

Ministry of Agriculture, Food and Agribusiness

Risk of Internal Browning in Apples

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Internal browning
Flesh browning
Diffuse browning



Stem-end browning
Shoulder browning

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This presentation...

Factors affecting internal browning

Fruit maturity at harvest

Plant growth regulators (PGRs)

- Anti-ethylene – Harvista, ReTain

Storage conditions

- Low oxygen, CO₂, postharvest 1-MCP
- Storage temperature

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#1 = Maturity at harvest

Harvest at optimum fruit maturity for storage to reduce internal browning

- Ethylene production/ IEC
- Starch content (index)
- Firmness
- Soluble solids/ Brix
- Titratable acidity/ Malic acid
- Delta absorbance (DA meter)
- Color (ground, blush)



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Best to use multiple indices
Cultivars mature differently, so no single recipe
DAFB to start

- Empire, McIntosh, Cortland – internal ethylene
- Gala, Honeycrisp – starch, background color
- Ambrosia – background color, DA meter

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Ambrosia

4 months Air storage at 0.5°C

7 days at RT

*clean on Day 1

	Internal Browning (%)
Orch 1 H1 (Opt)	0 ^C
H2 (+ 6d)	50 ^A
Orch 2 H1	0 ^C
H2	23 ^B

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Empire

7 months CA storage at ~2.5°C

		Internal Browning (%)	
0	2.4	H1 (Early)	0 ^B
0	2.3	H2 (+ 5d)	5 ^B
0	2.7	H3 (+ 5d, Opt)	2 ^B
0	3.7	H4 (+ 5d)	6 ^B
0.1	4.6	H5 (+ 5d, Late)	32 ^A

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#2 = Plant growth regulators

Anti-ethylene, delay ripening

i.e. Harvista (1-MCP)

ReTain (AVG)



Keeping fruit at an earlier maturity,
narrowing range of maturity

Remember...

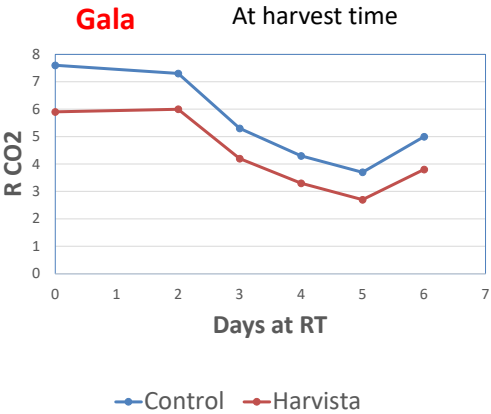
advanced maturity = more internal browning

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Preharvest 1-MCP

- Lower fruit respiration



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Gala

- Slows starch degradation, narrower range



	Average	Min	Max
Control			
1	2.3	1	5
2	2	1	4
3	2.2	1	4
60 g/ ac			
1	1.6	1	3
2	1.1	1	2
3	1.3	1	2
120 g/ac			
1	1.4	1	2
2	1.4	1	2
3	1.4	1	2

Spray Sept. 6
Evaluation Sept. 12

Starch Index
Cornell chart, 1-8

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Gala

Spray Sept. 6 and 12
Harvest (late) Sept. 22

8 months of CA storage (2.5% O₂ + 2% CO₂) at 1.5°C

	Stem-end browning (%)	Flesh browning (incl. stem-end) (%)
Control	23 ^A	29 ^A
60 g/ac	14 ^B	31 ^A
120 g/ac	6 ^C	14 ^B
60 g × 2	7 ^C	15 ^B

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#3 = Storage conditions

- Low Oxygen**

4 Strains
CA at 1°C, 9 Months

	Stem-end browning (%)
No SmFr	
1.5% O ₂	27 b
2.5%	34 a
+ SmFr	
1.5% O ₂	26 b
2.5%	34 a

Gala

Lab Pod
0.2 – 0.4% O₂ = ZERO!



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Ambrosia

9 months in CA storage at 0.5°C

	Internal Browning (%)
0.5% O₂ (LabPod)	
No SmFr	19 ^C
+SmFr at 9mo	13 ^C
1.2% O₂	
No SmFr	48 ^B
+SmFr at harv	60 ^A
+SmFr at 9mo	64 ^A

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• CO₂ concentration

Ambrosia

6 months in storage at 0.5°C

1.2% O₂, +SmFr

CO₂ 1% = 1.5% internal browning

2% = 8.2% P<0.05

No effect of CO₂ on firmness

No greasiness for 21 days at RT

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- **Delayed CA**

Empire

+SmFr, +/- 1 month in Air then CA

7 months total storage at ~2.5°C

CA = 1.5% O₂ + 1% CO₂

No significant
effect on
firmness

	<u>Internal browning (%)</u>		<u>External CO₂ injury (%)</u>	
	<u>No delay</u>	<u>Delay</u>	<u>No delay</u>	<u>Delay</u>
H1	0	0	28	0
H2	3	1	41	0
H3	1	0.5	41	0
H4	5	8	30	0
H5	27	24	27	0

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- **1-MCP**



Preharvest application, Harvista

Consistent reduction in internal browning

Postharvest application, i.e. SmartFresh

Variable effects on internal browning

No significant effect, increased or decreased incidence

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- Storage duration and shelf-life

Gala

More browning with increased storage time, and increased holding at RT

CA storage at 1°C	Internal + stem-end browning (%)
7 Months	
1 day at RT	0 ^D
7 days	6 ^{BCD}
14 days	4 ^{BCD}
20 days	13 ^{BC}
9 Months	
1 day at RT	3 ^{CD}
7 days	9 ^{BCD}
14 days	18 ^B
20 days	43 ^A

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- Storage temperature

Cultivar specific + dependent

Ambrosia 0.5°C, slow
 Empire 2°C
 Gala 0.5-2°C, PGRs
 Honeycrisp 3°C, bp

Gala

CA (2.5% O₂) in 0.5 vs 3°C, 25 vs 44% browning ****

NY data says opposite IF using PGRs and ultra-low O₂

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Gala

Conditioning (temperature)

10°C for 0 or 1 week before 0.5°C

8 months in storage at 0.5°C, +SmFr

1.5% O₂ + 1% CO₂

+ 10°C = 10% internal browning

No = 22% P<0.05

No effect of 10°C on firmness

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Ambrosia

Conditioning (temperature)

10°C for 0 or 1 week before 0.5°C

8 months in storage at 0.5°C, +SmFr

1.7% O₂ + 1.2% CO₂

+ 10°C = 1% internal browning

No = 13% P<0.05

No effect of 10°C on firmness

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Ambrosia

Delay at 3°C before 0.5°C

0, 1, 2, or 4 weeks at 3°C before 0.5°C

8 months in storage at 0.5°C, +SmFr

1.7% O₂ + 1.2% CO₂

	Internal Browning (%)	
0 wk at 3°C	14 ^A	No effect on firmness
1	10 ^{AB}	
2	13 ^{AB}	
4	6 ^B	

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Gala

Cooling rate

8 months
CA at 1°C

	Internal browning (%)	
No SmFr		
Rapid	54 a	
Slow	10 b	
+ SmFr		
Rapid	47 a	
Slow	5 c	

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Gala

Cooling rate

8 months
CA at 1°C

	Internal browning (%)	Lenticel breakdown (%)
No SmFr		
Rapid	54 a	1
Slow	10 b	2
+ SmFr		
Rapid	47 a	10
Slow	5 c	1



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Summary – Factors affecting internal browning

1. Maturity at harvest

- More browning with advanced maturity, later harvests

2. Plant growth regulators

- Anti-ethylene, delay ripening and less browning

3. Storage conditions

- Lower oxygen = less internal browning
- Higher CO₂ levels can increase browning
- Postharvest 1-MCP, inconsistent effect
- More browning with increased storage and holding at RT
- Storage temperature, cultivar specific
 - Conditioning (1 wk at 10°C) can reduce browning
 - Slower cooling can reduce browning

And.. Orchard! Ex. Gala, bottom vs top of hill

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