

Maintaining Fruit Firmness of McIntosh and Cortland Apples with ReTain[®] and SmartFreshSM

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SmartFreshSM (1-methylcyclopropene) maintains firmness of McIntosh up to four months in regular air and seven months or longer in controlled atmosphere (CA) storage. However, effectiveness is reduced with high levels of internal ethylene at harvest. Ethylene, a naturally occurring gas produced by fruit, controls many ripening processes of apple. To temporarily suppress ethylene production by apples, ReTain[®] is applied 4 weeks prior to harvest. Other studies in New York and Massachusetts have shown that ReTain can extend the period in which SmartFresh can be used on McIntosh, a variety that is prone to excess softening in storage.

SmartFresh can prevent scald in many varieties, but has not consistently prevented it in Cortland. Harvest at later stages of maturity or following cooler temperatures, which typically occur with later harvest, can reduce the incidence of this disorder. ReTain can be used to extend harvest and possibly increase effectiveness in scald prevention.

The use of both ReTain and SmartFresh can be very costly, so controlled studies are needed to determine when this strategy is most effective. The goal of this project was to evaluate the effectiveness of ReTain and SmartFresh in maintaining firmness and preventing scald in McIntosh and Cortland apples.

Materials & Methods

Four McIntosh and two Cortland orchards, located at the Maine Agricultural Experiment Station in Monmouth, Maine, were sprayed with the full rate of ReTain Aug. 27, 2003, four weeks before anticipated first harvest. In 2004, five McIntosh orchards and four Cortland orchards were sprayed with ReTain Aug. 26. In 2004, three of these orchards were located at the experiment station in Monmouth and the others in a

commercial orchard in Turner, Maine. The trees were on semidwarfing rootstocks, MM.106 and MM.111, and ranged in age from 20 to 30 years. Two rows of trees in each orchard were left untreated and the rest were sprayed with ReTain at the full rate, (50 g active ingredient per acre), with a spray volume of 90 gal. / acre (3X concentrate). Organosilicone surfactant (Silwet L77, Helena Chemical Co., Collierville, Tenn.) was added at a rate of 0.05% v/v.

Approximately 60 McIntosh fruit were harvested from each orchard September 24 and October 13, 2003, coinciding with the end of harvest for CA storage (starch index of 5.8) and the end of harvest for immediate sale (starch index was not measured), respectively. A composite sample of fruit was harvested from two to seven trees in each orchard. An additional 60 fruit were harvested for treatment with SmartFresh. Cortland apples were harvested September 27 (starch index of 1.4) and October 14 (starch index was not measured). In 2004, McIntosh were harvested September 16 (starch index 4.0) and September 26 (starch index of 5.8), corresponding with the start and end of harvest for CA storage, respectively. Cortland apples were harvested September 29 (starch index of 1.8) and October 7 (starch index of 4.2). Starch index was measured on ten fruit using a visual rating where 1 = all starch remaining and 8 = no starch. Internal ethylene concentration was measured on ten fruit from each orchard to determine the efficacy of ReTain (Table 1). To measure internal ethylene, a stainless steel needle with syringe was inserted through the calyx end, and gas was removed and injected into a gas chromatograph.

SmartFresh was applied within 24 hours of harvest. Fruit were exposed for 20 hours to 1 ppm in 48-quart portable, plastic beverage coolers. Fruit were then placed in cold storage at 37°F. Controlled atmosphere

conditions were established 3-7 days following harvest. Large plastic bags and compressed nitrogen gas were used to maintain the concentration of O₂ in the range of 2.8-3.2% with occasional variations up to 3.5%. The concentration of CO₂ remained below 2%.

Twenty McIntosh apples from each orchard were removed from storage in late January, and remaining apples were removed from storage in late April. Cortland apples were removed in early February and early May. After removal from storage, fruit were kept at 64°F for 1 and 7 days, at which times firmness was measured on ten fruit from each orchard. In 2004, fruit were separated into large and small sizes for firmness measurement with five fruit in each size category. This was done in order to determine if SmartFresh was less effective on larger sized fruit. Fruit were weighed after storage. Firmness of peeled flesh was measured on the green and red side of each fruit with an electronic firmness tester. The occurrence of superficial scald on McIntosh in January and Cortland in February was measured on ten fruit after 7 days at 64°F. Superficial scald was measured on all remaining fruit (approximately 40 per orchard) in April or May.

Results & Discussion

ReTain reduced internal ethylene in McIntosh, but not until the second harvest in each year (Table 1). ReTain maintained firmness at harvest but only in 2003 with the second harvest of McIntosh which was 0.9 lb. firmer than untreated fruit. ReTain did not significantly lower ethylene of Cortland with either harvest. However, at the second harvest in 2003, 75% of the untreated Cortland fruit were preclimacteric, meaning internal ethylene concentration was less than 1 ppm. This indicates that large differences in maturity did not exist between untreated and ReTain-treated fruit of this variety.

In 2003, untreated McIntosh softened in storage, losing 5.4 lbs. of firmness after 120 days with the first harvest and 3.5 lbs. with the second harvest (Figure

Table 1. Harvest date and ReTain at four weeks prior to harvest affected internal ethylene concentration of McIntosh, but not Cortland apple fruit.

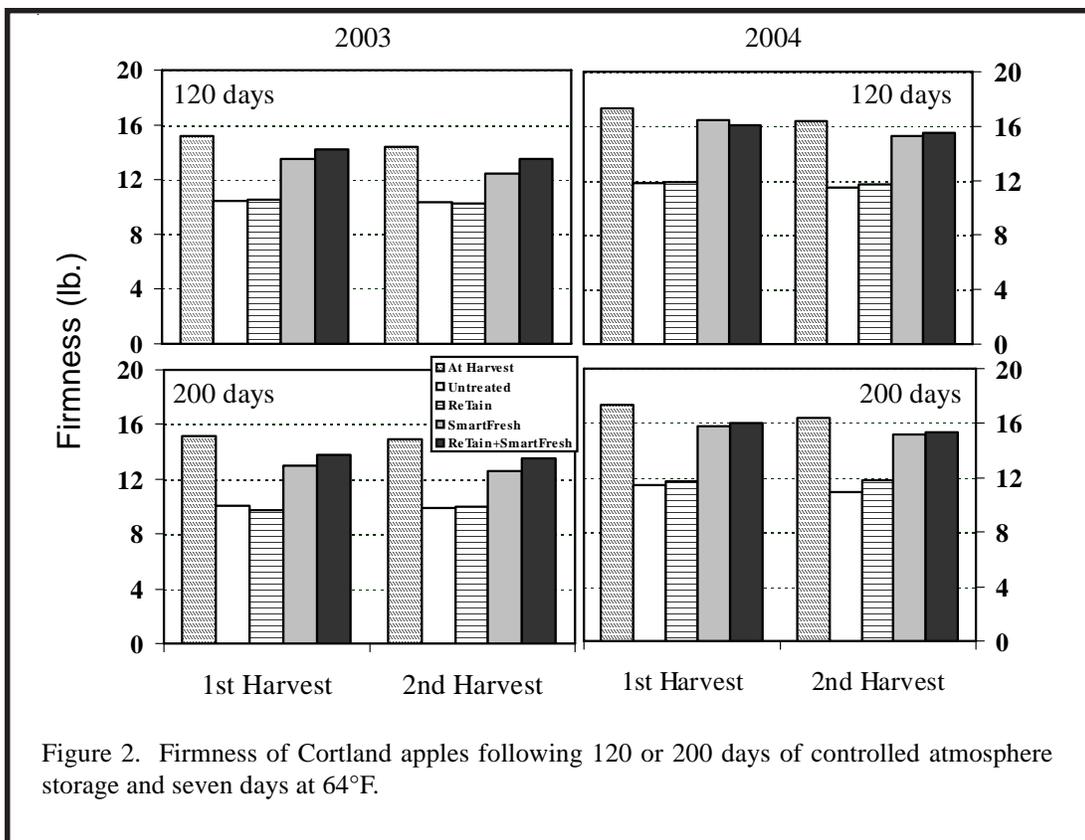
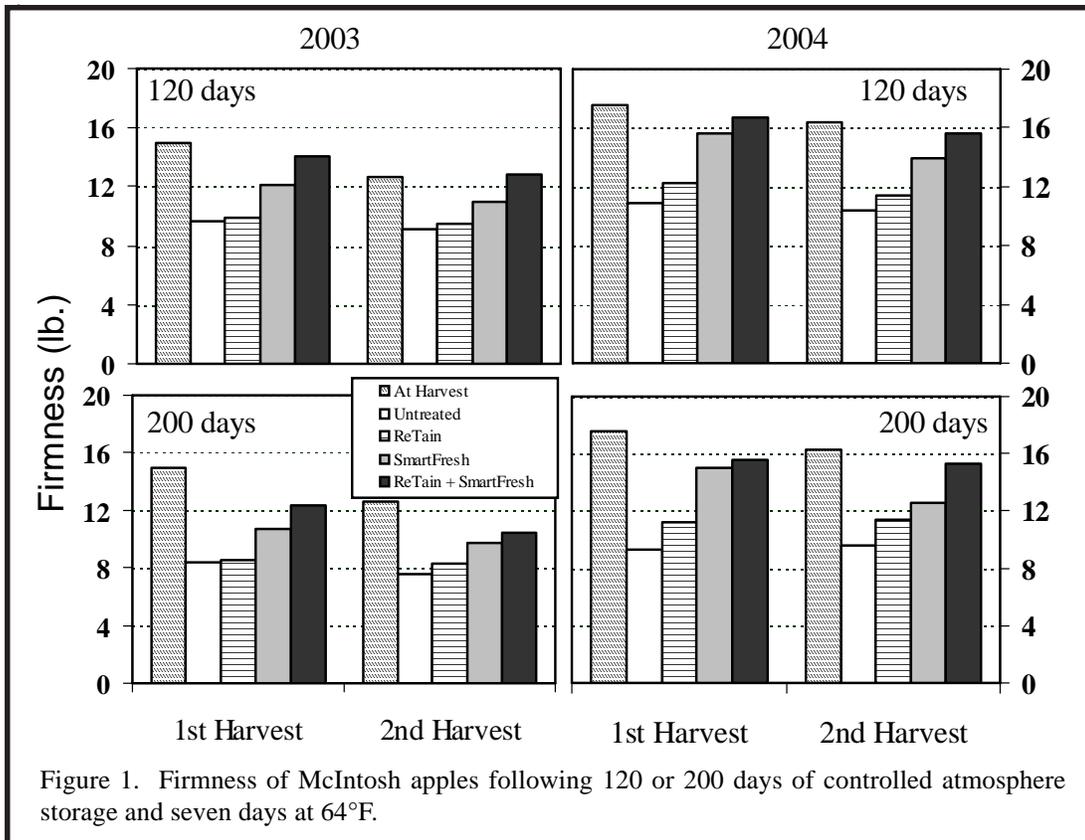
| Harvest | Treatment | Internal ethylene at harvest (ppm) | | | |
|------------|-----------|------------------------------------|------|----------|------|
| | | McIntosh | | Cortland | |
| | | 2003 | 2004 | 2003 | 2004 |
| Late Sept. | None | 21 c * | 12 b | 0 | 1.1 |
| | ReTain | 44 bc | 0 b | 0 | 0.0 |
| Mid Oct. | None | 475 a | 56 a | 36 | 0.9 |
| | ReTain | 243 b | 14 b | 0 | 0.5 |

* Within a column, means followed by the same letter are not significantly different at odds of 19 to 1.

1). ReTain maintained firmness in fruit from both harvests, but only when used with SmartFresh. The combination of ReTain and SmartFresh maintained firmness more than SmartFresh used alone, except in second-harvest fruit stored 200 days. This is not surprising since most fruit from the second harvest were climacteric or ripe at harvest and were not suitable for storage. Fruit were softer than normal in 2003 because of advanced maturity at harvest and above average fruit size. By 200 days of storage, firmness of fruit from the first harvest remained above 12 lbs. when treated with both ReTain and SmartFresh. All other treatments were below 12 lbs. firmness. The goal of growers and packers is to have firmness of McIntosh at least 12 lbs., since the number of consumers that reject apples increases as firmness decreases below 12 to 13 lbs.

In 2004, ReTain maintained firmness by 0.7 to 1.9 lbs. above the untreated control and SmartFresh by 3.0 to 5.7 lbs. when each was used alone. ReTain and SmartFresh together maintained firmness by an additional 1.1 to 2.7 lbs. This was more apparent in fruit from the second harvest. Smaller sized McIntosh (4.5 oz.) were 1.3 to 1.6 lbs. firmer than larger fruit (7.0 oz.). Smaller sized Cortland (5.7 oz.) were 1.0 to 1.2 lbs. firmer than large fruit (7.6 oz.). Fruit size did not influence how well SmartFresh or ReTain maintained firmness.

In 2002, ReTain had little influence on the efficacy of SmartFresh when used on pre-climacteric McIntosh, fruit harvested for long-term CA, indicating



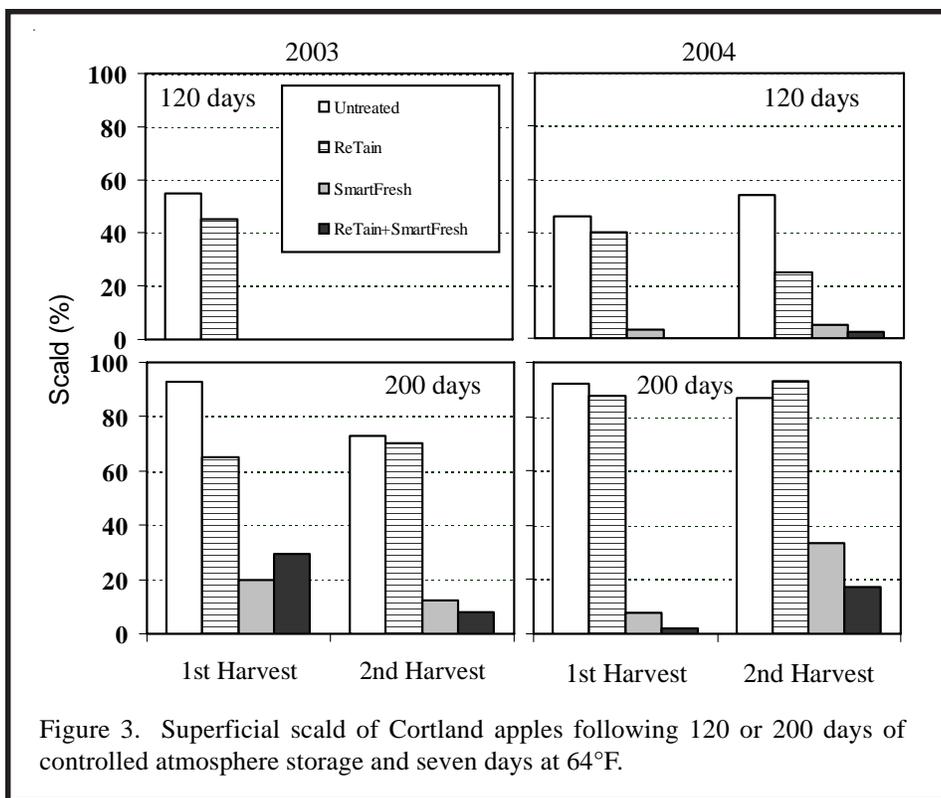


Figure 3. Superficial scald of Cortland apples following 120 or 200 days of controlled atmosphere storage and seven days at 64°F.

significant effect on the occurrence of superficial scald after 200 days of storage even though 192 hours below 50 °F had occurred between the two harvest dates in 2003 and 94 hours in 2004. Previous research has shown that occurrence of scald in Cortland is reduced by increasing exposure to low temperature. However, most of our fruit were harvested from trees with dense canopies, so fruit were grown under low light levels. Fruit grown in shaded conditions are more prone to scald with little difference between harvest dates, and this may explain why scald after long-term storage was not

that this combination is best used on fruit from later harvests.

ReTain by itself did not maintain firmness of Cortland in either year or with either harvest (Figure 2). SmartFresh maintained firmness above 12 lbs. in both harvests and both storage durations. When used with ReTain, SmartFresh maintained firmness by an additional 1.0 lb., but this was significant only in 2003 after 200 days of storage. The effects of ReTain and SmartFresh on firmness of Cortland was not as great in 2004, and this result may be attributable to the lack of internal ethylene differences at harvest.

Superficial scald of McIntosh occurred after 200 days of storage, but fewer than 20% of the untreated fruit and none of the fruit treated with SmartFresh were affected.

Cortland developed scald by 120 days (Figure 3). The later harvest reduced its occurrence to less than 1% in 2003, but only after the shorter storage duration. There was little difference in scald occurrence between the two harvests in 2004. Harvest date had no

affected by harvest date in our study.

SmartFresh was effective in preventing scald of Cortland after 120 days storage in 2003 and reducing it to less than 5% in 2004. By 200 days, severe scald occurred, and this was reduced by SmartFresh, but not as effectively as after 120 days.

Results of this study were based on SmartFresh application within one day of harvest. However, a delay in application can reduce efficacy, particularly in mature fruit.

ReTain reduced ethylene levels at harvest and improved the efficacy of SmartFresh on McIntosh fruit. Although they were larger in size and not as firm at harvest, fruit from the second harvest treated with both SmartFresh and ReTain remained as firm as fruit from the first harvest treated with only SmartFresh. However, CA storage duration of late-harvested fruit may be limited to 4 months, since ReTain and SmartFresh were not as effective in maintaining firmness of McIntosh after 7 months when internal ethylene at harvest was very high.

