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Preserving the Quality of Cold-stored Rose Flowers with Ethylene Antagonists

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Abstract. **The effects of inhibitors of ethylene synthesis and action on the vase life and quality of fresh and cold-stored 'Gabriella' roses (*Rosa hybrida* L. cv. Gabriella) were investigated. Aminooxyacetic acid (AOA) as a 1-hr pulse at 3 or 10 mM had no effect on the longevity of fresh flowers. However, the 10 mM pulse, applied either before or after cold-storage, extended by up to 2.7 days the longevity of roses that had been stored for 3 weeks at 1C. Silver thiosulfate (STS), as a 0.5-hr pulse at 0.5 mM, extended the life of fresh and cold-stored roses by 2 and 3 days, respectively.**

Storage of cut rose flowers is economically important because it enables producers and handlers to spread supply, meet peak demands, and transport roses over long distances (8, 9). However, prolonged cold storage shortens subsequent vase life, reduces flower opening and causes bluing of red rose petals (4, 7, 10, 11). The earlier senescence of cold-stored roses appears to be caused, at least in part, by earlier and increased ethylene production in petals (3, 5). Flowers age during cold storage and petal ethylene production rises (4, 5). Inhibitors of ethylene synthesis and action [aminooxyacetic acid (AOA) and silver thiosulfate (STS), respectively] delayed senescence of 'Mercedes' rose petals, as measured by reduced ion leakage, and STS treatment increased the vase life of fresh and cold-stored 'Mercedes' roses (3, 5).

The aim of this study was to determine whether inhibitors of ethylene synthesis and action could be used to increase the vase life and quality of cold-stored 'Gabriella' roses.

The experiments were carried out with red 'Gabriella' roses cut when the corolla was cylindrical. Flowers were cut in the morning at a local grower's greenhouse and conditioned in tap water at 1C for 5 hr. The flowers were then selected for uniformity, randomized into treatment groups of 10 to 12 flowers each, and the stems were recut to 40 cm. All flowers were sprayed with iprodione fungicide (1 g·liter $^{-1}$). For storage, precooled flowers were wrapped tightly in newspaper, then in polyethylene sheeting (40 μm thickness) and placed in fiberboard boxes in a cold room at 1 to 2C. Following storage, flower stems were unwrapped and recut while the rest of the flower parts remained wrapped. The flowers were rehydrated in a solution of citric acid (300 mg·liter $^{-1}$) for 1 hr at 20C and then in chlorine germicide [sodium dichloroisocyanurate (SDI) 50 mg available chlorine/liter] for 16 hr at 1C. The flowers were then unwrapped and placed in vases.

Silver thiosulfate was prepared according to Reid et al. (12) and flower stems were placed in a solution of 0.5 mM STS for 0.5 hr at 20C. This concentration and time was found to be optimal in preliminary experiments and resulted in an uptake of 0.22 μmol Ag^{+}/g fresh weight in fresh flowers. Similarly, stems were placed in solutions of AOA for 1 hr at 20C.

For evaluation of vase life 10 to 12 replicate flowers were placed in 1-liter vases containing chlorine germicide and held at 20 ± 1C and 60% ± 5% RH in continuous cool-white fluorescent light (irradiance of 3 W·m $^{-2}$ at 400 to 700 nm). The solution was changed and the flower stems were recut every 2 days. Vase life was considered to have ended when petal wilting or bluing, or sepal yellowing, became unacceptable. Flower diameter was taken as the mean of two measurements at right angles.

Treatment of fresh 'Gabriella' flowers with AOA at 1 or 10 mM for 1 hr at 20C neither extended the vase life nor affected flower diameter (P = 0.05, data not shown). However, treatment with 10 mM AOA, before or after cold storage for 3 weeks, increased the subsequent vase life, particularly if applied before storage, which increased vase life by 2.7 days (Table 1). The major effect of AOA was to delay petal wilting. Flower diameter was not affected by the AOA treatment (P = 0.05, data not shown).

STS pulse treatment extended the vase life of fresh 'Gabriella' roses by 2.0 to 2.7 days, largely because it delayed petal wilting (Table 2). Chlorine germicide (SDI) was used in all our experiments and it, alone, also extended the vase life of the roses (Table 2). STS treatment did not affect flower diameter (P = 0.05, data not shown).

STS increased the vase life of roses that had been cold-stored for 3 weeks by 3.2 to 3.4 days (Table 3). It was effective whether the treatment was given before or after storage. STS applied before storage sometimes reduced the subsequent flower opening (diameter), but it did not have this effect when it was applied after storage (P = 0.05, data not shown). The addition of a sucrose pulse treatment, before or after storage, to STS-treated flowers (30 g sucrose/liter plus SDI for 18 hr at 1C) increased flower vase life by an additional 1 to 1.5 days (P = 0.05, data not shown).

Our results show that the vase life of fresh and cold-stored 'Gabriella' roses can be increased by inhibitors of ethylene synthesis and action. Thus, it is clear that the life of 'Gabriella' roses is limited, at least in part,

Table 1. Effect of aminooxyacetic acid (AOA) treatment on vase life of 'Gabriella' roses after 3 weeks of cold storage.

Treatment[z]	AOA concn (mM)	Vase life (days)
Control	0	7.9
Before storage	3	8.6
	10	10.6
After storage	3	7.5
	10	9.5
LSD (P = 0.05)		1.1

[z]AOA was applied as a 1-hr pulse at 20C before or after storage.

Table 2. Effect of silver thiosulfate (STS) and chlorine germicide on vase life of fresh 'Gabriella' roses.

Treatment[z]	Vase life (days)
Deionized water	9.9
Water + STS	12.6
Chlorine germicide	11.3
Chlorine + STS	13.3
LSD (P = 0.05)	0.9

[z]STS was supplied at 0.5 mM for 0.5 hr at 20C.

Table 3. Effect of silver thiosulfate (STS) treatment, before or after 3 weeks cold storage, on vase life of 'Gabriella' roses.

Treatment[z]	Vase life (days)
Before storage	
Control	9.8
STS	13.2
LSD (P = 0.05)	1.0
After storage	
Control	11.8
STS	15.0
LSD (P = 0.05)	2.1

[z]STS was supplied at 0.5 mM for 0.5 hr at 20C. The effects of treatment before and after storage were tested in two separate experiments.

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by the action of endogenous ethylene and presumably by exogenous ethylene. These results are consistent with those of our previous studies with 'Mercedes' roses (3, 5).

AOA did not affect the life of fresh flowers, but it increased the life of cold-stored flowers, particularly when it was applied before storage. It is difficult to simply interpret results of experiments with AOA because it is not a specific inhibitor of ethylene synthesis. However, our results suggest that ethylene plays a greater role in senescence of cold-stored flowers than in fresh flowers and that ethylene is active during storage. In other experiments with inhibitors of ethylene synthesis, the inhibitors failed to increase the vase life of fresh 'Forever Yours', 'Samantha', and 'Mercedes' roses (ref. 14; unpublished data).

STS increased the vase life of cold-stored flowers slightly more than it did in fresh flowers, again suggesting the greater importance of ethylene in senescence of cold-stored roses than in fresh ones. However, in experiments with 'Mercedes' roses, STS led to virtually the same increase in vase life in fresh flowers as in stored flowers treated before or after storage (8). STS did not increase the life of either fresh or cold-stored 'Sonia' flowers (2, 13).

The adverse effect of cold-storage on roses appears to be due, at least in part, to the action of ethylene, probably both during and after storage. Endogenous ethylene production by 'Gabriella' petals increases markedly during cold storage, and, after storage, ethylene production greatly exceeds that in petals of unstored flowers (6). Thus, the effects of cold storage are essentially those of aging, which continues during storage, but ethylene production rates are stimulated (5, 6). In addition, the ethylene produced by the flowers may accumulate in the tightly closed packages of stored roses and promote further petal senescence.

Flower quality depends on opening and color as well as vase life. Cold storage inhibited flower opening and caused some petal bluing, but STS and AOA had very little effect on these changes (data not shown). The only clear effect was that STS applied before storage inhibited flower opening after storage, an effect also observed with 'Mercedes' and 'Sonia' roses (2). It is possible that ethylene is required for petal growth, as it was found in carnations (1).

Rose cultivars differ in their response to ethylene and ethylene inhibitors. While the vase life of 'Gabriella' and 'Mercedes' roses can be increased by STS treatment, this is not so for 'Sonia' (13). Further, it has recently been shown that several rose cultivars differ in their response to exogenous ethylene (M.S. Reid, personal communication). The practical application of STS to extend the life of roses would have to be tested on a wide range of cultivars.

Our results indicate that endogenous and, presumably, exogenous ethylene is important in senescence of at least some rose cultivars, that it is particularly important in cold-stored flowers, and that inhibitors of ethylene action and synthesis can extend the vase life of roses.

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Postharvest Handling of *Alstroemeria*

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Abstract. **Vase life of *Alstroemeria hybrida* 'Regina' was longest in inflorescences with secondary and tertiary florets. The presence of additional florets on a cyme decreased the vase life of the primary floret. Maximum flower opening and normal coloration occurred when the primary florets were harvested at the "rolled petal stage". Cutting *Alstroemeria* stems above the blanched portion of the stem before placement in water increased water uptake and vase life. When secondary florets were present, leaf removal did not decrease vase life.**

Although *Alstroemeria* has become a popular cut flower, little research has been conducted to determine optimum postharvest handling procedures (Verboom, 1980). Leaf chlorosis, loss of leaf turgidity, and floret desiccation are problems associated with postharvest handling of *Alstroemeria* (Halevy and Mayak, 1981). The use of gibberellin and cytokinin to delay leaf yellowing and treatment with silver thiosulfate to delay petal drop is a standard pretreatment in Europe. (M. Reid, personal communication).

Alstroemeria shoots at times fail to absorb water and the leaves, florets, and, in severe cases, stems become flaccid when the stem base is either not cut or cut through the blanched portion of the stem. The blanched stem segment is the portion of the stem below the soil line. This blanched area can be from 1 to 20 cm long.

Alstroemeria shoots produce a whorled cymose inflorescence. Each cyme is sympodially branched with up to four florets per cyme (Fig. 1). The primary florets within the whorl open synchronously, as do the secondary, tertiary, and quaternary florets. We observed the secondary and subsequent florets on a cyme to open as the preceding floret

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