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Utilization of environmentally friendly extracts and some chemical solutions to improving the postharvest quality of *Chrysanthemum* cut flowers

Atef M.Z. Sarhan[1], Hamdy M. Elbagoury[1], Mona A. Darwesh[1], Faisal M. Saadawy[2], Souad A. M. Khenizy[2] and Mai M.M. Ibrahim[2,]*

[1]*Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Cairo, Egypt.*
[2]*Ornamental Plants and Landscape Gardening Research Department, Horticultural Research Institute, Agricultural Research Center, Giza, Egypt.*

Abstract

Chrysanthemum (*Dendranthema grandiflorum* Kitam.) is an ornamental plant that has high economic value, it is a great demand domestically or abroad. A trial was consummated at Postharvest Lab of Ornamental Plants and Landscape Gardening Research Dept., Hort. Res. Inst., ARC during 2020 and 2021 seasons to improve quality of Chrysanthemum (*Dendranthema grandiflorum* Kitam.) cv. "White Zembla" cut flowers through studying the effect of holding solutions including Distilled water (DW) which was used as a control (Cont.), sucrose (Suc) (3% , 5%), Benzyladenine (BA 15, 25 ppm), Aluminium sulfate (Al_2 (so_4) 7.5, 10 mg/l), Extract of *Moringa oleifera* leaves (Mor 2, 5 g/l) and Extract of *Punica granatum* (Pomegranate (PGE10, 20 mg/l) to identify the best treatments to increase flower vase life and other related characteristics of cut chrysanthemum. The obtained data exhibited that all holding solutions caused a marked increment in the studied characteristics compared to that registered from distilled water (control). In this respect, the utmost high values of vase life, diameter of cut flowers, general appearance, Fresh weight change (FWC%), water uptake rate, chlorophyll a, chlorophyll b and carotenoids and Total, reducing and non-reducing sugars (%) was the treatment of holding chrysanthemum cut flowers in solution contain PGE10mg/l) followed by PGE 20 mg/l). Therefore, treatment of chrysanthemum cut flowers with pomegranate peel extract is recommended.

Keywords: Chrysanthemum, cut flowers, BA, aluminum sulfate, water uptake, fresh weight, Pomegranate, *Moringa oleifera.*

Full length article **Corresponding Author*, e-mail: mai_bonbonty@yahoo.com

1. Introduction

The quality of cut flowers depends on the appearance and durability of freshness. Flowers with prime quality have a higher sale value compared to low-quality cut flowers. To maintain the quality of prime cut flowers still need to be implemented several treatments, especially when the flowers are ready to harvest to the consumers. This treatment harvests and post-harvest includes harvesting, storage, transportation, to display in flower shops [1]. Several factors can reduce the quality of fresh cut flowers, namely the inability of stems to absorb water due to the inhibition of microorganisms (bacteria and fungi), embolism or physiological reaction of the flower itself. The second factor is the low carbohydrate content so it is inadequate to support respiration. The third factor is that plants suffer from too much water loss due to high ambient temperatures. The other factor is the presence of ethylene produced by the damaged tissue. The last factor is due to disease or pest attack [2]. Among various factors, senescence of leaves is controlled by exogenous levels of plant growth regulators [3]. In general, chlorophyll loss is delayed by auxins, cytokinins and gibberellins and enhanced by ethylene and abscisic acid [4]. Cytokinins have been known to delay or reverse leaf yellowing and senescence in various species. Adding chemical preservatives to the holding solution is recommended to preserve the best quality of flower after harvest. All holding solutions must contain sugars (sucrose), acids (citric acid) growth regulators, such gibberellic acid and antimicrobials such as 8-Hydroxyquinoline [5]. Sugar play important role in plants as substances for respiration, the addition of sugars such as sucrose to vase water is effective in improving the vase life of cut flowers [6]. Sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers. The exogenous application of the sucrose supplies the cut flowers with much needed substrates for respiration, and enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally [7]. Aluminum as $AlCl_3$ and $Al2(SO_4)_+$ in the holding solution has been shown to enhance the quality and longevity of cut flowers such as roses and chrysanthemum due to the effect of Al3+ in reducing the pH of petal cells and stabilizing the anthocyanins. Also, aluminum sulfate is reported to acidify the holding solution, and keep it free of microorganisms and also help in better opening of flower buds, thereby maintaining the freshness of cut roses [8,9]. [10] showed that vase life and membrane stability of the cut spike of gladiolus have been increased by using benzyladenine (BA) and gibberellic acid (GA_3). [11] reported that BA delayed ethylene production compared to the control. The weight loss, chlorophyll and anthocyanin degradation were significantly reduced by the application of 25 and 50 mg. L^{-1} BA of cut Eustoma flowers. Moringa (*Moringa oleifera* Lam.) is native to the Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world. The tree is known by such regional names as Benzolive, Drumstick tree, Horseradish tree, Kelor, Marango, Mlonge, Mulangay, Saijihan and Sajna [12]. The plant thrives best under the tropical insular climate. It can grow well in the humid tropics or hot dry lands and can survive in less fertile soils and it is also little affected by drought [13]. It is considered as one of the World's most useful trees, as almost every part of the moringa tree can be used for food, medication and industrial purposes [14]. People use its leaves, flowers and fresh pods as vegetables, while others use it as livestock feed [15]. This tree has the potential to improve nutrition, boost food security and foster rural development [16]. Seeds of moringa contain an active coagulant compound traditionally used for the purification of drinking water [17]. The dried leaves had the following mineral contents: calcium (3.65%), phosphorus (0.3%), magnesium (0.5%), potassium (1.5%), sodium (0.164%), sulphur (0.63%), zinc (13.03 mg/kg), copper (8.25%), manganese (86.8 mg/kg), iron (490 mg/kg) and selenium (363 mg/kg) [18]. Pomegranate *(P. granatum)* is an important source of anthocyanins, hydrolysable tannins punicalagin and punicalin [19], ellagic and gallic acids [20] and also contains vitamin C [21]. The antioxidant and free radical scavenging activity of phenolic compounds derived from pomegranates [22] and vitamin C [23] have been reported. Chrysanthemum (*Chrysanthemum morifolium* R.) is one of the most popular cut flowers in the world. Stem end blockage and water stress are two problems in shortening the vase life of cut Chrysanthemum. Essential oils are noble alternative substitutes for silver and chemical compounds because of their antimicrobial activities and environmentally friendly nature of the extracts. A pomegranate peel extract (PGE) was evaluated as a natural antifungal preparation for the control of postharvest rots. [24]. Hydroalcoholic extract of *P. granatum* had a significant antibacterial effect on common oral bacterial pathogens with maximum effect on *S. mutans*, which is the main microorganism responsible for dental plaque and caries. [25] extract pomegranate peel as food by product to extended the shelf life of yoghurt as functional dairy products [26].

2. Materials and Methods

This study was conducted at the Ornamental Horticulture Department, Faculty of Agriculture Cairo University, Egypt and carried out at postharvest laboratory of Ornamental Plants and Landscape Gardening Research Dept., Hort. Res. Inst., ARC; Giza, Egypt in mid of December. during the two successive seasons of 2020 and 2021. The aim of this study is to investigate the effect of environmentally friendly extracts as preservative holding solutions to enhance the quality and extending the vase life period of Chrysanthemum (*Dendranthema grandiflorum* Kitam.) cv. "White Zembla" cut flowers.

2.1. Plant material

Chrysanthemum (*Dendranthema grandiflorum* Kitam.) cv. "White Zembla" cut flowers (standard: one flower on the stem) which belongs to the Asteraceae family. Cut flowers were obtained from a local commercial greenhouse farm in Giza, Egypt. The flowering stems were cut in the early morning at the beginning opening, and selected for uniformity in terms of development; the stems were trimmed to an equal length (60 cm) and wrapped in Kraft paper in groups each containing (25) cut flowers. Cut flowers were transported under dry conditions to the laboratory within an hour then rapidly precooling by placing them in ice cold water for two hours. The precooling is an important postharvest operation, which removes the field heat, greatly improves quality and enhances vase life of cut flowers. The stem base was recut to about 5 cm and the leaves on the lower third part of the stems were also removed. After that, cut flowers were transferred to glass jars (500ml) containing 300 ml of different holding solutions as follows:

T1: Distilled water (DW) which was used as a control (Cont.)
T2: Sucrose (suc 3%).
T3: Sucrose (Suc 5%)
T4: Benzyladenine (BA 15 ppm)
T5: Benzyladenine (BA 25 ppm).
T6: Aluminium sulfate (Al_2 (so$_4$)) 7.5 mg/l
T7: Aluminium sulfate (Al_2 (so$_4$))10 mg/l
T8: Extract of *Moringa oleifera* leaves (Mor 2 g/l)
T9: Extract of *Moringa oleifera* leaves (Mor 5 g/l)
T10: Extract of *Punica granatum* (Pomegranate (PGE) 10 mg/l)
T11: Extract of *Punica granatum* (Pomegranate (PGE) 20 mg/l

and kept in the laboratory under room temperature at 16±2ºC and 50-60% relative humidity and continuous lighting with fluorescent lamps 1000 Lux to end the longevity.

2.2. Method of extraction of moringa

Dry leaves of moringa (*Moringa oleifera*) were ground and kept at laboratory temperature until use, for the preparation of aqueous extract, 40 grams of moringa powder were taken, placed in the two conical flasks containing 200 cm^3 of distilled water, mixed by magnetic blender for 30 minutes and a centrifuge for 15 minutes. After that the solution stand in the electric furnace at 35 °C until we get the extract and from it, we prepared solutions [27].

2.3. Method of extraction of Pomegranate Peel

The natural product strips were assembled and dried in the shade for 4-5 days. The dried strips were then ground into the best powder. 1g of grounded strip powder was gauged and disintegrated in 100ml of refined water to set up the pomegranate strip remove. The combination was cooked for 10 minutes by warming the mantle at 70 °C. The bubbled concentrate of the pomegranate strip was sifted utilizing Whatmann No.1 channel paper. The sifted extricate was prepared for additional utilization in a virus state. [28].

2.4. Data Recorded

2.4.1. Vase life

The longevity of Chrysanthemum cut flowers (day) was calculated by counting the days from applying the treatment (first day) until wilting the leaves and the flower [29].

2.4.2. Diameter of cut flowers (cm)

The diameter of head flowers was calculated as a mean of three cut flowers per treatment and assessed as marketable.

2.4.3. General appearance

The quality of cut flowers and leaves was evaluated based a scale ranging, where 1= poor; 2= moderate; 3= good; 4= very good; 5= excellent. 1= poor to 5 = excellent. A rating of 1 represented a plant with light-green to yellow foliage and distorted and/or faded flowers, a rating of 5 represented a plant with dark-green foliage, uniform flower display, and no flower-color fading. [30].

2.4.4. Fresh weight change (FWC%)

Relative fresh weight of the cut flowers was determined just before the immersing of the cut flower into the solution and repeated every 3 days until the vase life of the cut flower were terminated. The fresh flower of each flower was expressed relative to the initial weight to represent the water status of the cut flower and it was calculated by following formula. Relative fresh weight of stems was calculated using the following formula [31].

Fresh weight change : (FWC%): =

$$\frac{\text{Fresh weight of 3 stem in mentioned day 0,3,6,...} - \text{Fresh weight of 3 stem in day zero}}{\text{Fresh weight of 3 stem in day zero}} \times 100.$$

2.4.5. Water uptake rate (g/flower/ day)

Weights of vases containing vase solution without the cut flowers were recorded 0 day, 3rd, 6th, 9th during the vase-life evaluation period. Average daily Vase solution uptake rate was calculated by the formula:

Vase solution uptake rate [g g^{-1} initial fresh weight (IFW)] =

$$\frac{St^{-1} - St}{\text{initial fresh weight of the stem}}$$

Where St^{-1} is weight of vase solution (g) on the initial day and St is weight of vase solution (g) at t = 0 day, 3rd, 6th, 9th and St^{-1} is the weight of vase solution (g) on the the initial day [32].

2.4.6. Chemical analyses

Chlorophyll a, chlorophyll b and carotenoids (mg/100g FW) were determined in fresh leaf samples at the end of longevity and measured according to [33] .Total, reducing and non-reducing sugars (%) in flowers and leaves was recorded every four days during the shelf life periods according to [34].

2.5. Layout and statistical analysis

The layout of the experiment was a complete randomized design with 11 treatments, each treatment contained 3 replicates and each replicate contained 3 cut flowers of chrysanthemum. (11 treatments ×3 replicates× 3 flowers = 99 flowers, each treatment was repeated three times, each replicate contained of 3 flowers i.e. 9 flowers in each treatment).

2.6. Statistical analysis

All data were subjected to statistical analysis according to the procedure reported by [35], data were tabulated and subjected to analysis of variance using [36]. Duncan's Multiple Range Test at 5% level as indicated by [37] compared means of treatments.

3. Results and Discussion

3.1: Effect of holding solution treatments on vase life (day), diameter (cm) and general appearance on chrysanthemum cut flowers

Data presented in Table (1) illustrate that, in most cases all holding solution treatments recorded significant increase in vase life (day), diameter (cm) and general appearance of chrysanthemum cut flowers compared with Dw in both seasons. Holding of chrysanthemum cut flowers in natural extracts solution containing PGE (10 mg/l) was the most effective treatment for increasing vase life (23.51 , 22.97 day), diameter (8.53, 8.47cm) and general appearance (4.0, 4.0) as compared to cut flowers held in distilled water where recorded, vase life (16.99,17.23 day) diameter (4.17cm, 4.20) and general appearance (2.0,2.0) followed by the last solution containing with (PGE 20 mg/l) gave longevity (21.77,21.22 day), diameter (6.30, 6.33 cm) and general appearance (3.0, 3.0) in the first and second seasons, respectively. Overall, the results indicated that the extract of PGE both concentrations in the preservative solution

Table 1. Effect of holding solution treatments on vase life (day), diameter (cm) and general appearance of chrysanthemum cut flowers during 2020 and 2021 seasons

Treatments	First season (2020)		
	vase life (day)	**Flower diameter (cm)**	**General appearance**
Cont (DW)	16.99 d	4.17 d	2.00 d
Suc (3%)	20.44 c	5.13 c	2.00 c
Suc (5%)	16.88 e	3.33 h	1.00 e
BA (15 ppm)	16.14 i	3.23 k	1.00 f
BA (25 ppm)	16.02 j	3.37 g	1.00 j
$Al2(SO_4)_3$ (7.5 mg/l)	16.32 g	3.43 e	1.00 k
$Al2(SO_4)_3$ (10 mg/l)	15.61 k	3.27 i	1.00 g
Mor (2 g/l)	16.22 h	3.37 f	1.00 h
Mor (5 g/l)	16.39 f	3.27 j	1.00 i
PGE (10 mg/l)	23.51 a	8.53 a	4.00 a
PGE (20 mg/l)	21.77 b	6.30 b	3.00 b
Second season (2021)			
Cont (DW)	17.23 d	4.20 d	2.00 d
Suc (3%)	19.89 c	5.20 c	2.00 c
Suc (5%)	16.33 f	3.43 g	1.00 e
BA (15 ppm)	17.11 e	3.27 i	1.00 f
BA (25 ppm)	15.99 k	3.50 e	1.00 j
$Al2(SO_4)_3$ (7.5 mg/l)	16.28 g	3.47 f	1.00 k
$Al2(SO_4)_3$ (10 mg/l)	16.14 h	3.40 h	1.00 g
Mor (2 g/l)	16.14 i	3.27 j	1.00 h
Mor (5 g/l)	16.03 j	3.17 k	1.00 i
PGE (10 mg/l)	22.97 a	8.47 a	4.00 a
PGE (20 mg/l)	21.22 b	6.33 b	3.00 b

* Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 2. Effect of holding solution treatments on fresh weight change (FWC%)/ one cut flower of chrysanthemum cut flowers during 2020 and 2021 seasons

Treatments / Day	First season (2020)								
	fresh weight change (FWC%)								
	3rd	6th	9th	12 th	15th	18th	21 st	24th	27th
Cont (DW)	3.08 k	6.64 k	9.17 j	4.67 d	-2.82 e	0.00 d	0.00 d	0.00 d	0.00
Suc (3%)	8.01 f	18.85 c	21.64 d	14.22 a	-0.77 c	-8.00 b	-14.37b	-21.05c	0.00
Suc (5%)	5.07 g	9.69 g	14.36 g	6.63 c	-9.44 i	0.00 d	0.00 d	0.00 d	0.00
BA (15 ppm)	16.41 b	20.12 b	21.95 b	12.98 a	-12.33k	0.00 d	0.00 d	0.00 d	0.00
BA (25 ppm)	17.28 a	20.32 a	21.85 c	10.10 b	-6.87 f	0.00 i	0.00 d	0.00 d	0.00
Al2(SO_4)$_3$ (7.5 mg/l)	11.30 c	18.30 e	20.17 e	11.10 b	-2.18 d	0.00 d	0.00 d	0.00 d	0.00
Al2(SO_4)$_3$ (10 mg/l)	8.92 e	13.90 f	16.96 f	7.63 c	-0.59 b	0.00d	0.00 d	0.00 d	0.00
Mor (2 g/l)	3.79 h	7.24 i	9.38 h	3.85 d	-8.60 h	0.00 d	0.00 d	0.00 d	0.00
Mor (5 g/l)	3.51 j	7.22 j	8.52 k	3.28 d	-10.55 j	0.00 d	0.00 d	0.00 d	0.00
PGE (10 mg/l)	11.13 d	18.31 d	24.17 a	14.26 a	8.70 a	5.20 a	1.81 a	-7.16 a	0.00
PGE (20 mg/l)	3.75 i	7.48 h	9.33 i	4.40 d	-8.45 g	-13.71c	-16.1c	-17.58b	0.00
Second season (2021)									
Cont (DW)	3.55 k	6.56 k	10.83 i	1.73 k	-3.60 c	0.00 d	0.00 d	0.00 d	0.00
Suc (3%)	8.48 d	11.92 e	16.19 e	9.21 d	-14.96 j	-16.45c	-18.75c	-20.58c	0.00
Suc (5%)	4.25 i	6.83 i	12.10 g	3.97 g	-16.98k	0.00 d	0.00 d	0.00 d	0.00
BA (15 ppm)	9.09 c	12.93 c	17.00 c	9.74 c	-13.94 i	0.00 d	0.00 d	0.00 d	0.00
BA (25 ppm)	11.72 b	15.89 b	18.80 b	11.24 b	-12.75h	0.00 d	0.00 d	0.00 d	0.00
Al2(SO_4)$_3$ (7.5 mg/l)	8.22 e	11.81 f	16.89 d	8.93 e	-10.19e	0.00 d	0.00 d	0.00 d	0.00
Al2(SO_4)$_3$ (10 mg/l)	8.00 f	12.85 d	14.53 f	7.92 f	-0.23 b	0.00 d	0.00 d	0.00 d	0.00
Mor (2 g/l)	4.41 h	7.01 h	8.90 j	3.63 h	-8.22 d	0.00 d	0.00 d	0.00 d	0.00
Mor (5 g/l)	5.05 g	6.77 j	8.82 k	2.35 j	-11.92g	0.00 d	0.00 d	0.00 d	0.00
PGE (10 mg/l)	12.70 a	18.22 a	21.48 a	12.05 a	1.49 a	-7.32 a	-11.20a	-14.49a	0.00
PGE (20 mg/l)	4.16 j	7.71 g	10.92 h	2.90 i	-10.48 f	-14.06b	-16.44b	-18.54b	0.00

* Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 3. Effect of holding solution treatments on Water uptake rate (g/g initial fresh weigh of flower / day) of chrysanthemum cut flowers during 2020 and 2021 seasons

Treatments / Day	First season (2020)								
	Water uptake rate (g/ g initial fresh weigh of flower / day)								
	3rd	6th	9th	12 th	15th	18th	21 st	24th	27th
Cont (DW)	0.66 k	0.39 e	0.84 b	1.10 a	1.09 a	0.00 d	0.00 d	0.00 d	0.00
Suc (3%)	2.12 a	0.31 h	0.31 g	0.93 b	0.13 j	0.19 c	0.15 b	0.08 b	0.00
Suc (5%)	0.92 j	0.14 j	0.35 d	0.35 e	0.35 e	0.00 d	0.00 d	0.00 d	0.00
BA (15 ppm)	1.27 f	0.38 f	0.31 h	0.10 g	0.10 k	0.00 d	0.00 d	0.00 d	0.00
BA (25 ppm)	1.67 c	0.20 i	0.25 i	0.24 f	0.56 b	0.00 d	0.00 d	0.00 d	0.00
Al2$(SO_4)_3$ (7.5 mg/l)	1.20 g	0.82 b	0.34 e	0.57 d	0.40 d	0.00 d	0.00 d	0.00 d	0.00
Al2$(SO_4)_3$ (10 mg/l)	1.45 d	0.91 a	0.32 f	0.78 c	0.23 g	0.00 d	0.00 d	0.00 d	0.00
Mor (2 g/l)	1.12 h	0.49 d	0.24 j	0.26 f	0.15 h	0.00d	0.00 d	0.00 d	0.00
Mor (5 g/l)	1.08 i	0.37 g	0.22 k	0.13 g	0.14 i	0.00 d	0.00 d	0.00 d	+0.00
PGE (10 mg/l)	1.30 e	0.13 k	0.41 c	0.35 e	0.42 c	0.23 b	0.11 c	0.44 a	0.00
PGE (20 mg/l)	1.87 b	0.52 c	0.88 a	0.24 f	0.26 f	0.64 a	0.21 a	0.06 c	0.00
Second season (2021)									
Cont (DW)	0.84 k	0.34 h	0.55 abc	1.14 a	1.10 a	0.00 d	0.00 d	0.00 d	0.00
Suc (3%)	1.13 h	1.13 a	0.48 abc	0.90 b	0.15 j	0.20 c	0.13 b	0.07 c	0.00
Suc (5%)	0.95 j	0.24 j	0.23 c	0.35 d	0.41 e	0.00 d	0.00 d	0.00 d	0.00
BA (15 ppm)	1.65 c	0.34 g	0.27 c	0.17 i	0.14 k	0.00 d	0.00 d	0.00 d	0.00
BA (25 ppm)	1.84 a	0.27 i	0.27 c	0.20 g	0.68 b	0.00 d	0.00 d	0.00 d	0.00
Al2$(SO_4)_3$ (7.5 mg/l)	1.28 e	0.86 c	0.83 a	0.18 h	0.47 c	0.00 d	0.00 d	0.00 d	0.00
Al2$(SO_4)_3$ (10 mg/l)	1.55 d	0.91 b	0.34 bc	0.70 c	0.28 g	0.00 d	0.00 d	0.00 d	0.00
Mor (2 g/l)	1.14 g	0.39 e	0.32 bc	0.22 f	0.16 h	0.00 d	0.00 d	0.00 d	0.00
Mor (5 g/l)	1.02 i	0.39 f	0.10 c	0.10 k	0.15 i	0.00 d	0.00 d	0.00 d	0.00
PGE (10 mg/l)	1.27 f	0.11 k	0.38 abc	0.25 e	0.41 d	0.21 b	0.25 a	0.38 a	0.00
PGE (20 mg/l)	1.80 b	0.70 d	0.74 ab	0.16 j	0.28 f	0.70 a	0.10 c	0.10 b	0.00

* Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 4. Effect of holding solution treatments on total, reducing and non-reducing sugars (%) of chrysanthemum cut flowers during 2020 and 2021 seasons

Treatments	First season (2020)			Second season (2021)		
	Sugars %					
	Total	Reducing	Non-Reducing	Total	Reducing	Non Reducing
Cont (DW)	6.26 g	1.93 k	4.33 b	6.45 f	2.19 j	4.26 b
Suc (3%)	4.40 k	2.88 i	1.52 h	4.47 k	3.07 h	1.39 i
Suc (5%)	7.53 c	4.44 d	3.10 e	7.77 b	4.70 d	3.07 e
BA (15 ppm)	4.57 j	3.19 g	1.38 i	4.77 j	3.23 g	1.54 h
BA (25 ppm)	5.55 i	2.01 j	3.54 d	5.71 i	2.15 k	3.56 d
Al2(SO_4)$_3$ (7.5 mg/l)	7.65 b	3.00 h	4.65 a	7.63 c	3.02 i	4.61 a
Al2(SO_4)$_3$ (10 mg/l)	7.46 d	3.53 f	3.93 c	7.26 d	3.56 f	3.70 c
Mor (2 g/l)	5.84 h	3.65 e	2.19 f	5.71 h	3.65 e	2.06 f
Mor (5 g/l)	7.08 e	5.29 c	1.79 g	7.08 e	5.43 b	1.64 g
PGE (10 mg/l)	7.86 a	6.90 a	0.96 k	7.99 a	6.95 a	1.04 j
PGE (20 mg/l)	6.36 f	5.30 b	1.06 j	6.39 g	5.39 c	1.00 k

* Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level.

Table 5. Effect of holding solution treatments on chlorophyll a, b and carotenoid (mg/100g f.w) in leaves of chrysanthemum cut flowers during 2020 and 2021 seasons

Treatments	First season (2020)			Second season (2021)		
	chlorophyll a	chlorophyll b	carotenoids	chlorophyll a	chlorophyll b	carotenoids
Cont (DW)	0.035 k	0.009 k	0.017 k	0.036 k	0.012 f	0.017 k
Suc (3%)	0.115 j	0.045 j	0.053 b	0.115 j	0.046 e	0.052 c
Suc (5%)	0.152 c	0.093 g	0.038 i	0.152 c	0.156 ab	0.038 i
BA (15 ppm)	0.145 g	0.102 f	0.050 e	0.145 g	0.102 cd	0.050 e
BA (25 ppm)	0.148 e	0.138 d	0.042 h	0.149 e	0.095 d	0.042 h
Al2(SO_4)$_3$ (7.5 mg/l)	0.142 h	0.118 e	0.046 f	0.142 h	0.114 c	0.047 f
Al2(SO_4)$_3$ (10 mg/l)	0.118 i	0.061 i	0.053 c	0.127 i	0.058 e	0.051 d
Mor (2 g/l)	0.146 f	0.141 c	0.042 g	0.147 f	0.140 b	0.042 g
Mor (5 g/l)	0.151 d	0.088 h	0.036 j	0.151 d	0.090 d	0.036 j
PGE (10 mg/l)	0.154 a	0.167 a	0.053 a	0.157 a	0.170 a	0.053 a
PGE (20 mg/l)	0.152 b	0.155 b	0.051 d	0.153 b	0.140 b	0.052 b

* Means within a column or row having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level.

significantly extended the vase life, increased the diameter and improved general appearance of chrysanthemum cut flowers compared to the control (distilled water). These findings were confirmed by [24] found that pomegranate peel extracts, extracts of cv. 'Shahvar dane sefid' showed the highest effect on extending vase life, decreasing electrolyte leakage and stem end bacteria, and thus, recommended for extending the vase life of chrysanthemum cut flowers. Also, [38] reported that increased levels of antioxidants usually retard senescence, and vice versa. For instance, knock-down of the rate-limiting enzyme of the tocopherol biosynthetic pathway homogentisate phytyltransferase by RNA-directed silencing led to decreased tocopherol levels, ROS build-up and accelerated senescence in tobacco. In addition to [39], who mentioned that pomegranate peel was found as a good source for synthesis of AgNO3 due to presence of crude pectin, sugars and ellagic acid (main phenolic compound) present in peel.

3.2. Fresh weight change: (FWC%) / one cut flower

Data in Table (2) indicated that most of the holding solutions used significantly gave the greatest RFW% of chrysanthemum cut flowers compared with the control (distilled water) until the 9th day, which had the lowest FWC% of chrysanthemum cut flowers in the two seasons (9.17 and 10.83 %, respectively). Whereas, the heavier values of FWC% of cut flowers recorded in the holding solution containing PGE (10 mg/l) in both seasons (24.17 and 21.48 %,) and continued to increase until 15th day (8.70 and 1.49%), respectively in both seasons) [40] reported that the results obtained promote the use of natural extracts analyzed like fungicides to control postharvest fruits decay. Furthermore, to extend the shelf life of strawberry, we used the extract with concentrations very similar to those recommended for chemicals. Also, *P. granatum* peel extract (PGE) could be an alternative to synthetic products to control postharvest deteriorations and improve postharvest quality of strawberry fruits by avoiding the impact of chemicals on human health.

3.3. Vase solution uptake rate (g/ g initial fresh weigh of flower / day)

As shown in Table (3) the best values of water uptake resulted in chrysanthemum cut flowers were obtained from the holding solution of PGE (10 mg/l) registered (0.44, and 0.38 g/ g initial fresh weigh of flower / day) after 24 day compared to control (1.09 and 1.01 g / g initial fresh weigh of flower / day) after 15 day in the first and second seasons, respectively. these results agreed with [24] showed that chrysanthemum (*Chrysanthemum morifolium* R.) is one of the most popular cut flowers in the world. Stem end blockage and water stress are two problems in shortening the vase life of cut chrysanthemum. Essential oils are noble alternative substitutes for silver and chemical compounds because of their antimicrobial activities and environmentally friendly nature of the extracts. A pomegranate peel extract (PGE) was evaluated as a natural antifungal preparation for the control of postharvest rots, explain that Several factors can reduce the quality of fresh cut flowers, namely the inability of stems to absorb water due to the inhibition of microorganisms (bacteria and fungi), embolism or physiological reaction of the flower itself. Also, carbohydrate content is inadequate to support respiration. The third factor is that plants suffer from too much water loss due to high ambient temperatures. The other factor is the presence of ethylene produced by the damaged tissue. The last factor is due to disease or pest attack [2]. Regarding total and reducing sugars in leaves, data Table (4) clear that chrysanthemum cut flowers which held in PGE (10 mg/l) increased the level of total and reducing sugars in leaves until the end of vase life as compared to other treatments (7.86, 6.90) and (7.99, 6.95) respectively in the two seasons. Perhaps this is due to the pomegranate peel containing a high percentage of carbohydrates, the sugar content is important factor controlling longevity of cut flowers after harvested. These results confirm with the findings of [41] who found that pomegranate peels contain fat 0.85%, ash 4.32%, moisture 7.27%, protein 3.74%, fiber 17.31% and carbohydrates 66.51%.

3.4. Chlorophyll a, Chlorophyll b and Carotenoids in leaves (mg/100 g FW)

As shown in Table (5) the data indicated that PGE (10 mg/l) as a holding solution recorded the best values in chlorophyll a content in leaves of chrysanthemum leaves (0.154 and 0.157 mg/100 g F.W.) and chlorophyll b content (0.167and 0.170 mg/100 g F.W.) compared to the control (DW) (chlorophyll a, 0.035, 0.036) and (chlorophyll b, 0.009, 0.012 mg/100g F.W.) for the two seasons, respectively. Pomegranate peel needs more study and research.

4. Conclusions

It could be concluded that the best treatment of Chrysanthemum (*Dendranthema grandiflorum* Kitam.) cv. "White Zembla" cut flowers was holding in the preservative solution contain PGE (10mg/l).

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