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Impact of Some Floral Preservatives on Gerbera Cut Flowers cv. Rosalin Characteristics

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ABSTRACT

This experiment was conducted to clarify the influence of the preservative solutions on some characteristics of *Gerbera jamesonii* cut flowers. The first group was the ethylene inhibitors and their components: nano-silver particles (NS), silver nitrate ($AgNO_3$) at 5 and 10 mg/l, and silver thiosulfate (STS) at 0.2 mM and0.4 mM. The second group was the chemical preservatives such as gibberellic acid (GA_3) and benzyl adenine (BA) at 10 and 15 mg/l and 8-hydroxyquinoline (8-HQ) at 200 and 300 mg/l. The third group was the natural preservatives such as rosemary and oregano oils at 1 and 2 mg/l. also, 2.5% sucrose (Suc) was added to all treatments; the control was distilled water. The obtained results showed that the first group achieved excellent results, whereas, NS at 10mg /l prolonged the longevity under room temperature and cold storage conditions and enhanced the fresh weight, as well as, had a positive effect on the lignin ratio, total sugars, anthocyanin content, and particularly microbial count. It reduced the microorganisms in the vase solution, thereby improving the water uptake through the vessels of cut flowers. A similar trend was observed from the results of the chemical preservatives, chiefly BA at 15mg/l was the superior treatment. Referring to the eco-friendly group (the natural preservatives) they increased the amount of water uptake, delayed the onset of flower symptoms senescence, and improved the chemical components, focusing on preventing xylem blockage and avoiding possible contamination during vase life. Currently, synthetic preservatives containing chemicals are unfavorable in general compared to other preservatives containing natural substances.

Keywords: longevity, cut flowers, cold storage, NS, $AgNO_3$, STS, rosemary, oregano.

1. Introduction

Cut flowers can be defined as flowers that have been harvested from the open field or the greenhouse for various purposes where they play an important part in the decoration, so it is necessary to pay serious attention to quality control, free from diseases and wilting, with a view to their good general appearance in several floral arrangements.

Gerbera (*Gerbera jamesonii*) as cut flowers belong to the largest Asteraceae Family of flowering plants and it is one of the most valuable cut flower crops as it currently ranks fifth in the list of best-performing crops worldwide, and it is very important to maintain the quality by the common method of using preservative solutions as De Silva *et al.,* (2013) showed that chemical preservative solutions contain carbohydrates, germicide, ethylene inhibitors, growth regulators, and some mineral compounds or natural preservatives such as essential oils, all of which slow down wilting and extend the vase life of cut flowers. Wilting of cut flowers is caused by either air embolisms in the stem xylem or by bacteria entering the end of the stem, preventing the absorption that is the major factor in the imbalance between water uptake and water loss, giving rise to premature deterioration.

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Nano-silver compounds (NS) are a somewhat novel agent in chemical preservative solutions having strong antimicrobial activity because the small-sized volume particles with large surfaces increase their links with microorganisms, thereby preventing their negative effects in vase solutions. Likewise, Bahrehmand *et al.* (2014) suggested that NS reduces transpiration in association with reducing stomatal aperture (stomata closure), increases hydraulic conductance, inhibits bacterial growth in the vase solution and at the cut stem end, and prevents ethylene-mediated processes. NS may also act as a carrier to transport Ag^+ more efficiently to bacteria cells whose proton motive force would consequently reduce the local pH and increase Ag+ release (Ovais *et al.,* 2016). Moreover, it is believed that silver nanoparticles form free radicals upon contact with bacteria that damage the cell membrane, making it porous (Singh *et al.,* 2016).

Silver nitrate ($AgNO_3$) has a well-known antimicrobial activity because Ag^+ ions replace hydrogen cations (H^+) on the surface of proteins in bacterial cell membranes, resulting in membrane integrity loss and cell death (Feng *et al.,* 2000). Silver nitrate ($AgNO_3$) is one of the most common forms of silver salts used in commercial flower preservative solutions and is mostly used either as an ethylene binding inhibitor or an antimicrobial (MohyEldeen, 2011). Moreover, silver ions and AgNP suspension can have a bactericidal, bacteriostatic, antiviral, and antifungal effect on a large number of pathogenic microorganisms, yeast fungi, and viruses (Mikhailova, 2020).

Silver thiosulfate (STS) as an effective compound in extending the vase life of cut flowers has been verified as an environment-unfriend chemical with several possible environmental and biological side effects, especially in cases of huge commercial applications (Marandi *et al.,* 2011). Generally, STS as a pulsing treatment is recommended for improving the vase life of flowers (Ichimura, 2020).

Gibberellic acid (GA_3) is a known plant growth regulator that has gained much attention as a potential elicitor of shelf life increasing in cut flowers and cut foliages. It is involved in various metabolic processes and could improve the water, and carbohydrate contents of cut flowers. Hunter *et al.,* (2004) reported that treating daffodils with GA_3 repressed the accumulation of the seven senescence-associated transcripts. Sumanasiri *et al.,* (2013) showed that GA_3 can be used to improve flower quality and that it increases the marketing value of ceylon rock primrose flowers.

Benzyl adenine (BA) is considered a synthetic cytokinin, that mainly affects cell division and delays senescence in ornamental plants (Iqbal *et al.,* 2012). Moreover, its influence on many other physiological processes increases the vase's life and delays the senescence of cut carnations by inhibiting ethylene biosynthesis (Farag *et al.,* 2018).

8-Hydroxyquinoline (8-HQ) is one of the most important chemical preservatives used as a germicide in the floral industry. It acts as an antifungal and antimicrobial agent, prevents the growth of microorganisms in xylem vessels, maintaining water uptake and thus prolonging vase life. 8HQ and its derivatives are potent antioxidants, reduce ROS formation, and are reported to exert antimicrobial activities against a variety of microorganisms such as *Mycobacterium tuberculosis, Escherichia coli, Staphylococcus aureus*, *Streptococcus mutans, Candida albicans* (Srisung *et al.,* 2013). 8-HQS reduces respiration rate and increases water uptake in dendrobium and gladiolus cut flowers, thereby prolonging their longevity (Dung *et al.,* 2017).

Essential oils (EOs) are extracted from plant materials like flowers, leaves, herbs, buds, wood, twigs, bark, seeds, fruits, and roots. They are natural, organic, safe, and eco-friendly substances that have strong anti-inflammatory, antibacterial, antifungal, antioxidant, and anti-carcinogenic effects, and these properties are attributed to the high levels of phenolic compounds such as eugenol, carvacrol, and thymol (Amin and ElSayed, 2021). *Rosmarinus officinalis* has displayed antispasmodic, anticarcinogenic, antitumorigenic, antimicrobial, anti-inflammatory, and antioxidant properties. These biological properties have made rosemary a potential new therapeutic agent in the treatment of many diseases. The studies have only recently begun to realize its potential contributions to modern medicine, and the strong antioxidant compounds found in its extract and essential oil account for many of rosemary's biological activities (Hamidpour *et al.,* 2017). *Origanum majorana* has been reported as having antibacterial, antifungal, antispasmodic, acetylcholine esterase inhibition, radical-scavenging effect, antioxidant, antimicrobial, and anti-inflammatory effects, which are attributed to its high content of phenolic acids and flavonoids (Wahby *et al.,* 2015).

This study aimed to compare the effects of different chemical preservative solutions (whether as holding or pulsing solutions) and natural preservative solutions on the longevity and keeping quality of cut *Gerbera jamesonii* flowers cv. Rosalin.

2. Materials and Methods

The experiment was carried out in the Laboratory of the Ornamental Plants and Landscape Gardening Research Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt, during the two successive seasons of 2020 and 2021.

2.1. Plant material

Cut flowers of *Gerbera jamesonii* were obtained from the local commercial greenhouses of Floramix Farm (El-Mansouria, Giza) in each season. Flowers were picked in the early morning at the commercial stage which had two rows of outer florets open on the central disk (Safa *et al.,* 2012) and directly wrapped in groups and transported to the laboratory within 2 hours and pre-cooled by placed in cold water for half an hour to remove the effect of high field heat. Thereafter, stem bases were recut underwater to avoid air embolism. Stems (Injury-free) were adjusted to the same length (45cm).

2.2. Experiment treatments: Cut flowers were divided into three groups:

- **First group:** Cut flowers were treated with one of the following solutions (ethylene inhibitors):
  1-Nano-silver particles (NS) at 5 and 10 mg/l +2.5% sucrose (Suc).
  2-Silver nitrate ($AgNO_3$) at 5 and 10 mg/l +2.5% sucrose (Suc).
  3- Silver thiosulfate (STS) at 0.2 mM and0.4 mM + 2.5% sucrose (Suc).

- **Second group:** Cut flowers were treated with one of the following solutions (chemical preservatives):
  1- Gibberellic acid (GA_3) at 10 and 15 mg/l +2.5% sucrose (Suc).
  2- Benzyl adenine (BA) at 10 and 15 mg/l +2.5% sucrose (Suc).
  3- 8-Hydroxyqunoline (8-HQ) at 200 and 300 mg/l +2.5% sucrose (Suc).

- **Third group:** Cut flowers were treated with one of the following solutions (natural preservatives):
  1- Rosemary oil (*Rosmarinus officinalis*) at 1 and 2 mg/l +2.5% sucrose (Suc).
  2- Oregano oil **(***Origanum vulgare*) at 1 and 2 mg/l +2.5% sucrose (Suc).

Distilled water (Dw) was used as a control, half the number of flowers in the three groups were placed inside those solutions as mentioned above (holding solutions) while the other half number of flowers were stored at 5°C for 5 days, after which held in the holding solutions, except for STS, which was the pulse treatment of flowers for 1 hour and then transferred to distilled water. The cut flowers were placed in glass bottles (500 ml) containing 400 ml of holding solutions, each treatment consisted of 3 replicates and each bottle contained 3 stems of cut flowers. Cut flowers were placed in ambient conditions at 20±2 °C, the light level was about15 µmol $m^{-2}S^{-1}$ partially from natural light and partially from fluorescent cool light for 12h/day.

2.3. Extraction of the essential oils

The selected essential oils were extracted from leaves of *Rosmarinus* officinalis (rosemary) and *Origanum vulgare* (oregano) and extracted according to British Pharmacopeia (1963) methods, Tween-20 (0.1 ml/l) was used as a wetting agent.

2.4. Preparation of STS solution: The STS was prepared as described by Gorin *et al.,* (1985).

2.5. Experimental measurements:

- **Longevity of cut flowers**: The time from the start of treatment until the senescence of flowers (days).
- **Total water uptake**: Cumulative water uptake was recorded for the entire period of the vase life of the flower stalk (g/flower stem), according to Amin (2017).
- **Maximum increase in fresh weight:** It was recorded daily in 1, 3,…etc. during the experiment according to He *et al.* (2006) and calculated as FW (%) = fresh weight of stem on the mentioned day divided by the fresh weight of stem in zero days multiplied by 100.

2.6. Chemical constituents:

- **Lignin ratio** was determined according to Bruce and West (1989).
- **Total sugars (%):** were determined colorimetrically according to the methods described by Dubois *et al.* (1956).

- **Anthocyanin content** (mg/g) in petals was determined according to Ichimura and Hiraya (1999).
- **Microbial count:** Microbial count (log^{10} CFU ml^{-1}) according to Jowkar (2006).

Statistical analysis

Data were tabulated in a randomized complete design. Means were compared by the least significant difference (L.S.D.) test as given by Snedecor and Cochran (1980).

3. Results and Discussion

3.1. The role of some ethylene inhibitors on postharvest characteristics of *Gerbera jamesonii* flowers:

3.1.1. Longevity of cut flowers

The results illustrated in the Figures revealed that ethylene inhibitors such as nano-silver particles (NS), silver nitrate ($AgNO_3$), and silver thiosulfate (STS) significantly increased the longevity of cut flowers over the control treatment during the two studied seasons. (Nano-silver particles treatment with the two concentrations surpassed all other treatments in both seasons, NS at 10 mg per liter +2.5% sucrose (Suc) was significantly superior. STS treatment at 0.4 mM gave close proportions to NS (Fig.1). This effect of the ethylene inhibitors action in extending the longevity of cut flowers of gerbera may be due to the positive effect of silver ion in reducing bacterial growth in the vase solution and at the end of cut stems of flowers also, it delays senescence of cut flowers. The previous results are in agreement with the results obtained by Wongjunta *et al.,* (2021) who reported that ethylene is involved in the regulation of the mokara flower senescence, the longer vase life of the 'Dao-lai' hybrid as compared to that of the 'Moo-Deang' hybrid, could be due to its lower sensitivity to ethylene and its lower ethylene production rates and pretreatment with ethylene inhibitors significantly improved their vase life longevity. NS increases the vase life of several cut flowers by inhibiting ethylene production and bacterial growth (Hassan *et al.,* 2014; Li *et al.,* 2017). Hatefi *et al.,* (2014) stated that nanosilver as an antimicrobial material with sucrose increased the quality and cut flower's vase life of alstroemeria cv. Isola. Likewise, Moradi *et al.,* (2012) on carnation cv. Cream Viana; Safa *et al.,* (2012) on *Gerbera jamesonii* L. cv 'Balance.

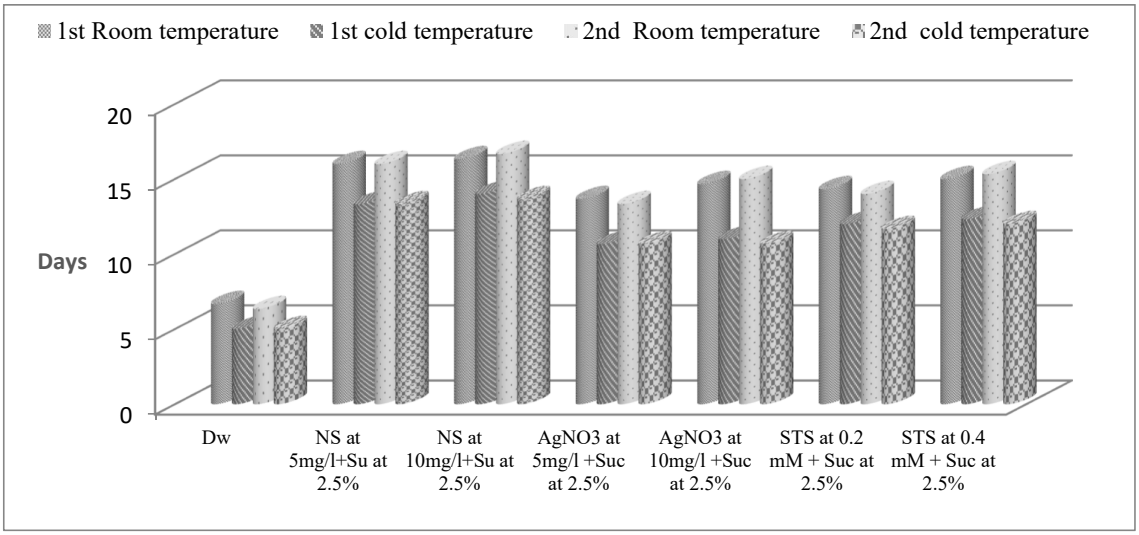

Fig. 1: Influence of some ethylene inhibitors on longevity (days) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.1.2. Total water uptake

All studied treatments with different concentrations significantly promoted the rate of absorption in gerbera-cut flowers. The effect of NS at 10 mg/g treatment was uppermost pronounced in enhancing the water uptake of cut flowers. It is noteworthy from the obtained results, that the absorption rate (total water uptake) is lower in the case of cold storage, despite the superiority of the treatments (NS, STS

and $AgNO_3$) in relation to the control (Fig.2). These results are in accordance with some researchers who indicated that NS as an antimicrobial agent inhibits bacterial growth in cut flower stem xylem, thereby increasing the absorption of cut flowers (Liu *et al.,* 2009; Li *et al.,* 2012; Li *et al.,* 2017).

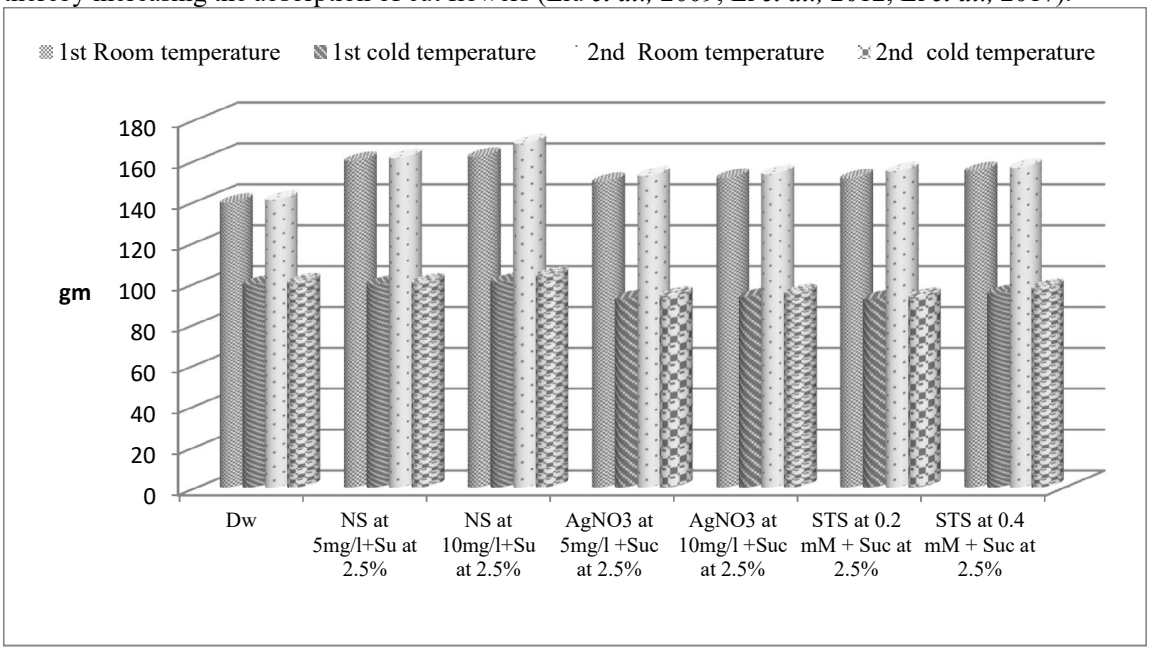

Fig. 2: Influence of some ethylene inhibitors on total water uptake (g) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.1.3. Maximum increase in fresh weight (%)

It is evident from the results illustrated in the figures obtained that *Gerbera jamesonii* which were treated with nano silver particles achieved the highest fresh weight percentage values either in cold storage or in room temperature conditions compared to control and other treatments. Silver nitrate at 10 mg/g treatment under room temperature conditions was the least effective, but it outperformed the control treatment in both seasons (Fig.3).

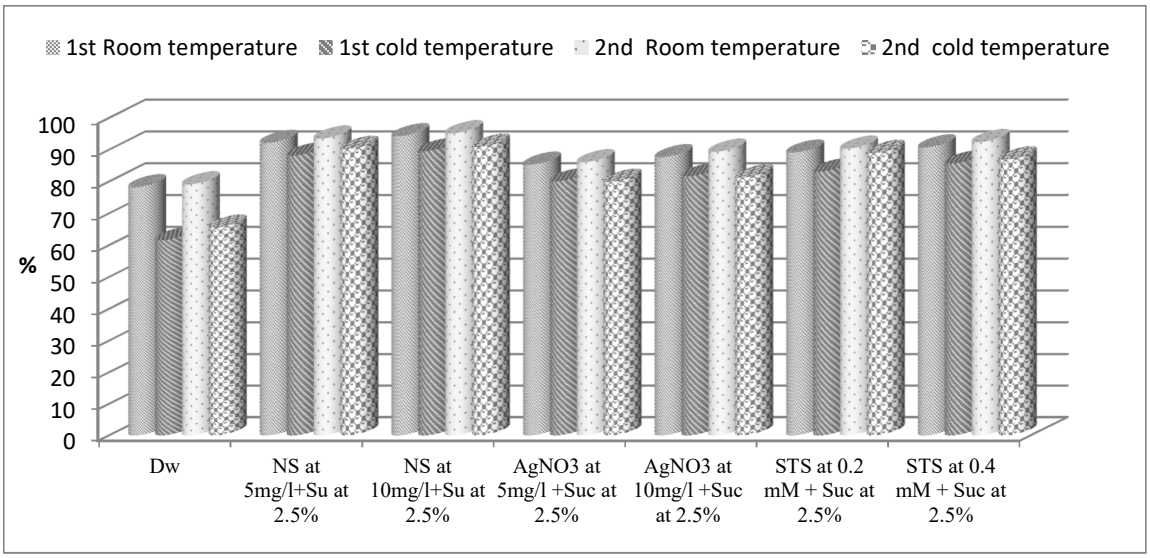

Fig. 3: Influence of some ethylene inhibitors on the maximum increase in fresh weight (%) of cut *Gerbera jamesonii* flowers cv. Rosalin.

Decreasing the value of the fresh weight of cut flowers closely coincided with their senescence symptoms that terminated their longevity. The deterioration may be attributed to increased endogenous ethylene biosynthesis. Hatami *et al.* (2011) showed that pulse treatment with silver nanoparticles prevented fresh weight loss during the vase life of the cut rose. Park *et al.,* (2017) confirmed the positive effect of ethylene inhibitors as NS induced the value of relative fresh weight.

3.1.4. Lignin ratio and microbial count

Data shown in Table (1) revealed that ethylene inhibitors under study significantly improved the lignin content in cut gerbera in both seasons under room and cold temperatures. The treatment of NS was the most superior, these results coincide with the findings of Naing *et al.* (2017) who pointed that out nano-silver particles maintain lignin content by triggering lignin biosynthetic genes. It is clear from the same Table (1), that among all treatments, the microbial count obtained from the nano-silver particles (NS) treated stems was the lowest throughout the vase life period. This may be attributed to that the nano-silver particles being able to physically interact with the surfaces of different bacteria cells. There are various rules for the effect of NS on the cell: adhesion to the surface of the bacterial cell wall and membrane, penetration into the cell and disruption of intracellular organelles and biomolecules, induction of oxidative stress, and modulation of signal transduction pathways. The adhesion and accumulation of NS on the cell surface were particularly observed for Gram-negative bacteria. NS can penetrate bacterial cells through a water-filled channel called porins in the outer membrane of Gram-negative bacteria. The thick cell wall of Gram-positive bacteria may result in the penetration of silver ions into the cytoplasm, so the effect of NS is more pronounced in Gram-negative bacteria than in Gram-positive bacteria (Dakal *et al.,* 2016). It may be also that the presence of lipopolysaccharides contributes to the structural integrity of the cell wall of Gram-negative bacteria, making these bacteria more sensitive to NS because the negative charge of lipopolysaccharides enhances NS adhesion (Pal *et al.,* 2007).

Some researchers hypothesize that the ability of NS to adhere to the bacterial cell wall is due to the electrostatic interaction between positively charged silver ions and the negatively charged surface of the cell membrane due to the carboxyl, amino groups, and phosphate and gain a later opportunity for it. The structural changes in the cell membrane begin and thereby caused permeability leading to the dispersion of the proton driving force occurring and thus the destruction of the membrane (Netala *et al.,* 2014; Rashid *et al.,* 2017).

Table 1: Influence of some ethylene inhibitors on lignin ratio and microbial count of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Lignin ratio (%)				Microbial count (log^{10} CFU ml^{-1})			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	1.10	1.67	0.90	0.93	10.32	10.00	11.19	10.81
NS at 5mg/l+Su at 2.5%	3.13	3.17	2.40	2.47	4.85	4.77	4.98	4.90
NS at 10mg/l+Su at 2.5%	3.17	3.20	2.50	2.57	4.61	4.42	4.90	4.63
$AgNO_3$ at 5mg/l +Suc at 2.5%	2.50	2.30	2.00	2.13	5.48	5.33	5.94	5.72
$AgNO_3$ at 10mg/l +Suc at 2.5%	2.70	2.77	2.20	2.60	5.39	5.20	5.92	5.58
STS at 0.2 mM + Suc at 2.5% su	2.70	2.77	2.13	2.17	5.40	5.11	5.90	5.62
STS at 0.4 mM + Suc at 2.5% s	2.90	2.97	2.30	2.33	5.28	5.00	5.70	5.43
L.S.D. at 5 %	0.1552	0.1435	0.1228	0.1363	0.2221	0.2168	0.2107	0.2051

3.1.5. Total sugars and anthocyanin content

According to data presented in Table (2) pulsed cut flowers in STS led to maintaining the content of total sugars thereby delaying senescence by a reduction in the respiratory condition. In this respect, Helaly (2019) declared that STS with 8-HQS as a pulsing solution and storage at 5°C for 5 days recorded a significant increase in total sugars percentage compared to the control. Data indicated also, that the results obtained from treated cut flowers with NS and those treated with STS are convergent at

low concentrations and under room temperature. These gains are supported by the results of Kuroshima *et al.,* (2017) who mentioned that treating *Delphinium elatum* with 4% sucrose in combination with STS significantly increased the anthocyanin concentration in the sepals and improved the pigmentation of the flower color compared with that of STS alone or at 10°C for 48 h to simulate long-distance transport.

Table 2: Influence of some ethylene inhibitors on total sugars and anthocyanin content of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Total sugars (%)				Anthocyanin content(mg/g)			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	2.53	2.85	2.18	2.37	0.180	0.200	0.150	0.190
NS at 5mg/l + Su at 2.5%	5.85	5.89	5.60	5.64	0.411	0.420	0.370	0.350
NS at 10mg/l + Su at 2.5%	5.91	6.00	5.62	5.73	0.440	0.450	0.390	0.400
$AgNO_3$ at 5mg/l + Suc at 2.5%	4.71	4.80	3.79	3.98	0.300	0.320	0.240	0.270
$AgNO_3$ at 10mg/l + Suc at 2.5%	4.75	4.92	3.98	4.00	0.320	0.330	0.260	0.270
STS at 0.2 mM + Suc at 2.5% su	5.27	5.33	4.48	4.71	0.410	0.410	0.350	0.330
STS at 0.4 mM + Suc at 2.5% su	5.50	5.67	4.55	4.86	0.400	0.400	0.340	0.320
L.S.D. at 5 %	0.1786	0.1942	0.1866	0.1729	0.0885	0.0723	0.0799	0.0590

3.2. Role of some chemical preservatives on postharvest characteristics of *Gerbera jamesonii* flowers:

3.2.1. Longevity of cut flowers

The chemical preservatives; gibberellic acid (GA_3), benzyl adenine (BA), and 8-hydroxyquinoline (8-HQ) gave significantly higher values of the longevity of cut flowers in the two seasons than the control treatment. Data showed that maximum longevity (vase life in days) of gerbera cut flowers was achieved by benzyl adenine at 15 mg/l +2.5% sucrose (15 days in the first and second seasons, respectively) compared to other treatments under room temperature. On the other hand, control gave the significantly lowest vase life (6.67 and 6.33 days in the first and second seasons, respectively). Nonetheless, treated cut flowers with BA at the same concentration recorded 11.67 and 12 days in the first and second seasons, respectively as a result of placing them in cold temperatures (Fig.4). Similar results were obtained by Danaee *et al.,* (2011) and Vieira *et al.,* (2010) as they denoted that the application of PGRs such as GA_3 and BA has been recommended to improve cut flowers and increase lifespan. The authors emphasized that the mechanisms by which the growth regulator BA delays senescence in fallen lily leaves are still unknown, but since the respiration rate was low in BA-treated leaves, it can be said that it leads to a rapid decrease in protein degradation, anti-aging substances can generate maximum soluble protein content, increase intracellular macromolecules, prevent leakage and reduce water absorption and cell wall degradation which lead to senescence (Farazmandi *et al.,* 2020). Toyohara *et al.,* (2020) found that the application of BA or a mixture of BA and GA_3 inhibited senescence leading to a prolonged flower vase life of the Iris. In this study, it was also found that the 8-HQ outperformed the control and prolonged the duration of the flowers in the vase. In a previous study Asrar (2012) concluded that the 8-HQC + sugar used as a preservative solution led to prolong vase life, delay senescence, and enhance postharvest quality in cut snapdragon flowers.

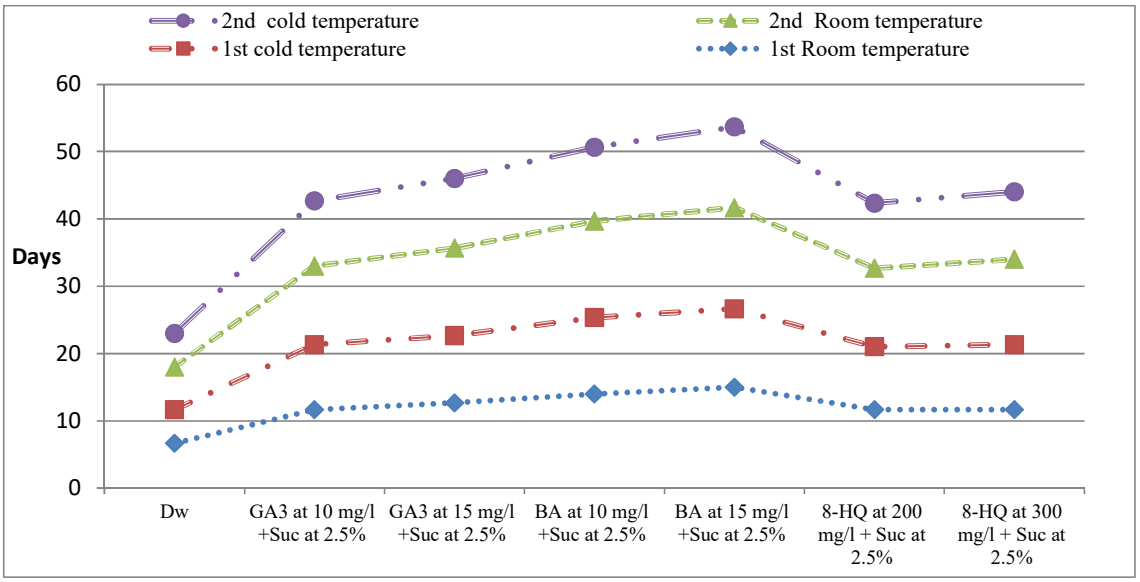

Fig. 4: Influence of some chemical preservatives on longevity (days) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.2.2. Total water uptake

It is clear that gerbera cut flowers under room temperature treated with BA, GA_3, and 8-HQ (at high and low concentrations) raised the amount of water uptake compared to those stored at cold temperatures in both seasons. The highest rate of water uptake was recorded from cut flowers treated with BA at15 mg/l+2.5% Suc and recorded162.10 and 167.35g compared to cut flowers held in distilled water as recorded 139.30 and140.59g in the first and second seasons, respectively (Fig.5). BA delays lipid peroxidation in the cells and decreases ion leakage leading to improvement in the permanency of the cell membrane, thereby BA extended the lifespan of cut flowers. The present finding also lent credence to the observation made by Kapri *et al.,* (2018). GA_3 and BA increase the absorption rate from preservative solutions (Danaee *et al.,* 2011; Abshahi *et al.,* 2016).

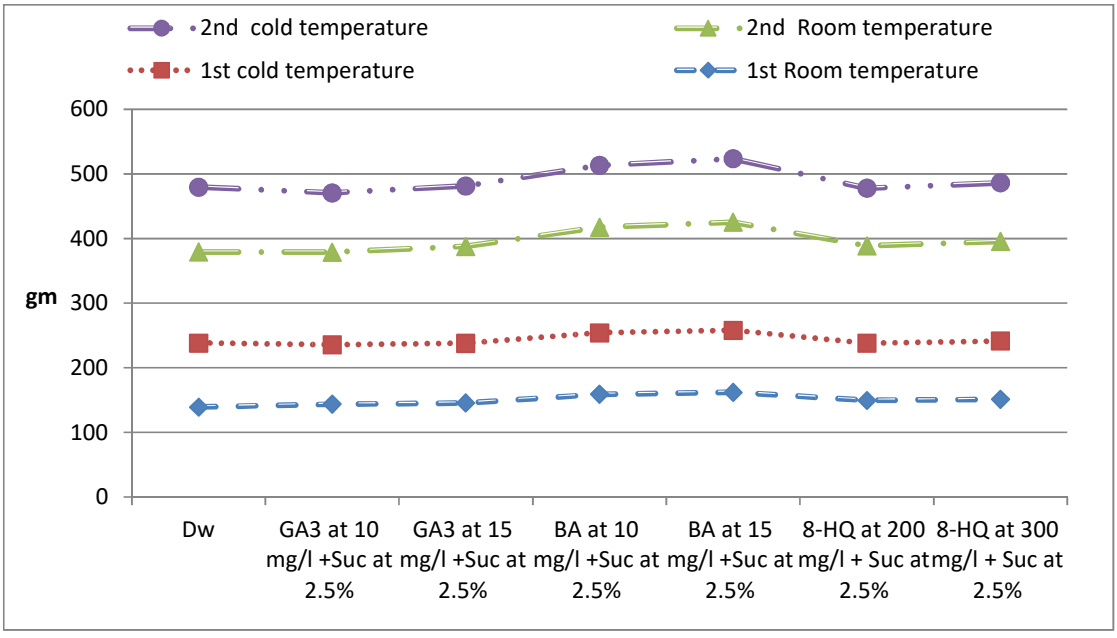

Fig. 5: Influence of some chemical preservatives on total water uptake (g) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.2.3. Maximum increase in fresh weight (%)

The percentages of increase in the fresh weight of gerbera cut flowers during the vase life are shown in Fig. 6 whereas, the cut flowers kept in distilled water lose weight and recorded the lowest percentage of fresh weight under room and cold temperatures in the two seasons while the highest value was achieved from those of held in BA followed by GA_3 then 8-HQ. These results agreed with those of Mohamindicating indicated that the treatment with GA_3 or BA recorded a highly significant increase in change percentage in fresh weight of cut inflorescence of *Symphyotrichum novi-belgii*. On the other hand, the gibberellic acid significantly affected α- amylase synthesis, therefore total soluble carbohydrates content increased and this could contribute to improving the energy pool (or resource) and/or increasing the osmotic potential of flowers (Andrew, 2010). Furthermore, Elhindi (2012) established that 8-HQS combined + sucrose showed increasing in the fresh weight of *Lathyrus odoratu.*

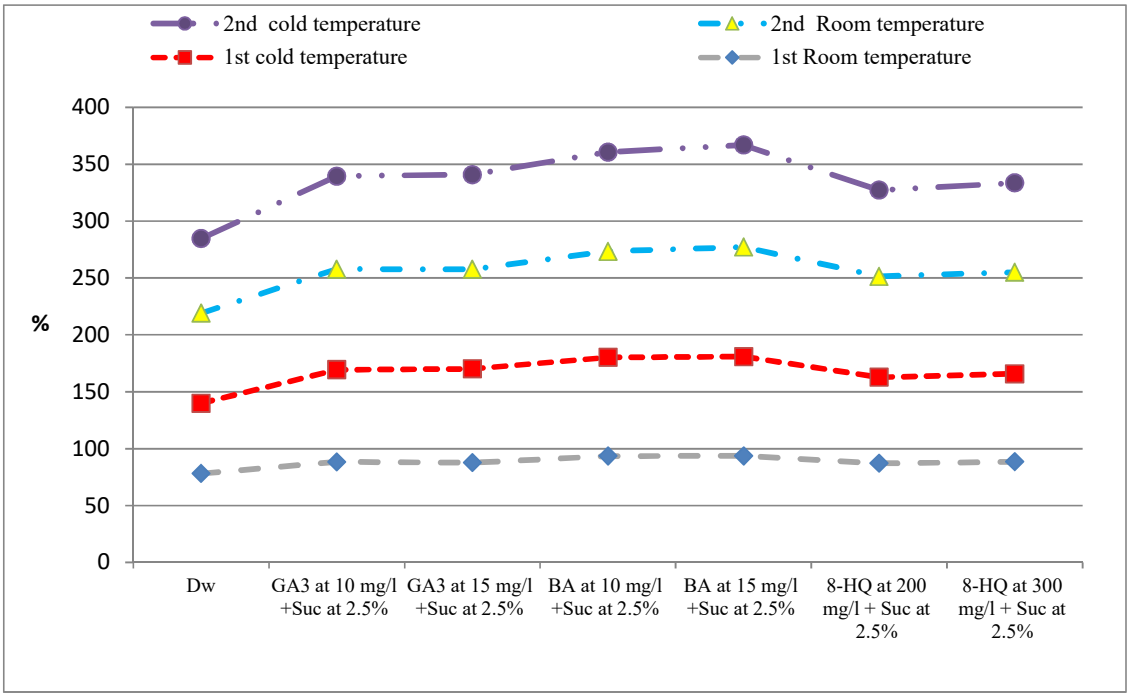

Fig. 6: Influence of some chemical preservatives on the maximum increase in fresh weight (%) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.2.4. Lignin ratio and microbial count

As shown in Table (3) data clearly resulted that the use of preservation solutions that contain,in BA, G,A_3 and finally 8-HQ all of those plus 2.5% Suc improved the percentage of intracellular lignin. The best treatment was BA at a high concentration under room (2.80 and 2.87 %) and cold (2.60 and 2.40%) temperatures compared to control (1.10 and 1.67%) in room temperature (0.90 and 0. %) and in cold temperatures in the first and second seasons, respectively. Farazmandi *et al.,* (2020) attributed cytokinin effectiveness to the stimulation of calcium ion absorption in cell walls and demonstrated that certain cytokinins impact the induction of phosphoenolpyruvate carboxylase (the key enzyme in crassulacean acid metabolism, accumulation of proline, and PEPCase and carbonic dehydrogenase in plants). Data illustrated in Table (3) showed that under room temperature; the cut flowers kept in a holding solution with 8-HQ at 300mg/l recorded the lowest microbial growth (6.24 and 5.97 CFU/ml in the first and second seasons, respectively) during the lifespan compared to the flowers kept in the distilled water which recorded the highest microbial count (10.32 and 10.00 CFU/ml in the first and second seasons respectively). This could be due to that sucrose in the vase solution serving as a source of energy for microorganisms that might be helped to grow and increase their population. This conforms to the findings of Kong *et al.,* (2021) who demonstrated that the preservatives composed of 8-HQ and sucrose could 8-HQ inhibit the growth of microorganisms in the solution.

Table 3: Influence of some chemical preservatives on lignin ratio and microbial count of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Lignin ratio (%)				Microbial count (log^{10} CFU ml^{-1})			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	1.10	1.67	0.90	0.93	10.32	10.00	11.19	10.81
GA_3 at 10 mg/l + Suc at 2.5%	2.10	2.17	1.80	1.83	8.91	8.55	9.46	9.27
GA_3 at 15 mg/l + Suc at 2.5%	2.30	2.37	1.90	1.93	8.58	8.44	9.23	9.16
BA at 10 mg/l + Suc at 2.5%	2.60	2.67	2.30	2.33	8.64	8.48	9.21	9.10
BA at 15 mg/l + Suc at 2.5%	2.80	2.87	2.60	2.40	8.06	8.00	9.10	8.98
8-HQ at 200 mg/l + Suc at 2.5%	2.20	2.27	1.90	1.93	6.37	6.21	6.78	6.39
8-HQ at 300 mg/l + Suc at 2.5%	2.30	2.37	2.00	2.07	6.24	5.97	6.75	6.72
L.S.D. at 5 %	0.1330	0.1404	0.1308	0.1192	0.2468	0.2360	0.2329	0.2260

3.2.5. Total sugars and anthocyanin content

According to data presented in Table (4) it is obvious that the preservative solutions in the study improved the content of sugars during the lifespan of gerbera cut flowers. Benzyl adenine had preponderance in this concern, it was observed that BA had a significant effect, especially during cold storage. This agreed with the results found by Han (1995) who indicated that benzyl adenine can increase sugars availability in cells by increasing α- amylase and inverse enzyme activity. It can be noticed from data recorded in the same Table that, under room temperature, the application with 8-HQ at 300mg/l +2.5%Suc had superiority in maximizing the content of anthocyanin content in cut flowers in the first season which is equal in value to BA at 15mg/l+2.5% Suc. The application of BA at the two doses gained the highest value in the second season under all conditions compared to other preservative solutions in the experiment.

Table 4: Influence of some chemical preservatives on total sugars and anthocyanin content of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Total sugars (%)				Anthocyanin content(mg/g)			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	2.53	2.85	2.18	2.37	0.180	0.200	0.150	0.190
GA_3 at 10 mg/l + Suc at 2.5%	4.72	4.70	3.80	3.82	0.220	0.210	0.200	0.200
GA_3 at 15 mg/l + Suc at 2.5%	4.73	4.79	3.84	3.91	0.240	0.250	0.220	0.220
BA at 10 mg/l + Suc at 2.5%	4.80	4.92	4.10	4.23	0.280	0.270	0.260	0.240
BA at 15 mg/l + Suc at 2.5%	4.99	4.98	4.15	4.40	0.290	0.300	0.260	0.250
8-HQ at 200 mg/l + Suc at 2.5%	4.75	4.80	4.05	4.22	0.270	0.250	0.230	0.210
8-HQ at 300 mg/l + Suc at 2.5%	4.80	4.82	4.09	4.10	0.290	0.290	0.250	0.240
L.S.D. at 5 %	0.1064	0.1104	0.1168	0.0948	0.0565	0.0381	0.0295	0.0170

3.3. Role of some natural preservatives on postharvest characteristics of *Gerbera jamesonii* flowers

3.3.1. Longevity of cut flowers

It can appear from Fig (7) that there were significant differences between the two used essential oils and the control. The longevity of cut gerbera is reduced with decreasing concentration and the presence of cold storage conditions. Rosemary oil at 2ml/l +2.5% Suc achieved the maximum days of longevity under room temperature, while oregano oil at 1ml/l +2.5% Suc under cold storage gave a minimum value of longevity but it has still a highly significant difference compared to control. That proves the great effect of essential oils on the longevity of cut flowers. Similar findings were also suggested that non-chemical alternatives such as essential oils are applied by several authors who have

been reported to prolong the longevity of many cut flowers **(**Bazaz *et al.,* 2015 Bidarigh, 2015; Hashemabadi *et al.,* 2013). Furthermore, Kazemi *et al.,* (2014) established that rosemary oil had significantly increased the vase life of *Eustoma grandiflorum.* Consequently, the essential oils may help to maintain membrane integrity against the oxidation process. This can occur either directly, through interaction with peroxyl fatty radicals, or indirectly by inhibiting the activity of the lipoxyl enzyme, thereby maintaining membrane integrity and preventing senescence.

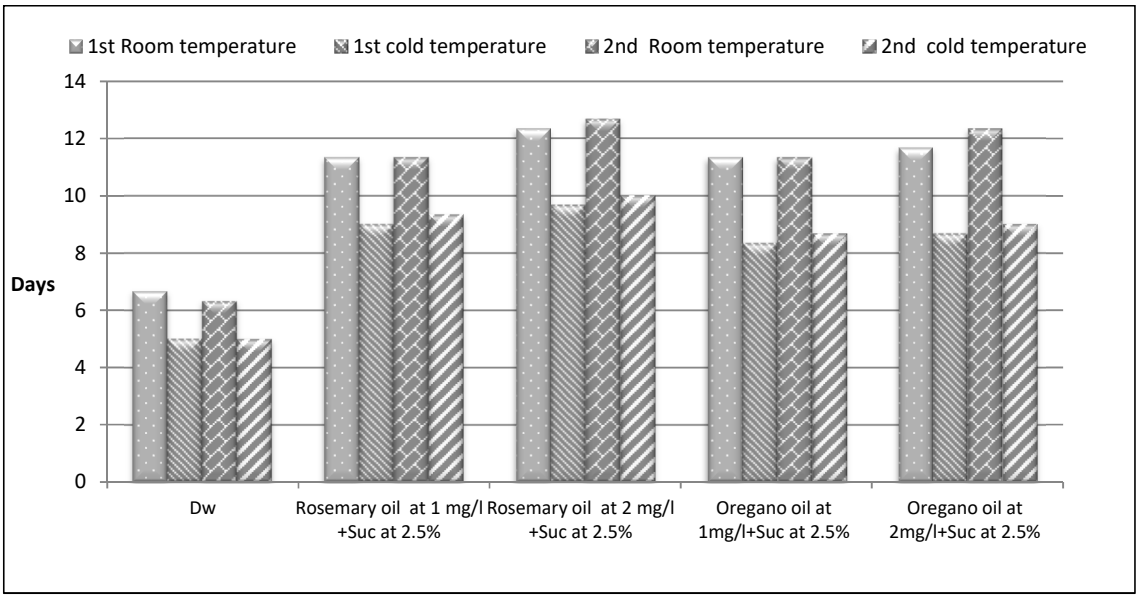

Fig. 7: Influence of some natural preservatives on longevity (days) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.3.2. Total water uptake

Regarding the effect of natural preservative solutions, it was inferred from the data presented in Fig. (8). The treatments significantly decreased the amount of water loss either in the room or in cold temperatures in both seasons. The prevalence was for rosemary oil at 2ml/l +2.5% sucrose solution, which led flowers of gerbera to absorb a higher amount of water than other solutions in both seasons. This may indicate the role of natural preservatives that are used in the regulation of the water flux into the xylem vessels by controlling transpiration or the active phenolic compounds in essential oils might inhibit the microorganisms in vase solution leading to enhancing the absorption in cut flowers. These findings are in agreement with those previously obtained by Braga *et al.,* (2008) who investigated that carvacrol derived from the oregano plant damages bacterial cell walls of *Escherichia coli.* It seems that the antimicrobial effect of rosemary essential oils which are associated with their acidic compounds led to relieving obstruction of vessels and increased solution absorption (Babarabie *et al.,* 2018).

3.3.3 Maximum increase in fresh weight (%)

The deterioration of cut flowers can be caused by water imbalance within the vascular blockage thereby resulting in senescence. The increase in fresh weight was often related to the rate of absorption, in this study, the superiority was for rosemary oil at 2ml/l +2.5% Suc solution, which induced the utmost high change (%) in fresh weight of cut flowers in both seasons in comparison with control and oregano essential oil (Fig.9). These findings are in accordance with those attained by Bayat *et al.,* (2013) who reported a significant response of essential oil added with relative fresh weight and freshness of the flowers.

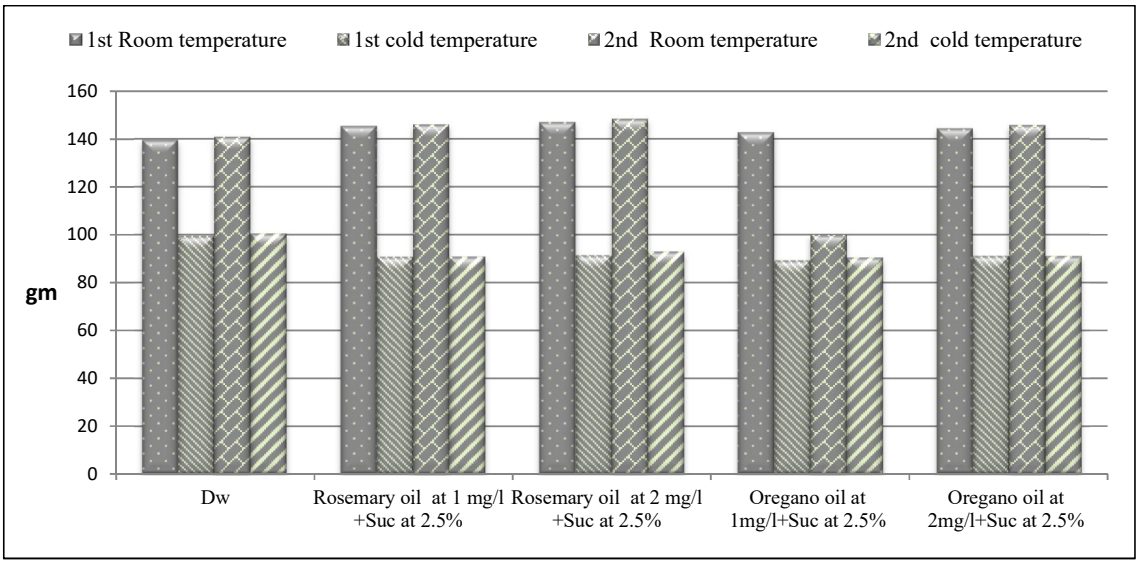

Fig. 8: Influence of some natural preservatives on total water uptake (g) of cut *Gerbera jamesonii* flowers cv. Rosalin.

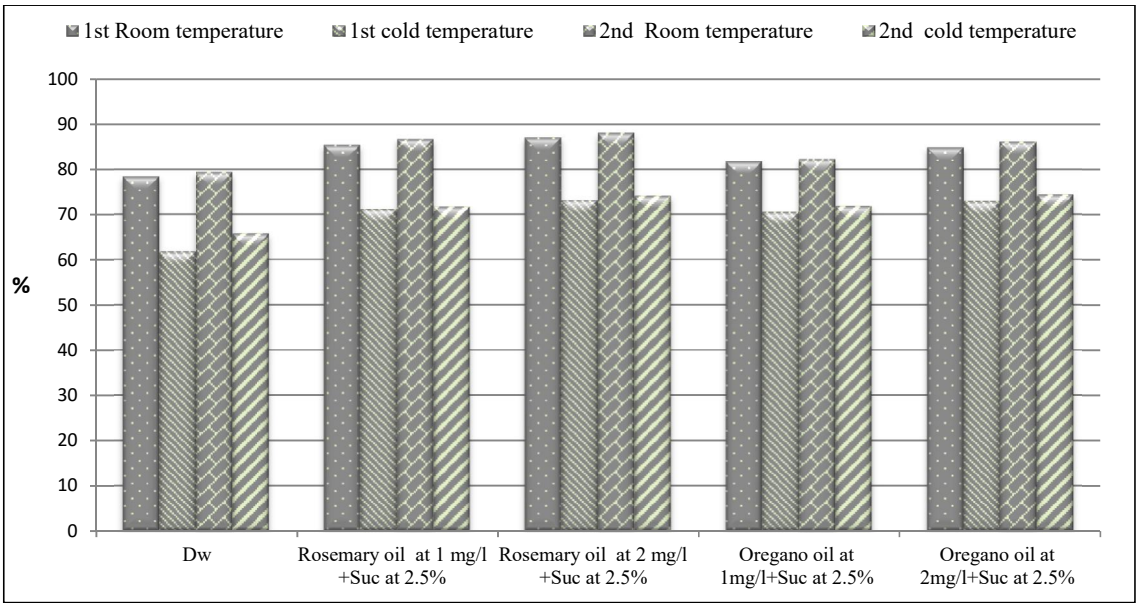

Fig. 9: Influence of some natural preservatives on the maximum increase in fresh weight (%) of cut *Gerbera jamesonii* flowers cv. Rosalin.

3.3.4. Lignin ratio and microbial count

It is evident from the data presented in Table (5) that all treatments showed that, the essential oils treatments led to a significant change compared to the control ones during the two seasons. The effect of the treatments was greater under room temperature conditions than under cold conditions. Generally, Lignin is one of the major cell wall components in vascular plants. By filling up spaces between cell wall polysaccharides (cellulose and hemicelluloses), lignin confers increased mechanical strength, imperviousness, and resistance to pathogens (Lam *et al.,* 2017). The enzymes involved in the lignification process include peroxidase, polyphenol oxidase, catechol oxidase, and phenylalanine ammonia-lyase. Peroxidase inhibitors delay the wilting in chrysanthemum and increase solution uptake which may be to the reduction of vascular occlusion (Van Doorn and Vaslier, 2002). Data exhibited in

Table (5) cleared that, under room temperature, treated cut flowers with oregano oil at 2mg/l+ Suc at 2.5% was a very effective treatment as the dose was appropriate compared to the control in both seasons. Rosemary oil also achieved a superior result compared to the control, with a close effect on reducing microbes from oregano oil. The conclusion is that the essential oils achieved the topmost results in controlling and reducing microorganisms that caused blockage leading to a lower amount of water uptake which is the most post-harvest problem. Microorganisms can also produce ethylene and secrete toxic compounds, also pectinase, and accelerated senescence (Williamson *et al.,* 2002). Rosemary is a herb rich in phenolic compounds and has antimicrobial activity against gram-positive and gram-negative bacteria (Ouattara *et al.,* 1997).

Table 5: Influence of some natural preservatives on lignin ratio and microbial count of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Lignin ratio (%)				Microbial count (log^{10} CFU ml^{-1})			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	1.10	1.67	0.90	0.93	10.32	10.00	11.19	10.81
Rosemary oil at 1 mg/l +Suc at 2.5%	2.00	2.07	1.70	1.80	4.98	4.83	5.60	5.32
Rosemary oil at 2 mg/l +Suc at 2.5%	2.10	2.17	1.80	1.87	4.92	4.79	5.42	5.36
Oregano oil at 1mg/l+Suc at 2.5%	1.60	1.70	1.10	1.20	4.91	4.81	5.51	5.30
Oregano oil at 2mg/l+Suc at 2.5%	1.80	1.87	1.40	1.43	4.88	4.77	5.40	5.00
L.S.D. at 5 %	0.1465	0.1368	0.1263	0.1188	0.2538	0.2483	0.2427	0.2215

3.3.5. Total sugars and anthocyanin content

From the obtained data in Table (6) it can be concluded that the total sugars concentration was the maximum percentage when the cut flowers were kept in a treated vase solution than control. The highest percentage of total sugars was recorded by rosemary oil at 2 mg/l +Suc at 2.5% and under cold storage. Based on the data in Table (6), it can be observed that the essential oils improve the anthocyanin content in cut gerbera. Treated cut flowers with rosemary oil at 2 mg/l +Suc at 2.5% and oregano oil at 2mg/l+ Suc at 2.5% gave similar results under room temperature in the first season. Color is considered a significant role in determining the quality and the anthocyanins which are flavonoids that produced antioxidant activity but when the production of free radicals increases that associated senescence begins.

Table 6: Influence of some natural preservatives on total sugars and anthocyanin content of *Gerbera jamesonii* flowers cv. Rosalin.

Treatments	Total sugars (%)				Anthocyanin content (mg/g)			
	Room temperature		Cold temperature		Room temperature		Cold temperature	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Dw	2.53	2.85	2.18	2.37	0.180	0.200	0.150	0.190
Rosemary oil at 1 mg/l +Suc at 2.5%	5.77	5.81	5.11	5.22	0.350	0.360	0.280	0.280
Rosemary oil at 2 mg/l +Suc at 2.5%	5.82	5.89	5.30	5.31	0.390	0.380	0.300	0.290
Oregano oil at 1mg/l+Suc at 2.5%	5.00	5.12	4.76	4.90	0.330	0.350	0.290	0.280
Oregano oil at 2mg/l+Suc at 2.5%	5.04	5.13	4.82	4.97	0.390	0.370	0.250	0.260
L.S.D. at 5 %	0.0975	0.1051	0.1135	0.1201	0.3033	0.0248	0.0392	0.0175

Babarabie *et al.,* (2016) reported that rosemary and peppermint essential oils having high antimicrobial effect reduce the number of microorganisms in the solution and increase the freshness and quality of flower color and prevent the discoloration and reduction of pigment in the petals of Alstroemeria cut flowers.

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