Canadian Agri-Science Cluster for Horticulture 3

Update to Industry

Final Report – 2018 - 2023

Activity title: Optimizing Storage and Postharvest Practices to Reduce Apple Loss and Improve Quality

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Activity Objectives *(as per approved workplan):*

1) Optimize postharvest practices and storage regimes for rising cultivars (i.e. Honeycrisp, Ambrosia, and Gala strains)
2) Evaluate new low oxygen storage and dynamic regimes to reduce apple loss
3) Investigate new technology for harvest management and fruit maturity

Research Progress & Results *(use plain language, not to exceed 1,000 words)*:

Final year results –

Objective 1. Optimize postharvest practices and storage regimes for rising cultivars

1.1. 'Honeycrisp' – postharvest treatments

Temperature conditioning for 1 week at 10°C after harvest (then 3°C) and delaying controlled atmosphere (CA, 3% O_2 + 1.5% CO_2) storage for 1 month, in combination with or without postharvest 1-methylcyclopropene (1-MCP, SmartFresh™ (AgroFresh, Inc.)) were evaluated in 'Honeycrisp' apples for a second season. 1-MCP significantly reduced greasiness and ethylene production, slowed ground color change from green to yellow, and improved acidity retention. 1-MCP also reduced internal browning, but increased the incidence of peel blotch, ultimately having no overall effect on total disorders.

1.2. 'Gala' – CO_2 concentration

Two 'Gala' apple orchards were sprayed with 1/4 and 1/3 label rates of ReTain (AVG), 4 and 2 weeks prior to harvest, respectively. Harvista™ (1-MCP) was then sprayed 8 days prior to harvest, at a rate of 60 g/ acre. All sprays are known to increase CO_2 injury during storage. Apples from each orchard were treated with postharvest 1-MCP (SmartFresh™) at harvest time or after storage, or not treated as controls. CA storage with 1.6% O_2 + 1.5, 1 or 0.5% CO_2 at 0.5°C was established 2 days after harvest, and O_2 concentration for all apples was reduced to 0.6% after 11 days. Apples were evaluated for quality after 8 months of storage, plus 1, 7 and 14 days at room temperature. 'Gala' held in 1.5% CO_2 had significantly more stem-end and internal browning,

compared to those held in lower CO_2 regimes (45 vs 30-31%, respectively). There were no significant differences in disorders between apples stored in 1 or 0.5% CO_2. 1-MCP had no significant effect on stem-end and internal browning. There was a large difference between orchards however, with 50 vs 19% incidence of disorders.

1.3. 'Gala' – Pre and postharvest 1-MCP

'Gala' from the same orchards and sprayed the same as above but with and without preharvest 1-MCP (Harvista) were treated with postharvest 1-MCP (SmartFresh™) at harvest time or after storage, or not treated as controls. CA storage with 1.5% O_2 + 1.5% CO_2 at 0.5°C was established 3 days after harvest. Apples were evaluated for quality after 6 and 8 months of storage, plus 1, 7 and 14 days at room temperature. 'Gala' that were sprayed preharvest with 1-MCP had significantly less stem-end and internal browning, compared to those not sprayed (48 vs 82%, respectively). Postharvest treatment with 1-MCP had no significant effect on stem-end and internal browning, regardless of treatment timing. As expected, 1-MCP significantly improved fruit firmness retention and this effect was found for both preharvest spray and postharvest treatment. There was also an additive effect, as 'Gala' treated with both pre- and postharvest 1-MCP were significantly firmer than apples from all other treatment combinations (+2 lb).

Similar 'Gala' apples were also harvested 2 weeks later, treated with and without postharvest 1-MCP at harvest time, held in ambient air storage at 0.5°C for 4 months. 'Gala' that were sprayed preharvest with 1-MCP had significantly less stem-end and internal browning, compared to those not sprayed (20 vs 34%, respectively). In contrast, postharvest treatment with 1-MCP resulted in higher incidence of browning disorders compared to no postharvest treatment (46 vs 8%, respectively). There was a significant interaction of pre- and postharvest 1-MCP, with the highest incidence (71%) of stem-end and internal browning in apples not sprayed preharvest with 1-MCP but treated postharvest with 1-MCP, and the lowest incidence (10%) in those that did not receive any 1-MCP treatment. As expected, 1-MCP significantly improved fruit firmness retention and this effect was found for both preharvest spray and postharvest treatment. There was also an additive effect, as 'Gala' treated with both pre- and postharvest 1-MCP were significantly firmer than apples from all other treatment combinations (+2.5 lb).

1.4. 'Ambrosia' – Maturity and storage

'Ambrosia' apples from two orchards were harvested twice, 6 days apart. All apples were cooled overnight to 0.5°C and treated with (1-MCP, SmartFresh™) the following day. CA storage was established 4 days after harvest, as 1.7% O_2 + 1.2% CO_2 at 0.5°C. Apples were evaluated for quality after 8 months of storage, plus 1, 7 and 14 days at room temperature. 'Ambrosia' from the first harvest had significantly less stem-end and internal browning, compared to those from the later harvest (31 vs 63%, respectively). This is very important to note, as harvesting only 6 days later resulted in over double the amount of browning. There was also a large difference between orchards, with 58 vs 37% incidence of browning. As expected, apples from the first harvest were firmer than those from the later harvest (+ ~2 lb).

Similar 'Ambrosia' apples were also stored in ambient air storage at 0.5°C for 4 months. 'Ambrosia' from the first harvest had significantly less stem-end and internal browning, compared to those from the later harvest (8 vs 37%, respectively). The was also a large difference between orchards, with 28 vs 15% incidence of browning. As expected, apples from the first harvest were firmer than those from the later harvest (+ ~1 lb).

Objective 2. Evaluate new low oxygen storage and dynamic regimes to reduce apple loss

2.1. 'Honeycrisp' – SafePod™ technology, ~1% O_2

'Honeycrisp' apples from Québec were transported to the *Apple Storage Research Facility* in Simcoe, ON within 4 days of harvest, during which time the temperature was ~3°C. All apples were then held at 10°C for 1 week and subsequent air storage at 3°C for ~3 weeks. One month after harvest, apples were transferred to

CA storage at 3°C and 0.5°C. Low oxygen at 0.8% (with <1% CO_2) was established slowly over several months after initial rapid oxygen reduction to 3%, based on fruit respiration measurements using dynamic SafePod™ technology (Storage Control Systems, Inc.). After 8 months, apples were removed from storage and treated with or without 1-MCP (SmartFresh™), and evaluated for quality after 1, 7 and 14 days at room temperature. 'Honeycrisp' developed more soft scald at 0.5°C than 3°C (8 vs 1%, respectively), and there was no significant effect of 1-MCP on its incidence. Apples exhibited lower respiration rates during storage 0.5°C, compared to 3°C. 1-MCP reduced greasiness incidence and severity during 14 days at room temperature. There were no significant differences in other quality attributes.

2.2. 'Cortland' – Low oxygen

'Cortland' apples from Québec were transported to the *Apple Storage Research Facility* in Simcoe, ON within 3 days of harvest, during which time the temperature was ~3°C. Apples were then stored at 0.5°C and CA established as 2.5% O_2 + 2% CO_2 or 1.5% O_2 + 1% CO_2. Apples were treated with postharvest 1-MCP (SmartFresh™) upon arrival at the lab or after 8½ months of storage, or not treated as controls. Fruit quality evaluations were made after additional 1 and 8 days at room temperature. 'Cortland' from the lower oxygen regime with 1.5% O_2 developed significantly less superficial scald compared to apples stored in 2.5% O_2 (51 vs 70%). 1-MCP treatment upon arrival at the lab (4 days from harvest) also reduced superficial scald development, compared to those not treated or with 1-MCP after storage (36 vs 71 and 76%, respectively). The earlier 1-MCP treatment also reduced ethylene production and improved firmness and acidity retention during storage.

Objective 3. Investigate new technology for harvest management and fruit maturity

3.1. I_{AD} readings from DA meter

Index of Absorbance Difference (I_{AD}) data were analyzed for four major apple cultivars ('Honeycrisp', 'Ambrosia', 'Gala' and 'McIntosh') from 4 or more years during harvest time, as well as I_{AD} relationships with fruit firmness, internal ethylene concentration, and starch index values. I_{AD} values differed among the four cultivars, with 'McIntosh' showing the highest I_{AD} overall and 'Gala' having the lowest (1.17 and 0.33, respectively). Principal component analysis showed that the cultivars were separated into distinct groups. 'Honeycrisp' was clustered with starch and ethylene, while 'Gala' and 'McIntosh' were mainly clustered with firmness and I_{AD}, respectively. Correlations between I_{AD} and other maturity indices were very variable over the years. In conclusion, I_{AD} may relate to harvest maturity, but it did not correlate closely or consistently with other maturity indices, varied greatly year-to-year, and was cultivar dependent. A scientific paper from this work is pending publication.

Project Conclusions –

- Specific postharvest treatments can have both positive and negative effects on disorders, and therefore a compromised approach to storage is needed
- Orchard block is a strong factor in the development of postharvest storage disorders
- Harvesting only 6 days later than optimum can over double the amount of internal browning
- Ultra-low O_2 (<1%) storage is very effective at reducing internal browning, but minimum safe gas levels vary with cultivar and growing season
- Pre-harvest 1-MCP orchard spray reduces internal browning and improves quality retention, but efficacy its very dependent on rate and application timing
- DA meter (I_{AD} measurements) should not be used alone to judge apple maturity and I_{AD} standards are not consistent year-to-year or among regions, orchards, and harvest times

Key Message(s):
The key statement(s) from the project highlighting the benefit to industry.

This project has led to improved quality retention in apples during storage, thereby extending the availability of Canadian/ local apples and increasing marketing opportunities.

Overall benefit to industry:
Expand the key message(s) and provide all grower-relevant details in a form easy to assimilate and compare.

Using lower oxygen (<1.5%) concentrations for storage of 'Ambrosia' and 'Gala' apples will help the Canadian apple industry extend storage life and reduce fruit loss.

'Honeycrisp' apples respond well to holding 1 week at 10°C after harvest and then storage at 3°C, treatment with postharvest 1-MCP, and delaying controlled atmosphere (CA, 3% O_2 + 1.5% CO_2) for 1 month – good fruit quality has been found after 6-8 months of storage.

Using more than one application of postharvest 1-MCP during the storage season will further delay fruit ripening and extend storability, thereby extending the availability of Canadian apples.

Pre-harvest 1-MCP orchard spray will improve fruit quality retention and reduce internal browning during storage.

Canadian apple industry now has a better understanding of the shortcomings in using a DA meter to judge fruit maturity, as I_{AD} standards are not consistent year-to-year or among regions, orchards, and harvest times.

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