WSU Tree Fruit Extension

# FRUIT MATURITY AND QUALITY

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**KEYWORDS**
respiration, ethylene, ripening, color change, starch conversion, soluble solids, titratable acidity, softening, texture, aroma

**ABSTRACT**
Maturation is the process through which fruit develop marketable appearance and gain the capacity to ripen. Harvest ends the maturation process and maturity stage at harvest determines fruit quality after storage. Maturity has two important definitions. Physiological maturity is attained when fruit have the capacity to ripen after harvest. Horticultural maturity means fruit have developed marketable appearance and edibility. Fruit at physiological maturity typically have a long storage life but may not be horticulturally mature. This is commonly the case for red varieties where red color development lags behind the start of ripening. Physiologically immature fruit ripen poorly, do not develop typical flavor, and can be highly susceptible to shrivel, bitter pit, superficial scald, and external $CO_2$ injury during storage. Picking late in the maturation process when ripening has begun limits storage life due to softening, low acidity, and high susceptibility to chilling injury and internal $CO_2$ injury in susceptible varieties. Because maturation and ripening patterns vary among varieties, some varieties are best harvested before the fruit eats well while others should not be harvested until some typical flavor is detected.

Ripening of apples and European pears requires ethylene gas. Ethylene is produced naturally by fruit but can also be applied from an external source to accelerate ripening. Ethylene production increases as maturation progresses and ethylene analysis is a means to assess physiological maturation. Fruit ethylene production is not always easily interpreted in part because the pattern of ethylene production varies considerably with cultivar and ethylene production trends vary from year to year. Other common indicators used to assess maturity include starch loss, peel ground color, firmness, soluble solids, and titratable acidity. Together these maturity indices provide an indication at harvest of where fruit is on its developmental path as well as what quality can be expected after storage. While changes in these attributes occur during maturation in all varieties, the patterns of change vary considerably among varieties. For example, starch index at optimum maturity for Red Delicious is very low compared to Honeycrisp.

Once harvested, the starch remaining is converted to sugar, softening and texture changes occur, chlorophyll breaks down, yellow pigments accumulate, aroma increases, the peel may become greasy, and acidity decreases as acid is used to fuel respiration. Many of these aspects of ripening require ethylene to proceed including softening, chlorophyll degradation, greasiness, and production of volatile compounds responsible for ripe aroma. The rate of acid loss is also an ethylene response. These processes all occur simultaneously but may not progress at the same rate, particularly when ripening is slowed due to use of postharvest technology. The beginning of physiological disorder development also occurs soon after harvest although visual symptoms of some disorders may not develop until months later.

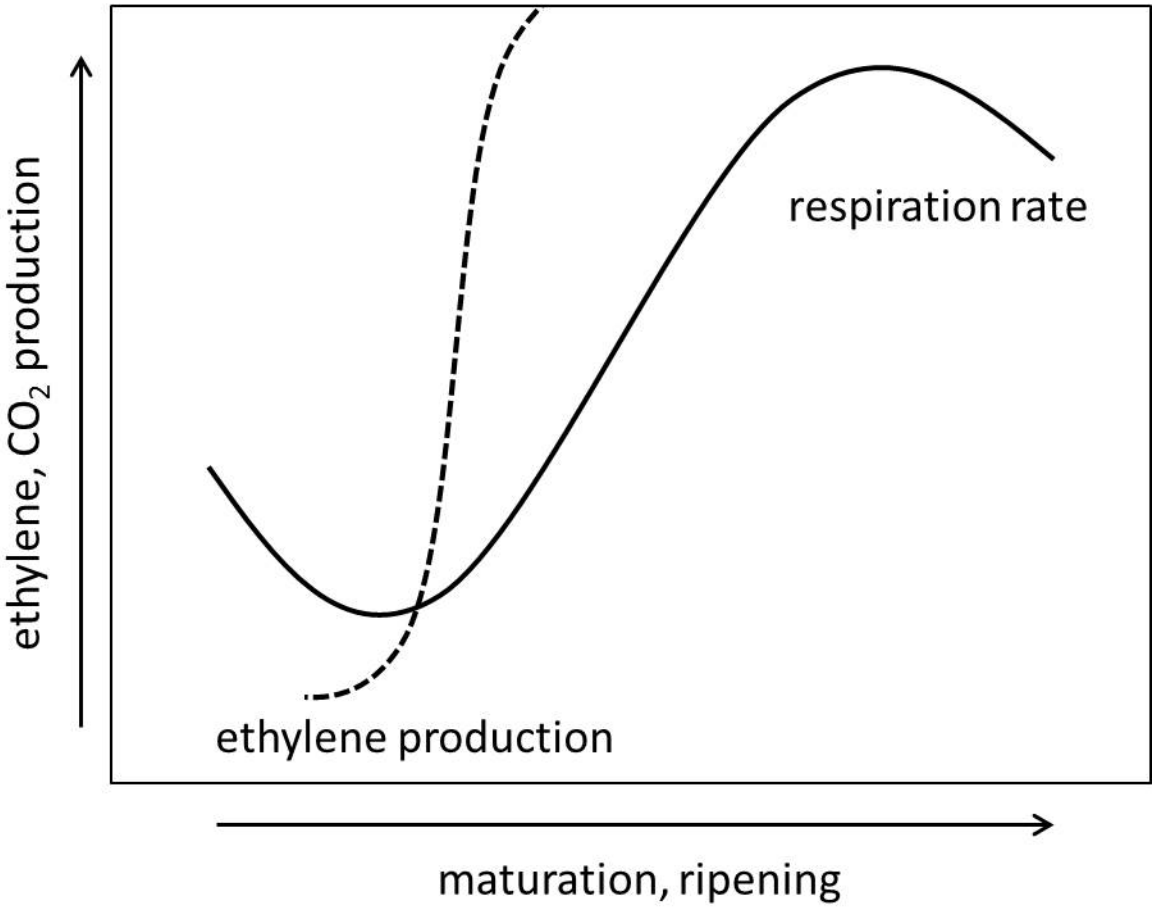



*Figure 1. Ethylene production and respiration rate during maturation and ripening of apple fruit.*

# Fruit Maturity and Quality

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# Topics

- Maturity definitions
- Ethylene
- Maturity and quality indicators
- Firmness
- Volatiles
- Greasiness



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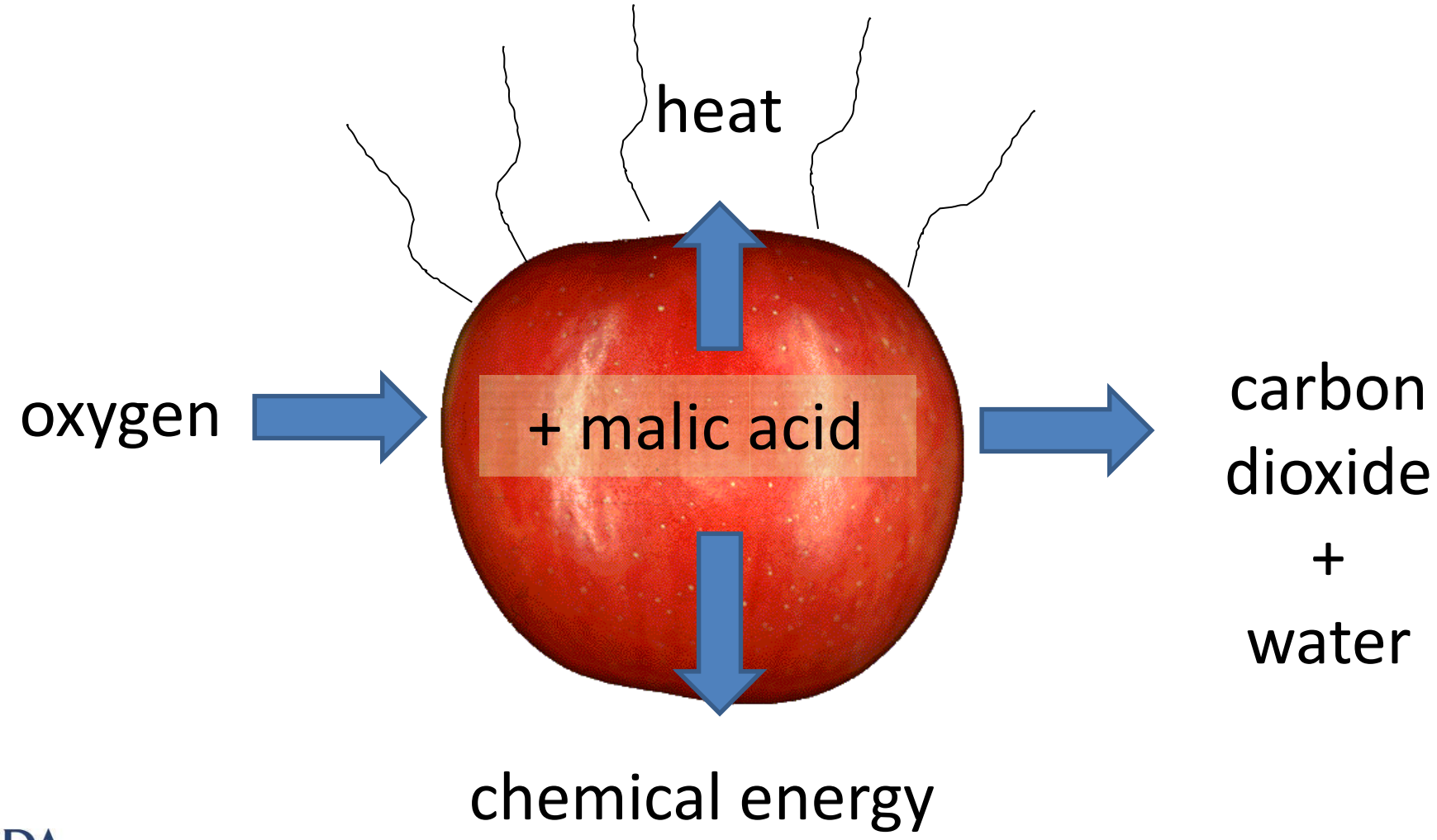
# Apple Fruit Maturation

- Color change
- Starch, firmness loss
- Soluble solids, titratable acidity increase
- Aroma change
- Greasiness development
- Patterns characteristic for each variety, strain

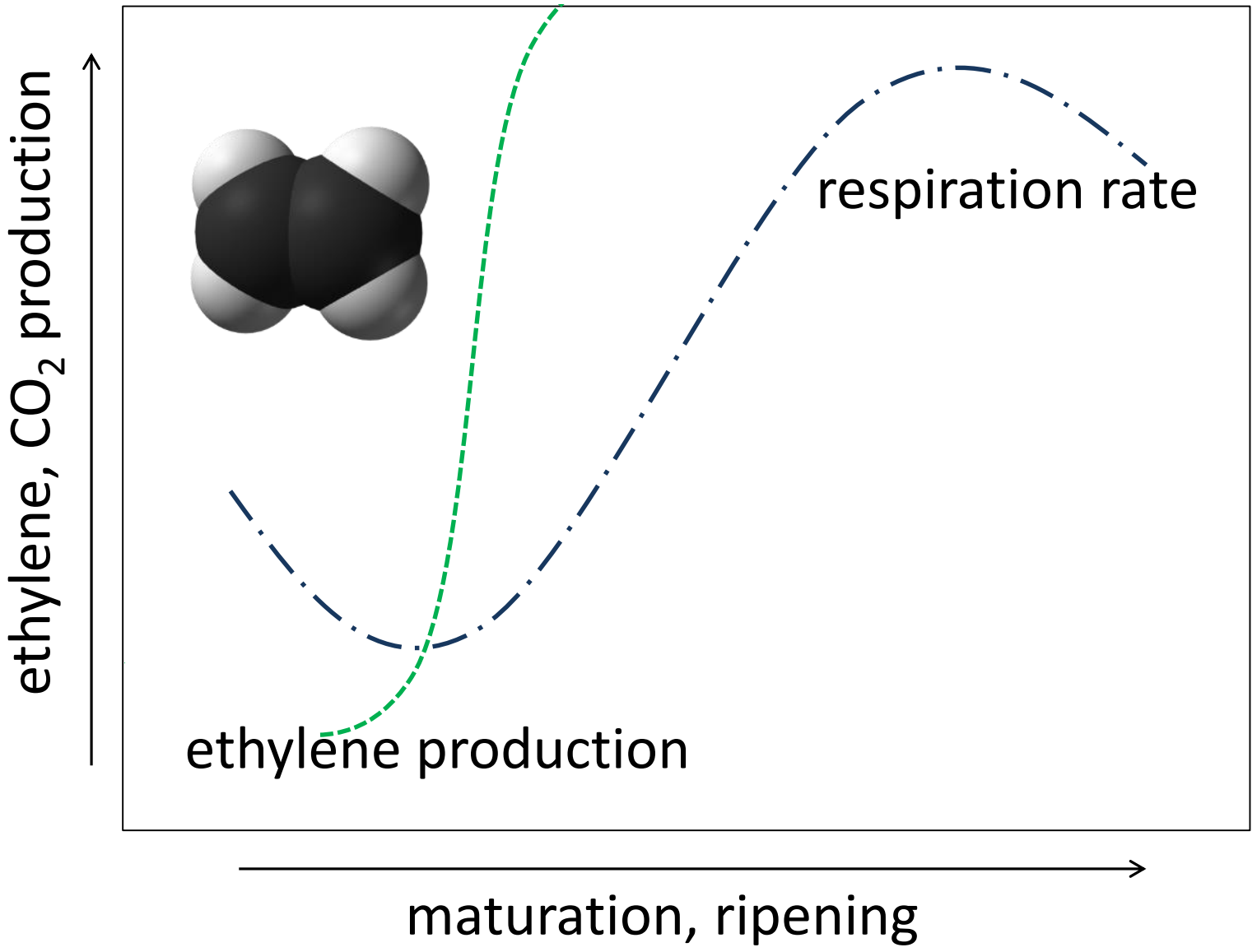


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# Respiration



# Physiological Change During Apple Fruit Maturation and Ripening




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# Apple Fruit Maturity

- Physiological: will ripen after harvest
- Horticultural: appearance, marketability



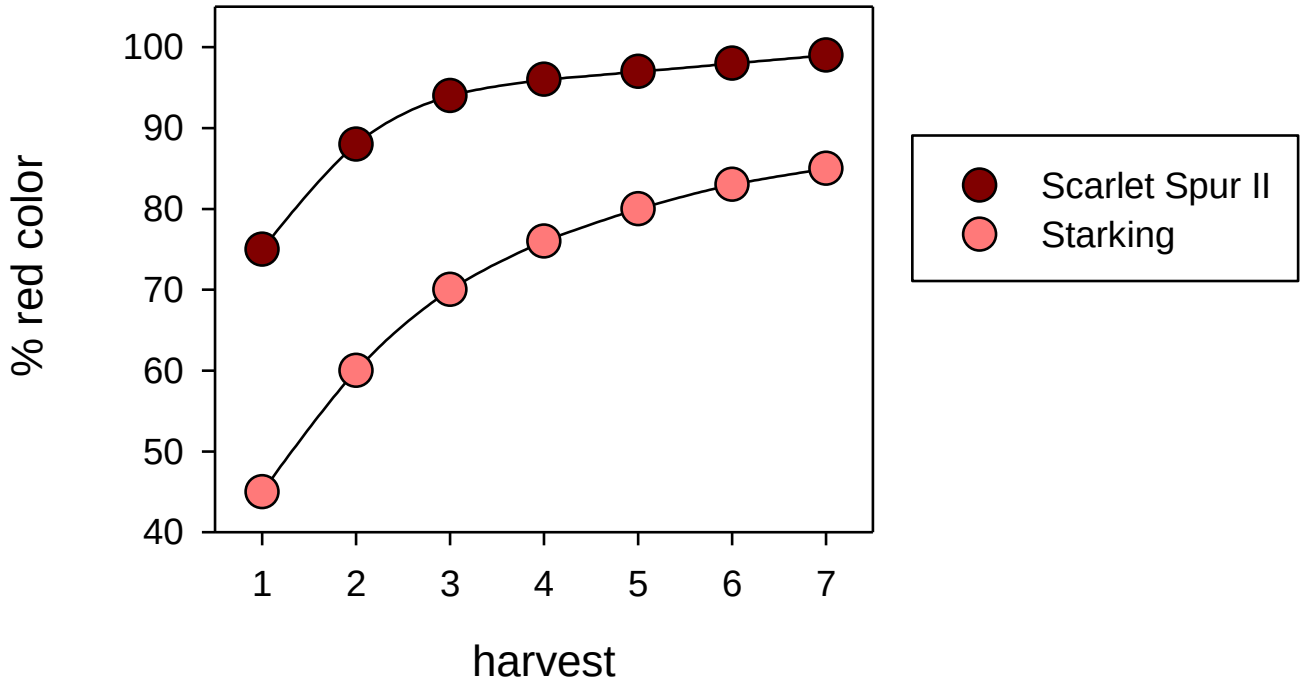

‘Starking Delicious’



‘Scarlet Spur II’

# Apple Fruit Maturity

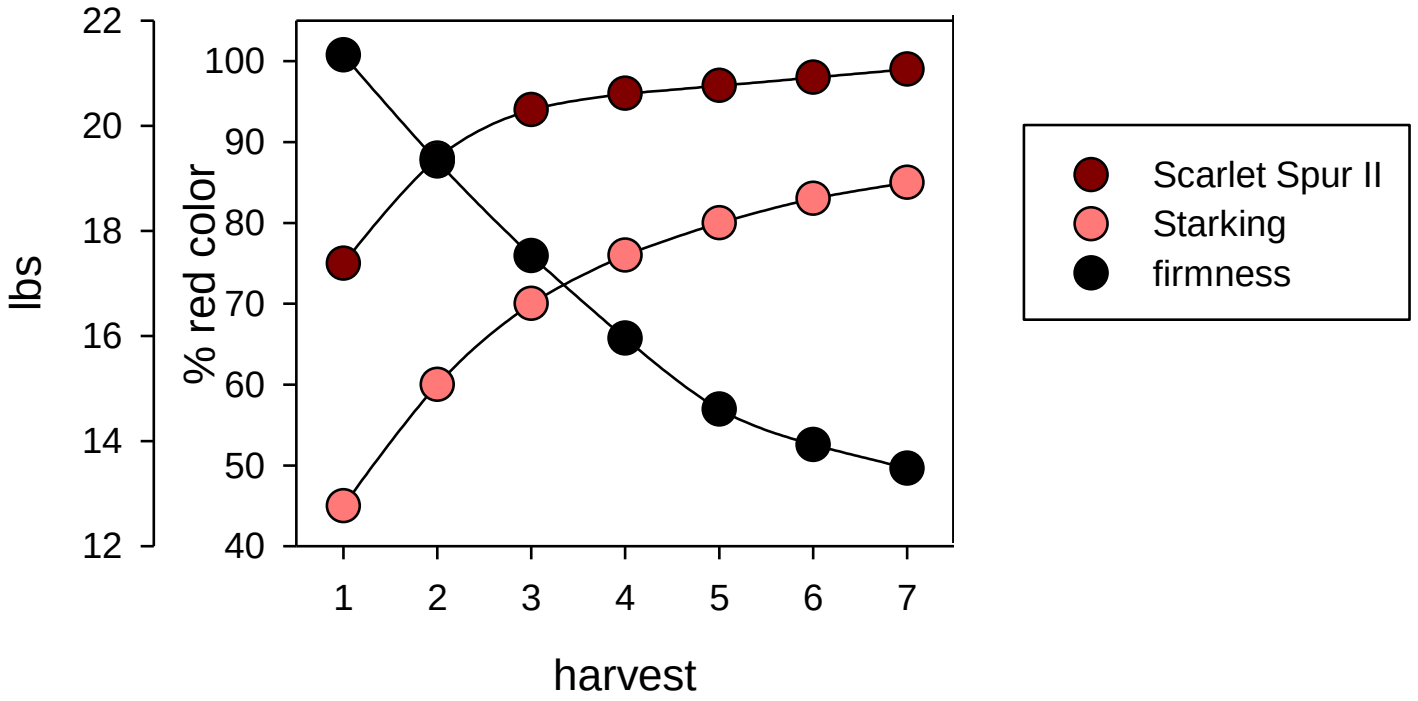
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# Apple Fruit Maturity

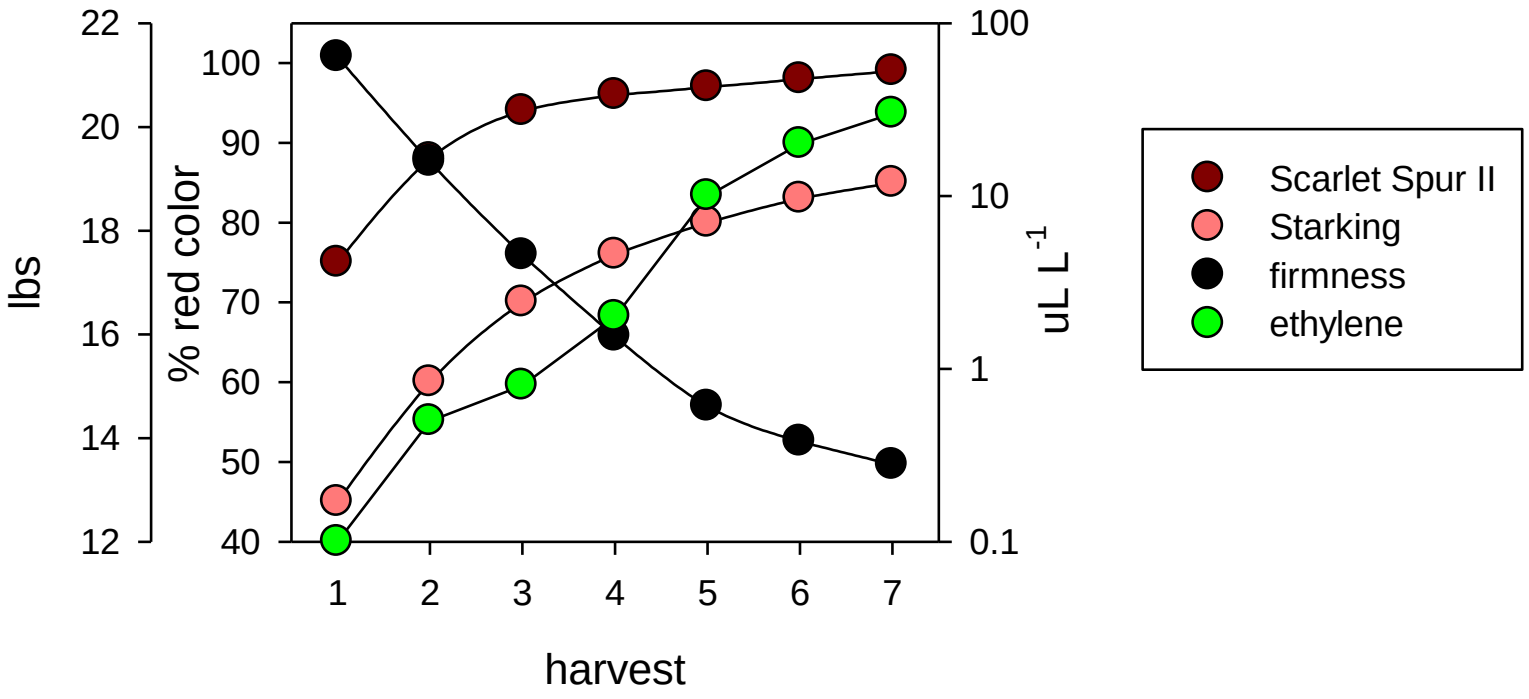
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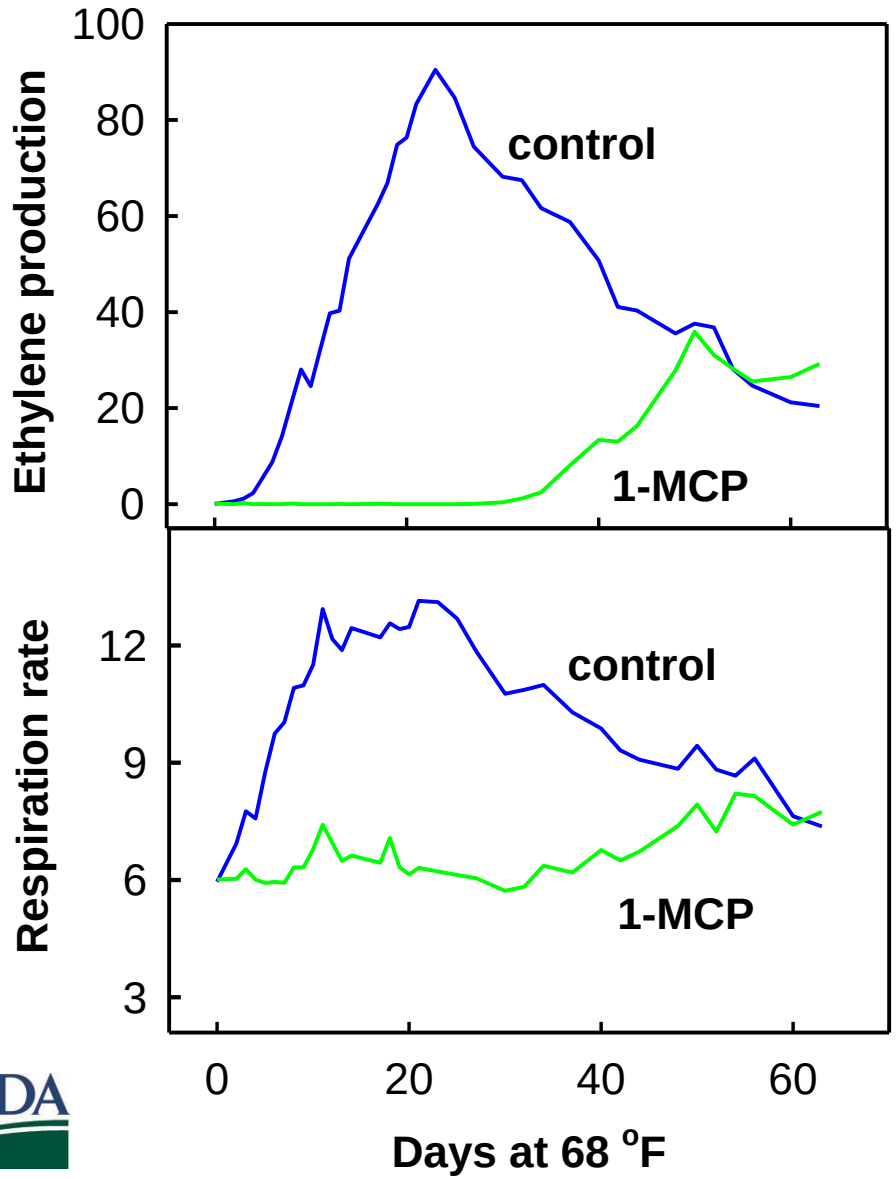

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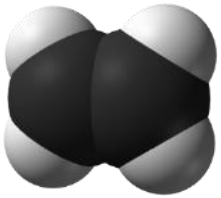
# Apple Fruit Maturity

- Physiological: will ripen after harvest
- Horticultural: appearance, marketability

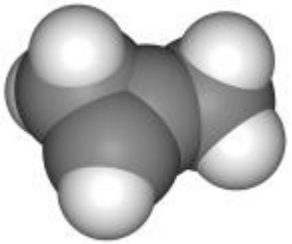


# Climacteric respiration and ethylene

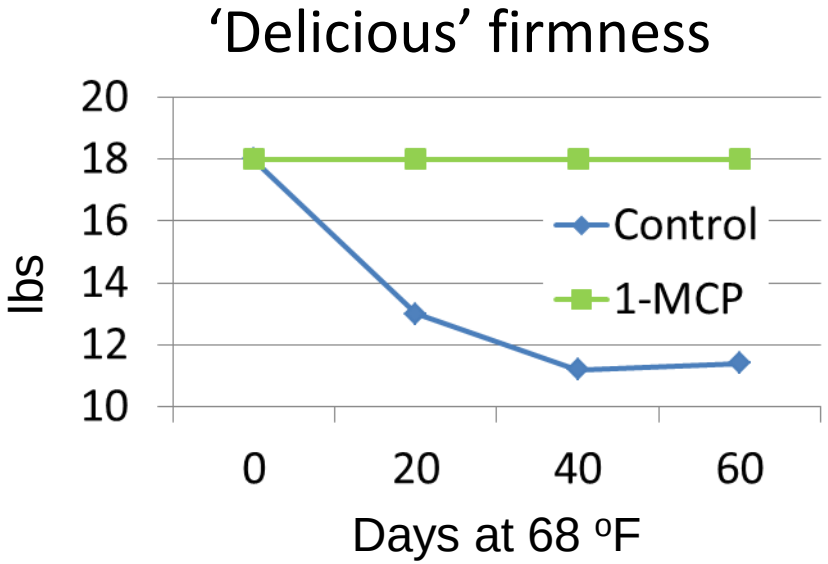


ethylene



1-methylcyclopropene




Fan et al., JASHS, 1999

- This chart accounts for variations between apple varieties and is suitable for assessing all starch patterns after iodine solution staining.
- Use a 20 fruit sample for meaningful results
- Score fruit based on unstained area, not intensity of staining.
- Refer to ENZAFRUIT Maturity Procedures Manual for further measurement procedures

# STARCH PATTERN INDEX FOR APPLES

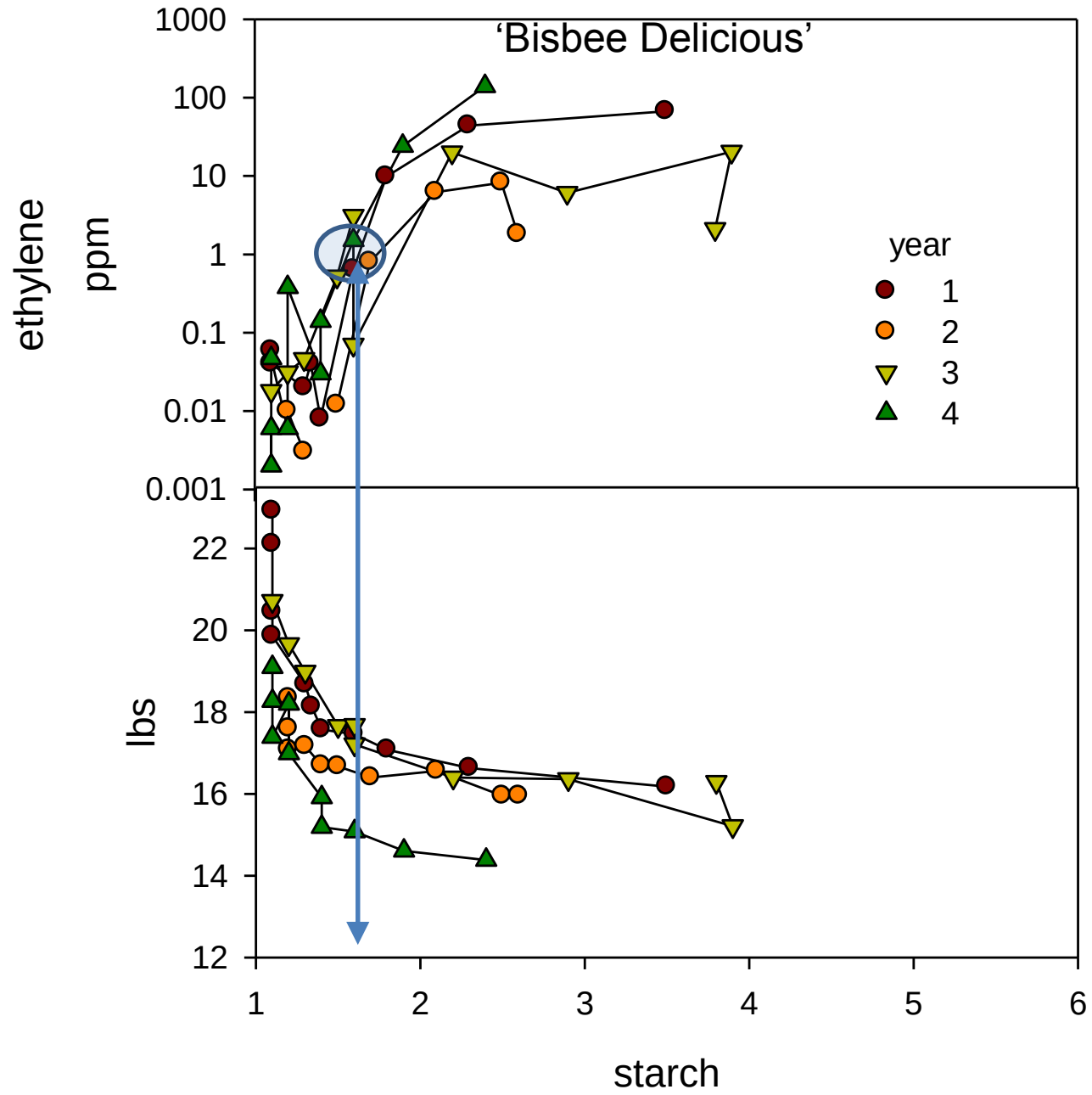
ENZAFRUIT
ENZAFRUIT is the trading name of ENZA Limited



0 1 2 3 4 5 6

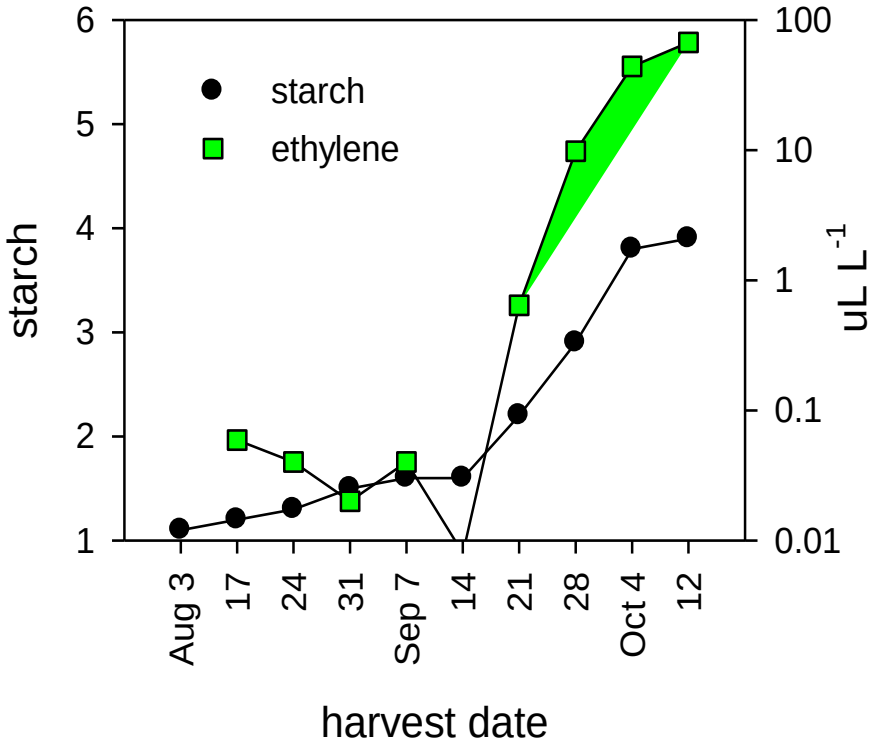
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# Apple Fruit Maturation: Ethylene,Firmness,Starch

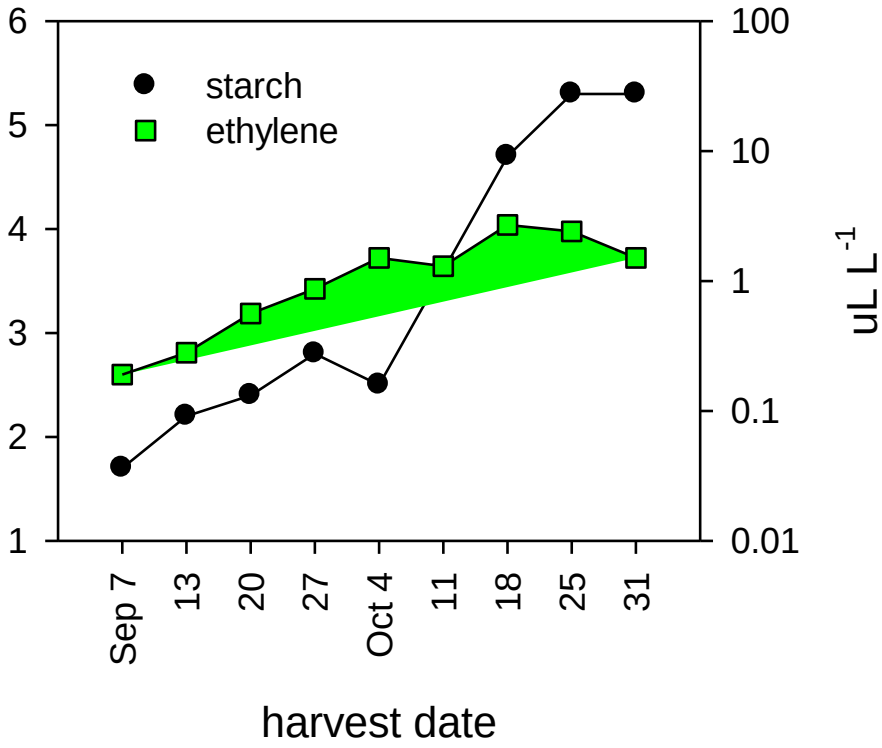


# Assessing apple fruit maturity

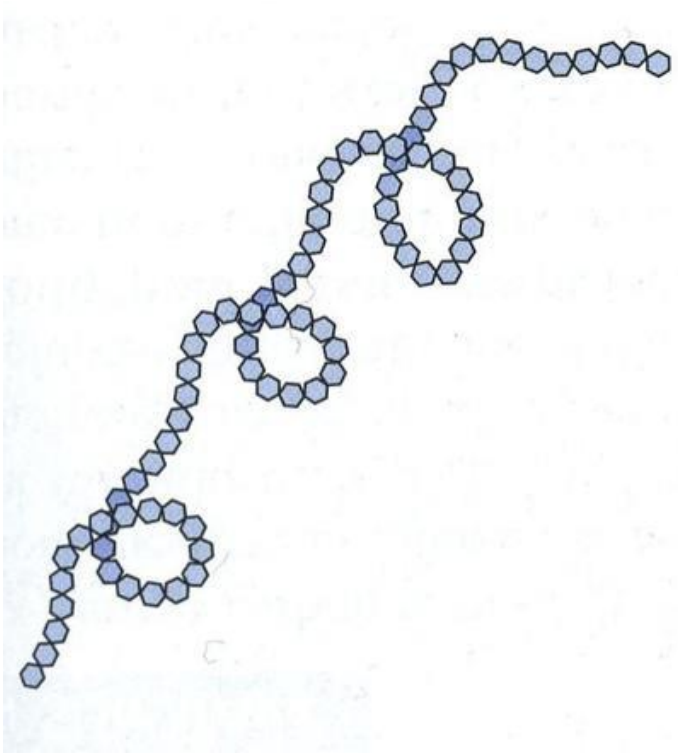
‘Bisbee Delicious’



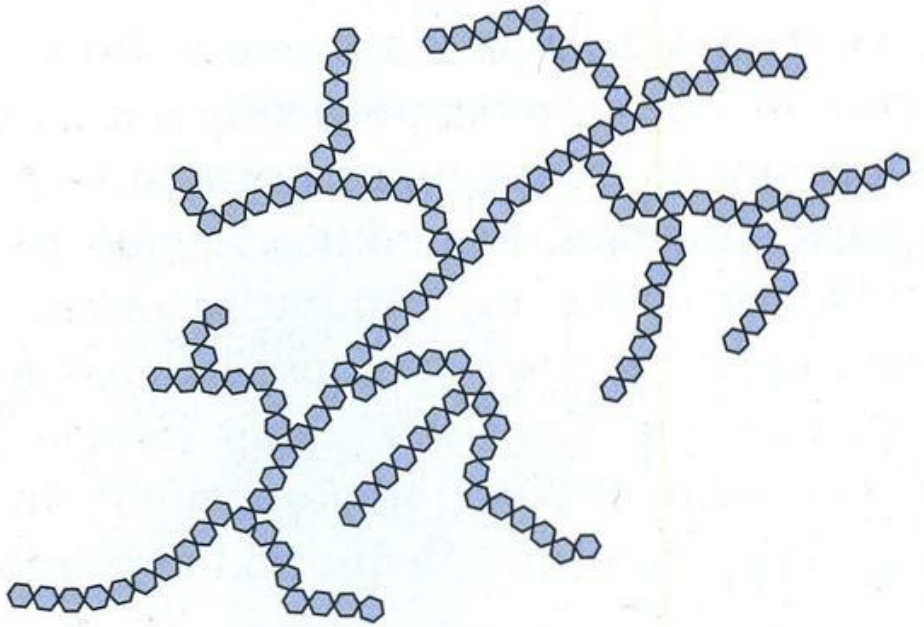

‘Fuji’



# Starch Polymers in Apple and Pear Fruit



amylose

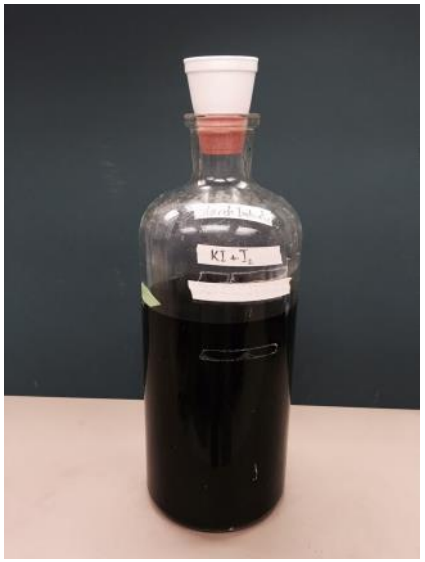


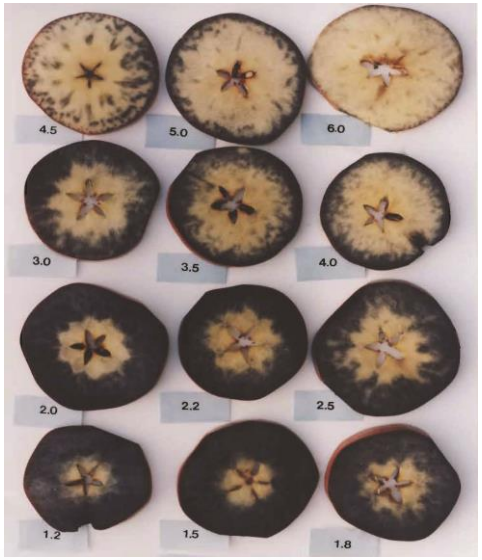
amylopectin

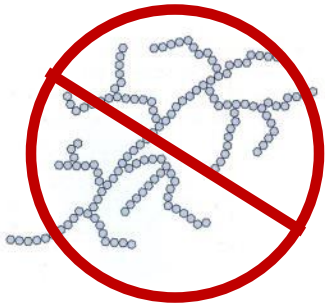
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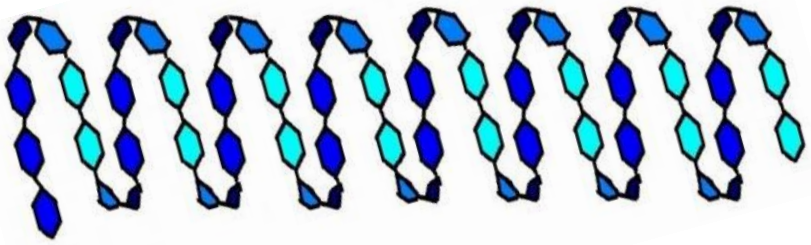
http://i.imgur.com/30Tam.jpg

# Amylose staining with $I_2$-KI solution

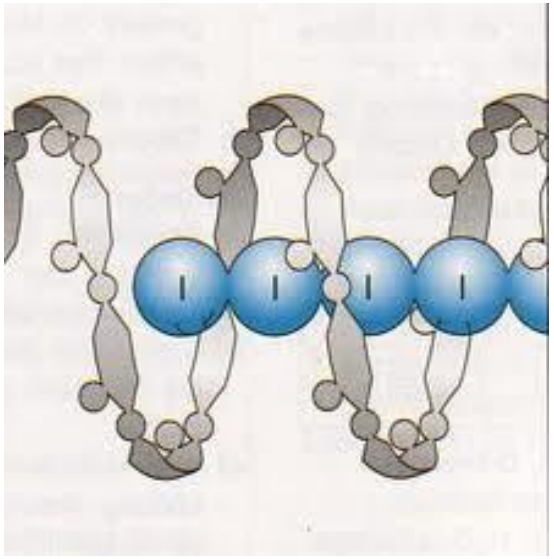




amylose

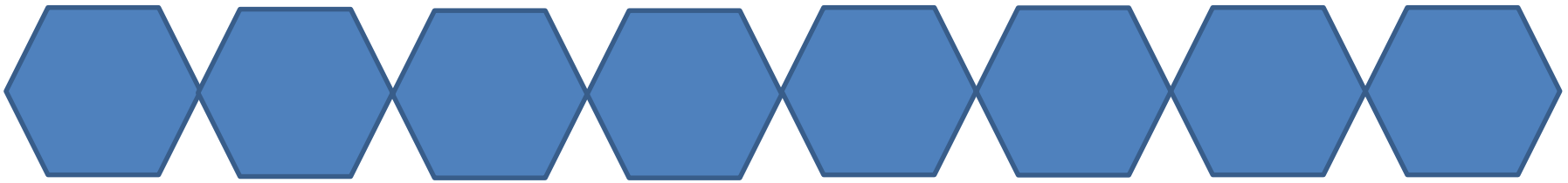


amylose plus iodine

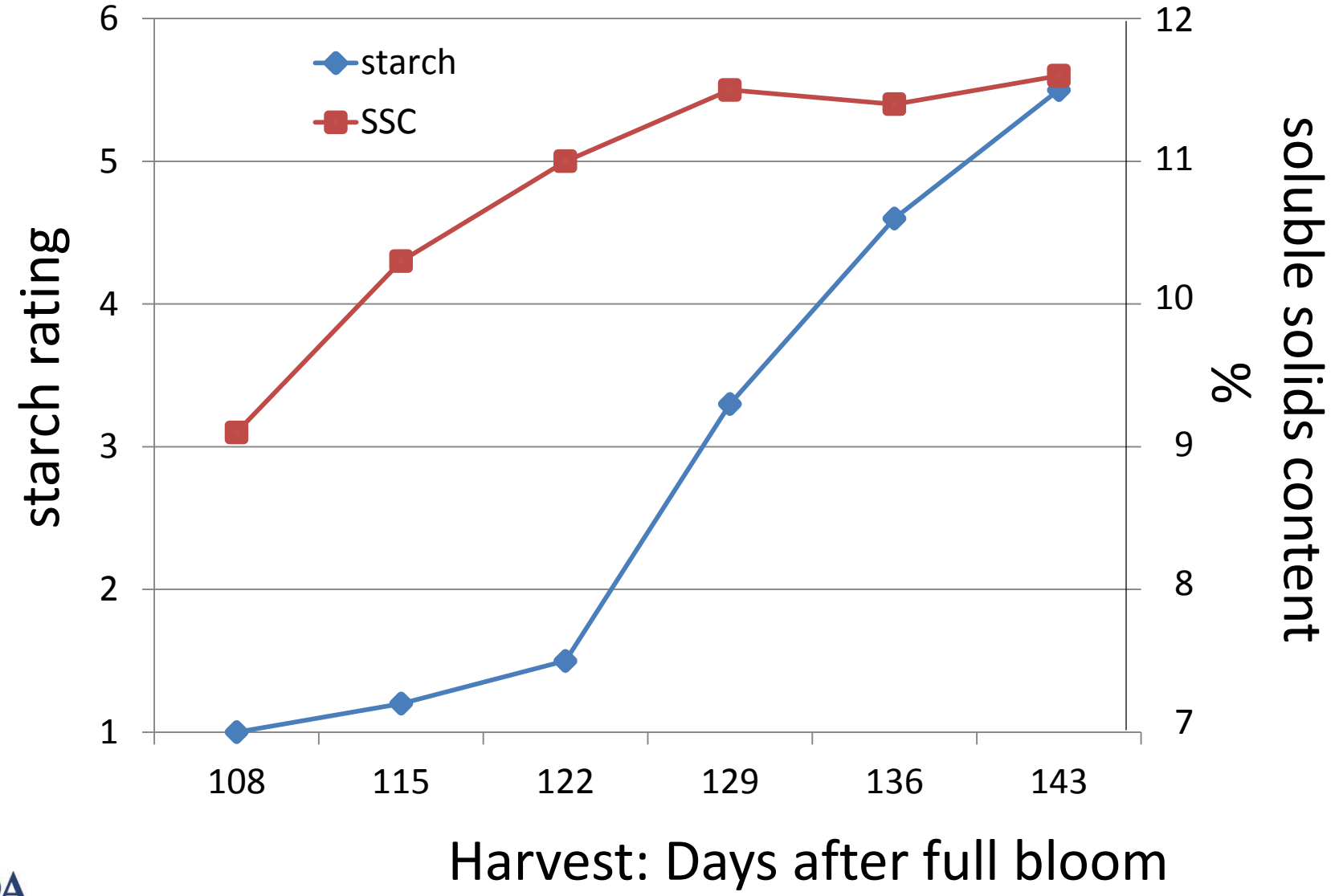
http://beerandwinejournal.com/wp-content/uploads/2014/10/amyloseBWJ-1024x643.jpg

http://grade9chem.weebly.com/uploads/6/0/6/4/6064529/8365541_orig.jpg

# Starch Hydrolysis

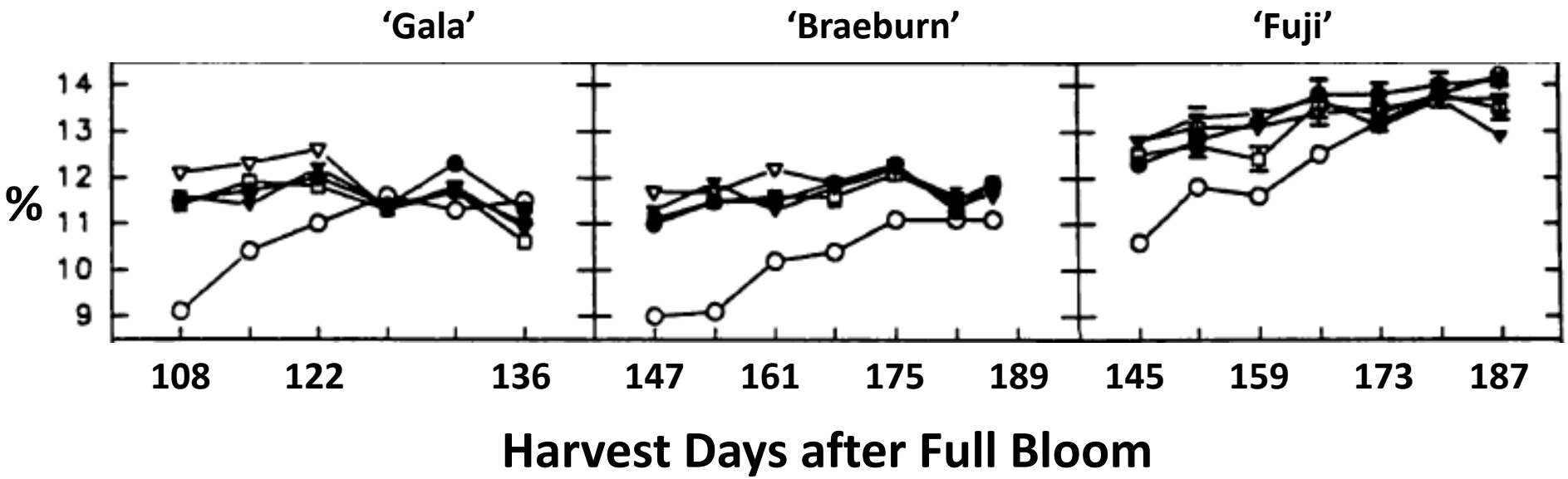


# Soluble Solids and Starch during ‘Gala’ Maturation




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# Soluble Solids Content at Harvest and after Storage




**Weeks in Storage**

- 0 (at harvest)
- 6
- 12
- 18
- 24

Plotto et al., Fruit Var J, 1995

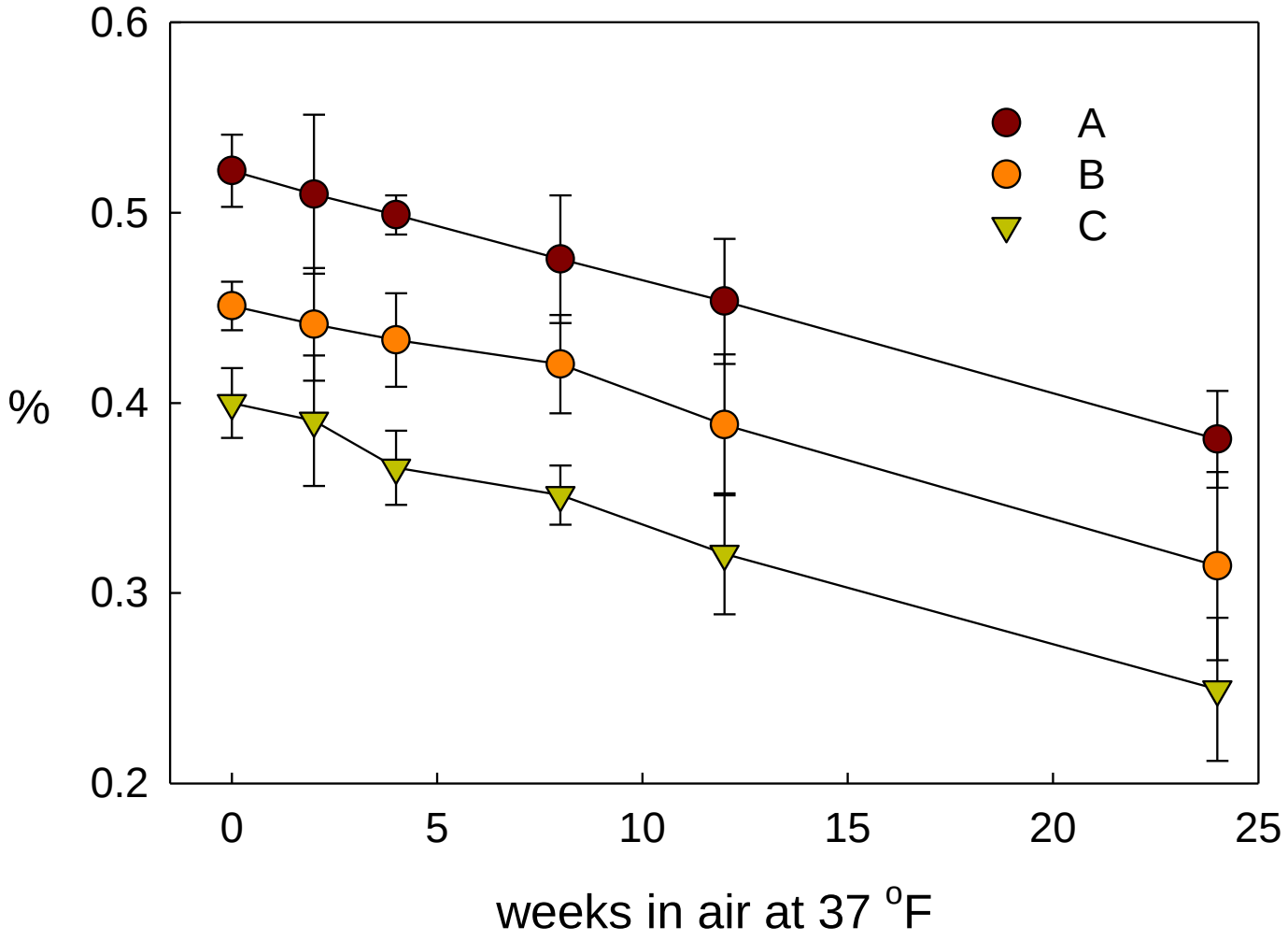
# ‘Honeycrisp’ Maturity: grouped by titratable acidity

| lots | TA % | starch (1-6) | SSC % | color (1-5) | ethylene ppm |
|---|---|---|---|---|---|
| A:1-5 | 0.522 | 5.1 | 13.7 | 3.5 | 5.7 |
| B:6-10 | 0.451 | 5.5 | 13.1 | 3.5 | 2.9 |
| C:11-15 | 0.400 | 5.6 | 12.7 | 3.2 | 7.5 |



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# ‘Honeycrisp’ titratable acidity after storage

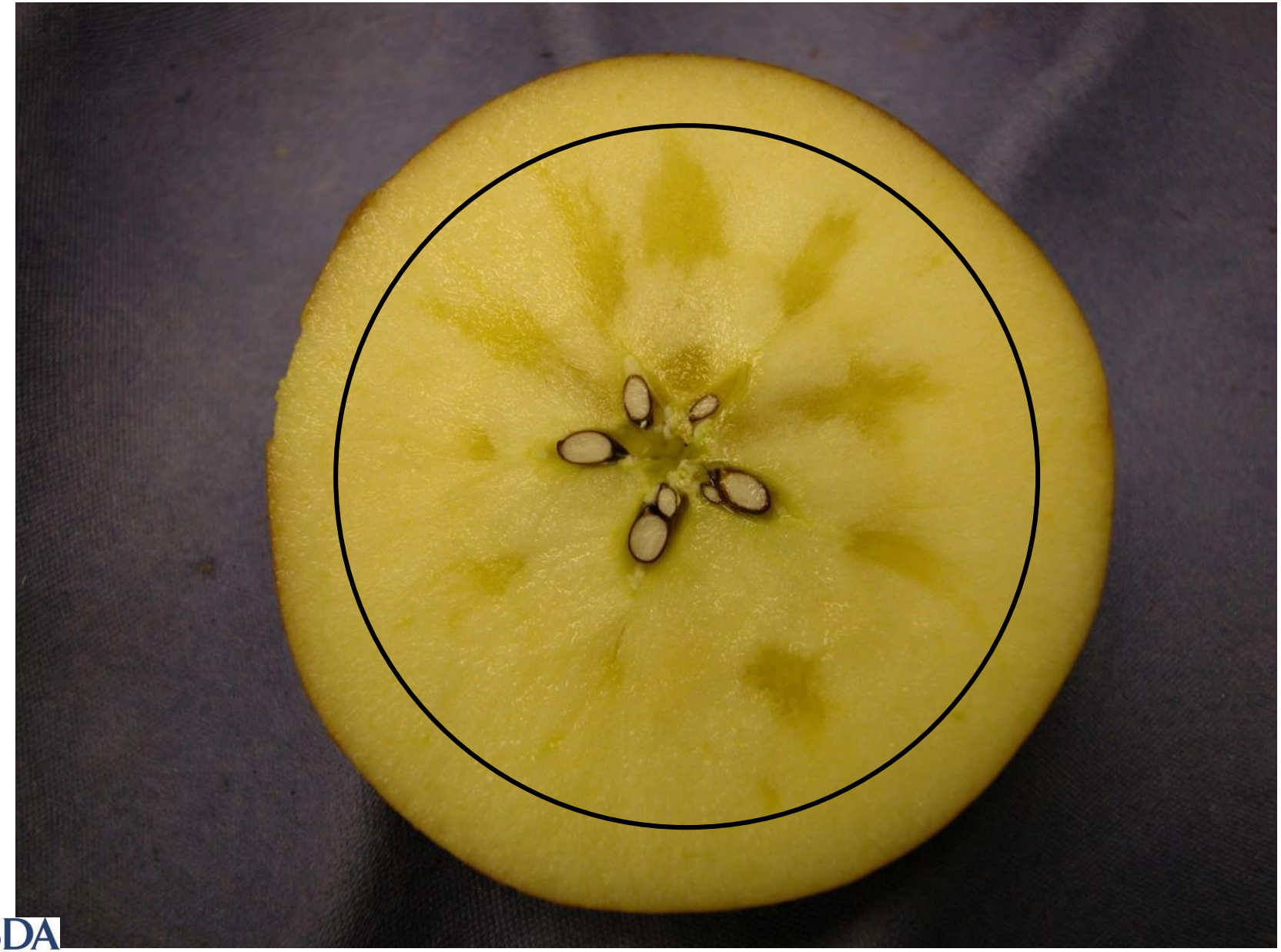


# Firmness

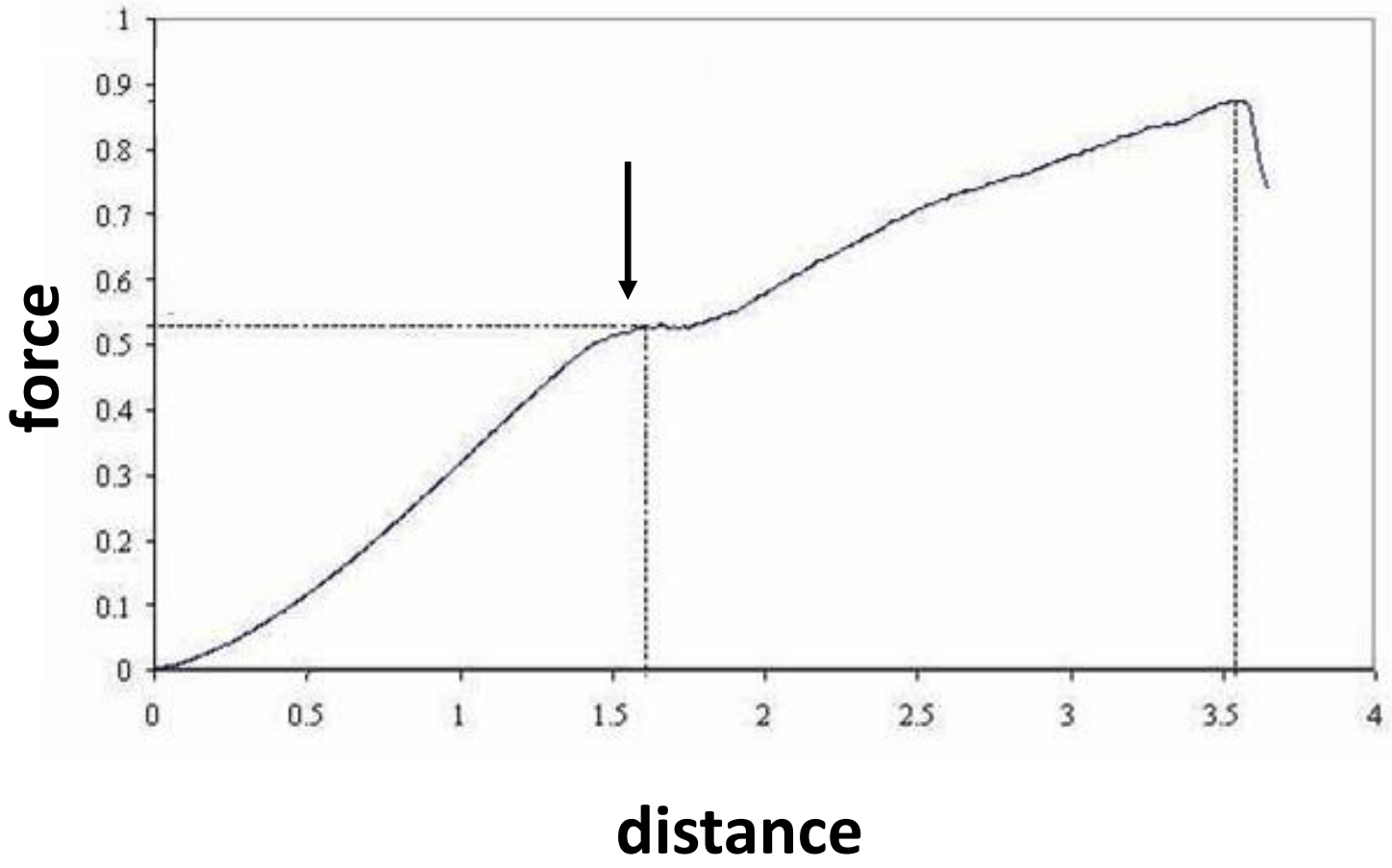
- Penetrometers measure outer portion fruit



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# Firmness Change with Distance into Fruit




http://epa.oszk.hu/00000/00025/00003/gyumolcs.html

# Firmness

- Softening can be non-uniform within fruit
- Firmness ≠ Texture








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# Fruit Firmness/Texture

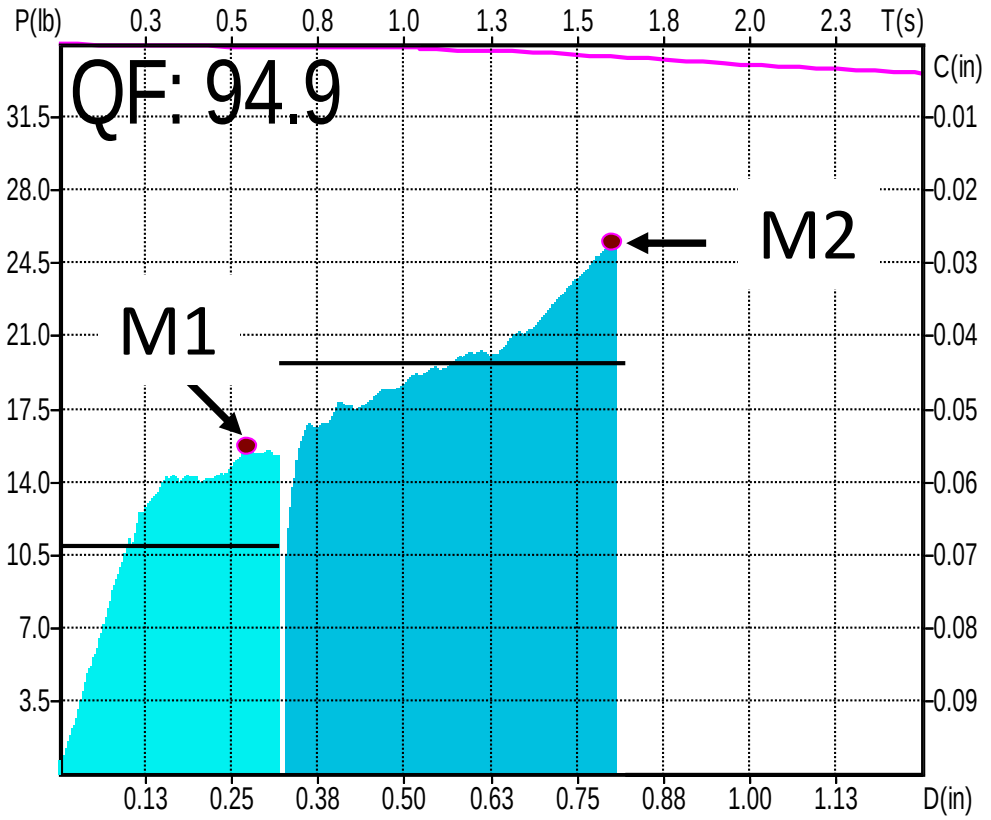
- outer 0.32”
- 0.32” to coreline
- Core boundary
- Crispness
- Visco-elasticity (creep)
- Quality Factor




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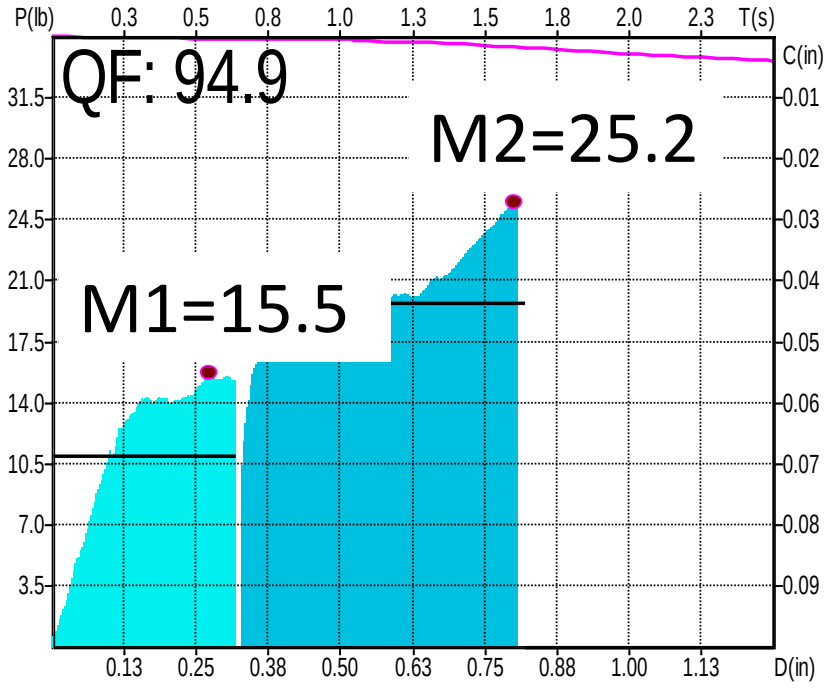
# Fruit Firmness/Texture

- M1=lbs
- M2=lbs
- Co=creep
- QF=quality factor

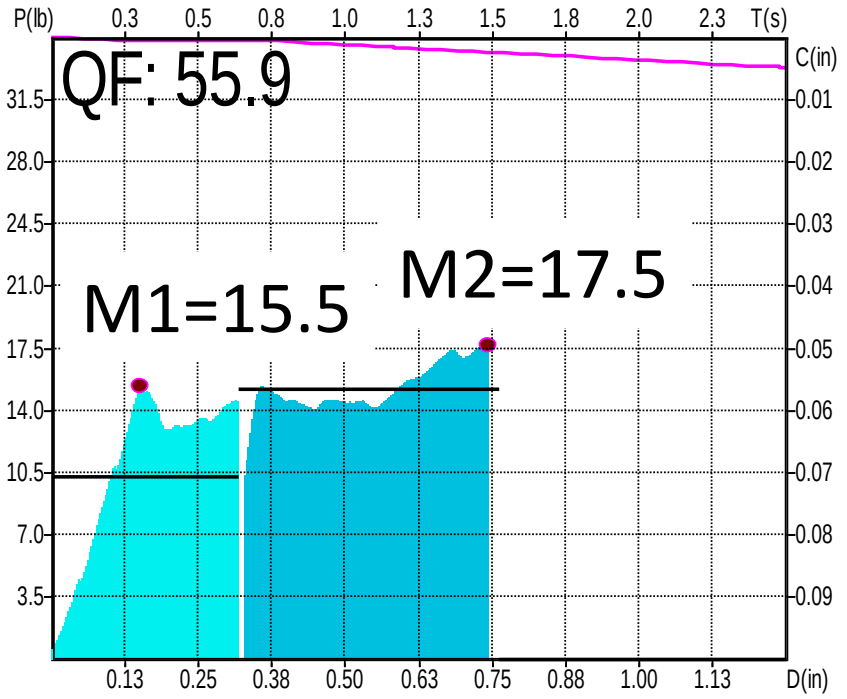


# ‘Golden Delicious’

## Harvest Sep 18



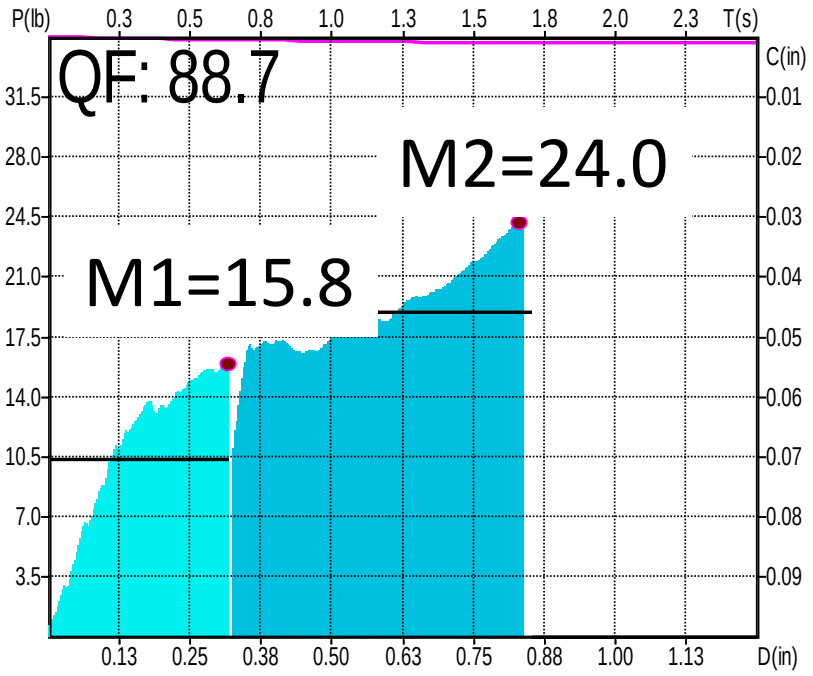

## Harvest Oct 26



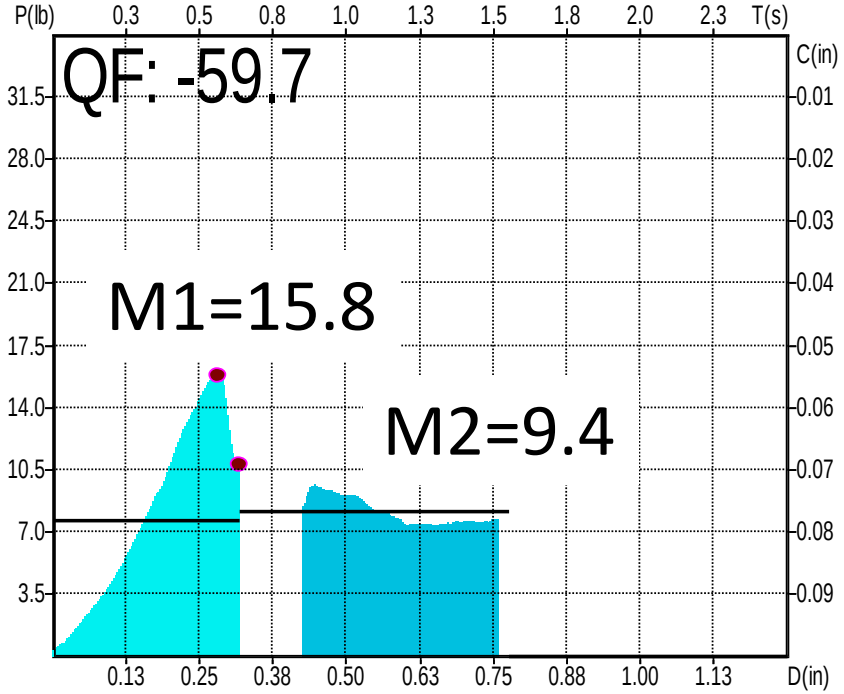

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# ‘Golden Delicious’

## Harvest Sep 13



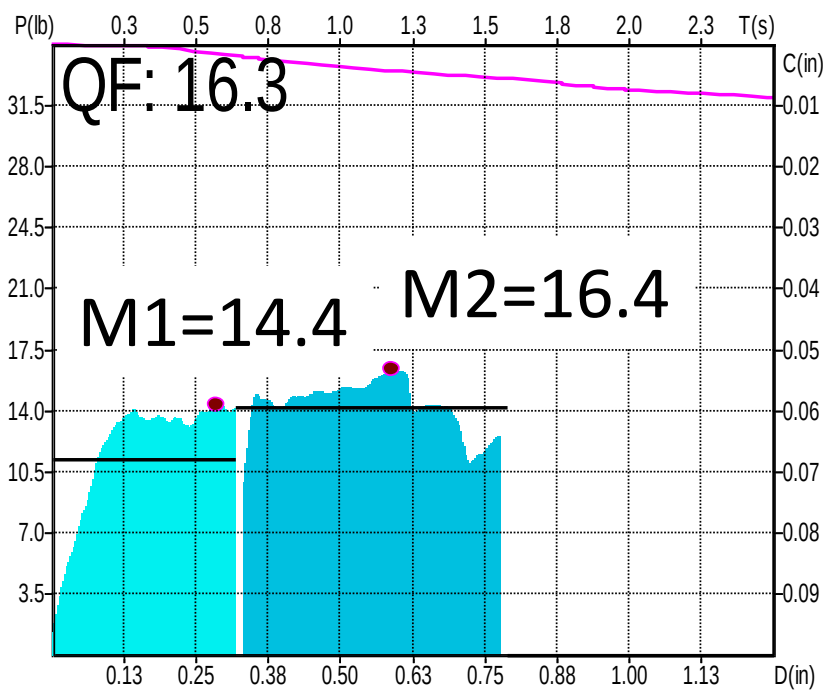

## Harvest Sep 26
## 5 weeks @ 70 ºF



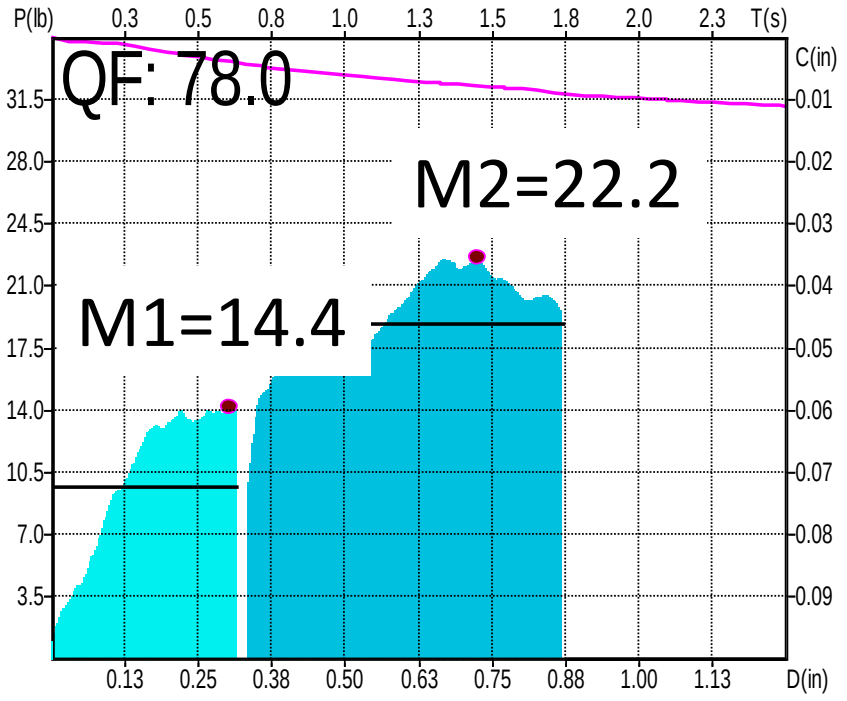

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# Gala: 2 months storage

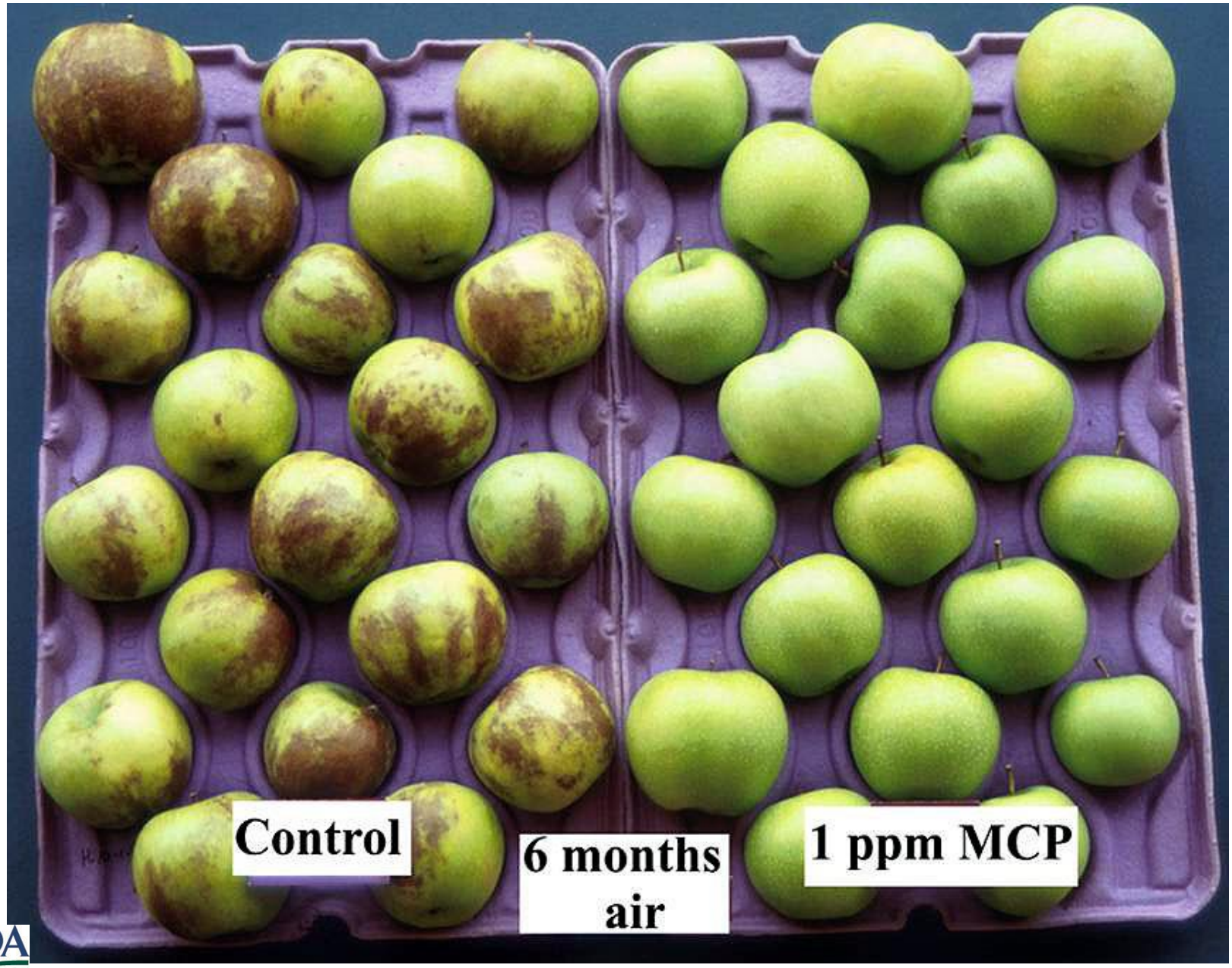
air: 7 d @ 70 ºF



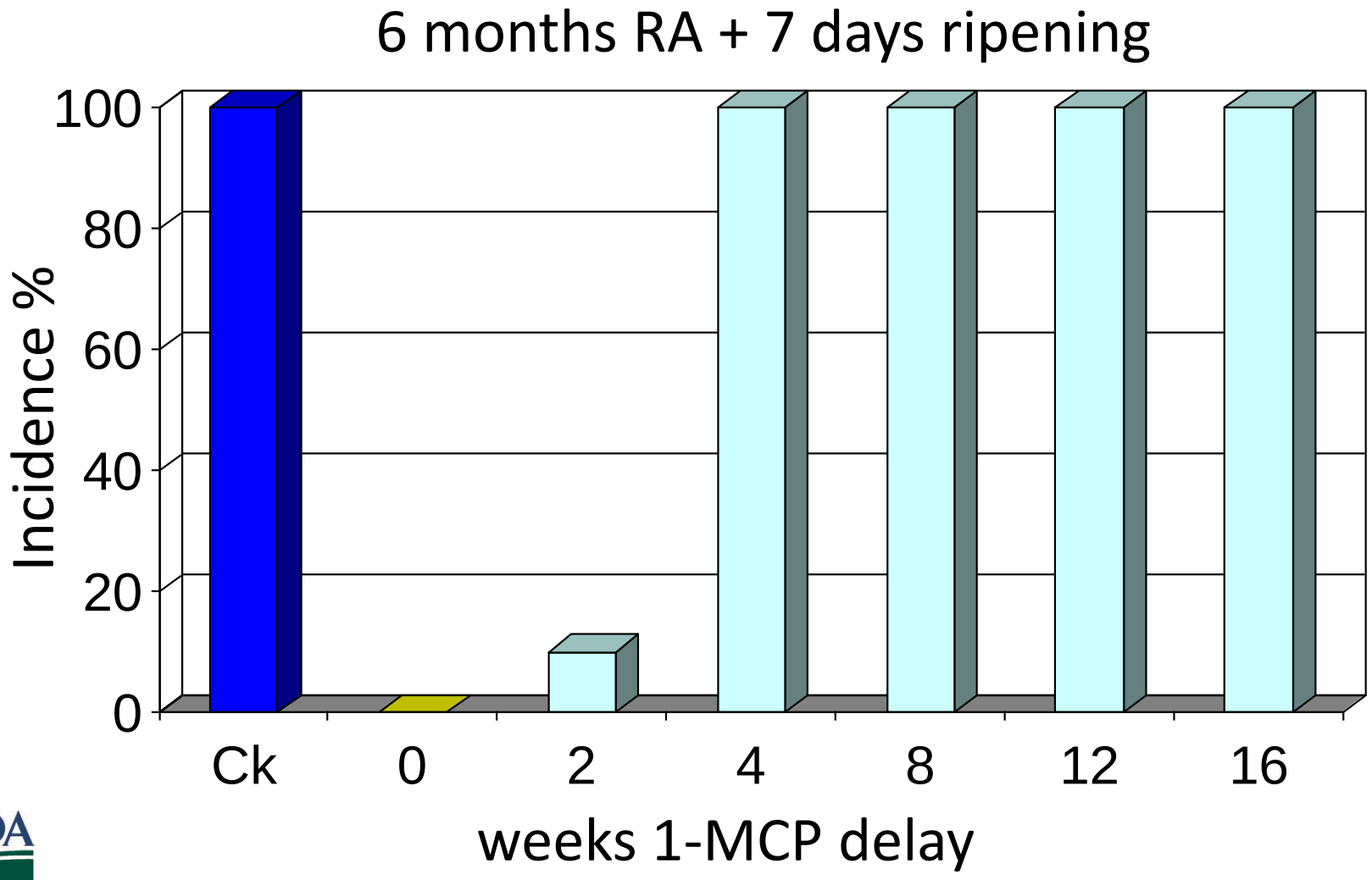

CA: 7 d @ 70 ºF




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Control
6 months
air
1 ppm MCP

# Granny Smith Scald



# Apple Fruit Volatiles

- >300, aldehydes, alcohols, esters
- cultivar specific
- harvest maturity
- ethylene regulated
- storage environment







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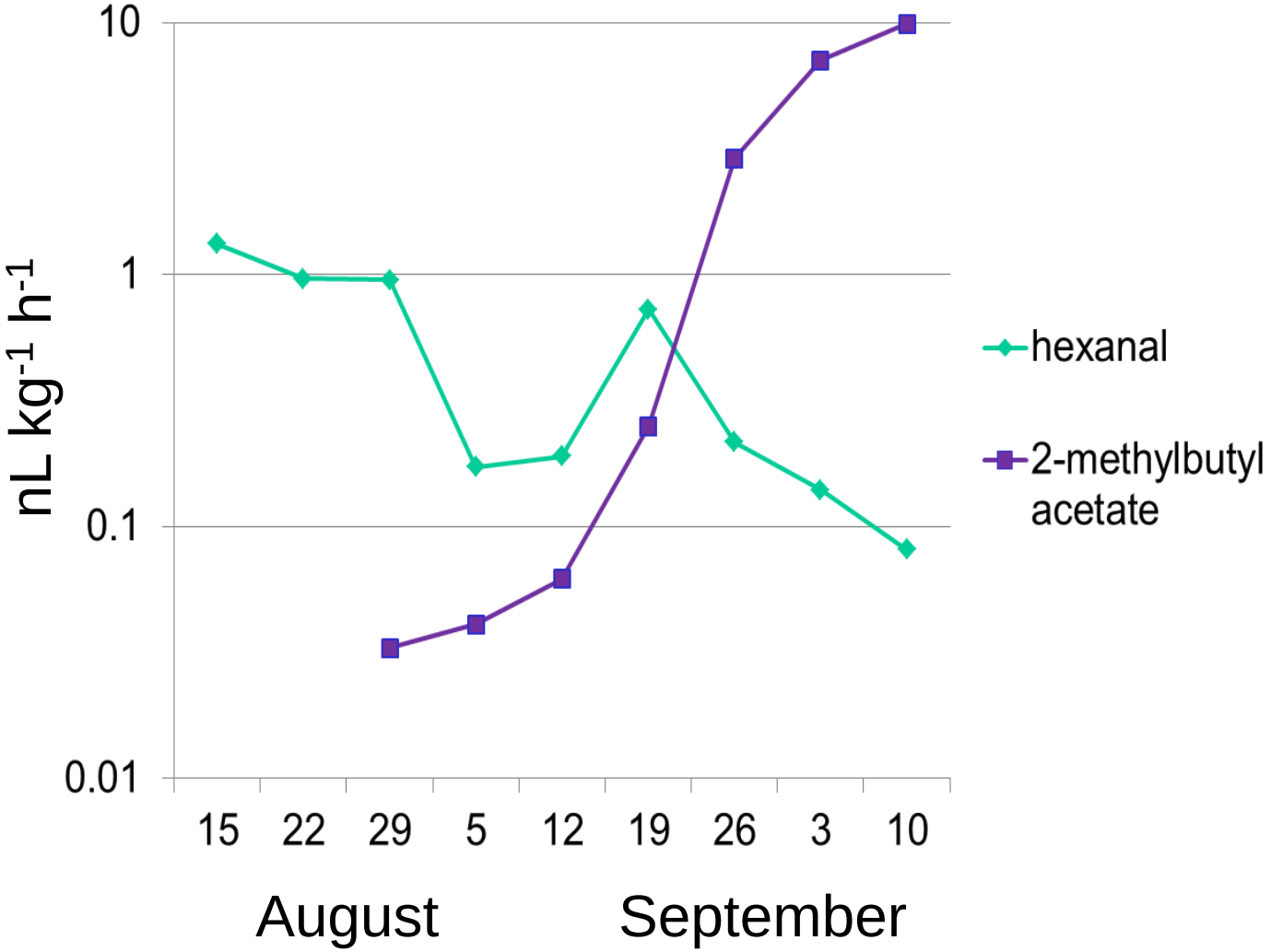
# Apple Fruit Volatiles

- Unripe: aldehydes - green, grassy
- Ripe: esters - fruity, sweet
- Ester production regulated by ethylene



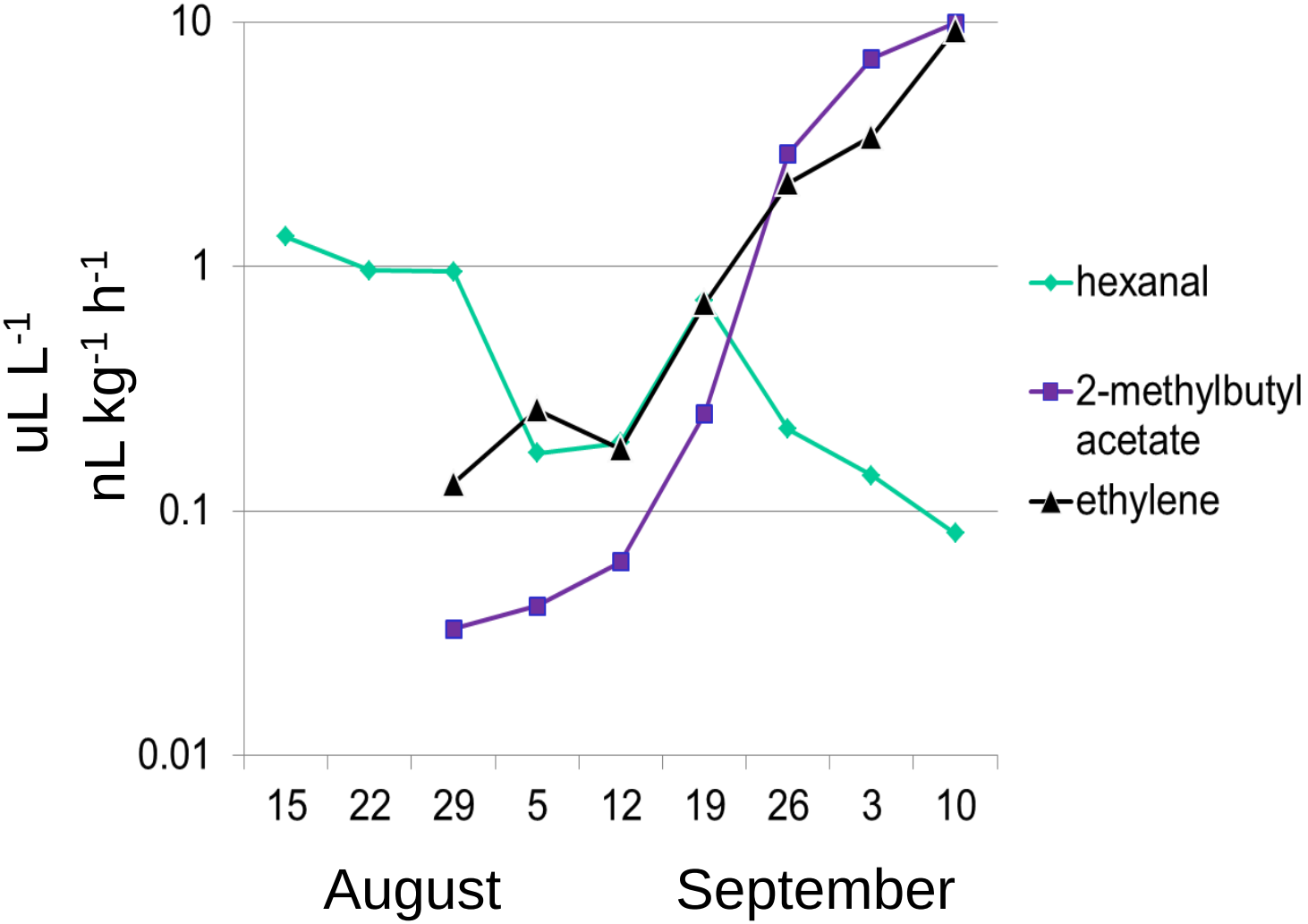
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# ‘Delicious’ Volatile Production



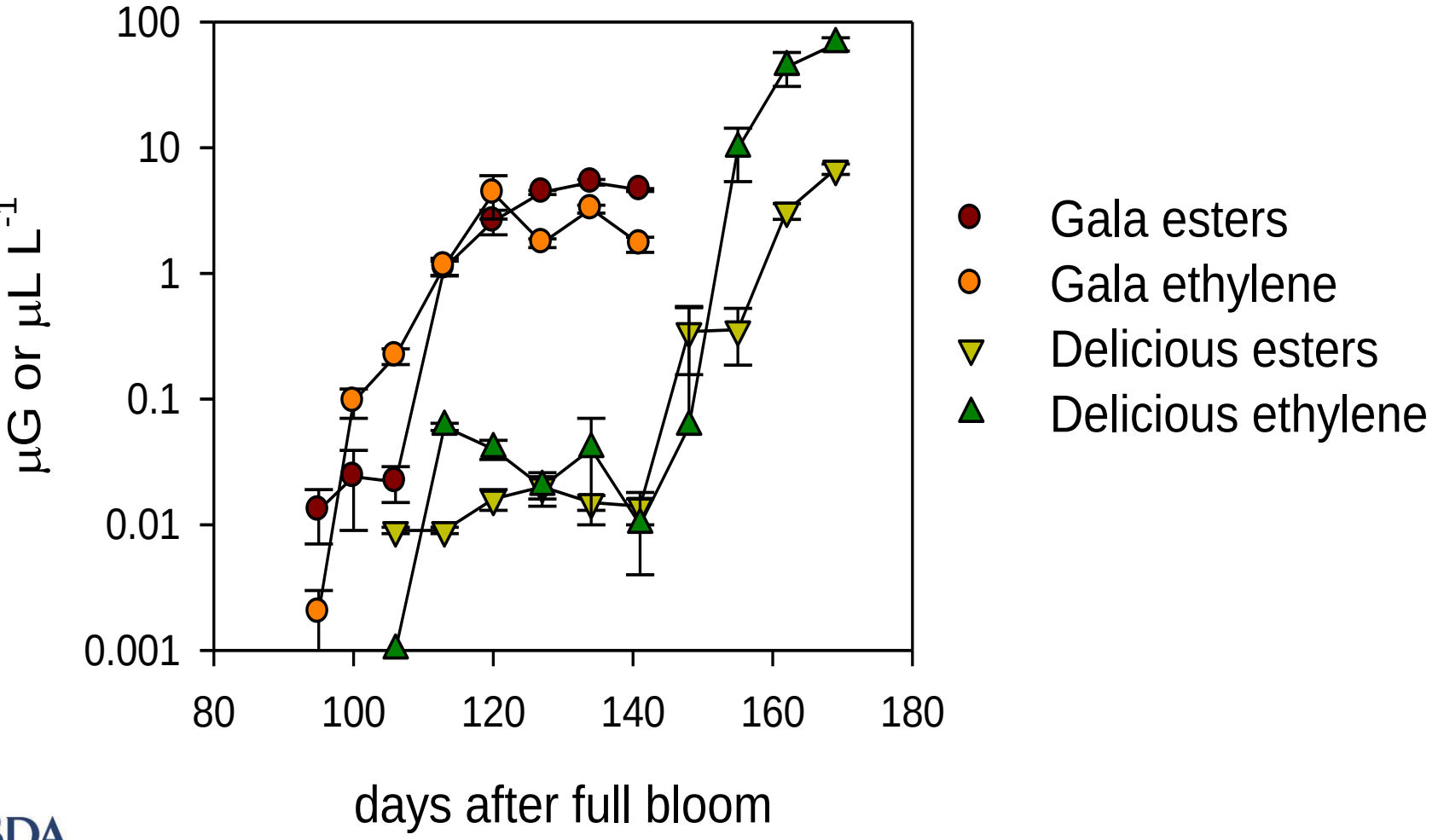

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# ‘Delicious’ Volatile Production



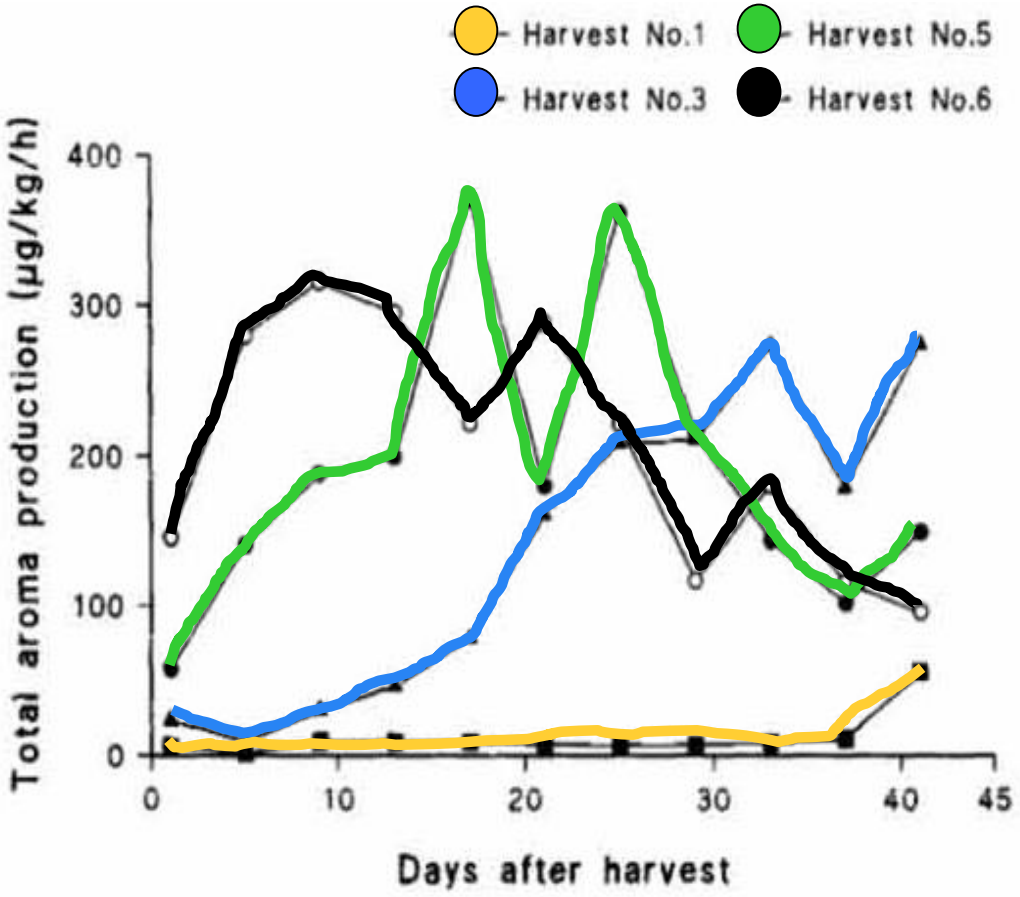

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# Maturity, ester, and ethylene production




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# ‘Golden Delicious’ volatile production




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Song and Bangerth, PBT, 1995

# Peel Greasiness

- Can be present on mature fruit (Gala, Honeycrisp)
- A sign of ripening
- Fruit resources used to produce
- Prompt management for storage





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# Summary

- Physiological and Horticultural Maturity
- Ethylene required for ripening
- Starch as a maturity index
- SSC, acidity, firmness as quality indicators
- Disorders incited close to harvest
- Volatiles/aroma maturity dependent
- Greasiness: A sign of ripening

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# Acknowledgements

Dave Buchanan
Janie Countryman
Luiz Argenta
Xuetong Fan
Anne Plotto







