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Postharvest Dip in a Natural Lipid, Lysophosphatidylethanolamine, May Prolong Vase Life of Snapdragon Flowers

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Abstract. **We investigated the use of lysophosphatidylethanolamine (LPE) for prolonging vase life of snapdragon (*Antirrhinum majus* L.). Freshly cut snapdragon spikes were set into a LPE solution at 25 mg·L^{-1} for 24 h and then transferred to deionized water. The vase life was enhanced by LPE. The flowers on spikes treated with LPE showed symptoms of wilting or browning 4 or 6 days later than those on the spikes given deionized water in inbred or 'Potomac White', respectively. All the spikes were of marketable quality for 5 to 7 days after harvest when treated with LPE, whereas in the control only about half of the flowers were of marketable quality at 2 days after harvest. LPE treatment also delayed fresh mass loss, lowered endogenous ethylene production, and reduced ion leakage. These results suggest that LPE has commercial potential in enhancing vase life of snapdragons.**

Endogenous ethylene production is known to be a prime cause of early senescence in cut snapdragons (Rogers, 1992). One of the reasons for enhanced shelf life in hypobaric storage of cut flowers is the constant removal of trace quantities of ethylene from the storage atmosphere (Burg, 1973). The equipment necessary for this technology, however, has been expensive to acquire and difficult to operate. Pretreatment of cut snapdragon stems for 20 h immediately after harvest in a solution containing silver thiosulfate (STS) and sucrose inhibits ethylene-induced senescence and floret abscission (Nowak, 1981; Veen, 1979). However, the silver ion in STS raises potential environmental concerns. Thus, an alternate means of prolonging shelf life of snapdragons would be desirable.

Recent results from our laboratory show that lysophosphatidylethanolamine (LPE), a naturally occurring phospholipid, can retard senescence in attached and detached leaves and fruits of tomato (*Lycopersicon esculentum* Mill.) (Farag and Palta, 1993a). LPE-treated tomatoes had a longer shelf life whether they were harvested at the breaker, pink, or red stages of maturity (Farag and Palta, 1993b). These results suggest a specific role of LPE in aging and senescence. Since LPE is a natural phospholipid (egg yolk contains 0.14% by fresh weight), it could provide an environmentally safe means for prolonging shelf life of cut flowers. In the present study, we investigated the use of LPE for prolonging the vase life of snapdragons.

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Materials and Methods

Plant material and treatments. The snapdragons we used were either 'Potomac White' obtained from the commercial grower (Pyramid Flowers, Oxnard, Calif.) or the long-duration inbred line obtained from Dennis Stimart, Dept. of Horticulture, Univ. of Wisconsin, Madison.

The seeds of the inbred line were germinated in an incubator at 25 °C under 16 h of cool-white fluorescent light (30 μmol·m^{-2}·s^{-1}) in cell packs containing sterilized mix of 1 soil : 1 sand : 1 sphagnum peat (by volume). After 1 week, the cell packs were placed in the Univ. greenhouses. After 6 weeks, the seedlings were transplanted to 785-mL plastic pots and were grown for additional 6 weeks under natural light. They were watered daily with tap water. Insecticide and fertilizer were applied once during the growing season. Spikes were harvested when one-third of the florets present on the spike were open (Rogers, 1992). The harvested spikes of inbred line were defoliated to reduce variation among spikes due to leaves. Variations in the number of leaves on cut flower stem are known to result in variations in flower senescence (Saks and Staden, 1993). Each spike was cut to a length of 30 cm. All harvested spikes were pooled and randomly selected for the treatments.

Flowering spikes of 'Potomac White' were harvested and delivered to our laboratory 1 d thereafter. Upon receipt, the stem ends of spikes were recut under distilled water and allowed to rehydrate for 4 h. After rehydration, spikes were trimmed to a length of 40 cm

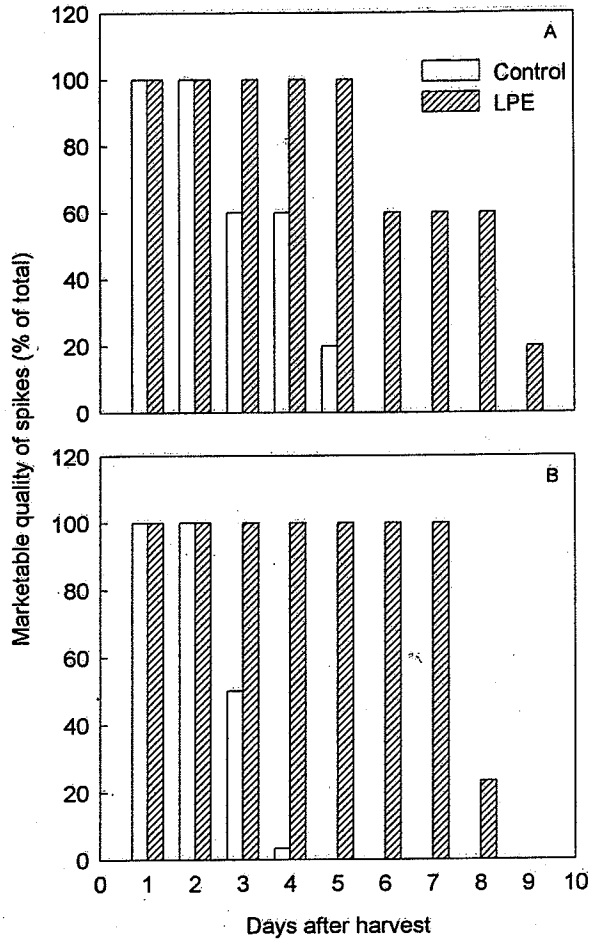

Fig. 1. Effect of lysophosphatidylethanolamine (LPE) at 25 mg·L^{-1} on vase life of snapdragons from inbred line (**A**) and 'Potomac White' (**B**). Marketable quality was defined as the number of days from stem cut to discard; stems were discarded when 50% of spike florets wilted or browned.

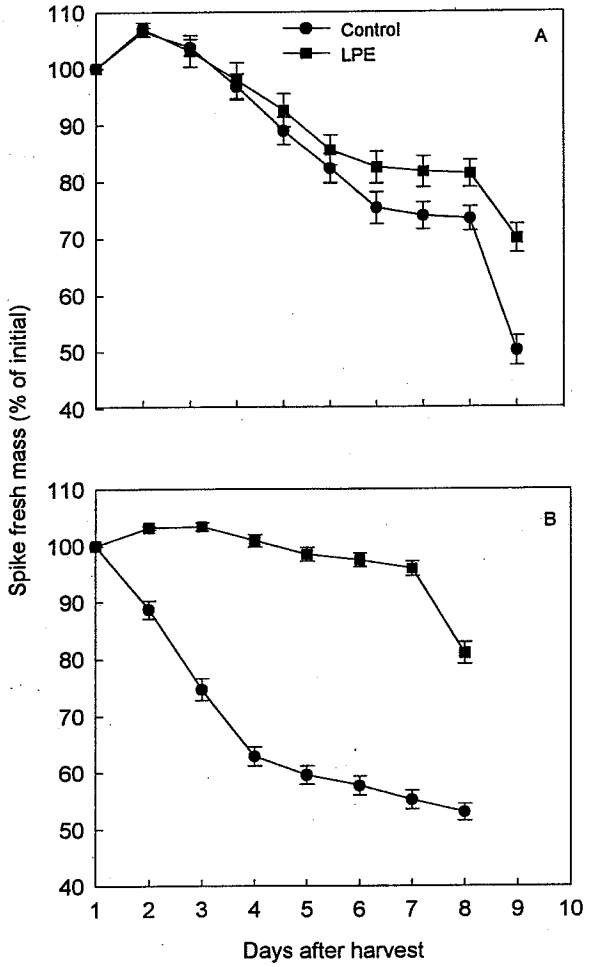

Fig. 2. Effect of lysophosphatidylethanolamine (LPE) at 25 mg·L^{-1} on the fresh mass change of snapdragons following harvest. (**A**) inbred line, means and standard errors are for 10 spikes. Values for day 7 and 8 are significantly different at $P \leq 0.05$. (**B**) 'Potomac White', means and standard errors are for 30 spikes. Two treatments are significantly different at $P \leq 0.001$ at day 2 and thereafter.

and leaves on the lower 18 cm of the spike were removed. All spikes were then pooled and randomly selected for the treatments.

LPE used in our experiments was obtained from Sigma Chemical Co. (St. Louis) and was purified from egg yolk. LPE was dissolved in 1 methanol : 2 chloroform (v/v) and then mixed with deionized water. A continuous stream of N was bubbled into this solution until methanol and chloroform were completely evaporated. For the LPE treatment, the cut end of the spikes were held 24 h in a solution of LPE at 25 mg·L^{-1} after which they were transferred to deionized water. Cut ends of the control spikes were kept continuously in deionized water.

Spikes were observed for opening of floral buds and also for symptoms of senescence (wilting and browning). Marketable quality or vase life was defined as the number of days from harvest to discard; stems were discarded when 50% of the florets on a spike had wilted or turned brown. The fresh mass of spikes was determined daily for the duration of the experiment. The results are expressed as percent of initial fresh mass for each day after harvest.

Ion leakage. Ion leakage was used to assess injury, as is done to estimate freeze-thaw stress (Steffen and Palta, 1986). At the end of the experiment, petals from each spike were cut into pieces and placed in a flask with 50 mL of deionized water, vacuum infiltrated and incubated for 3 h on a gyrotory shaker (G10; New Brunswick Scientific Co., New Brunswick, N.J.) at 200 rpm at room temperature (25 ± 2 °C). The electrical conductivity of the incubating solution was measured using a conductivity meter (model 32; Yellow Springs Instruments, Yellow Springs, Ohio). Another set of readings was taken after the solution had been autoclaved for 20 min and cooled to room temperature. Ion leakage was expressed as a percentage of ions leaked at 3 h as compared to total ion leakage following autoclaving.

Ethylene measurement. Ethylene production was measured at the end of the experiment by enclosing the spikes in 42-L gas-tight chambers for 24 h, after which the headspace gas was sampled and ethylene concentration determined by use of gas chromatograph equipped with a flame ionization detector (Shimadzu 9AM; Shimadzu Corp., Kyoto, Japan). The column was at 40 °C while the injector and the detector were at 150 °C. The flow rate was 70 mL·min^{-1}. A 1.2-m metal 80/100 Porapak KQ Supelco column was used (Supelco, Bellefonte, Pa.).

Results

LPE treatment was able to delay senescence and prolong vase life of snapdragons for the inbred line and 'Potomac White' (Fig. 1). Five days after harvest, all LPE-treated spikes of inbred line were of marketable quality as compared to only 20% spikes of the control (Fig. 1A). Marketable quality of both genotypes had declined significantly by the third day in controls as compared to the sixth and eighth day for LPE treatment (Fig. 1 A and B). For example, of the 10 spikes studied in the inbred line, six remained of marketable quality at 8 d after harvest when treated with LPE, whereas in 'Potomac White', all 30 LPE-treated spikes remained of marketable quality at 7 d. LPE treatment also slowed the loss in fresh mass associated with senescence (Fig. 2). Spikes from inbred line treated with LPE tended to have a higher fresh mass than the controls 3 d after harvest (Fig. 2A). LPE had significant effect on this characteristic at and after 7 d from harvest. Nine days following harvest, the LPE-treated spikes had retained 70% of their initial fresh mass as compared to 50% for the control. LPE-treated 'Potomac White' spikes maintained their fresh mass for 7 d (Fig. 2B), after which it declined, reaching 81% of initial fresh mass by day 8 (Fig. 2B). However, control spikes showed a significant loss of fresh mass at 2 d after harvest and their fresh mass continued to decline for 8 d.

Florets on spikes from the inbred line treated with LPE at 25 mg·L^{-1} opened 1.4 d earlier than those on the controls (Table 1). In addition, with the LPE treatment, all the floral buds on all the spikes opened, whereas in control the percentage of floral buds that opened on a given spike ranged from 50% to 100%. For 'Potomac White', more florets (70 ± 8) tended

Table 1. Effect of lysophosphatidylethanolamine (LPE) at 25 mg·L^{-1} on flowering of an inbred snapdragon line.

	Criterion			
	Time to maximal no.[z] open flowers (days)		Flower buds opened at discard (%)	
LPE	Avg ± SD	Range	Avg ± SD	Range
–	3.6 ± 1.0	2–5	88 ± 16	50–100
+	2.2 ± 1.0	1–4	100 ± 0	---
Significance	**[y]		***[x]	

[z]Time 0 was at harvest.
[y]Treatments significantly different at $P \leq 0.01$ by t test.
[x]Treatments significantly different at $P \leq 0.001$ based on binomial distribution with n = 10, and probability of all flowers opening in controls at 0.50.

Table 2. Effect of lysophosphatidylethanolamine (LPE) at 25 mg·L^{-1} on ion leakage from snapdragon flowers and on ethylene production by the spikes 9 (inbred line) and 8 ('Potomac White') days after harvest.

	Genotype			
	Inbred line		Potomac White	
LPE	Ion leakage (% of total)	Ethylene production (nL g^{-1}·h^{-1})	Ion leakage (% of total)	Ethylene production (nL·g^{-1}·h^{-1})
–	51.0 ± 3.0	7.71 ± 1.1	72.63 ± 1.6	0.85 ± 0.02
+	42.0 ± 2.3	5.13 ± 0.09	60.07 ± 1.0	0.28 ± 0.05
Significance	*[z]	**[y]	***[x]	***[w]

[z]Mean ± SE of 10 samples. Significantly different from control at $P = 0.027$, by t test.
[y]Mean ± SE of 2 composite samples of five spikes each. Significantly different from control at $P = 0.0016$, by t test.
[x]Mean ± SE of 15 samples. Significantly different from control at $P \leq 0.001$, by t test.
[w]Mean ± SE of three replications (10 spikes each replication). Significantly different from control at $P \leq 0.001$, by t test.

to open faster (3.9 ± 2.4 d) when treated with LPE than in the control (63 ± 6); also, the controls took on average 0.5 d longer to bloom (4.4 ± 2.4 d).

At termination of the experiment, the percent ion leakage from florets of both genotypes was 17% to 18% lower in spikes treated with LPE at 25 mg·L^{-1} than for the controls (Table 2). Similarly, ethylene production by the spikes treated with LPE was significantly lower than for the controls (Table 2). This suppression of ethylene in LPE-treated spikes was 35% for the inbred line and 67% for 'Potomac White'.

Discussion

An increase in membrane permeability, and an associated water stress in petal tissue, together with ethylene production are key regulatory factors in the sequence of events leading to senescence (Eze et al., 1986). We do not yet know the mode of action of LPE. Our results suggest that LPE may be improving vase life of cut snapdragon flowers by retarding loss of water and/or maintaining water uptake by the spikes. Furthermore, our results also suggest LPE may be enhancing the longevity of these cut flowers by suppressing ethylene production. Our results are consistent with the observation of retardation of senescence and lesser ion leakage in LPE-treated tomato fruits and leaves (Farag and Palta, 1993a).

Our study suggests that LPE has the potential to enhance vase life of cut flowers. Various other methods or applications reducing the ethylene are available for prolonging postharvest life. Rhizobitoxine analogs have been used to suppress ethylene formation (Wang et al., 1977); alternatively, brominated charcoal has been used to remove ethylene in orchids (Akamine, 1963). Hypobaric storage to enhance longevity of cut flowers has also been used (Burg, 1973), but it involves expensive infrastructure. Currently, STS, a highly toxic heavy metal environmental contaminant, is extensively used by commercial cut-flower producers to inhibit ethylene-induced senescence (Veen, 1979). Since LPE is a natural phospholipid from egg yolk, our result suggest an environmentally safe means to enhance vase life of flowers.

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