

Ministry of Agriculture, Food and Agribusiness

# Optimizing Storage for Honeycrisp, Gala, and Ambrosia Apples

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## **This presentation...**

### **Honeycrisp, Gala, and Ambrosia**

#### **Optimum maturity for long-term storage**

- Critical for successful storage!
- Cannot improve apple quality in storage

#### **Common disorders and how to control**

- Often reduce certain disorders  
while aggravating others

#### **Storage guidelines**

- CA regimes, temperatures, etc.

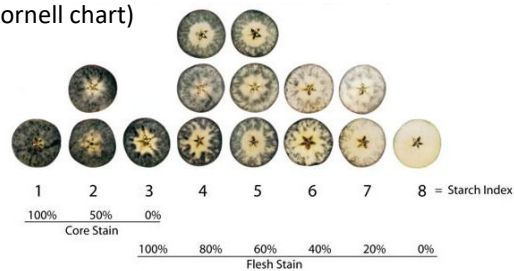
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## Harvest maturity for Honeycrisp storage

- Background color starting to change from green to yellow
- Internal ethylene present
- Starch values near 5 (Cornell chart)

**No core stain +  
~50% flesh stain**



- $I_{AD}$  (DA meter) not consistent

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## Harvest maturity continued...

- Desired maturity will depend on use/ market
- Differences in maturity do not always exist among apples with varying levels of red color
- Honeycrisp harvested too early do not develop varietal flavor
- Undesirable flavors will develop if harvested too late, plus become more prone to storage disorders
- **Substantial variation** among orchards and trees  
... often becomes strongest factor in experiments

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## Honeycrisp

... is very chilling sensitive

**Conditioning** at 10°C for ~1 week prior to cold storage at 3°C reduces soft scald, soggy breakdown, chilling-related disorders



These can be found pre-harvest!

- watch orchard temperatures

**Conditioning** promotes bitter pit, lenticel breakdown, peel blotch



and reduces acidity  
(physical & sensory,  
especially >10°C)

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## Honeycrisp

...is very sensitive to CO<sub>2</sub>

- CO<sub>2</sub> sensitivity increases with lower O<sub>2</sub>
- Postharvest 1-MCP increases CO<sub>2</sub> sensitivity and injury
- DPA controls CO<sub>2</sub> injury
- Delayed CA reduces CO<sub>2</sub> injury
- 3% O<sub>2</sub> + 1.5% CO<sub>2</sub> at 3°C

*DeEll et al. 2016 Can. J. Plant Sci.*



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## Lower oxygen <3%, DCA ???

- Can result in more marketable apples (free of disorders)
- Does not reduce all disorders, can increase CA-related disorders
- Interactions with 1-MCP



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## Honeycrisp confusion



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## Honeycrisp



### What we know...

- Harvest maturity important for storage
- Prone to bitter pit, lenticel breakdown, peel/ leather blotch
- Chilling sensitive - soft scald, soggy breakdown
- CO<sub>2</sub> sensitive - internal with cavities
- Low O<sub>2</sub> sensitive\*
- Initial temperature conditioning reduces chilling disorders
- Higher storage temperature reduces chilling disorders, but can increase bitter pit, lenticel breakdown
- Postharvest 1-MCP worsens peel/ leather blotch, increases CO<sub>2</sub> sensitivity/ injury
- Preharvest 1-MCP (Harvista) reduces soft scald
- DPA or delayed CA reduces CO<sub>2</sub> injury

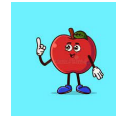
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## Honeycrisp guidelines

### ...a compromise

know your orchards and marketing plans



- Harvest as ground color starts turning, follow starch
- Pre- and/or postharvest 1-MCP treatment
- Conditioning for 5-7 days at 10°C
- DPA or delay CA (Ambient air for 1-2 months, 3°C)
- CA at 3°C, 2-3% O<sub>2</sub> + 1-3% CO<sub>2</sub> dependent
  - Research needed on <3% O<sub>2</sub> with various conditions
  - High bitter pit risk, initial CA for 1-2 weeks (WA)
  - Initial 0.5°C for 4 weeks (NY)

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## Harvest maturity for Gala storage

- Internal ethylene present (<1 ppm)
- Starch values of 2.5 to 3.0 (Cornell chart)  
...wide range, 2-7
- Firmness >18 lb
- Background color changing to yellow



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## Internal browning

Mid- long-term storage  
Starts at stem-end  
Leads to mealiness and splits  
Stem-end cracks assoc.



### Factors -

Maturity at harvest  
Storage temperature  
Oxygen levels  
1-MCP

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Internal browning

‘Gala’ after 8 mo CA storage at 0.5°C, plus 14 days at RT

	Browning (%)	
Increases with advanced maturity		
Increases with storage duration, and holding at RT	1.2% O <sub>2</sub>	
	3°C	42 <sup>A</sup>
	0.5°C	23 <sup>B</sup>
Increases* at 3°C vs 0.5°C	Slow 0.5°C	8 <sup>C</sup>
Decreases with low oxygen	0.6% O <sub>2</sub>	
Decreases with slow cooling to 0.5°C or initial week at 10°C	3°C	17 <sup>BC</sup>
	0.5°C	13 <sup>BC</sup>
	Slow 0.5°C	11 <sup>C</sup>

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‘Gala’ after 9 mo of CA storage at 1°C  
(4 strains)

	Stem-end/ internal browning (%)
No SmFr	
1.5% O <sub>2</sub>	27 <sup>b</sup>
2.5%	34 <sup>a</sup>
+ SmFr	
1.5% O <sub>2</sub>	26 <sup>b</sup>
2.5%	34 <sup>a</sup>

0.2 – 0.4% O<sub>2</sub> = Zero !!



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## Gala

### Preharvest 1-MCP (Harvista™)



- Less stem cavity cracking
- Less internal/ stem-end browning
- Slows starch degradation, narrower range
  - Reduces number of harvests
- Improves firmness retention after harvest and during storage
- Lower fruit respiration
- *Can delay red color development*  
*..Spray closer to harvest after color developed*

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## Gala

### What we know...



- Harvest maturity important for storage
  - Prone to stem-end cracking
  - Chilling sensitive - internal browning
  - Tolerant to low oxygen
- 
- Lower oxygen = less internal browning
  - Storage temperature affects internal browning
  - Postharvest 1-MCP (SmartFresh) inconsistent effect on internal browning
  - Preharvest 1-MCP (Harvista) reduces internal browning and stem-end cracking

*DeEll et al. 2022 Frontiers in Plant Sci.*

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## Gala guidelines



- Harvest when background changing to yellow, follow ethylene and starch
- Storage temperature 0.5-2°C, dependent
  - Slow cooling to 0.5°C (or 10°C for a week, 1-MCP)
- 1-1.2% O<sub>2</sub> + 1% CO<sub>2</sub> (0.5-1% O<sub>2</sub> (DCA) if monitoring fruit)
- DCA or low O<sub>2</sub> <1% × temperature (interaction), varies with region, PGRs

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## Harvest maturity for Ambrosia storage



BC Color Chart for Ambrosia

- Background color should show more green than yellow at harvest (#2)
- Internal ethylene is NOT a good maturity indicator (<1 ppm)
- Starch values of 2.5 to 4.0 (1-8 Cornell chart)
- I<sub>AD</sub> (DA meter) ~ 0.7 to 0.5 (measure on interface)

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## Susceptible to...

**Diseases** – plenty!

### Disorders

Lenticel breakdown

Internal browning  
(some core, vascular)

Senescent breakdown

Mealiness, splits

Soft scald      **Chilling sensitive**  
CO<sub>2</sub> injury    **CO<sub>2</sub> sensitive**  
Others?



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## Internal browning

Mid- long-term storage

Starts at stem-end

Leads to mealiness and splits



### Factors -

Maturity at harvest

Storage temperature

Oxygen levels

1-MCP

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**'Ambrosia'** after 8 mo of CA storage (1.2% O<sub>2</sub> + 1% CO<sub>2</sub>)  
at 0.5 or 3°C, plus 1 day at RT (~20°C) / SmFr at harvest

		Storage temp. (°C)	Internal browning (%)	Firmness (lb)
+ 5 d	H1	0.5	17	16.5
		3	0	14.9
	H2	0.5	53	16.7
		3	17	14.4

Results led to investigating delayed and stepwise cooling...

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**'Ambrosia'** after 8 mo of CA storage at 0.5°C

	Internal browning (%)
0.6% O <sub>2</sub> (LabPod)	<1 <sup>C</sup>
1.7% O <sub>2</sub>	8 <sup>B</sup>
2.5% O <sub>2</sub>	24 <sup>A</sup>



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## Ambrosia



### What we know...

- Harvest maturity extremely important for storage
- Chilling sensitive - internal browning, soft scald
- CO<sub>2</sub> sensitive - internal with cavities, external
- Lower oxygen = less internal browning
- Storage temperature affects internal browning
- Postharvest 1-MCP (SmartFresh)
  - inconsistent effect on internal browning
  - exacerbates CO<sub>2</sub> injury
- Preharvest 1-MCP (Harvista) reduces internal browning
- DPA controls CO<sub>2</sub> injury

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## Ambrosia guidelines



- Harvest before yellow background, follow I<sub>AD</sub> and starch
- Storage temperature 0.5-1°C, but with **slow cooling**
- 1.2% O<sub>2</sub> + 1% CO<sub>2</sub> (<1% O<sub>2</sub> (DCA) if monitoring fruit)

### Current research

- Slow and delayed cooling to 0.5°C
- Oxygen <1%, LOL variability

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## Thanks to...

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