Preharvest Ethylene Production in McIntosh Apples Reduces Effectiveness of SmartFresh™ (1-MCP) in Maintaining Fruit Quality

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SmartFresh™, as 1-MCP is marketed, is a new postharvest treatment which helps maintain high quality of cold-stored apples. Consistent benefit, as measured by firmness retention, has been documented on a number of cultivars. McIntosh is not among them. Some years, some lots of McIntosh have maintained firmness much longer when treated with 1-MCP, but in other situations no benefit has been found. It would be useful to know why some fruit respond well and others do not. It would be even more useful to know prior to treatment which McIntosh would benefit from 1-MCP. This chemical acts through disabling ethylene's ripening effects, so impact on ethylene production has been a focus of research.

This research was conducted in order to determine if McIntosh's inconsistent response to 1-MCP treatment could be attributed primarily to ethylene production and action already occurring in the fruit at the time of harvest. A secondary objective was to determine whether or not fruit stored in controlled atmospheres (CA) would demonstrate preharvest, ethylene-related differences similar to those found in refrigerated air (RA) stored fruit.

Materials & Methods

Rogers McIntosh from a block of trees growing at the UMass Cold Spring Orchard Research & Education Center were harvested on September 9, 2004 and September 16, 2004. At each harvest, internal ethylene of about 300 apples was measured on a 1 ml sample taken from the core cavity of the apple. The sample was taken by poking into the calyx a bent needle and removing a gas sample with a syringe. Ethylene detection was by gas chromatography with an activated alumina column. Fruit were categorized according to internal ethylene concentration. Fruit from each internal ethylene category were further divided into groups for RA and groups for CA storage. Some non-ethylene-measured fruit were also stored and 1-MCP treated with each group. Half the fruit destined for RA storage were treated at room temperature with 1 ppm 1-MCP for 24 hours prior to cold storage. Treatment with 1-MCP began approximately 24 hours after harvest. Following the 1-MCP treatment, the treated and untreated fruit were stored together in 36°F RA. All fruit which were CA stored received 1ppm 1-MCP treatment as the treatment was applied to the entire CA room before the controlled atmosphere was applied. The CA-stored fruit from the two harvests were in separate CA rooms, so all could be treated within 2 to 3 days of harvest. Half the RA fruit from both harvests was removed from cold storage on November 11, 2004, and the other half was removed from storage on December 21, 2004. The CA fruit from the first harvest were removed from storage on February 3, 2005, and the CA fruit from the second harvest were removed from storage on March 15, 2005.

Assessment of stored fruit was similar for all groups. Fruit were allowed to sit at room temperature for 24 hours before ratings began. The day after removal from storage, up to ten fruit from each (harvest ethylene by 1-MCP treatment) category were weighed, ethylene was measured as at harvest, fruit firmness was measured (using EP1 pressure tester), and fruit were halved to look for internal disorders, primarily brown

Table 1. Distribution (% of harvest within year) of fruit according to internal ethylene concentration at harvest.

Harvest date	Internal ethylene concentration (ppm)	No ReTain		ReTain
		2004	2005	2005
Harvest 1	0-1	85	83	98
9/6 to 9/9	1-100	7	11	1
	>100	8	6	0.5
Harvest 2	0-1	64	67	95
9/16	1-100	10	13	5
	>100	26	20	0

core. If superficial scald was present, it was noted. If a category of fruit contained more than ten apples, the excess fruit were left at room temperature for one or two weeks, and then assessed as the other fruit had been assessed the day following removal from storage.

The experiment was repeated in 2005 with some modifications. Additions to the 2004 materials included use of Marshall and Gatsky as well as Rogers McIntosh, and use of fruit treated with ReTain as well as fruit without ReTain treatment. No fruit were stored in CA in 2005. Also in 2005, all fruit were removed from storage November 30 (September 6 harvest) or December 6 (September 16 harvest).

Results

Fruit were placed in groups according to ethylene production. Categories were defined based on internal ethylene measured at harvest. Table 1 shows how the measured fruit from the two harvests were categorized. On the whole, more fruit were producing more ethylene at the second harvest than at the first. It is of some interest to note that, overall, the majority of fruit which were producing any ethylene were producing a great deal of ethylene, in excess of 100 ppm measured in the core cavity.

At the first removal from storage in 2004, only fruit which had no measurable ethylene and fruit which had not had ethylene measured were removed from storage and assessed. This was done to determine 1) if the "poking" of the needle used to sample the core ethylene at harvest had a lasting effect on the fruit and 2) if the "poking" had an effect, if it was different on the 1-MCP-treated fruit. The assumption was made that the distribution of harvest ethylene concentrations in the unmeasured fruit would be similar to those in the measured group. Because some of the "unpoked" fruit likely produced ethylene at harvest, a truly fair comparison of poststorage ethylene production changes cannot be made, but it should be possible to see if there was a very large "poking" effect on ethylene production or firmness. Approximately 83% of measured fruit from the first harvest and 64% of measured fruit from the second harvest had no ethylene detectable in the.

Table 2 shows very nicely that the "poked" fruit did not produce more ethylene than the unmeasured fruit. The higher ethylene concentrations in the unmeasured fruit may be attributed to (at least some of) those fruit having some ethylene at harvest. In any case, it is clear that poking the fruit in order to measure ethylene did not cause fruit to respond by producing a great deal of ethylene, and that is what we wished to confirm. The dramatic differences in ethylene production were between the 1-MCP-treated fruit and those not treated with 1-MCP. The 1-MCP-treated fruit were about one pound firmer than those that were not

Table 2. Effects of calyx "poking" at harvest (to measure ethylene) and harvest date on post-storage ethylene concentration and flesh firmness. All fruit were removed from 32°F cold storage to 68°F air on 11/16/04.

Treatment grouping	1-MCP treatment	Two days at 68°F		Seven days at 68°F	
		Harvest 1	Harvest 2	Harvest 1	Harvest 2
		Post-storage ethylene concentration (ppm)			
Fruit "poked", no ethylene production at harvest	- 1-MCP	480	320	530	260
	+ 1-MCP	7	4	12	5
Non-poked fruit, harvest ethylene unmeasured	- 1-MCP	710	260	630	630
	+ 1-MCP	23	20	26	12
		Post-storage flesh firmness (lbs)			
Fruit "poked", no ethylene production at harvest	-1-MCP	10.3	10.5	10.3	11.0
	+1-MCP	10.7	12.3	11.2	11.7
Non-poked fruit, harvest ethylene unmeasured	- 1-MCP	10.7	10.8	10.9	10.6
	+ 1-MCP	12.2	11.8	11.8	12.4

Table 3. Effects of preharvest ethylene level on efficacy of 1-MCP on McIntosh in 32°F cold storage from harvest through late November to mid-December. Measurements were taken following 2 days of 68°F air.

Preharvest internal ethylene concentration (ppm)	1-MCP treatment	Ethylene (ppm)		Firmness (lbs)	
		2004	2005	2004	2005
0-1	none	330	270	10.1	10.9
1-100	none	160	230	10.6	10.9
>100	none	240	230	10.2	10.4
0-1	1 ppm	70	0.5	11.0	12.7
1-100	1 ppm	50	30	10.9	11.5
>100	1 ppm	250	230	10.2	10.6

treated.

In the absence of 1-MCP treatment, preharvest ethylene in McIntosh did not have a substantial effect on either ethylene production or firmness of stored fruit in December (Table 3); however, there was a marked reduction in ethylene production and an increase in firmness retention in 1-MCP-treated fruit which had not been producing a large amount of ethylene at harvest. Note that 1-MCP appears to have had no effect on either ethylene production or fruit firmness when fruit had ethylene concentrations in excess of 100 ppm ethylene at the time of harvest. The 1-MCP-treated fruit were about 1 lb firmer than non-1-MCP treated fruit, but only when the treated fruit did not contain

over 100 ppm intermal ethylene at harvest. In 2005, the 1-MCP benefit was almost 2 lb in fruit containing less than1 ppm ethylene at harvest (more than 95% of ReTain-treated fruit). Note from Table 1 above that 6-8% of non-ReTain-treated fruit from the first harvest and 20-26 % of those from the second harvest had at least 100 ppm internal ethylene at harvest. Those fruit would not appear to be good candidates for 1-MCP treatment. Essentially none of the ReTain-treated fruit were producing significant ethylene at either harvest, and would therefore be considered good candidates for 1-MCP treatment. The data shown in Table 3 (2005) are the combined results of all three strains as well as with or without ReTain as the strain effect was not significant, and the ReTain effect appeared only as its influence on ethylene production at the time of harvest.

A third removal of 2004 fruit from storage was made in February. This removal included some fruit in controlled atmosphere (CA) storage. A fourth removal from CA was made in March. Observations of the effect of 1-MCP as influenced by preharvest ethylene on these fruit will be reported later.

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