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Applications of Essential Oils to Prolong the Vase Life of Rose (*Rosa hybrida* L. cv. "Grand") Cut Flowers

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Abstract: Nine essential oils were investigated namely; anise (*Pimpinella anisum* L.), cumin (*Cuminium cyminum* L.), geranium (*Pelargonium graveolens* L. (Hér)), common lavender (*Lavandula angustifolia* Mill.), sage (*Salvia officinalis* L.), sweet basil (*Ocimum basilicum* L.), cinnamon (*Cinnamomum zeylanicum* Blume.), blue gum (*Eucalyptus camaldulensis* Dehnh.) and lemon grass (*Cymbopogon citratus* (DC.) Stapf.) and tested as antimicrobial agents for effects on the vase life and other related characters of rose cut flowers. The results indicated that lavender, geranium, anise and cumin oils significantly prolonged the vase life of rose cut flowers and increased the fresh weight and water uptake. Also, the first three oils had a superior effect in terms of reducing the rate of water loss. Cut roses that were treated with blue gum, geranium or anise and cumin oils had the lowest transpiration rates. Cinnamon, sage, blue gum and sweet basil oils came in the second rank in their effects on the studied characters of rose cut flowers. There were no significant differences between the effects of lemon grass and the control on the studied characters. Examination with a scanning electron microscope revealed that geranium, lavender, anise and sweet basil oils suppressed the blockage of xylem vessels by reducing the number of bacteria and fungi in the vase solutions, compared to the control or to the flowers treated with cinnamon or lemon grass oils, in which xylem vessels were blocked and the cells destroyed, with the appearance of masses of these microorganisms.

Key words: Essential oils · Rose cut flowers · Vase life · Water uptake · Scanning electron microscope

INTRODUCTION

Roses (*Rosa hybrida* L.), the most important ornamental species of the Rosaceae family, are recognized for their high economic value and are used in agro-based industries, especially in cosmetics and perfumes. Additionally, roses play a vital role in the manufacturing of various products of medicinal and nutritional importance. However, roses are mainly cultivated for the commercial production of their cut flowers, which constitute a considerable portion of the floriculture business [1, 2].

Vase life of rose cut flowers is usually short. Cut flowers wilt and the floral axis becomes bent below the flower head (bent-neck). The development of such symptoms is considered to be caused by vascular occlusion, which inhibits water supply to the flowers. The major form of vascular occlusion is the blockage of xylem vessels by air and microorganisms [3]. Microorganisms, especially bacteria and fungi which grow in preservative solutions have a marked adverse effect on the longevity of cut flowers. These microorganisms and their chemical products plug the stem ends and restrict the water absorption, which in turn decreases the longevity of flowers [4].

The main tool in this study is to use the essential oils as safe and environmentally friendly substances and for their antimicrobial properties against some bacteria and fungi [5, 6]. The main constituents of the used essential oils are phenolic and monoterpenic compounds. The antimicrobial mechanism of essential oils is due to the synthetic inhibition of DNA, RNA, protein and polysaccarides [7].

The aim of this study was to prolong the vase life of cut flowers and to keep their freshness for long periods by using some essential oils.

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MATERIALS AND METHODS

Experimental Site: The experiment was carried out at the laboratory of the Ornamental Horticultural Department, Faculty of Agriculture, Cairo University during the two seasons 2010-2011.

Extraction of Essential Oils: The selected essential oils were extracted by steam distillation for 5-6 hrs in the laboratory according to the method described in the British Pharmacopeia [8]. The essential oils were extracted from different plant parts depending on the species; from seeds (as in anise and cumin), leaves (as in sage, sweet basil, blue gum and lemon grass), herb (as in geranium), flowers (as in common lavender) and from bark (as in cinnamon).

The selected essential oils were tested at three concentrations (25, 50 and 100 mg L^{-1}). Stock solutions of the oils were prepared by dissolving 0.4 g of the crude oil in 100 ml of 80% ethyl alcohol, giving a stock solution of 4000 mg L^{-1} of each tested oils. Triton x 100 was used to dissolve the oil before adding to the preservative solutions. From the nine stock solutions, the three mentioned concentrations were prepared for the experiments, in addition to the control treatment (ethyl alcohol + water + Triton x100).

Plant Materials: Rose flowers were obtained from a commercial nursery in Giza governorate, Egypt. The flowers stems were cut in the greenhouse to a length of 45-50 cm, at normal harvest maturity (sepals starting to reflex), then placed in tap water and pre-cooled at 2°C for 24 hrs. Roses were moved to the laboratory which had an average temperature of 23°C. Prior to the start of the experiments, the flower stems were re-cut to a length of 40 cm. The rose cut flowers were then placed in glass bottles (750 ml) containing 500 ml of the oil solution. The experiment was carried out at room temperature (23 ± 1°C), 70% relative humidity and light from a white fluorescent lamp.

Experimental Design: The layout of this experiment was a completely randomized design (CRD) with three replicates for each treatment. Each replicate consisted of one glass bottle in which 3 cut rose flowers were placed. Then each treatment was represented by 9 cut flowers/ treatment.

Data Recorded: Vase life was recorded as a main parameter. Fresh weight of cut flowers and the volume of water uptake were recorded daily. The volume of water loss was calculated by subtracting the increase in fresh weight from the volume of water uptake. Transpiration rate was calculated by dividing the amount of water loss by the initial fresh weight [9].

Microscopic Examination: Scanning electron microscopy (SEM) was conducted to examine the xylem occlusion of flower stems. At the end of vase life, two sections (0.5 cm in length and thickness) were taken at the base of cut flower stems which receiving the control treatment as well as those treated by lavender, geranium, anise, sweet basil, cinnamon and lemon grass oils at the concentration of 25 mg L^{-1}. Flower stem samples were dried in a dryer apparatus and fragments were positioned on stubs prior to gold coating in a sputter coater (SC 11430, USA), using the method described by Kim and Lee [10]. Following coating with a thin layer of gold the specimens were examined and were micro graphed using SEM (Jeol JSM-5200, Japan).

Bacteria and Fungi Counts: The microbiological examination of the holding solution was carried out at the Central Laboratory, Faculty of Agriculture, Cairo University, where 10 ml vase solution samples were taken and diluted in 1% (w/v) water peptone solution. A standard plate count was applied for enumerating the total bacteria on glucose-yeast-extract agar [11]. Plates were aerobically incubated at 30°C for 48 hrs. Fungal isolates were counted according to some of their morphological characteristics and microscopic examination [12]. The bacterial and fungal counts were recorded at the fourth day of the vase life for all treatments because it is the last day of vase life of control flowers.

Statistical Analysis: The recorded data were statistically analyzed as combined analysis of variance over two seasons with two ways factor. Analysis was conducted by MSTAT-C software package [13]. Comparison of means was done using the Least Significant Difference (LSD) test at the 0.05 level as described by Snedecor and Cochran [14]. Prior to statistical analysis of daily fresh weight and cumulative percentages data were transformed to Arc sin.

RESULTS

Vase Life: Data in Table 1 showed that the used essential oils and concentrations as well as the interaction between them have significant effects on vase life of rose cut flowers. Regardless the effect of essential oil concentrations and relative to the control, common

Table 1: Effects of essential oil treatments on the vase life of rose cut flowers (average of two seasons).

	Vase life (days)			
	Essential oil concentrations (mg L^{-1}) (B)			
Essential oils (A)	25	50	100	Mean (oil)
Control	4.00	4.00	4.00	4.00
Anise	7.20	7.40	6.80	7.13
Cumin	7.40	6.40	5.20	6.33
Geranium	7.60	6.40	5.60	6.53
Common lavender	8.20	7.80	6.40	7.47
Sage	5.40	5.00	4.80	5.07
Sweet basil	5.80	5.40	4.80	5.33
Cinnamon	4.20	4.60	4.60	4.47
Blue gum	5.40	5.20	5.40	5.33
Lemon grass	4.00	4.00	4.00	4.00
Mean (Conc.)	5.92	5.62	5.16	

$LSD_{5\%}$: Oil (A) = 0.28, Concentration (B) = 0.22, Oil X Conc. (A X B) = 0.18

lavender oil had a significant effect on prolonging the vase life of rose cut flower. The prolongation percentage exceeded that of control by 86.75%. Anise, geranium and cumin oils came in the following categories after lavender in their effects on vase life by (78.25, 63.25 and 58.25%), respectively although there is significant difference between the last two oils. Contrary, the shortest periods of vase life, relative to the control, were observed with the cinnamon, sage followed by blue gum or sweet basal oils (11.75, 26.75 and 33.25%) in the same order. There was no significant difference between the control treatment and that of lemon grass on their effect on vase life.

Concerning the essential oils concentrations, 25 mg L^{-1} had the greatest effect (5.92 days) on prolonged the vase life of rose cut flowers, contrary with the effect of 100 mg L^{-1} (5.16 day). Meanwhile the effect of 50 mg L^{-1} was in between the previous two effects (5.62 day). Common lavender oil at 25 and 50 mg L^{-1} significantly prolonged the vase life of rose cut flowers by 105 and 95% compared to the control, while flowers treated by anise oil at the highest concentration (100 mg L^{-1}) had a longer vase life than that flowers treated with any of the other oils at the same concentration. The other essential oil treatments showed a relatively narrow range of significant effects on prolonging the vase life, compared to the control. The prolongation percentages of vase life, compared to the control, ranged between 5 to 15% with cinnamon oil at 25 mg L^{-1} and 50/or 100 mg L^{-1}, respectively. There was no significant difference between the values of vase life of flowers treated with the different concentrations of lemon grass and that of the control treatment (Table 1).

From these results, it could be concluded that, depending on their effect on vase life, the oils with highly significant effects were common lavender, geranium, cumin and anise, while the oils with moderate effects were sweet basil, sage, blue gum and cinnamon. In contrast that oil which had no significant effect on vase life was lemon grass.

Relative Fresh Weight: Generally data in Table 2 showed that, the relative percentages of fresh weight were significantly varied upon the used essential oils or the adopted concentrations. It is obvious also that control flowers sustained alive for only four days in contrast those received any concentration of the used oils, where the latter remaining relatively longer period till the 6^{th} or 8^{th} day. Flowers treated with anise oil at 50 mg L^{-1} in the 2^{nd} day represented the highest percentage of fresh weight (116.7%) among all oils and concentrations.

Comparing to the control at the 4^{th} day and concerning, the effect of the essential oil on this character, it could be stated that geranium, lavender, cumin and anise oils presented the highest flower fresh weight percentages; 51.42, 50.25, 49.92 and 45.08%, respectively. Reversely, flowers treated with lemon grass and cinnamon produced the lowest percentages of fresh weight (18.03 and 21.70%).

The adopted concentrations represented fluctuation effects on the fresh weight percentages. The flower treated with geranium, lavender and cumin oils at 25 mg L^{-1} produced the highest percentages of fresh weight (62.94, 62.94 and 55.76%), in addition to anise oil (62.10%) at 50 mg L^{-1}. The lowest percentages of fresh weight (19.37 and 24.88%) were observed with those flowers treated with cinnamon and lemon grass at 100 mg L^{-1}.

Water Relations: The importance of improving water relations as a means for prolonging the vase life of rose cut flowers has long been recognized and there have been substantial studies of the factors affecting water relations of different species of cut flowers [15-18]. In general, the water relations of cut flowers are determined by the difference between the amount of water lost by transpiration and the water uptake. When transpiration is high and the water uptake is low, the flowers will wilt and the vise versa.

Table 2: Effect of various concentrations of tested oils on relative fresh weight (% from initial F.W) of rose cut flowers (average of two seasons).

		Days															
		1		2		3		4		5		6		7		8	
Essential																	
Oils	Conc.ml/L.	%	Arc	%	Arc	%	Arc	%	Arc	%	Arc	%	Arc	%	Arc	%	Arc
Control	0	100	97.8	92.7	90.7	76.1	100	61.2	59.9	0	0	0	0	0	0	0	0
Anise	25	100	97.8	113.8	111.3	102.2	100	99	96.8	94.2	92.1	89.6	87.6	81.6	79.8	78	76.3
	50	100	97.8	119.3	116.7	108.6	106.2	99.3	97.1	91.4	89.4	88.6	86.7	84.4	82.5	81.3	79.5
	100	100	97.8	103.5	101.2	99.4	97.2	96	93.9	88.5	86.6	83.3	81.5	79.9	78.1	0	0
Mean		100	97.8	107.3	105.0	96.6	100.9	88.9	86.9	68.5	67.0	65.4	64.0	61.5	60.1	39.8	39.0
Cumin	25	100	97.8	113.1	110.6	101.8	99.6	95.4	93.3	86.3	84.4	80.3	78.5	78.8	77.1	75	73.4
	50	100	97.8	106	103.7	95.4	93.3	88.7	86.7	87	85.1	84.8	82.9	81.3	79.5	0	0
	100	100	97.8	102.8	100.5	96.2	94.1	91.3	89.3	84.8	82.9	77.5	75.8	0	0	0	0
Mean		100	97.8	107.3	104.9	97.8	95.7	91.8	89.8	86.0	84.1	80.9	79.1	53.4	52.2	25.0	24.5
Geranium	25	100	97.8	115.8	113.3	102.2	100	99.8	97.6	91.3	89.3	87.9	86	84.9	83	81.3	79.5
	50	100	97.8	109.9	107.5	99	96.8	94.1	92	88.7	86.7	81.7	79.9	80.5	78.7	0	0
	100	100	97.8	107.2	104.8	98.9	96.7	84.3	82.4	72.6	71	61.8	60.4	0	0	0	0
Mean		100	97.8	111.0	108.5	100.0	97.8	92.7	90.7	84.2	82.3	77.1	75.4	55.1	53.9	27.1	26.5
Common	25	100	97.8	118.2	115.6	101.8	99.6	99.8	97.6	87.2	85.3	84.2	82.3	81.2	79.4	79.1	77.4
Lavender	50	100	97.8	116.3	113.7	101.9	99.7	95.3	93.2	90.4	88.4	88.6	86.7	82.8	81	78.1	76.4
	100	100	97.8	105.8	103.5	88.5	86.6	81.1	79.3	77.4	75.7	75.4	73.7	69.6	68.1	0	0
Mean		100.0	97.8	113.4	110.9	97.4	95.3	92.1	90.0	85.0	83.1	82.7	80.9	77.9	76.2	52.4	51.3
Sage	25	100	97.8	106.9	104.5	99	96.8	84.2	82.3	79	77.3	72.1	70.5	0	0	0	0
	50	100	97.8	104.9	102.6	98.6	96.4	90.2	88.2	84.4	82.5	74.3	72.7	0	0	0	0
	100	100	97.8	90	88	82	80.2	76.4	74.7	69.7	68.2	0	0	0	0	0	0
Mean		100.0	97.8	100.6	98.4	93.2	91.1	83.6	81.7	77.7	76.0	73.2	71.6	0.0	0.0	0.0	0.0
Sweet Basil	25	100	97.8	103.3	101	97.8	95.6	88.4	86.5	74.9	73.3	70	68.5	0	0	0	0
	50	100	97.8	102.5	100.2	93.8	91.7	84.2	82.3	71	69.4	0	0	0	0	0	0
	100	100	97.8	90.8	88.8	83.2	81.4	75.7	74	69.9	68.4	0	0	0	0	0	0
Mean		100	97.8	98.9	96.7	91.6	89.6	82.8	80.9	71.9	70.4	23.3	22.8	0.0	0.0	0.0	0.0
Cinnamon	25	100	97.8	88.6	86.7	78.3	76.6	72.2	70.6	68.7	67.2	0	0	0	0	0	0
	50	100	97.8	84.2	82.3	78.2	76.5	75.1	73.4	68.2	66.7	0	0	0	0	0	0
	100	100	97.8	89	87	81.6	79.8	76.5	74.8	71.1	69.5	0	0	0	0	0	0
Mean		100	97.8	87.3	85.3	79.4	77.6	74.6	72.9	69.3	67.8	0.0	0.0	0.0	0.0	0.0	0.0
Blue gum	25	100	97.8	101.6	99.4	92.8	90.8	84.1	82.2	78.7	77	77	75.3	0	0	0	0
	50	100	97.8	91.4	89.4	83.2	81.4	77.4	75.7	72.5	70.9	68.4	66.9	0	0	0	0
	100	100	97.8	101.3	99.1	92.3	90.3	85.2	83.3	79.1	77.4	71.5	69.9	0	0	0	0
Mean		100	97.8	98.1	96.0	89.4	87.5	82.2	80.4	76.8	75.1	72.3	70.7	0.0	0.0	0.0	0.0
Lemon Grass	25	100	97.8	87.2	85.3	81.3	79.5	73	71.4	63.1	61.7	0	0	0	0	0	0
	50	100	97.8	91.8	89.8	80	78.2	70.7	69.1	62.1	60.7	0	0	0	0	0	0
	100	100	97.8	92.6	90.6	81.3	79.5	73.1	71.5	62.7	61.3	0	0	0	0	0	0
Mean		100	97.8	90.5	88.6	80.9	79.1	72.3	70.7	62.6	61.2	0.0	0.0	0.0	0.0	0.0	0.0
LSD $_{5\%}$ Oil			---		1.12		1.33		1.35		1.54		1.9		1.03		1.78
LSD $_{5\%}$ conc.			---		5.83		2.92		4.12		3.57		3.19		2.04		2.53

Water Uptake: Regardless the effect of essential oil concentrations, common lavender oil had a significant effect on increasing the water uptake by rose cut flower by 214.8% over the control effect, which reflecting on prolonging the vase life, followed by geranium then anise or blue gum oils by 177.7 and 159.3%, respectively. While using cinnamon and sage oils represented the lowest values of water uptake (55.55 and 92.95%) comparing to the control. The intermediate effect of oils on the values of water uptake was noticed with cumin, sweet basil and lemon grass oils.

Table 3: Effect of essential oil treatments on water uptake by rose cut flowers (average of two seasons)

	Water uptake (ml/g)			
	Essential oil concentrations (mg L^{-1})			
Essential oils	25	50	100	Mean (oil)
Control	0.27	0.27	0.27	0.27
Anise	0.64	0.77	0.69	0.70
Cumin	0.81	0.56	0.48	0.62
Geranium	0.85	0.84	0.57	0.75
SCommon lavender	1.09	0.88	0.59	0.85
Sage	0.58	0.49	0.49	0.52
Sweet basil	0.61	0.63	0.54	0.59
Cinnamon	0.49	0.43	0.35	0.42
Blue gum	0.64	0.77	0.69	0.70
Lemon grass	0.81	0.56	0.48	0.62
Mean (Conc.)	0.65	0.58	0.49	

$LSD_{5\%}$: Oil = 0.12, Concentration = 0.06, Oil X Concentration = 0.20

Table 4: Effect of various concentrations of tested oils on water loss of rose cut flowers (average of two seasons)

	Water Loss (ml/g)			
	Essential oil concentrations (mg L^{-1})			
Essential Oils	25	50	100	Mean
Control	0.73	0.73	0.73	0.73
Anise	0.53	0.42	0.32	0.42
Cumin	0.62	0.54	0.45	0.54
Geranium	0.53	0.43	0.36	0.44
Common lavender	0.58	0.51	0.46	0.52
Sage	0.68	0.68	0.64	0.67
Sweet basil	0.61	0.54	0.50	0.55
Cinnamon	0.65	0.57	0.52	0.58
Blue gum	0.60	0.55	0.49	0.55
Lemon grass	0.63	0.59	0.55	0.59
Mean	0.62	0.57	0.50	

$LSD_{5\%}$: Oil = 0.018, Concentration = 0.047, Oil X Concentration = 0.041

Concerning the essential oils concentrations, 25 mg L^{-1} had the greatest effect (0.65 ml/g) on increasing the amount of water uptake by rose cut flowers, contrary with the effect of 100 mg L^{-1} (0.49 ml/g). Meanwhile the effect of 50 mg L^{-1} was intermediate between the previous two effects (0.58 ml/g).

The obtained results (Table 3) showed that the tested essential oils which significantly increased water uptake by rose cut flowers and resulted in prolonging the vase life includes common lavender and geranium oils at 25 and 50 mg L^{-1}, as well as cumin or lemon grass oil at 25 mg L^{-1}, while the effect of anise or blue gum oils came in the third rank at all concentrations. Common lavender and geranium oils at 25 and 50 mg L^{-1} significantly increased the amount of water uptake of rose cut flowers by 303.7 - 225.9% and 214.8 - 211.11% over the control. Flowers treated by anise or blue gum oils at the same concentrations represented an intermediate effects (137.0 -185.2%) on increasing the mount of water uptake absorbed than that flowers treated with any of the other oils at the same concentrations. The other essential oil treatments showed the lowest range of significant effects, compared to the control. This range was between 29.62 with cinnamon at 100 mg L^{-1} to 125.9% with sweet basil at 25 mg L^{-1} (Table 3).

Water Loss: Regardless the effect of essential oil concentrations and relative to the control treatment, anise and geranium oils had a significant effect on decreasing the amount of water loss by rose cut flower by 42.46 and 39.73 %, followed by common lavender then cumin and blue gum oils by 28.76, 26.03 and 24.66 %, respectively. While using sage and lemon grass oils represented the highest percentages of water loss by flower (8.21 and 19.18 %) comparing to the control. The intermediate effect of oils on the percentages of water loss (24.66 and 20.55%) was noticed with sweet basil and cinnamon oils, respectively.

Concerning the essential oils concentrations, 100 mg L^{-1} had the greatest effect on decreasing the amount of water loss by rose cut flowers, contrary with the effect of 25 mg L^{-1}. Meanwhile the effect of 50 mg L^{-1} was intermediate between the previous two effects.

Anise and geranium oils at 100, 50 then 25 mg L^{-1}, as well as common lavender at 50 and 25 mg L^{-1} represented the lowest percentages of water loss by the treated flowers. Anise and geranium oils significantly decreased the amount of water loss of rose cut flowers by (55.62, 42.47 and 27.40%) and (51.78, 41.10 and 28.07%) compared to control. The sage oil treatments showed the highest percentages of water loss by flowers (12.33, 6.85 and 6.85%) at the same concentrations, compared to the control. Flowers treated by sweet basil, cinnamon, blue gum and lemon grass oils represented an intermediate effects on decreasing the amount of water loss (Table 4).

Transpiration Rate: Generally, as the transpiration rate decreased the vase life of cut flowers increased. Regardless the effect of essential oil concentrations and relative to the control treatment, geranium, anise, cumin then blue gum had a significant effect on decreasing the amount of transpiration rate by rose cut flower by 38.98, 33.90, 20.34 and 18.64 %, respectively. While using sage

Table 5: Effect of various concentrations of tested oils on transpiration rate of rose cut flowers (average of two seasons)

	Transpiration Rate (ml/g)			
	Essential oil concentrations (mg L^{-1})			
Essential Oils	25	50	100	Mean
Control	0.59	0.59	0.59	0.59
Anise	0.47	0.38	0.31	0.38
Cumin	0.57	0.51	0.46	0.47
Geranium	0.43	0.35	0.31	0.36
Common lavender	0.57	0.53	0.40	0.50
Sage	0.64	0.63	0.60	0.63
Sweet basil	0.58	0.54	0.49	0.54
Cinnamon	0.58	0.53	0.51	0.54
Blue gum	0.56	0.44	0.43	0.48
Lemon grass	0.59	0.57	0.53	0.56
Mean	0.56	0.51	0.46	----

$LSD_{5\%}$: Oil = 0.024, Concentration = 0.046Oil X, Concentration = 0.062

oil represented the highest values of transpiration rate (6.78%) comparing to the control. The effect of common lavender, sweet basil, cinnamon and lemon grass on the transpiration rate of rose cut flowers was intermediate.

Concerning the essential oils concentrations, 100 mg L^{-1} had the greatest effect on decreasing the rate of transpiration by rose cut flowers, contrary with the effect of 25 mg L^{-1}. Meanwhile the effect of 50 mg L^{-1} was intermediate between the previous two effects.

Anise and geranium oils at 100, 50 then 25 mg L^{-1}, as well as common lavender at 100 mg L^{-1} represented the lowest values of transpiration rate by the treated flowers. Anise and geranium oils significantly decreased the rate of transpiration of rose cut flowers by (47.46, 35.59 and 20.34%) and (47.46, 40.78 and 27.12 %) compared to control. The sage oil treatments showed the highest percentages of water loss by flowers (1.69, 6.78 and 8.47%) at the same concentrations, compared to the control. Flowers treated by sweet basil, cinnamon, blue gum and lemon grass oils represented an intermediate effects between the highest and lowest ones on decreasing the rate of transpiration (Table 5).

Scanning Electron Microscopy (SEM): The transportation of water and minerals through the xylem vessels is of vital importance for the development of cut flowers. Occlusion of these vessels by the microorganisms present in preservative solution is a common problem affecting the vase life and the quality of cut flowers.

Samples of stem base for scanning electron microscopy (SEM) trial were taken at the end of the vase life of the flowers held in the solution of control treatment, as well as samples from the that flowers in solutions containing different oils especially at 25 mg L^{-1}, which gave the best results for vase life, compared to the other two concentrations. The results of the study showed that the xylem vessels of the majority of rose cut flower stems which were held in the control solution, or in solutions containing oils of sweet basil, cinnamon or lemon grass were conspicuously plugged by the accumulation of microorganisms (bacteria and fungi). The growth of these organisms destroyed the vessel cells and, as a result, xylem occlusion took place.

Table 6: Effect of different essential oil concentrations on total counts of bacteria and fungi at day four (Log ^{10} CFU/ml)

	Bacteria counts at day four				Fungi counts at day four			
	Essential oil concentrations (mg L^{-1})				Essential oil concentrations (mg L^{-1})			
Essential Oils	25	50	100	Mean	25	50	100	Mean
Control	6.80	6.80	6.80	6.80	24.0	24.0	24.0	24.00
Anise	6.20	5.90	5.50	5.87	7.0	5.0	5.0	5.67
Cumin	6.70	6.50	6.40	6.53	10.0	9.0	7.0	8.67
Geranium	5.90	5.70	5.50	5.70	11.0	8.0	7.0	8.67
Common Lavender	5.30	5.30	5.10	5.23	3.0	2.0	2.0	2.33
Sage	6.50	6.40	6.10	6.34	21.0	18.0	16.0	18.33
Sweet basil	6.80	6.60	6.10	6.50	15.0	12.0	11.0	12.67
Cinnamon	6.80	6.70	6.60	6.70	24.0	21.0	19.0	21.33
Blue gum	6.80	6.70	6.30	6.60	20.0	18.0	15.0	17.67
Lemon grass	7.00	6.80	6.50	6.77	24.0	22.0	18.0	21.33
Mean	6.52	6.37	6.14	6.34	15.9	13.9	12.4	14.06

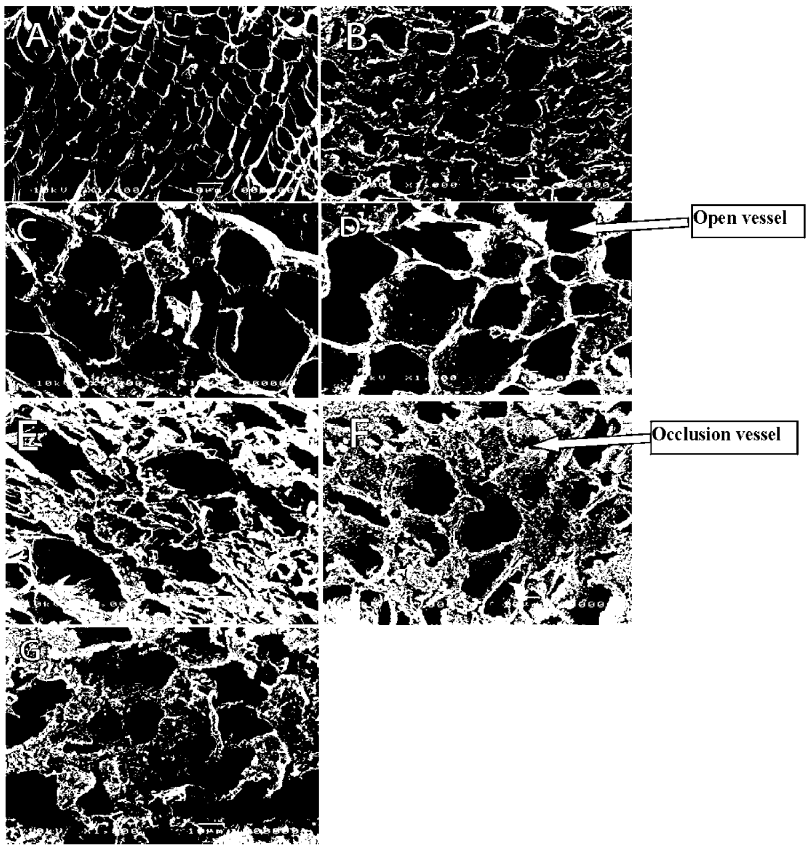

Fig. 1: Cross sections of the base stem of cut rose flowers showing oils with highly positive effects: (geranium (A), lavender (B) and anise (C)); moderate effects: (sweet basil (D)) and low effects: (cinnamon (E), lemon grass (F) and control (G)). (x 1000)

In contrast, using the essential oils of common lavender, geranium and anise minimized or inhibited the growth of microbial organisms and caused an enhancement of conductivity within the xylem vessels, especially in the presence of many scalariform perforation plates (several elongated openings on top of each other in a ladder-like design on the vessel walls) (Fig. 1).

Due to the fact that cut flowers held in the control solution reached senescence after 4 days, it was necessary to count the microbial organisms at that time. The results of this count confirmed that obtained from the SEM, where the greatest bacterial and fungal counts were with the control solution (6.9 and 24 Log ^{10}CFU/ml), followed by lemon grass and cinnamon solutions (6.7 and 21.3 Log ^{10}CFU/ml). Contrary, the lowest bacterial and fungal counts (5.2, 5.8, 5.7 and 2.3, 5.7, 8.7 Log ^{10}CFU/ml) were observed with the solutions of common lavender, anise and geranium oils, respectively. These solutions were very effective as antimicrobial agents in inhibiting the growth of microorganisms, thus preventing the xylem occlusion, as a result, the vase life of cut flowers continued for more than 6 days.

These results suggest that the inhibition of water uptake occurred mainly by the occlusion of xylem vessels containing high counts of microorganisms. This inhibition of water uptake could be the reason for the unbalance in the water relations (between water uptake and water loss), which leads the flowers into early senescence and shortens its vase life (Table 6).

DISCUSSION

The lavender, geranium, cumin and anise oils increased the fresh weight of cut flowers immediately on the second day after treatment and then decreased gradually. Moreover, these oils also increased the water uptake by flowers and reduced the amount of water loss and transpiration rate, which could be the reason for prolonging the vase life of cut flowers. Solgi *et al*. [19]

on gerbera and Shanan *et al.* [20] on carnation stated that using different essential oils, which have the same mode of action, significantly improved the vase life. Bazaz and Tehranifar [21] mentioned that cumin essential oil had a similar effect, which led to extending the vase life of *Alstroemeria*.

In this study, the lowest microbial counts (bacteria and fungi) were recorded in the preservative solutions containing lavender, geranium, cumin and anise oils compared to the control, or any other essential oils). These solutions were very effective as antimicrobial agents in inhibiting the growth of microorganisms and, consequently, preventing the occlusion of xylem vessels. As a result, the vase life of cut flowers continued for 6 or more days.

Griffin *et al.* [22] suggested that the antibacterial activity of essential oils is associated with the presence of high monoterpene concentrations. Geranium essential oil possesses high antimicrobial activities against various microorganisms and these effects are mainly the result of a combination of some biologically active principal aroma compounds (including geraniol). Some *Pelargonium* species are considered the main source of monoterpenes and phenolic acids, which are recommended as an easily available and renewable source of antimicrobial agents [23, 24]. Anise essential oil and its major components exhibited a broad antibacterial spectrum against Gram positive and Gram negative bacteria and are highly effective against *Aspergillus parasiticus* [25].

The essential oil of *Cuminum cyminum* L. and its main components are very active against some genera of bacteria. When these components are found at high concentrations, they act as antimicrobial agents by inhibiting microbial growth, thus preventing bacterial plugging of the water-conducting tissues and allowing water absorption to take place [26].

Finally, many essential oils act as antimicrobial agents against microbial infections, by separating the liquid components of the bacterial cell membrane and mitochonderia, binding the membrane proteins and releasing lipopolysaccharides (LPS) which cause a disturbance of the bacteria cell wall structures [27, 28].

CONCLUSION

In conclusion, using different concentrations (especially, 25 and 50 mg L^{-1}) of lavender, geranium, cumin and anise essential oils emulsified in water showed promising prospects for prolonging the vase life of rose cut flowers, increasing their fresh weight for the first two days, increasing the water uptake and reducing both water loss and transpiration rate.

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