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POSTHARVEST QUALITY EFFECTS OF DIFFERENT VASELIFE SOLUTIONS ON CUT ROSE (*Rosa hybrida* L.)

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Abstract. Cut flowers last only for a few days maintaining their beauty and attractiveness. Thus, using appropriate preservatives could extend the vase life of harvested flowers. The study aimed to prolong the postharvest quality and vase life of cut rose. The experiment was laid out in Completely Randomized Design with 5 treatments and 10 replications (flowers). The treatments (vase solutions) were as follows: T1- Filtered water, T2- 0.02 M STS + 2 % Sucrose, T3- 0.02 M STS + 2 % Glucose, T4- 250 mg/L HQS + 2 % Sucrose and T5- 250 mg/L HQS + 2 % Glucose. All treatments were kept at 25 °C and quality was determined by recording the relative fresh weight (%), solution uptake, maximum flower head diameter (MFHD), blueing symptom, senescence flower and vaselife (days) after 4 and 6 days of holding. Results showed detrimental effects of vase solutions with silver thiosulfate (STS) in combination with sucrose and glucose after 4 days. However, hydroxyquinoline sulfate (HQS) vase solution with glucose maintained a vaselife of 4.5 days. Maximum flower head diameter was better with HQS vase solution with glucose (84.42 mm) after 6 days compared to filtered water (66.01 mm), but was statistically comparable with HQS vase solution with sucrose (82.34 mm). Generally, vase solution of HQS with glucose manifested better results compared to other treatments in terms of percent weightloss (26.62 %), maximum flower head diameter (84.42) and vaselife of 4.5 days after 6 days of holding.

Keywords: Cut rose, glucose, hydroxyquinoline, silver thiosulfate, sucrose

INTRODUCTION

Cut flowers last only for a few days maintaining their beauty and attractiveness. However, most of the people would like to enjoy them for a longer period. Short vase life of cut flowers is related to wilting, ethylene production and vascular blockage by air or microorganisms. Flower senescence and shortening the vase life is influenced by several factors including endogenous ethylene (Seglie et al., 2012). Ethylene induces leaf yellowing, flower or petal drop, irregular opening and premature death (Nowak and Rudnicki, 1990). It also causes loss of cellular turgor, chlorophyll and pigment degradation and hence product quality such as vase life (Serek et al., 2006). Therefore, ethylene control is a critical factor in the flower maintaining quality after harvest. Since then, the best “weapon” against ethylene has been silver thiosulfate (STS), which can at least double the vase life of cut flowers (Reid et al., 1999).

Hassan and Ali (2014) cited that Silver thiosulphate (STS) is the most widely used substance as ethylene binding inhibitor. The benefits of using STS are so great that it is mandatory to be used with many species of flowers entering the flower auctions. STS appears to be having also further benefits than as a biocide, which makes it an even more popular substance (Bishop 2002). Different authors reported that vase life was extended and therefore the postharvest quality was improved as a result of STS treatment (Beura et al. 2001; Petridau et al., 2001; Song et al., 2001; Celikel and Reid 2002; Ichimura and Goto, 2002;Hassan et al. 2003; Hassan and Schmidt 2004; Hassan et al. 2004; Dole et al. 2005; Sexton et al. 2005;Williamson and Joyce, 2013). Silver thiosulfate (STS) has been often used in the pulsing of flowers (Han, 1998). This substance improves the vase life of many species of flowers, by inhibiting the action of ethylene (Serek & Reid, 1993). Many studies have utilized STS to increase flower vase life, but few have examined its ability to control *B. cinerea* in roses. And since STS contains silver, recently considered a potential environmental pollutant, there have been some restrictions on its commercial use (Cross, 1996). Therefore, other alternatives to STS should be used.

Preservative solutions are generally required to supply energy source, reduce microbial contamination, reduce vascular blockage, increase water uptake. Thus, using appropriate preservatives could extend the vase life of the harvested flowers. Motaghayer and Esna-Ashari (2009) cited that there are different flower preservatives that provide water and energy which are required to improve flowers vase-life and to keep their quality over the period of presentation. Moreover, required energy for cell activities is prepared by sugars that oxidize in mitochondria and results in preservation of other organelles' structure and function. Motaghayer and Esna-Ashari (2009) also cited that the addition of sugar to vase solution causes flower bud opening in *Gladiolus hybrids.* It has also been reported that continuous sucrose treatment plus silver thiosulfate complex (STS) pulsing extended mini-gladiolus cut spikes vase-life and maintained flower quality. Liao et al. (2000) indicated that an STS pulse treatment for 2 hrs followed by sucrose treatment in combination with 8-hydroxyquinoline sulfate (8-HQS) preserved rose flowers' quality and increased their vase-life.

Microorganisms on the other hand, which exist in vase water, prevent water absorption by some cut flowers and have negative effect on their vase-life extension. Studies cited by Motaghayer and Esna-Ashari (2009) showed that both hydroxyquinoline citrate (HQC) and Hydroxyquinoline sulfate(HQS) have anti-bacterial and anti-ethylene effects. This study ascertained the postharvest quality and vase life of cut rose using different vase solutions continuously treated.

MATERIALS AND METHODS

Roses were imported from China and were transported to the Postharvest Laboratory for Ornamentals at Bangkhuntien campus, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi. Roses were selected with the same size and without any defects and were immersed directly in containers with water while petal protection was removed individually from each sample rose. Stem end were cut 30 centimeters from base of flower by pruning shears. Leaves noticed to be under water in the vase were removed. Thereafter, roses were placed in vase solution as following: Treatment 1: Filtered water, Treatment 2: 0.02 M STS + 2% Sucrose, Treatment 3: 0.02 M STS + 2% Glucose, Treatment 4: 250 mg/L HQS + 2% Sucrose and Treatment 5: 250 mg/L HQS + 2% Glucose. STS stands for Silver Thiosulfate and HQS stands for Hydroxyquinoline Sulfate. All treatments were kept at 25 °C and quality were determined using the following parameters: Relative fresh weight, Solution uptake, Maximum

flower head diameter(MFHD), Blueing symptom, Senescence flower, pH of vase solution after preparation and vase life (days).

Quality and vase life determination of cut rose

*Relative fresh weight (%).*Fresh weight of flowers was determined just before immersion into solutions and was repeated every two days until the vase life of flowers was terminated. Flowers were taken out of solutions for such a short time as possible (20 to 30 s). After Roses were recut, these were weighed, labeled and placed in the solution. The fresh weight of each flower was expressed relative to the initial weight to represent the water status of the flower (Joyce and Jones, 1992).

Solution uptake (mL/day). Solution uptake was determined by taking flower stalks and subtracting the volume of water evaporated from a flask of the same volume without cut flower (Chamani et al., 2005). Generally, uptake of vase solution was measured daily by weighing the vase solution and cut flower separately.

Maximum flower head diameter (MFHD). Flower bud diameter was measured daily using the digital vernier-caliper. The MFHD of four cut flowers were recorded using the procedure of Van Doorn et al. (1991).

Blueing symptom. Blueing symptom index of 1-4 was used as basis in scoring, wherein 1(red, no blueing), 2(Slight, <25% of flower blueing), 3 (Moderate, 25-50% of flower blueing) and 4(Severe, >50% of flower blueing).

Senescence flower. Senescence flower was determined using the leaf senescence index 1-4, wherein 1(green, no wilt), 2(slightly wilt, <25% leaf wilting), 3(moderately wilt, 25-50% leaf wilting) and 4(severe, >50% leaf wilting).

Vase life (days). Flower longevity was recorded as the number of days on vase until the flowers showed symptoms of bent neck or advanced signs of fading on all petals (Liao et al., 2000).

pH of vase solution. After preparation of vase solution, only initial pH was determined.

Preparation of Silver Thiosulfate (STS) Solution

Silver Thiosulfate is commonly used to block the action of ethylene in plant cell cultures. Ethylene is a hormone that is present in gaseous state. Ethylene increases during senescence and ripening, and has been shown to increase in plant cell cultures due to wounding or the presence of auxins. Silver nitrate may be used alone to block the action of ethylene, but it is not transported as well as STS. Thus, silver nitrate is seldom used alone.

A 0.1 M Sodium Thiosulfate (STS) stock solution was prepared by dissolving 1.58 g of Sodium Thiosulfate into 100 ml of water. A 0.1 M Silver Nitrate stock solution was prepared by dissolving 1.7 g of Silver nitrate into 100 ml of water. Stock solution was stored in the dark until needed to prepare the STS.

The STS solution was prepared with a molar ratio between silver and thiosulfate of 1:4 respectively. Nearly all of the silver present in the solution was in the form of $[Ag(S_2O_3)_2]^{3-}$, the active complex for ethylene effect inhibition.

A 0.02 M STS was prepared by slowly pouring 20 ml of 0.1 M silver nitrate stock solution into 80 ml of 0.1 M sodium thiosulfate stock solution. The STS can be stored in refrigerator for up to a month. However, preparation of STS just prior to use is recommended.

Statistical Analysis

The experiment was laid out in Completely Randomized Design with 5 treatments and 10 replications (flowers). Data was subjected to analysis of variance (ANOVA) using the Statistical Tool for Agricultural Research or STAR statistical software, version 2.0.1 from the International Rice Research Institute (IRRI). Tukeys's Honestly Significant Difference (HSD) was used to determine mean comparisons between treatments and figures were presented using the Graph Pad Prism 5.00.288.

RESULTS AND DISCUSSION

Relative fresh weight.

Hydroxyquinoline sulfate (HQS) treatment positively influenced the weightloss of cut rose. Vase solutions with 250 mg/L Hydroxyquinoline sulfate(HQS) in combination with 2% sucrose and 2% glucose statistically have lesser percentage cumulative weightloss, but were comparable to the untreated vase solution or control(filtered water).Treatments with 0.02 M silver thiosulfate (STS) in combination with 2% sucrose and 2% glucose revealed to have the highest percentage weightloss on cut rose after 4 days of holding as presented in Figure 1. Continuous use of STS treatments as vase solutions after 4 days revealed to be toxic on cut rose. Numerically, T5(HQS + glucose) have minimal weight loss with 26.62 % than T4(HQS + sucrose) with 33.37% and T1(Control) with 40.75%.

Solution uptake.

Vase solutions with glucose combinations have better solution uptake but were statistically comparable with the untreated and vase solutions with sucrose. In general, vase solutions with silver Thiosulfate were deleterious at 6^{th} day of holding as shown in Figure 2.

Maximum flower head diameter.

Silver Thiosulfate(STS) vase solutions with sucrose and glucose combination were definitely fatal at 4^{th} day of holding as shown in Figure 3. T3(HQS + glucose) have numerically retained higher flower head diameter (84.42 mm) than T1(untreated) with 66.01 mm and T4(HQS + sucrose) of 82.34mm. However, these treatments were statistically comparable to each other.

Blueing symptom.

Severe blueing were already observed after 4 days of holding on vase solutions with silver thiosulfate (STS) treatment. Figure 4 presents the rate of blueing on cut rose after 6days of holding of cut rose.

Senescence flower.

Withering of leaves below the sepals of cut rose was recorded to determine the degree of senescence. Vase solution with silver Thiosulfate (STS) senesced totally after 4 days of

holding as presented in Figure 5. This was statistically significant in comparison to T1 (filtered water) that senesced after 2.8 days, T4(HQS +sucrose) at 4 days and T5(HQS + glucose) at 3.5 days.

Vaselife and pH.

Vase solution of 0.02 M Silver thiosulfate (STS) regardless of the sugar combination was found toxic to cut rose. Thus, instead of extending its vase life, results in Table 1 denoted death of cut rose after 4 days of holding at temperatures ranging from 22-25°C. While initial pH evidently shows that Hydroxyquinoline sulfate vase solution was more acidic and effective in maintaining the vase life of cut rose.

Table 1. Vaselife and pH of Cut rose (*Rosa hybrida* L.) as influenced by different vase solutions

Treatment	Vase life (days)	pH
T1: Filtered water	1.10 b	7.84 a
T2: 0.02 M STS + 2% Sucrose	1.40 b	6.52 b
T3: 0.02 M STS + 2% Glucose	1.70 b	6.46b
T4: 250 mg/L HQS + 2% Sucrose	0.60 b	4.05c
T5: 250 mg/L HQS + 2% Glucose	4.50 a	4.13c

Means with the same letter are not significantly different at Tukeys's 5% HSD.

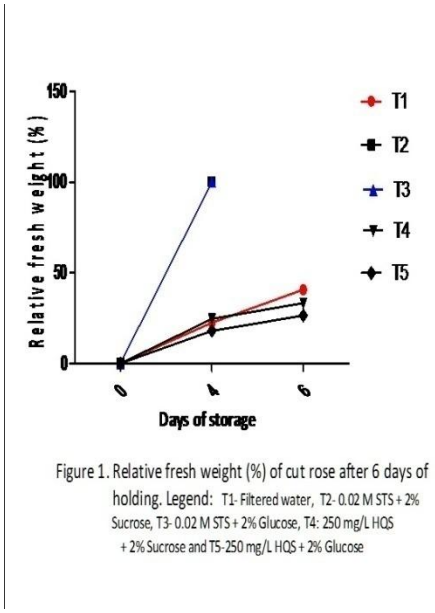

Figure 1. Relative fresh weight (%) of cut rose after 6 days of holding. Legend: T1- Filtered water, T2- 0.02 M STS + 2% Sucrose, T3- 0.02 M STS + 2% Glucose, T4: 250 mg/L HQS + 2% Sucrose and T5-250 mg/L HQS + 2% Glucose

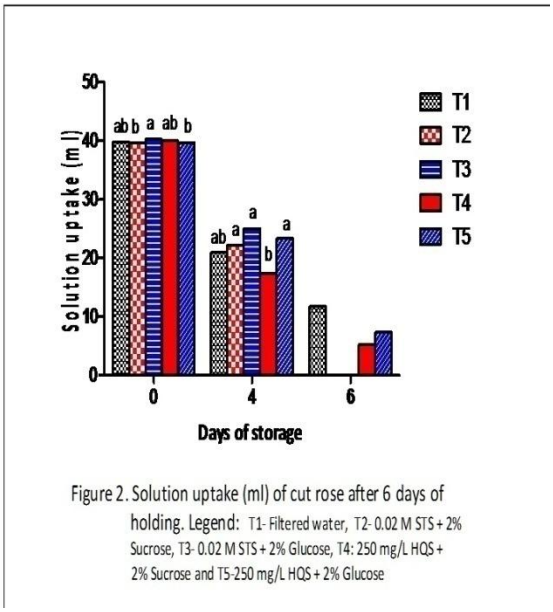

Figure 2. Solution uptake (ml) of cut rose after 6 days of holding. Legend: T1- Filtered water, T2- 0.02 M STS + 2% Sucrose, T3- 0.02 M STS + 2% Glucose, T4: 250 mg/L HQS + 2% Sucrose and T5-250 mg/L HQS + 2% Glucose

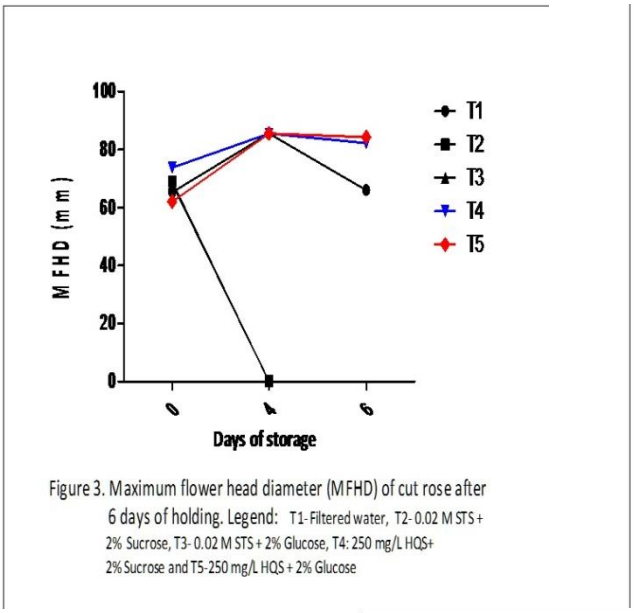

Figure 3. Maximum flower head diameter (MFHD) of cut rose after 6 days of holding. Legend: T1-Filtered water, T2-0.02 M STS + 2% Sucrose, T3-0.02 M STS + 2% Glucose, T4: 250 mg/L HQS+ 2% Sucrose and T5-250 mg/L HQS + 2% Glucose

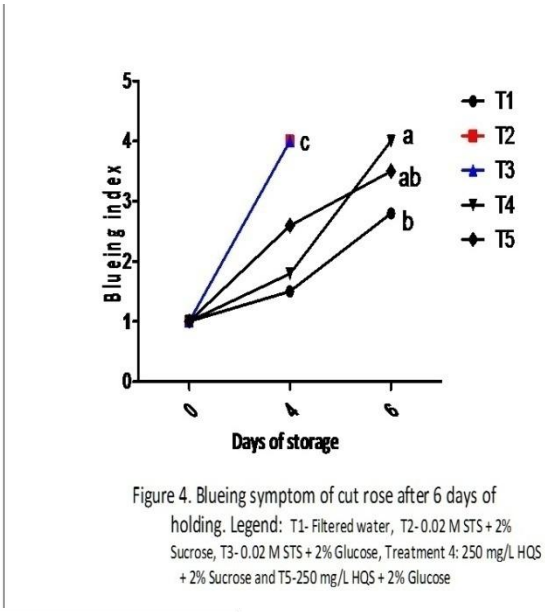

Figure 4. Blueing symptom of cut rose after 6 days of holding. Legend: T1-Filtered water, T2-0.02 M STS + 2% Sucrose, T3-0.02 M STS + 2% Glucose, Treatment 4: 250 mg/L HQS + 2% Sucrose and T5-250 mg/L HQS + 2% Glucose

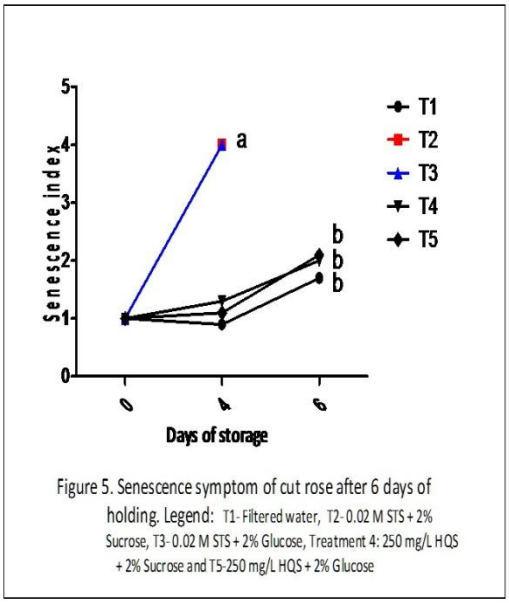

Figure 5. Senescence symptom of cut rose after 6 days of holding. Legend: T1-Filtered water, T2-0.02 M STS + 2% Sucrose, T3-0.02 M STS + 2% Glucose, Treatment 4: 250 mg/L HQS + 2% Sucrose and T5-250 mg/L HQS + 2% Glucose

Silver Thiosulfate (STS) as vase solution of cut rose in combination with sucrose and glucose were detrimental on its overall quality and did shorten its vase life. Instead of prolonging the postharvest quality and vase life of cut rose, death was accelerated after 4 days of holding (Figure 1). STS concentration of 0.02 M as ethylene inhibitor was toxic to cut rose regardless of the sugar combination. Studies of Rezvanypour and Osfoori (2011) stated that STS decreased visual flower quality due to burning of petals and leaves. However, it increased fresh weight and flower diameter. So for this cultivar, it is better to use STS in lower concentrations or in shorter time. This result evidently denotes that application of STS on cut rose is better through pulsing rather than as vase solution continuously for days. Hassan and Ali (2014) cited that little is known on retarding the senescence of rose cut flowers and not much information is yet available

regarding the use of STS to retard ethylene dependent senescence processes for various rose cultivars. There is a compelling need to find the optimum dose of STS for each cultivar.

DAY 4

T5 T4 T3 T2 T1

DAY 6

T1 T2 T3 T4 T5

Low pH of HQS vase solutions were beneficial on cut rose because it inhibited microorganisms growth. And since one of the main factors reducing the vase life of many cut flowers is ethylene, which directly accelerates senescence and results in flower drop (Nowak and Rudnicki, 1990), T5 with vase solution of 250 mg/L HQS + 2% Glucose was effective in maintaining the vase life of cut rose until 4.5 days. This was associated by the study of Beura et al. (2001) showing that the combination treatment of 8-HQS and sucrose improved the postharvest quality of Gladiolus spikes. And that in *Dendrobium* cut flowers, holding solutions containing 8-HQS + sucrose extended the vase life and improved flower quality, water consumption, fresh weight, flower freshness, and reduced respiration rate and physiological weight loss (Asrar, 2012).

Moreover, Capdeville et al. (2003) cited that pulsing flowers with substances such as citric acid, salicylic acid, sucrose, calcium sulfate, and silver thiosulfate (STS) is promising in reducing damage caused by *B. cinerea* (Nowak & Rudnick, 1990). The term pulsing has been used by scientists to describe a technique where flower stems are immersed in a chemical solution to carry to the tissues, through the xylem, substances that may reduce senescence and increase the vase life of the flowers.

CONCLUSION

Effects of vase solutions with silver thiosulfate (STS) in combination with sucrose and glucose after 4 days of holding on cut rose were detrimental. However, hydroxyquinoline sulfate (HQS) vase solution with glucose maintained a vaselife of 4.5 days. Maximum flower head diameter was better with HQS vase solution with glucose (84.42 mm) after 6 days compared to filtered water (66.01 mm), but was statistically comparable with HQS vase solution with sucrose (82.34 mm). Generally, vase solution of HQS with glucose manifested better results compared to other treatments in terms of percent weightloss (26.62 %), maximum flower head diameter (84.42) and vaselife of 4.5 days after 6 days of holding.

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