Longevity and postharvest quality of Rosa hybrida L. cv. “Happy Hour” cut flowers as affected by Silver thiosulphate (STS) treatment

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Abstract

In order to improve the postharvest quality and the export ability of cut rose (Rosa hybrida L.) cv. Happy Hour, the effect of silver thiosulphate (STS) as an ethylene inhibitor was investigated. STS was used at 0.2, 0.3, 0.4 and 0.5 mM as pulsing treatment for 6 h while control flower were kept in distilled water. STS treatment significantly extended the vase life and minimized the weight loss compared to the control. STS treatment enhanced the relative water content (RWC) of flowers and significantly retarded the degradation of chlorophyll and carbohydrate contents of cut flowers during vase life evaluation. The ethylene production by rose cut flowers was significantly decreased by applying STS treatment. The treatment of STS at 0.4 mM was recommended in order to inhibit the negative effects of ethylene and hence prolong the vase life and maintain the postharvest quality of rose cut flowers. Therefore, STS treatment is advisable during rose transport and handling in areas where the air is commonly contaminated with ethylene.

Keywords: Rose, STS, ethylene, vase life, chlorophyll

Introduction

Postharvest of rose flowers has been engaging the attention of growers and researchers for many years. Understanding the variable postharvest performance of rose is important not only for ensuring maximum life of those that presently are of commercial importance, but also for developing new selections with improved postharvest quality. Rose flowers are mainly grown in countries where labor is cheap and the climate offers relatively favorable conditions such as Colombia, Ecuador, Kenya, Zambia and Zimbabwe. The markets of flowers, however, are mainly in countries where the standard of living is relatively high as is the flower consumption per capita such as North America, Japan, Netherlands and Germany (Hassan et al., 2004).

The problem with the distribution is that flowers nowadays have to be transported all over the world. The cost of air shipment of flowers is a major factor influencing profitability in the flower trade. There is a big difference in the costs between airfreight and sea shipment. To achieve these savings, the vase life of flowers must be extended to provide the consumer with equivalent flower quality (Zeltzer et al., 2001). Cut flowers are often exposed to ethylene during production, transport, storage or retail marketing. Moreover, unfavorable transport conditions, such as high temperature, high humidity, darkness, and shaking in the truck, can reduce the vase life of cut roses as a result of endogenous ethylene produced in response to stresses in the postharvest environment. Some deleterious effects of ethylene exposure include leaf yellowing, flower (or petal) drop, irregular opening and premature death (Nowak and Rudnicki, 1990). It has been known for years that many roses are ethylene senstive. The sensitivity to ethylene has important implications during the transport and handling the cut roses in supermarkets and other areas where the air is commonly contaminated with ethylene. The symptoms of ethylene are exaggerated when put under the stress of mass market condition and there were marked differences in sensitivity and response to ethylene among cultivars (Serek, 1993; Muller et al., 1998).

Faragher et al. (1987) and Mor et al. (1989) showed that cut roses produce substantial amounts of ethylene in response to stresses such as cold storage. Moreover, there were significant differences in the longevity of a range of commercial cultivars of roses. This variation in display life partly appeared to be a result of differences in ethylene production or sensitivity to ethylene exposure (Muller et al., 1998). There is a marked confusion over the role of ethylene in rose senescence, as Woltering and Van Doorn (1988) found that the sensitivity of roses to ethylene was very low until the flower was fully open for several days and the same authors reported that, in roses too, exposure to ethylene accelerates...
the abscission of petals suggesting that sensitivity to ethylene in rose flower is relatively high (Kumar and Dixit, 2008). Furthermore, Reid et al., 1989 a, b commented that ethylene does not appear to be an important natural regulator of the postharvest life of cut roses however exogenous ethylene inhibit opening in cut roses (Tan et al., 2006) and the flowers were responded to anti ethylene inhibitors (Hassan et al., 2004). Therefore, ethylene control is an important factor in rose storage and shipping environment.

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 was very effective in prolonging the vase life of different cut flowers (Dole et al., 2005; Sexton et al., 2005; Fukai and Uehara, 2006; Abou El-Ghait et al., 2012). Pulsing cut rose flowers with STS inhibited the ethylene synthesis and improved the postharvest quality (Burzo and Dobrescu, 1995). Cut roses treated with STS showed maximum beneficial effects on postharvest life and quality. In addition, this solution led to a progressive rise in the total soluble sugar content. In general, petals contained the greatest amount of total soluble sugars, followed by leaves and stems (De et al., 1996; Singh and Tiwari, 2002). Pulsing rose cut flowers with STS improved both the vase life and quality and reduced the frequency of bent necks of cut flowers (Bhattacharjee and De, 1998; Jen et al., 2000; Maitra et al., 2001; Song et al., 2001; Chikkasubbanna and Yogitha, 2002; Singh and Tiwari, 2002). The silver ion is known to have a bactericidal property and also an inhibitory effect on ethylene action (Torre and Fjeld, 2001). The treatment with STS inhibited chlorophyll, soluble protein and sugar losses during chrysanthemum senescence (WeiMing et al., 1997). The maintenance of carbohydrates may contribute to the maintenance of water uptake and retard wilting in the capitula of cut flowers. The vase life and the quality of chrysanthemum cut flowers were improved by retarding water loss and chlorophyll degradation in the leaves (Petridau et al., 2001). However, 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. STS treatment may be results in a significant increase in the vase life allowing maximizing the postharvest quality as well as the export ability of cut roses. Therefore, the aim of this study was to investigate the effect of STS treatment on the vase life and postharvest quality measurements of (Rosa hybrida L.) cv. Happy Hour.

Materials and methods

Plant material

Cut flowers used in the experiment were Rosa hybrida L. cv. Happy Hour. The flowers were obtained from a commercial grower at commercial maturity (open bud stage) and were brought to the laboratory of Tanta University, Egypt as soon as possible. Lower leaves were removed and the flowering stems were trimmed to a uniform length of 45 cm. The experiments were repeated twice during 2011 season.

STS treatments

Silver thiosulfate (STS) was prepared as described by Gorin et al. (1985). The preparation of STS solution proceeds as follows:

Dissolve 0.079 g AgNO₃ in 500 ml of deionized water.

Dissolve 0.462 g Na₂S₂O₃ 5 H₂O in 500 ml of deionized water.

Pour AgNO₃ solution into Na₂S₂O₃ 5 H₂O solution while stirring.

The concentration of silver is 0.463 mM. The STS solution is now ready to use. If not used immediately, the solution may be kept in a dark glass or plastic container at 20-30°C, in total darkness for up to 4 days.

Cut flowers were pulsed with STS for 6 h at concentrations of 0.2, 0.3, 0.4 and 0.5 mM. After pulsing treatments, treated and non treated cut flowers were put in beakers containing 500 ml distilled water till the end of experiment. Five treatments with three replicates were applied and each replicate consists of 5 flowers.

Vase life evaluation

The longevity of rose cut flowers was determined in a vase life evaluation room at 23 ± 1°C and 60 – 70 % RH. Visual rating of flowers was evaluated on a scale from 1 to 4 when: 1 = entirely fresh flowers, 2 = initiation of wilting in 20% of petals and beginning of bent neck, 3 = wilting in 20–50% of petals and increasing the bent neck, 4 = wilting in 50–100% of petals. The longevity of rose cut flowers was defined as the number of days in vase life required for 50% of the flowers to reach stage 2 or more advanced stages.

Fresh weight measurements

The stems of rose cut flowers were initially weighed at the beginning of the experiment. The fresh weight was repeated again at the end of vase life of control flowers. The fresh weight of each flower was expressed relative to the initial weight to represent the weight losses percentage.

Relative water content (RWC)

Flower RWC was determined and calculated from the following relationship:
(W\text{fresh} - W\text{dry}) / (W\text{turgid} - W\text{dry}) \times 100$, where \(W\text{fresh}\) is the sample fresh weight, \(W\text{turgid}\) is the sample turgid weight after saturating with distilled water for 24 h at 4 °C, and \(W\text{dry}\) is the oven-dry (70 °C for 48 h) weight of the sample (Weatherley, 1950).

**Chlorophyll determination**

Leaves fresh samples were randomly taken at days 1,3,5 and 7 for chlorophyll determination. Chlorophyll content was determined according to Sadasivam and Manickam (1992) by using spectrophotometer (type GBC, UV/VIS 916) and calculated as (mg g\(^{-1}\) FW).

**Total carbohydrates**

Total carbohydrate percentages were determined in petals at the same days of chlorophyll. All samples were dried in an electric oven at 70 °C for 24 hours, and then the fine powder was used to determine total carbohydrate percentages according to (Herbert et al., 1971).

**Determination of ethylene production**

Rose flowers were individually weighed and placed in 500 ml air tight glass vessels fit with gas sampling ports. The vessels were kept at 22 °C and 70-80 % RH for 2 h. Gas samles (1 ml) were withdrawn from the headspace of vessels for ethylene determination. Ethylene content of the samples was quantitatively analyzed by gas chromatography using a Packard 427 GC, which was equipped with an aluminum oxide column (1/8 inch x 1 m) and a flame ionization detector. The injector, column, and detector temperatures were 80, 100 and 220 °C, respectively (Heiser et al., 1998). Ethylene values were indicated as (nl g\(^{-1}\) h\(^{-1}\)) and each treatment comprised three vessels.

**Statistical analysis of results**

Five treatments of three replicates each, in this experiment, were arranged in a completely randomized design. The experiment was performed twice and had qualitative and quantitative similar results. Analysis of variance (ANOVA) was performed using SPSS program Base 9, SPSS Inc. USA. Means were compared by using Duncan multiple range test at 0.05 level and values were presented as means ± S.D. (n=6).

**Results**

**Vase life and weight loss**

STS treatment was very effective in extending the vase life of rose cut flowers compared to the control (Fig. 1). The differences were significant between any STS treatment against the untreated control. The best treatments in this concern were 0.3 and 0.4 mM STS since there were no significant differences between them. On the other hand, untreated flowers recorded the shortest vase life. STS treatment positively influenced the weight loss as expressed of initial fresh weight of cut rose. All concentrations of STS significantly minimized the percentage of weight loss in comparison with the control. After three days from the beginning of the experiment, the control flowers of Happy Hour cultivar lost 19.41 % from the initial weight, however the flowers lost only 3.11 and 3.226 % when treated with STS at 0.3 and 0.4 mM, respectively .

![Figure 1. Effect of different concentrations of STS on the vase life (Days) and weight loss (%) of Rosa hybrida L. cv. Happy Hour. STS treatments were applied as pulsing treatment for 6 h. Control flowers were placed in distilled water for the same period. Values are means ± S.D. (n=6).](image-url)
Relative water content (RWC)

The effect of different STS concentrations on the flower RWC was presented in (Fig. 2). RWC recorded at different days of vase life declined at all time points in all treatments as well as control. However, STS treatment significantly retarded this decline in flower RWC compared to the control. The differences between STS treatments were clearly appeared with the progressive in days after harvest. Treatments of 0.3 and 0.4 mM STS resulted in the highest RWC values since there were no significant differences between them.

![Figure 2](image-url)

**Figure 2.** Effect of different concentrations of STS treatment on the flower Relative Water Content (RWC) of Rosa hybrida L. cv. Happy Hour. STS treatments were applied as pulsing treatment for 6 h. Control flowers were placed in distilled water for the same period. Values are means ± S.D. (n=6).

Chlorophyll content

The total chlorophyll content of leaves was gradually declined with increasing the days in vase life evaluation period, however a sharp decrease in chlorophyll content was observed in untreated control (Fig. 3). STS treatment significantly reduced the chlorophyll degradation at any applied level compared to the control. The best treatment in this respect was STS at and the difference between them was insignificant (Fig. 3).

![Figure 3](image-url)

**Figure 3.** Effect of different concentrations of STS on chlorophyll content (mg g⁻¹ fresh weight) of Rosa hybrida L. cv. Happy Hour. STS treatments were applied as pulsing treatment for 6 h. Control flowers were placed in distilled water for the same period. Values are means ± S.D. (n=6).

Carbohydrate content

The effect of various STS treatments on the total carbohydrate content of flower petals of Happy Hour rose cultivar was presented in Fig. (4). The carbohydrate content of untreated control was sharply reduced from the beginning of the experiment. Meanwhile, applying STS significantly retarded this reduction of carbohydrate during the period of vase life evaluation. Treatments of 0.3 and 0.4 mM STS maintained carbohydrate contents compared to the other STS treatments.
Ethylene production

The ethylene production of both rose cultivars was significantly inhibited by applying STS treatment compared to the control (Fig. 4). The ethylene production of control flowers was sharply increased and reached its maximum value at the third day of the experiment and decreased thereafter. A climacteric-like peak in ethylene production was observed on the third day in control flowers while, STS treatments delayed and inhibited the peak of ethylene production and the lowest ethylene production was obtained by using 0.4 mM STS.

Discussion

Pretreatment with STS significantly extended the vase life and minimized the weight loss of Happy Hour cut roses (Fig. 1). These results could be explained through the role of STS in retarding the loss of fresh weight (Fig. 1) and maintaining higher RWC compared to the control as shown in (Fig. 2). The senescence-related processes including chlorophyll as well as carbohydrate degradation were significantly retarded by STS treatment (Figs. 3 and 4). These positive results on postharvest quality confirmed other results on different cut flowers (Celikel and Reid, 2002; Picchioni et al., 2002; Hassan et al., 2004; Uthaichay et al., 2007). Nowak and Rudnicki (1990) mentioned another explanation for this positive effect of STS that it was a very potent inhibitor of ethylene action in plant tissues. It also provides some antimicrobial activity inside the tissues, thus it is beneficial for ethylene-sensitive flowers. Similar results were obtained by Dole et al. (2005), Sexton et al. (2005), Fukai and Uehara (2006) and Hassan (2009).

The ethylene production was significantly inhibited as a result of STS treatment (Fig. 5). These results were in accordance with the results of Uthaichay et al. (2007) who mentioned that, STS not only inhibited ethylene action but also inhibited ethylene production. The high ethylene production by untreated control, might be adequate to explain the effect of STS on the vase life of cut rose flowers. Contrary to the conclusions of Reid et al. (1989 a, b), these results suggest that
ethylene is an important natural regulator of flower senescence, at least in some rose cultivars. Similar findings were obtained by different authors (Hassan et al., 2004; Chamani et al., 2005; Uthaichay et al., 2007; Valenzuela-Vazquez et al., 2007). The STS mechanism in extending the vase life of cut flowers is related to suppression in the induction of autocatalytic production ( Sexton et al., 1995; Ichimura and Hiraya, 1999) and inhibition of ethylene production as our data indicated (Fig. 5).

Other researchers have also demonstrated that the involvement of ethylene in senescence of some flowers may depend on cultivar ( Muller et al., 1989; Hunter et al., 2004) and consequently, the effect of STS, as an ethylene inhibitor, will differ according to the cultivar. From these results, it can be assumed that STS will be an important practical tool for increasing the postharvest life after ethylene exposure that may, for example, result from contamination during transport. The ability to mix ethylene sensitive and ethylene producing commodities can be increased by applying STS treatment and hence expand export opportunities. It is clear that STS plays a key role in the maintenance of the vase life of cut rose flowers. Therefore, to maintain the postharvest quality of rose cut flowers the treatment of STS at 0.3 mM was recommended.

References


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