

FINAL REPORT
WTFRC Project #PH-02-245

Project title: Bioregulators to enhance apple fruit quality and maintain condition

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Original objectives of the project:

1. Evaluate effects of aminoethoxyvinylglycine (AVG, ReTain[®], Valent BioSciences, Walnut Creek CA), ethephon (ETH, Ethrel[®], Bayer CropScience, Montvale, NJ), a sprayable formulation of 1-MCP (sMCP, AgroFresh, Inc., Spring House, PA), and SmartFresh[®] (MCP PH, AgroFresh, Inc., Spring House, PA) on maturation and harvest quality of apples.
2. Examine the effect of preharvest spray timings and concentrations of sMCP on control of fruit ripening and maintenance of post-storage fruit quality after short- and long-term cold storage.
3. Determine whether AVG and ETH can be used together to advance fruit maturity for earlier harvest of Pink Lady[®] apples while producing acceptable fruit quality for commercial purposes.

Significant findings:

- Applying sMCP 4 weeks before first (commercial) harvest (WBFH) to ‘Gale Gala’ produced very little in the way of measurable benefits in terms of post-storage fruit quality at harvest. AVG applied 4 WBFH reduced starch hydrolysis, reduced total soluble solids (TSS), reduced C₂H₄ in the fruit, and resulted in greener fruit on both harvest dates. sMCP had little effect on starch, C₂H₄, or fruit color. ETH showed little effect at harvest.
- After 60 days of RA storage, AVG-treated ‘Gale Gala’ fruit were firmer for both harvest dates; sMCP fruit were even firmer for the second harvest date. After 7 days ripening, firmness was low for all treatments, below 11 lbs. AVG reduced C₂H₄ production while sMCP did not. ETH had little effect, either alone or when applied after either AVG or sMCP.
- After 120 or 180 days of CA storage, there were few effects from any of the bioregulators on ‘Gale Gala’ fruit. sMCP-treated fruit were not materially different than any other treatments, including the control, in important properties such as firmness, TSS, TA or C₂H₄ production. Disorders were minor in incidence. No effects were observed on cracking on any evaluation date since incidence was very low.
- At harvest, AVG, sMCP applied at 2 or 1 WBFH, and MCP PH all reduced C₂H₄ production of ‘Scarletspur Delicious’ fruit but had little other discernible effect on fruit harvested at normal commercial maturity or 2 weeks later.

- After 60 days of RA storage, all sMCP and MCP PH treatments on ‘Scarletspur Delicious’ showed lower C₂H₄ immediately out of storage; sMCP fruit treated 2 or 1 WBFH were up to 2 lb. firmer. After 7 days of room-temperature ripening, sMCP at 1 WBFH and MCP PH showed 4-5 lb. firmer fruit for fruit harvested at commercial maturity. Second harvest-date fruit receiving the MCP PH treatment were 4-5 lb. firmer after 7 days ripening, while sMCP 1 WBFH fruit maintained about 1 lb. more firmness. sMCP applied earlier than 1 WBFH had little or no effect.
- After 120 days of CA storage, ‘Scarletspur Delicious’ fruit receiving any treatment were firmer than controls when taken out of storage, regardless of harvest date. MCP PH held firmness over 7 ripening days better than AVG; sMCP 1 WBFH was as effective as AVG and nearly as good as MCP PH.
- After 220 days of CA storage, harvest date had a large effect on the fruit quality results with ‘Scarletspur Delicious’. Fruit harvested at commercial maturity and treated with sMCP 1 WBFH or MCP PH had the greatest preservation of fruit firmness (+ 3 lbs.), with AVG fruit at +2 lbs. over controls immediately after storage. Fruit harvested 2 weeks later and treated with either sMCP 1 WBFH or MCP PH were as much as 5 lbs. firmer than controls. Both MCP treatments and AVG maintained control over C₂H₄ formation by the fruit after storage. Disorders at all evaluation dates were minor and basically unaffected by treatment. sMCP 1 WBFH and MCP PH reduced the appearance of scald after extended CA storage and 7 days ripening.
- After 220 days of CA storage and 7 days of room-temperature exposure, ‘Scarletspur Delicious’ fruit treated with either sMCP 1 WBFH or MCP PH lost almost no firmness. Fruit treated with AVG lost about 1 lb. Fruit treated with sMCP on earlier dates showed progressively less effect on fruit quality. Control fruit were at approximately 12 lbs. for harvest 1 and less than 11 lbs. for harvest 2.
- When Pink Lady[®] apples were harvested 2 weeks before normal harvest, fruit showed almost no differences due to preharvest applications of either AVG and/or ETH other than greater starch hydrolysis, higher C₂H₄ production and much redder fruit color due to ETH. ETH-treated fruit harvested at the normal time were less firm than AVG-treated fruit, showed greater starch hydrolysis, C₂H₄ evolution and redder fruit color.
- After 80 days of RA storage, Pink Lady[®] fruit harvested 2 weeks early and treated with AVG and ETH showed low C₂H₄ production but firmness, TSS, TA and sugar/acid ratios equivalent to untreated fruit harvested 2 weeks later. After ripening for 7 days, the AVG and ETH fruit were similar in fruit quality parameters to untreated fruit harvested 2 weeks later and held at room temperature for 7 days, while sMCP 1 WBFH fruit maintained about 1 lb. more firmness. sMCP applied earlier than 1 WBFH had no effect.
- After 130 days of CA storage, the same results were observed for Pink Lady[®] fruit treated with AVG and ETH compared to untreated fruit. Disorders were minor and not affected by treatments.

Methods:

Over the one-year period of this project, trials were established in three apple orchards to determine effects of various bioregulator products on fruit quality and storage response. All trials employed single- or double-tree plots in randomized complete-block designs.

Results and discussion:

During the course of this project, progress was made on all objectives.

A. 'Gale Gala'

1. The ethylene biosynthesis inhibitor AVG is normally applied 4 weeks before the first apple harvest. In this, our first experience with sMCP, we decided to apply at the same time in anticipation of the possible need to shut off active C₂H₄ receptor sites well before any C₂H₄ production could begin and initiate ripening. In this trial AVG inhibited C₂H₄ biosynthesis effectively, regardless of whether fruit were post-treated with ETH, but applying sMCP this early in the fruit development cycle appeared to be an incorrect strategy. Applying sMCP 4 WBFH, either alone or followed by ETH, did not have very strong effects on postharvest behavior of 'Gale Gala' apples.

B. 'Scarletspur Delicious'

1. Sprayable MCP was compared to AVG and MCP PH in this study. sMCP was applied at 125 or 250 ppm either 3, 2 or 1 WBFH. In general, applying MCP 1 WBFH was almost as effective as applying MCP after harvest in terms of its beneficial effects on post-storage fruit quality.
2. Applying sMCP progressively earlier than first harvest proportionally reduced its effectiveness in controlling ripening, C₂H₄ production by the fruit and loss of firmness and fruit quality after storage. Evidently, either C₂H₄ action inhibitor sites develop only in the last few days or weeks before fruit maturity or those sites cannot be irreversibly inhibited by preharvest MCP until shortly before harvest.
3. Despite the fact that MCP PH cannot be applied until the fruit are harvested, and thus is applied at whatever stage the fruit have reached by that harvest date, MCP PH is still very effective at inhibiting negative changes in fruit flesh firmness and other quality parameters after storage. Among the preharvest MCP treatments, the applications 1 WBFH were the best for reducing fruit quality deterioration overall.
4. Over very long-term CA storage (230 days), AVG, MCP PH and sMCP 1 WBFH were fairly comparable for inhibiting C₂H₄ production and the associated negative changes in fruit quality associated with the production of C₂H₄. Sprayable MCP appears to have significant potential as an alternative approach for employing MCP for apple fruit quality management.

C. Pink Lady[®]

1. AVG and/or ETH were applied to Pink Lady[®] apple trees based on a first harvest 2 weeks earlier than normal. ETH applied 2 WBFH (4 weeks before normal harvest) had a small effect on fruit firmness at first harvest but altered TSS, TA, S/A ratio and starch level so that these values resembled those from untreated apples harvested 2 weeks later, at the normal time. AVG inhibited fruit color development, fruit softening and accumulation of soluble solids.
2. Application of ETH stimulated C₂H₄ production from treated fruit. Applying ETH after AVG did not result in increased C₂H₄ production even though other changes in fruit quality parameters were observed. Fruit treated with AVG and ETH and harvested 2 weeks early were comparable to untreated fruit harvested 2 weeks later in quality and storability.
3. Using ETH to temporarily stimulate beneficial fruit quality changes while employing AVG to inhibit the uncontrolled initiation of ripening appears to make it possible to harvest Pink Lady[®] apples earlier than normal while retaining acceptable fruit quality. This strategy needs further testing but may be beneficial if producers have concerns about possible losses due to preharvest freezing events.

Summary:

Sprayable MCP appears to have real potential as a fruit quality control agent when used prior to harvest. The advantage of such a product would include giving the grower flexibility in reducing preharvest fruit quality losses in blocks that might have to be harvested later than at commercial maturity. Although little evidence of beneficial effects is apparent at harvest, after storage the amount of quality deterioration is reduced. Especially after long-term storage and 7 days of ripening, the sMCP showed its ability to retard quality loss, nearly equivalent to MCP PH in some cases. Using the properties of AVG and ETH in combination to advance the harvest date of a very late cultivar such as Pink Lady[®] while being able to produce a better quality fruit may increase the opportunity for growers to better cope with the risks of preharvest cold damage in such late-harvested cultivars. Concentrations and timing of applications for sprayable MCP still need further research.

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Summary of total project costs:

Project duration:	One year
Total project costs:	\$5,000