

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

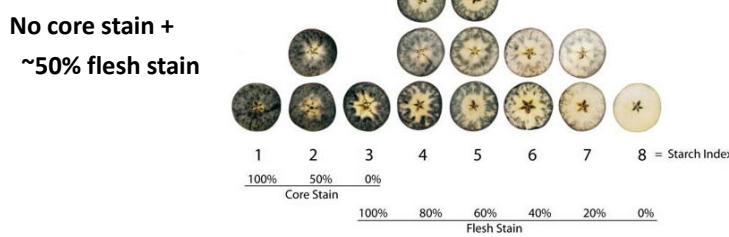
- CA regimes, temperatures, etc.

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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)



- 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

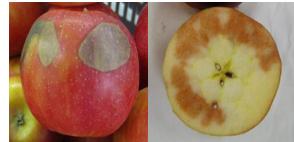
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Honeycrisp

... 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 CO₂

- CO₂ sensitivity increases with lower O₂
- Postharvest 1-MCP increases CO₂ sensitivity and injury
- DPA controls CO₂ injury
- Delayed CA reduces CO₂ injury
DeEll et al. 2016 Can. J. Plant Sci.
- 3% O₂ + 1.5% CO₂ at 3°C



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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
- CO₂ sensitive - internal with cavities
- Low O₂ 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 CO₂ sensitivity/ injury
- Preharvest 1-MCP (Harvista) reduces soft scald
- DPA or delayed CA reduces CO₂ 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% O₂ + 1-3% CO₂ dependent
 - Research needed on <3% O₂ 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% O₂	
	3°C	42 ^a	
	0.5°C	23 ^b	
	Slow 0.5°C	8 ^c	
Increases* at 3°C vs 0.5°C			
Decreases with low oxygen		0.6% O₂	
Decreases with slow cooling to 0.5°C or initial week at 10°C		3°C	17 ^{bc}
	0.5°C	13 ^{bc}	
	Slow 0.5°C	11 ^c	

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'Gala' after 9 mo of CA storage at 1°C (4 strains)		
	Stem-end/ internal browning (%)	0.2 – 0.4% O₂ = Zero !!
No SmFr		
1.5% O ₂	27 ^b	
2.5%	34 ^a	
+ SmFr		
1.5% O ₂	26 ^b	
2.5%	34 ^a	

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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% O₂ + 1% CO₂ (0.5-1% O₂ (DCA) if monitoring fruit)
- DCA or low O₂ < 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_{AD} (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**

CO₂ injury **CO₂ 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% O₂ + 1% CO₂)
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
		3	0
	H2	0.5	53
		3	17

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 ₂ (LabPod)	<1 ^c
1.7% O ₂	8 ^b
2.5% O ₂	24 ^a



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Ambrosia

What we know...



- Harvest maturity extremely important for storage
- Chilling sensitive - internal browning, soft scald
- CO_2 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_2 injury
- Preharvest 1-MCP (Harvista) reduces internal browning
- DPA controls CO_2 injury

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Ambrosia guidelines



- Harvest before yellow background, follow I_{AD} and starch
- Storage temperature 0.5-1°C, but with [slow cooling](#)
- 1.2% O_2 + 1% CO_2 (<1% O_2 (DCA) if monitoring fruit)

Current research

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

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