

Ministry of Agriculture, Food and Agribusiness

# Storage and Disorders of 'Ambrosia' Apples

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## 'Ambrosia' apple



1990s  
Cawston, BC  
Wilfred and Sally Mennell  
Chance seedling  
Jonagold block  
Golden Delicious, Starking  
Delicious, plums

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## Susceptible to...

**Diseases** – plenty!

### Disorders

Lenticel breakdown

Internal browning  
(some core, vascular)

Senescent breakdown

Mealiness, splits

CO<sub>2</sub> injury

Soft scald

Others?

Chilling sensitive  
CO<sub>2</sub> sensitive



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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 (sometimes)

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## Harvest maturity for 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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## Effect of maturity at harvest time

6 days makes a big difference!

	4 months Air 0.5°C	8 months, 0.5°C 1.7% O <sub>2</sub> + 1.2% CO <sub>2</sub>	
+ SmartFresh	Internal browning (%)	Internal browning (%)	Eq /stem
Orch 1 H1 (Opt)	0 <sup>C</sup>	48 <sup>BC</sup>	27 / 21
	H2 (+ 6d) 50 <sup>A</sup>	81 <sup>CA</sup>	57 / 24
Orch 2 H1	0 <sup>C</sup>	28 <sup>C</sup>	9 / 19
	H2 23 <sup>B</sup> ***	48 <sup>B</sup> ***	10 / 38

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### Effect of low oxygen

8 months at 0.5°C

No 1-MCP

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

9 months at 0.5°C

	Internal browning (%)
1.2% O <sub>2</sub>	48 <sup>B</sup>
+ 1-MCP	60 <sup>A</sup>
0.5% (LabPod)	19 <sup>C</sup>

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### Effect of CO<sub>2</sub> with low oxygen

6 months in storage at 0.5°C  
SmartFresh

1.2% O<sub>2</sub> +  
CO<sub>2</sub> 1% = 1.5% internal browning  
2% = 8.2% \*

No effect of CO<sub>2</sub> on firmness  
No quality advantage of higher CO<sub>2</sub>  
(\$\$)



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### Effect of storage temperature

8 months in storage at 0.5°C, +SmFr  
1.7% O<sub>2</sub> + 1.2% CO<sub>2</sub>

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

4 weeks for significant reduction in internal browning  
14 vs. 6% with 0 or 4 weeks, respectively  
Slightly less acidic and greasier with 4 weeks

#### 10°C for 0 or 1 week before 0.5°C

13 vs. 1% with 0 or 1 week, respectively

No effects on firmness (but all with 1-MCP)

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### Effect of temperature and low oxygen

2022

H1, + SmartFresh, 8 months storage

Temp (°C)	Oxygen (%)	Internal brwn (%)	Stem-end brwn (%)	Firmness 1d RT (lb)	Firmness 7d RT (lb)
0.5	0.6	<1 <sup>B</sup>	5 <sup>B</sup>	16.3 <sup>ABC</sup>	16.2 <sup>BC</sup>
	1.2	5 <sup>A</sup>	30 <sup>A</sup>	16.5 <sup>AB</sup>	16.6 <sup>AB</sup>
3.0	0.6	<1 <sup>B</sup>	<1 <sup>B</sup>	15.9 <sup>CD</sup>	16.1 <sup>BC</sup>
	1.2	0 <sup>B</sup>	1 <sup>B</sup>	14.9 <sup>E</sup>	14.9 <sup>D</sup>

Main effects -

More yellow, less firm at 3 vs 0.5°C

More yellow, less firm, less acidity at 1.2 vs 0.6%

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**2022**

H2, + SmartFresh, 8 months storage

Temp (°C)	Oxygen (%)	Internal brwn (%)	Stem-end brwn (%)	Firmness 1d RT (lb)	Firmness 7d RT (lb)
0.5	0.6	9 <sup>AB</sup>	23 <sup>B</sup>	16.5 <sup>AB</sup>	16.7 <sup>A</sup>
	1.2	11 <sup>A</sup>	38 <sup>A</sup>	16.5 <sup>AB</sup>	16.5 <sup>AB</sup>
3.0	0.6	13 <sup>A</sup>	13 <sup>C</sup>	15.4 <sup>C</sup>	14.8 <sup>C</sup>
	1.2	5 <sup>B</sup>	9 <sup>C</sup>	14.8 <sup>D</sup>	14.7 <sup>C</sup>

Main effects -

Less firm at 3 vs 0.5°C

More yellow, less firm at 1.2 vs 0.6%

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**Effect of cooling rate****2023**

+ SmartFresh, 8 months storage

Temp (°C)	Internal brwn (%)	Stem-end brwn (%)	Firmness 14d RT (lb)
0.5 direct	3	13	17.2
0.5 slow	1	3	16.8
10 1wk, 0.5	1	3	16.7

Slow = 2d 50F, 2d 46F, 1 d 44F, 1d 42, 1d 37

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### Postharvest 1-MCP / SmartFresh

- 'Ambrosia' responds well, low ethylene producer
- NS, 1-MCP treatment 1 or 4 days after harvest
- Improves firmness retention, strong effect
- Reduces greasiness
- Maintains higher acidity and soluble solids
- **Inconsistent effect on internal browning**

### Preharvest 1-MCP / Harvista

- **Reduces internal browning**
- Slows starch degradation, narrower range, fewer harvests
- Improves firmness retention
- Reduces stem end cracking
- Can delay color development

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### 2006-2008 BC (Toivonen) and Ontario (DeEll) collaboration



Soft scald

BC 'Ambrosia'

Onset of soft scald?  
External CO2 injury?Mixed storage regimes  
Up to 3% in Air  
Reduced with CA

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**BC 'Ambrosia'  
2008**

**Soft scald**

Specific orchards very susceptible  
Less at 3°C than 0.5°C in Air storage  
Common across CA regimes and 1-MCP

**Hard skin bronzing**

Underlying flesh is clean  
Found in all storage regimes  
More in soft scald orchards  
Not reduced with no CO<sub>2</sub>

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**Ontario 'Ambrosia'  
2007**

**External CO<sub>2</sub> injury ?**



<u>0.5°C</u>	<b>3 mo</b>
Air	31 <sup>F-K</sup>
Air + SF	56 <sup>A-D</sup>
Air + Delay	36 <sup>D-I</sup>
CA1	9 <sup>K</sup>
CA1 + SF	47 <sup>B-G</sup>
CA2	18 <sup>H-K</sup>
CA2 + SF	44 <sup>B-G</sup>
<hr/>	
<u>3°C</u>	
CA1	20 <sup>H-K</sup>
CA1 + SF	60 <sup>A-C</sup>
CA2	36 <sup>D-I</sup>
CA2 + SF	64 <sup>A-B</sup>

Delay = 3 d at 20°C  
SF = SmartFresh, 1-MCP  
CA 1 = 1.2% O<sub>2</sub> + 1.5% CO<sub>2</sub>  
CA 2 = 0.7% O<sub>2</sub> + 1% CO<sub>2</sub>

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3mo air at 0.5°C  
7 Days at 21°C

**Ontario 'Ambrosia'  
2008**

	Firm.. (lb)	IEC (ppm)	Malic acid (mg)	Greas.. (1-3)	Hard skin bronzing (%)	Soft scald (%)	Internal brwn (%)	Vasc. brkdn (%)	Senesc. brkdn (%)
Control	13.2 <sup>D</sup>	2.5 <sup>A</sup>	235 <sup>C</sup>	1.3 <sup>A</sup>	40 <sup>A</sup>	14 <sup>A</sup>	18 <sup>B</sup>	33 <sup>B</sup>	13.3 <sup>A</sup>
<b>DPA</b>	<b>12.6<sup>D</sup></b>	1.4 <sup>BC</sup>	268 <sup>B</sup>	<b>1.4<sup>A</sup></b>	<b>0<sup>C</sup></b>	<b>0<sup>B</sup></b>	<b>22<sup>B</sup></b>	<b>29<sup>B</sup></b>	<b>18.3<sup>A</sup></b>
<b>1-MCP</b>	<b>15.7<sup>B</sup></b>	0.5 <sup>CD</sup>	335 <sup>A</sup>	<b>1.0<sup>C</sup></b>	<b>19<sup>B</sup></b>	6 <sup>AB</sup>	<b>35<sup>A</sup></b>	<b>13<sup>C</sup></b>	<b>1.0<sup>B</sup></b>



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DPA injury on Ambrosia, +SmFr  
2011, commercial drench, 1130 ppm



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2018 = 10 years later!

Ontario 'Ambrosia'



Hard skin  
bronzing



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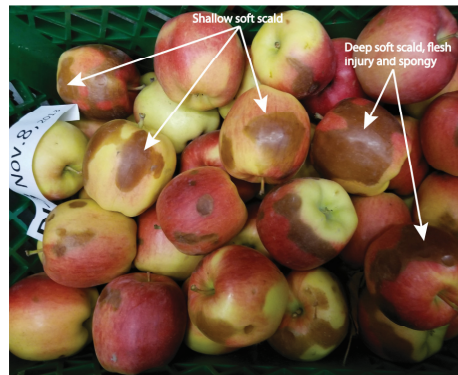
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2018 = 10 years later

BC 'Ambrosia'  
Toivonen

Different stages  
of soft scald

Lesions all with  
well defined edges



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### 'Ambrosia' – What we know...

- Harvest maturity extremely important for storage
- Chilling and CO<sub>2</sub> sensitive
- Lower oxygen = less internal browning
- Higher CO<sub>2</sub> levels increased internal browning, some cavities
- Cooling rate affects internal browning
- Postharvest 1-MCP, inconsistent effect on internal browning  
exacerbates CO<sub>2</sub> injury
- Preharvest 1-MCP reduces internal browning
- DPA controls CO<sub>2</sub> injury
- Harvest before yellow background
- Slow or delayed cooling to 0.5°C
- 1.2% O<sub>2</sub> + 1% CO<sub>2</sub> (<1% O<sub>2</sub> (DCA) if monitoring fruit)

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