The Continuing Quest for optimal Harvest Management and Storage of Apples'

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Thanks for the many growers and storage operators who contribute fruit for our research

Three topics today

- DA Meter
- Honeycrisp storage
- Dynamic Controlled Atmosphere Storage

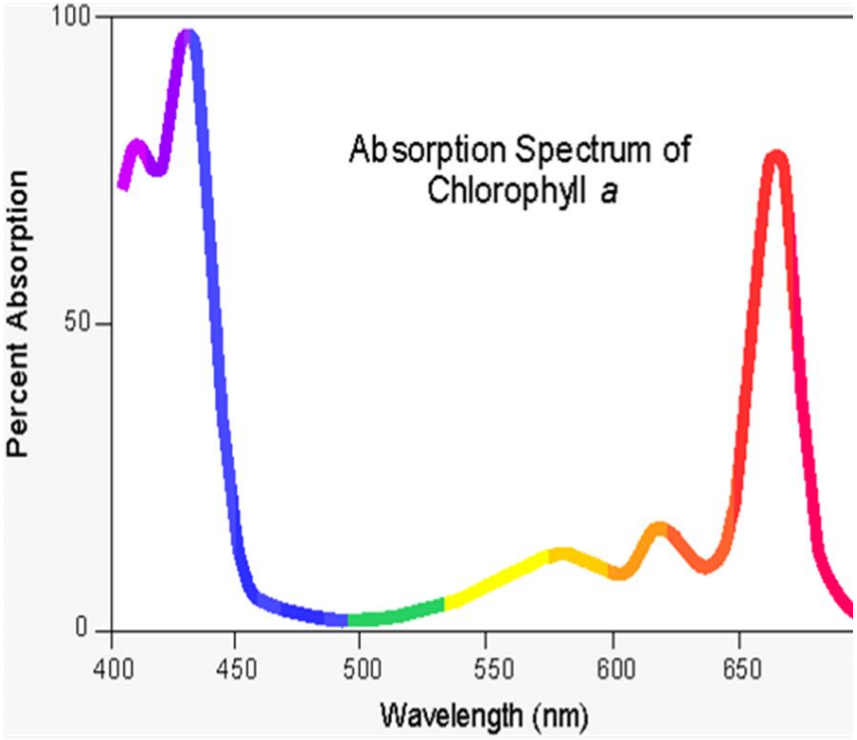
1. Delta Absorbance (DA) meter

- Hand held non-destructive measurement
- Developed using vis/NIR spectroscopy

Absorbance measurement principles

- Chlorophyll *a* peaks at ~ 660 nm
- I_{AD} measures Chlorophyll *a* in the peel

  I_{AD} = Abs (670 nm) – Abs (720 nm)



http://www.umich.edu/~chem125/softchalk/Exp2_Final_2/Exp2_Final_2_print.html

Essentially an electronic color chart that provides an index representing Chlorophyll a concentrations

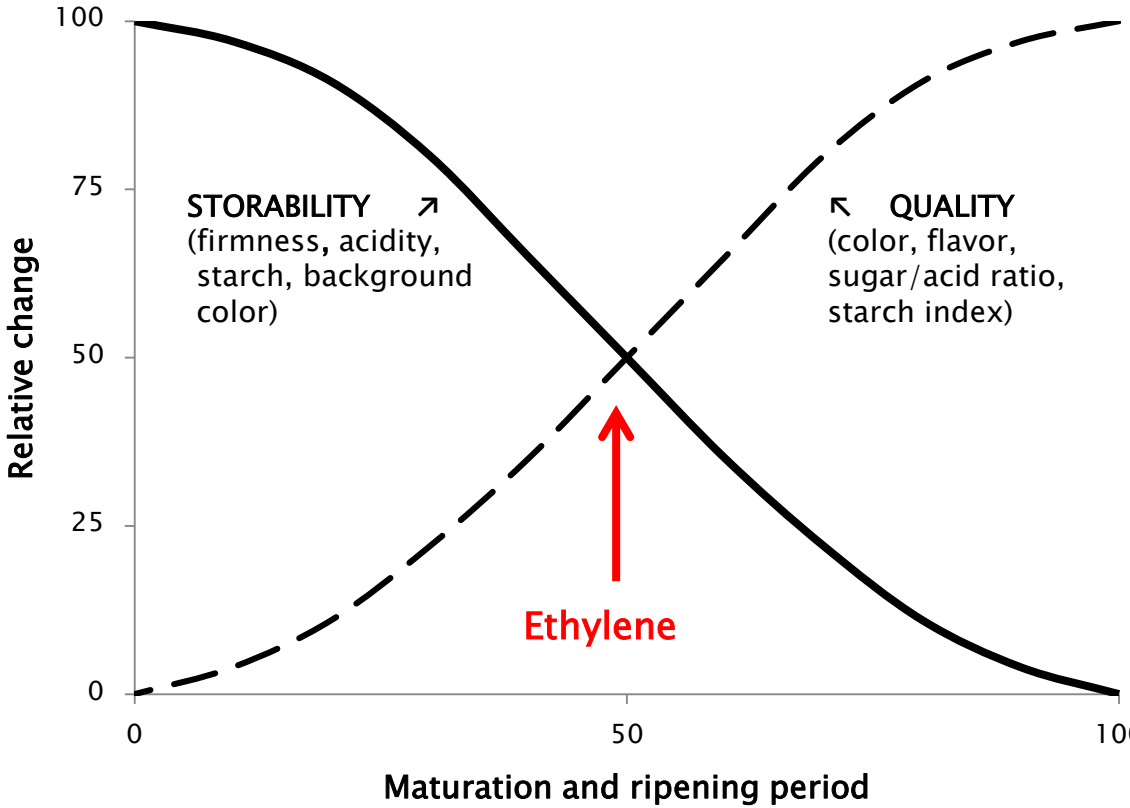
But DA meter is not limited by red coloration of fruit

Relationships between I_{AD} values and chlorophyll a

Cultivar	R^2
NY-1	0.797
NY-2	0.756
Cortland	0.818
Fuji	0.732
Honeycrisp	0.817
Jonagold	0.481
Mutsu	0.678
McIntosh	0.671
RedCort	0.633

DA meter provides readings in the range of 0 to 3.0 for apple fruit

Harvest date is critical to quality of fruit in the market place, and often associated with storage disorder issues



Current tools to assess "Maturity" (Harvest) indices

MATURITY INDICES

- **Internal ethylene concentration (IEC)**
- Starch pattern index (SPI)

Where does the DA meter fit in?

QUALITY INDICES

- Firmness
- Soluble solids concentration
- Acidity
- Red coloration
- (background color/ground color)

With courtesy of John Delong

Honeycrisp DA meter model steps:

i) Measure fruit quality attributes 'at harvest' [including DA meter readings(I_{AD})];

ii) Store 38°F for 3-4 months;

iii) Assess disorder incidence after removal;

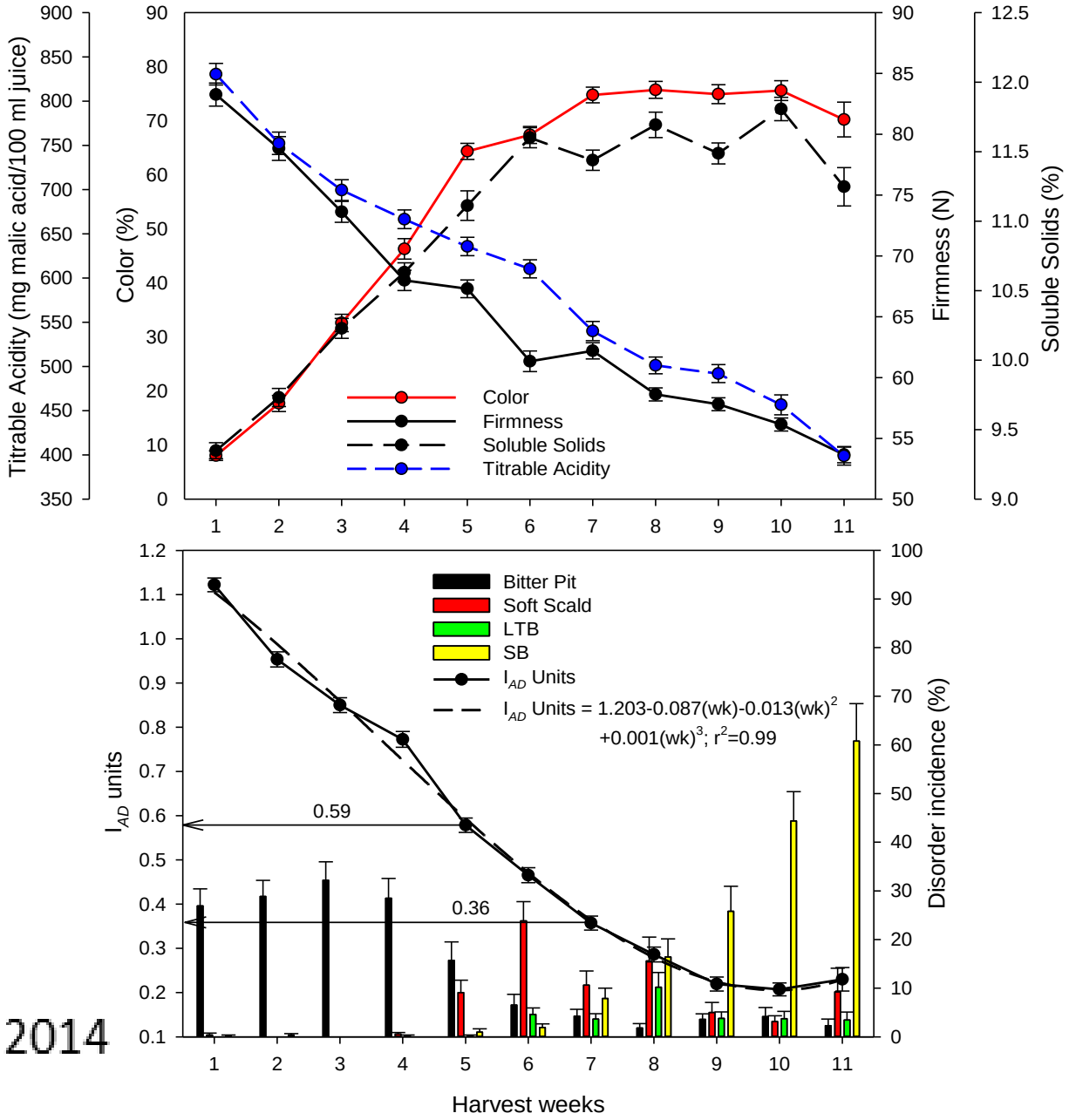
iv) Optimal harvest window = period having high quality attributes (at harvest),

and fewest disorders (post-harvest);

v) Optimal harvest window delineated in DA meter units.

(Note: usually a 2-week period)

2010-2012 Honeycrisp Quality, I_{AD} & Disorder Data



DeLong et al., 2014

Honeycrisp Harvest Maturity conclusions for Nova Scotia (John DeLong et al.)

DA meter model message:

As the Honeycrisp reading:

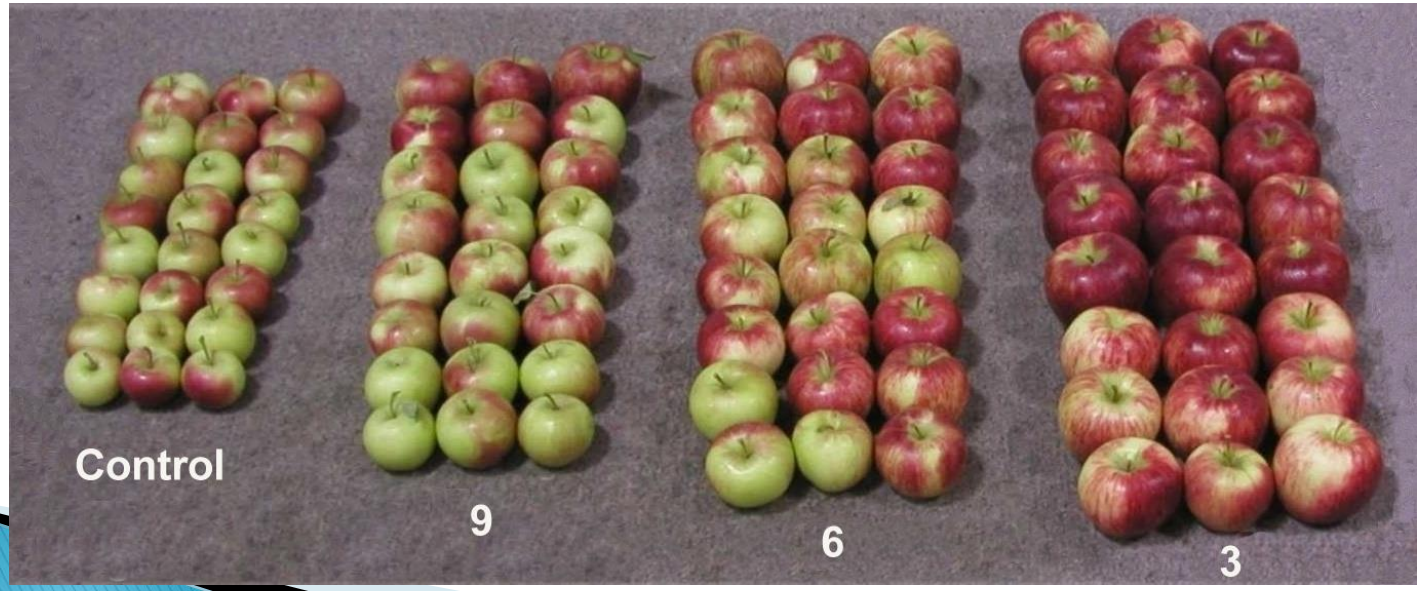
i) $\leq$ 0.60 ➡ begin harvest

i) Between 0.60 and 0.35 ➡ good for long-term storage

ii) <0.35 ➡ sell first. No long-term storage

Ignored admonitions from DeLong et al. (2014)

- Develop for each cultivar
- Regionally based



Fruit per cm^{-2} TCSA

Why region is important

- Excellent color development in Nova Scotia
- Different maturity profiles allowing more concentrated harvest dates
  - 3-4 harvests not uncommon in NY
- Different disorder development profiles
  - Stippen (on tree pit appears more problematic in NY)
  - Depending on region and growing season we have much greater concern about soft scald and soggy breakdown

Average maturity indices

Growing region	IEC (ppm)	SPI	DA meter reading
Champlain	8	6.6	0.71
Hudson Valley	11	7.0	0.65
Western NY	14	7.6	0.51
PA	23	7.7	0.311

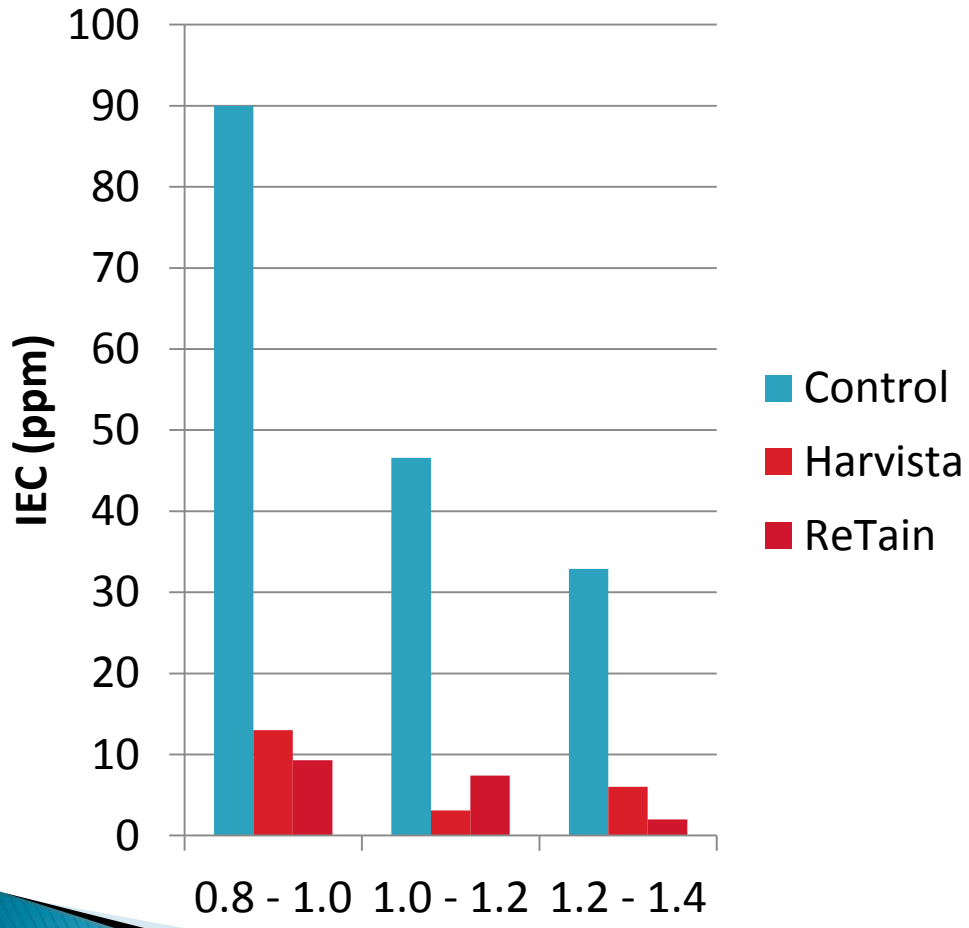
Honeycrisp separation by DA reading

Honeycrisp separation by DA reading

Summary:

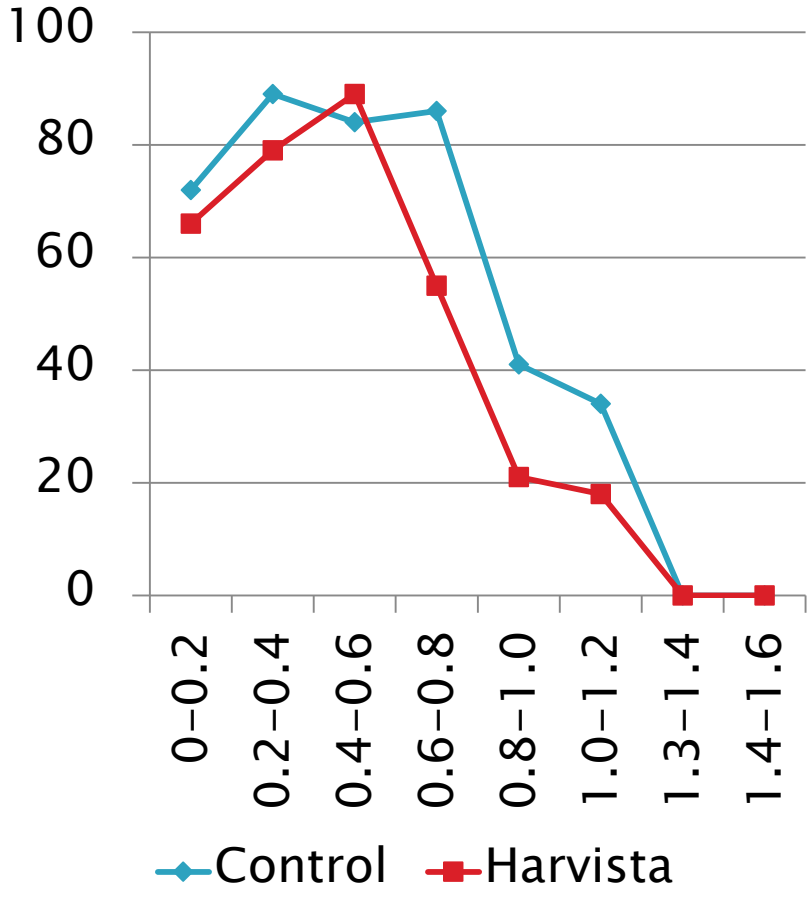
- Generally good correlations between I_{AD} values and chlorophyll concentrations, but exceptions exist.
- Depending on cultivar (e.g. 'RedCort'), relationships between I_{AD} values and IEC and starch indices are good. Suggests that in some cases might be useful non-destructive measure if relationships apply across orchards and growing regions.
- But just chlorophyll is being measured – effects of N, position of fruit on tree, PGRs

I_{AD} values and internal ethylene concentrations (ppm) – Delicious

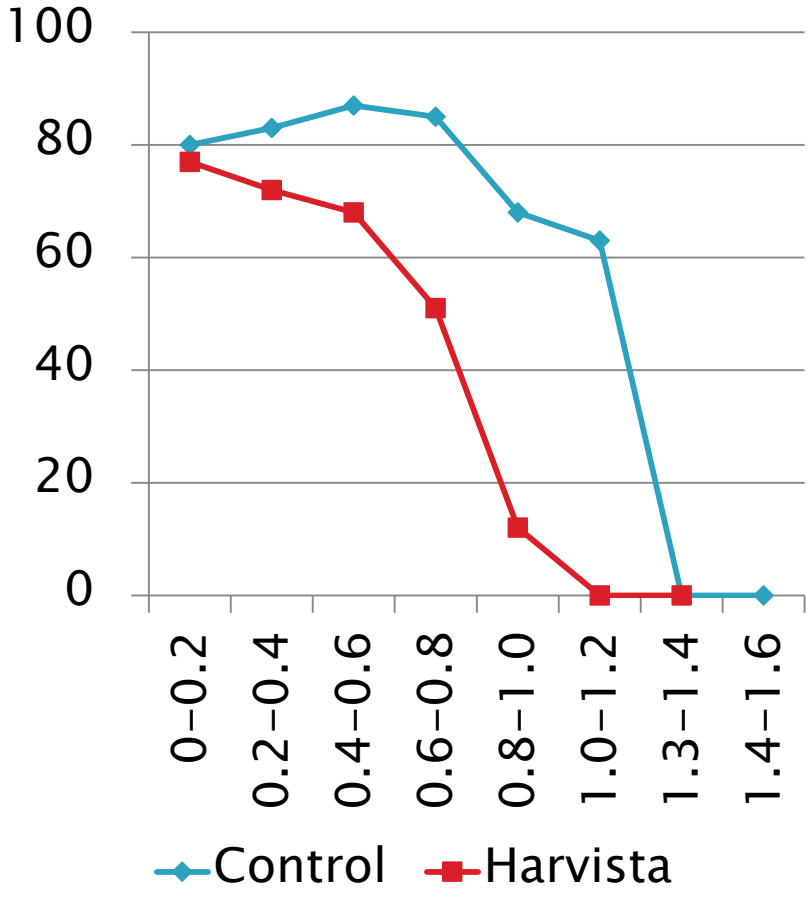


- Relationships between and I_{AD} values good for untreated fruit
  - lower I_{AD} values = riper fruit and higher IEC.
- Harvista and ReTain trts result in loss of relationship within an given I_{AD} value.

Soft scald (%) in Honeycrisp separated at harvest by DA meter readings



Harvest 1



Harvest 2

Field use?

Courtesy of Ines Hanrahan,

Washington Tree Fruit Research Commission

Courtesy of Peter Toivonen,

Agriculture and Food Canada, BC

Conclusions

- Correlations of I_{AD} values with other harvest indices are present, but variable, and depend on cultivar.
  - 'I_{AD} tells you about how much chlorophyll is in the peel of the apple – nothing more'
- Relationship between I_{AD} values at harvest and disorders may be affected by preharvest factors such as PGRs.
- Overall unlikely to replace standard harvest indices, but rather supplement, although future potential for precision harvest if it can be made reliable in the field.
- Big question for how a grower might use such a meter.

2. Honeycrisp storage

Focus

- Effects of conditioning
- Can we avoid conditioning? (regional)
- CA storage

Effects of conditioning on bitter pit and soft scald of fruit stored at 33°F or 38°F (2013/2014)

- Honeycrisp apples from WNY (2 orchards) and PA (1 orchard)
- Fruit untreated or conditioned at 50°F before storage at 33°F or 38°F
- Stored for 20 weeks plus 7 days at 68°F

Effect of conditioning Soft scald (%)

	WNY-1	WNY-2	PA
33F	22a	28a	8a
33F + conditioning	3b	3b	6a
38F	0.3b	0b	0b
38F + conditioning	0b	0b	0b

Effect of conditioning Bitter pit (%)

	WNY-1	WNY-2	PA
33F	5c	2b	4b
33F + conditioning	8bc	2b	24a
38F	13ab	3b	5b
38F + conditioning	20a	5a	28a

- 38F is the safe storage temperature for HC

- Conditioning is a problem
  - Can increase bitter pit development
  - Annoying from management perspective

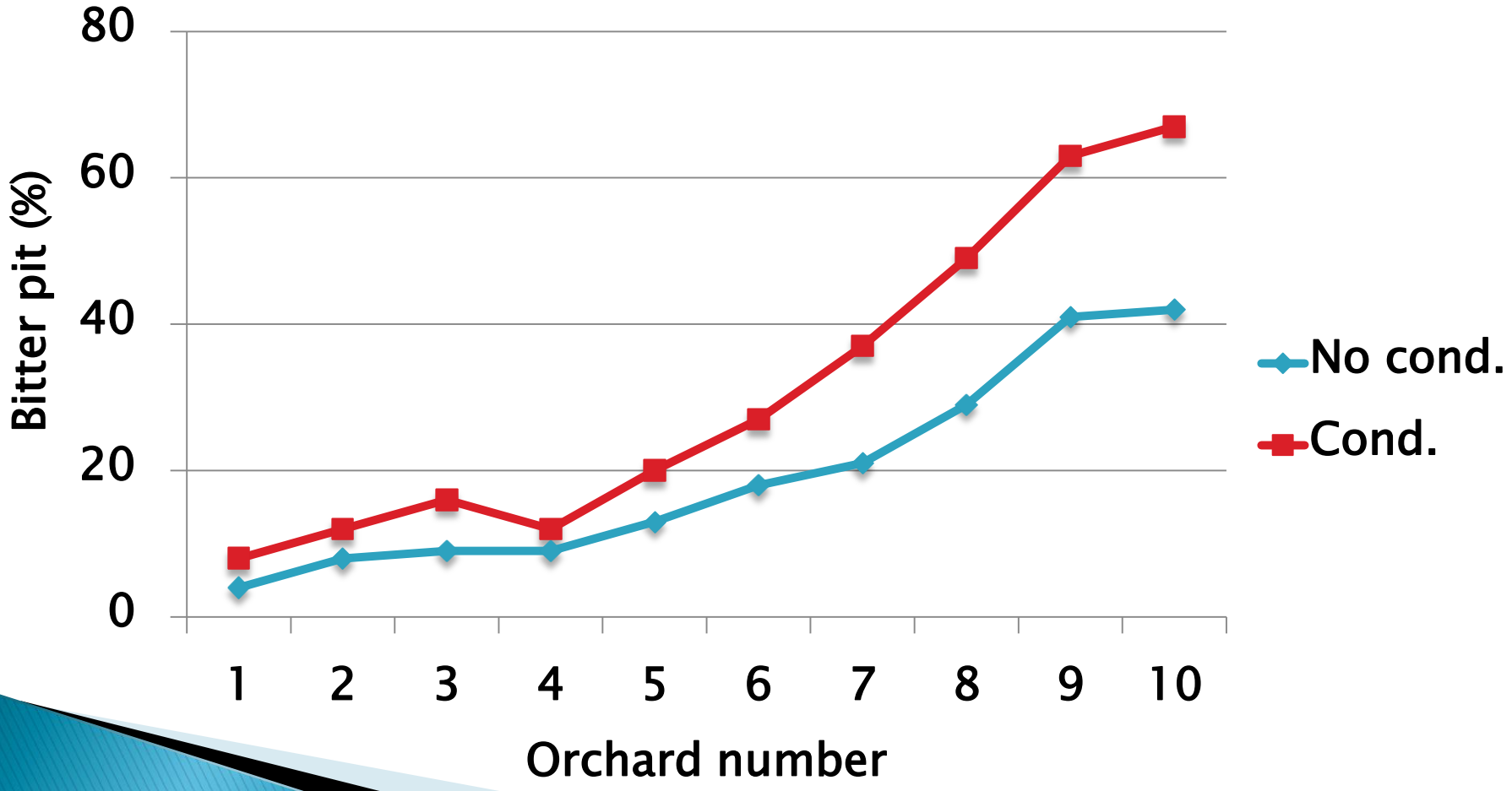
Effects of conditioning on bitter pit and soft scald of fruit stored at 38°F (2014/2015)

- Honeycrisp apples from HV (3 orchards), WNY (2 orchards), Champlain (3 orchards) and PA (2 orchards)
- Fruit untreated or conditioned at 50°F before storage at 38°F
- Storage for 20 weeks plus 7 days at 68°F
- *Results today are based on 10 weeks evaluations during cold storage*

Effects of conditioning on bitter pit incidence (%) at 10 weeks [2014/15]

	38°F	50°F + 38°F	% Increase over 'no conditioning'
PA1	21	37	76
PA2	9	16	78
HV1	42	67	60
HV2	29	49	69
HV3	13	20	54
WNY1	8	12	50
WNY2	18	27	50
CH1	41	63	54
CH2	4	8	50
CH3	9	12	33
Average	19	31	63

Effect of conditioning on bitter pit incidence (%) at 10 weeks [2014/15]



Effects of conditioning on soft scald incidence (%) at 10 weeks [2014/15]

	38°F	50°F + 38°F
PA1	0.3	0
PA2	0	0
HV1	0	0
HV2	9	0
HV3	1	0
WNY1	3	0
WNY2	0	0
CH1	2	0
CH2	4	0
CH3	0.3	0
Average	**2**	**0**

Sub-summary

- Conditioning ALWAYS increases losses due to bitter pit
  - Only control factor is in the orchard
  - Less pit potential at harvest = less loss to pit after storage
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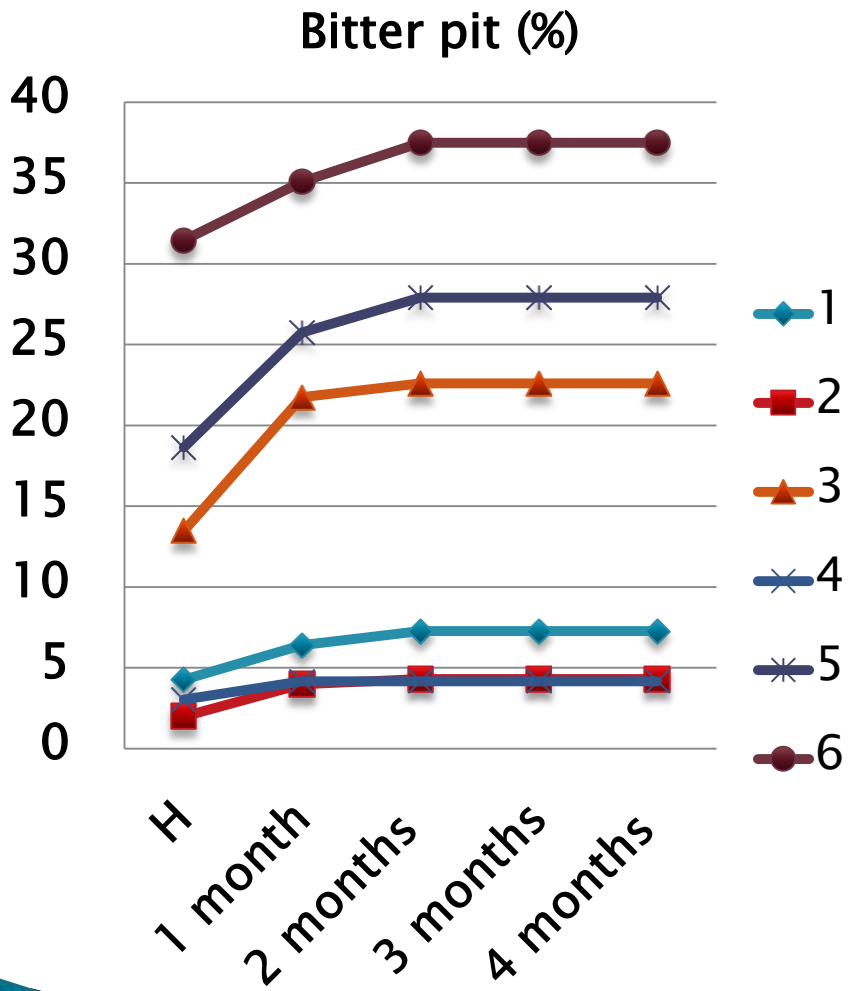
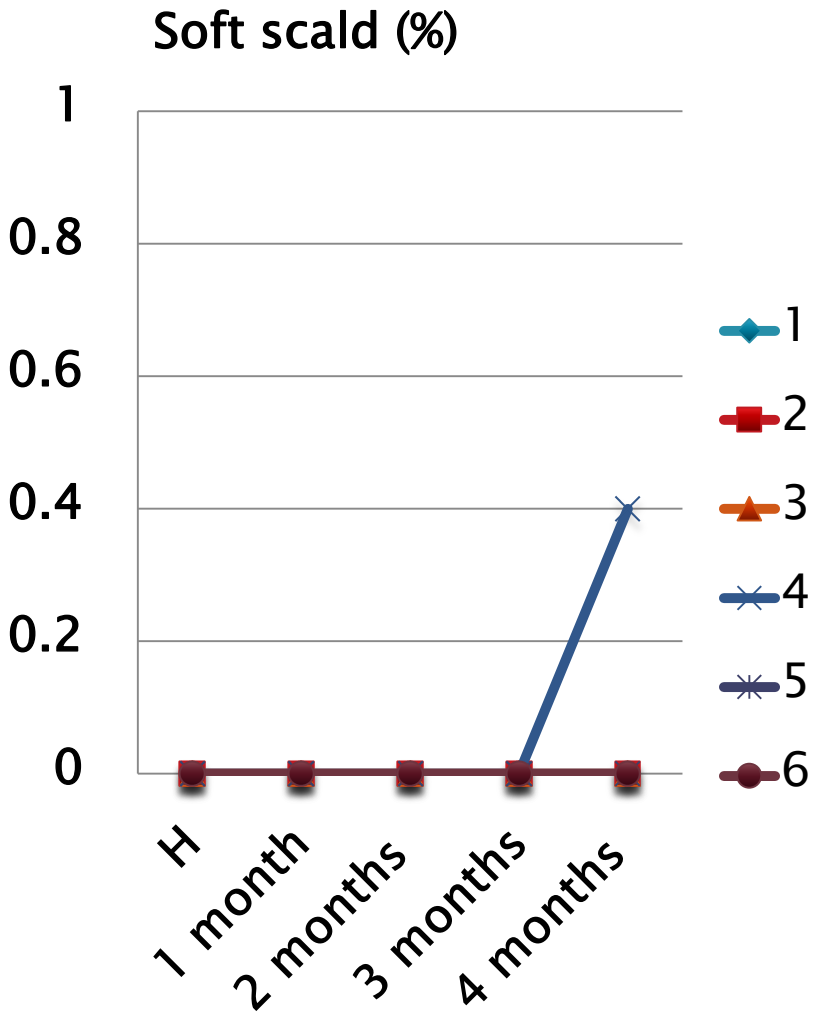
- Interested in timing of disorder incidence

The dynamics of bitter pit and soft scald development (2013/2014)

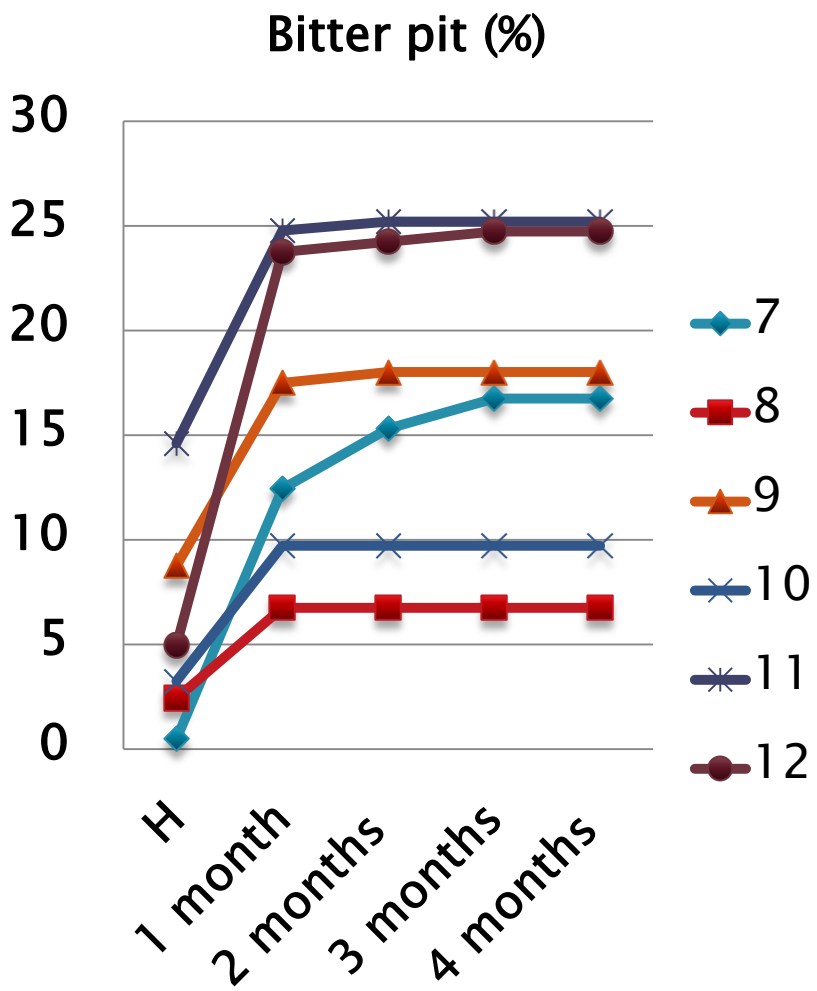
- Fruit from 6 HV orchard blocks and 12 western NY orchard blocks
- Stored at 38^{o}F without conditioning
- Bitter pit and soft scald development assessed on stored fruit at monthly intervals for 4 months

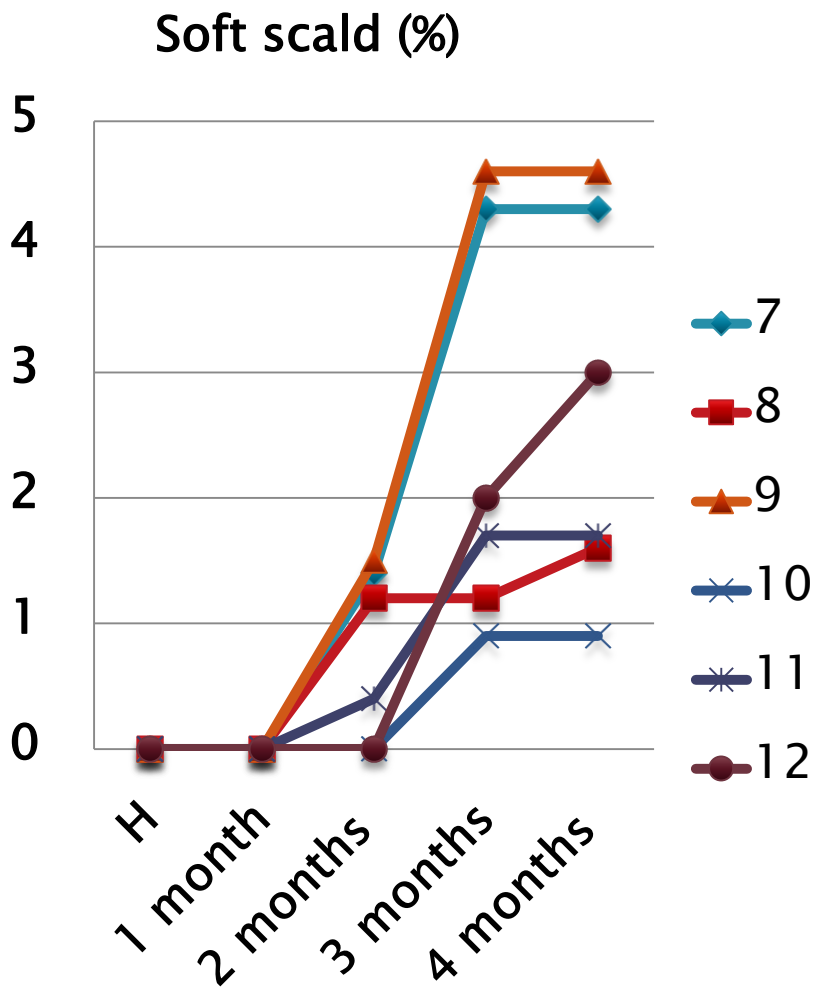
Hudson Valley





Western NY


Bitter pit (%)
30
25
20
15
10
5
0
H
1 month
2 months
3 months
4 months
7
8
9
10
11
12


Soft scald (%)
5
4
3
2
1
0
H
1 month
2 months
3 months
4 months
7
8
9
10
11
12

Take home messages

- Variation among orchards – recurrent theme
- *Storage of Honeycrisp at 33°F is a high risk endeavor regardless of conditioning (for long storage periods)*
- Conditioning of fruit consistently reduces soft scald development but results in higher bitter pit development
- **Lower bitter pit potential results in lower losses due to conditioning**
- **Negligible soft scald at 38°F for short term storage**

- Soft scald development risk is HIGH in the Champlain, low in Hudson Valley, while WNY is more variable.
- Not conditioning in Champlain and WNY is a high risk activity! Every year is different!!!
- In HV may be possible to use low storage temperatures and avoid conditioning if storage periods are short (1-2 months)
- Ideal would be to have prediction test available (β testing this season), also testing ethanol, but you should sample.

Controlled atmosphere (CA) storage

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Untrt vs SF (air) vs CA – 6 months

	UNTRT	1-MCP
Firmness (lb-f)	15.5	15.5
SSC (%)	12.0	12.4*
TA (%)	0.228	0.267***

Untrt vs SF (air) vs CA – 6 months

	UNTRT	1-MCP	CA
Firmness (lb-f)	15.5	15.5	15.5
SSC (%)	12.0	12.4*	12.8***
TA (%)	0.228	0.267***	0.297***

Control of CO_2 injury

- Diphenylamine (DPA)
- Delayed CA
- High temperature conditioning (Randy Beaudry, MSU)

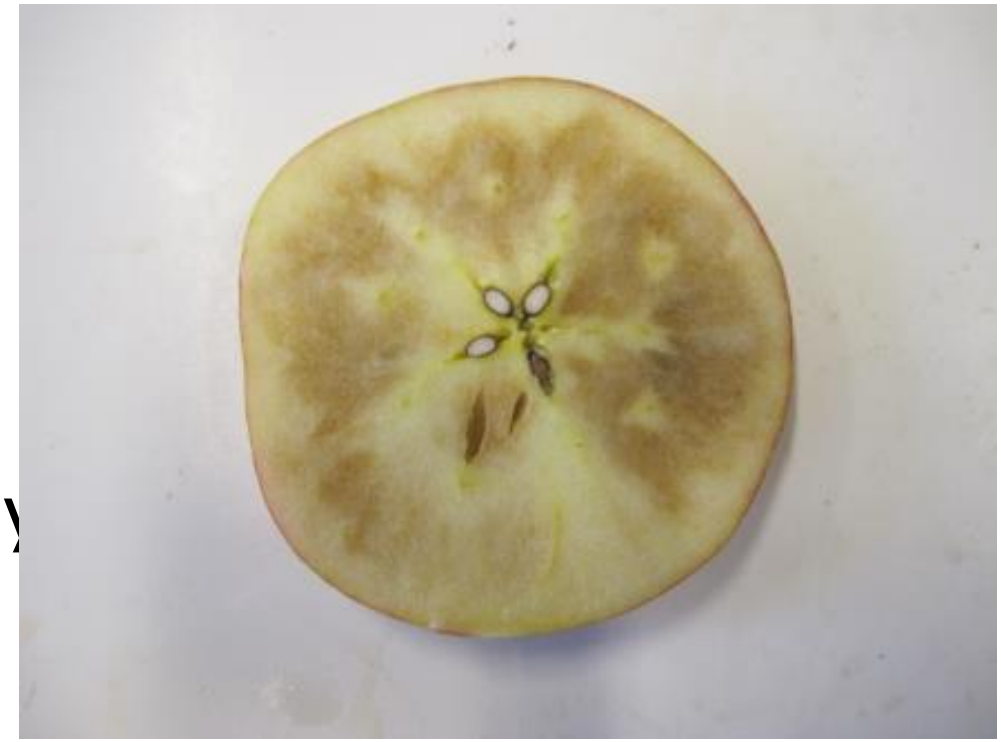
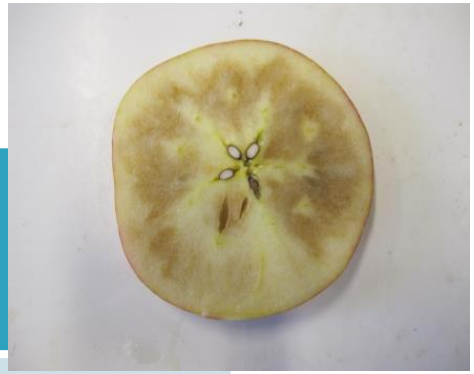


Table 1. % Internal CO_2 injury in 'Honeycrisp' apples from 5 WNY orchards after CA (3% oxygen/3% carbon dioxide) storage (2013).



	% Internal CO_2 injury				
	Orchard #				
delay	1	2	3	4	5
1 week	15	10	2	2	32
3 week	10	1	0	0	10
5 week	1	2	0	0	4

CA experiments 2014 harvest objective to control CO_2 injury by delaying CA

- Fruit from 3 orchard blocks in each of Champlain and Western NY
- Fruit treated on day 1 or day 6 during conditioning.
- CA (3% oxygen with 1.5% or 3% carbon dioxide) applied after 0 or 4 weeks.
- Assessment after 6 months of CA storage

Thank you for your ongoing support

Questions?