Canadian Agri-Science Cluster for Horticulture 2

Progress Report April 2016

Activity 2, Apple 1

Utilizing Multiple Storage Technologies to Improve Efficiency, Reduce Energy Consumption, and Extend the Availability of Canadian Apples for Domestic and Export Markets

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Activity Objectives

1) Methods to control CO_2 injury without using diphenylamine (DPA)
2) Evaluations of DPA residues on fruit and within storage facilities
3) Optimizing storage regimes for 'Honeycrisp' and 'Gala'
4) Effects of cooling rate on apple quality after storage

Research Progress to Date

Objective 1: Methods to control CO_2 injury without using diphenylamine (DPA)

1.1 - Assessment of external CO_2 injury development in 'McIntosh' and 'Empire' apples during storage room loading

Pioneer and Summerland 'McIntosh' were treated with SmartFresh (1 ppm, 1-MCP) overnight, while half of the 'Empire' apples were treated. SmartFresh treatment was either at 3°C with rapid cooling or during slow cooling from 22°C down to 14°C. After 24 hours, all apples were held in ~ 17% O_2 + 4% CO_2 at 3°C for up to 6 weeks. This scenario was intended to mimic the build-up CO_2 during commercial room loading before the establishment of controlled atmosphere. Summerland was more susceptible to external CO_2 injury than Pioneer 'McIntosh', developing notable symptoms after 4 weeks of storage. SmartFresh treatment increased the incidence of external CO_2 injury in 'Empire', with up to 31% incidence after only 2 weeks. SmartFresh-treated 'Empire' cooled rapidly developed less external CO_2 injury than those cooled slowly.

1.2 - Effect of delayed CA on external CO_2 injury development in 'Empire' apples

'Empire' apples were treated with or without SmartFresh overnight at 3°C. Fruit treated with SmartFresh were held in air storage at 3°C for 0 or 4 weeks, while non-treated fruit were held in air at 3°C for 0 or 2 weeks. Apples were then transferred to CA (2.5% O_2 + 2% CO_2) at 3°C for a total of 8 months storage time.

Delaying CA establishment for 4 weeks eliminated external CO_2 injury in SmartFresh-treated 'Empire'. Delaying CA also increased the incidence of core browning and stem-end browning in these fruit, as well as reduced fruit firmness after 7 days at RT. Similarly, delaying CA establishment for 2 weeks eliminated external CO_2 injury in 'Empire' not treated with SmartFresh. Delaying CA also increased the incidence of flesh browning in these fruit, as well as substantially reduced fruit firmness.

Objective 2: Evaluations of DPA residues on fruit and within storage facilities

2.1 - Full vs. half rate DPA aerosol on 'Empire' and 'Ambrosia' apples

'Empire' and 'Ambrosia' apples were treated with either half rate (3.5 g a.i.) or full rate (7 g a.i.) of Decco DPA aerosol in a commercial storage room. Apples were then held in air storage at 0-1^{o}C and removed periodically to test for DPA residues. As expected, residues were less using half rate than the full rate, and all decreased with storage time. However, SmartFresh did not seem to influence the rate of residue decrease over time.

2.2 - DPA drench concentrations for 'Ambrosia'

'Ambrosia' apples were drenched with DPA for 2 minute dips at concentrations of 8000, 4000, 2000, 1000, 500 or 0 ppm. Apples were then held in air storage at 0-1^{o}C and removed periodically to test for DPA residues. DPA concentrations of 8000 or 4000 ppm resulted in severe DPA injury, whereas 2000 ppm resulted in slight injury.

Objective 3: Optimizing storage regimes for 'Honeycrisp' and 'Gala'

3.1 - Effect of orchard block on disorder development in 'Honeycrisp' during storage

This trial was a repeat of the previous year, but without the component of storage air flow. 'Honeycrisp' apples from four orchard blocks were harvested and cooled overnight to 3^{o}C, with no prior conditioning (i.e. 7 days at 10^{o}C) to allow the development of storage disorders. After 6 months in air storage, Orchard 3 exhibited high incidence of soft scald, in contrast to last year when Orchards 1 and 2 exhibited high incidence of soft scald. Orchard 4 exhibited high incidence of bitter pit, which was similar to last year. Orchard 2 tended to have fruit with significantly more greasiness in both years. There tends to be block variation as well as seasonal variation in disorders of 'Honeycrisp'.

3.2 - Effects of tree and fruit location on disorder development in 'Honeycrisp' during storage

'Honeycrisp' from three similar uniform trees in each of three different locations (north bottom of hill, central top of hill, and south bottom of hill) within the same orchard block were harvested from the east and west sides of the trees and fruit kept separate for analyses. Apples were cooled overnight to 3^{o}C, with no prior conditioning (i.e. 7 days at 10^{o}C) to allow the development of storage disorders. After 6 months in air storage, fruit from the south bottom of the hill had significantly lower internal ethylene concentration, as well as higher firmness, soluble solids, and malic acid content. Fruit from the south bottom of the hill also had significantly higher incidence of soft scald, with those from Tree 3 exhibiting substantially higher incidence. Fruit from the north bottom of the hill had significantly more greasiness. Fruit from the west side of the trees had significantly higher internal ethylene concentration, as well as more greasiness than those from the east side.

3.3 - Evaluation of delayed controlled atmosphere storage for 'Honeycrisp'

For the third consecutive year, 'Honeycrisp' apples were harvested from the same orchard block. Fruit were conditioned for 4 days at 13-19^{o}C and then held in air storage at 3^{o}C for 0, 2, 4 or 8 weeks before being stored in CA (3% O_2 + 1.5% CO_2) at 3^{o}C for a total of 8 months storage time. No major storage disorders were found during this season. However, there was a trend of increased greasiness with longer delay in CA storage.

3.4 - Effects of low O_2 storage and SmartFresh on 'Gala' strains

Four strains of 'Gala' apples were cooled overnight to 3^{o}C and then half of the fruit were treated with SmartFresh for 24 hours. Apples were then stored in CA at 1^{o}C, in either 2.5% O_2 + 2% CO_2 (SCA) or 1.5% O_2 + 1-1.5% CO_2 (LO) for 8 months. 'Gala' held in LO had less internal browning, stem-end browning, and core browning, and slightly more malic acid than fruit held in SCA. There was up to 10% incidence of storage rots, with slightly more in SCA than LO. SmartFresh-treated 'Gala' had slightly lower internal ethylene, higher firmness, and more malic acid than

those not treated. Twin Bee had higher incidence of internal browning than the other strains, while Royal 'Gala' had less internal and stem-end browning. Pacific 'Gala' had higher incidence of lenticel damage and Imperial 'Gala' was firmer than the other strains.

Objective 4: Effects of cooling rate on apple quality after storage

4.1 – Effects of cooling rate and SmartFresh on 'McIntosh' quality

'McIntosh' apples were cooled overnight from 22 to 14°C, while SmartFresh was applied to half of the samples. Half of the apples with or without SmartFresh were then cooled slowly by holding at 9-15°C for 4 days, followed by 1 week at 9°C, 1 week at 5°C, and then final cooling to 3°C. The remaining apples were cooled rapidly to 3°C, immediately after SmartFresh treatment. Standard CA was established 6 days after harvest, within the temperature regimes noted. Fruit cooled slowly had higher weight loss during 4 months of storage, but this effect was lost after 8 months. When cooled slowly, 'McIntosh' treated with SmartFresh had more external CO_2 injury, compared to those not treated. Slow cooling resulted in less firmness, compared to rapid cooling. SmartFresh resulted in greater firmness and acidity retention, as well as higher incidence of external CO_2 injury and lower incidence of senescent breakdown after 8 months.

4.2 – Effects of cooling rate and SmartFresh on 'Gala' quality

'Gala' fruit were either cooled rapidly to 3°C or slowly from 20 to 10°C overnight, while SmartFresh was applied to half of the fruit within each cooling regime. Apples cooled rapidly with and without SmartFresh were then transferred to 0-1°C, while fruit cooled slowly remained at 10°C for 5-6 days, then at 4-5°C for 6-7 days, 3°C for 16-17 days, and finally at 0-1°C. CA (2.5% O_2 + 2% CO_2) was established 5-6 days after harvest, within the temperature regimes noted. After 4 months of storage plus 1 day at room temperature, Royal 'Gala' cooled slowly were firmer with SmartFresh than without. After 4 months plus 7 days at room temperature, those treated with SmartFresh were firmer with rapid cooling than with slow. After 8 months of storage, rapid cooling resulted in higher incidence of internal browning, stem-end browning, and lenticel rots in Pacific 'Gala'. SmartFresh also increased lenticel damage in these fruit, especially when cooled rapidly.

Extension Activities

Peer reviewed publication

DeEll, J.R., G.B. Lum, and B. Ehsani-Moghaddam. 2016. Elevated carbon dioxide in storage rooms prior to establishment of controlled atmosphere affects apple fruit quality. Postharvest Biol. Technol. 118:11-16.

Information items

DeEll, J. 2015. Beware of CO2 accumulation in 'Empire' apple storage rooms during loading. The Grower 65(8):12.
DeEll, J. 2015. Development of external CO2 injury in 'Empire' apples during storage room loading. Hort Shorts – CHC, November 2015, p. 5 (plus link).
DeEll, J. 2015. CO2 accumulation in apple storage rooms during loading. Proc. of the Great Lakes Fruit Workers' Meeting, p. 53-54. Geneva, New York.
DeEll, J. 2015. Risk of chilling disorders in apples for 2015-16 storage season. Orchard Network 19(4):12.
DeEll, J. 2016. Delayed controlled atmosphere storage for 'Honeycrisp' apples. Orchard Network 20(1):13.

Information events

CO2 accumulation in apple storage rooms during loading. 2015. Presentation at the Great Lakes Fruit Workers' Meeting, Geneva, New York.
Techniques to improve apple quality during storage. 2016. Presentation at the Ontario Fruit and vegetable Convention, Niagara Falls, New York.

Early Outcomes (if any) or Challenges

Results noted above.

Key Message(s)

- Slow cooling increases CO_2 injury in 'McIntosh' and 'Empire', especially when treated with SmartFresh.
- Orchard block tends to have an overwhelming effect on disorder incidence in 'Honeycrisp'.
- 'Gala' strains vary in susceptibility to storage disorders.
- There is potential for using lower O_2 concentrations to improve apple quality after long-term storage.

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