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INFLUENCE OF HOLDING SOLUTIONS ON VASE LIFE OF CUT *HYDRANGEA* FLOWERS (*HYDRANGEA MACROPHYLLA* THUNB.)

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ABSTRACT

The vase life of cut flowers is the most important factor affecting the market value popularity of hydrangeas as cut flowers has increased steadily in recent years. However, the vase life of cut hydrangea flowers is short depends on wilting and sepal browning. In this study SUA (succinic acid) (50 mg L^{-1} and 100 mg L^{-1}), GA (glycolic acid) (38 mg L^{-1} and 76 mg L^{-1}, BC (benzethonium chloride) (25 mg L^{-1}), CA (citric acid) (100 mg L^{-1}) and 8-HQS (8-hydroxyquinoline sulfate) (250 mg L^{-1}) were used to determine the effects on vase life of cut hydrangea flowers (*Hydrangea macrophylla* 'Ankong Rose'). Distilled water was used as the control. Vase life, relative fresh weight, daily and total solution uptake were measured. The experiment was a completely randomized design with ten replications and there was one flower in each replication. The longest vase life of hydrangea flowers was 12,10 days with 8-HQS (250 mg L^{-1}), followed by 76 mg L^{-1} of GA (10.70 days) and 38 mg L^{-1} of GA (9.70 days). 8-HQS significantly increased the vase life of hydrangeas and also determined that same treatment increased the total solution uptake and delayed relative fresh weight loss. These results indicated that 8-HQS can be used to prolong the vase life of cut hydrangea flowers.

KEYWORDS:
Hydrangea, cut flower, vase life, 8-hydroxyquinoline sulfate, benzetonium chloride

INTRODUCTION

Hydrangea is an ornamental plant for using in the garden and as potted plant, and also for cut flower production [1]. *Hydrangea macrophylla* is the most widely grown among the Hydrangea species [2]. This plants are "an ideal cut flower" and are ranked 8th among the most sold flowers in the Holland flower auction [3]. The popularity of cut hydrangea flowers is increasing every year.

Vase life of cut hydrangeas are usually short and it ranges from 7 to 15 days [4]. Hydrangeas vase life is related to physiochemical processes as in all cut flowers and reduces through ethylene production (freshly-harvested flowers are ethylene sensitive but flowers harvested in the classic stage are not) [5] and bacterial contamination in vase solution [6]. The reason of vascular occlusion is the air embolii and microorganisms caused by the blockage of the xylem vessels [7]. Microorganisms, in paticularly bacteria and fungi, have a negative effect on the longevity of the cut flowers. These microorganisms block the stem end and shorten the vase life by restricting the uptake of water [6, 7]. Some applications have been applied to prolong the vase life of cut flowers by adding various germicides to the vase water [6, 8]. In cut flowers, several agents have been used for extending vase life by improving water uptake and diminish the bacterial growth [9]. In many studies, 8-hydroxyquinoline (8-HQ), 8-HQS and 8-hydroxyquinolinium citrate (8-HQC) are the most commonly used fungicides. They has prevented the growth of more than 40 bacteria and fungus species in cut flowers [10]. Benzethonium chloride (BC) is one of the most important quaternary ammonium compounds (QACs) which have a surfactant ability which is substantially compatible with adhesion BC is used as a protective and antimicrobial agent for antibacterial hand wipes, antiseptic creams and antipruritic ointments [11]. Succinic acid (SUA) is an antimicrobial agent that affects various physiological and biochemical functions in plants. SUA is a carbohydrate produced in the creps cycle in all living things. Citric acid (CA) is an organic acid and provides carbon and energy source for cellsand also used in the respiratory cycle and some other biochemical pathways [12, 13]. CA reduces the microorganism population in vase solution and improve the water conductivity of cut flowers in xylem [7] [11, 13, 14]. Glycolic acid (GA) is an alpha hydroxy carboxylic acid. Although some plants appear naturally, their trade is produced synthetically. Glycolic acid is a surfactant and has anti-microbial activity. GA is used due to its antimicrobial effect against many bacteria and fungi. Although the positive effects of 8-HQS [6] and citric acid (CA) out of these compounds on the vase life of cut flowers have been revealed, research on succinic acid, glycolic acid and Benzethonium chloride is limited [11]. Therefore, the effects of succinic acid, glycolic acid, benzethonium chloride as well as 8-HQS and citric acid on the vase life of cut hydrangea flowers were investigated in this study.

MATERIALS AND METHODS

This study was carried out in 2017 in the Department of Horticulture, Faculty of Agriculture, Ankara University, Ankara-Turkey. Hydrangea (*Hydrangea macrophylla* 'Ankong Rose') plants were grown greenhouse (39°57'40.2"N 32°51'51.7"E) located in Ankara University. Hydrangea's harvested when the petals opened 25%, immediately placed in tap water and taken to the laboratory of the same department. The flower stems were recut a 45 cm and then taken in a temperature-controlled room at tempeture of 21±2 °C and relative humidity of 60±5% and fluorescent lamps provided by 1000 lux light for 12 hours photoperiod. Cut flowers were placed individually in a into measuring cylinder filled with 100 ml of vase solutions (Table 1). All solutions were freshly prepared at the begining of experiment and solution was added to the vases when solution ended during the experiment.

TABLE 1
Chemicals and concentration used on vase life (days) of cut hydrangea 'Ankong Rose'

Treatment	Cas No	Concentration
C (Control)		Distilled water
GA_1 (Glycolic acid, Merck)	S7172386703	38 mg L^{-1}
GA_2 (Glycolic acid, Merck)		76 mg L^{-1}
SUA_1 (Succinic acid, Merck)	110-15-6	50 mg L^{-1}
SUA_2 (Succinic acid, Merck)		100 mg L^{-1}
BC (Benzethonium chloride, Sigma Aldrich	121-54-0	25mg L^{-1}
8-HQS (8-hydroxyquinoline sulfate, Sigma-Aldrich,	207386-91-2	250 mg L^{-1}
CA (Citric acid, Carlo Erba Reagents)	5949-291-1	100 mg L^{-1}

Measured Factors. Vase Life (Day). Vase life was terminated when withering, sepal browning, or sepal desiccation became apparent on approximately 80% of decorative florets in an inflorescence based on daily observations [15].

Solution Uptake. For measuring the amount of solution absorption, control bottles (distilled water) with the same volume of the test solution containing measuring cylinder (100 ml) were used to find the evaporative loss by weight. This was subtsracted from the weight reduction in flower containing bottles and the values were expressed g $stem^{-1}$ day^{-1}. This process was done daily for 13 days for each replication. Additional solutions were added to the applications where the solutions were finished.

Water Uptake and Relative Fresh Weight. The daily amount of vase solution taken by hydrangeas, vases and flower stems were calculated by weighing each day separately. The results were substracted and stated in mL. For fresh weight of flower stems, they were measured daily and individually and the values were stated as a % of the initial fresh weight. Fresh weight of cut flowers was measured daily through the experiment from day 1 to 13.

Statistical analysis. The experiment with seven treatments was conducted in completely randomized design (CRD) with ten replicates and one flowers for each replication. Statistical significance between mean values was stated using analysis of variance (ANOVA) and Duncan's Multiple Range Test at $p \leq 0.05$ using IBM SPSS Statistics (20.0).

RESULTS AND DISCUSSION

Vase Life (Day). There were statistically significant differences in the vase life of the hydrangea flowers. The longest vase life was 12.10 days with 8-HQS followed by 76 mg L^{-1} of GA_2 (10.70 days) and 38 mg L^{-1} of GA_1 (9.70 days) respectively. The lowest value was recorded with CA (7.20 days) and the control was measured 8.50 days (Fig. 1).

This result can be explained by the fact that 8-HQS controlled the development of microorganisms, prolonging the vase life and prevented the vascular occlusion of acidic solutions and increased the vase life by eliminating the obstructions of water uptake [16]. Similary positive effects of HQS on the vase life of gerbera jamesonii and affects the bio-chemical changes related to senescence, reduces the leakage of ions were reported [17, 18]. While in parallel with the increasing doses of GA, the vase life of the flowers increased compared to the control. Moreover, CA did not provide any increase in vase life. This is due to the fact that the dose used in the CA treatment had a toxic effect on stems of the flowers.

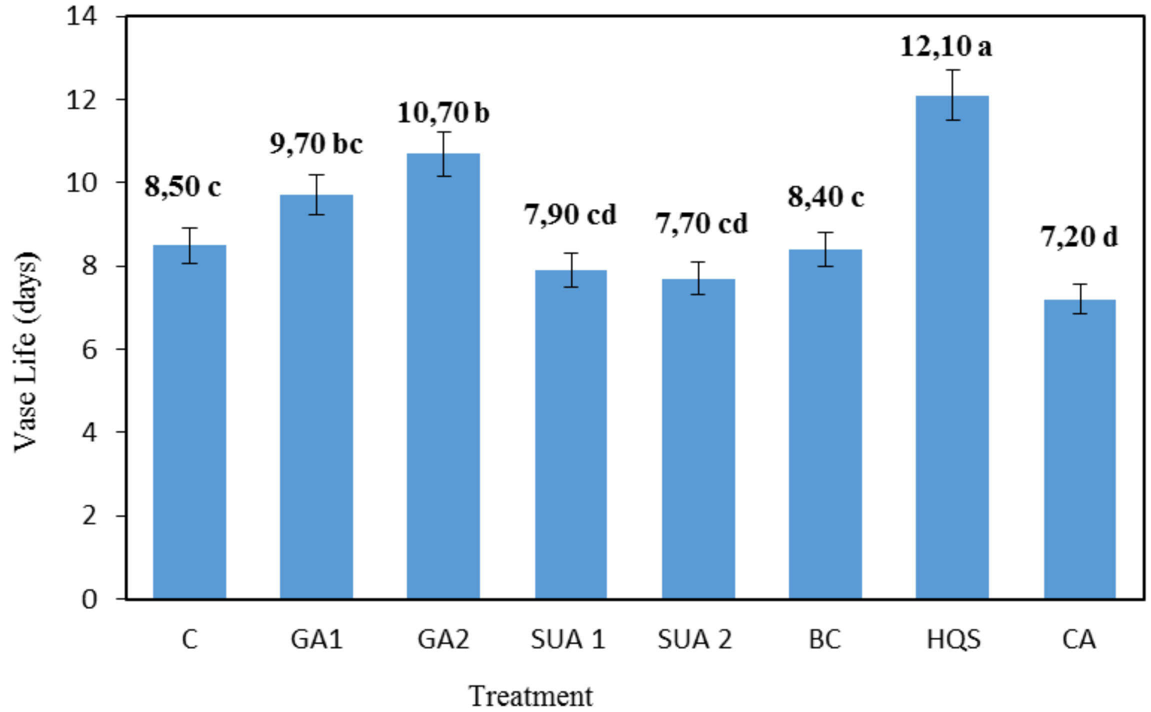

FIGURE 1
Effect of different holding solutions on vase life (days) of cut hydrangea 'Ankong Rose'

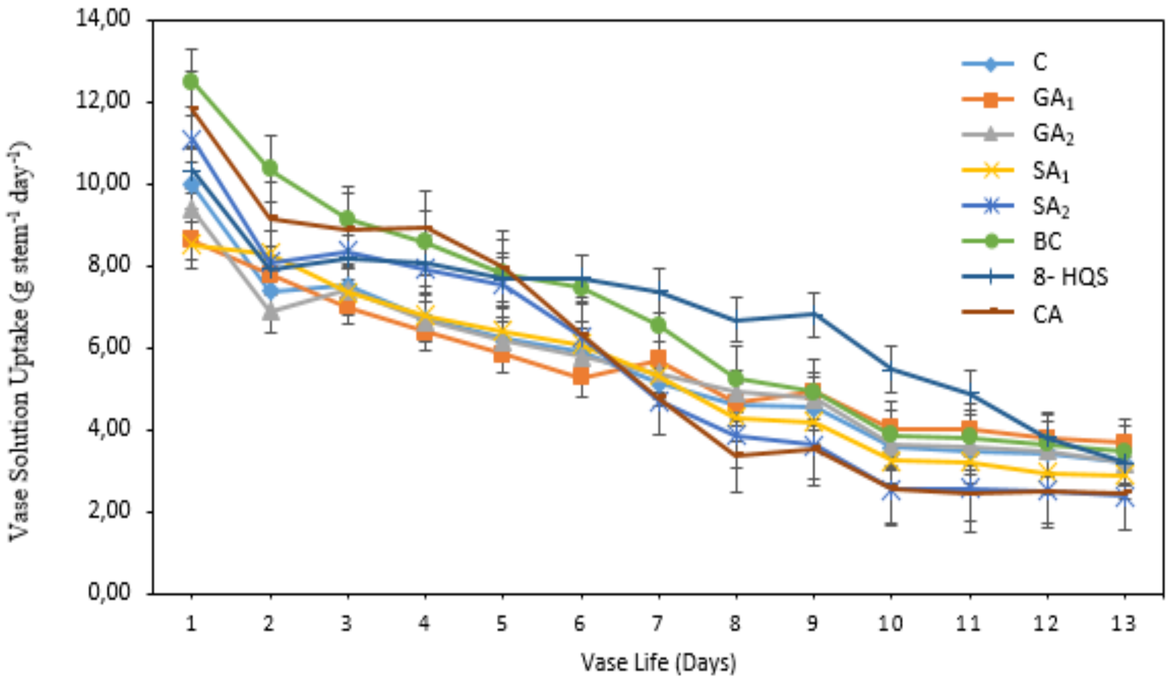

FIGURE 2
Effect of different holding solutions on daily solution uptake (g stem^{-1} day^{-1}) of cut hydrangea 'Ankong Rose'

Solution Uptake. In all treatments, including the control daily uptake of solutions decreased by certain rates until the end of the vase life (Fig. 3). At the end of the vase life, no statistically significant difference was found between the control, 38 mg L^{-1} of GA_1, 76 mg L^{-1} of GA_2 and 100 mg L^{-1} of SUA_2. The daily uptake of 8-HQS was higher than the other treatments and this treatment followed by BC. The lowest value of the daily solution uptake was of 50 mg L^{-1} of SUA_1 (Fig. 2).

Total Vase Solution Uptake. According to statistical analysis, differences between applications were found to be significant. 8-HQS had the highest value in total vase solution uptake with 88,08% while SUA_1 had the lowest value with 69,61% (Table 2)

As a result of the findings, the vase life was closely correlated to the vase solution. There has been a positive relationship between the water uptake and the prolongation of the vase life of the hydrangeas, showed that is associated to the plugging of water flow in the stem. The cut hydrangeas treated with 8-HQS had a higher uptake that resulted in a longer vase life and prolonging is positively corelated with water uptake. Reddy et al. (1996) reported that 8-HQS reduces microorganisms and cause an increase in water uptake with cut flowers [19]. BC is used as a protective and antimicrobial agent and plays a role in facilitating the water uptake. Blockage of vascular by microorganism causes reducing water uptake and finally results in breaking of stem or bending and wilding of petal in hydrangeas, roses, gladious and dendrobium flowers. However, these problems are eliminated with the use of 8-HQS [11, 20, 21, 22, 23].

Relative Fresh Weight. There is a significiant difference were found among the treatment in relative fresh weight. Generally, the relative fresh weight of all treatment constantly decreased from the third day after the begining of the experiment until the death while 8-HQS treated flowers relative fresh weight gradually increased over the first seven days (Fig 3). The highest realtive fresh weight was obtained in cut flowers kept in 250 mg L^{-1} of 8-HQS, 38 mg L^{-1} of GA and 76 mg L^{-1} of GA vase solutions respectively. However The lowest realtive fresh weight was obtained in cut flowers kept in 100 mg L^{-1} of SUA.

In parallel with this study; especially 8-HQS, increasing the vase life and being very positive effect in reducing respiratory rate and physiological weight loss in dendrobium [22] and gladiolus flowers [21]. Similarly, the positive effects of 8-HQS on the fresh weight of the carnation, alstroemeria and zinnia [24] were reported. Because of the fact that GA has antimicrobial activity, it is thought to be effective in reducing weight loss. Although BC treatment has a positive effect on the water uptake of flowers, it was found to be inversely proportional to the relative fresh weight. It has been thought that this may be due to the destruction of nutrients in parallel with the increase in respiratory rate.

TABLE 2
Effect of different holding solutions on total vase solution uptake (%) of cut hydrangea 'Ankong Rose'

Treatment	Total Vase Solution Uptake (%)
Control	71,68 bc
GA_1 (38 mg L^{-1})	71,62 bc
GA_2 (76 mg L^{-1})	71,19 bc
SUA_1 (50 mg L^{-1})	69,61 c
SUA_2 (100 mg L^{-1})	71,39 bc
BC (25 mg L^{-1})	87,28 b
8-HQS (250 mg L^{-1})	88,08 a
CA (100 mg L^{-1})	74,69 ab

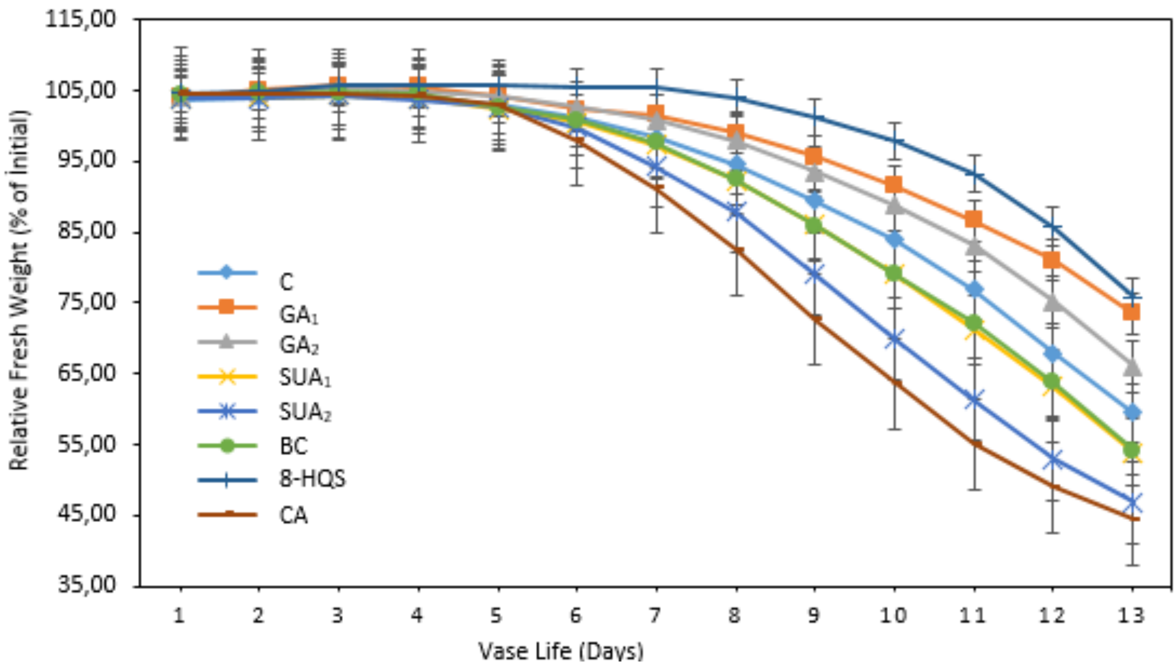

FIGURE 3
Effect of different holding solutions on relative fresh weight of cut 'Ankong Rose'

CONCLUSION

In this study was set to determine the potential role of GA, SUA, BC, 8-HQS and CA in maintaining good marketable quality of cut hydrangea flowers and in extending flowers vase life. In conclusion compared to control, 8-HQS (250 mg L^{-1}) and 76 mg L^{-1} of GA significantly extend the vase life of hydrangea flowers as 42.35 % (3.6 days) and 25.8 % (2.2 days) respectively. The results showed that 8-HQS can be used to extend the vase life of the cut hydrangea flowers. However 100 mg L^{-1} of citric acid and 100 mg L^{-1} of succinic acid shortened the vase life of the hydrangeas compared the control. These treatment were thought to have a toxic effect on plants due to their high concentration. Therefore lower doses of succinic acid and citric acid should be reduced and new studies should be performed.

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