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RESEARCH PAPER

Extending the Vase Life of Gerberas with Organic Compounds

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Abstract

The popular cut flower gerbera (*Gerbera jamesonii*) has a limited vase life at the end request of user because proper postharvest treatments are not used. Vulnerable to microbial contamination. The purpose of this study was to ascertain how various preservation solutions affected the cut *Gerbera jamesonii* flower (cv. Yeliz) quality and vase life. Cut flowers were placed in glass jars containing solutions in six different treatments: 100, 150, and 250 mg L^{-1} of citric acid; 100, 150, and 200 mg L^{-1} of thymol; and distilled water as a control. Fresh flower weight, water uptake, vase life, pH, EC, and pigment color assessment were among the parameters that were noted based on 0, 3, 6, 9, 12, and 15 days of storage. According to the results, the solution containing 250 mg L^{-1} of citric acid produced the highest values for fresh weight, water uptake, and flower vase life and least color change of the flowers. This was followed by the solution containing 100 mg L^{-1} of thymol. Flowers treated with 200 mg L^{-1} of thymol had the lowest fresh weight and vase life performance. The quality and vase life of cut *Gerbera jamesonii* flowers were found to be significantly affected by the use of 250 mg L^{-1} citric acid in preservation solutions. In comparison to other treatments, high dosages of tyhmol (150 and 200 mg L^{-1}) had a negative impact on floral quality and vase life.

1. Introduction

Gerbera (*Gerbera jamesonii*), sometimes referred to as the Transvaal daisy, is fourth among the top ten commercially cut flowers worldwide (Flora Cultural International, 2022). The appeal of gerbera is attributed to its attractive aesthetics, broad range of color, and adaptability to various environmental circumstances (Hema et al., 2018). As is the case all other cut flowers, gerberas have a very short vase life and are highly perishable. Their commercial value is largely determined by their ability to bend their stems, also known as scape-bending or bent neck (Perik et al., 2014; Naing et al., 2017; Muraleedharan et al., 2019; Shabanian et al., 2019).

Vase treatments are used to reduce cut flower postharvest challenges. Vase conditions also influence the development of microbes on the stem that can obstruct the water uptake and cause dehydration in delicate flowers by influencing their production of ethylene (Hema et al., 2018; Muraleedharan et al., 2019).

Vase solutions contain active ingredients that are categorized based on their function. These include antioxidants like citric acid and salicylic acid, antibacterial agents like 8-hydroxyquinoline, silver nitrate, and silver nanoparticles, and ethylene inhibitors like silver thiosulfate (Li et al., 2018). Many organic acids, like ascorbic acid, citric acid (CA), malic acid, and salicylic acid, are crucial in increasing the postharvest life of cut flowers. Organic acids are utilized in the respiratory cycle and other metabolic pathways, providing cells with energy and carbon (da Silva, 2003; Darandeh and Hadavi, 2012). Like other organic acids, citric acid may impact the duration that cut flowers last in a vase. According to van Doorn (1997), citric acid enhances the water conductivity in the xylem of cut flowers and decreases the number of bacteria in vase solution. Since citric acid is one of the iron forms that are mobile in plants, it is crucial to the transfer of iron (Hell and Stephan, 2003; Darandeh and Hadavi, 2012). By decreasing the pH of the water and encouraging the growth of bacteria, citric acid blocks the xylem vessels in the area that has been cut (Nowak and Rudnicki, 1990). Citric acid has been shown to improve the postharvest longevity of several cut flowers, such as tuberose and lilies (Eidyan, 2010; Darandeh and Hadavi, 2012). Essential oils are healthy, organic natural compounds that are not damaging to the environment. Due to their high concentrations of phenolic compounds including eugenol, thymol, and carvacrol, essential oils exhibit potent antibacterial effects against a variety of diseases (Bounatirou et al., 2007; Sharififar et al., 2007). Antimicrobial activity of carvacrol against certain bacteria and fungi was recently discovered (Botelho et al., 2007; Martinez-Romero et al., 2007; Yahyazadeh et al., 2008). Other essential oils that have been found to be effective against some bacteria and fungi include thymol, thyme oil, and zataria oil. These oils are used to prevent plant diseases, especially those that affect fruit (Svircev et al., 2007; Braga et al., 2008; Yahyazadeh et al., 2008). On the other hand, insufficient data is currently accessible on the application of thymol to reduce microbial contamination and prolong the vase life of cut flowers, including gerberas. This study investigated to determine whether different concentrations of thymol and citric acid affected the vase life, post-harvest quality, and other characteristics of cut gerbera (*Gerbera jamesonii* cv 'Yeliz') flowers.

2. Material and Method

2.1. Plant material

The experiments were conducted at Bingol University, Department of Horticulture (38°53'59.34"N, 40°29'15.95"E). *Gerbera jamesonii cv.* 'Yeliz' was obtained from a commercial farm in Antalya, Türkiye, in May 2024. The handling and harvesting of the gerbera flowers followed the procedure described by Tonooka et al. (2023a). The cut flowers were pre-cooled for six hours at 4°C to lessen the impact of the high field temperature. Afterward, they were carried in dry conditions (12 hours at room temperature) to the vase life room at Bingol University, Department of Horticulture The blooming stems were clipped to a length of 40 cm.

2.2. Treatments and design of the experiment

There were six treatments in the randomized complete blocks design (RCBD) trial. Treatments included thymol at doses of 100, 150, and 200 mg L^{-1}, citric acid at doses of 100, 150 and 250 mg L^{-1} in addition to the control. A glass (1000 ml) containing 750 ml of vase solutions was filled with the cut flowers. Each treatment had five replicates, with three blossoms in each. As a control, distilled water was utilized. Every solution was made from scratch at the start of the experiment. The temperature in the vase life room was 21±2°C, the relative humidity was 60±5%, and there was 1000 lux of light.

2.3. Vase life, relative fresh weight (RFW), and water uptake

Vase life was measured from the conclusion of pretreatment until one of the following symptoms appeared: a flower stem bent more than 90°, a single ray petal abscission, a break right below the flower head, or withering of the petals. For each treatment, fifteen flowers were utilized. Once every three days, the fresh weight of the cut flowers and the amount of water absorbed were measured. The method described by He et al. (2006) was used for calculating the relative fresh weight (RFW).

2.4. pH and EC measurements in the solutions

pH of solutions were measured by a pH/ORP meter (HI 2211 HANNA Instruments RI/USA) and Electrical conductivity (EC) was measured by a Conductivity Benchtop (Orion 3-Star, Thermo Scientific).

2.5. Color measurements of the pigment

Colorimeter (Lovibond; Spectrophotometer a sphere, Serie SP60) was used to measure the pigment color. CIELAB values were obtained, and color variations were observed once every three days.

2.6. Statistical analysis

A completely randomized design was used to evaluate the obtained data in the study. Fifteen flowers were utilized for each treatment. The data were subjected to a one-way analysis of variance (ANOVA) using IBM SPSS Statistic 20.0. The means were compared at ($P \leq 0.05$) using the Duncan's test.

3. Results and Discussion

3.1. Vase life, relative fresh weight (RFW), and water uptake

Statistically significant differences were observed in the vase life of cut gerbera flowers of 'Yeliz' ($P \leq 0.05$). The citric acid 250 mg L^{-1} had the longest vase life (12.87 days), which was 1.8 days longer than the control group (11.07 days). The second longest vase life was determined 100 mg L^{-1} (12.80 days), despite the fact that thymol 200 mg L^{-1} had the shortest vase life (10.20 days) (Figure 1).

The RFW of the cut flowers increased in all treatments for the first three or four days and thereafter decreased. Although there is an increase in the RFW ratio between the 6th and 9th day, a decrease is observed in all treatments after the 6th day (Figure 2).

Although in terms of total water uptake, there was no statistically significant variation, the highest total solution uptake was determined in Citric acid 250 mg L^{-1} with 23.02 ml, followed by Citric acid 150 mg L^{-1} with 22.53 ml and Thymol 100 mg L^{-1} with 22.49 ml (Figure 3).

Water stress affects cut gerbera flowers, and a deficiency in water causes the water balance of calyxes to become negative. Water stress is mostly caused by vascular blockage at the stem tip and disruption of the water supply (Tonooka et al., 2023b). The majority of cut flowers, including cut gerbera flowers, have a high rate of initial solution uptake; however, with time, this rate decreases mostly because of air embolism and microbial vascular blockage (Mashhadian et al., 2012). It is believed that cut gerbera are susceptible to water shortages brought on by upsetting the postharvest water balance is the basis for the impact of maintained water relations on prolonging the vase life (Mashhadian et al., 2012; Rafi et al., 2013; Kazaz et al., 2019). The benchmark for the end of the vase life is when the flowers wither and the quality of the cut flowers deteriorates if these causes continue (Shabanian et al., 2018). Similar to our comparison results of preservative treatment, solution uptake through preservative treatment increased the water balance and freshness of flowers and decreased early wilting, consequently improving the vase life of cut flowers (Ichimura and Goto, 2000). In order to increase the marketability of cut gerbera flowers, we observed in our study the vase life of the flowers based on the combination of a preservation solution at the consumer stage and solution combination for each postharvest treatment stage after harvest. The antibacterial agents thymol and citric acid were utilized in this investigation (Yagi and Elgimabi, 2014; Memar et al., 2017). Thymol and citric acid are useful in prolonging the vase life of certain cut flowers, according to numerous studies on the subject (Asrar, 2012; Babarabie et al., 2015; Kazaz et al., 2020; Alkaç et al., 2023). According to our results, citric acid 250 mg L^{-1} (12.87 days) and thymol 100 mg L^{-1} (12.80 days) extended the vase life of cut gerberas. These results might be explained by function of citric acid and thymol as an antibacterial agent, which may have decreased stem plugging. However, when thymol dosages increased, a decrease in floral vase life was seen. Pourianejad et al. (2014) achieved similar results. Due to their herbicidal activity in a variety of plant systems, essential oils like thymol have a phytotoxic effect that can lead to electrolyte leakage and subsequent cell death (Kordali et al., 2008). High thymol treatment concentrations in this study may be toxic and cause cell death, which would explain why the vase life of the treatments was shorter than that of the control.

As a result of their potent antibacterial properties, citric acid and thymol preserve solution absorption by inhibiting the growth of microbes in the xylem vessels of cut flower stems (Salehi Sardoei et al., 2014; Elgimabi and Yagi, 2016). Our results showed that all treatments of citric acid and thymol 100 mg L^{-1} enhanced solution absorption. This is assumed to be caused by antibacterial properties of citric acid. Citric acid-like acidic

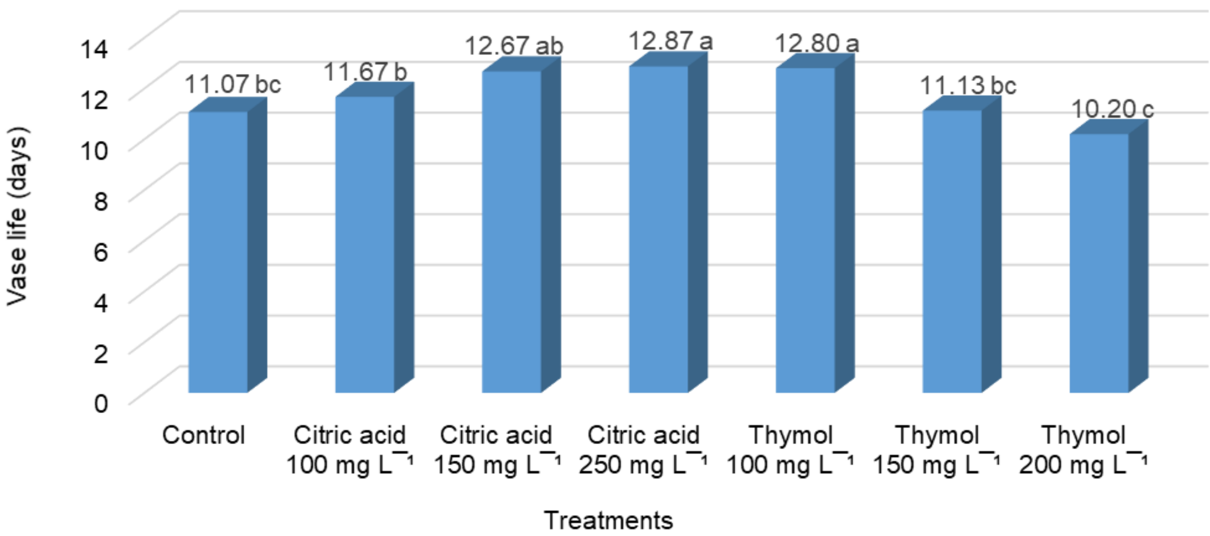

Figure 1. Effect of some organic acid compounds on the vase life of cut *Gerbera jamesonii* cv. 'Yeliz'. (Different letters at each time point indicate significant differences "P≤0.05" using the Duncan's test).

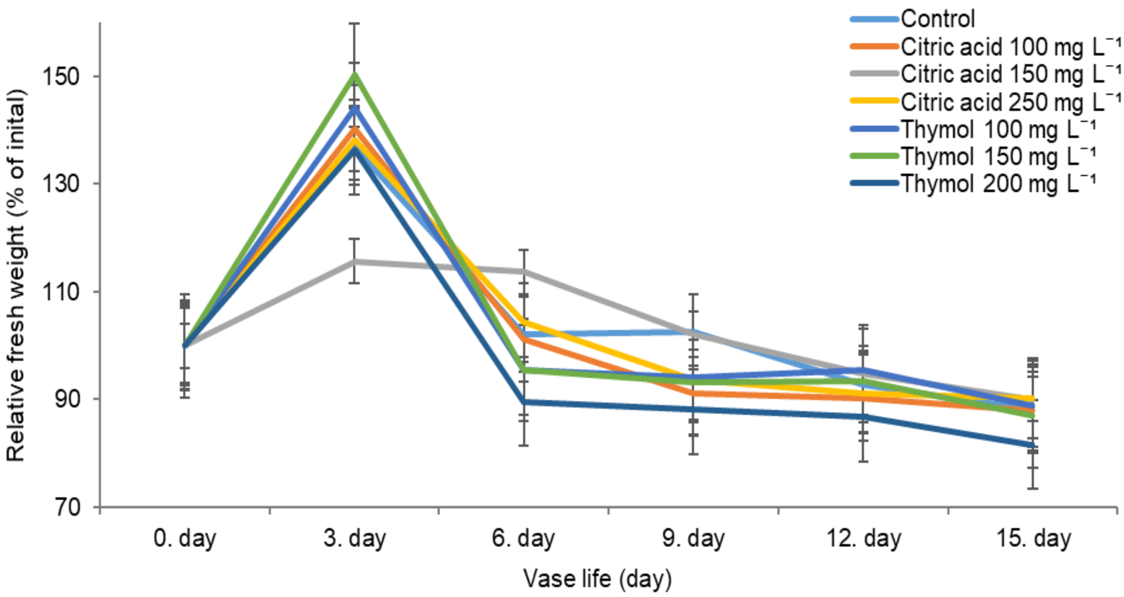

Figure 2. Effect of some organic acid compounds on the relative fresh weight (%) of cut *Gerbera jamesonii* cv. 'Yeliz'

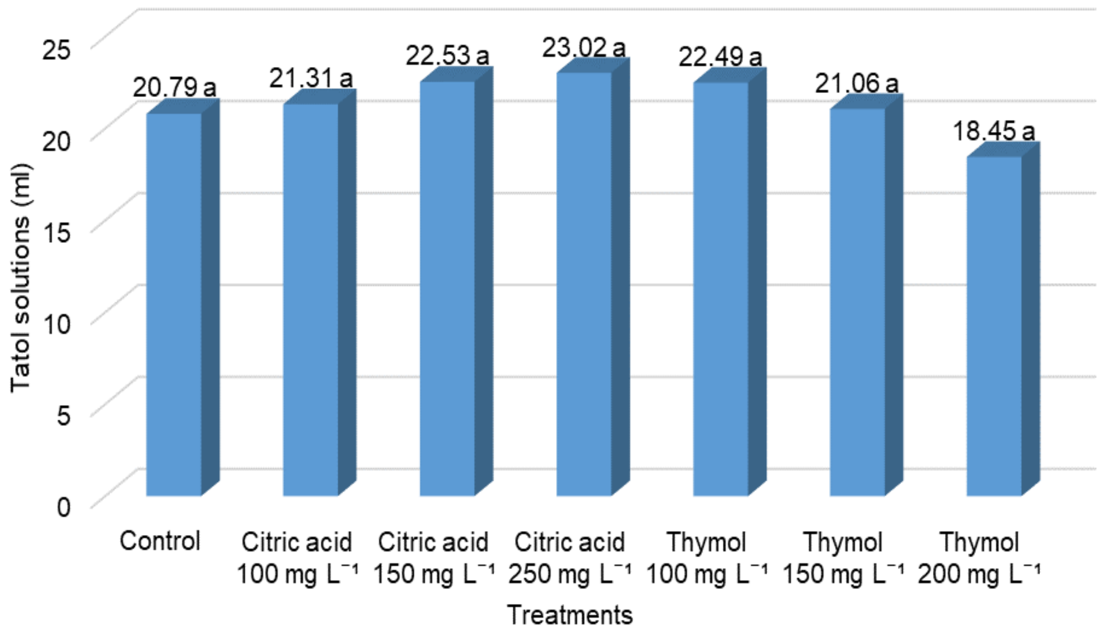

Figure 3. Effect of some organic acid compounds on the total solution cut *Gerbera jamesonii* cv. 'Yeliz' (Different letters at each time point indicate significant differences "P≤0.05" using the Duncan's test).

components have been found to improve the water intake of cut flowers by preventing bacteria development and accumulation in vase solutions, similar to the current findings (Alaey et al., 2011; Mansouri, 2012). Additionally, it was noted that treatments with citric acid increased plants of *Acacia holosericea* stem water uptake from vase solution (MohdRafdi et al., 2018). Higher thymol concentrations, on the other hand, reduced solution absorption. Prior research has indicated that high thymol concentrations have detrimental effects on solution absorption (Bazaz and Tehranifar, 2011; Salehi Sardoei et al., 2014). Additionally, it was said that essential oil concentrations, such as thymol, are extremely important and require more research (Mirdehghan and Aghamolayi, 2016).

Citric acid 250 mg L^{-1}, citric acid 150 mg L^{-1} and thymol 100 mg L^{-1} treatments decreased the fresh weight loss compared to other treatments, based on our findings about relative fresh weight. Treatments with 150 mg L^{-1} and 200 mg L^{-1} of thymol hadn't worked to prevent relative weight loss. Increased solution uptake and decreased transpiration rate prevent cut flowers from losing water, which may have had a good impact on fresh weight. Prior research has indicated a connection between fresh weight and solution uptake (Alaey et al., 2011; Amin, 2017). In addition, in parallel with the study by Alkaç et al. (2023) citric acid applications reduced the bacterial population, prevented clogging of vascular tissues and promoted water uptake. Thus, the best results in terms of vase life, total vase

Table 1. Effect of some organic acid compounds on the pH and EC (dS m^{-1}) variation during the vase life of cut *Gerbera jamesonii* cv. 'Yeliz'.

Treatment	0. day		3. day		6.day		9. day		12. day		15. day		Change in pH	Change in EC
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC		
Control	6.68 a	6.80 e	5.54 b	24.00 e	5.29 b	30.00 d	5.82 bc	32.00 c	5.87 b	40.30 d	5.95 a	40.4 d	0.70 a	-33.57 c
Citric acid 100 mg L⁻¹	3.71 d	253.90 a	3.73 d	208.90 b	3.84 d	199.74 b	4.12 d	198.30 a	4.32 d	199.10 a	4.39 b	199.97 a	0.68 b	-58.43 b
Citric acid 150 mg L⁻¹	3.78 d	177.00 d	4.04 c	137.60 d	4.26 d	142.1 c	5.43 c	125.40 b	6.54 ab	108.50 c	6.67 a	105.80 c	-2.89 d	71.19 b
Citric acid 250 mg L⁻¹	3.75 d	216.00 b	3.82 d	168.70 cd	3.97 d	134.30 c	4.45 d	123.37 b	5.17 c	116.40 bc	5.77 a	115. 0 bc	-2.03 cd	100.10 b
Thymol 100 mg L⁻¹	5.83 c	199.60 c	6.35 a	180.80 bc	6.03 ab	166.90 bc	6.26 ab	138.90 b	6.77 a	133.00 bc	6.88 a	132.50 bc	-1.05 bc	67.09 b
Thymol 150 mg L⁻¹	6.36 b	217.40 b	6.39 a	191.00 bc	6.30 ab	180.30 b	6.36 a	157.50 ab	6.53 ab	148.80 bc	6.71 a	140.80 bc	-0.35 b	76.64 b
Thymol 200 mg L⁻¹	6.44 b	311.00 a	6.60 a	249.80 a	6.61 a	240.50 a	6.61 a	193.00 a	6.61 ab	157.10 ab	6.63 a	153.10 b	-0.19 ab	157.93 a

($P \leq 0.05$).

solution uptake and relative fresh weights were obtained with this treatment.

3.2. pH and EC measurements in the solutions

The pH and EC of the vase solutions of gerbera flowers varied at certain rates for 15 days and showed statistically significant differences ($P \leq 0.05$). During the vase life, pH value of contol and citric acid 100 mg L^{-1} increased (0.70 and 0.68, respectively) and EC value decreased (-33.57, -58.43, respectively). Except for these two treatments, pH value of the other five treatments decreased and EC value increased (Table 1).

Due to their increased H^+ ion release, citric acid combinations have a lower pH than other preservative solutions. The pH fluctuations observed during the vase's longevity could potentially be attributed to the composition of the liquids within, the transport physiology of the plant, and the quantity of microorganisms involved in its metabolism. Shanan (2017) and Paul et al. (2021) have discovered similar results in their studies. EC values decreased during the vase life except for the control group. This is because flowers can absorb minerals and nutrients, which reduces the amount of dissolved matter in the vase water.

In addition, some substances can precipitate and settle to the bottom of the vase, lowering the concentrations in the water. In the control group, dissolved minerals and salts in the water may accumulate in the vase solution as the flowers absorb water, which may cause an increase in electrical conductivity, and cell fluids released from plant stems may also increase the EC value. In addition, since bacteria grow in the vase solution, organic and inorganic substances may be released as a result of the metabolic activities of these microorganisms, which may increase the EC value of the water.

3.3. Color measurements of the pigment

Different variations in L, a, and b values were seen in the study throughout the red gerberas' vase life. The fresh gerbera color exhibits high luminosity, or brightness, which is why the 'Yeliz' cultivar of gerbera flowers had a high L rating on the first day. The color turned dull and the L value dropped in all treatments-including the control-when the blossom had fully faded (Figure 4). In general, the value of the control treatment increased as the flower withered and turned brown, orange, pink, or yellow in the latter days of its vase life. (Figure 5). The b value of "Yeliz" in gerberas is positive during the vase life. Aging may cause a modest browning or yellowing of the plants. The maximum color change was determined at 150 mg L^{-1} of thymol (Figure 6).

There are several possible reasons why the L value (lightness or brightness value) of red gerberas gradually decreases during their vase life. The first is that flowers naturally lose their colour over time. Secondly, as microorganisms such as bacteria and fungi may accumulate in the vase water, they may prevent the water uptake of the flowers and cause faster fading and discolouration. In our study, the fading rate of the colours progressed in parallel with the vase life and in parallel with the development of microorganisms, the least change was seen in thymol 100 mg L^{-1} and citric acid 250 mg L^{-1} in all treatments.

4. Conclusions

The impact of various preservation treatments on vase life of *Gerbera jamesonii* cv. 'Yeliz' was examined in the present study. Cut gerberas and adding 250 mg L^{-1} of citric acid and 100 mg L^{-1} of thymol prolonged their vase life although increased thymol concentration did not prolong the vase life of cut gerbera flowers. The two most crucial recommendations for professional growers and contributors are as follows: firstly, for practical use, organic acid must be formulated in the right amounts, and research on how to apply them should be expanded upon and secondly using citric acid to prolong the vase life of cut gerbera flowers and treating with thymol solution to inhibit the growth of germs are both beneficial. Nonetheless,

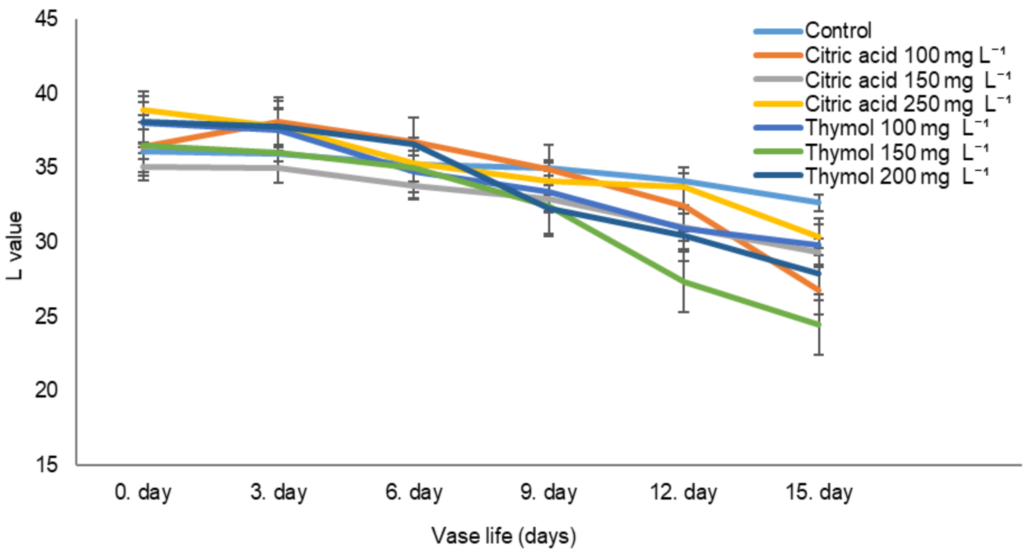

Figure 4. Variances in '*Gerbera jamesonii* cv. 'Yeliz' flower color and L value (brightness) during the vase life.

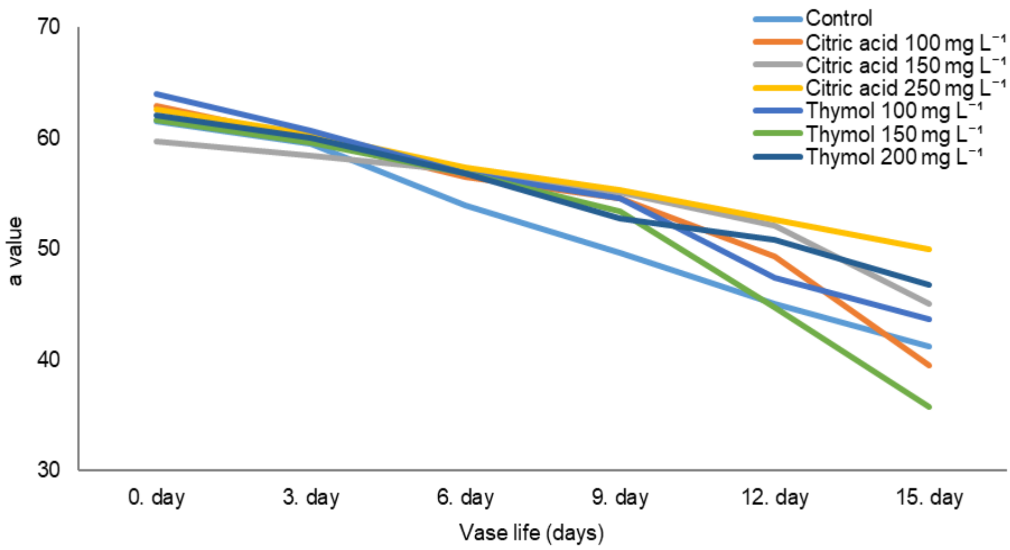

Figure 5. Variances in *a* value color of '*Gerbera jamesonii* cv. 'Yeliz' flowers during vase life.

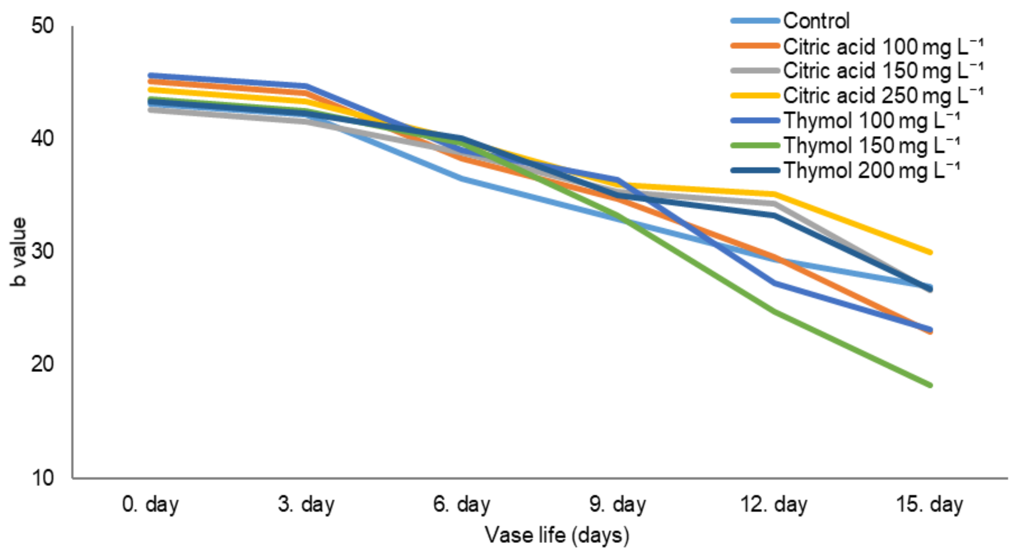

Figure 6. Variances in *b* value color of '*Gerbera jamesonii* cv. 'Yeliz' flowers during vase life.

further research is required to ascertain the precise concentration of thymol and citric acid as well as the vase life of cut gerbera flowers.

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