USE OF AVG TO CONTROL RIPENING OF APPLES

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Initial studies showed that aminoethoxyvinylglycine (AVG), an inhibitor of ethylene biosynthesis, delayed the ripening of apples and pears (1, 2, 5, 7). We thus initiated tests to determine how AVG use might alter current postharvest handling of apples.

In 1979-80 we found that preharvest sprays with 500 ppm AVG delayed or prevented postharvest ripening of several apple cultivars at room temperature, but that after 3 or 4 months of air storage at 0°C there was no discernible effect of AVG on fruit ripening (3). These results were extended in 1980-81, with 3 experiments designed to answer specific questions about use of AVG.

The results of 1979-80 suggested that the effects from a given AVG concentration increased when it was applied to late maturing cultivars. To test this observation, limb treatments of 0, 125, 250, 500, or 1000 ppm AVG were applied 1 week before harvest to Early McIntosh, McIntosh, Cortland, and Delicious trees, cultivars that ripen from early-August to mid-October.

Ripening was monitored by alternate day measurement of internal ethylene concentrations of harvested fruit kept in a well-ventilated laboratory at 70-75°F. The same fruit were used continuously unless rot developed. Fruit were judged to be ripe when internal ethylene concentration reached 1 ppm.

Results are summarized in Figure 1, in which the mean number of days for fruit to reach 1 ppm internal ethylene concentration after harvest is plotted against AVG concentration. Overall, there was a highly significant quadratic relationship between AVG concentrations and days required for fruit to ripen. However, there was also a highly significant interaction between the effects of AVG concentrations and the days from bloom to ripening (i.e., time to maturity) for a given cultivar. Substantial delay of Early McIntosh ripening required 500 to 1000 ppm AVG, while ripening of Cortland and especially Delicious were substantially delayed by 125 ppm AVG. Whereas 1000 ppm delayed ripening of Early McIntosh by about 10 days, it delayed ripening of McIntosh by about a month, while only 125 ppm delayed ripening of Cortland by about 10 days

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and ripening of Delicious by about 3 weeks. In all cultivars peak internal ethylene levels were reduced as AVG concentration increased, and the percent reduction by a given concentration was approximately the same for all cultivars, although early maturing cultivars produced much more ethylene than later maturing ones.

This test showed that optimum AVG concentration for delaying apple ripening varied with cultivar, and that in general greater concentrations were required and less response was obtained for an earlier maturing than for a later maturing cultivar.

In the 1979-80 test, results were about the same whether AVG was applied 3 or 18 days before harvest of McIntosh and Spartan (3). To test the importance of time of application and to see if early application might influence maturation processes as well as the onset of ripening, limb treatments with 500 ppm AVG were applied to trees of Puritan, an early maturing cultivar, on June 26, July 11, or July 28. Ten fruit were harvested from each limb on August 1, 4, 7 and 10 and were used to assess fruit firmness, soluble solids, peel chlorophyll, titratable acidicy, and internal ethylene. AVG treatments all delayed ripening and reduced ethylene peak height (Figure 2). However, the fruit from the earliest treatment ripened significantly faster than those from the 2 later treatments (Table 1). No application, even the one 6 weeks before harvest, had a significant effect on firmness, soluble solids, peel chlorophyll, or titratable acidity (Table 1). It therefore appears that although greater response was obtained from treatments within a couple of weeks of the onset of ripening, treatment could be made earlier without an evident effect on maturation processes of the fruit.

The third experiment was designed to test whether the loss of AVG effect during storage that was seen the previous year was due to storage ethylene levels, or to an effect of low temperature. McIntosh and Delicious tree limbs were sprayed with 500 ppm AVG 1 week before harvest. Only AVG-treated fruit were used, and these were stored in 3 different storage conditions: (a) 0°C, low ethylene; (b) 3.3°C, low ethylene; (c) 3.3°C high ethylene. (McIntosh is a cold-sensitive cultivar and Delicious is cold tolerant). "Low ethylene" was maintained well below 0.1 ppm by placing 150 g of Purafil in each box of fruit; these samples were the only fruit in a 200 bu. storage room. Relatively high ethylene was attained by placing additional ripe apples in a room with the samples, and also by occasionally injecting sufficient ethylene into the atmosphere to temporarily reach 10 ppm. Fruit were kept in storage for 23 weeks after harvest and then were assessed for internal ethylene, firmness, ground color (McIntosh only), and occurrences of disorders at room temperature. For McIntosh, there was no difference in internal ethylene between low ethylene and high ethylene storage, but internal ethylene was initially lower from the 0°C storage (Figure 3). In all cases, however, internal ethylene exceeded levels likely to be needed to trigger ripening, hence all samples had apparently initiated ripening during storage. Delicious fruit all had very low ethylene levels initially, but they gradually rose to about 0.5 ppm regardless of storage environment (data not shown).

After 1 and 3 weeks at room temperature, AVG-treated McIntosh stored in a low ethylene environment had less breakdown than ones stored in a higher-ethylene environment (Table 2). Furthermore, ones stored at 0°C were firmer, had a significantly greener ground color, and had less decay after 3 weeks at room temperature. Thus, exogenous ethylene had a somewhat deleterious effect on AVG-treated McIntosh, whereas lower temperature (0°C) helped conserve quality of these fruit. Fruit in all storages developed 60-70% browncore. This might account for the relatively small differences between fruit in low-and high-ethylene rooms: low-temperature stress may have produced sufficient endogenous ethylene to trigger ripening in the low-ethylene room.

For Delicious there was little effect of storage conditions on properties of the fruit after storage except that fruit from 3.3°C were softer than ones from 0°C storage. Apparently, Delicious did not initiate ripening in any of the storage conditions.

From these results, and those of others, the potential roles of AVG or another ethylene inhibitor in handling of apples can be envisioned. AVG certainly can delay ripening on the tree and have a stop-drop effect (6) and while the magnitude of delay has not been determined, for at least late-maturing cultivars it could be profound. After harvest and without refrigeration the delays for late-maturing cultivars were profound; the delay from high concentrations exceeded the limits of our tests in the absence of high concentrations of exogenous ethylene. Even for inherently fast-ripening early maturing cultivars, ripening of harvested fruit was slowed substantially. AVG therefore might be a very good marketing tool, producing slower ripening of freshly harvested apples as they pass through the marketing channels, and an important benefit might be in marketing of early maturing cultivars that normally ripen very fast. AVG might also reduce energy comsumption by reducing the need for refrigeration of apples destined for immediate marketing.

AVG would seem to have limited value for air-stored fruit, since an accumulation of ethylene in the storage atmosphere will override the AVG effect. However, if fruit are intended for only short storage in air, a significant effect might be obtained. Its usefulness in CA might be greater, assuming that pre-climacteric fruit were placed under CA conditions before ripening was initiated. In a CA atmosphere AVG-treated fruit will probably start to ripen more slowly, thereby slowing the buildup of ethylene in CA-storage.

The effects of AVG are similar to the effects of Alar (daminozide) in a number of ways (6). Its effects in conjunction with Alar would be interesting to test and it may be that AVG could contribute significantly to low-ethylene CA storage, especially in combination with Alar.

A potential concern is the apparent increase in brown core in AVG-treated fruit (3,4). Development of browncore is usually avoided by storage at 3.3°C, yet we obtained as much at this temperature as at 0°C (Table 2). If AVG increases cold-temperature sensitivity, serious problems could be encountered.

AVG is no longer available for use in significant quantities and its safety has not been established. Nevertheless, other ethylene-inhibiting compounds are becoming available for testing, and the results with AVG should provide models for testing these materials.

Literature Cited

1. Baker, J.E., M. Lieberman, and J.D. Anderson. 1978. Inhibition of ethylene production in fruit slices by a rhizobitoxine analog and free radicle scavengers. Plant Physiol. 61: 886-888.

2. Bangerth, F. 1978. The effects of substituted amino acids on ethylene biosynthesis, respiration, ripening, and preharvest drop of apple fruits. J. Amer. Soc. Hort. Sci. 103: 401-404.

3. Bramlage, W.J., D.W. Greene, W.R. Autio, and J.M. McLaughlin. 1980. Effects of aminoethyoxyvinylglycine on internal ethylene concentrations and storage of apples. J. Amer. Soc. Hort. Sci. 105: 847-851.

4. Chu, C.L., D.C. Elfving, and E.C. Lougheed. 1981. Aminoethoxyvinylglycine (AVG) effects on apple fruit storage. HortScience 16(3): 238.

5. Ness, P.J. and R.J. Romani. 1980. Effects of aminoethoxyvinlglycine and counter-effects of ethylene on ripening of Bartlett pear fruit. Plant Physiol. 65: 372-376.

6. Walsh, C.S. and T. Solomos. 1981. Effect of AVG and daminozide on ACC concentration, ethylene evolution, and ripening of apple fruits. HortScience 16(3): 239.

7. Wang, C.Y. and W.M. Mellenthin. 1977. Effect of aminoethoxy analog of rhizobitoxine on ripening of pears. Plant Physiol. 59: 548-549.

Table 1. Effects of 500 ppm AVG, applied on different dates, on the properties of Puritan apples after harvest. Data are means ot harvests on August 1, 4, 7, and 10.

Treatment date	Days to ripen	Peel chlorophyll (ug/g f.wt.)	Firmness (lbs)[z]	Soluble solids (%)	Titratable acidity (ml 0.1 N NaOH/5 ml)
June 26	3.9b[y]	93.7a	20.1a	12.4a	7.5a
July 11	6.4c	94.6a	19.9a	12.5a	7.4a
July 28	6.2c	90.0a	20.0a	11.6a	7.4a
Control	2.8a	92.2a	20.1a	11.8a	7.2a

[z]Firmness values were adjusted by covariance to account for different fruit sizes.

[y]Means in columns not followed by a common letter are significantly different at the 5% level.

Table 2. Effects of temperature and C_2H_4 concentration in storage on poststorage properties of apples that had been sprayed with 500 ppm AVG before harvest.

Cultivar	Storage conditions	Firmness (lbs. pressure)	% decay		% breakdown		% browncore	Ground color[z]
			1 wk.	3 wks.	1 wk.	3 wks.		
McIntosh	Prestorage	17.5a[y]	---	---	---	---	---	---
	Low C_2H_4[x], 0°	11.0b	2a	3a	1a	3a	63a	3.3a
	Low C_2H_4, 3.3°	10.3c	1a	9b	8b	15b	69a	2.6b
	High C_2H_4[w], 3.3°	9.7c	3a	9b	17c	25c	61a	2.3b
Delicious	Prestorage	20.2a	---	---	---	---	---	---
	Low C_2H_4[x], 0°	16.6b	1a	8a	1a	3a	---	---
	Low C_2H_4, 3.3°	14.8c	0a	9a	0a	4a	---	---
	High C_2H_4[w], 3.3°	13.8c	2a	9a	1a	5a	---	---

[z] Color scale: 1 = light yellow-green, to 5 = dark green, using Cornell color chart.

[y] Means in a column and cultivar not followed by a common letter are significantly different at the 5% level.

[x] Low C_2H_4 varied from 0.001 to 0.014 ppm atmospheric C_2H_4 during periodic measurements.

[w] C_2H_4 was injected into the atmosphere to attain 10 ppm concentration at intervals.

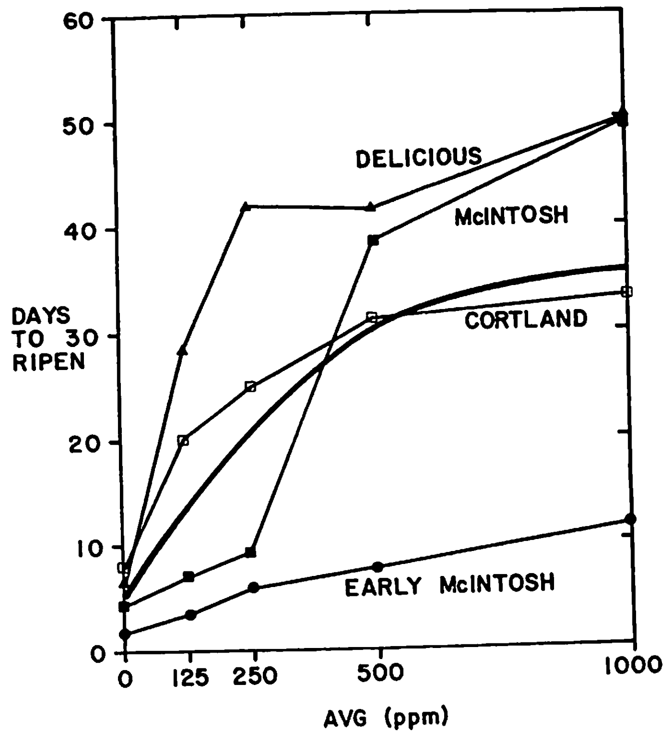

Figure 1. Days at room temperature required for fruit to reach 1 ppm internal C_2H_4 following AVG application 1 week before harvest. Each value is the mean within a treatment and cultivar for all the fruit that ultimately reached ripeness (1 ppm internal C_2H_4). The central line is the calculated quadratic relationship for all cultivars.

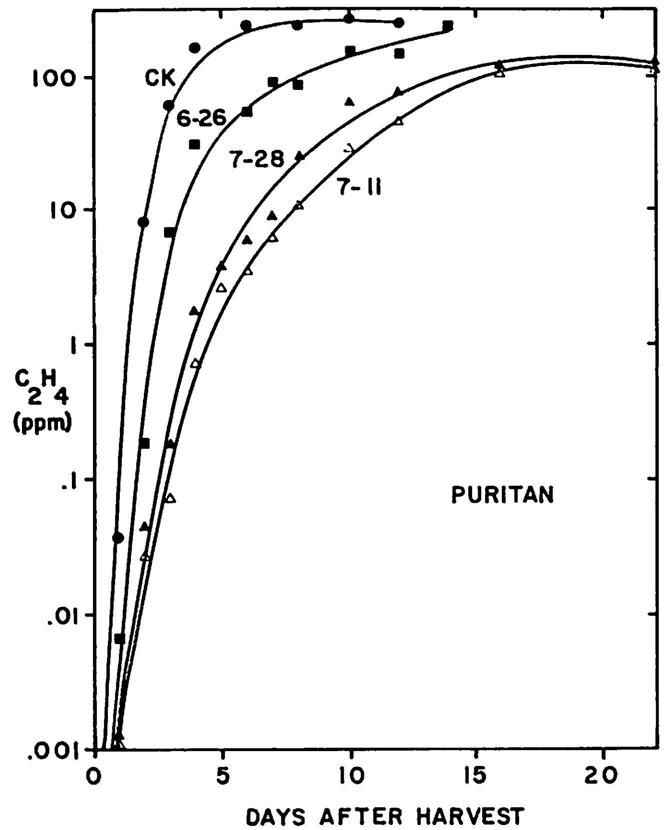

Figure 2. Internal C_2H_4 concentrations of Puritan apples, sprayed with 500 ppm AVG on indicated dates, at intervals after harvest. Values are means of harvests on August 1, 4, 7, and 10.

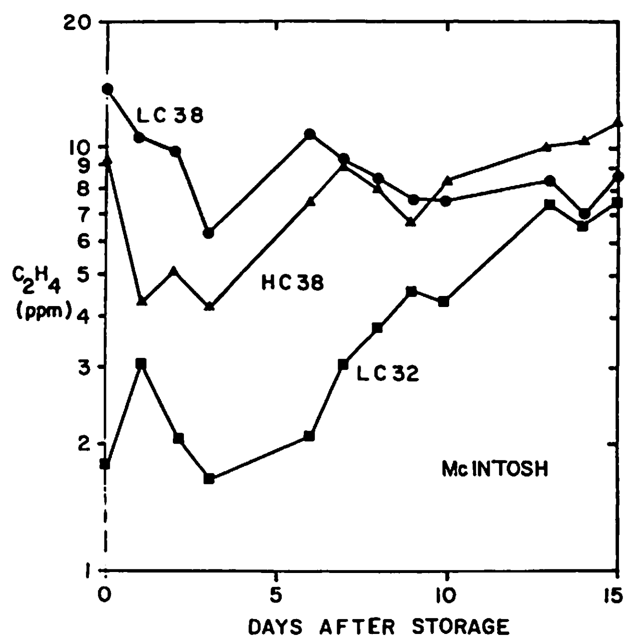

Figure 3. Internal C_2H_4 concentrations of McIntosh apples after storage for 23 weeks at relatively low (LC) or high (HC) C_2H_4 concentrations at 0°C (32) or 3.3° C (38).