

Harvest Maturity of High-Value Varieties for CA storage

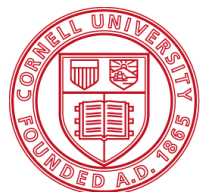


Craig Kahlke
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Cornell Cooperative Extension
Lake Ontario Fruit Program
Western NY Conference
February 9th, 2024



Outline

- Proper Maturity Testing & sampling
- Gala
- Honeycrisp
- Fuji
- NY1 (SnapDragon™)
- MAIA-1 (Evercrisp™)



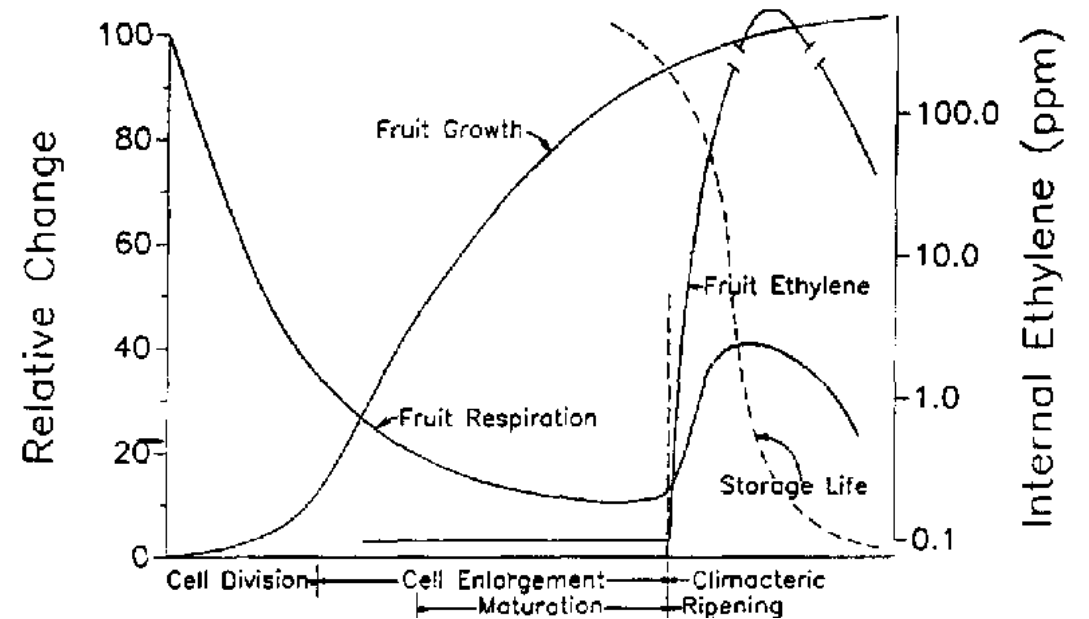
Proper Maturity Testing

- Notebook to record results
- Penetrometer
 - Hand-held devices cost ~\$350-\$800
- Refractometer
 - Eyepiece models cost ~\$125
 - Digital models cost ~\$350
- Iodine Solution
 - For LOF, \$10/pint, \$40/gallon
 - Starch charts included



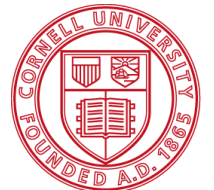
Harvest Maturity

- Early harvest – long term CA, under-ripe fruit, full flavor potential usually not fully realized, but fruit to market when demand high
- Late harvest – near tree-ripened flavor, but short storage life and marketing window
- Both ends of the spectrum (any everything in between!) can have storage disorders



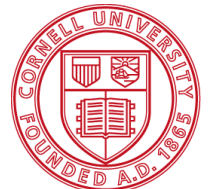
Maturity & Quality Indicators

- Firmness (measured with a penetrometer, in lbs/square inch)
- Total soluble solids (TSS) or brix, or % sugars (measured with a refractometer)
- Starch Pattern Index, or starch iodine test, (read with a chart)
- Color (measured by hand-held equipment in the field, or packing house sorters or roughly visualized by eye)
- Internal ethylene concentration (measured in ppm with a gas chromatograph) – limited to regional harvest maturity programs
- Delta Absorbance (DA) Meter (measured in units as the chlorophyll remaining in the peel)



Proper Sample Collection

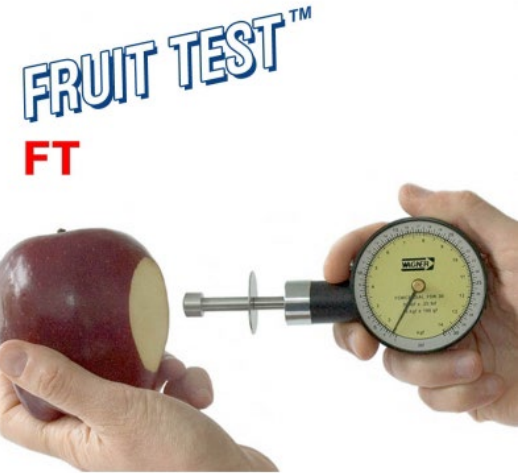
- Pick 11-12 apples from across a block, from the same variety
- If this is a single pick variety, randomly choose the apples
- If this is a multiple pick variety, choose the apples nearest the next pick
- Do not pick overripe apples (insect or disease damaged, bitter pit, etc.)
- Label bag with variety, farm, block, date, time
- Choose 10 to test



Firmness Testing with a Penetrometer

- Follow manufacturer instructions
 - Peel on both sides of apple (sunny vs shade)
 - Use consistent pressure if a hand-held device
 - Always test against a hard surface
 - Average readings from both sides, and all 10 apples
 - Try to collect the juice for brix testing

Not correct technique! ↘



Brix (% Total Soluble Solids or sugars) Testing with a Refractometer

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- Collect juice from 20 apple punches from refractometer testing
 - Alternatively, you could slice pieces of flesh (no skin) and press into juice with a garlic press
- Follow manufacturer's instructions
 - Pour juice in device and look through eyepiece to read in analog models
 - Pour juice and press button to get reading in digital hand-held models
 - Average readings from both sides, and all 10 apples
 - Rinse between samples with distilled water



Starch Pattern Index (SPI) AKA Starch-Iodine Test

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- Measures starch (purple) to sugars (white/clearing) conversion
- Highly variable with seasonal weather patterns
- Is positively correlated with internal ethylene concentration & DA meter
- In many instances, a range of SPI is recommended for harvest for CA
- More important is the rate of change



Starch Pattern Index

- Cut 10 fruit from a block, spray one of the halves of each with the iodine solution
- Wait 30-60 seconds
- Read with the use of charts
- MSU/SCS has new charts for most varieties
 - Available for free download or to purchase hard copies

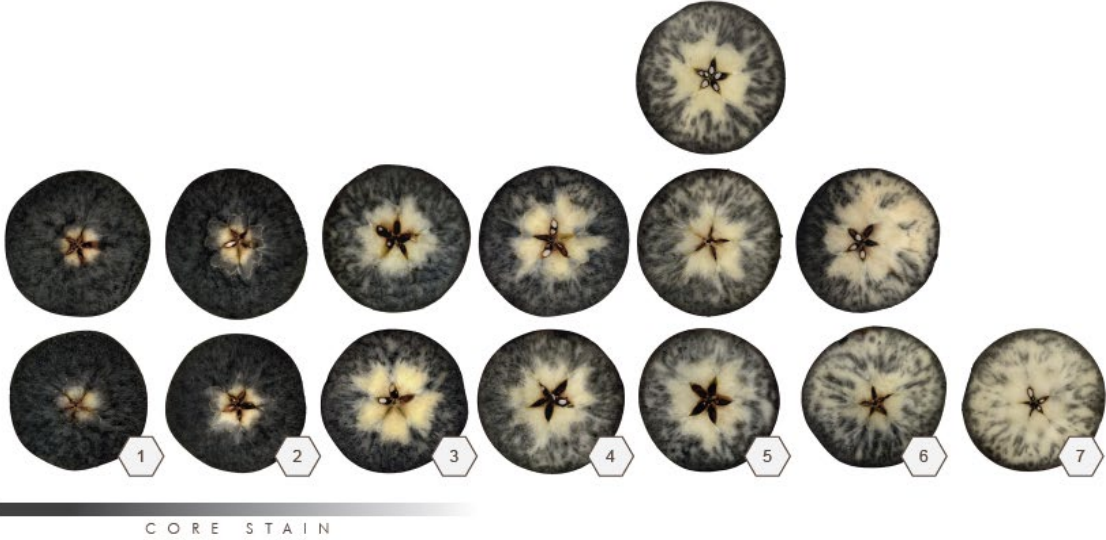


Starch-Iodine Test from Storage Control Systems & MSU

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STARCH INDEX SCALE v1.0

EMPIRE



TESTING INSTRUCTIONS

- Collect a sample of apples from the orchard. Maturity tests should be performed on at least 10 fruit to represent the average in the block. Samples should be at least room temperature for best results.
- Stain apples as soon as possible after samples have been collected. Use an iodine solution of 10g I₂ and 40g KI per gallon.
- Cut apples in half at the equator. Immediately dip, spray, or roll starch solution on cut surface.
- Wait for pattern to develop, which may be several minutes, but rate sample within 20-30 minutes before cut surface of fruit turns brown.
- Compare each fruit with patterns in this chart and record the corresponding starch value.

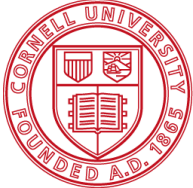
FIRMNESS (POUNDS)	14	SHORT CA
	15	MID CA
	16	LONG CA
STARCH INDEX	2	OPTIMAL CA
	3.5	MATURE
	6	OVER MATURE

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MICHIGAN STATE UNIVERSITY
Photos & Development by the Michigan State University Apple Maturity Program
Contact: Randy Beaudry · beaudry@msu.edu



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Fruit Color

- Highly dependent on weather patterns at fruit ripening
- Sunny/cooler days and cool clear nights favor ideal color development
- Cloudy/warm weather (day or night) lead to subpar color
- Warm cloudy days or warm nights can negate the effects of good color



DA Meter

- Is correlated with internal ethylene production and SPI
- Expensive (~\$5000)
- Can do on-tree non-destructive measurements
 - But you have to be very careful to avoid errors associated with light exposure
- LOF is measuring all apples with a DA meter to develop a database
- May be a useful tool, but studies need to be done to follow fruit and evaluate % packout and disorder incidence



Gala

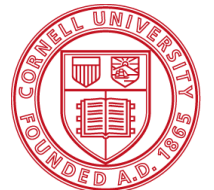
- Small Fruited, difficult to thin
- Manage crop load for target fruit size using PACMAN
- Multiple picks
- Reduce picks with ReTain™ or Harvista™
- Color requirements for Extra fancy – plant newer strains



Gala

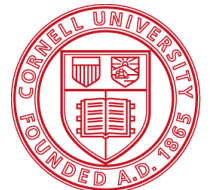
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- Internal ethylene production does correlate with DA readings for maturity
 - But IEP not a tool for predicting when to pick
- Firmness & brix rarely issues
- Varietal flavor & background color change is the main harvest maturity indicator
- In concert with acceptable flavor, Gala for long-term CA storage should be picked when the background color is changing from light green to cream. Fruit intended for short term CA or regular storage should be picked with cream to light yellow background.
- DA Meter can be useful for determining harvest for longer term storage



Gala – Harvest Maturity

- Multiple picks, PGR's may reduce the number of picks
 - Gala harvest can stretch ~ 3 weeks
- Later picks- questionable storage quality
- In heat-stressed seasons, storability may turn from good to poor quickly
 - PGRs don't necessarily help



Gala – Harvest Maturity

- Timing of Gala harvest and maturity indicators can vary from year to year in NY – especially since so much Retain and Harvista is used
- For mid to long CA storage, target fruit greater than 17 pounds firmness, with a SPI of approximately 2-3.5, though SPI can be highly variable in Gala, even in same block
- Brix > 12% for all markets



Gala – SPI

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STARCH INDEX SCALE v1.0

GALA



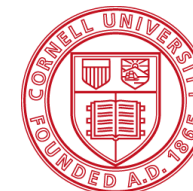
TESTING INSTRUCTIONS

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- Stain apples as soon as possible after samples have been collected. Use an iodine solution of 10g I₂ and 40g KI per gallon.
- Cut apples in half at the equator. Immediately dip, spray, or roll starch solution on cut surface.
- Wait for pattern to develop, which may be several minutes, but rate sample within 20-30 minutes before cut surface of fruit turns brown.
- Compare each fruit with patterns in this chart and record the corresponding starch value.

FIRMNESS (POUNDS)	16	SHORT CA
	17	MID CA
	18	LONG CA
STARCH INDEX	2	OPTIMAL CA
	3	MATURE
	6	OVER MATURE

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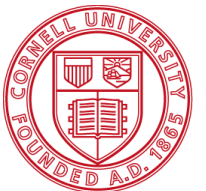


Gala Recommendations from Dr. Chris Watkins

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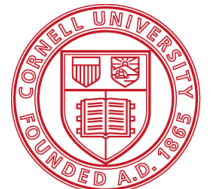
Recommendations to control browning

- Maturity is important. Fruit should be harvested when SPI is <4.0 and when I_{AD} values (DA meter) are > 0.4 .
- PGRs applied at the correct timings are critical for long term storage of Gala apples. Do not store Gala without PGR treatment for more than 4 months.
- Store Gala at 38°F (will benefit fruit without PGR treatment).
- Postharvest 1-MCP is recommended.
- 5% oxygen and 1% CO_2 recommended for long term storage.
- 2% oxygen and 1% CO_2 for standard CA.



Gala – Maximizing Grower Returns

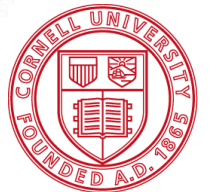
- Target fruit size/yield early
 - Use precision crop load management
 - Monitor maturity closely – every 2-3 days
 - Maturity can change practically overnight in stressed trees with or without PGR's
 - Earlier harvest better
 - Late harvest
 - Greasiness, increased risk of internal flesh browning



Honeycrisp

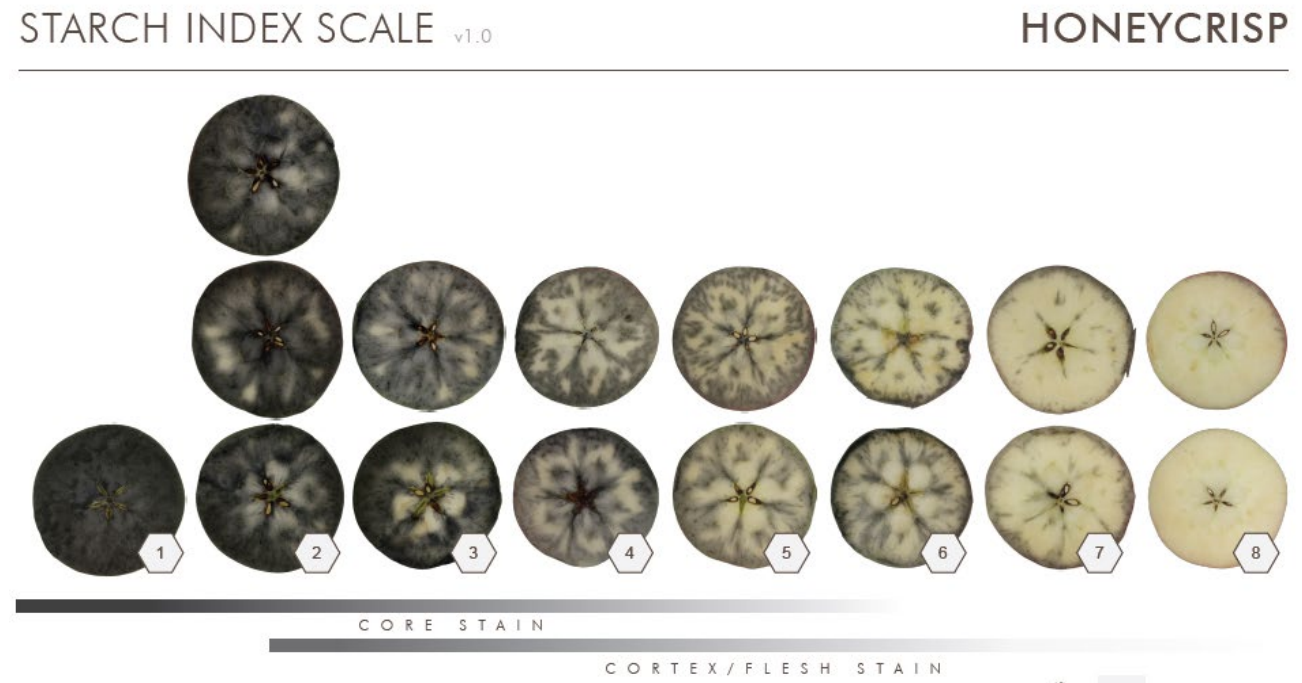
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- Internal ethylene production does NOT correlate with maturity
- Firmness & brix rarely issues
- Varietal flavor & background color change is the main harvest maturity indicator
 - In concert with acceptable flavor, look for color that “jumps out” when the yellow background color makes the red almost florescent or iridescent.
- A multiple pick variety, PGR use can help
- Color requirements for Extra fancy – plant newer strains



Honeycrisp Harvest Maturity - SPI

- Starch patterns in HC are different than most other varieties
 - Tend to ripen in cortex first
 - MSU had a chart that was specifically for Honeycrisp on a 1-6 scale
 - I'm going to push the new MSU-SCS chart
- Target an SPI of 3.5-5 for long to mid-term CA
- Firmness > 14 lbs
- Brix > 13%



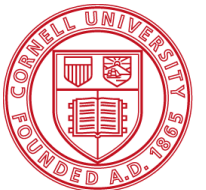
Honeycrisp Harvest Maturity – WA

- Titratable Acidity (TA) is an important component of HC acceptability
- Sending samples to QC lab
 - Background color, firmness, SPI, TSS
 - Brix/Acidity Ratios (ATAGO pocket kit), auto titrator, with test strips used for grapes
 - $<.4$ TA – sell by Xmas
 - $.4-.6$ – length of storage determined when factor in CL, vigor, variation in orchard blocks, etc
 - $.6$ – pretty much can store 10-12 months



Honeycrisp – Maximizing Grower Returns

- Manage crop load and vigor early to reduce biennial bearing and bitter pit
 - Use PACMAN with new technologies
- Sample early with peel sap model for bitter pit prediction
- Sample late with passive model for bitter pit prediction
- Monitor maturity closely – every 2-3 days
 - Color change can happen practically overnight
 - Late harvest
 - Greasiness, increased risk of soft scald/soggy breakdown
- If low bitter pit risk, condition at 50F for 7 days, then to 38F



Honeycrisp Recommendations from Dr. Chris Watkins

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Conditioning

Keep fruit at 50°F for 7 days and then store at 38°F.

- Conditioning increases risk of bitter pit development but will decrease soft scald risk.
- The use of PGRs (ReTain and Harvista) alone:**
- Slight benefit on firmness, and greener fruit with repeated and double rates.
- Can maintain bitter pit susceptibility because it delays fruit maturation. Therefore, PGR use is not recommended in orchard blocks that are predicted to have high bitter pit risk.
- Decreased risk of soft scald development.

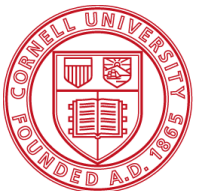
1-MCP alone

- Maintained higher acidity.
- Decreased bitter pit, senescent breakdown.
- Increased leather blotch in fruit treated with PGRs.
- Increased core browning.

Preventing CO₂ Injury in CA Stored Honeycrisp

If CA/DCA storage, conditioning at 50°F for one week recommended -then three options:

- 1.DPA treatment
- 2.Delayed CA/DCA –4 weeks looks pretty good
- 3.Maintaining very low CO₂ (<0.5%) levels in the storage.



Fuji

- High vigor
- Biennial bearing
- Control vigor
- Thin aggressively, start early
- Usually a 1 pick variety



Fuji – Maturity & Quality Indicators

- internal ethylene production correlates with maturity
- Firmness rarely a problem with Fuji
- Total Soluble Solids rarely a problem
- Color variable
- Varietal flavor & background color change is the main harvest maturity indicator



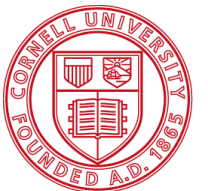
Fuji – Harvest Maturity

- Timing of Fuji harvest and maturity indicators are very even from year to year in WNY – peak is 3rd week of October
- For mid to long CA, target fruit greater than 16 pounds firmness, with a SPI of approximately 4-5
- Brix > 12%



Little Year-to-Year Variation in Maturity

Index	Oct. 15-16, 2018 n=6 untreated		Oct. 16-17, 2017 n=11 untreated		Oct. 17-18, 2016 n= 16 untreated		Oct. 12-13, 2015 n= 8 untreated	
	Average	Range	Average	Range	Average	Range	Average	Range
Firmness (lb.)	17.2	16.5-18.6	17.3	15.6-18.9	17.8	16.1-19.3	18.6	16.7-20.3
Soluble Solids (%)	14.4	12.4-15.4	13.9	11.7-16.1	14.1	9.5-16.6	13.4	9.5-16.1
Starch Pattern Index (SPI)	5.0	4.1-5.9	4.8	3.2-5.7	4.8	3.6-6.6	3.9	2.7-5.0
Producing > 0.5 ppm ethylene	3/59 apples (6%)		20/100 apples (18%)		35/160 apples (22%)		27/80 apples (34%)	



NY1 (SnapDragon™ as packed fruit)

- Low vigor, rootstock selection and correct spacing important
- Most likely a 2 pick variety
- Does not have the leaf chlorosis and bitter pit susceptibility of its Honeycrisp parent



NY1 – Maturity & Quality Indicators

- Internal ethylene correlates with maturity
 - However, there is no exponential rise
- Firmness rarely a problem
- TSS rarely a problem
- Color variable
- Varietal flavor & background color change is the main harvest maturity indicator



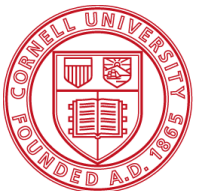
NY1 – Harvest Maturity



- Timing of NY1 harvest can vary slightly from year to year – late September through early October for 1st pick. If necessary, a second pick 5-7 days later.
- For mid to long CA, target fruit greater than 16 pounds firmness, with a SPI of approximately 3-4, with a brix >13%

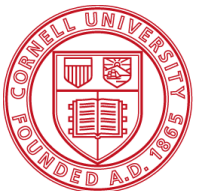


Starch Pattern Index (SPI) for NY-1. Courtesy of Dan Donahue, CCE Eastern NY Commercial Hort Team



NY1 – Storage Recommendations from Dr. Chris Watkins

- Harvest as early as possible to minimize browning risk, especially in CA.
- Store at 38°F.
- 1-MCP application is questionable for this variety – it does not always cause problems, but overall tends to enhance browning disorders. (Less of an issue in short term storage?)
- Conditioning provides variable responses.
- Low oxygen –DCA –may have promise but not for all disorders.
- Use of DPA is worth considering, especially in normal CA (tentative recommendation)
- Storage length is a major factor, although limited information



MAIA-1 (Evercrisp™ as packed fruit)

- Medium vigor with spreading branches
- Easy to thin/little needed on young trees
- Crop load management needed in mature trees – overcropped fruit will produce smaller fruit with poor color
- Large fruit size has caused trellis failure on multiple farms



MAIA-1 – Maturity & Quality Indicators

- Internal ethylene does not correlate with maturity
- Firmness rarely a problem
- TSS rarely a problem
- Color can be a problem
 - Reflective fabric highly recommended
- Varietal flavor & background color change is the main harvest maturity indicator



MAIA-1 – Harvest Maturity

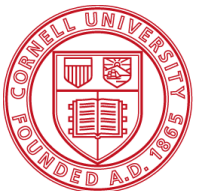
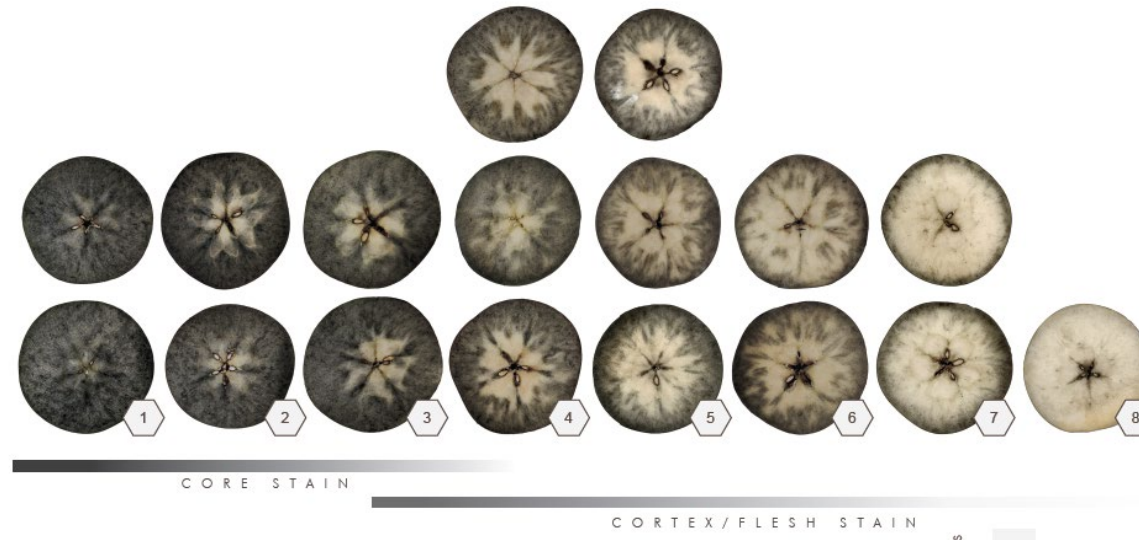
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- Consistently picks the last week of October in WNY
- Most likely a 1 pick variety
 - Remaining fruit may have poor color and size/risk of frost damage
- For mid to long CA, target fruit target a firmness > 17 lbs., a brix of 14-16%, and SPI of 3-5
- Harvest early to avoid severe watercore as well

STARCH INDEX SCALE v1.0

EVERCRISP

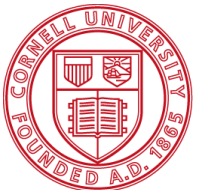


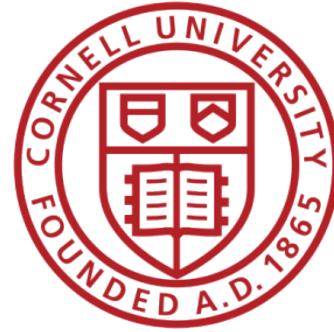
MAIA-1 – Storage Recommendations from Dr. Chris Watkins

MAIA-1 ‘EverCrisp’

More research is needed but recommendations to date are:

- Recommended storage temperature is 38°F.
- 1-MCP is not recommended as it can enhance flesh browning disorders.
- ReTain may reduce watercore at harvest and physiological disorder development during storage. Currently being investigated.
- Managing watercore is important to reduce physiological disorder development.





THANKS! QUESTIONS?

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