Effects of Preharvest Factors on Fruit Development and Quality

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Indian River Citrus School, Handling and Processing

Preharvest Effects on Fruit Quality

- Effect of Genetic Material

- Effect of Cultivar and Maturity

- Effect of Rootstock

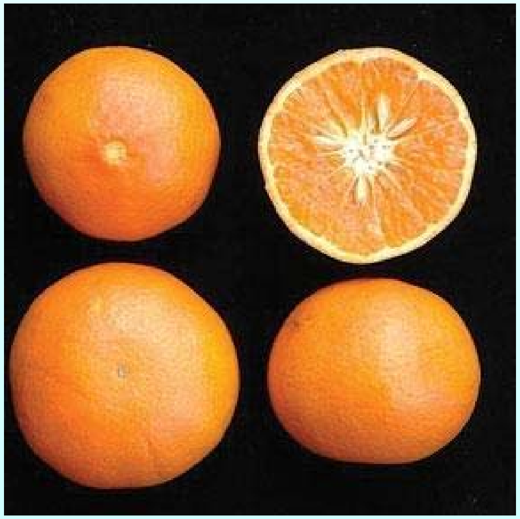
- Effect of Nutrient Deficiency

Effect of Genetic Material

'FALLGLO'

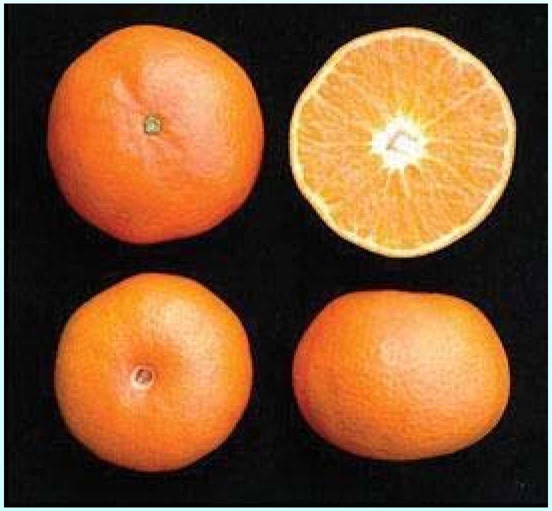
'Bower' [Citrus reticulata Blanco × (C.paradisi Macf. × Citrus reticulata) ×'Temple']

Released in 1987

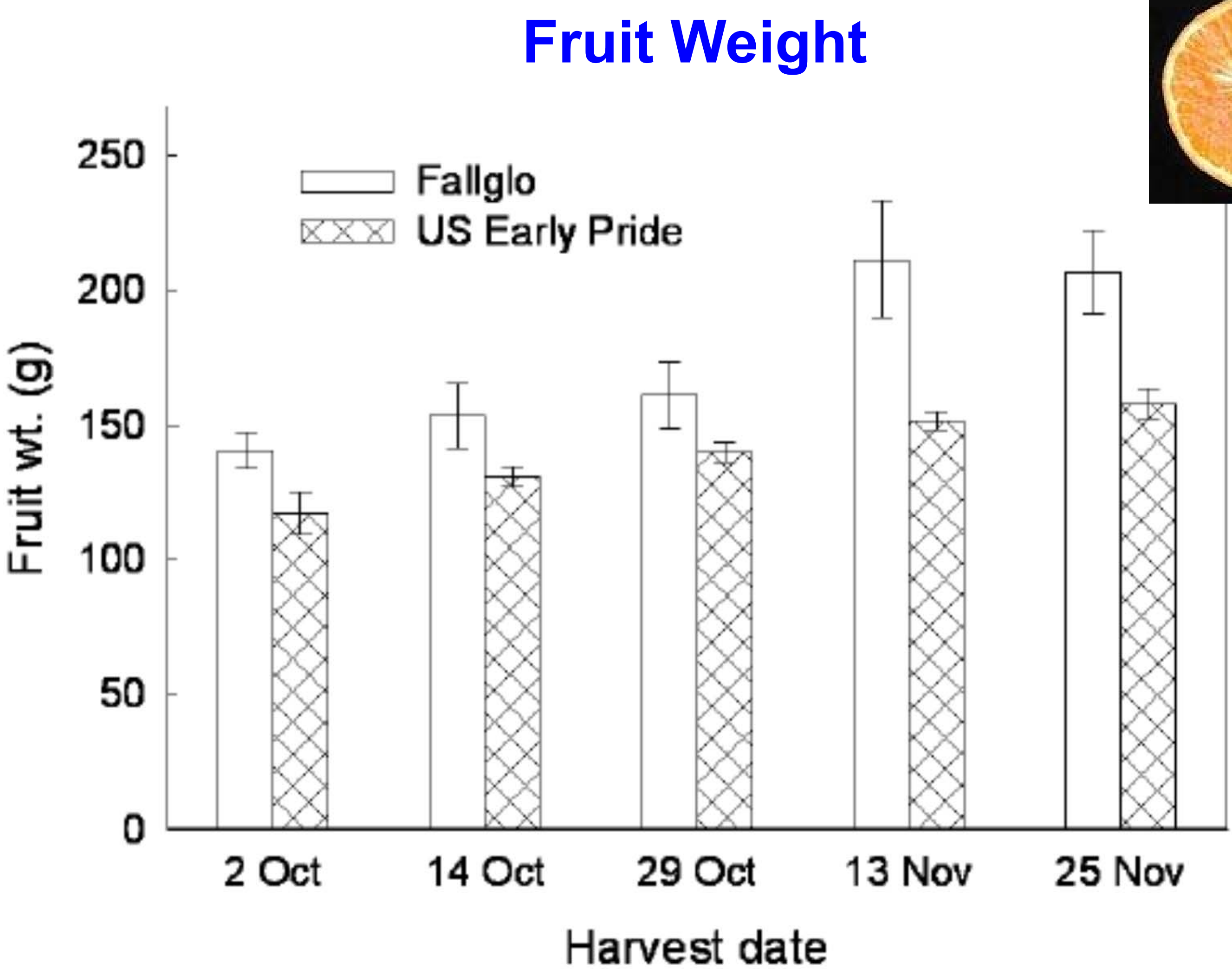


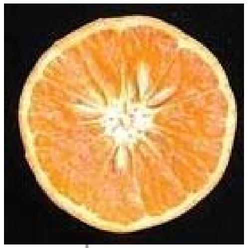
'US EARLY PRIDE'

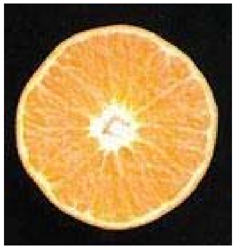
Irradiation induced mutation of Fallglo with very low seed count



Effect of Genetics on Fruit Size



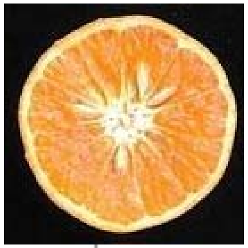


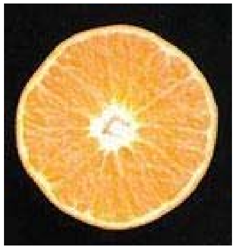


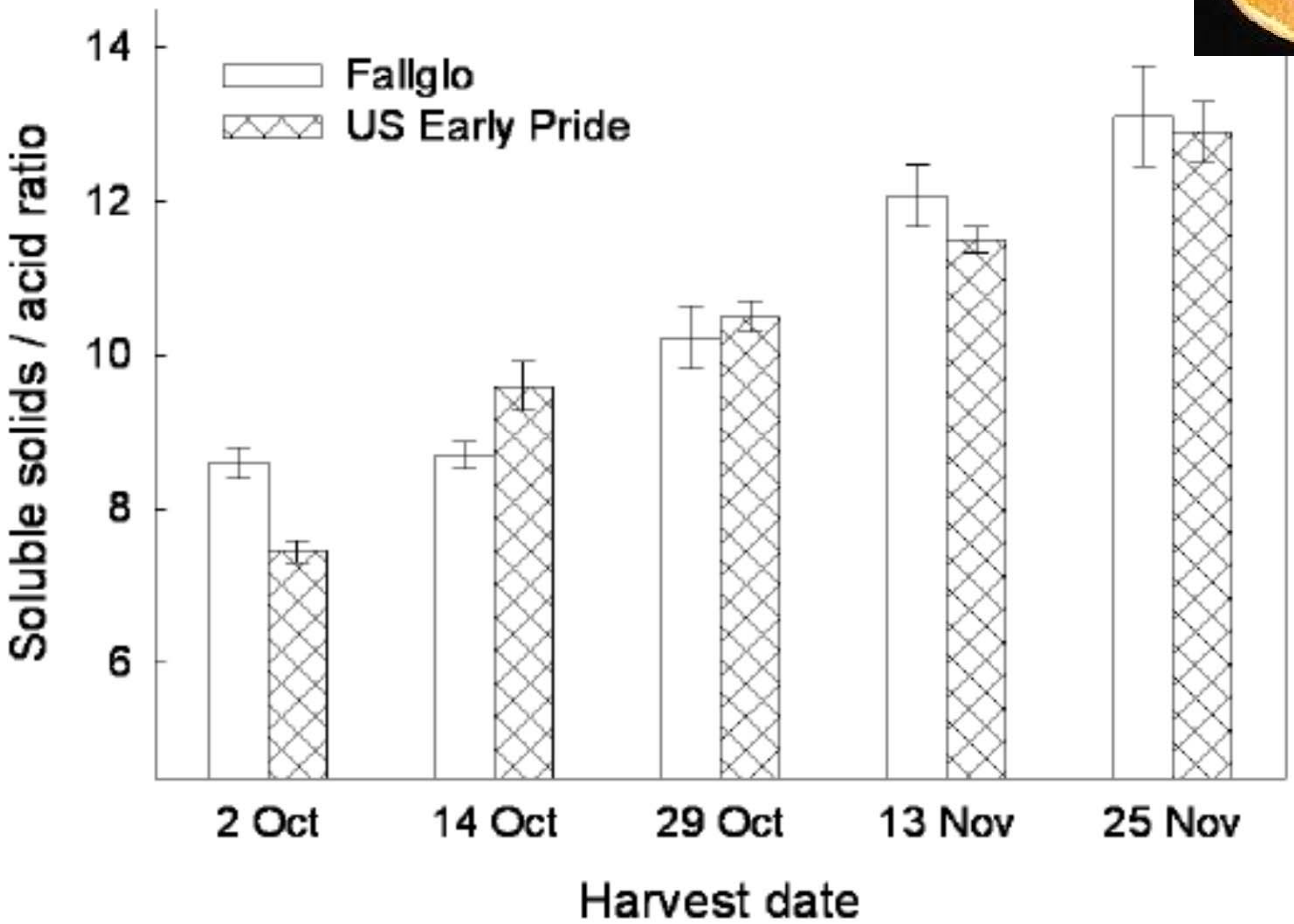
McCollum, Hearn, Ritenour, FSHS Proceedings 2010

Effect of Genetics on Maturity

SSC (Brix)/TA





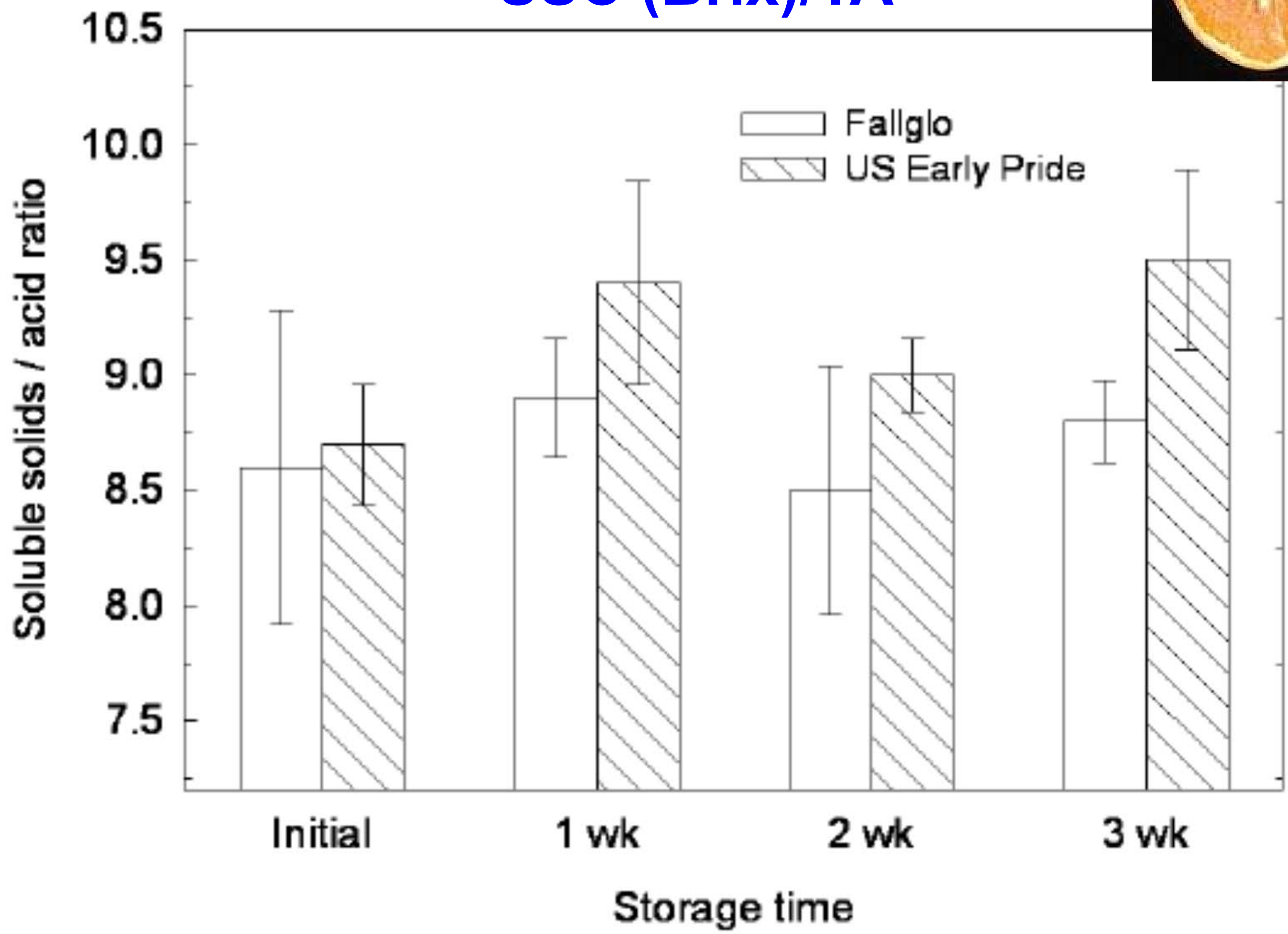


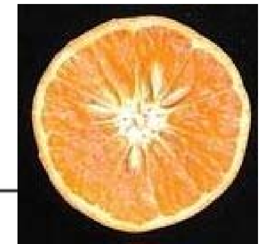
McCollum, Hearn, Ritenour, FSHS Proceedings 2010

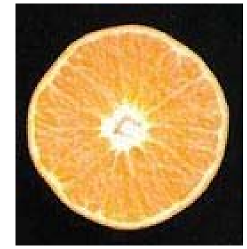
Effect of Genetics on Storage

Harvest October 21

SSC (Brix)/TA





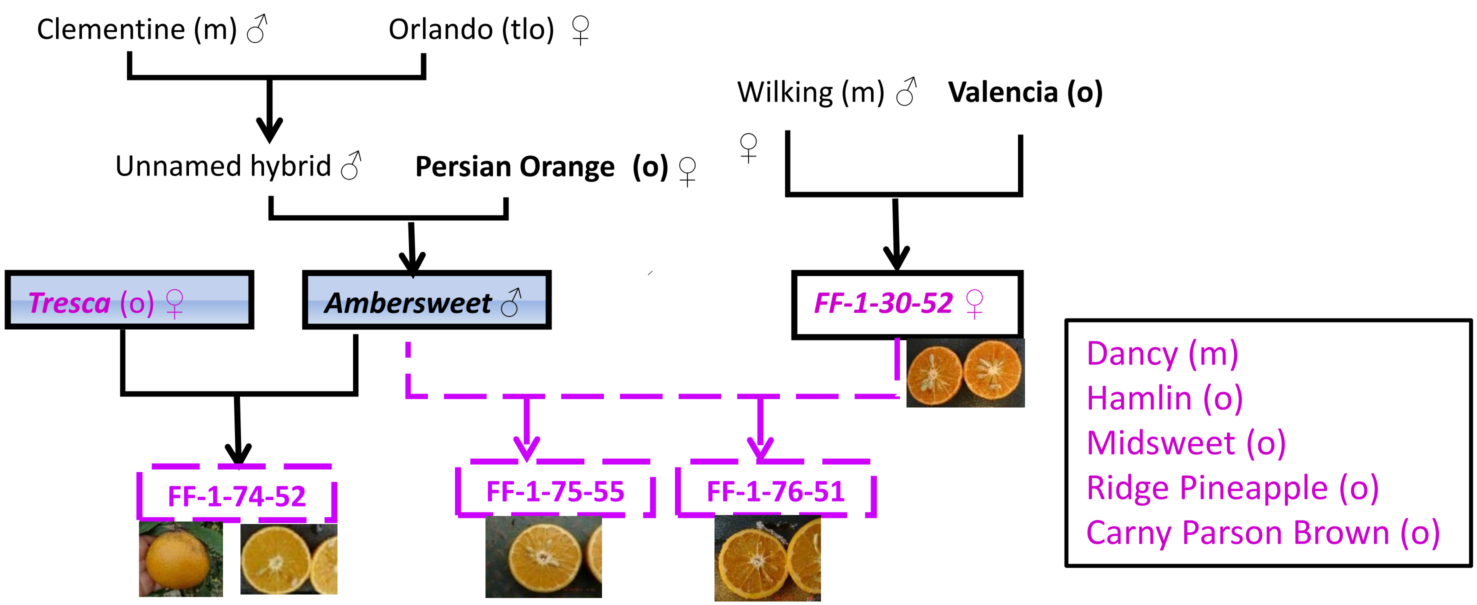


McCollum, Hearn, Ritenour, FSHS Proceedings 2010

Effect of Genetics on Volatiles

2014-2015 evaluation of USDA Sweet-orange-like hybrids

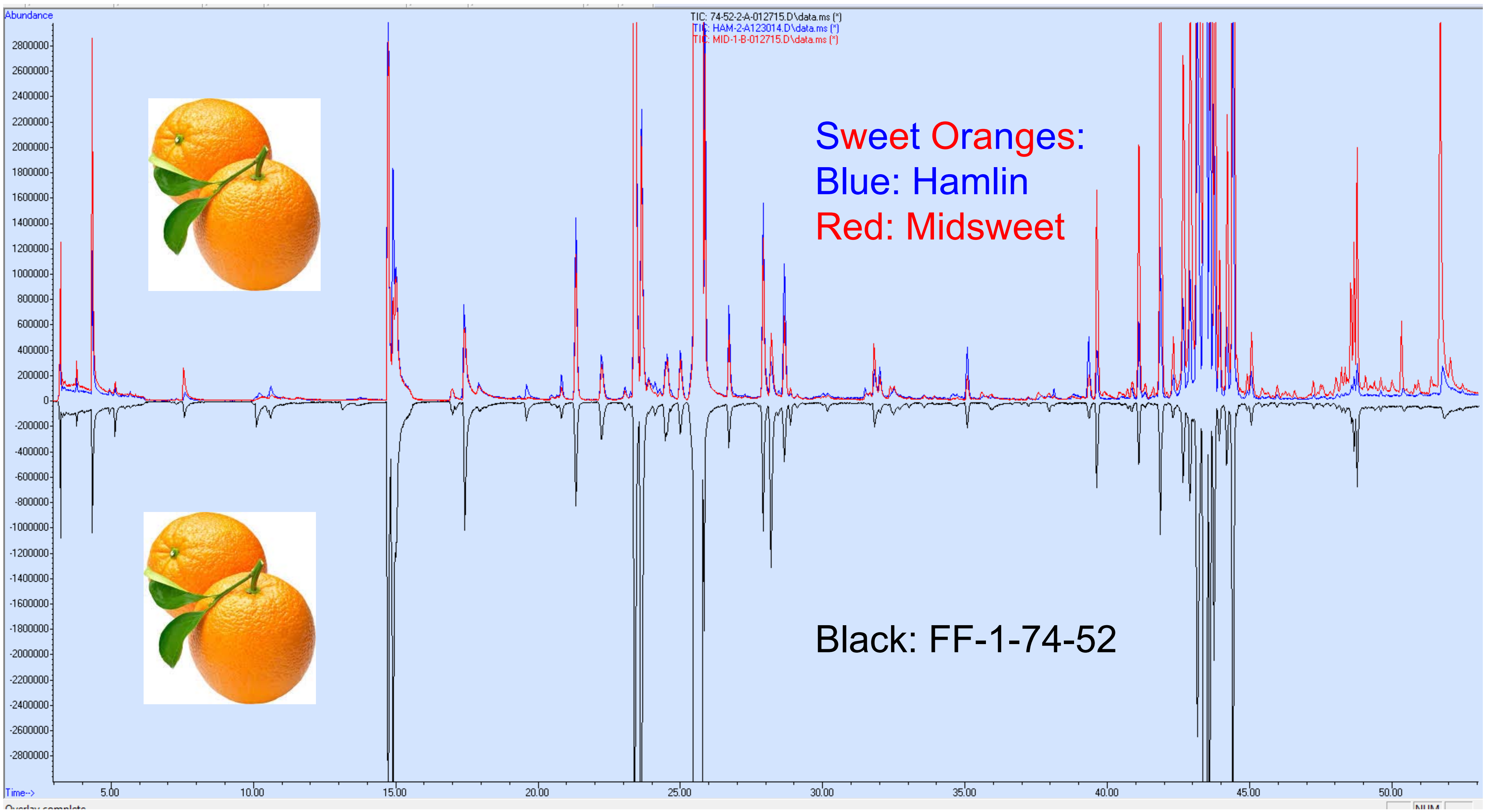
Jinhe Bai & Ed Stover



(m): mandarin (*C. reticulata*); **(o)**: sweet orange *(C.* × *sinensis); ***(tlo)**: tangelo [mandarin - grapefruit (*C.* × *paradisi)* hybrid].
Sweet orange and grapefruit are also hybrids as follows: sweet orange (mandarin - pummelo hybrid) and grapefruit [pummelo (*C. maxima*) -sweet orange hybrid]

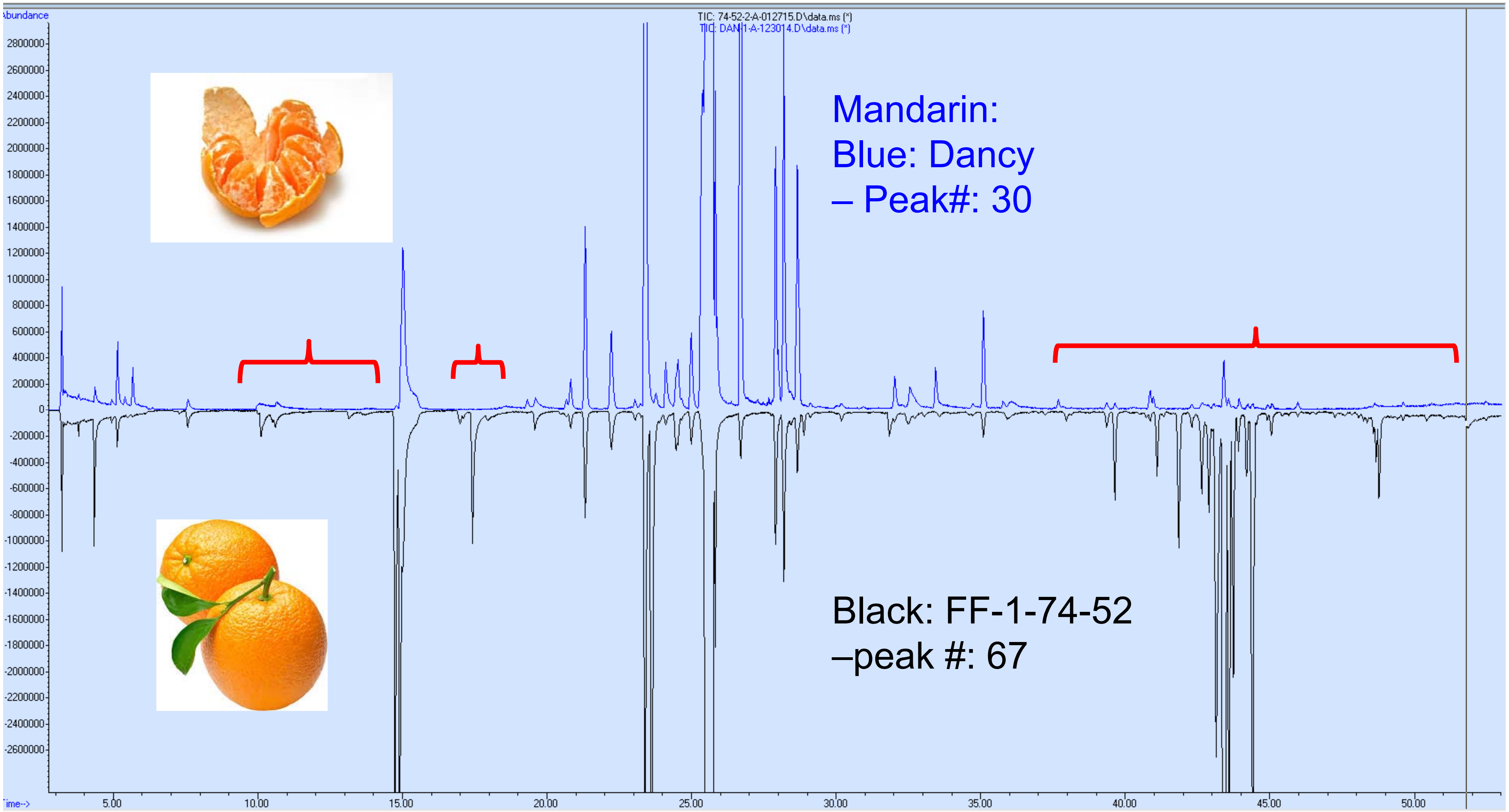
Pedigree of 'Ambersweet' and the hybrids (boxed) used in this research (Pink font color indicates varieties/lines for the flavor profile evaluation).

Chromatograms



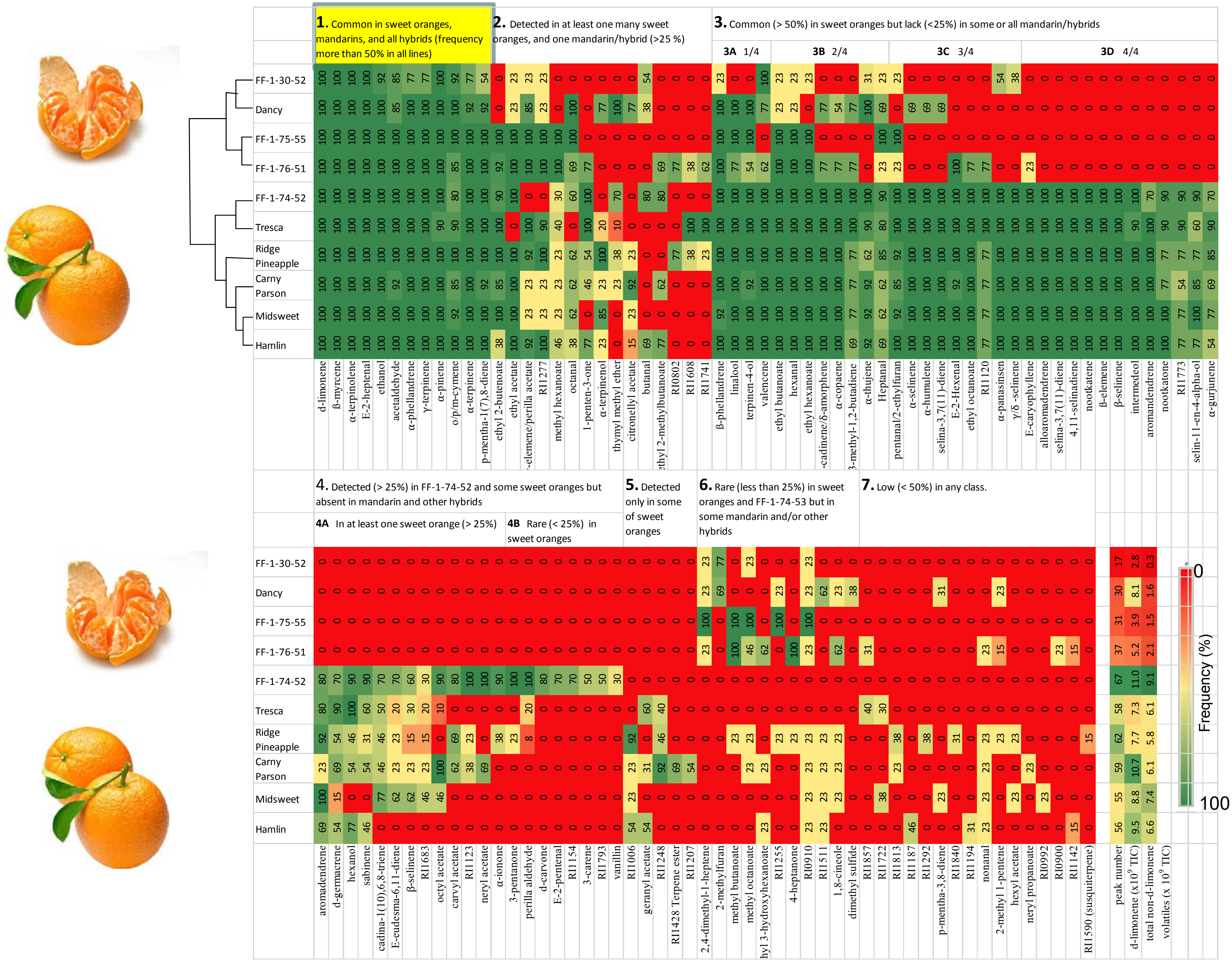
Volatile profile comparison:
FF-1-74-52 is similar to sweet oranges

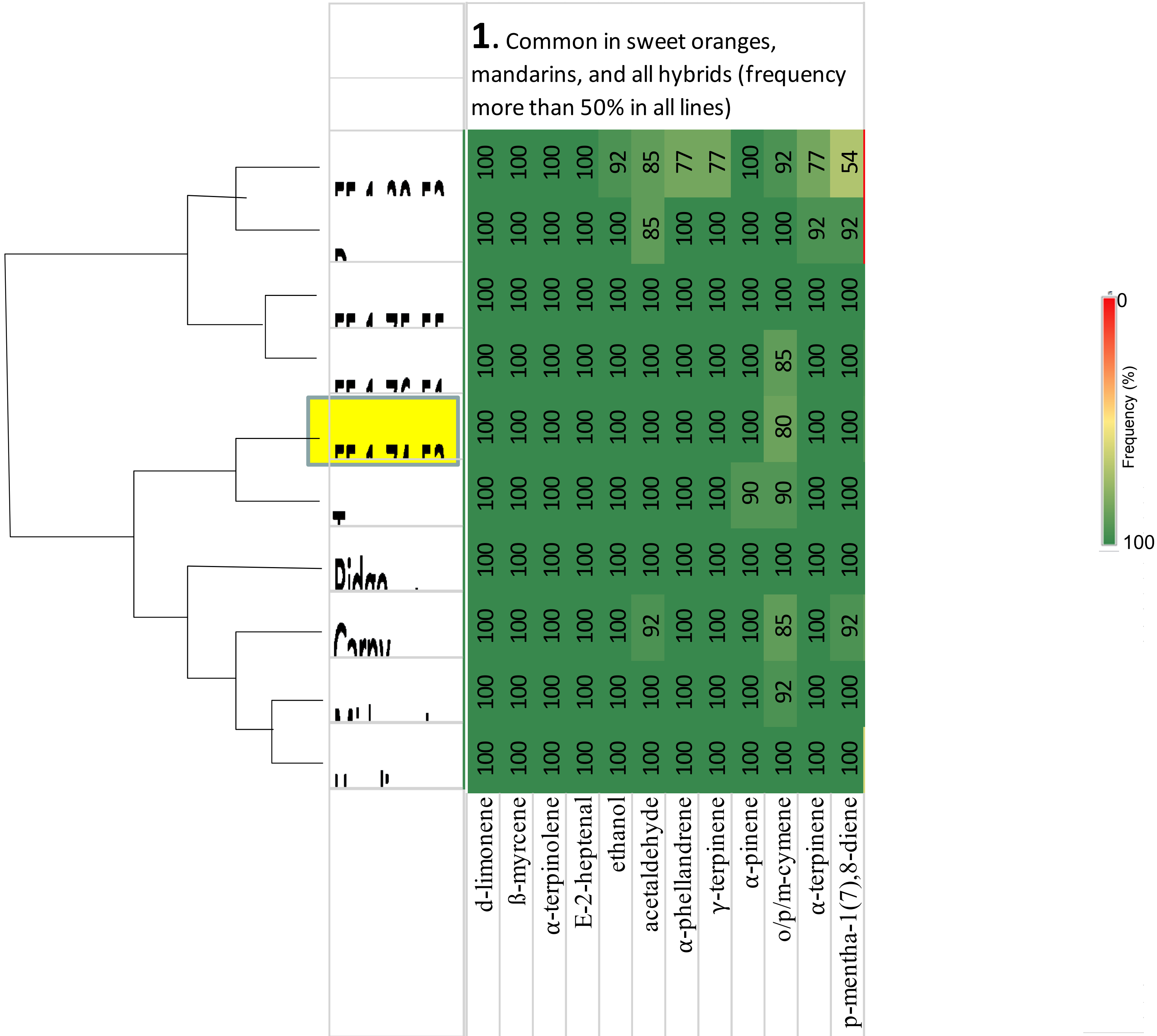
Chromatograms

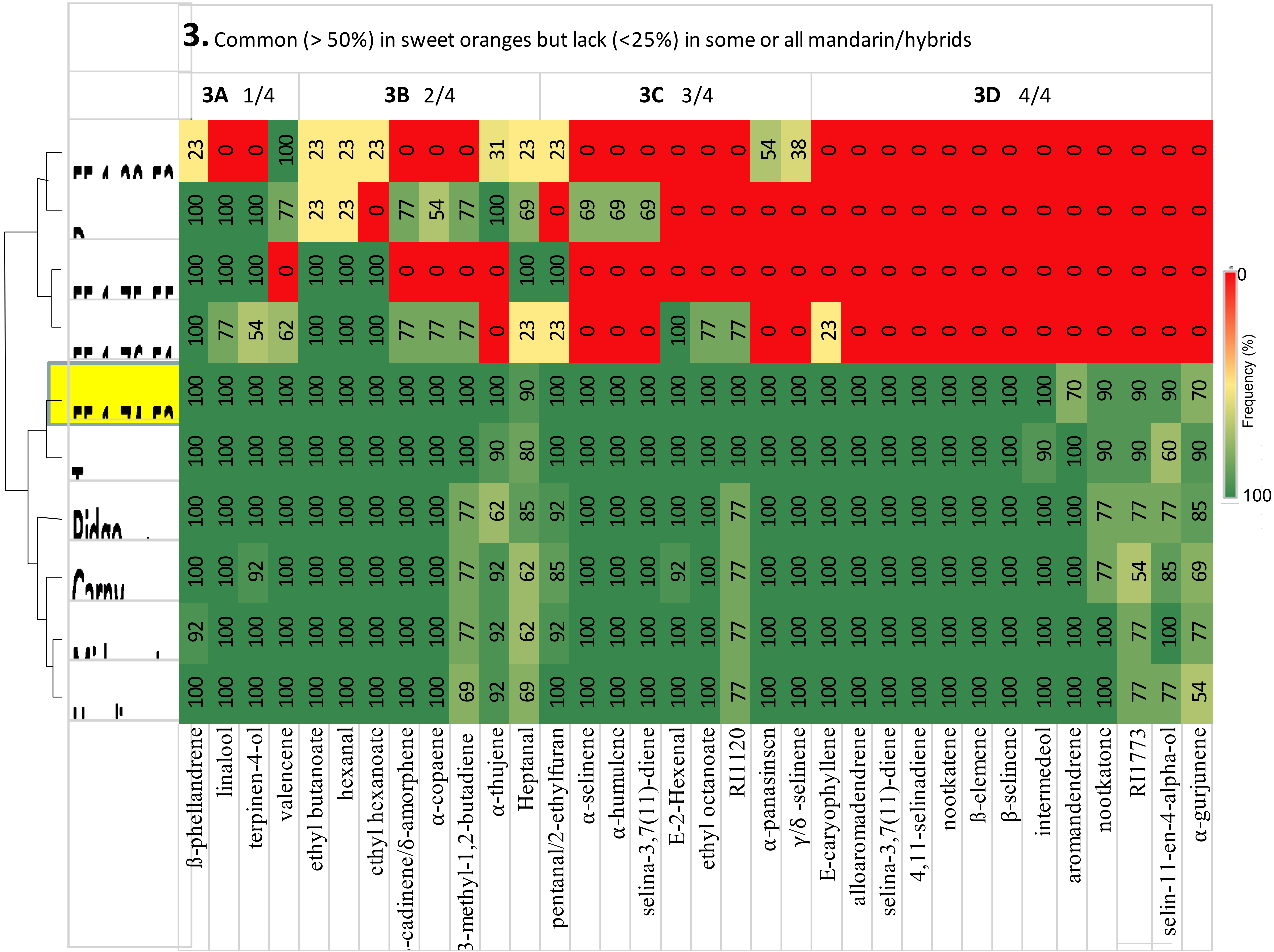


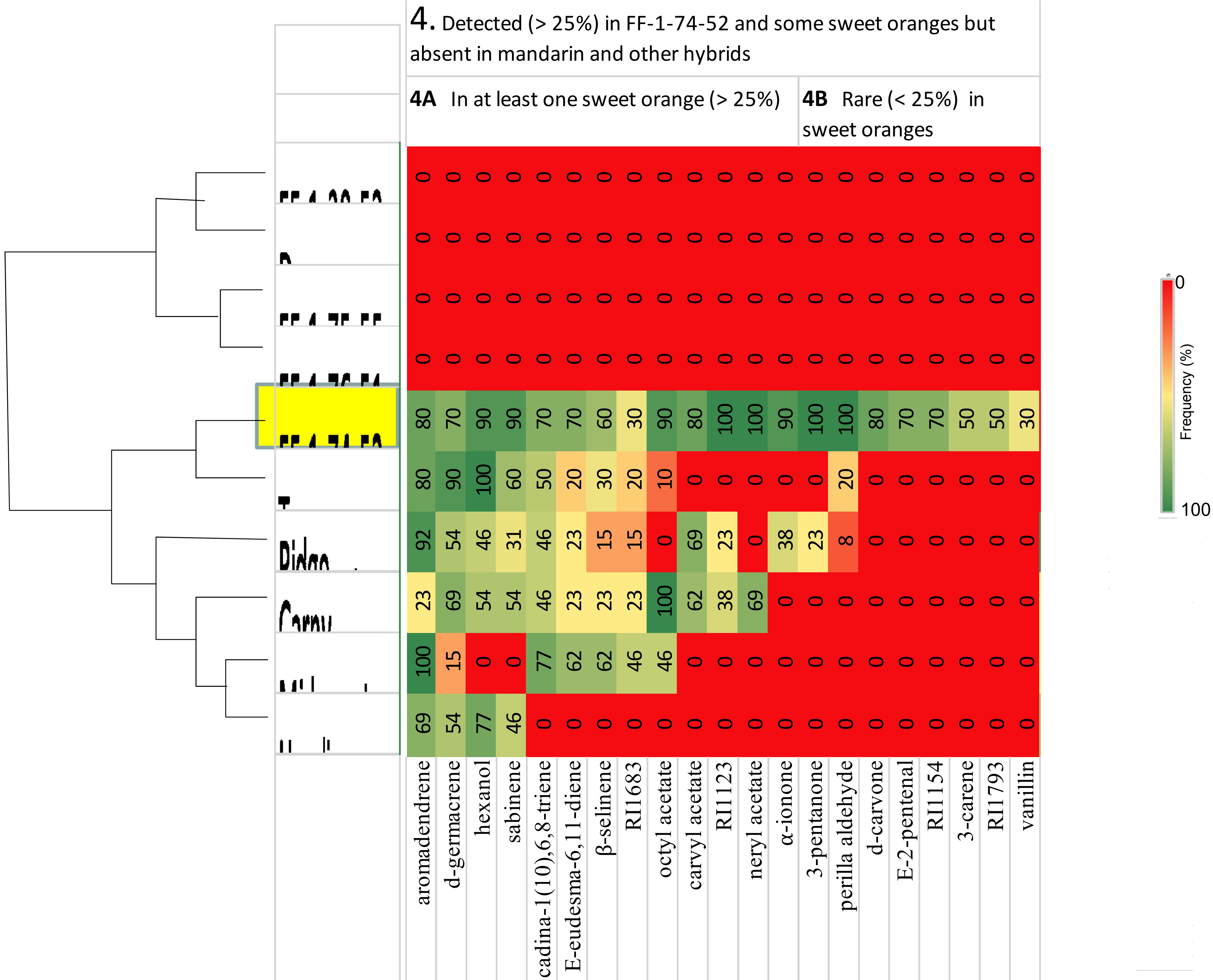
Volatile profile comparison:

FF-1-74-52 has more peaks (quality) and abundant concentration (quantity)


1. Common in sweet oranges, mandarins, and all hybrids (frequency more than 50% in all lines)
2. Detected in at least one many sweet oranges, and one mandarin/hybrid (>25 %)
3. Common (> 50%) in sweet oranges but lack (<25%) in some or all mandarin/hybrids
3A 1/4
3B 2/4
3C 3/4
3D 4/4
FF-1-30-52
Dancy
FF-1-75-55
FF-1-76-51
FF-1-74-52
Tresca
Ridge Pineapple
Carny Parson
Midsweet
Hamlin
d-limonene
β-myrcene
α-terpinolene
E-2-heptenal
ethanol
acetaldehyde
α-phellandrene
γ-terpinene
α-pinene
o/p/m-cymene
α-terpinene
p-mentha-1(7),8-diene
ethyl 2-butenoate
ethyl acetate
-elemene/perilla acetate
RI1277
methyl hexanoate
octanal
1-penten-3-one
α-terpinenol
thymyl methyl ether
citronellyl acetate
butanal
ethyl 2-methylbutanoate
RI0802
RI1608
RI1741
β-phellandrene
linalool
terpinen-4-ol
valencene
ethyl butanoate
hexanal
ethyl hexanoate
-cadinene/δ-amorphene
α-copaene
3-methyl-1,2-butadiene
α-thujene
Heptanal
pentanal/2-ethylfuran
α-selinene
α-humulene
selina-3,7(11)-diene
E-2-Hexenal
ethyl octanoate
RI1120
α-panasinsen
γ/δ -selinene
E-caryophyllene
alloaromadendrene
selina-3,7(11)-diene
4,11-selinadiene
nootkatene
β-elemene
β-selinene
intermedeol
aromandendrene
nootkatone
RI1773
selin-11-en-4-alpha-ol
α-gurjunene
4. Detected (> 25%) in FF-1-74-52 and some sweet oranges but absent in mandarin and other hybrids
4A In at least one sweet orange (> 25%)
4B Rare (< 25%) in sweet oranges
5. Detected only in some of sweet oranges
6. Rare (less than 25%) in sweet oranges and FF-1-74-53 but in some mandarin and/or other hybrids
7. Low (< 50%) in any class.
aromadendrene
d-germacrene
hexanol
sabinene
cadina-1(10),6,8-triene
E-eudesma-6,11-diene
β-selinene
RI1683
octyl acetate
carvyl acetate
RI1123
neryl acetate
α-ionone
3-pentanone
perilla aldehyde
d-carvone
E-2-pentenal
RI1154
3-carene
RI1793
vanillin
RI1006
geranyl acetate
RI1248
RI1428 Terpene ester
RI1207
2,4-dimethyl-1-heptene
2-methylfuran
methyl butanoate
methyl octanoate
hyl 3-hydroxyhexanoate
RI1255
4-heptanone
RI0910
RI1511
1,8-cineole
dimethyl sulfide
RI1857
RI1722
RI1813
RI1187
RI1292
p-mentha-3,8-diene
RI1840
RI1194
nonanal
2-methyl 1-pentene
hexyl acetate
neryl propanoate
RI0992
RI0900
RI1142
RI1590 (susquiterpene)
peak number
d-limonene (x10^9 TIC)
total non-d-limonene volatiles (x 10^9 TIC)
Frequency (%)
0
100


1. Common in sweet oranges, mandarins, and all hybrids (frequency more than 50% in all lines)
d-limonene
ß-myrcene
α-terpinolene
E-2-heptenal
ethanol
acetaldehyde
α-phellandrene
γ-terpinene
α-pinene
o/p/m-cymene
α-terpinene
p-mentha-1(7),8-diene
100 100 100 100 92 85 77 77 100 92 77 54
100 100 100 100 100 85 100 100 100 100 92 92
100 100 100 100 100 100 100 100 100 100 100 100
100 100 100 100 100 100 100 100 100 85 100 100
100 100 100 100 100 100 100 100 100 80 100 100
100 100 100 100 100 100 100 100 90 90 100 100
100 100 100 100 100 100 100 100 100 100 100 100
100 100 100 100 100 92 100 100 100 85 100 92
100 100 100 100 100 100 100 100 100 92 100 100
100 100 100 100 100 100 100 100 100 100 100 100
Frequency (%)
0
100


3. Common (> 50%) in sweet oranges but lack (<25%) in some or all mandarin/hybrids
3A 1/4
3B 2/4
3C 3/4
3D 4/4
β-phellandrene
linalool
terpinen-4-ol
valencene
ethyl butanoate
hexanal
ethyl hexanoate
-cadinene/δ-amorphene
α-copaene
3-methyl-1,2-butadiene
α-thujene
Heptanal
pentanal/2-ethylfuran
α-selinene
α-humulene
selina-3,7(11)-diene
E-2-Hexenal
ethyl octanoate
RI1120
α-panasinsen
γ/δ -selinene
E-caryophyllene
alloaromadendrene
selina-3,7(11)-diene
4,11-selinadiene
nootkatene
β-elemene
β-selinene
intermedeol
aromandendrene
nootkatone
RI1773
selin-11-en-4-alpha-ol
α-gurjunene
Frequency (%)
0
100


4. Detected (> 25%) in FF-1-74-52 and some sweet oranges but absent in mandarin and other hybrids
4A In at least one sweet orange (> 25%)
4B Rare (< 25%) in sweet oranges
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
80 70 90 90 70 70 60 30 90 80 100 100 90 100 100 80 70 70 50 50 30
80 90 100 60 50 20 30 20 10 0 0 0 0 0 20 0 0 0 0 0 0
92 54 46 31 46 23 15 15 0 69 23 0 38 23 8 0 0 0 0 0 0
23 69 54 54 46 23 23 23 100 62 38 69 0 0 0 0 0 0 0 0 0
100 15 0 0 77 62 62 46 46 0 0 0 0 0 0 0 0 0 0 0 0
69 54 77 46 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
aromadendrene
d-germacrene
hexanol
sabinene
cadina-1(10),6,8-triene
E-eudesma-6,11-diene
β-selinene
RI1683
octyl acetate
carvyl acetate
RI1123
neryl acetate
α-ionone
3-pentanone
perilla aldehyde
d-carvone
E-2-pentenal
RI1154
3-carene
RI1793
vanillin
0
Frequency (%)
100

Effect of Genetics on Volatiles

2014-2015 evaluation of USDA Sweet-orange-like hybrids

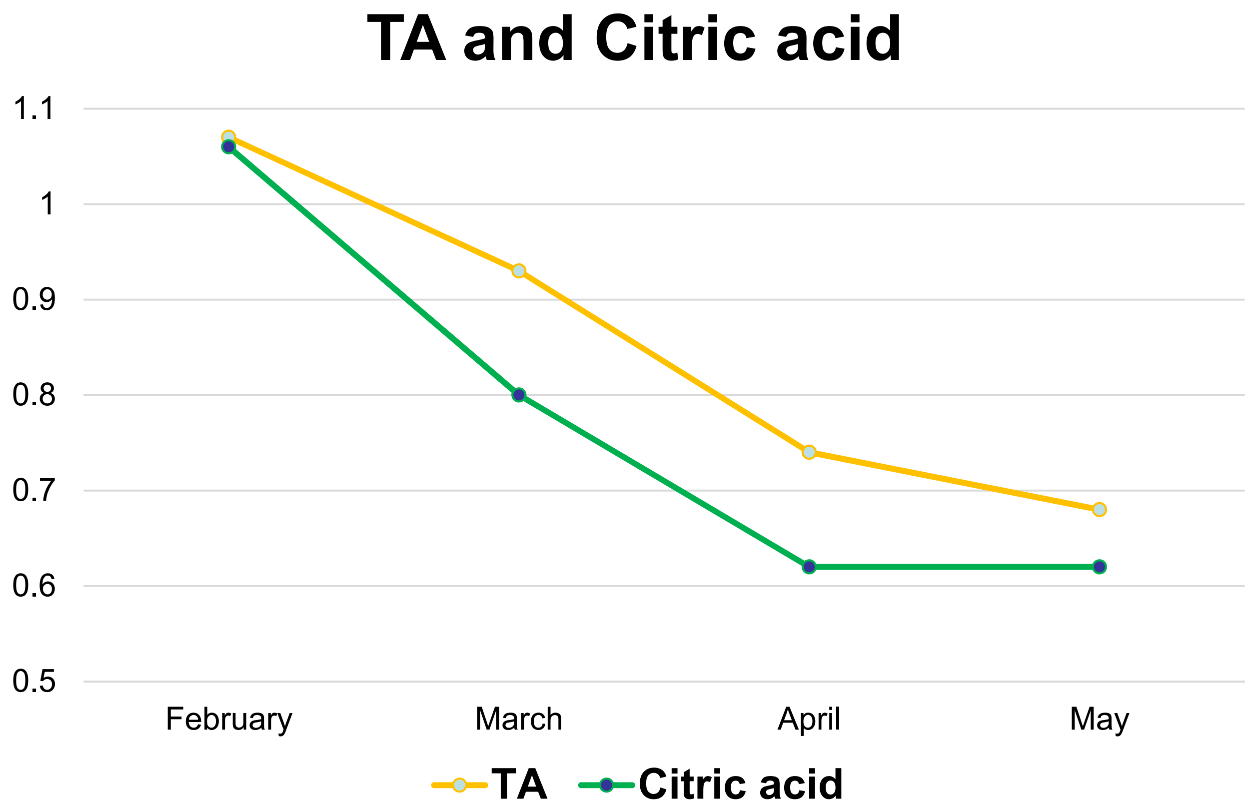
Jinhe Bai & Ed Stover

- ✓ Volatile analysis of FF-1-74-52 classifies it as a sweet orange.
- ✓ Volatiles of other hybrids were too different from sweet orange, and closer to mandarin profile.
- ✓ More esters and sesquiterpene hydrocarbons distinguish volatiles of oranges from mandarins (Takayuki et al, 2011 and Kerbiriou et al, 2007).

Effect of Fruit Maturity on Acids

Jinhe Bai

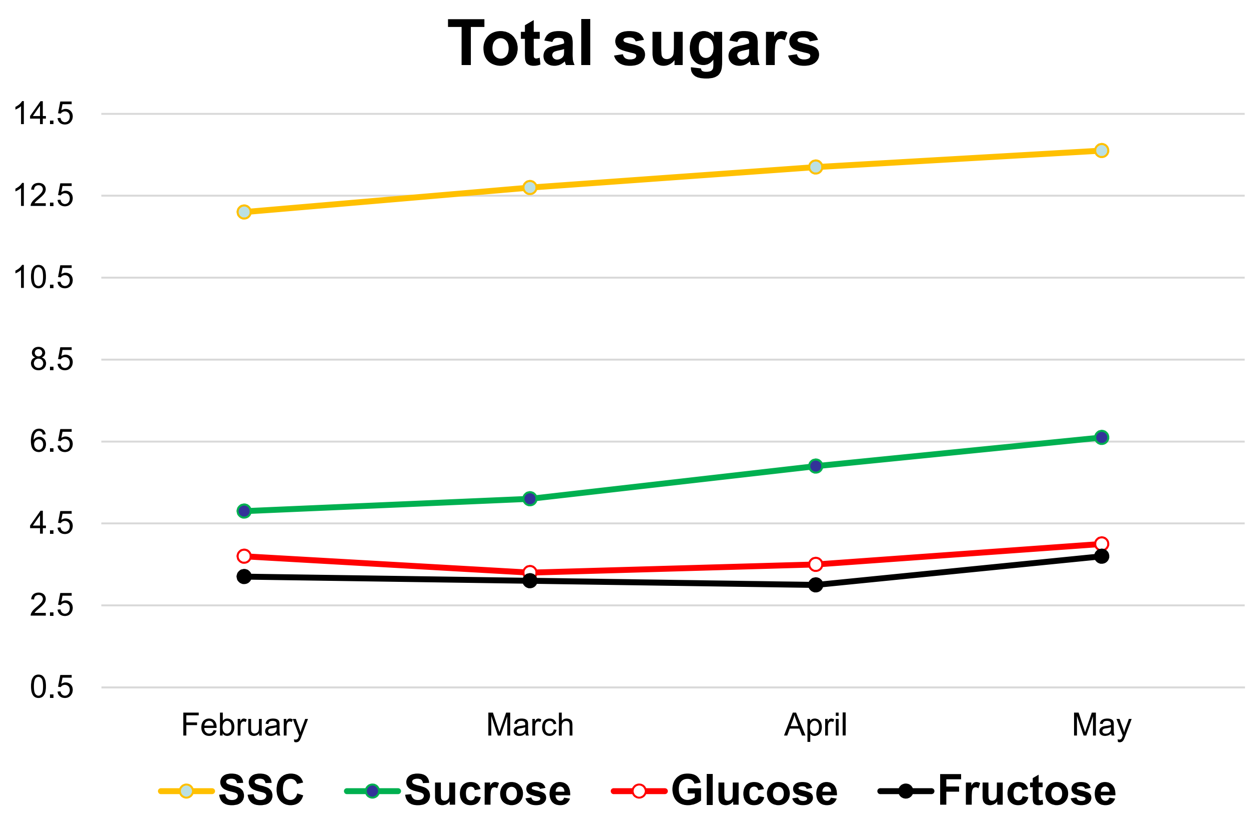
Valencia oranges harvested from February to May



Effect of Fruit Maturity on Sugars

Jinhe Bai

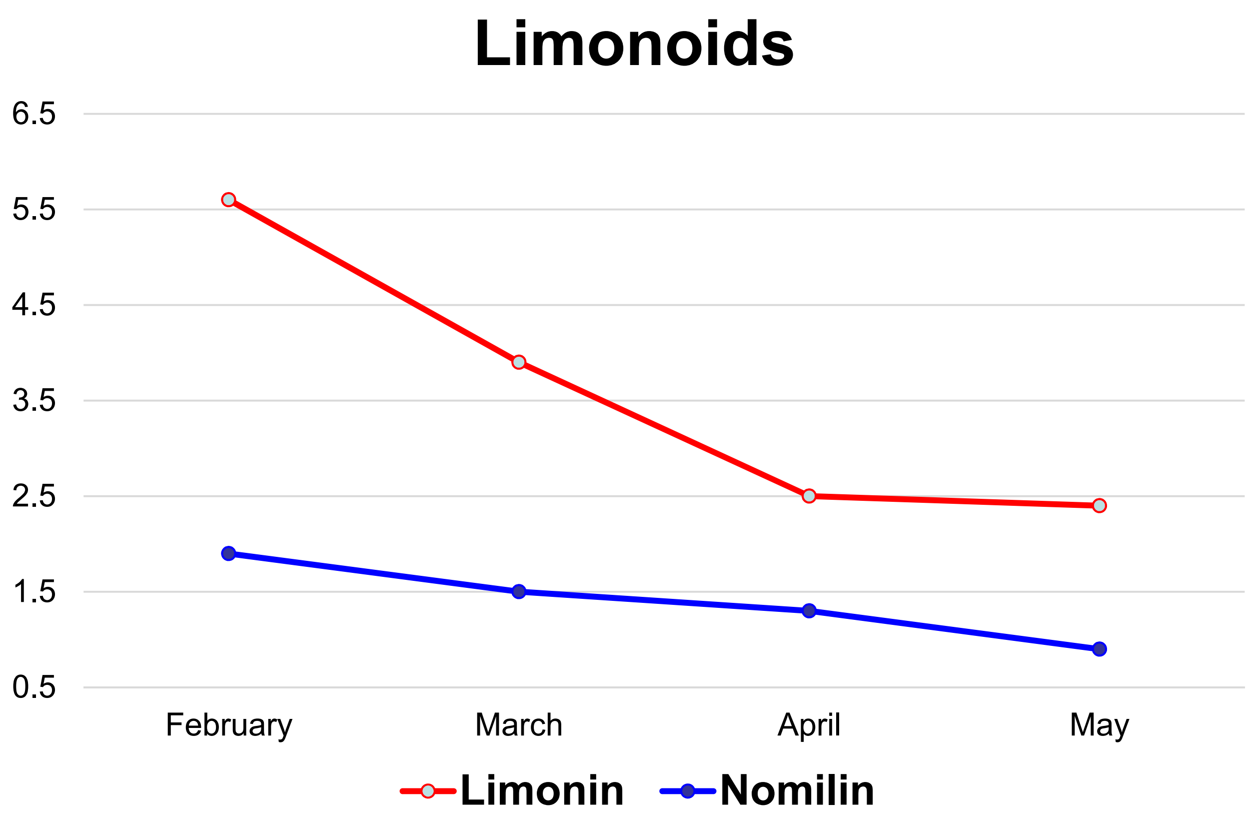
Valencia oranges harvested from February to May



Effect of Fruit Maturity on Limonoids

Jinhe Bai

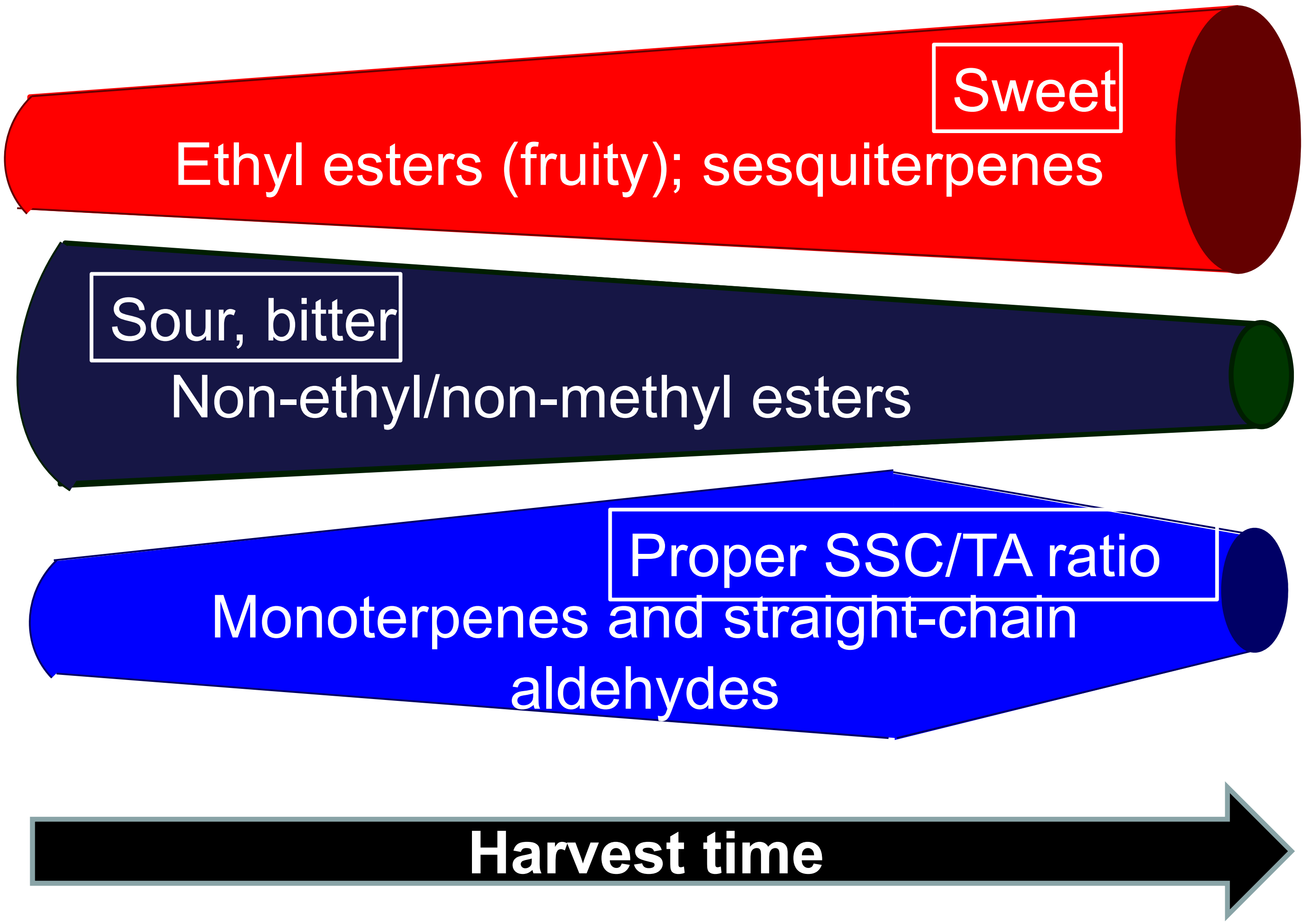
Valencia oranges harvested from February to May



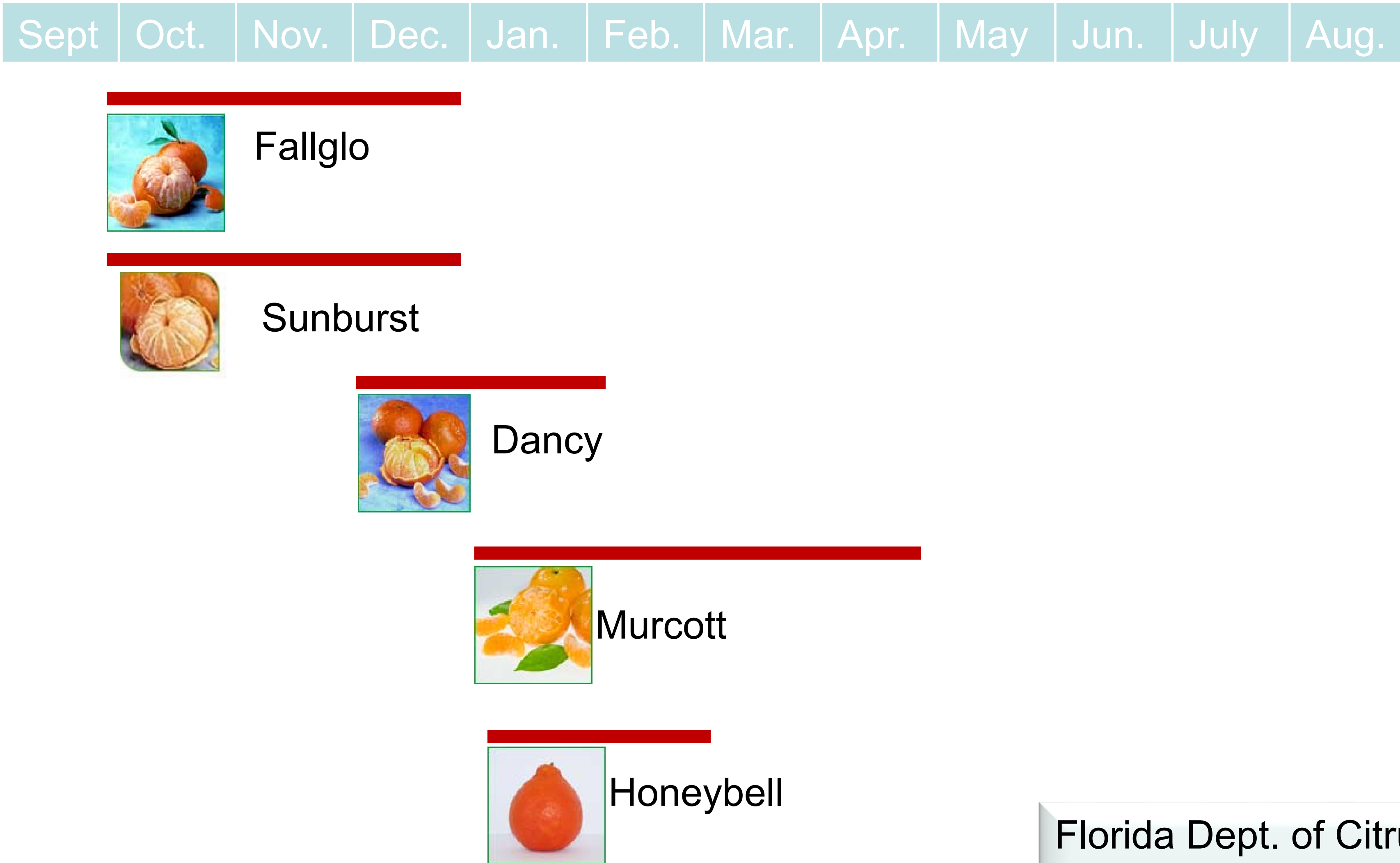
Effect of Fruit Maturity on Volatiles

Jinhe Bai

Valencia oranges harvested from February to May



Effect of Cultivar and Maturity



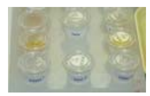
Florida Dept. of Citrus
www.floridajuice.com

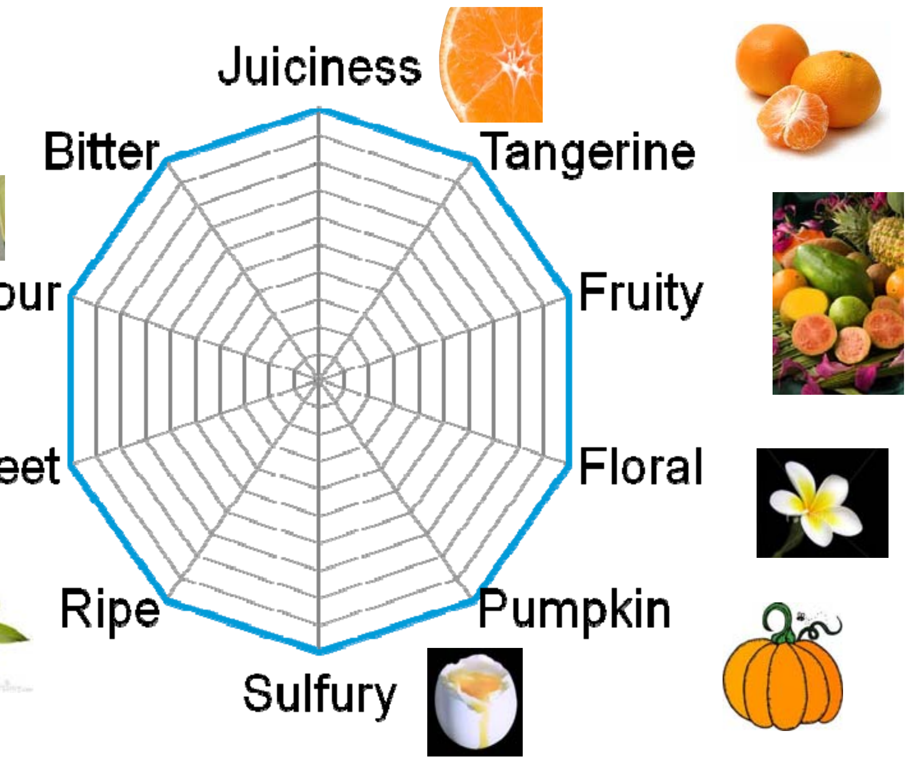
Objectives

- To determine harvest maturity of commercial and new tangerine cultivars
- Sensory evaluation and instrumental analysis

Sensory evaluation

- 10 panelists
- Training for eight 1-1½ hour sessions
- Ballot development
- Reference standards





Fruit samples

- Two locations
  - Lake Alfred (UF) and Leesburg (ARS)
- Harvest every 2 to 3 weeks:
  - 2010-2011: Dec 8, Jan 3, Jan 20, Feb 2, Mar 9
  - 2011-2012: Dec 12, Jan 9, Jan 30, Feb 20, Mar 5

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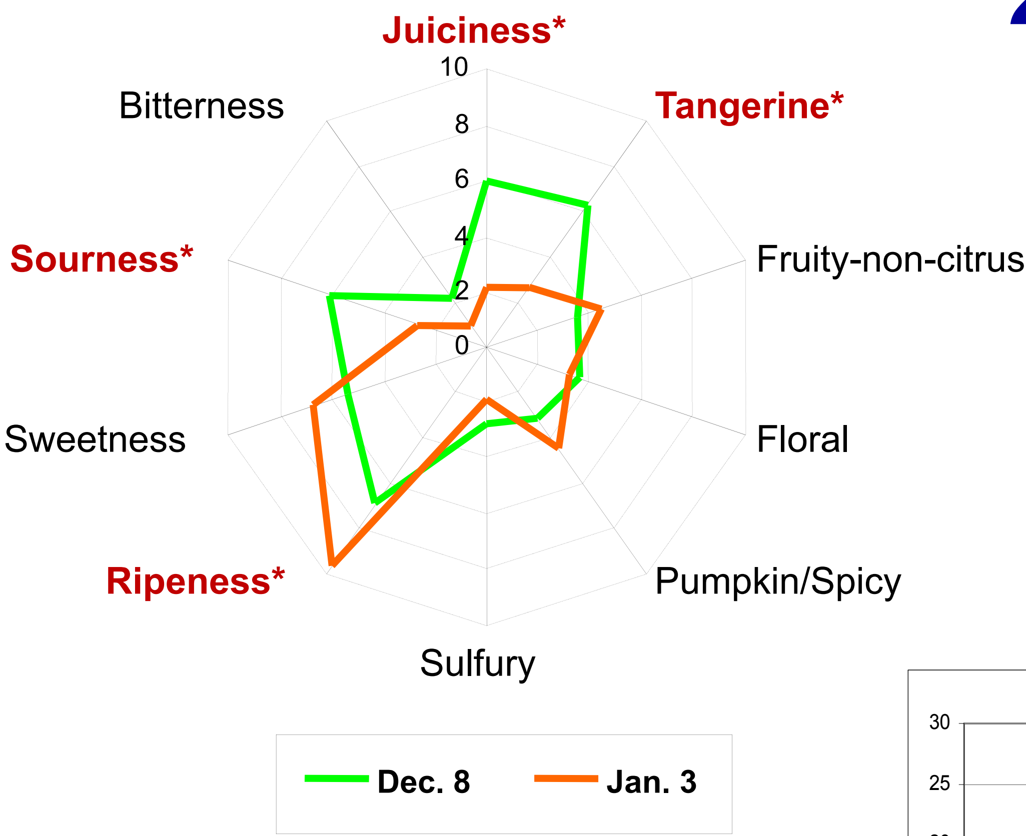
USDA 5-51-2

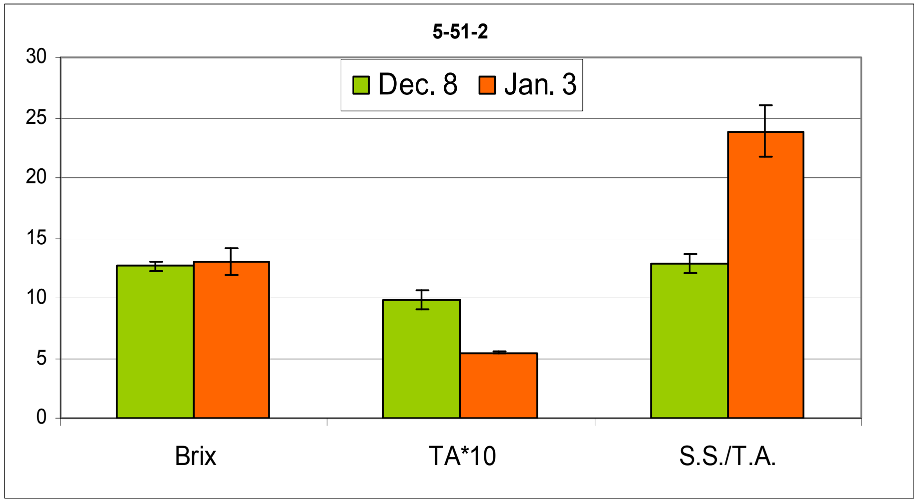
- Hybrid (Clementine x Orlando) x Seedling
- Mid-season sweet orange
- High quality juice
- Difficult to peel
- Less susceptible to HLB?

USDA 5-51-2

2010-2011



High peel oil
Dry and bland at 2nd harvest
(freezes)



Sugar Belle® 'LB8-9'
(U.S. Patent PP21,356)

- A mandarin hybrid released by UF IFAS citrus breeding program
- Similar to Minneola tangelo, but earlier maturity, greater disease resistance, and superior flavor
- Few to no seeds

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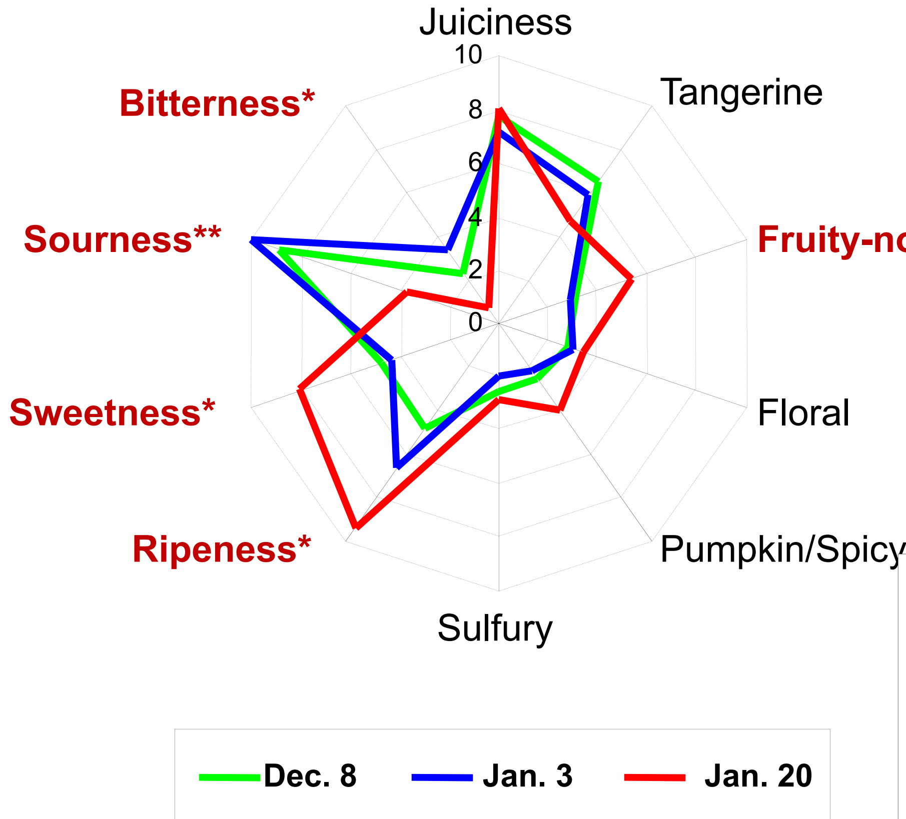
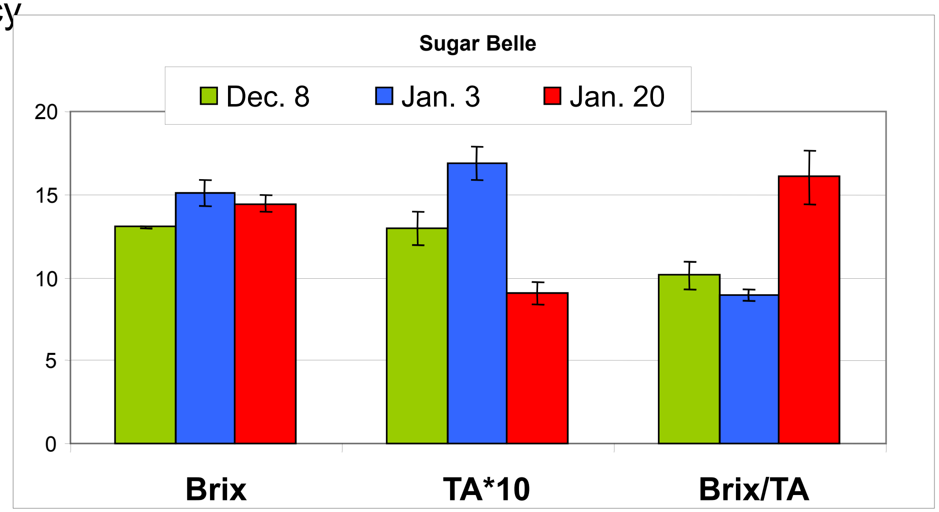
IFAS
Citrus Research and Education Center

Sugar Belle® 'LB8-9'

2010-2011 – "High acid" year

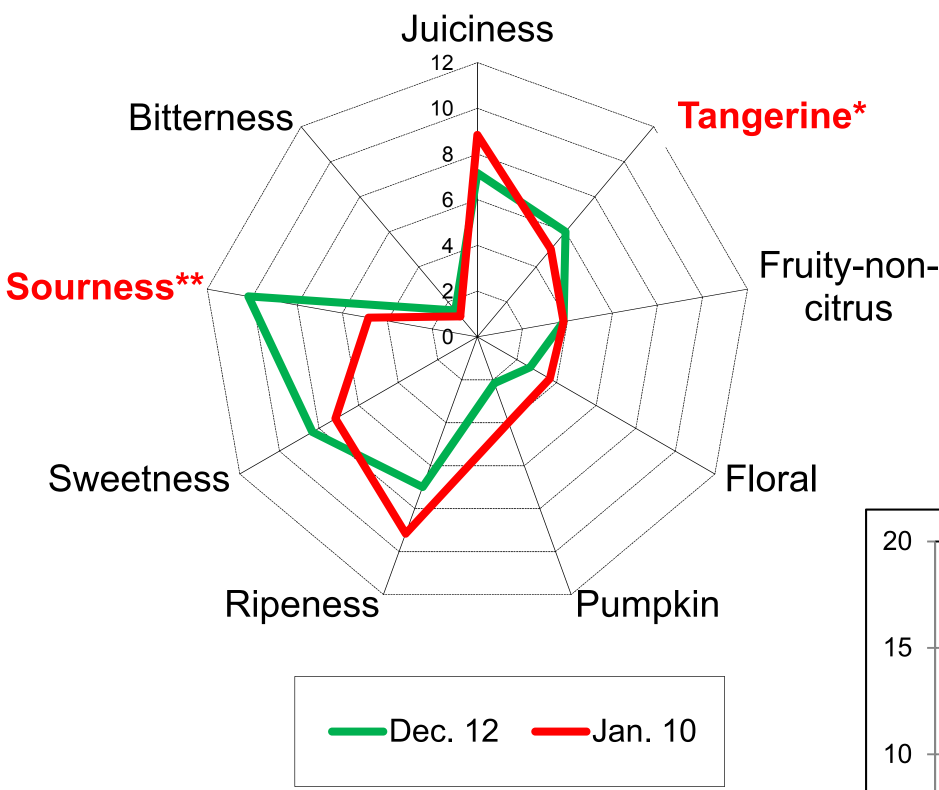


- ✓ Dec. 8: too sour, underripe
- ✓ Jan. 3: just right flavor, while still sour
- ✓ Jan. 20: overripe – slimy texture

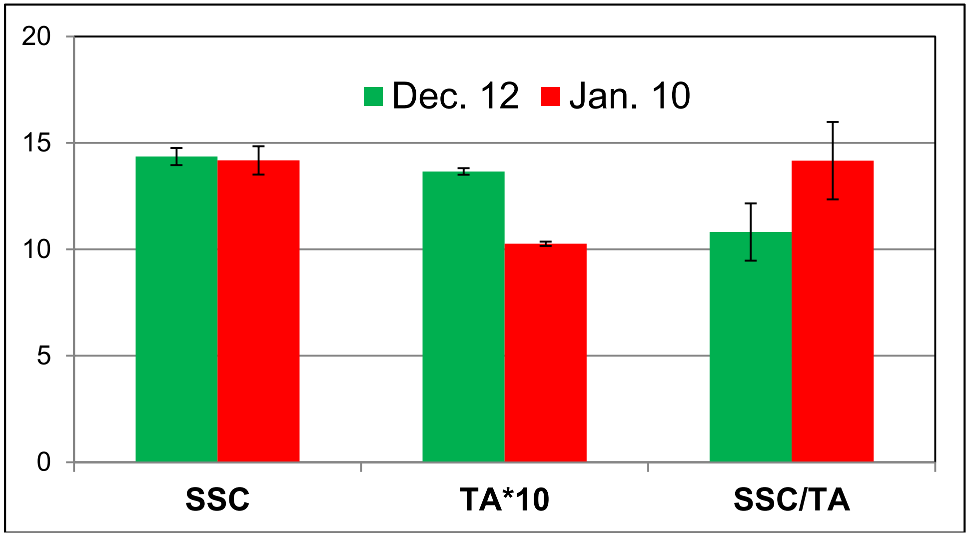


Sugar Belle® 'LB8-9'

2011-2012 – "Low acid" year



- ✓ Dec. 12: very sour, lemony
- ✓ Jan. 10: overripe



UF-411 (8-9 x Murcott)

- Large fruit, easy-to-peel, excellent flavor
- Maturity Jan. through March
- In the process of being released

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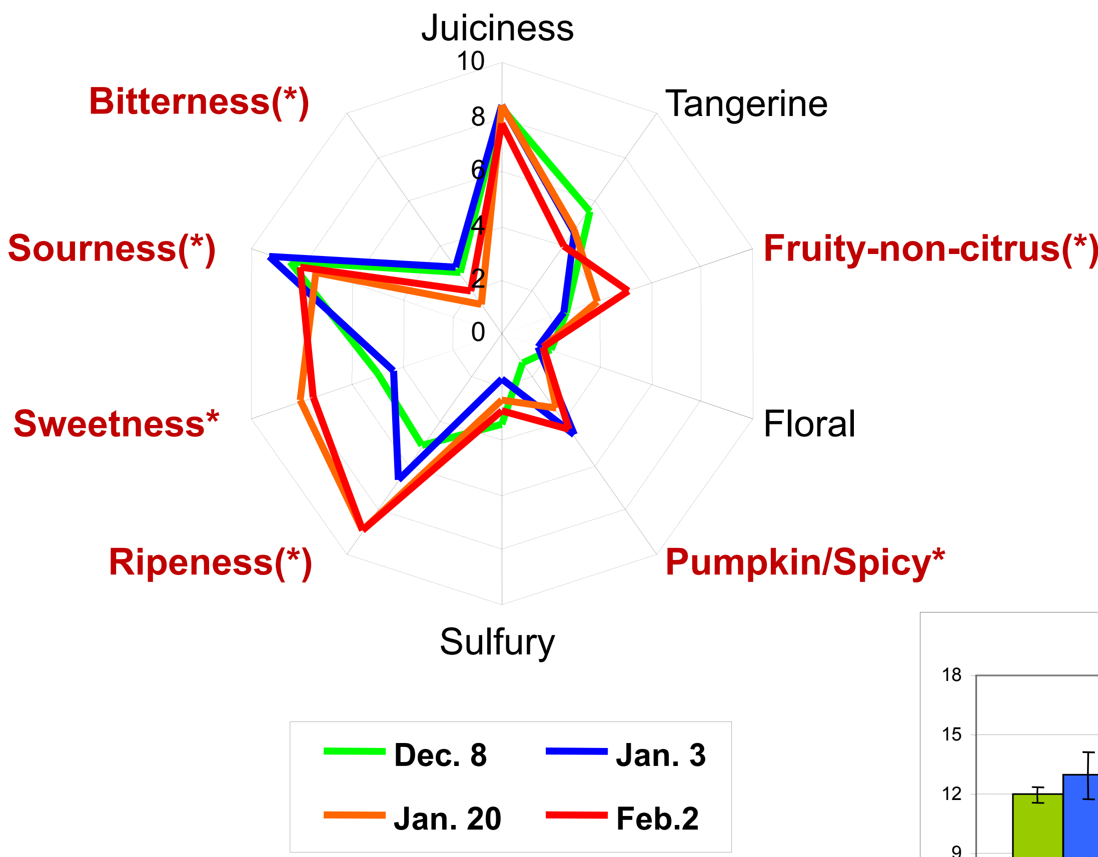
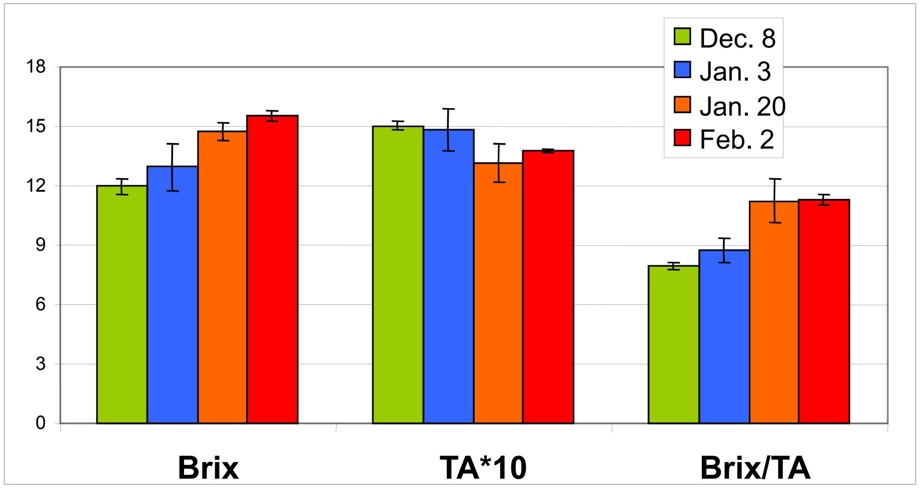
IFAS
Citrus Research and Education Center

UF-411 (8-9 x Murcott)

2010-2011– “High acid” year

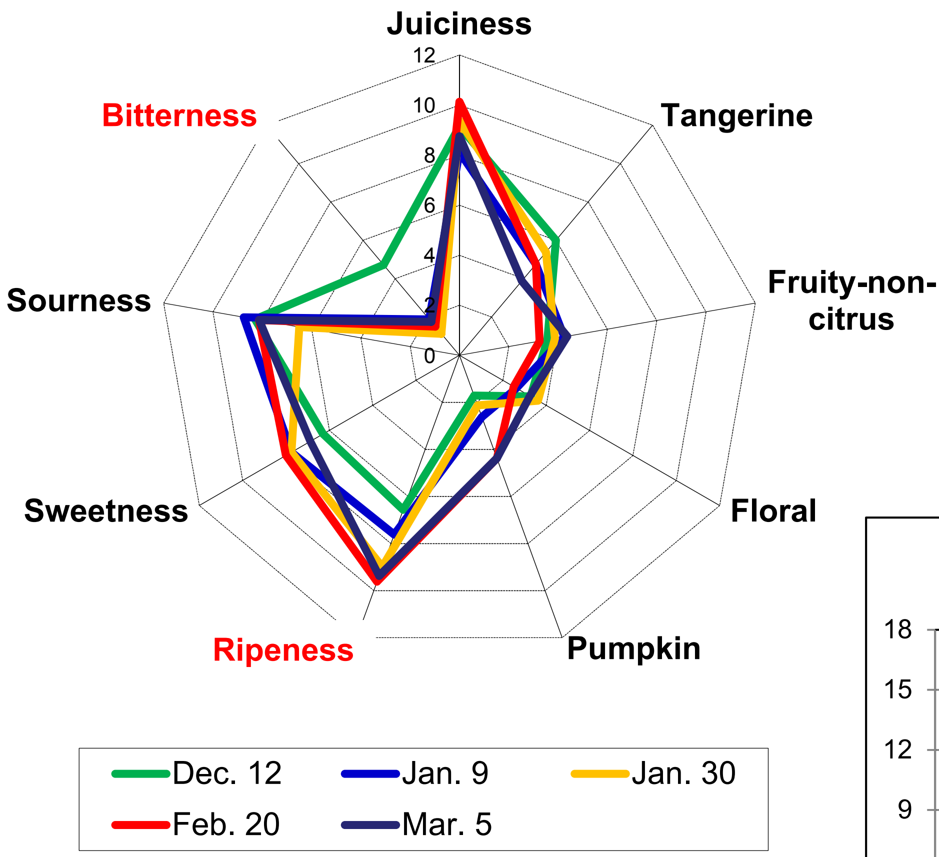


- ✓ Dec, Jan: too sour but interesting flavor
- ✓ End Jan and Feb: very sweet and sour, mix of orange and tangerine flavor

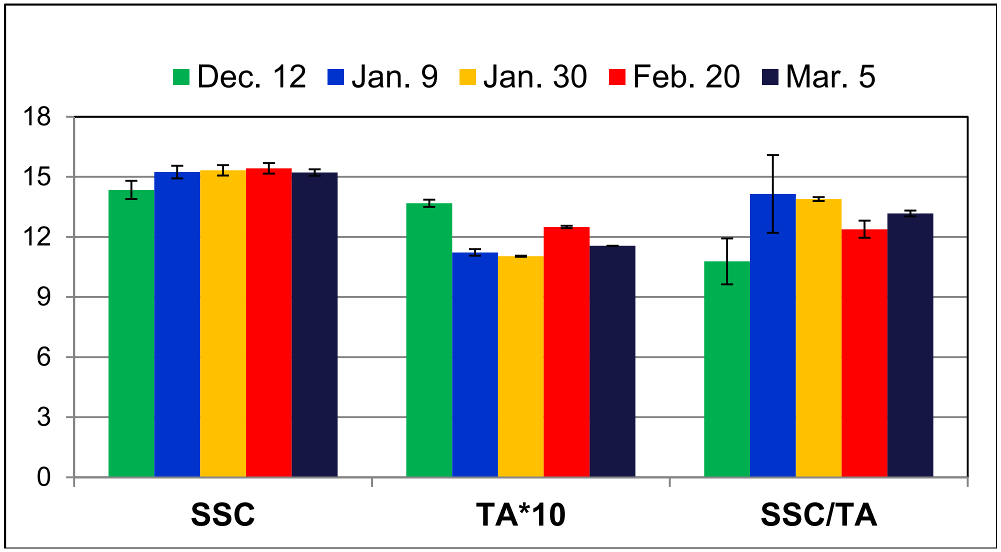


UF-411 (8-9 x Murcott)

2011-2012 – "Low acid" year



- ✓ Season characterized by low acid fruit
- ✓ Fruit maturity early January
- ✓ End Feb., March already overripe



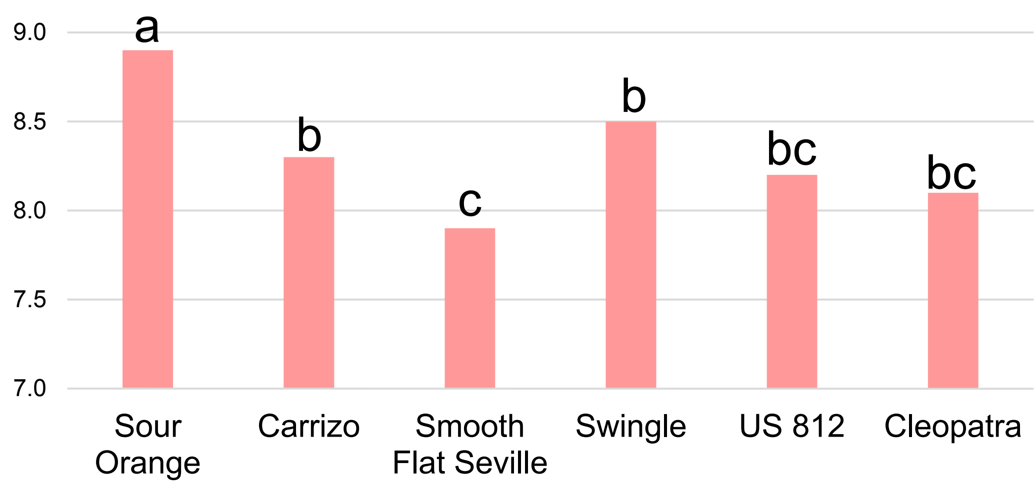
Conclusion Maturity Study

- Significant year effect: cold spring and late bloom in 2011 resulting in sour fruit; early season and low acid fruit in 2012.
- Determined harvest windows for Sugar Belle™, UF 411, LS Murcott, and other UF and USDA hybrids.
- Volatile data were analyzed to correlate with sensory data.

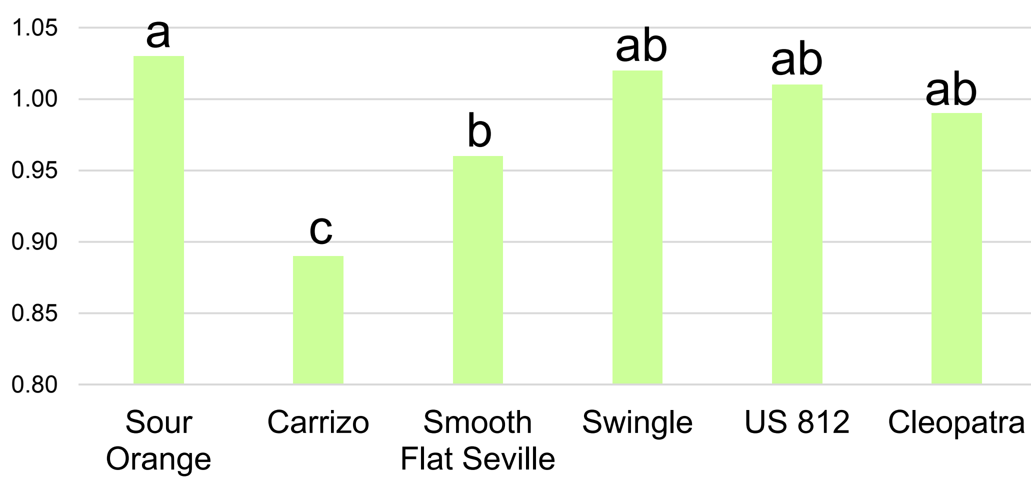
Rootstock Effect

Effect of Rootstock on Fruit Quality

SSC (°Brix)



TA



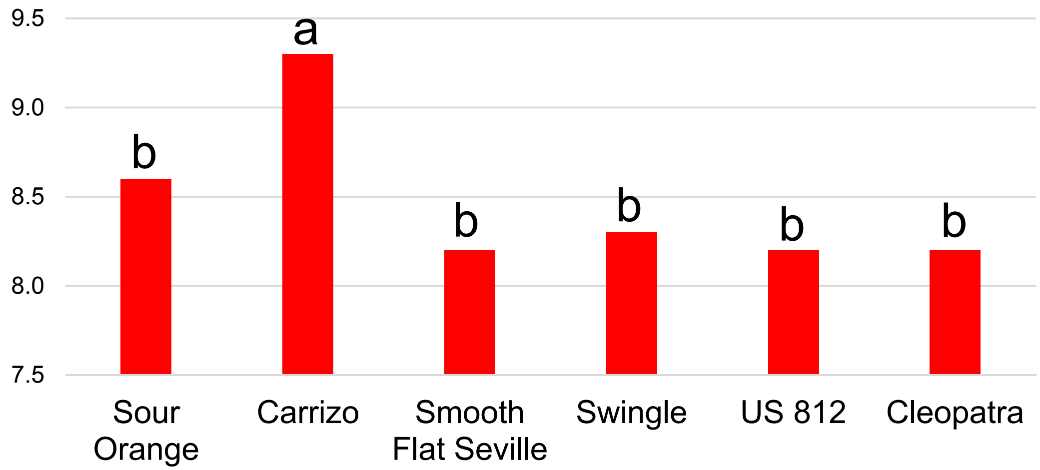
McCollum, Bowman & Castle
FSHS Proceedings 2002

- ‘Marsh’ Grapefruit
- Field Trial Martin County
- Harvest Dec. 12, 2001

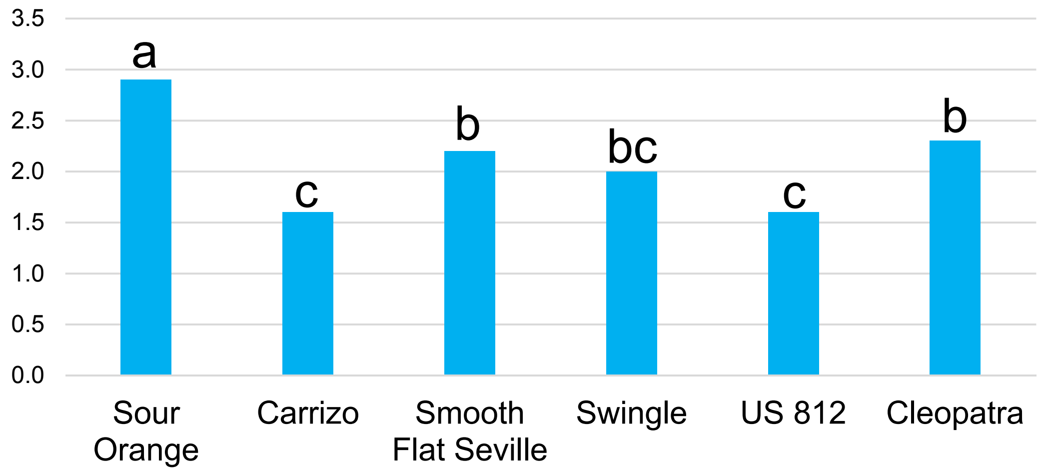
Effect of Rootstock on Fruit Quality

McCollum, Bowman & Castle
FSHS Proceedings 2002

SSC/TA

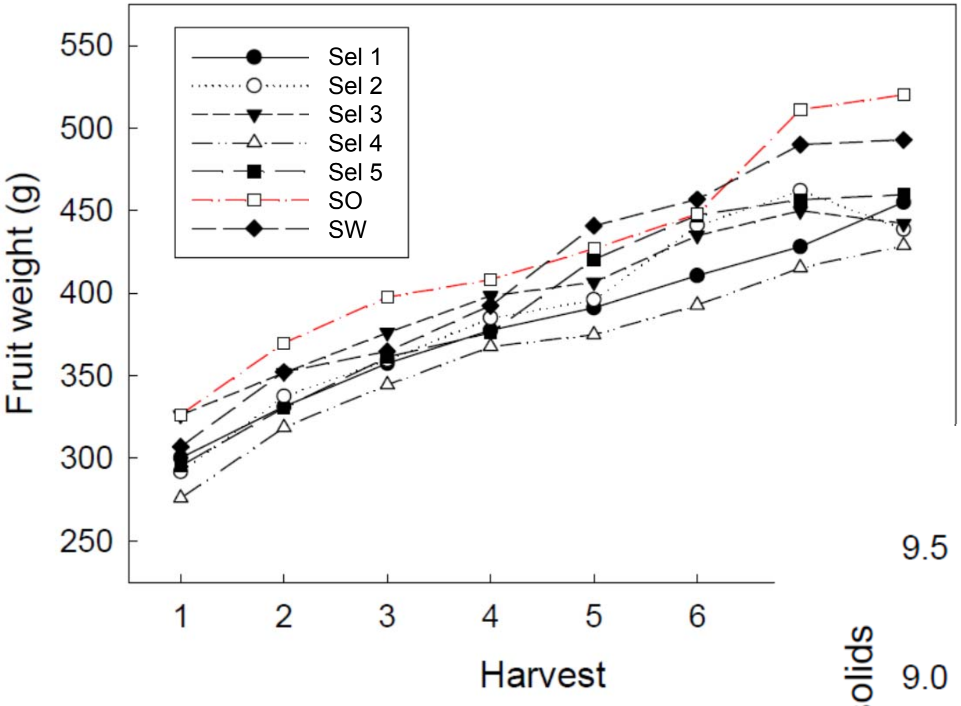


Chilling Injury (+ 5 weeks at 5 °C)



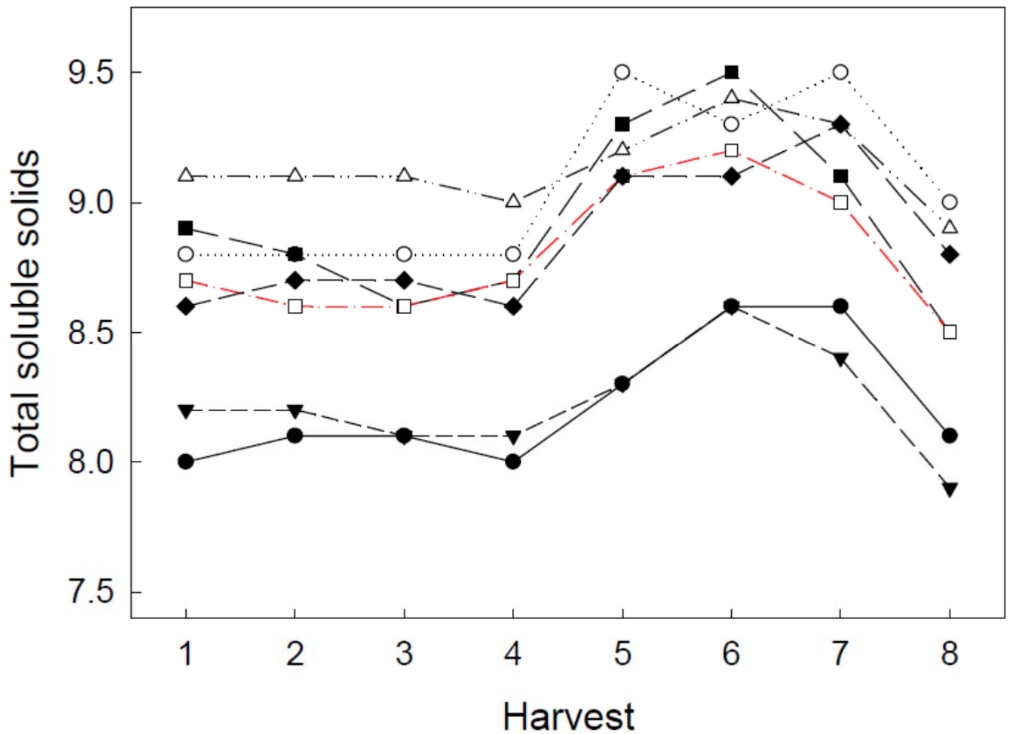
- 'Marsh' Grapefruit
- Field Trial Martin County
- Harvest Dec. 12, 2001

Effect of Rootstock on Fruit Quality



McCollum and Bowman, ASHS 2015

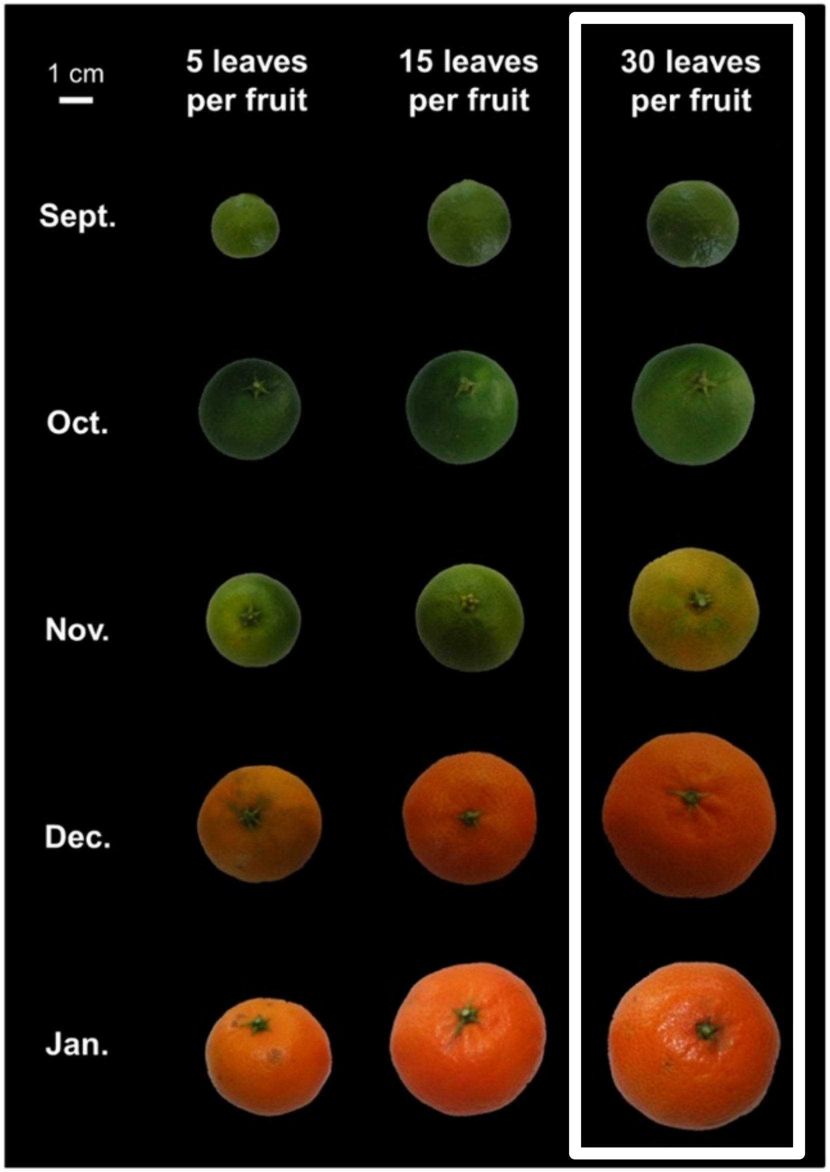
'Ray Ruby' Grapefruit

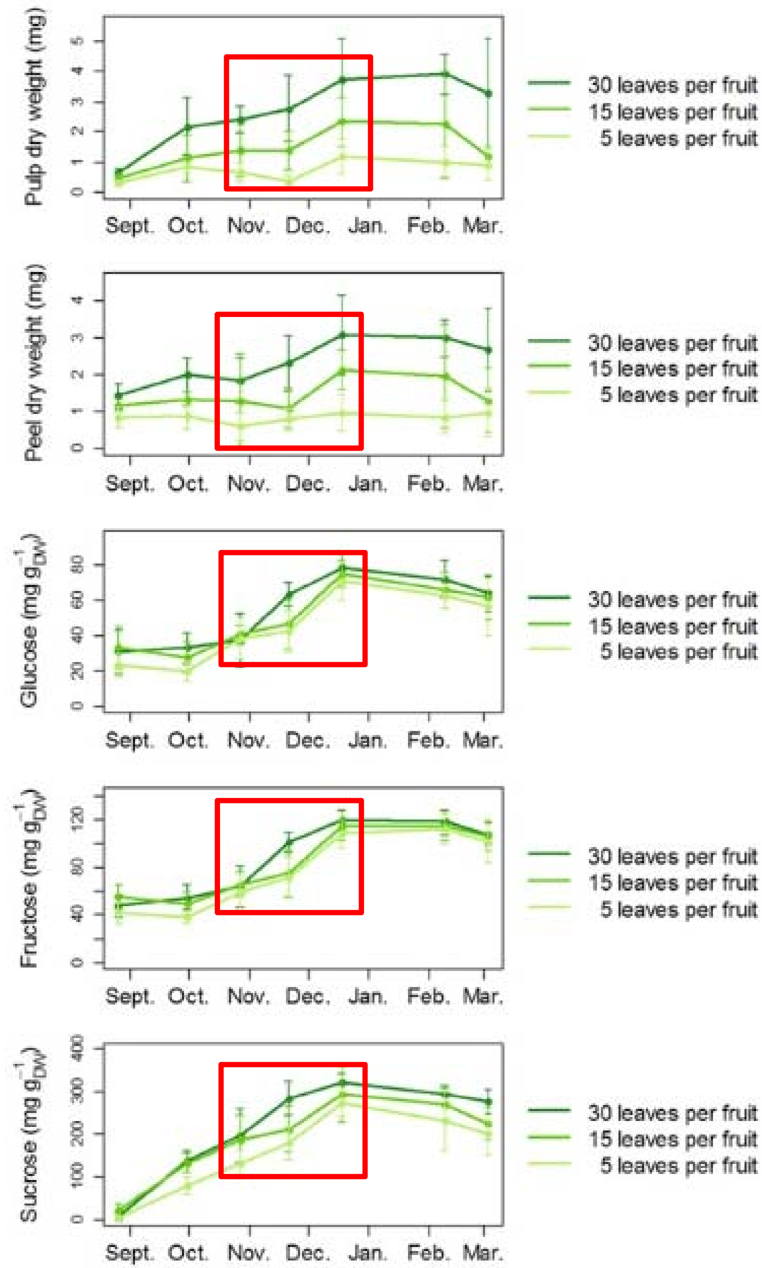


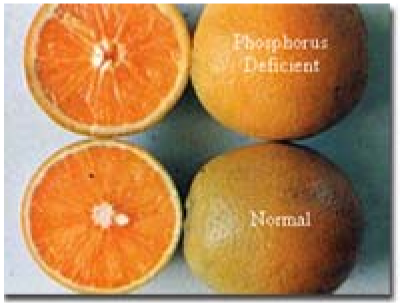
- Rootstock effect significant for all quality attributes
- Sour orange & Swingle largest fruit
- SO and SW highest for sheepnose

Effect of maturity and water deficit

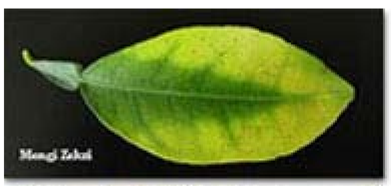
Pantin, Fanciullino, Massonet et al., 2013
Frontiers in Plant Science

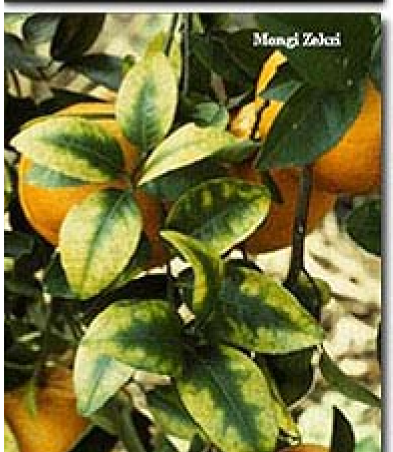






Effect of Nutrient Deficiency on Quality of Citrus Fruit





http://www.yara.com.au/crop-nutrition/crops/citrus/crop-nutrition/deficiencies/ca/01-4392-calcium-deficiency-on-orange---citrus/

http://www.haifa-group.com/files/guides/citrus.pdf

http://www.crec.ifas.ufl.edu/extension/greening/ndccg.shtml

Ca – Calcium MW 40

Sympton description
Cracking of the fruit.

Made worst by
Acidic soils. Sandy or light soils (leaching). Acid peat soils. Soils rich in sodium. Soils rich in aluminium. Drought conditions. Fruit high in nitrogen or potassium. Large fruit.

Important for
Leaves are properly formed and remain throughout cycle. Overall tree growth is more vigorous. Yield often increases. Fruit-size more regular and uniform. Better quality fruit. Better skins - less 'Albedo Breakdown' (creasing).

Cause description
Calcium deficiency

Creasing

P – Phosphorus MW 31

Sympton description

Phosphorus deficiency leads to fruits with coarse and thick peel.

Made worst by

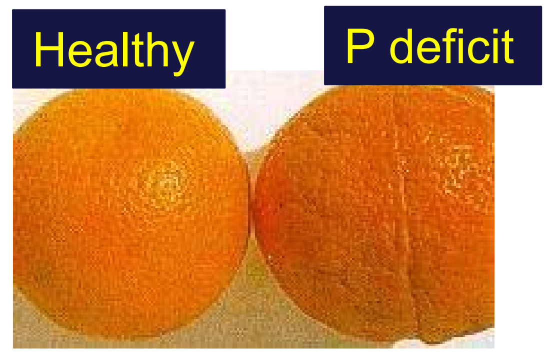
Acidic or very alkaline (calcareaus) soils. Low organic matter. Cold or wet conditions. Crops with a poorly developed root system. Soils with low P reserves. Soils with a high phosphate capacity. Iron rich soils.

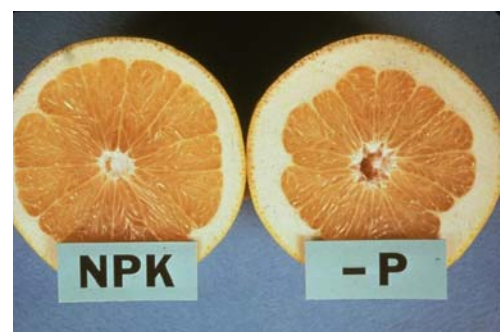
Important for

Vegetative growth increased. Leaves are much greener. Fruit set is increased. Yield boosted, fruit quality enhanced (sugar/acid improved). Particularly important in young trees with poorly developed root systems.

Cause description

Phosphorus deficiency on orange (right)





Coarse, hollow core and thick rinds

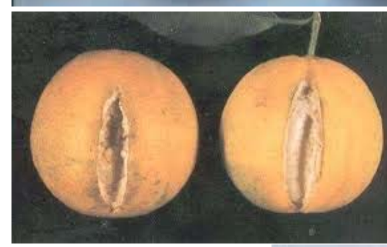
K – Potassium MW 39

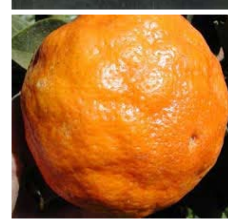
Sympton description
With potassium deficiency leaf margins of the older leaves turn pale yellow or sometimes bronze. With ongoing deficiency cholorosis spreads over the whole leaves.

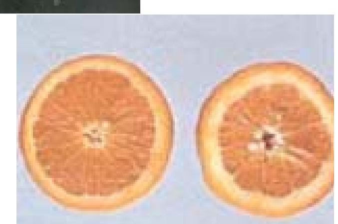
Made worst by
Acidic soils (low pH). Sandy or light soils (leaching). Drought conditions. High rainfall (leaching). or heavy irrigation. Heavy clay (illite) soils. Soils with low K reserves. Magnesium rich soils.

Important for
Larger leaf area maintaining through season. Shoot growth more vigorous. Fruit load increase/benefit to yield. Fruit are larger with better color, skin texture and flavoring (more acidity). Level of vitamin C increases.

Cause description
Potassium deficiency







reduced fruit size with very thin peels of smooth texture; easy to course plugging; creasing rind disorders; splitting at the styler or blossom-end

B- Boron MW 10.8

Sympton description
Boron deficiency causes the death of the terminal growing point. The tree loses its apical dominance and sends out multiple shoots.

Made worst by
Sandy soils. Alkaline soils. Soils low in organic matter. High levels of nitrogen. High levels of calcium. Cold wet weather. Periods of drought.

Important for
More uniform and vigorous vegetative growth. Leaves are properly formed and premature drop is avoided. Fruit set and development is improved. Fruit quality (juice/sugar levels) enhanced. Fruit/rind ratio improved. Yield increased.

Cause description
Boron deficiency on shoots

Necrotic-corky areas on the fruit surface

Cu – Copper MW 63.5

Sympton description
Copper deficient plants show dark green and enlarged leaves. Sterns are more slender than normal and appear flat and angular. Limbs die back and gumming may occur under new bark or on fruits. Symptoms are more prominent in young citrus.

Made worst by
Organic soils. Chalky soils. Sandy soils. Reclaimed heathland. High nitrogen applications.

Important for
Young trees come into production more rapidly. Vegetative growth is more even. Large foliage area (leaf number) maintained. Fruit mature better (flavor and juice levels enhanced). Premature fruit drop prevented. Fruit skin-quality is much improved.

Cause description
Copper deficiency on citrus Symptoms of copper deficiency are rarely seen where copper based fungicides are applied

Fruit splitting, gumming

N – Nitrogen MW 14

Sympton description

The older leaves are pale green to yellow and abscise. The life of a leaf can be shortened from 1-3 years to 6 months. The leaf veins have a clear color tending to white.

Made worst by

Low or high pH soils. Sandy or light soils (leaching.) Low organic matter. Drought conditions. High rainfall (leaching) or heavy irrigation. Addition or high levels of non-decomposed organic matter/manure (eg straw). Fast growing crops.

Important for

Foliage lusher and greener. Shoot growth vigour increased. Fruit set/crop load increased. Yield is increased. Juice quantity and quality improved (acidity and soluble solids increased).

Cause description

Nitrogen deficiency Sulfur deficiency causes similar symptoms, but it begins at the younger leaves and the veins are usually green

Thank you!

Questions?