THREE YEARS OF STORAGE RESEARCH ON PENNSYLVANIA HONEYCRISP—IMPLICATIONS FOR GROWERS AND PACKERS

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- NY Apple R&D Program
- NYFVI
- AgroFresh
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Honeycrisp recommendation

- Condition at 50F for 7 days and then store at 38F.
  - *Conditioning to prevent soft scald, but…*
  - *Growing region factors? (CH vs HV/PA)*

But knowns and unknowns…
Influenced by CH

Trt	Soggy bkdn (%)	Soft scald (%)
33°F	18a	62a
38°F	1b	9cd
Delay, 33°F	2b	14c
Delay, 38°F	0b	2d

Objectives

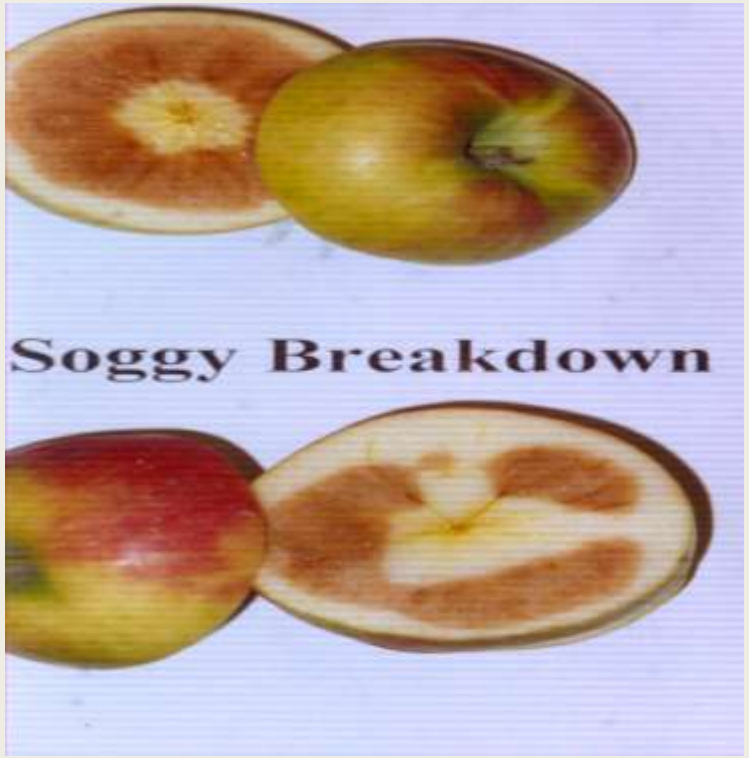
- To understand the dynamics of bitter pit and soft scald development
- To develop prediction methods for bitter pit development
- To develop prediction methods for soft scald development

- Controlled atmosphere storage of Honeycrisp apples – an update

THE DYNAMICS OF BITTER PIT AND SOFT SCALD DEVELOPMENT

Bitter pit

Soft scald

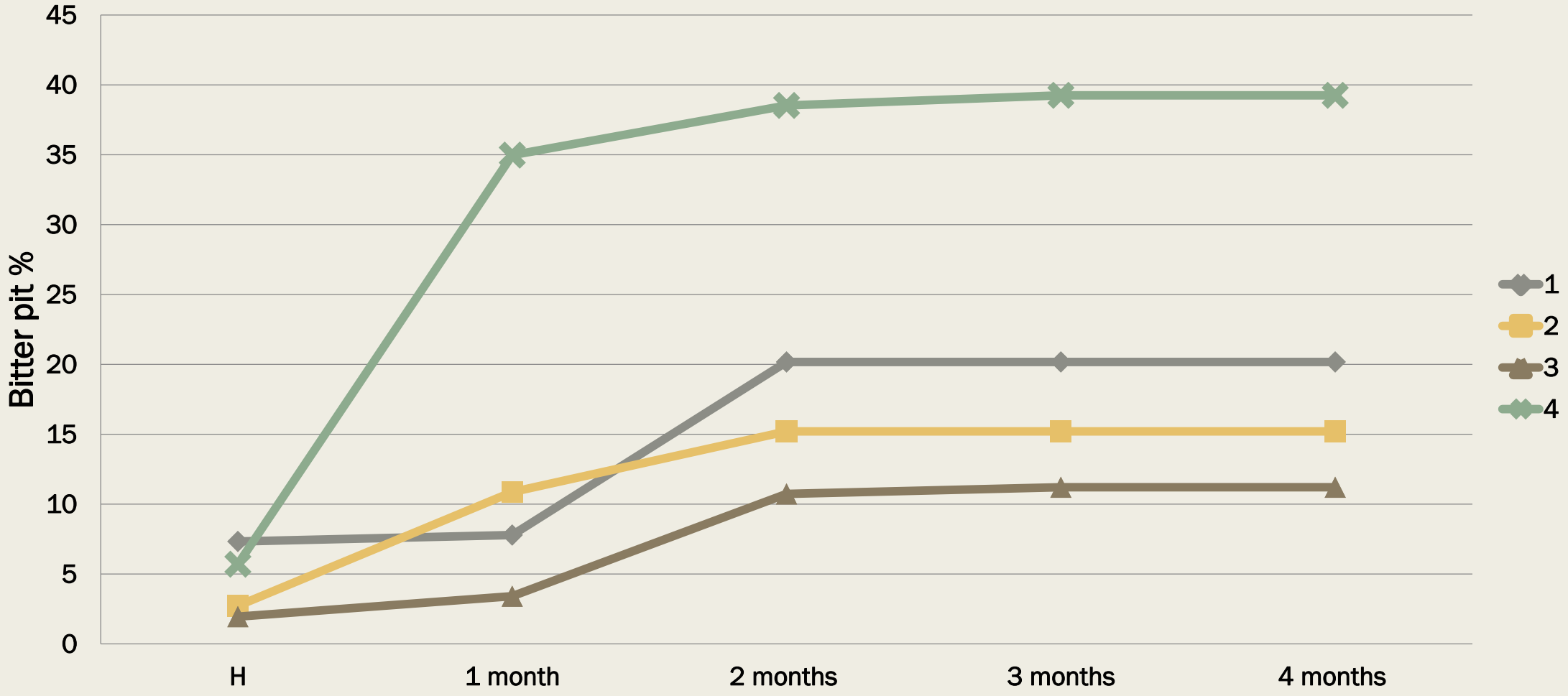

Soggy Breakdown

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

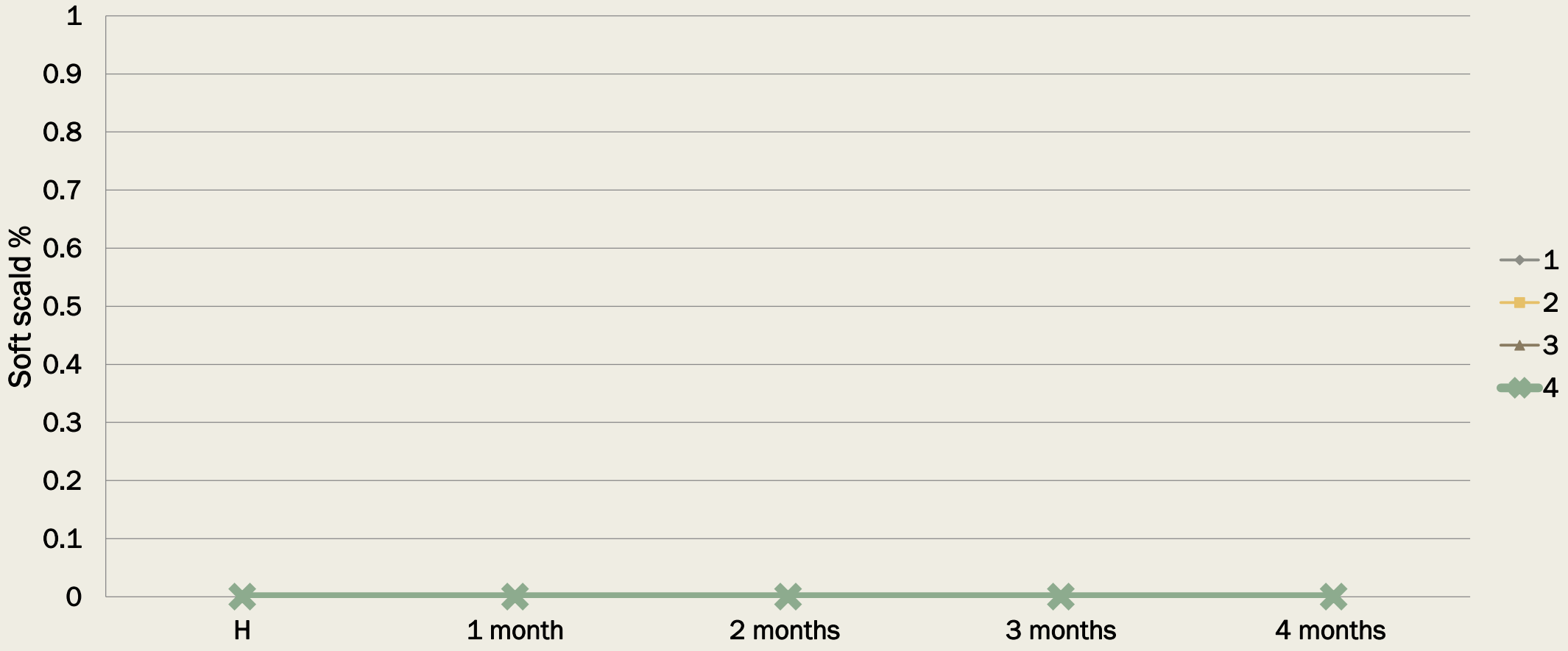
- Fruit from 4 PA orchard blocks, 6 HV orchard blocks and 12 WNY orchard blocks
- Minerals 3 weeks before harvest and at harvest, maturity assessment, and then storage at 38F for 4 months
- Stored at 38ºF without conditioning
- Bitter pit and soft scald development assessed on stored fruit at monthly intervals for 4 months

Only PA and WNY shown for illustration; CH comment

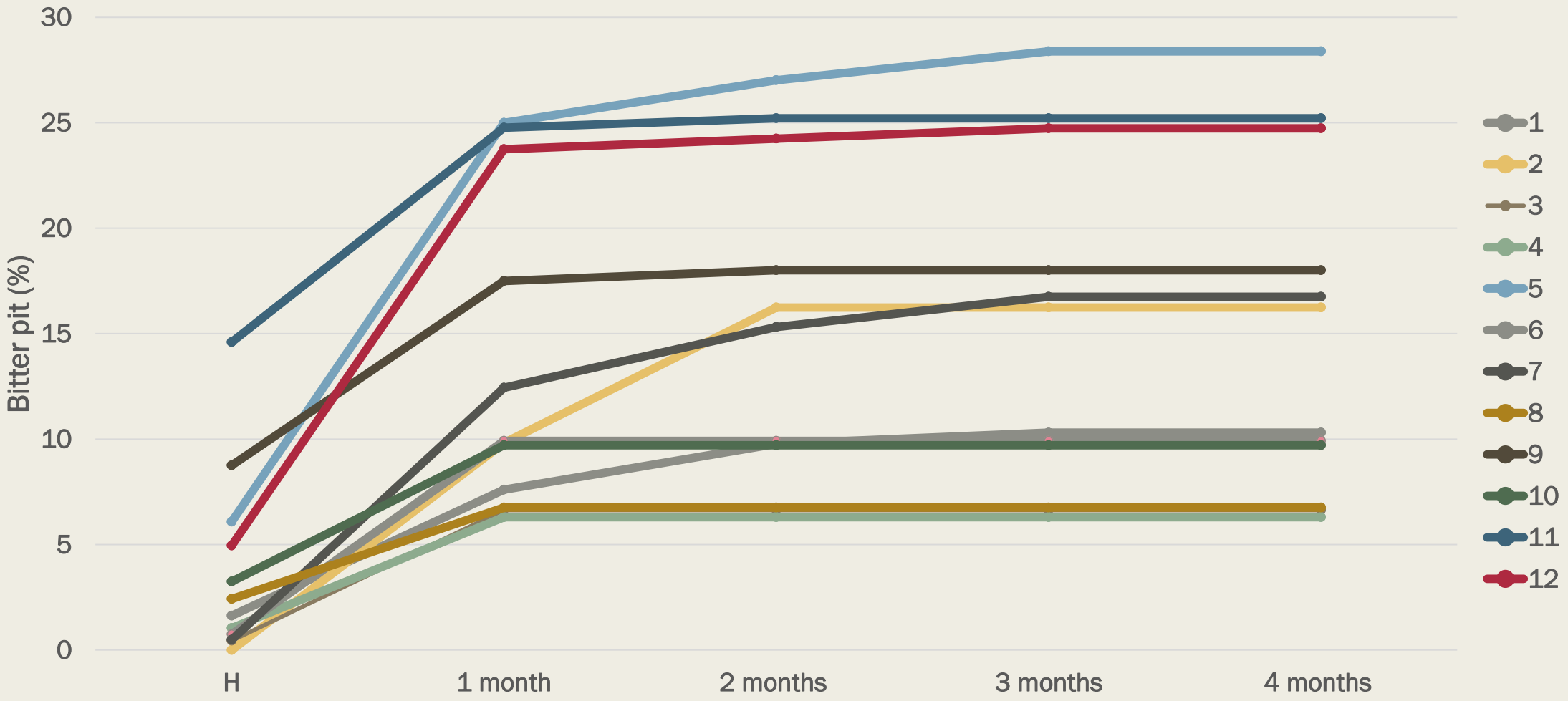
Bitter pit (PA): 2013 harvest



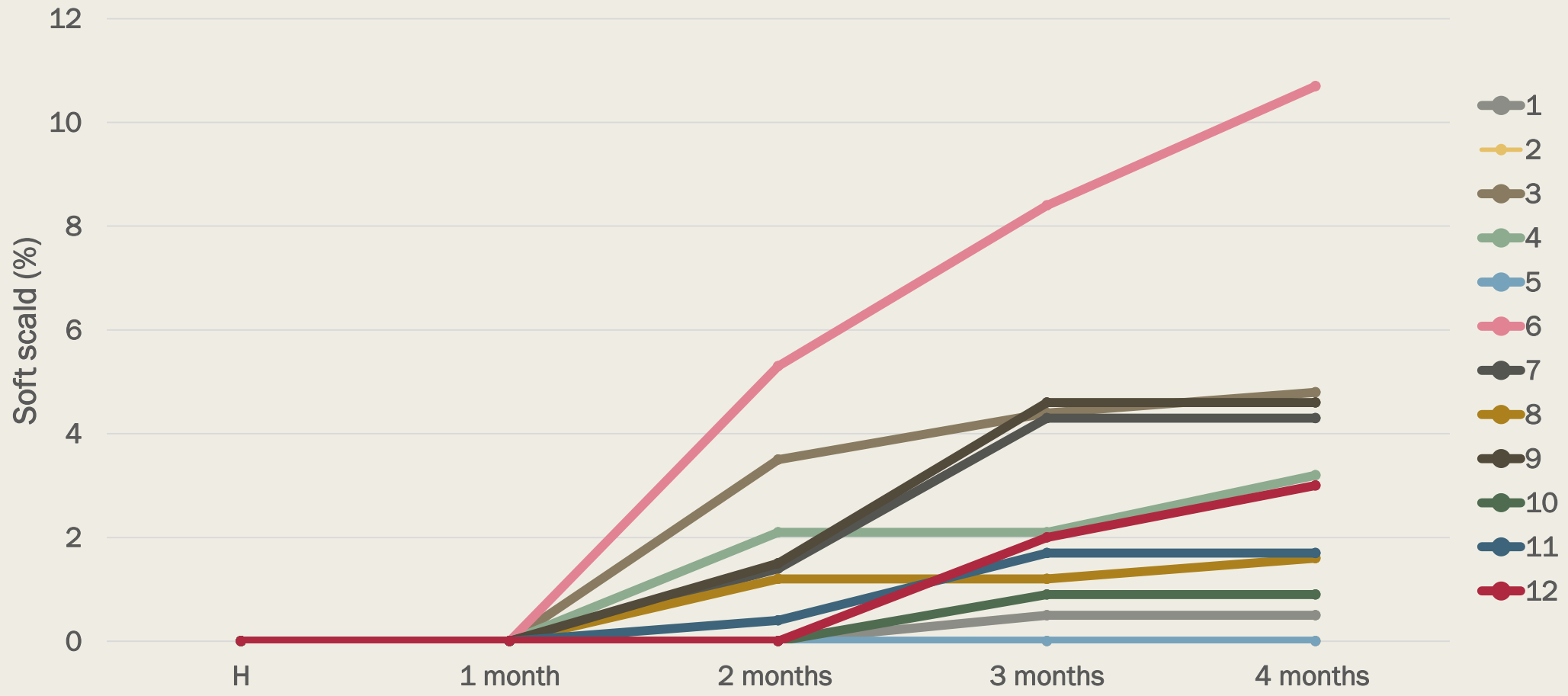
Soft scald (PA): 2013 harvest



Bitter pit (WNY): 2013 harvest

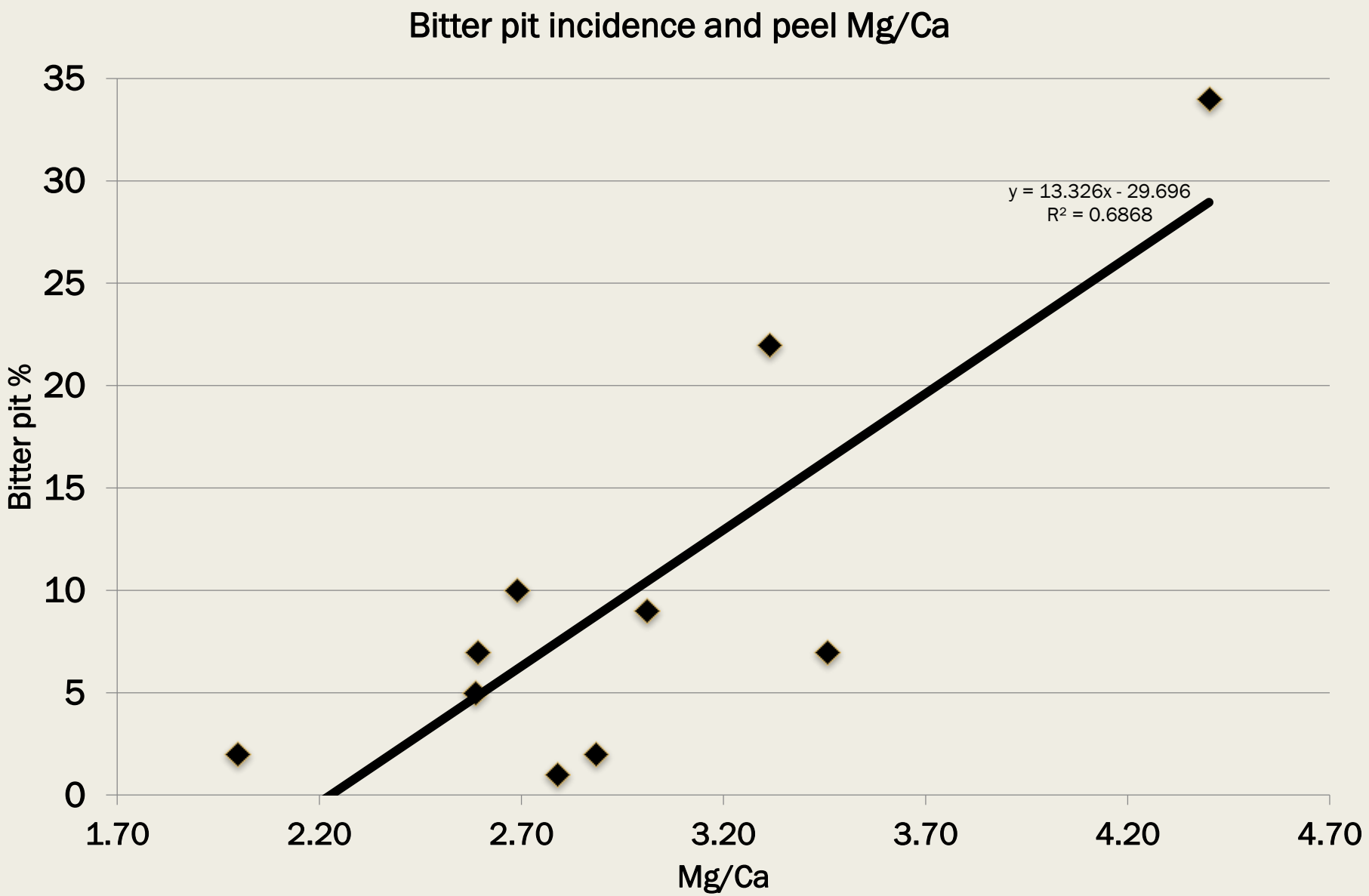


Soft scald (WNY): 2013 harvest



Mineral relationships

- In progress
- Need collective years of data
- Some results promising, e.g. Mg/Ca ratio


Bitter pit incidence and peel Mg/Ca
y = 13.326x - 29.696
R² = 0.6868
Bitter pit %
35
30
25
20
15
10
5
0
1.70
2.20
2.70
3.20
3.70
4.20
4.70
Mg/Ca

Dynamics of change

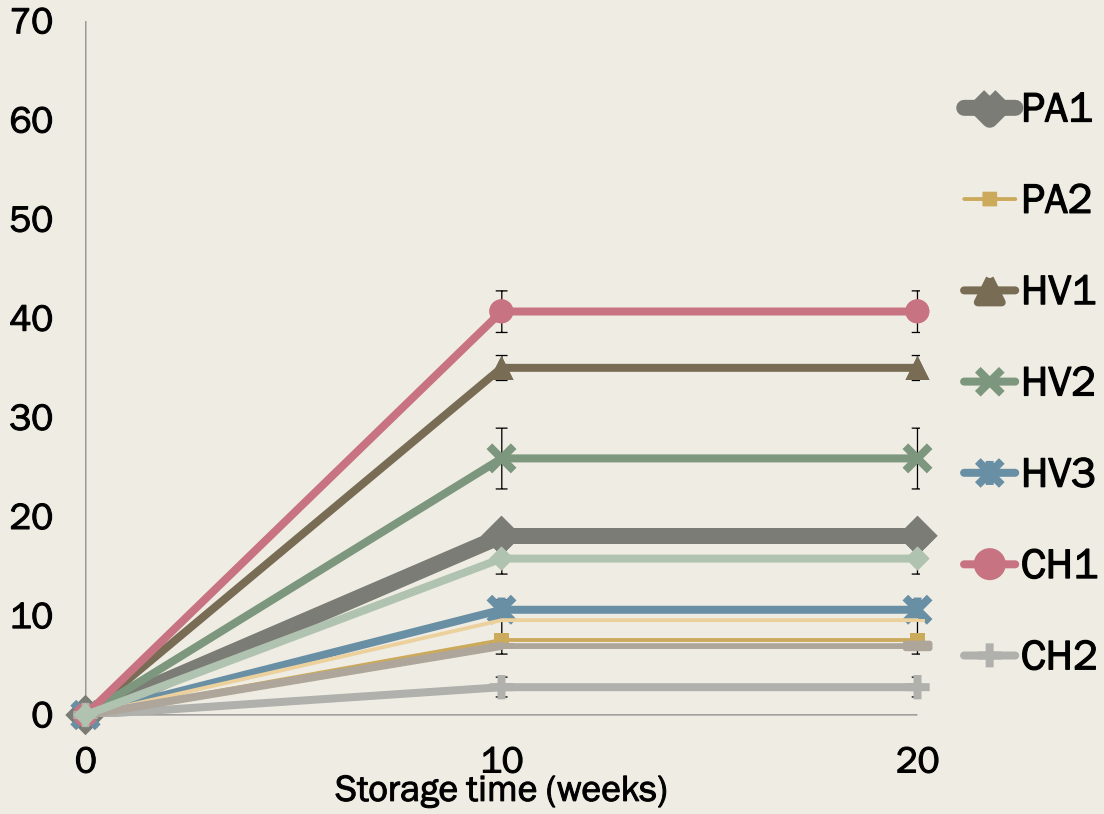
- Bitter pit usually near maximum after a month of storage, but exceptions in PA fruit.
- Soft scald does not become apparent until after 1 month of storage.
- Mineral relationships potentially strong.

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

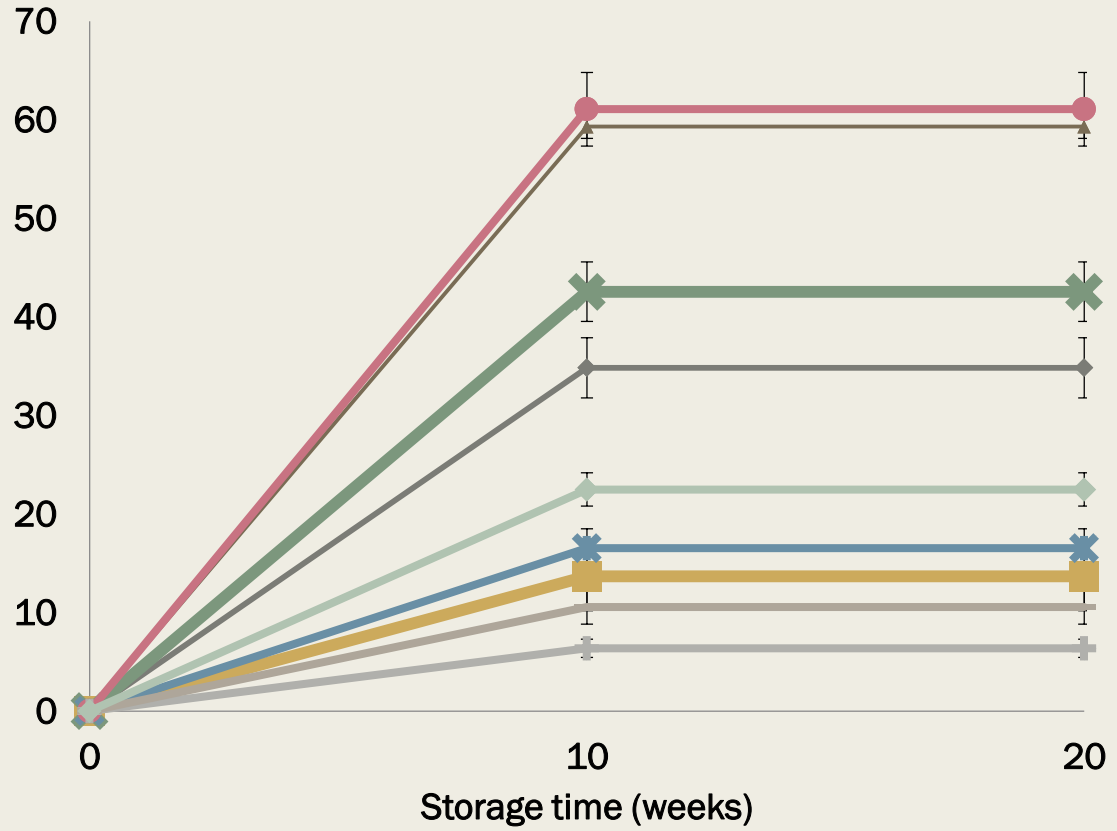
- Honeycrisp apples from PA (2 orchards), HV (3 orchards), WNY (2 orchards), and Champlain (3 orchards).
- Fruit untreated or conditioned at 50°F before storage at 38°F
- Storage for 20 weeks plus 7 days at 68°F

Bitter pit (%) 2014:
38F with and without conditioning

38F



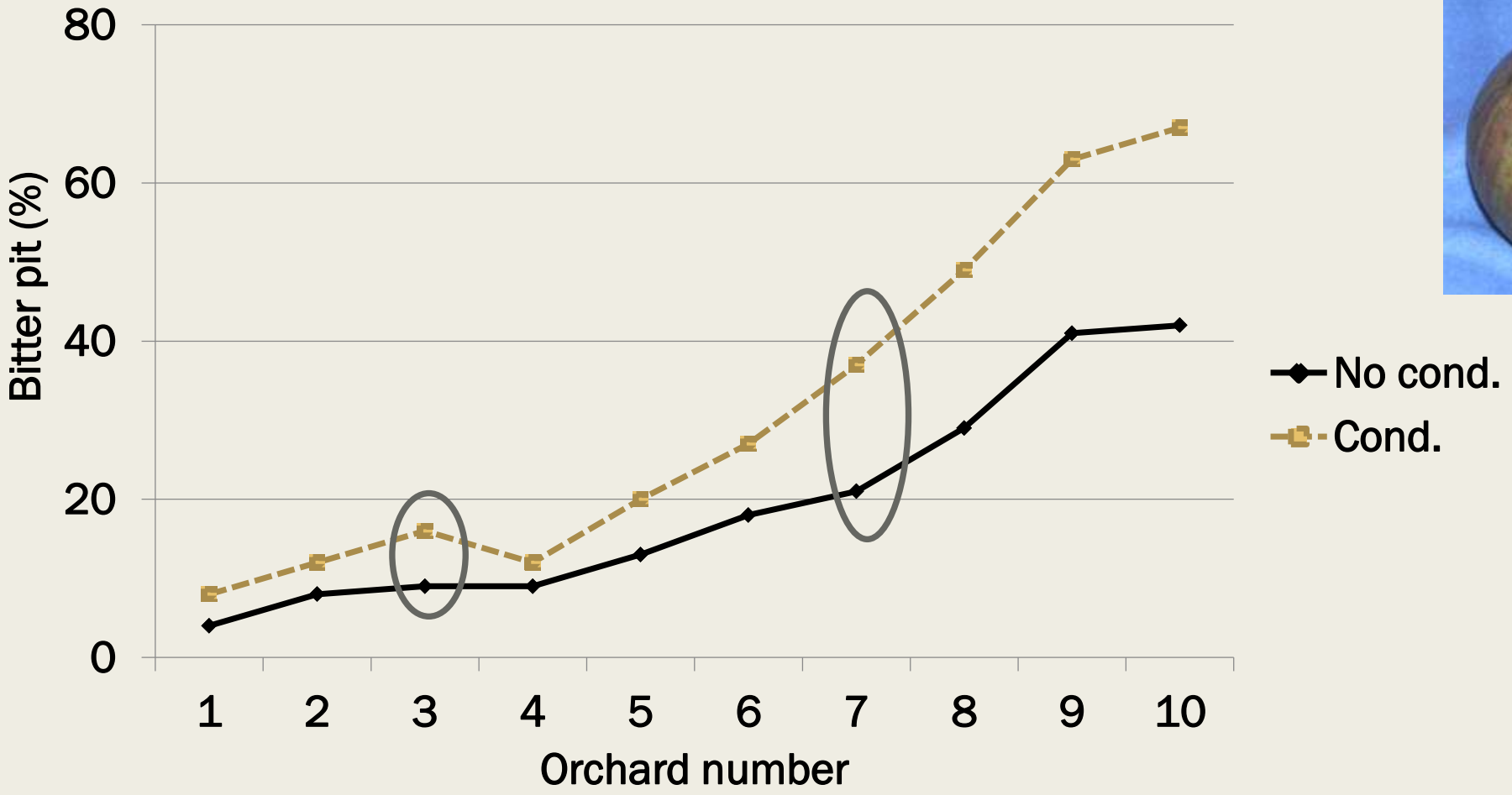
Conditioning + 38F



Effects of conditioning on bitter pit (%) after 20 weeks of air storage

	38°F	Cond. + 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 (%)



Effects of conditioning on soft scald (%) after 20 weeks of air storage

	38°F	Cond. + 38°F
PA1	3.5	0
PA2	0.6	0
HV1	0	0
HV2	7.3	0
HV3	2.2	0
WNY1	4.2	0
WNY2	0	0
CH1	2	0
CH2	3.9	0
CH3	0.2	0
Average	2.4	0

Effects of conditioning on senescent breakdown(%) after 20 weeks of air storage

	38°F	Cond. + 38°F
PA1	28	16
PA2	2	1
HV1	10	7
HV2	3	3
HV3	0	0
WNY1	0	0
WNY2	2	1
CH1	5	2
CH2	1	0
CH3	0	0
Average	5.1	3

Effects of conditioning on skin wrinkling (%) after 20 weeks of air storage [2014/15]

	38°F	Cond. + 38°F
PA1	38	38
PA2	2	0
HV1	0	0
HV2	0	2
HV3	0	0
WNY1	0	0
WNY2	0	0
CH1	0	0
CH2	0	0
CH3	0	0

Effects of conditioning on CO_2 injury (%) after 20 weeks of air storage [2014/15]

	38°F	Cond. + 38°F
PA1	0	0
PA2	0	0
HV1	0	0
HV2	5	4
HV3	1	2
WNY1	6	4
WNY2	0	0
CH1	4	3
CH2	0	0
CH3	0	0

What all our experiments tell us!

- Variation among orchards for both bitter pit and soft scald – recurrent theme
- Conditioning of fruit consistently reduces soft scald development, but aggravates bitter pit development.
- Storage at 38°F can result in higher bitter pit development compared with 33F.
- Lower bitter pit potential results in lower losses due to conditioning

- Other storage problems can occur and may have regional influence.

- Storage of Honeycrisp at 33°F is risky regardless of conditioning *(beyond 1-2 months), but results in minimal bitter pit.*
  - *Off setting risks – which is best?*

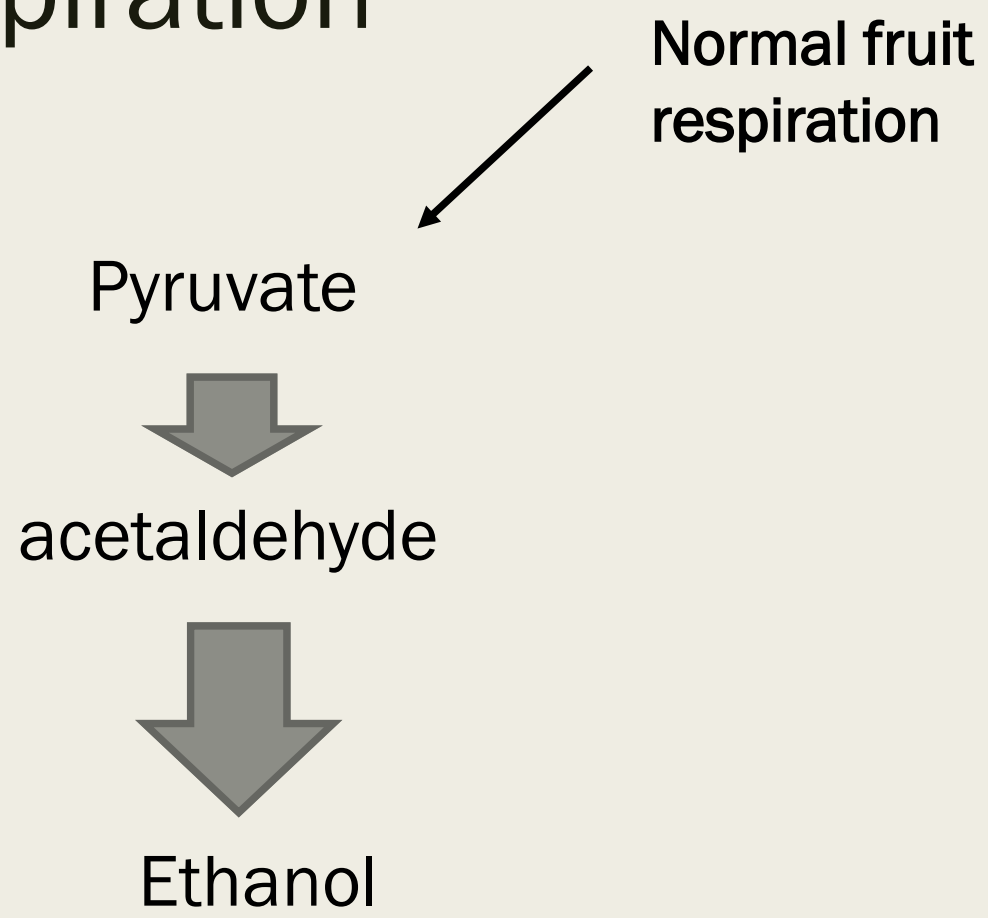
ETHANOL AS A PREDICTOR OF SOFT SCALD

Sometimes little soft scald without conditioning, especially if stored at 38F, but a prediction method might allow storage at 33F as well!

- But always uncertainty about season and fruit maturity

Fermentation flavor common, and ‘taste sampling’ program is a strong recommendation!

Anaerobic respiration



Prediction with and without conditioning

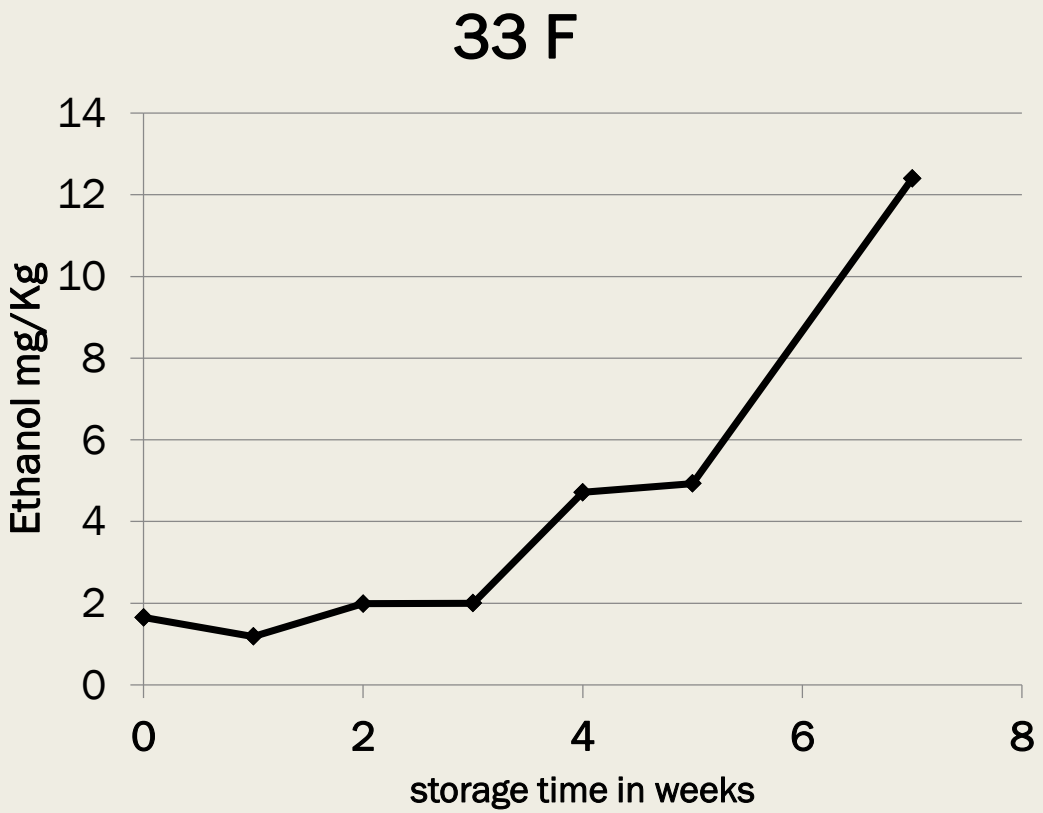
Champlain orchard harvested 9/21/13

33F and 38F with and without conditioning

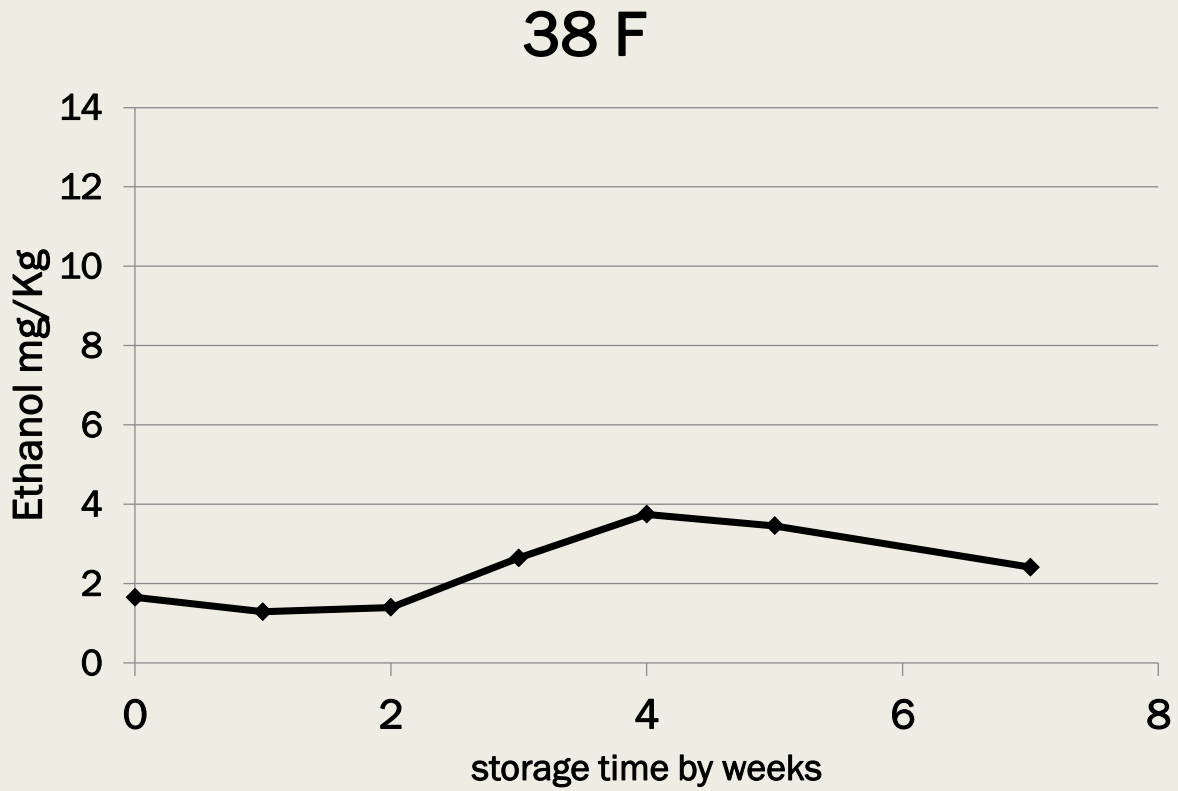
Samples taken during storage for ethanol

Assessed after 4 months plus 7 days at 68F

Ethanol accumulation as an indicator of soft scald? Effect of storage temperature.

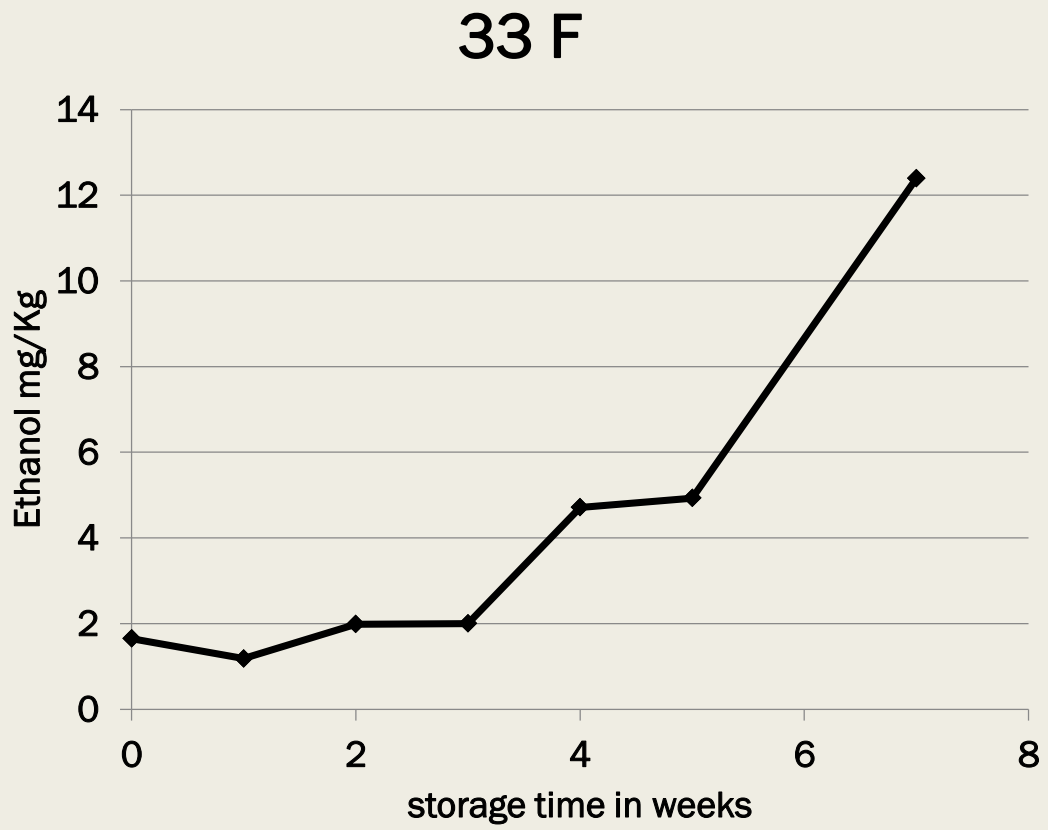


42% soft scald

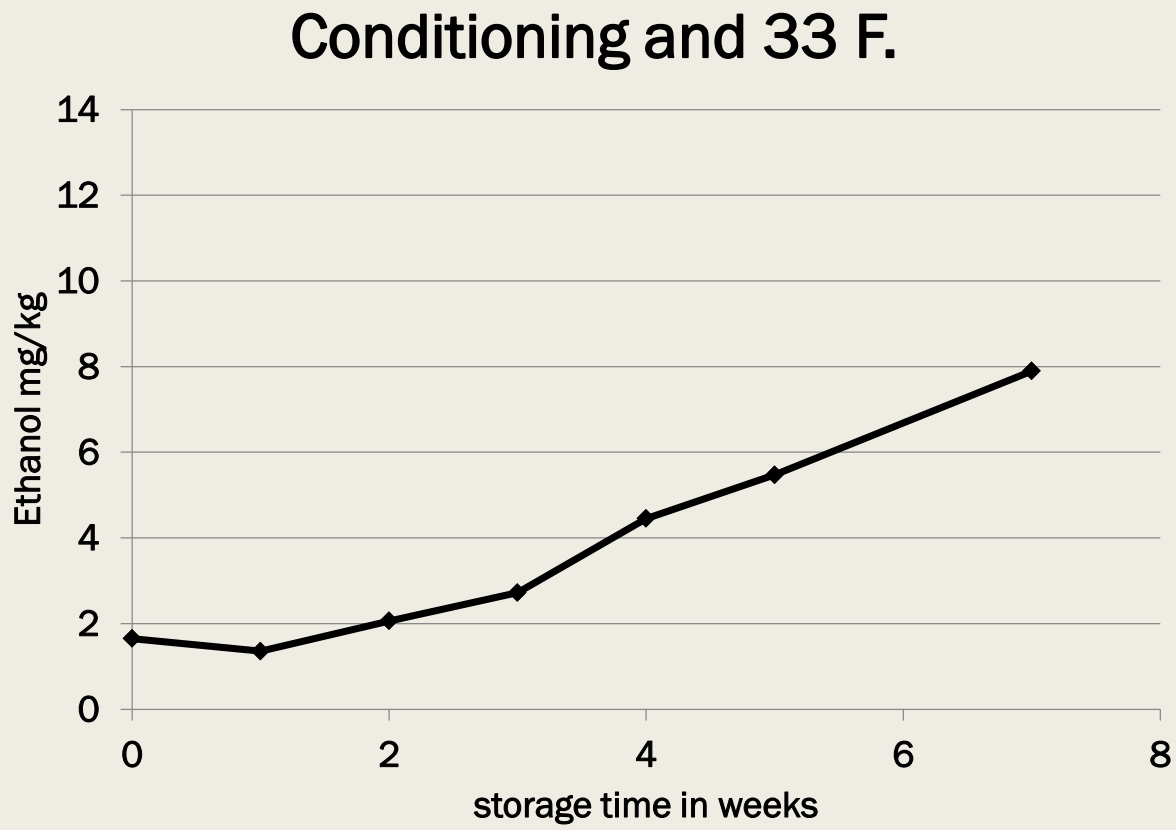


0% soft scald

Ethanol accumulation as an indicator of soft scald? Effect of conditioning at 33F.

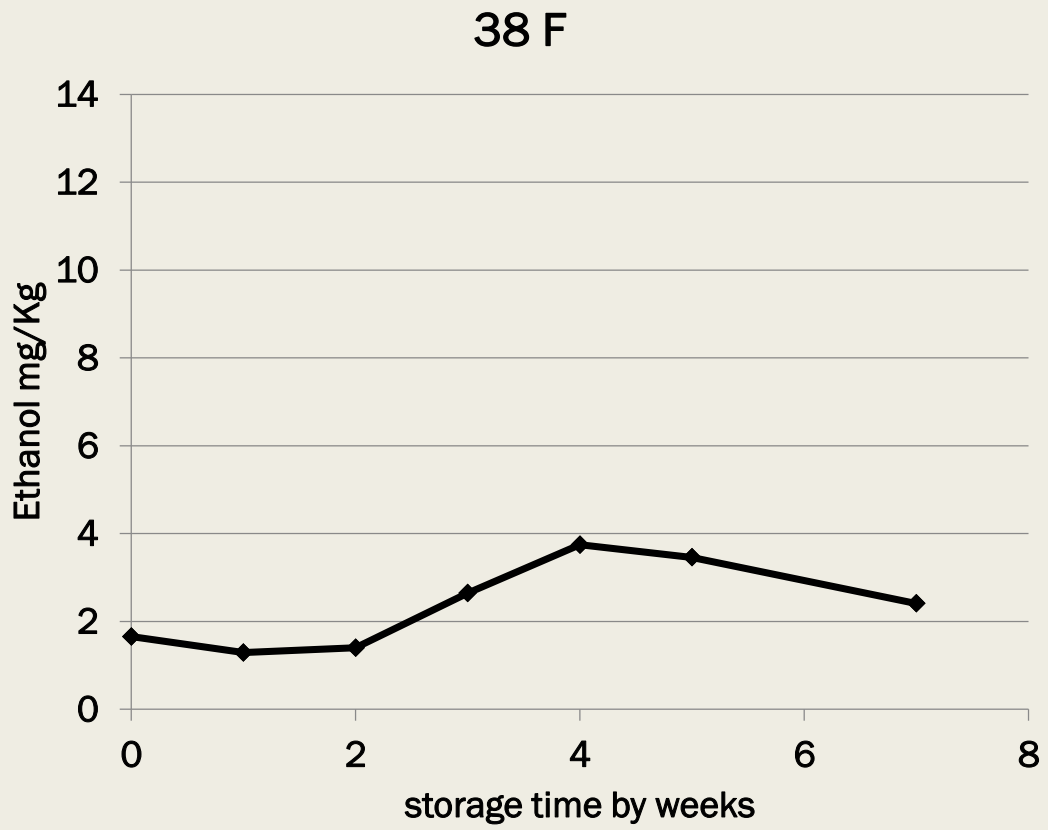


42% soft scald

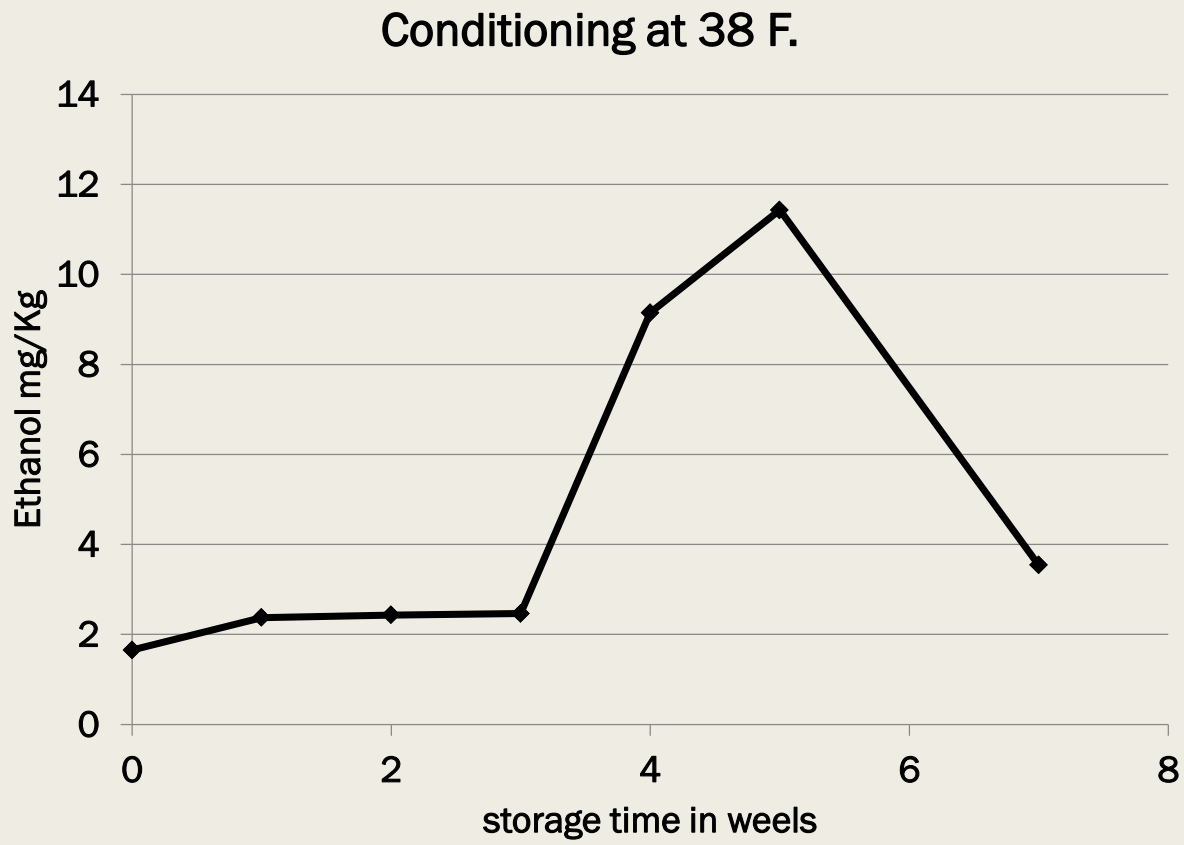


1% soft scald

Ethanol accumulation as an indicator of soft scald? Effect of conditioning at 38F.



0% soft scald



0% soft scald

Soft scald 2014

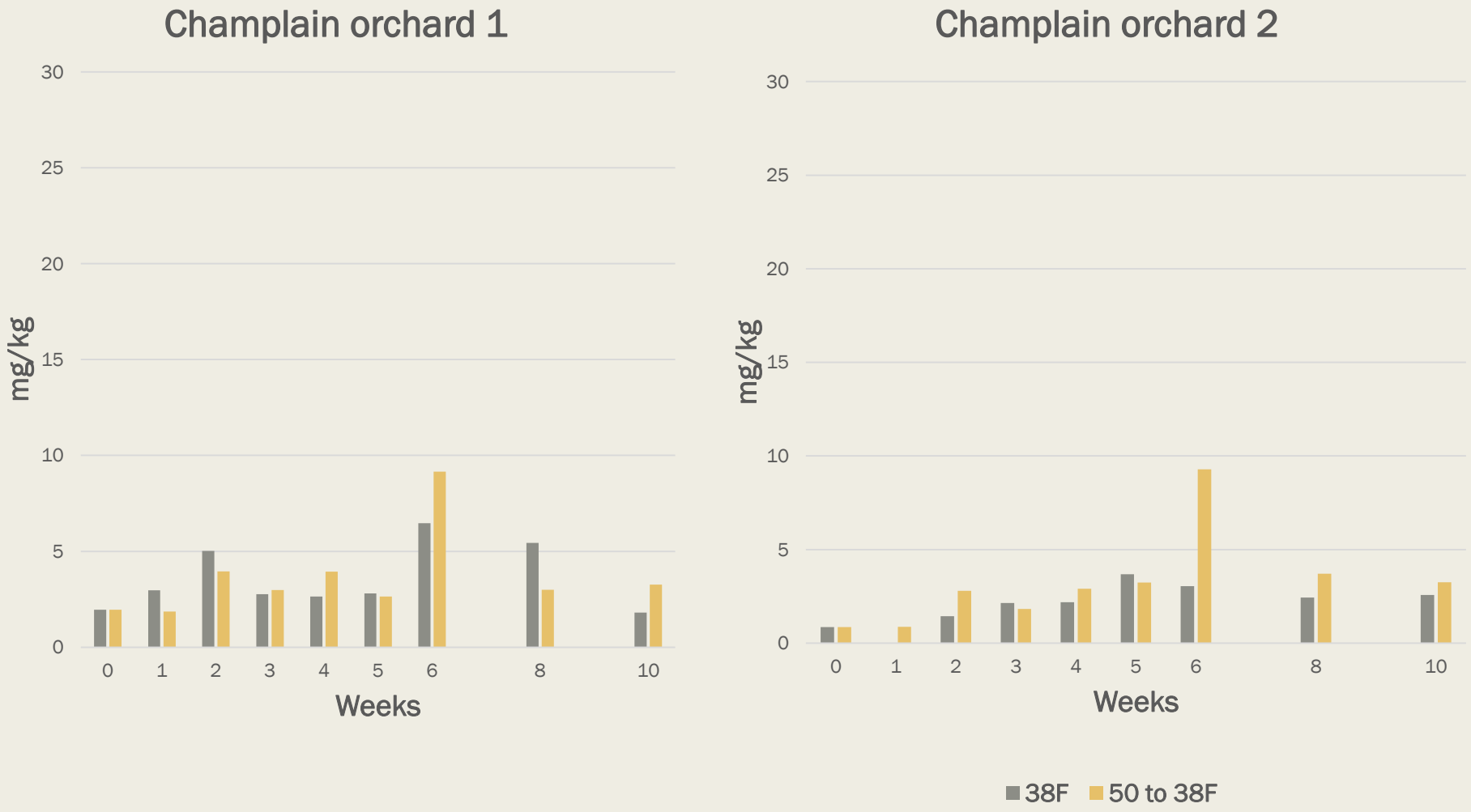
- Project as described before
- 18 orchards in NY, plus 2 PA orchards
- Stored only at 38F!
- Ethanol at intervals
- Soft scald at 10 and 20 weeks

Effects of conditioning on soft scald (%) after 20 weeks of air storage [2014/15]

	38°F	Cond. + 38°F
PA1	3.5	0
PA2	0.6	0
HV1	0	0
HV2	7.3	0
HV3	2.2	0
WNY1	4.2	0
WNY2	0	0
CH1	2	0
CH2	3.9	0
CH3	0.2	0
Average	2.4	0

Overall, low levels

Ethanol - examples



To this year!
Regional trial - 2015

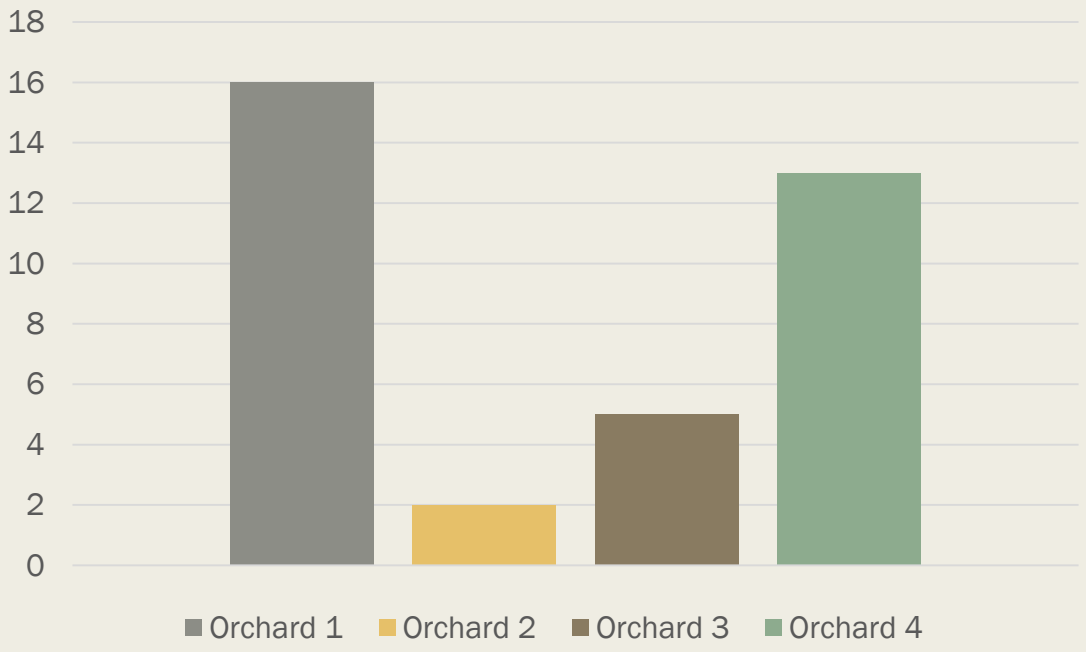
- Fruit from 4 PA, 3 HV, 3 WNY, 3 CH orchard blocks
- 33F and 38F with and without conditioning for 20 weeks
- Data – harvest indices, ethanol at 0, 1, 2, 3, 5 and 10 weeks
- Only PA storage results available – completed last week!

PA 2015 - Harvest indices

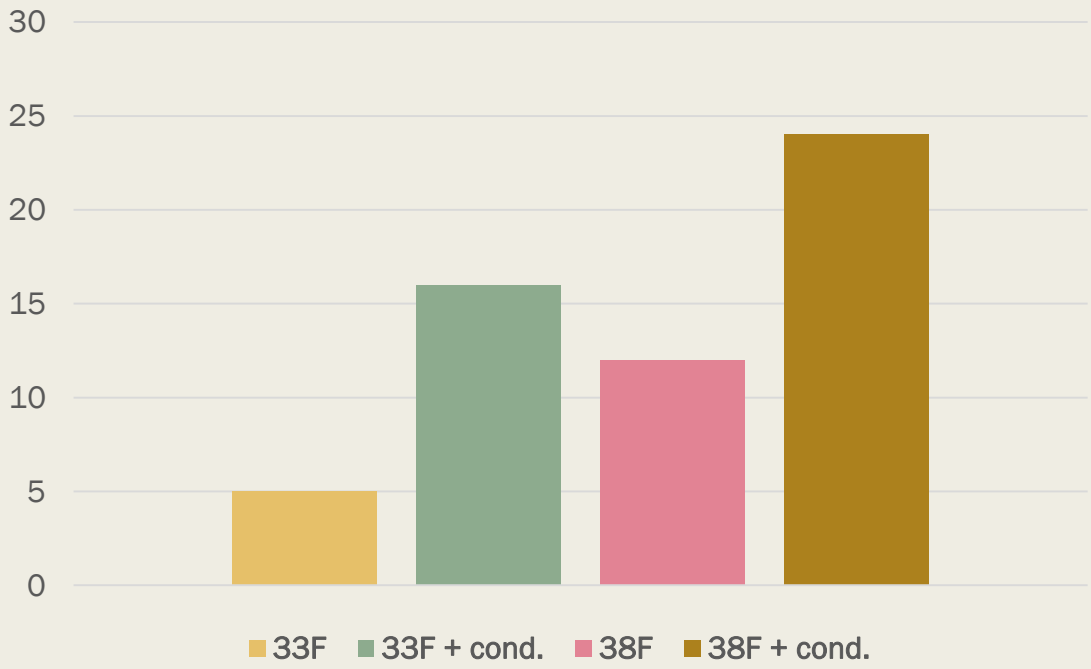
Orchard	IEC (ppm)	Firmness (lb-f)	SPI (1-8)	I_{AD} values	SSC (%)	Acidity (%)
1	22	15.1	6.8	0.47	12.9	0.405
2	14	16.2	7.1	0.35	14.5	0.521
3	41	14.6	7.7	0.64	13.1	0.415
4	21	15.6	7.7	0.27	13.3	0.414

PA harvest 2015 - Bitter pit (%)

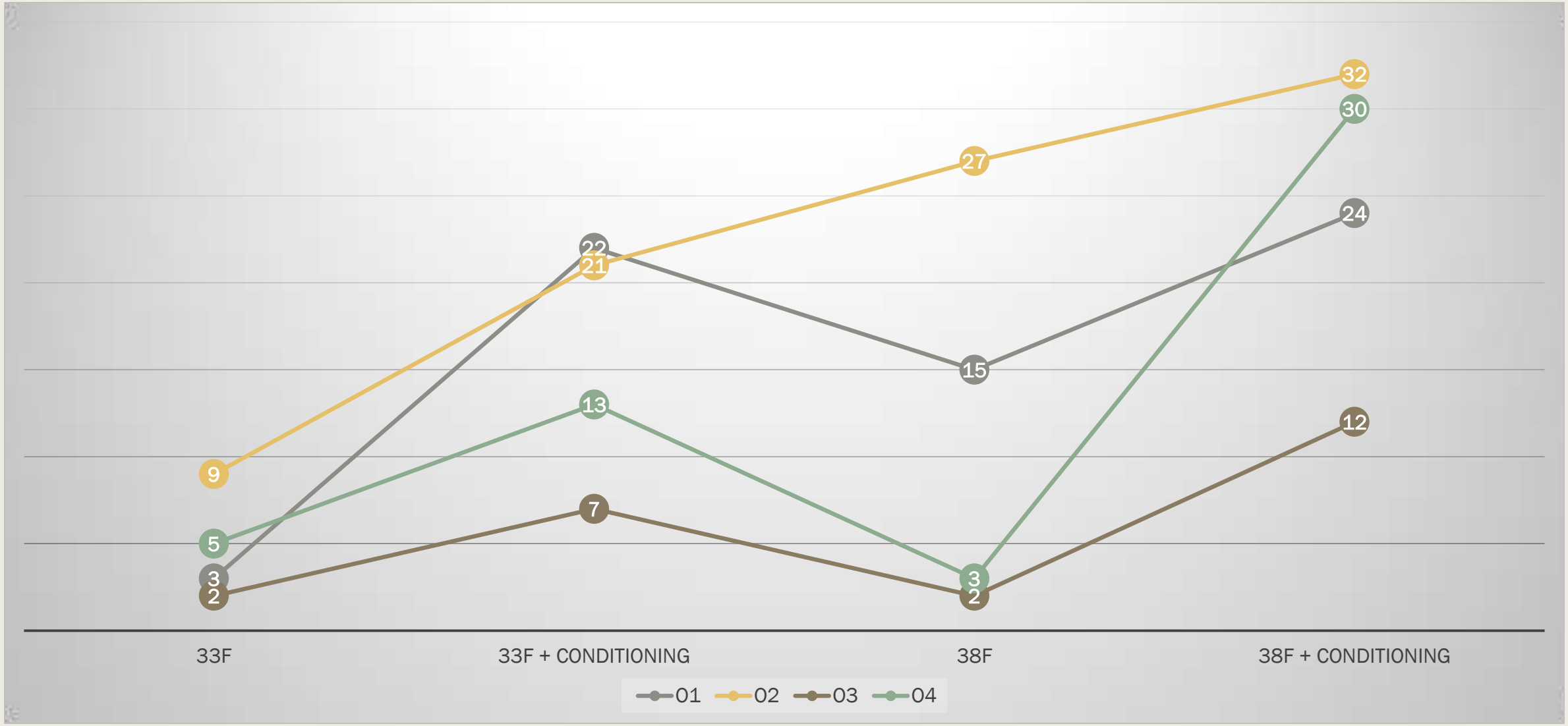
Orchards



Temperature x conditioning

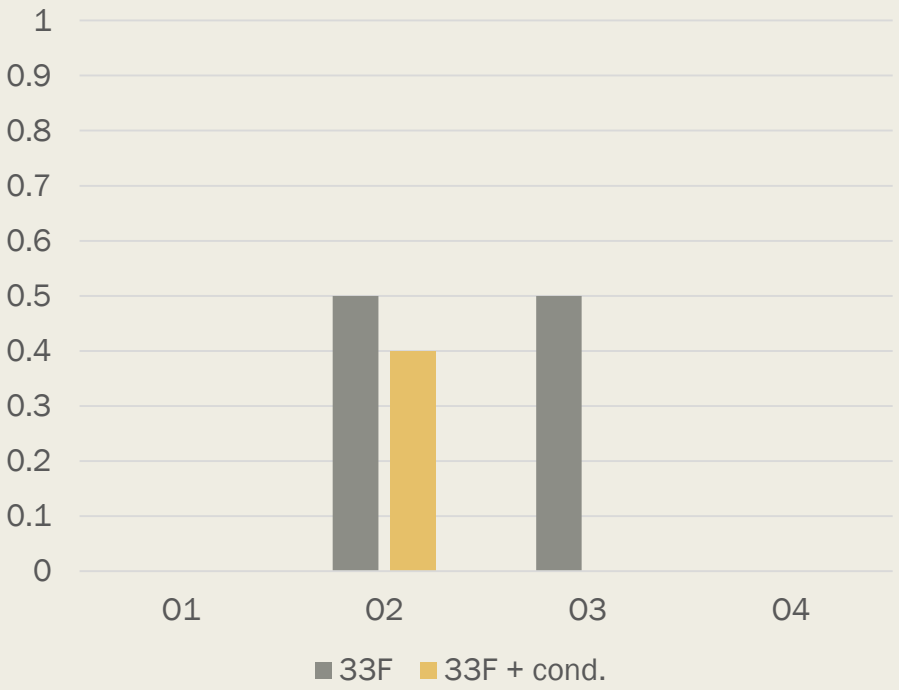


PA harvest 2015 – Bitter pit (%)

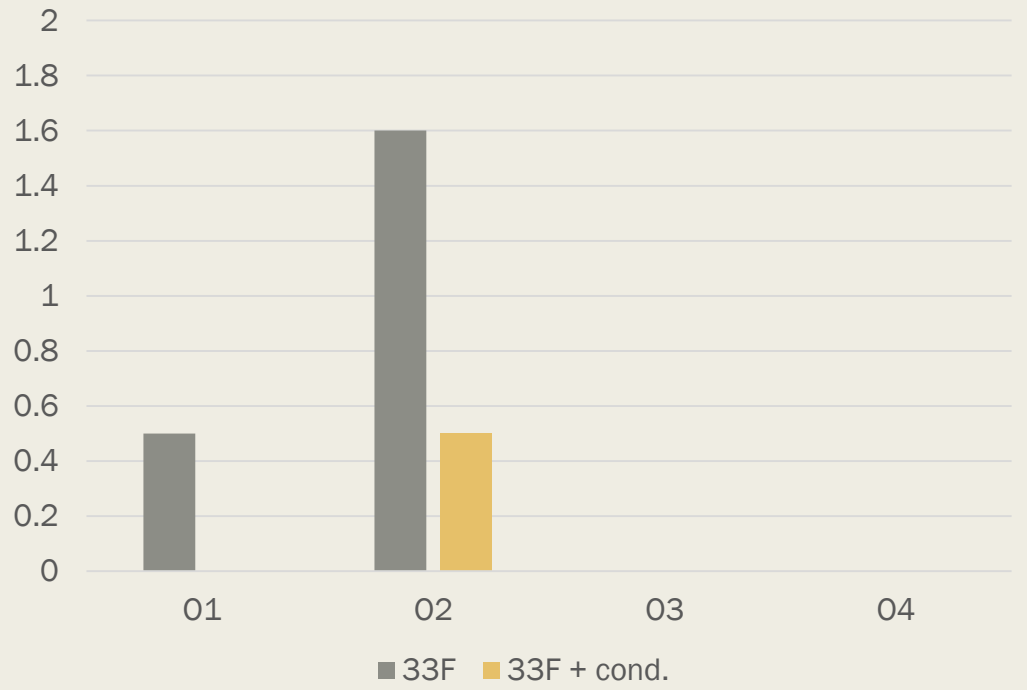


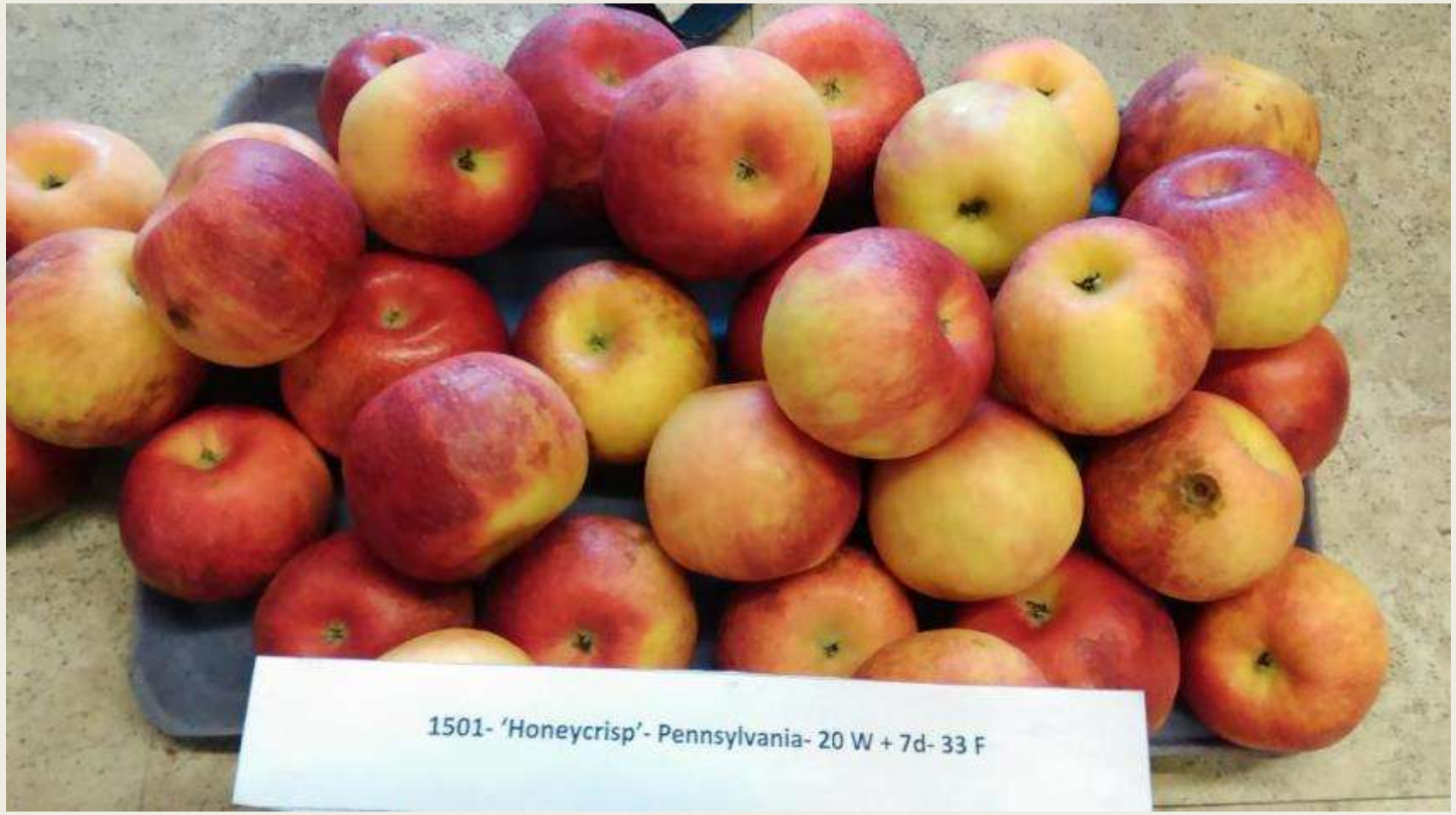
PA harvest 2015 – soft scald and soggy breakdown: only at 33F and trivial levels

Soft scald (%)



Soggy breakdown (%)





Trivial amounts of:
- Senescent breakdown
- CO_2 pockets
- 'Flesh browning' (moist)

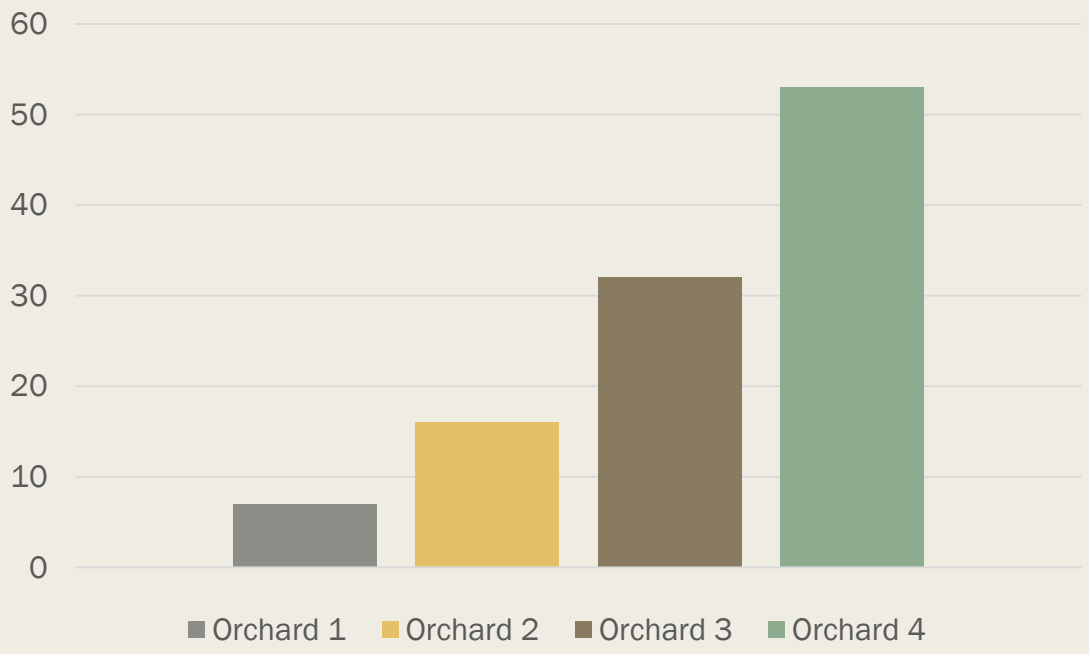
More severe decay at 38F than at 33F

But wrinkly skin

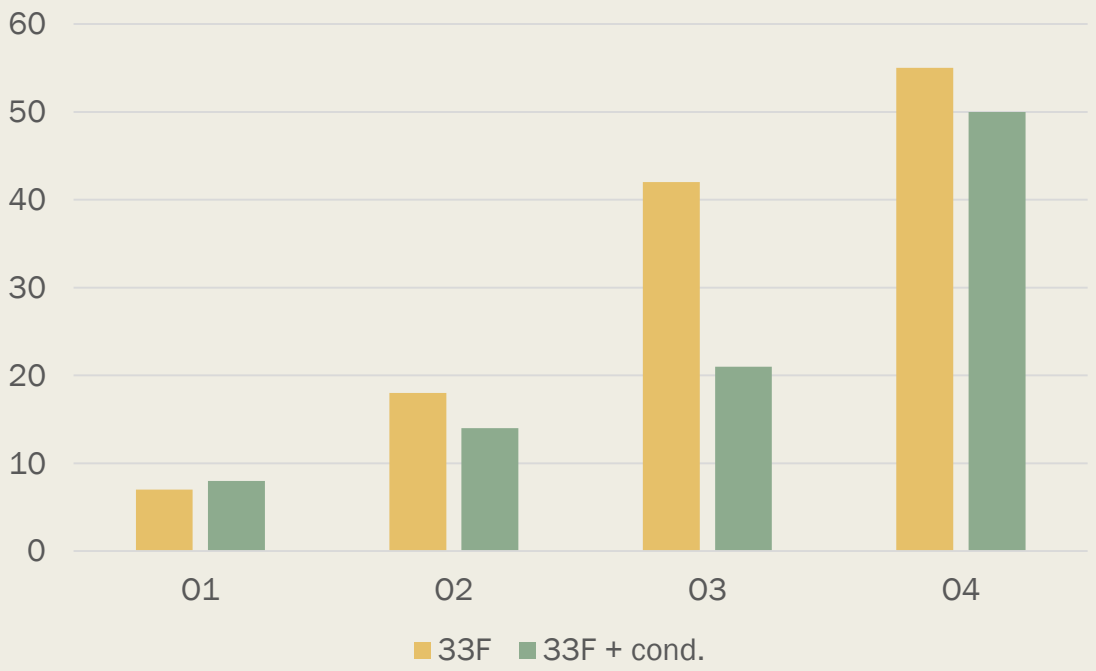

1501- 'Honeycrisp'- Pennsylvania- 20 W + 7d- 33 F

PA harvest 2015 – Skin wrinkling (%) only at 33F (though found at 38F in 2014)

Orchards



Orchard x Temperature x conditioning



PA 2015 - summary

- High bitter pit risk.
- Lowest soft scald risk, but ‘skin wrinkling/browning’ risk higher.
- Should fruit be stored at 33F without conditioning?
  - *What is risk? Is sporadic soft scald worth having if much larger losses from bitter pit can be alleviated?*
- Conservative storage temperature would be 38F (and I’d be willing to say without conditioning except where block history of soft scald)
- Bitter pit management in orchard #1 defense

Overall conclusion

- Honeycrisp represents the most difficult apple to work with
- A series of adventures, with different issues discovered each year!
- Still don’t have firm answers, only lots of speculation!
- If it wasn’t such a great eating experience it would rate as the world’s most disastrous apple ever bred!

CONTROLLED ATMOSPHERE STORAGE

Until now, major reservations about CA storage of Honeycrisp

- High risk of internal CO_2 injury
  - *Variable*
  - *Regional factor – generally worse southern regions*

- Limited urgency because of strong effects of 1-MCP on maintaining quality

Champlain: Untrt vs 1-MCP (air) vs CA – 6 months

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

Orchard variation in susceptibility to CO_2 injury - Orchard variation

CA regime (O_2/CO_2)	#2	#4	#5	#6
1.5/1.5	3	5	18	2
3.0/1.5	3	8	6	1
4.5/1.5	6	5	6	2
1.5/3.0	5	11	26	1
3.0/3.0	9	9	19	4
4.5/3.0	16	8	25	6

Internal CO_2 injury

Two main potential methods of control

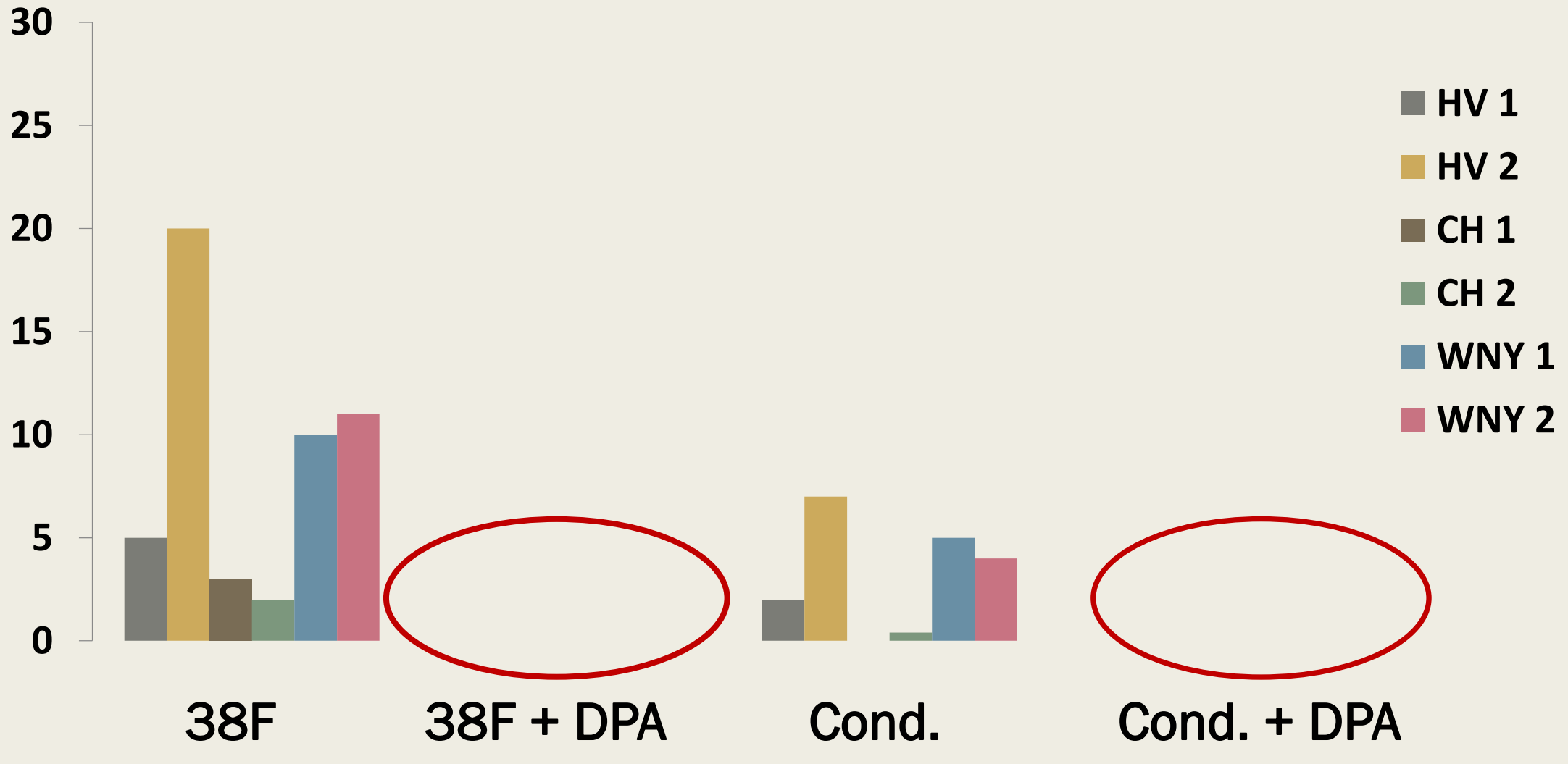
1. DPA

2. Delayed CA

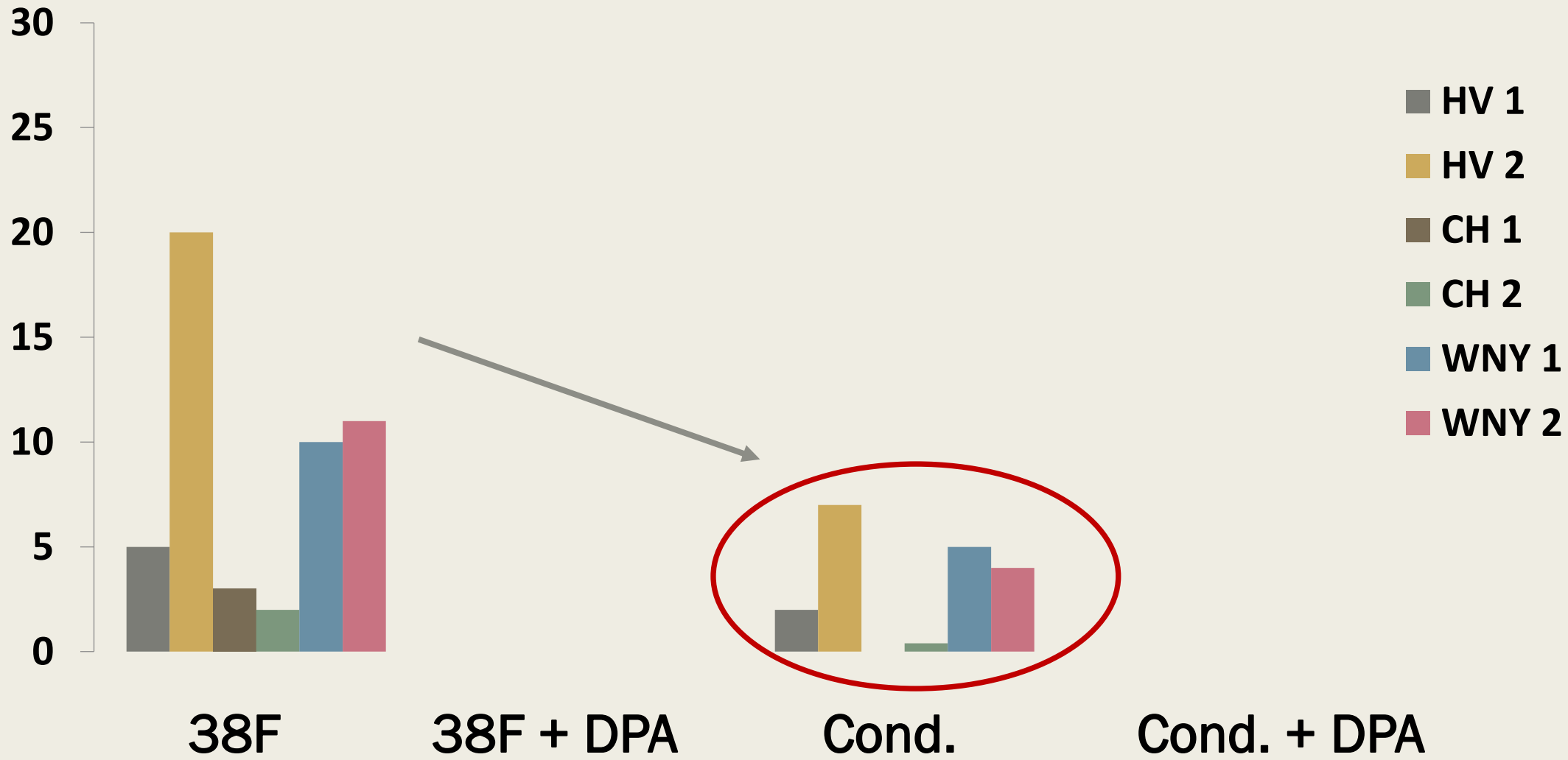
Effects of DPA

- Fruit from 2 orchard blocks in each region - Hudson Valley, WNY and Champlain
- Untreated or treated with DPA at harvest
- No delay, or conditioned at 50°F for 7 days
- CA applied 8 days after harvest
- CA (3% O_2/3% CO_2) at 38°F
- Evaluated after 6 months of storage plus 4 days at 68°F

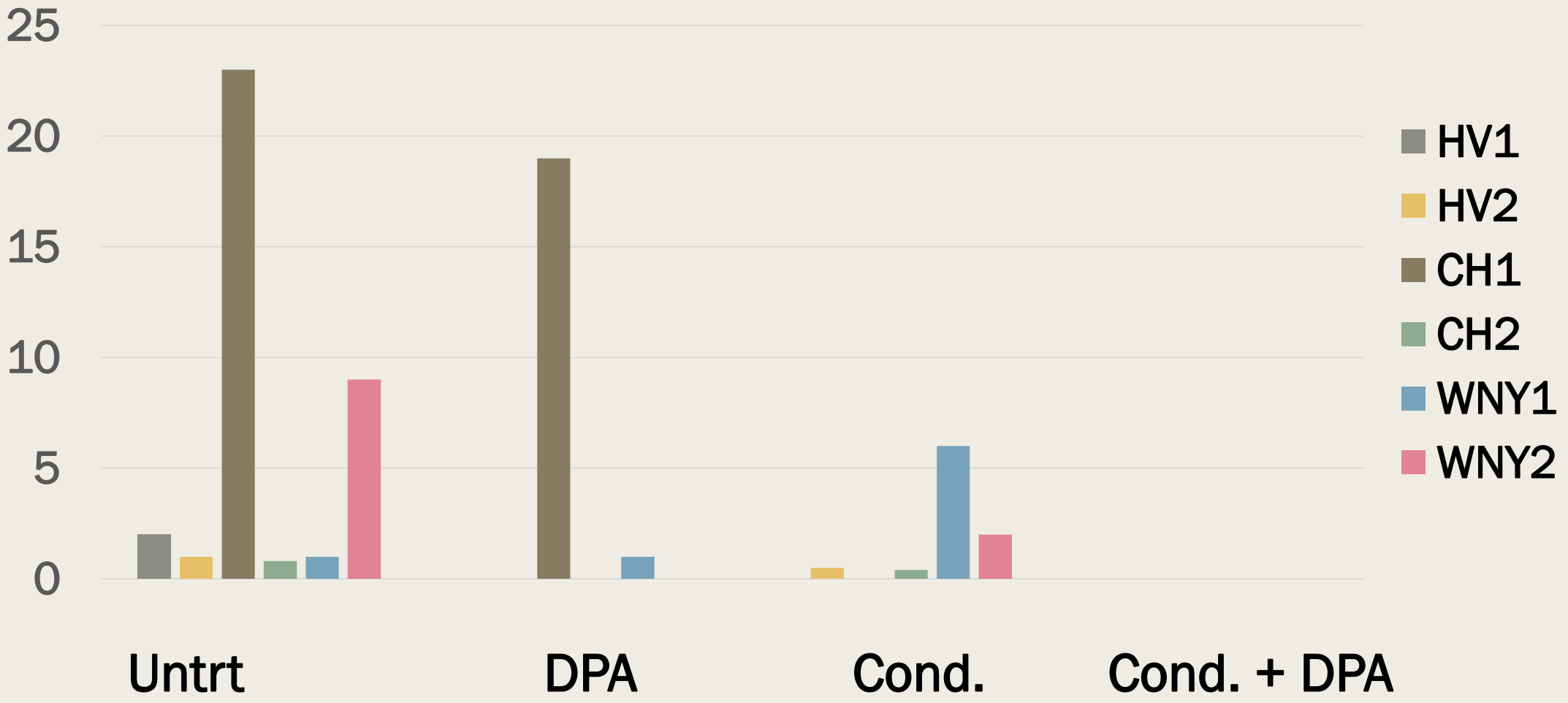
CO_2 injury (%) after storage



CO_2 injury (%) after storage



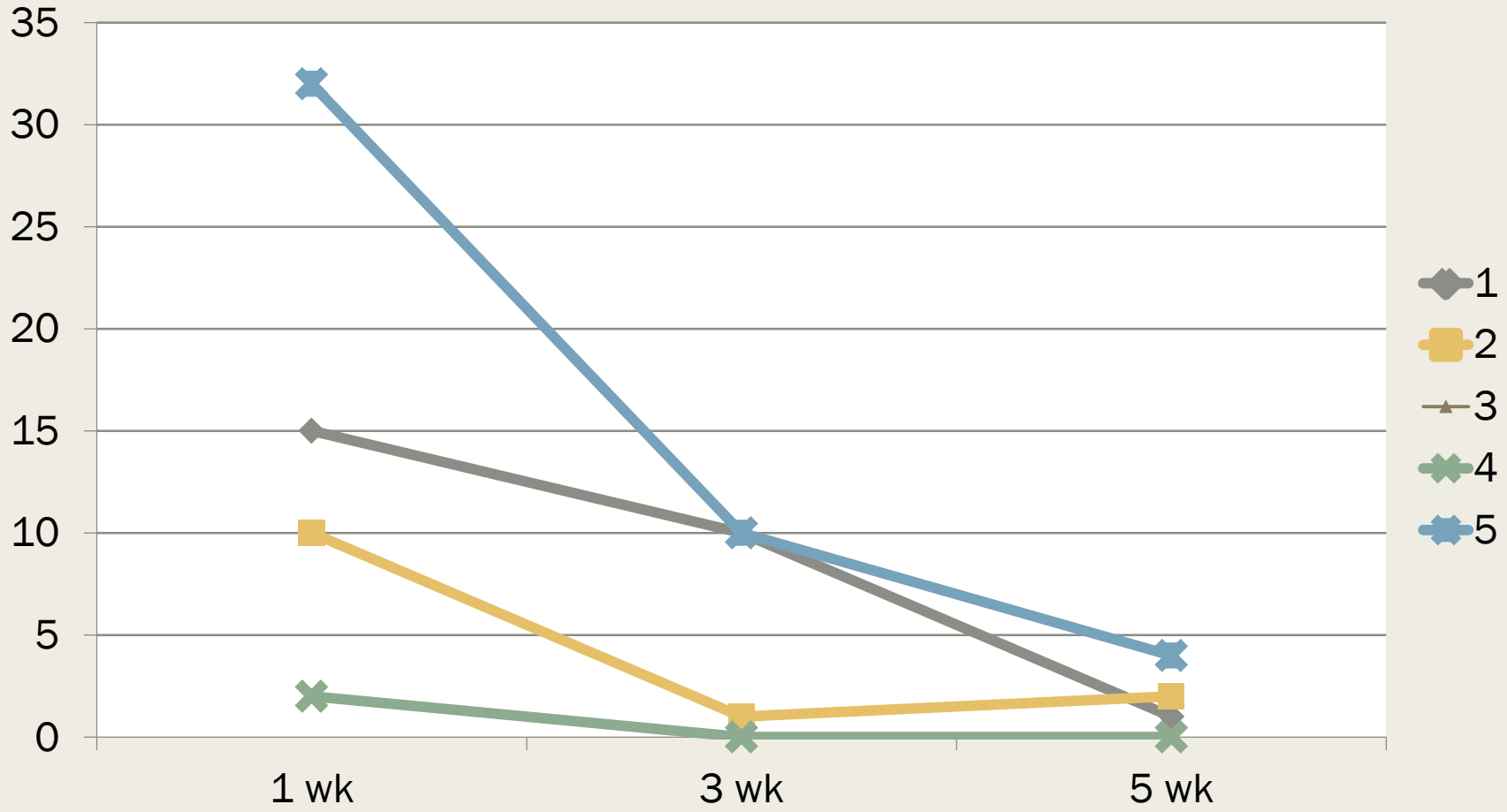
Soft scald (%) after storage – 38F



Effects of delayed CA

- Fruit harvested commercially from 5 WNY orchards on 9/19/2013
- Conditioning
- CA of 3%/3% applied after 1, 3 and 5 weeks at 38F
- Evaluated after 6 months plus 4 days at 68F

CO_2 injury (%) after CA (3%/3%) storage - *1, 3 and 5 week delay*



Negligible soft scald, little effect on bitter pit, small increase in greasiness.
Quality as judged by firmness, acidity, SSC is not compromised

Effects of delayed CA

- Fruit from 3 orchard blocks in each of Champlain and Western NY
  - *Champlain – 9/18*
  - *WNY – 9/24*
- All fruit were conditioned at 50°F for 1 week, with 1-MCP applied 1 or 6 days after harvest.
- Fruit cooled overnight to 38°F and CA applied immediately or after 4 weeks
- CA at 3% oxygen and either 1.5% or 3% carbon dioxide

CO_2 injury and greasiness in CA stored fruit

– CA immediately after conditioning or after 4 weeks at 38F in air

CO_2 injury (%)

Weeks	Champlain	WNY
0	14	32
4	4***	5***

Greasiness (%)

Weeks	Champlain	WNY
0	20	20
4	28**	28***

Core browning and flesh firmness in CA stored fruit

– CA immediately after conditioning or after 4 weeks at 38F in air

Core browning (%)

Weeks	Champlain	WNY
0	2	2
4	7***	4^{NS}

Firmness (lb-f)

Weeks	Champlain	WNY
0	14.7	15.1
4	14.7^{NS}	15.6***

No effects on SSC and acidity

Summary

Delaying CA for 4 weeks after conditioning:

- Markedly reduces CO_2 injury risk.
- Slightly increases greasiness, though ratings still slight.
- Small increased risk of core browning.
- No significant loss of quality – firmness, SSC or titratable acidity.

Overall conclusion

- Probably could avoid CA risk by using 1-MCP with air storage for the foreseeable future.

- If CA storage, conditioning recommended - then two options:

  1. DPA treatment (decay a concern)

  2. Delayed CA – 4 weeks looks pretty good

- CA – 3% oxygen/3% carbon dioxide at 38F.

THANK YOU!
QUESTIONS?