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Alternatives to Commercial Floral Preservatives for Improving Vase Life and Quality of Snapdragon Cut Flowers

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Abstract: This study was carried out in a laboratory of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two seasons of 2013 and 2014. Inflorescences of snapdragon (*Antirrhinum majus* L.) were cut from the plant at stage of development when lower one-third flowers were opened. The inflorescences were kept under standard environmental conditions of temperature 23°C, day length 12 hours, illumination of 2000 lux using white fluorescent lamps and relative humidity (RH) 60– 70%. Inflorescences were placed in glass vases filled with the tested preservative solutions (500 ml) as seven treatments: (1) Tap water (control), (2) 2 ml ethanol 8 %, (3) 2 ml ethanol 70 %, (4) 3 ml Orovex, (5) 3 ml Orovex + 0.5 ml ethanol 8 %, (6) 2 ml Elshabrawishi 555 lemon cologne and (7) 2 ml Cordo. Vase life, vase solution uptake, fresh weight loss, fresh and dry weights of inflorescences, petal total soluble solids, petal total protein and petal total carbohydrates as well as chlorophyll a, chlorophyll b and total carotenoids in leaves were increased by using the different keeping solutions as compared with the control which showed a dramatic decrease in the traits under study. 3 ml Orovex + 0.5 ml ethanol 8 % treatment and 2 ml ethanol 8% treatment recorded the highest and least values, respectively compared to other treatments in most cases. All the preservative solutions specially 3 ml Orovex + 0.5 ml ethanol 8 % decreased the total viable count of bacterial cells in vase solution and ethylene production comparing with control. Scanning electron microscope observations showed that control inflorescence (tap water) had highly xylem vessel occlusion in the base of its axis as vessels were full of occluding substances. However, 3 ml Orovex + 0.5 ml ethanol 8 % treatment mostly kept the xylem vessels without plugging substances in the base of inflorescence axis. So, 3 ml Orovex + 0.5 ml ethanol 8 % treatment was the recommended treatment.

Key words: Floral preservatives · Ethanol · Vase life · Quality · *Antirrhinum majus* · Snapdragon · Cut flower · Thymol · Menthol · Salicylic acid

INTRODUCTION

Snapdragon (*Antirrhinum majus*, L.) plant belongs to family Scrophulariaceae, inflorescence is simple raceme. It is native to Southern west Europe and the West Mediterranean region. Snapdragon is a popular ornamental herb largely grown in the landscape as pot plants, cut flowers or eye-catching bedding plants in beds; borders and edgings for its beautiful variously colored flowers. Snapdragons can be produced year round in greenhouses and most of the year in the field. The leaves and flowers have medicinal properties as antiphlogistic, bitter, resolvent and stimulant and have been used in treating inflammation and haemorrhoids. Snapdragons used to be sensitive to ethylene which causes abscission of leaves, buds, petals and flowers as well as their vase lives are relatively short [1,2].

Keeping beauty and freshness of cut flowers for a longer vase life is important for their economic value in floral display and exportation to the other countries. Short vase life is due to two factors: hormonal changes as a result of ethylene production and water balance including water uptake. Ethylene plays a vital role in senescence of ethylene sensitive flowers leading to changes in the color of petals as well as wilting and abscission of flowers [3]. Ethylene coordinates the expression of a large number of senescence-associated genes expressed during petal senescence. It encourages protein turnover which expresses the balance between protein synthesis and protein degradation to move into more breakdown than

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synthesis symptoms. This causes loss of membrane integrity and vacuolar autophagy which means degradation and recycling of cellular components where cytoplasmic constituents are isolated within double-membraned vesicles known as an autophagosomes. The autophagosome then blind with a lysosome (spherical vesicles containing hydrolytic enzymes capable of breaking down virtually all kinds of biomolecules, including proteins, nucleic acids and carbohydrates) and therefore the cell components are degraded. Inhibition of ethylene action has been found to prolong the vase life of snapdragon flowers [4-6]. Preservative solutions especially for ethylene sensitive flowers usually contain an ethylene antagonist to prolong vase life of the harvested flowers and eliminate the postharvest losses. Ethanol is one of the anti-ethylene compounds that reduces ethylene activity and increases vase life of cut flowers and it has successfully prolonged the vase life of cut flowers [7, 8]. Ethanol decreases the formation of ethylene through inhibiting the action of 1-aminocyclopropane- 1-carboxyli (ACC) synthase, the direct precursor of ethylene, as well as the activity of ACC oxidase that converts ACC to ethylene. Thereby retards flower color changes in wilting and abscission [9].

Water uptake is inhibited due to blockage of xylem vessels (water-transporting units) or formation of gas bubbles (air embolism) [10]. Living bacterial cells causes stem occlusion accordingly decreasing stem hydraulic conductivity as a result of their growth, multiplying and producing extracellular polysaccharides. Bacterial cells release slime which consists mainly of linear polysaccharides into the vase solution and is taken up to be released into the xylem vessels by parenchyma cells to deposit the plugging substance. Bacterial cells produce and release enzymes that degrade cell walls, as well as toxins that degrade cell membranes [11]. Moreover, Zagory and Reid [12] showed that some bacterial cells from vase water produce ethylene.

The biocide is a basic component of the floral preservative solution. It prohibits the presence of bacterial cells in a vase or stem. Bacterial cells have been proposed to play a role in decreasing stem hydraulic conductivity. Ethanol is an antiseptic and it kills bacterial cells by denaturing their proteins and dissolving their lipids [13]. Thymol and menthol are phenolic compounds in essential oils that have strong antimicrobial properties. Prior studies showed their role in enhancing longevity of some cut flowers like gerbera [14]; chrysanthemum [15]; alstroemeria [16]; carnation [17] and roses [18]. Salicylic acid and vitamin A (beta-carotene) are antiseptic agents and possess inhibitory action on bacterial cells [19]. Numerous authors have reported that salicylic acid prolonged vase life of cut flowers such as roses [20], gladiolus [21] and alstroemeria [22].Salicylic acid reduces bacterial cells growth, xylem vessel blockage, transpiration rate and water loss. It increases water uptake and chlorophyll content, meanwhile inhibits ethylene action [23].

The objective of this work was to assess effectiveness of applying some disinfectant products, made in Egypt and available at pharmacies, to act as unusual alternatives to commercial floral preservatives and to assess the best one in extending vase life and improving the quality of snapdragon cut flowers as well as controlling ethylene production and bacterial cells proliferation during post-harvest handling to slowdown the natural wilting process on an applied basis especially when used in flower arrangements and interior decorations.

MATERIALS AND METHODS

This study was carried out in the laboratory of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two seasons of 2013 and 2014. Inflorescences of snapdragon (*Antirrhinum majus* L.) were cut from the plant at stage of development when lower one-third flowers were opened. Uniform inflorescences were taken to laboratory and immediately were recut under water to length of 30 cm and the lower 10 cm of the axis were defoliated. Initial inflorescence fresh weight was recorded at the start of the experiment and then Inflorescences were placed in glass vases filled with the tested preservative solutions (500 ml). The inflorescences were kept under standard environmental conditions of temperature 23°C, day length 12 hours, illumination of 2000 lux using white fluorescent lamps and relative humidity (RH) 60– 70%. The treatments were consisted of seven tested preservative solutions: (1) Tap water (control), (2) 2 ml ethanol 8 %, (3) 2 ml ethanol 70%, (4) 3 ml Orovex, (5) 3 ml Orovex + 0.5 ml ethanol 8 %, (6) 2 ml Elshabrawishi 555 lemon cologne and (7) 2 ml Cordo. Chemical analysis of tap water used as the control treatment is presented in Table (1). Orovex contains thymol, menthol, glycerin, sodium saccharine, sodium mono fluorophosphates and chlorohexidine. It is produced by Macro Group Pharmaceuticals, Badr city, Cairo, Egypt. Elshabrawishi 555 lemon cologne composes of lemon fragrance in addition to ethanol 70% (v:v), it is produced by Perfumes and Essences Factory in

Table 1: Chemical analysis of tap water used as the control treatment

		Soluble anions (meq/l)			Soluble cations (meq/l)			
pH	EC(dS/m)	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.2	0.43	1.2	2.2	1.0	1.3	0.9	2.1	0.1

Hawamdia, Giza, Egypt. Cordo composes of ethanol 70%, potassium aluminium sulphate dodecahydrate, salicylic acid, vitamin A, glycerin and propylene glycol. It is produced by Macro Group Pharmaceuticals, Badr city, Cairo, Egypt. Vase life of each inflorescence was terminated when half of the flowers underwent color change and loose turgidity.

The experiment included seven treatments and was layed out in a completely randomized design with three replicates. Each treatment included 24 inflorescences; each replicate consisted of two glass vases with four inflorescences for each.

Data Recorded

Vase Life: Vase life considered on the basis of time (day) from harvest to when flowers lost their ornamental display value (petal color change and wilt). The vase life of the individual snapdragon inflorescence was terminated when half of the flowers were wilted.

Vase Solution Uptake: A glass vase without cut flowers, contains the same volume of the same vase solution for each treatment, was placed beside each replicate to determine the volume of vase solution evaporated. The volume of vase solution uptake (ml/inflorescence/day) was calculated by subtracting the volume of vase solution evaporated from a flask without cut flowers from the total volume of vase solution lost from the flask with cut flowers and the result was expressed as the mean of the flowers [24].

Fresh Weight Loss: Fresh weight of the inflorescence was determined just before the immersion of the inflorescence into the solutions and also at the termination of its vase life. Inflorescences were taken out of solutions for such a short time as possible (20 to 30 sec.). The fresh weight loss% was expressed relative to the initial fresh weight of the inflorescence [25].

Fresh Weight of Inflorescence: Fresh weight of inflorescence determined at the end of its vase life.

Dry Weight of Inflorescence (g): Samples were dried at the end of the vase life by using an electric oven for two days at a temperature of 70° C until a constant weight was obtained.

Bacterial Cells Counts in Vase Solution: The vase solutions used for standing snapdragon inflorescences were sampled and incubated at 30°C for 48 hours. The total viable count of bacterial cells in vase solution (CFU/ml) was assessed per milliliter by dilution plate method for the numeration of microorganisms on standard plate count agar medium [26]. The bacterial cells count was recorded on the seventh day of vase life for all treatments as it was the last day for control vase life.

Scanning Electron Microscope (SEM) Observations: Specimens (one cm) from the bases of the inflorescences axes were taken on the seventh day of inflorescence vase life. Specimens were confined the treatment of choice according to the data presented in Table (2) i.e. the control (the worst treatment), 3 ml Orovex + 0.5 ml ethanol 8% treatment (showed more beneficial effects) and 2 ml ethanol 8% treatment (gave higher values over control and less values than other treatments). Cross sections were prepared and examined with a scanning electron microscope (JEOL JSM- 6390 LA) to show bacterial cells proliferation and blockages in xylem vessels.

At the End of the Control Longevity, the Seventh Day of the Vase Life, Samples of Petals Were Used to Determine:

Petal Total Soluble Solids: Tissue sap was extracted from petals and total soluble solids % (TSS) was determined using hand-held Bausch and Lomb refractometer, number 39-45-01 with Brix Scale 0-32%, by placing two drops of clear juice on the prism surface and reading was taken as described by Lacey *et al*. [27].

Petal Total Carbohydrates: Total carbohydrates in the petals (%) were colorimetrically assessed as described by Dubois *et al*. [28].

Petal Total Protein (%FW): Quantitative determination of nitrogen was calculated by Kjeldahl digestion method [29] and then the results were multiplied with 6.25.

Ethylene Production: Three lower open flowers were cut from each replicate, seven days after harvest. The flowers were weighed and enclosed together in 350 ml glass jar, sealed with a metal lid for 24 h at 23 °C. One ml gas sample of the headspace was taken using a needle and syringe

then injected into Hewlett Packard 5890 series II gas chromatograph and ethylene production was measured (nl/g FW/h) [30].

Leaf Pigments: Chlorophyll a; chlorophyll b and total carotenoids were determined in leaves (mg/g FW) when the vase life of the control flowers was terminated. The analyses were determined according to Costache *et al*. [31].

Statistical Analysis: All data collected for both seasons were averaged and subjected to appropriate analysis of variance. The means were compared using the Least Significant Difference (LSD) test at 5% probability [32].

RESULTS AND DISCUSSION

Vase Life: Data presented in Table (2) revealed that all the tested vase solutions significantly increased vase life of snapdragon (*Antirrhinum majus* L.) inflorescence as compared to the control (tap water) which resulted in the shortest vase life (7.00 days). The significantly longest vase life (17.00 days) of inflorescence comparing with control was recorded with vase solution containing 3 ml Orovex + 0.5 ml ethanol 8 % followed by that placed in vase solution containing 2 ml Cordo (15.00 days), with no significant difference between the two treatments. Results obtained are in agreement with previous studies [4-8, 14-22, 33- 37].

Vase Solution Uptake: Data shown in Table (2) revealed that most of vase solutions used significantly increased vase solution uptake by snapdragon inflorescence as compared to the control (tap water) which showed dramatic decrease and resulted in the lowest vase solution uptake (6.20 ml/ inflorescence /day). Vase solutions containing 2 ml ethanol 8% or 2 ml ethanol 70% showed insignificantly higher vase solution uptake (6.40 and 6.80 ml/ inflorescence /day, respectively) as compared to the control. The significantly greatest vase solution uptake (14.40 ml/ inflorescence /day) was recorded with snapdragon inflorescence kept in 3 ml Orovex + 0.5 ml ethanol 8 % treatment. Results agreed with previous studies [33- 37].

Fresh Weight Loss: Data presented in Table (2) revealed that most of the used vase solutions significantly increased fresh weight loss (%) of snapdragon inflorescence as compared to the control (tap water) which resulted in the lowest fresh weight loss (45.75%). Snapdragon inflorescences kept in vase solutions containing 2 ml ethanol 8% or 2 ml ethanol 70% showed insignificantly higher fresh weight loss as compared to the control. The snapdragon inflorescences kept in vase solutions containing 3 ml Orovex (contains thymol and menthol) or 3 ml Orovex + 0.5 ml ethanol 8 % produced significantly highest fresh weight loss (68.34 and 60.36%, respectively) than control with no significant difference between them. Similar results were obtained by other studies [33, 35, 37].

Fresh Weight of Inflorescence: Data presented in Table (2) revealed that most of vase solutions tested significantly gave highest fresh weight of inflorescence at the end of the vase life as compared to the control (tap water) which resulted in the lowest fresh weight of inflorescence (7.52 g). Vase solutions containing 2 ml ethanol 8% or 2 ml ethanol 70% insignificantly gave higher fresh weight of inflorescence (8.52 and 8.88 g, respectively) as compared to the control. Statistically, the heavier fresh weight of inflorescence at the end of vase life (11.43 g) was recorded with vase solution containing

Table 2: Effect of preservative solutions on vase life, vase solution uptake, fresh weight loss, fresh weight and dry weight of snapdragon inflorescence as well as the total viable count of bacterial cells (average of two seasons)

Treatments	Vase life (days)	Vase solution uptake (ml/inflorescence/day)	Fresh weight loss (%)	Fresh weight of inflorescence (g)	Dry weight of inflorescence (g)	Total viable count of bacterial cells in vase solution (CFU/ml)
Tap water (control)	7.00	6.20	45.75	7.52	2.35	$5.3x10^7$
2 ml ethanol 8%	9.34	6.40	52.20	8.52	2.84	$3.8x10^7$
2 ml ethanol 70 %	11.45	6.80	53.38	8.88	2.61	$1.7x10^7$
3 ml Orovex	14.00	12.20	68.34	9.68	3.05	$6.0x10^5$
3 ml Orovex + 0.5 ml ethanol 8 %	17.00	14.40	60.36	9.51	3.44	$2.0x10^4$
2 ml Elshabrawishi 555 lemon cologne	12.00	11.00	57.69	11.43	4.86	$9.5x10^6$
2 ml Cordo	15.00	9.00	56.51	9.60	2.94	$2.4x10^6$
LSD 5%	2.14	2.03	8.11	1.98	0.41	$4.1 x10^2$

2 ml Elshabrawishi 555 lemon cologne (70% ethanol plus lemon fragrance) followed by that kept in vase solutions containing 3 ml Orovex, 2 ml Cordo, 3 ml Orovex + 0.5 ml ethanol 8 % (9.68, 9.60 and 9.51 g, respectively) with no significant difference among them. Results agreed with previous findings [32, 33, 36].

Dry Weight of Inflorescence: Data presented in Table (2) showed that most of vase solutions used significantly increased dry weight of snapdragon inflorescence as compared to that kept in tap water which resulted in the lightest dry weigh (2.35 g) at the end of vase life. Vase solution containing 2 ml ethanol 70% gave insignificantly higher dry weight of inflorescence (2.61 g) as compared to the control. The significantly heaviest dry weight of inflorescence (4.86 g) was recorded with that kept in solution containing 2 ml Elshabrawishi 555 lemon cologne comparing with other treatments. Results are in harmony with previous studies [34, 35, 37].

Total Viable Count of Bacterial Cells: Data presented in Table 2 revealed that all vase solutions treatments significantly decreased the total viable count of bacterial cells (CFU/ml) in vase solution as compared to the control (tap water) which recorded the highest total viable count of bacterial cells ($5.3x10^7$ CFU/ml). Vase solutions containing 3 ml Orovex + 0.5 ml ethanol 8 % resulted in the significantly lowest total viable count of bacterial cells ($2.0x10^4$ CFU/ml) in vase solution.

The vase solution uptake by the inflorescence is related to its vase life. The increase in vase solution uptake results in an increase in tissue water contents, helping in hydrolysis of sugars in cells of petals through respiration and producing energy needed to development of flowers. As a result, petals are turgid during inflorescence vase life and hold over their natural beautiful appearance for longer period of time as shown in Figure (1), petals of flowers kept in vase solution containing 3 ml Orovex + 0.5 ml ethanol 8 % were more turgid with water as compared with tap water (control) and 2 ml ethanol 8% treatments, after four days of harvest.

Scanning Electron Microscope (SEM) Observations: As seen under scanning electron microscope, Fig.2, A and B showed that the inflorescence kept in tap water (control) had highly blockages in xylem vessels at the base of the inflorescence axis as vessels were full of occluding substances. In this respect, tap water allowed the bacterial cells to grow within xylem vessels where the SEM observations in the current study (Fig.2, G and H) confirmed that bacteria are widely presented in xylem vessels of control inflorescence. Results obtained are in agreement with results of a prior study [11]. Ethanol 8% treatment could not maintain the xylem vessels without occlusion in the base of inflorescence axis (Fig.2, E and F). However, the xylem vessels of inflorescence kept in 8% ethanol solution had occluding substances less than the xylem vessels of control inflorescence. Preservative solution containing 3 ml Orovex + 0.5 ml ethanol 8 % mostly kept the xylem vessels without plugging substances in the base of the inflorescence axis. This declared that 3 ml Orovex + 0.5 ml ethanol 8 % treatment could play a role in increasing hydraulic conductivity in inflorescence accompanied with decreasing number of bacterial cells and occluding substances (Fig.2, C and D).

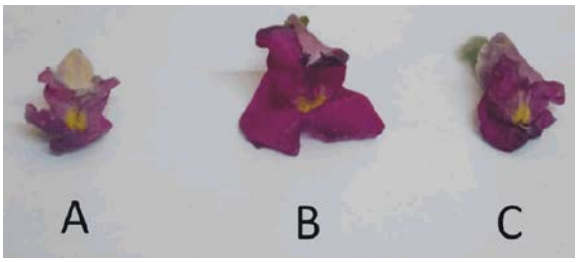

Fig. 1: Snapdragon flowers after four days of beginning the experiment (color and shape were changed) affected with: A: Tap water (control), B: 3 ml Orovex + 0.5 ml ethanol 8 % (the best treatment) and C: 2 ml ethanol 8% (gave higher results than control and lower values than other treatments)

Generally, all treatments of the preservative solutions improved the quality of snapdragon inflorescences as compared to the control (tap water). There is a relationship between the vase life of inflorescence, total viable count of bacterial cells in vase solution and plugging level in xylem vessels. Results showed that reduction of vase life was associated with low vase solution uptake and with a high total viable count of bacterial cells in vase solution, indicating that it was related to an occlusion in xylem vessels which retard water flow in the inflorescences caused by bacterial cells and/or their extra cellular products in the inflorescences. Results correlated the increase in total viable count of bacterial cells in vase solution with reduced inflorescence vase life and with a reduction in active xylem vessels in the inflorescence axis. The snapdragon inflorescences kept in ethanol 70% or 2 ml Elshabrawishi 555 lemon cologne or 2 ml Cordo solutions, all had the same component of ethanol 70%, varied in their vase lives and total viable count of bacterial cells in the vase solution.

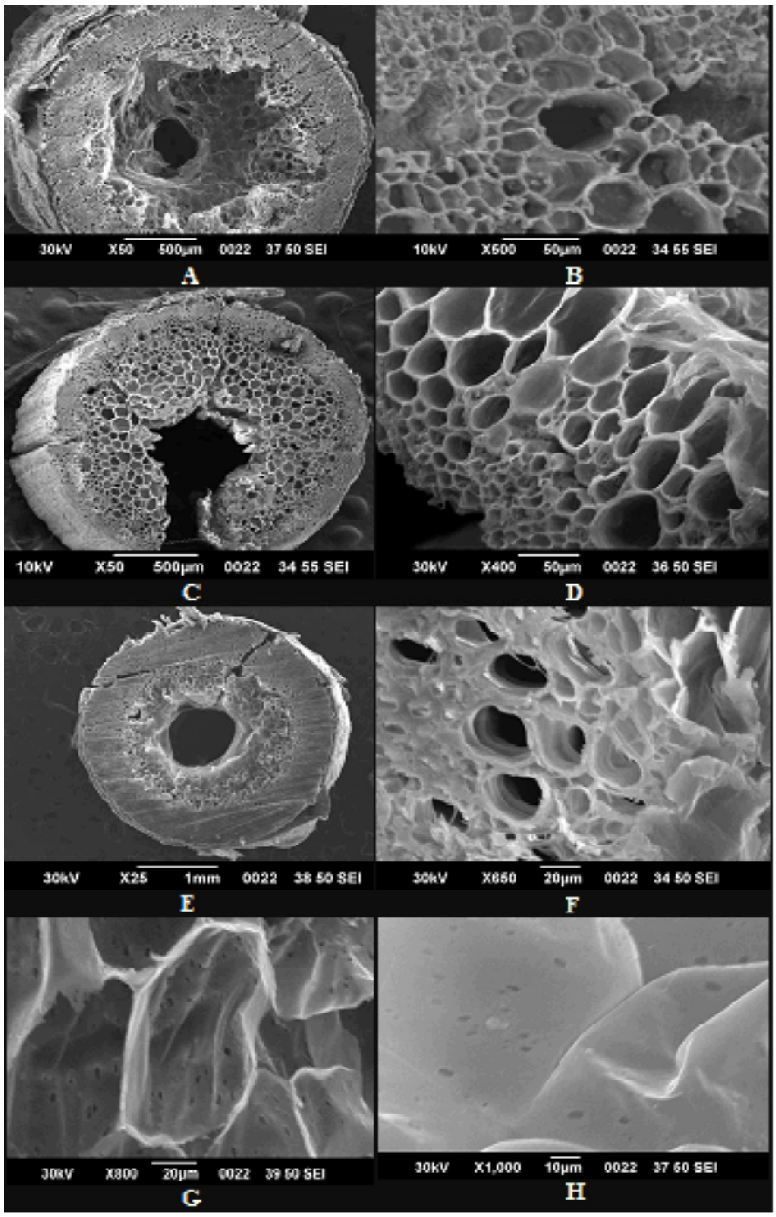

Fig. 2: Scanning electron microscope micrograph of snapdragon xylem vessels in cross section at the base of inflorescence axis showing the effect of some treatments on bacterial proliferation and blockages in xylem vessels.
A and B: control (tap water).
C and D: 3 ml Orovex + 0.5 ml ethanol 8% treatment.
E and F: 2 ml ethanol 8% treatment.
G and H: bacterial colonies in the xylem vessels of control.

In this respect, 2 ml Cordo treatment recorded highest vase life and least number of bacterial cells while 2 ml ethanol 70% keeping solution had the shortest vase life and the highest total viable count of bacterial cells. Salicylic acid and vitamin A in Cordo solution recorded positive increase in quality of flowers. They act as a bio-regulator in the solution and reduced accumulation of bacterial cells in the solution and in inflorescences and had a promotive effect on inflorescence longevity.

Improving longevity in the alcoholic solutions was due to inhibiting blockages in xylem vessels and increasing water absorption. Although, ethanol works as anti-ethylene agent for keeping quality of snapdragon flowers, using ethanol in low concentration (8%) recorded significantly higher longevity as compared to the control. Orovex, contains thymol and menthol, played a role as antibacterial regulator, showed moderate improvement in terms of vase life, vase solution uptake, fresh and dry weights of inflorescence and total viable count of bacterial cells. Combining ethanol at the low concentration(8%) with Orovex recorded the lowest total viable count of bacterial cells as well as the highest values of longevity and vase solution uptake. Also, it gave values of fresh weight loss and fresh weight of inflorescence statistically similar to the highest values of the same parameters. There was no significant difference between results obtained from using Orovex or Cordo (ethanol 70% with salicylic acid and vitamin A) solutions with respect to vase life, fresh weight and dry weight of inflorescence.

Petal Total Soluble Solids: Data presented in Table (3) revealed that most of preservative vase solutions tested significantly increased total soluble solids of snapdragon petals as compared to the control (tap water) which resulted in the lowest percentage (8.0%). The significantly highest percentage (9.0%) was recorded in petals of snapdragon cut flowers kept in vase solution containing 3 ml Orovex + 0.5 ml ethanol 8 % or 3 ml Orovex. Results agreed with a previous study on carnation [33].

Petal Total Carbohydrates: Data in Table (3) showed that most of vase solutions used significantly increased total carbohydrates % in petals of snapdragon cut flowers as compared to the control (tap water) which gave the lowest percentage (32.19%). Vase solutions containing 2 ml ethanol 8% or 2 ml ethanol 70% produced insignificantly higher carbohydrate percentages (32.60 and 34.10 %, respectively) as compared to the control.

The significantly greatest total carbohydrates % (36.95%) was recorded with snapdragon inflorescences kept in vase solutions containing 3 ml Orovex + 0.5 ml ethanol 8 %.

Petal Total Protein: Data presented in Table (3) revealed that all vase solutions investigated significantly increased total protein % in petals of snapdragon flowers as compared to the control (tap water) which resulted in the lowest percentage (5.77%). The snapdragon inflorescences kept in vase solution containing 3 ml Orovex + 0.5 ml ethanol 8 % recorded the significantly highest petal total protein % (10.51 %). Results obtained agreed with a prior study on *Rosa hybrida* [35].

Ethylene Production: Data in Table (3) pointed out that all vase solutions tested significantly decreased ethylene production of flowers on the seventh day of vase life as compared to the control (tap water) which resulted in the highest value (0.97 nl/g FW/h). Vase solution containing 2 ml ethanol 8% resulted in significantly higher ethylene production (0.72 nl/g FW/h) compared with other treatments. Statistically, the lowest ethylene production (0.10 nl/g FW/h) was recorded with vase solution containing 3 ml Orovex + 0.5 ml ethanol 8 %, followed by 3 ml Orovex, 2 ml Elshabrawishi 555 lemon cologne and 2 ml Cordo treatments (0.34, 0.37 and 0.47 nl/g FW/h, respectively) with no significant difference among them. The present results are in agreement with previous studies [7, 37].

Leaf pigments:

Chlorophyll a: Data presented in Table (3) showed that application of the different treatments, except 2 ml ethanol 8%, caused significant increase in chlorophyll a content compared to that of control plants which gave 0.45 mg/g fresh weight. Among all the treatments, 2 ml Cordo solution gave the highest chlorophyll a content

Table 3: Effect of preservative solutions on total soluble solids (TSS), total carbohydrates, total protein in petals, ethylene production in cut flowers as well as chlorophyll a, chlorophyll b and total carotenoids in leaves of snapdragon (average of two seasons)

Treatments	TSS (%)	Total carbohydrates (%)	Total protein (% FW)	Ethylene production (nl /g FW/h)	Chl. a (mg/g FW)	Chl. b (mg/g FW)	Total carotenoids (mg/g FW)
Tap water (control)	8.0	32.19	5.77	0.97	0.45	0.08	0.07
2 ml ethanol 8%	8.3	32.60	7.08	0.72	0.57	0.10	0.10
2 ml ethanol 70 %	8.3	34.10	7.13	0.50	0.93	0.17	0.11
3 ml Orovex	9.0	35.33	9.40	0.34	1.11	0.14	0.61
3 ml Orovex + 0.5 ml ethanol 8 %	9.0	36.95	10.51	0.10	1.38	0.18	0.87
2 ml Elshabrawishi 555 lemon cologne	8.5	34.59	8.42	0.37	1.58	0.10	0.11
2 ml Cordo	8.6	34.73	8.77	0.47	1.60	0.12	0.31
LSD 5%	0.5	2.20	0.71	0.15	0.33	0.04	0.04

(1.60 mg/g FW) followed by 2 ml Elshabrawishi 555 lemon cologne and 3 ml Orovex + 0.5 ml ethanol 8 % (1.58 and 1.38 mg/g fresh weight, respectively) with no significant difference among them. Results are in agreement with a prior study [37].

Chlorophyll b: The data presented in Table (3) revealed that chlorophyll b content was considerably higher in the leaves of inflorescences supplied with most of the tested treatments as compared with control. There were no significant difference between 2 ml ethanol 8% treatment, 2 ml Elshabrawishi 555 lemon cologne treatment and the control. The highest value of chlorophyll b was recorded with 3 ml Orovex + 0.5 ml ethanol 8 % treatment (0.18 mg/g FW). This followed by 2 ml ethanol 70 % and 3 ml Orovex treatment recording 0.17 and 0.14 mg/g FW, respectively with no significant difference between both of them.

Total Carotenoids: The data presented in Table (3) showed that the different treatments produced higher total carotenoids contents in leaves than those of control (0.07 mg/FW). Most of treatments significantly increased total carotenoids than control. The only exception was recorded with 2 ml ethanol 8% which insignificantly increased total carotenoids compared with the control. The significantly highest total carotenoids value was recorded with 3 ml Orovex + 0.5 ml ethanol 8 % treatment (0.87 mg/g FW) comparing with other treatments followed by 3 ml Orovex giving 0.61 mg/g FW.

Results in Tables (2 and 3) showed that the increase in both volume of water uptake and vase life were associated with increment in pigments content; percentages of carbohydrates, TSS and protein. Photosynthesis produces sugars, the main form of carbohydrate. High carbohydrates content represented as starch is hydrolyzed in petal cells to soluble solids or sugar (TSS), leading to improving their osmotic potential and augmented their ability to absorb water and maintain turgidity. Petal unfolding is generally due to cell expansion as a result of increasing osmotic solute levels by the conversion of polysaccharides (starch) to monosaccharides [38]. Sugars are a primary substrate for respiration; they are involved in production of energy and the synthesis of biochemical compounds which stabilizes cell membranes and thereby extend postharvest longevity. Protein induces antioxidant enzymes, catalase and peroxidase during flower development to protect cells from oxidative damage, resulting in extending petals life [39, 40]. Total protein decreases in flowers which had early senescence because free ammonia accumulates in senescence and this is correlated with activity of hydrolytic enzymes causing the breakdown of protein [41].

CONCLUSION

Based on the results of this study, it could be concluded that all alternatives of commercial floral preservatives used in this study improved the vase life and quality of snapdragon cut flowers. The present study indicates that the vase solution containing 3 ml Orovex + 0. 5 ml ethanol 8 % has a potential to be used as a commercial preservative solution for prolonging vase life and improving postharvest quality of snapdragon cut flowers.

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