jalili Marandi *et al*. (2011) stated that the use of essential oils of *Carum copticum* and *Satureja hortensis* delayed the relative fresh weight loss of the rose cut flower. Ahmad and Dole (2014) used lemon extract with sucrose in vase solution of cut flowers of *Rose* and Sunflower. This treatment increased the fresh weight and the vase life of flowers. It seems that herbal extracts due to having antimicrobial compounds and sour orange extract due to having the acidic compounds have provided favorable conditions for the absorption of water by the vessels, and have increased the fresh weight of the flowers.

The amount of total soluble solids was increased since the beginning of the test to seventh day. There were some levels of soluble carbohydrates in their petals in most of the cut flowers when they were close to wilting suggesting that the cells had also stored some sugar at the wilting time. Perhaps despite a high concentration of sugar in the vacuoles, cell organelles such as mitochondria do not have the ability to use it (van Doorn, 2001).

It seems that extracts of eucalyptus, rosemary and sour orange provides the receiving of the sucrose in preservative solution for flowers and thereby increase the total soluble solids. Golshadi Ghale-Shahi *et al*. (2015) reported the use of sour orange extract increases the amount of total soluble solids of petals and stems of *Narcissus* cut flowers.

Leaf senescence is usually associated with a decrease in chlorophyll, which can be caused by reducing hormone plant (Kazemi *et al.*, 2014). Cytokinins delay the senescence of the flowers through delaying the decomposition of chlorophyll and protein in the leaves (Arteca, 1996). In the present study, the highest chlorophyll content was related to sour orange extract. Sour orange includes compounds such as citric acid and malic acid (Montazer and Niakosari, 2012). Malic acid can reduce ACC oxidase activity and decrease the production of ethylene. Darandeh and Hadavi (2012) showed that the treatment with 75 mg l^{-1} of malic acid delayed the reduction of chlorophyll of *Lilium* leaves. Sour orange fruit extract, which contains these compounds, may delay the reduction of chlorophyll in leaves of tuberose cut flowers. Furthermore, Basiri *et al*. (2011) stated that the use of rosemary extract treatment for carnation cut flowers delayed the reduction of chlorophyll content of leaves, which is in accordance with our results.

CONCLUSION

The results of current study showed that the treatment of benzyladenine at 50 mg l^{-1} provided the maximum vase life of cut flowers and that among natural treatments, *Eucalyptus* and sour orange extracts showed better results as compared to rosemary extract about the vase life and other measured characteristics. Although, benzyladenine had the maximum vase life and percentage of florets opening, natural compounds especially the extracts of *Eucalyptus* and sour orange had a significant effect on the vase life and other characteristics. Therefore, the vase life of the flowers treated with 4.5 ml l^{-1} of sour orange extract was only 1.33 days shorter than the flowers treated with 50 mg l^{-1} of benzyladenine. Generally, the results of current study showed that natural used extracts can be used as a simple, healthy and cheap compounds in vase solution of tuberose cut flowers.

Literature Cited

Ahmad, I. and Dole, M.J. 2014. Postharvest performance of cut marigold, Rose and Sunflower stem as influenced by homemade and commercial floral preservatives. Turkish Journal of Agriculture and Forestry. 38: 916-925.

Amerin, M.A., Pangborn, R. and Rossler, E.B. 1965. Principles of sensory evaluation of food. Academic Press, New York. 602p.

Arnon, A.N. 1967. Method of extraction of chlorophyll in the plants. Agronomy Journal. 23: 112-121.

Arteca, R.N. 1996. Plant growth substances, principle and applications. New Yourk. Chapman and Hall. 250-283.

Babarabie, M., Zarei, H. and Varasteh, F. 2014. Effect of rosemary and apple juice on vase life of *Alstroemeria*. Third National Congress and Conventional Farming. Ardabil. Mohaghegh Ardabili University. 140-142.

Basiri, Y., Zarei, H., Mashayekhy, K. and Pahlavany, M.H. 2011. Effect of rosemary extract on vase life and some qualitative characteristics of carnation cut flowers (*Dianthus caryophyllus* cv. White Librity). Stored Products and Postharvest Research. 2(14): 261- 265.

Bowyer, M. C. and Wills, R.B.H. 2003. Delaying postharvest senescence of cut flower. Rural Industries Research and Development Corporation, Jamaica. 51p.

Danaee, E., Mostofi, Y. and Moradi, P. 2011. Effect of GA_3 and BA on postharvest quality and vase life of *Gerbera* cut flowers. Horticulture, Environment and Biotechnology. 52(2): 140-144.

Darandeh, N. and Hadavi, E. 2012. Effect of pre-harvest foliar application of citric acid and malic acid on chlorophyll content and post-harvest vase life of *Lilium* cv. Brunello. Front Plant Sciences. 2: 106.

Davis, P.J. 1998. Plant hormones and their role in plant growth and development. Kluwer Academic Publishers. 432p.

Dole, J.M. and Wilkins, H.F. 1999. Floriculture principles and species. Prentice -Hall Inc. New Jersey. 613p.

Ebtehaj, F. Mostafa, Y., Naderi, R. and Kalatejari, S. 2012. Effect of chemical treatments and harvest stages on vase life of tuberose cut flowers. Horticulture Science. 26(1): 25-34.

Evans, R.Y. and Reid, M.S. 1988. Changes in carbohydrates and osmotic potential during rhythmic expansion of rose petals. HortSciences. 113: 884-888.

Golshadi Ghale-Shahi, Z., Babarabie, M., Zarei, H. and Danyaei, A. 2015. Investigating the potential of increasing the vase life of cut flower of *Narcissus* by using sour orange fruit extract and sucrose in the storage conditions. Journal of Ornamental Plants. 5(1): 21-28.

Hoseini Darvishani, S.S. and Chamani, A. 2013. Investigate the possibility of improving vase life of rose cut flowers by some organic treatments and STS. Journal of Horticulture Sciences. 44(1): 31-41.

Ikani, N., Kalateh Jari, S., Abdoosi, V., Hasanzadeh, A. and Goseinzadeh, S. 2013. Effect of nanosilver and plant essential oils on some of postharvest morphological and physiological characteristics

of cut *Gerbera*. Plant Ecophysiological Researches of Iran. 8(3): 47-57.
Jalili Marandi, R., Hassani, A., Abdollahi, A. and Hanafi, S. 2011. Application of *Carum copticum* and *Satureja hormonsis* essential oils and salicylic acid and silver thiosulfate in increasing the vase life of rose cut flower. Medicinal Plants Research. 5(20): 5034-3034.
Joz- Ghasemi, S., Mortazavi, S.N. and Khodadi, M. 2013. Evaluation of effective factors on vase life of tuberose cut flowers (cv. Pearl). Journal of Horticulture Sciences. 28(3): 288-294.
Kazemi, S., Hasanpoor Asil, M. and Ghasemnejad, M. 2014. Evalution physiological effects of some of essential oils with comporison of 8-hydroxy quinoline in cut *Lisianthus.* Iran Horticultural Sciences. 45(2): 185-195.
Knee, M. 2000. Selection of biocidides for use in floral preservatives. Postharvest Biology and Technology. 18: 227-234.
Kushal, S. and Arosa, J.S. 2000. Effect of harvesting stages, BAP and GA3 on bud opening and vase life of tuberose. Journal of Ornamental Horticulture. 3: 111-113.
Mayers, A., Newman, J., Reid, M. and Dodge, L. 1997. New ethylene inhibitor could extend flower life. Perishables Handling Quarterly Issue No. 92.
Mehraj, H., Ona, A.F., Taufique, T., Mutahera, S. and Jamal Uddin, A.F.M. 2013. Vase life quality improvement of white snowball using vase life extanding solutions. Bangladesh Research Publications . 8(3): 191-194.
Montazer, Z. and Niakosari, M. 2012. Evaluation of the various stages of orange juice color changes during storage. Food Science and Technology. 37(9): 109-121.
Reid, M. 1996. Postharvest handling recommendation for cut tuberose, perishables handing. News Letter. 88: 21-22.
Robiza-Swider.J., Lukaszewska, A., Skutnik, E., Rybka, Z. and Wachowicz, M. 2004. Lipoxygenase in senescing cut leaves of *Zatedeschia aethiopica*. and Hosta "Undulata Erromena" treated with GA_3 or BA. Acta Physiologiae Plantarum. 26(4): 411-415.
Samiee, M., Zarchini, M., Haji Vand, S. and Hashemabadi, D. 2013. Improvement vase life, protein content and postharvest quality of *Dendranthema grandiflorum* by Artemisia oil. Annals of Biological Research. 4(3): 127-129.
Serek, M., Sisler, E. and Reid, S. 1995. 1-Methylcopropene, A novel gaseous inhibitor of ethylene action. Acta Horticulturae. 394: 337-345.
Solgi, M., Kafi, M., Taghavi, T.S. and Naderi, R. 2009. Essential oil and silver nanoparticles as novel agents to extend vase life *Gerbera* flowers. Postharvest Biology and Technology. 53: 155-158.
van Doorn, W.G. 2001. Role of soluble carbohydrates in flower senescence. Acta Horticulturea. 543: 179-183.
Wilson, C.L., Solar, J.M., El Ghauth, A. and Wisiniewski, M.E. 1997. Rapid evaluation of plant extracts and essential oils for antifungal activity against *Botrytis cinerea*. Plant Disease. 81: 204-210.
Yang, S.F. and Hoffman, N.F. 1984. Ethylen biosynthesis and its regulation in higher plant. Plant Physiology. 35: 153-189.