



Mandarin or Orange? They both taste so good!

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USDA, NIFA – Emergency Citrus Disease Research & Extension (2018-2023)

- USDA, ARS Fort Pierce (FL); University of Florida; University of California Riverside; New Mexico Consortium
- To identify HLB-resistant/tolerant hybrids with good flavor quality (orange-like and grapefruit-like, +/- Poncirus background)
- To characterize fruit and juice quality of HLB-tolerant scions, for either as stand-alone variety, or use in orange-like juice blends



<https://programs.ifas.ufl.edu/scion-guide/>

Hybrids Less Susceptible to CLas



Murcott

Photo Freg Gmitter



Sugar Belle®

Citrus (e.g. Sugar Belle® - University of Florida)

Citrus X Poncirus trifoliata in the background
(e.g. US SunDragon – ARS)






US SunDragon

Photo Ed Stover



Hamlin

Fruit Quality from the USDA Breeding Program

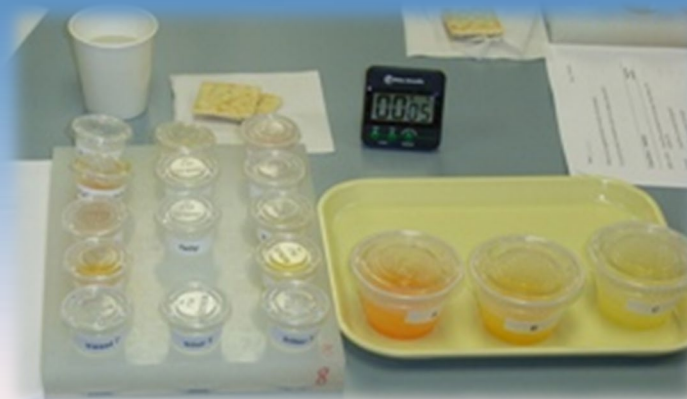
-  Fruit harvested at estimated maturity, multiple harvests
-  Wash, sanitize, juice
-  Take samples for volatiles, sugars, acids, SSC (Brix), TA, limonoids



Sensory Evaluation

- 🍷 Trained panel (10 years+ experience)
- 🍷 **Line scale with tick marks 0 to 15**
- 🍷 Reference standards served at each panel

0---1---2---3---4---5---6---7---8---9---10---11---12---13---14---15
low medium high





Since 2017-18 (5 seasons)

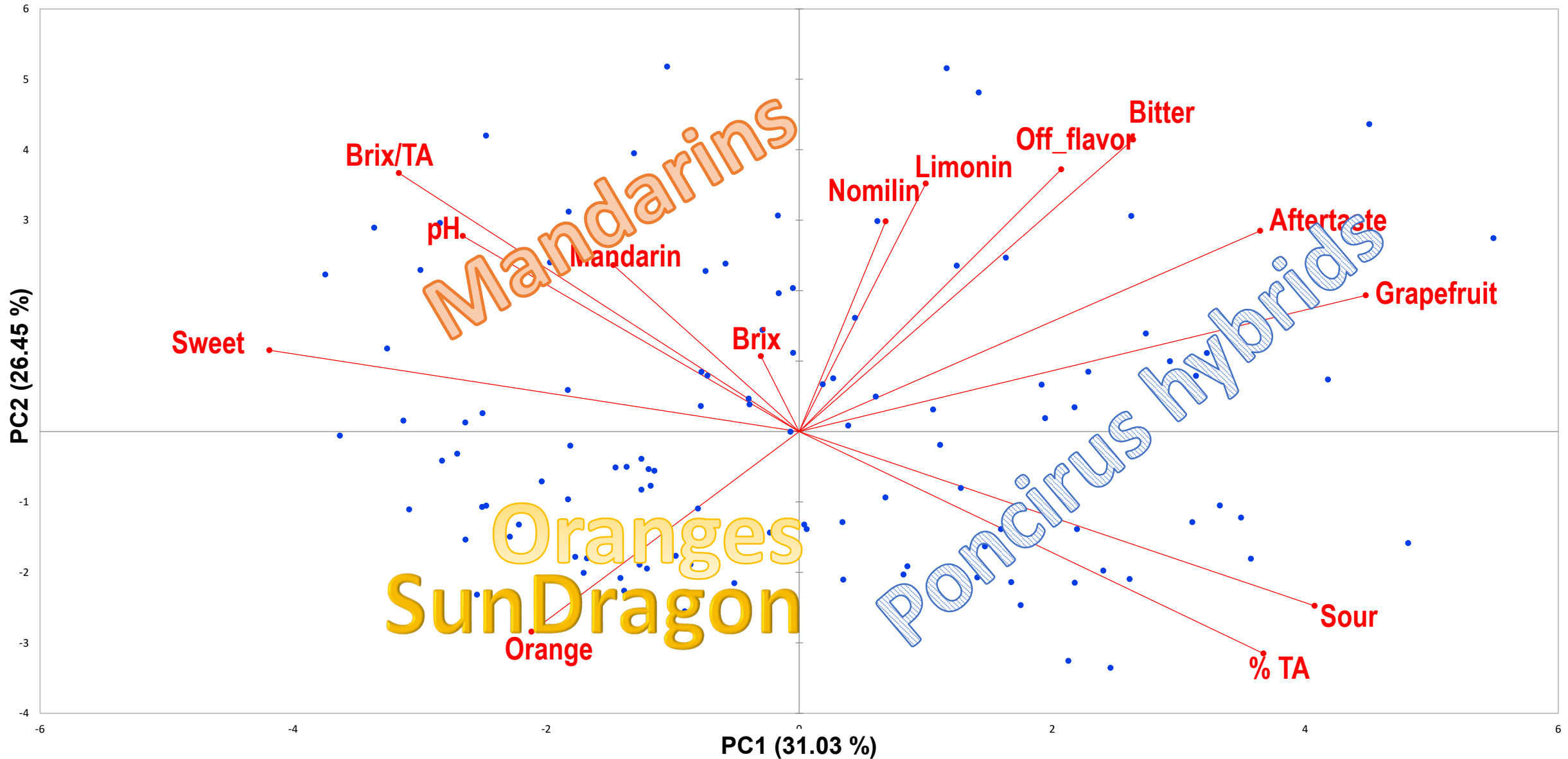
50+ orange-like hybrids & named varieties

Multiple harvests → 114 data points

	Orange flavor	Mandarin flavor	Sweet taste	Sour taste	Bitter taste	TA (% citric)	SSC (Brix)	SSC/TA	Limonin
Min	1.45	2.18	3.11	2.25	0.25	0.28	7.50	6.39	0.15
Max	8.12	7.69	8.57	11.14	9.12	1.82	15.94	54.76	18.91

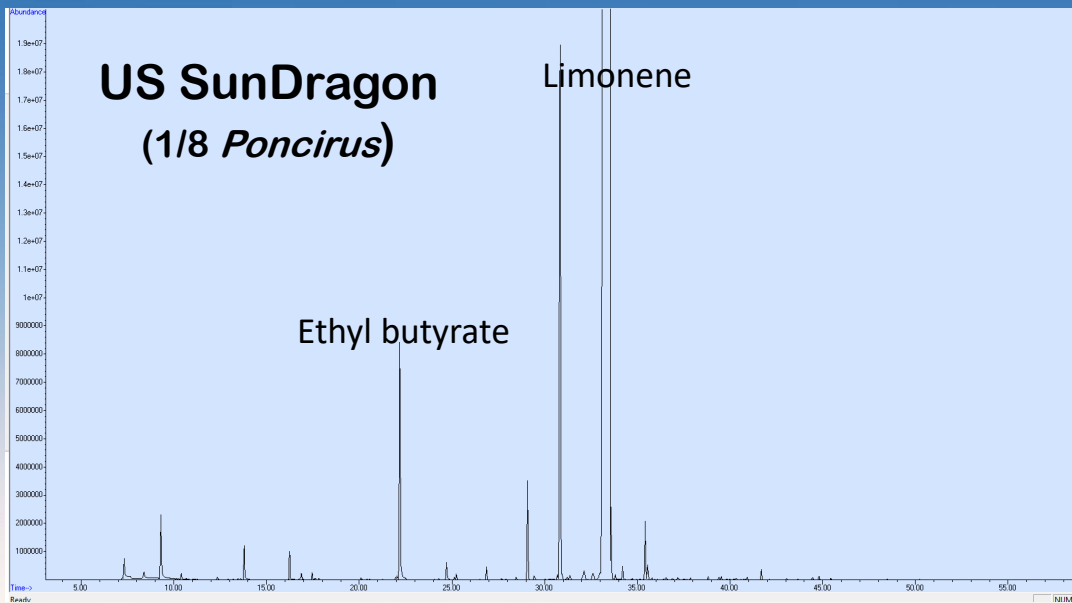
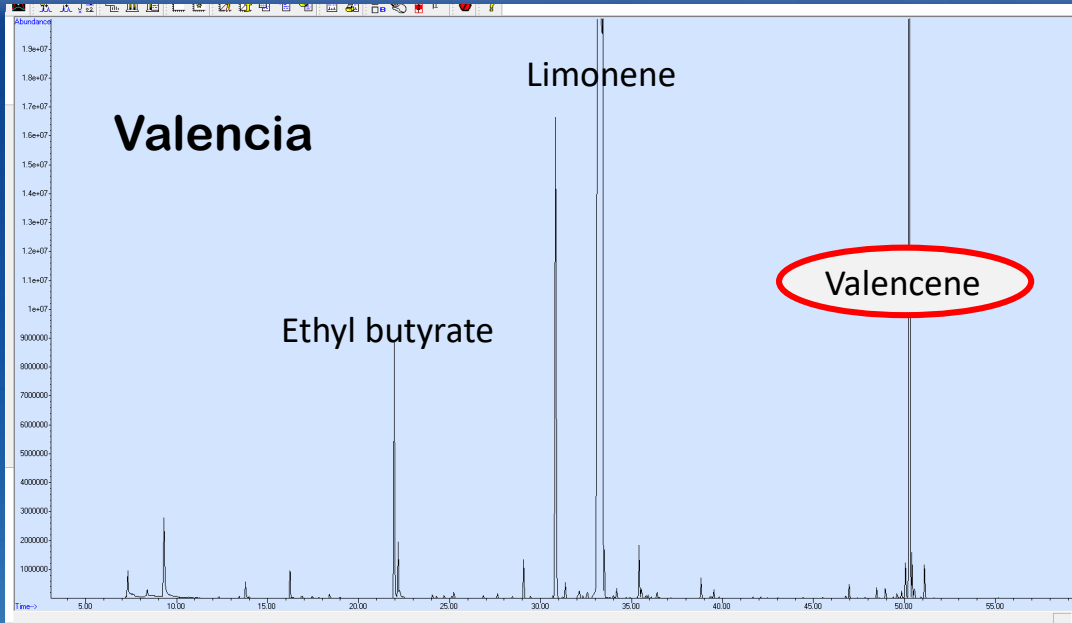
Flavor & Taste on a 0-15 scale

Summary Citrus Flavor Groups





Volatile Patterns



	Valencia	US SunDragon
Alcohols	82.8	61.7
Aldehydes	24.7	56.0
Esters	133.6	33.2
Monoterpenes	869.6	353.6
Sesquiterpenes	152.2	0.08
Others	0.12	0.13
Total	1,263.0	504.8

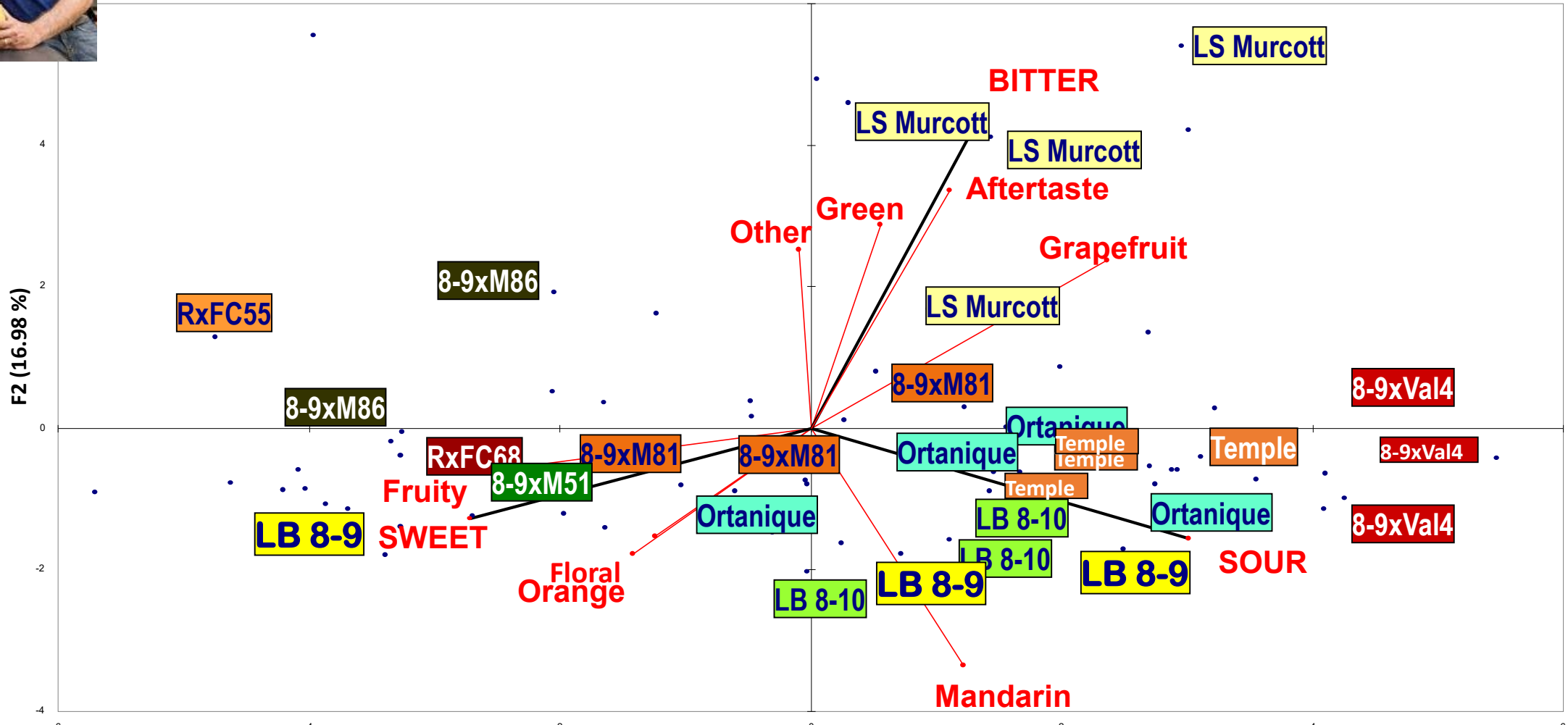


US SunDragon (ARS)

Back in Time... UF Hybrids



2006-07 Sensory PCA



✓ *Clementine x Minneola 'LB 8-9'*: typical mandarin flavor if harvested at the correct maturity

Consumer Surveys (2008)

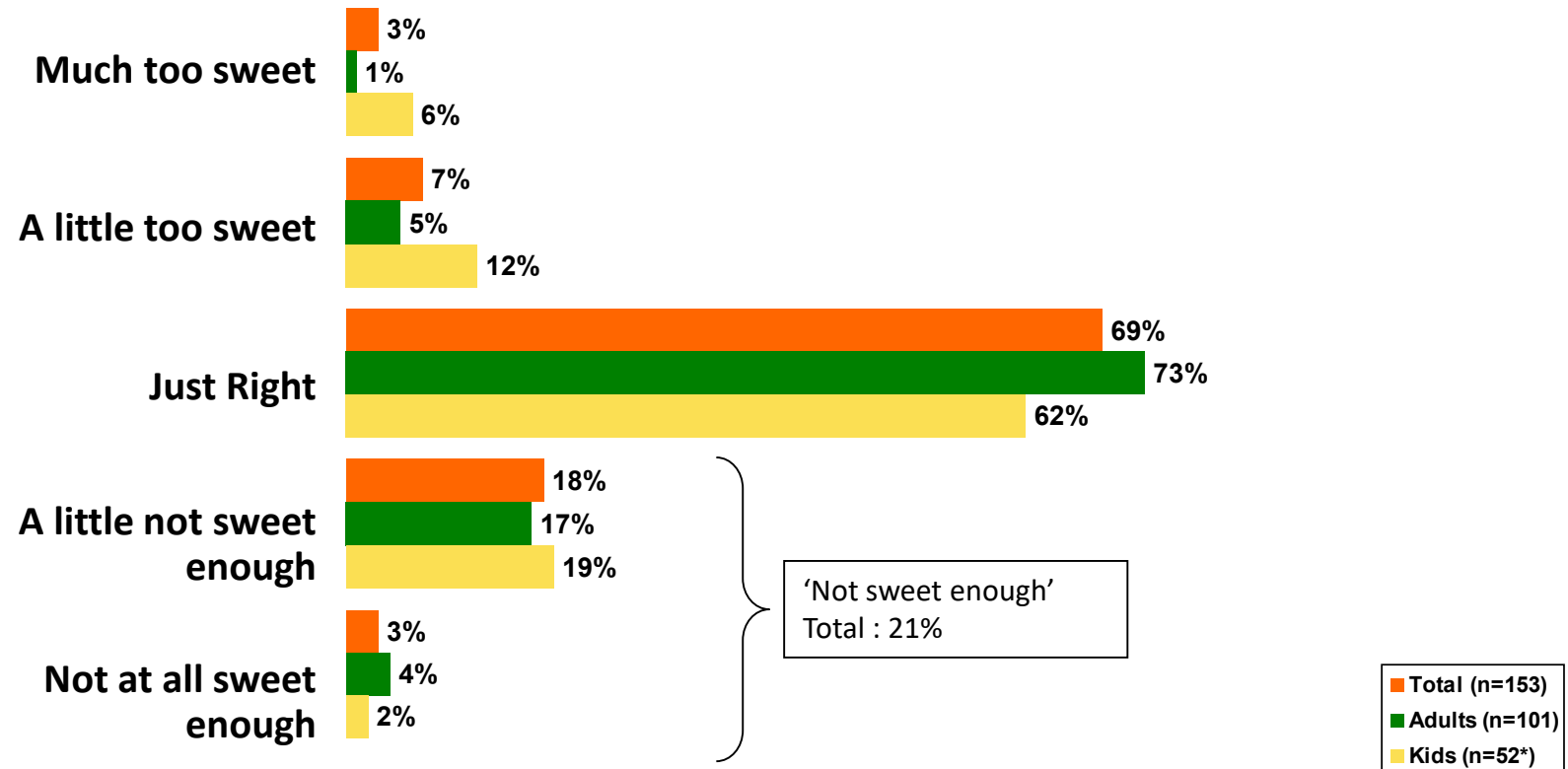
Conducted by IPSOS Reid for University of Florida, Funded by FDOC

- Chicago, Baltimore, Tampa (153 participants total)
- 15 hybrids & varieties tested over 3 time periods to cover maturities
- Sugar Belle® ranked 1st for general, and 3rd for sensory attributes



Sweetness

From House and Gao, 2009 report



Sugar Belle® Tolerant to HLB



Photo Fred Gmitter

Could HLB-Tolerant Mandarins be Blended?



LB8-9 mandarin:
Sugar Belle® (SB)



Sweet orange (O)
cultivars: Hamlin (H)
& Valencia (V)

Two sensory studies (spring & summer) on consumer preference and acceptance



5 different citrus juice blends



100% SB



100% O (H in
summer, V in
Spring)



10% SB/ 90% O



50% SB/ 50% O

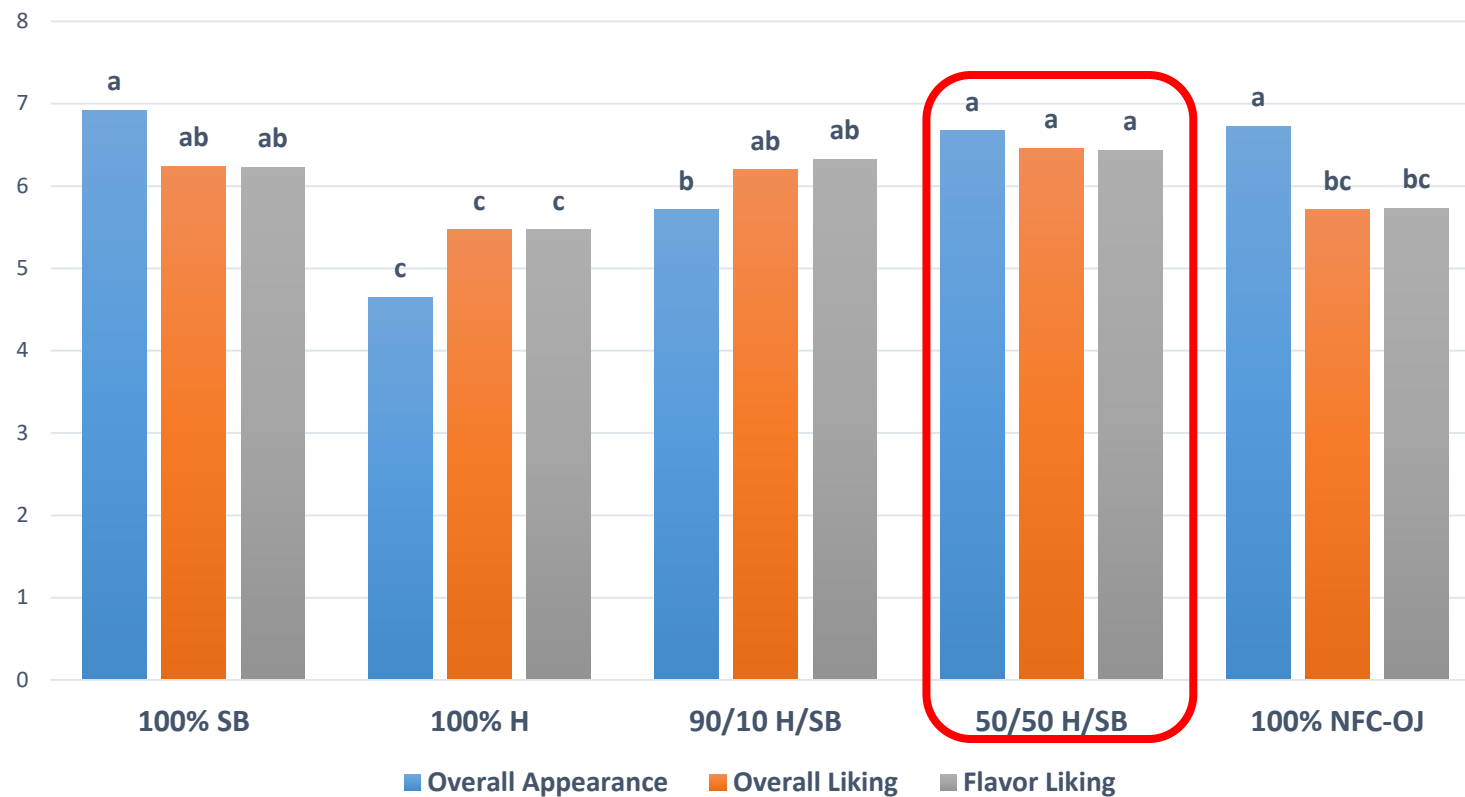


100% NFC-OJ

Consumers Prefer SB/O Juice over Pure OJ (Appearance & Flavor)



50% Sugar
Belle®/ 50%
Hamlin



* Different letters within groups indicate significant differences ($p < 0.05$).

Figure 1A. Overall ratings (Spring)

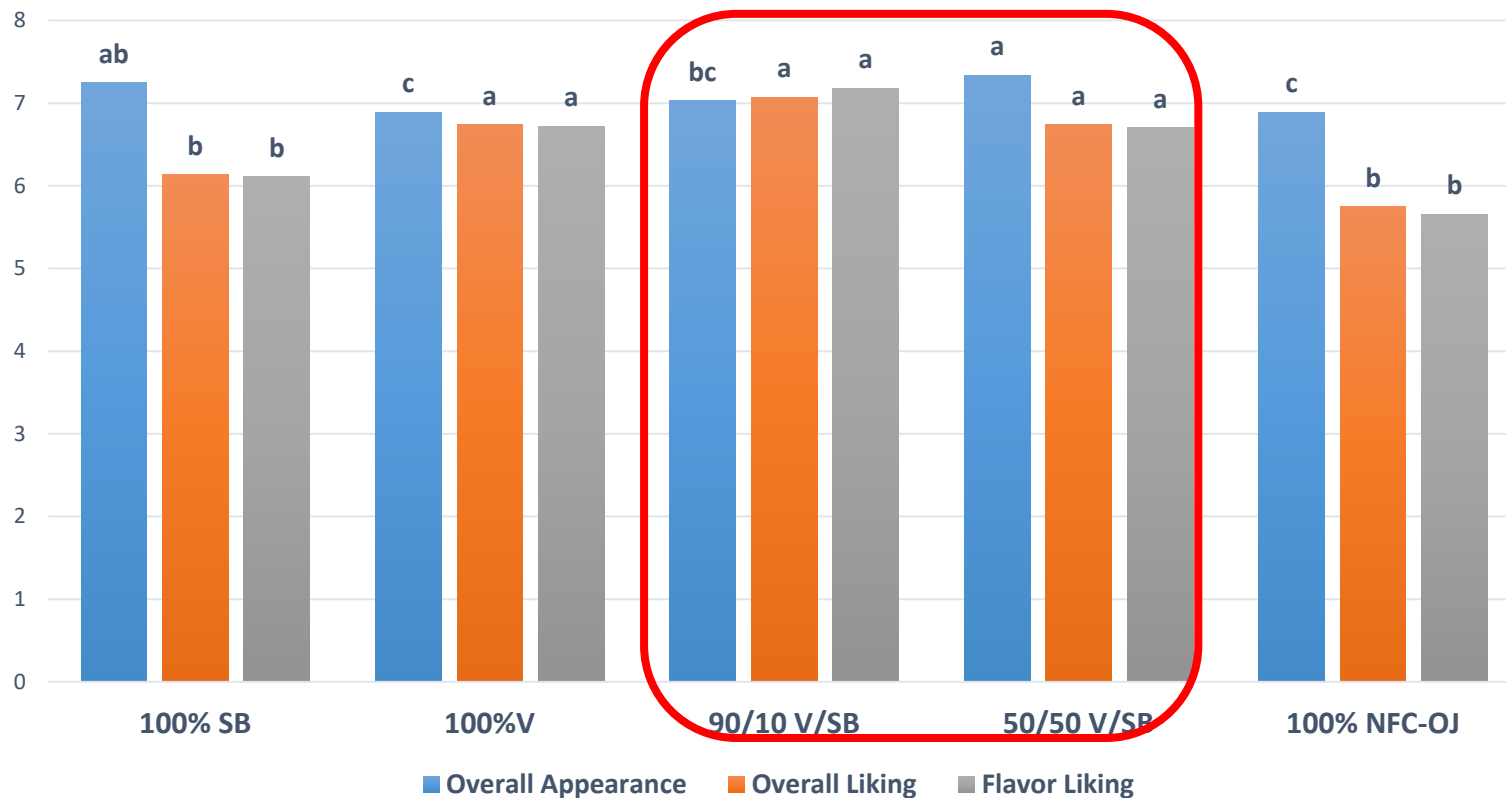
Consumers Prefer SB/O Juice over Pure OJ (Appearance & Flavor)



10% Sugar
Belle®/ 90%
Valencia



50% Sugar
Belle®/ 50%
Valencia



* Different letters within groups indicate significant differences ($p < 0.05$).

Figure 1B. Overall ratings (Summer)

Willingness to Pay (WTP) Indicates Consumer Preference

🍊 Consumer preference is positively correlated with WTP

🍊 Consumers are willing to pay an average of 50 cents more for 50/50 and 90/10 blended juice than commercial OJ.

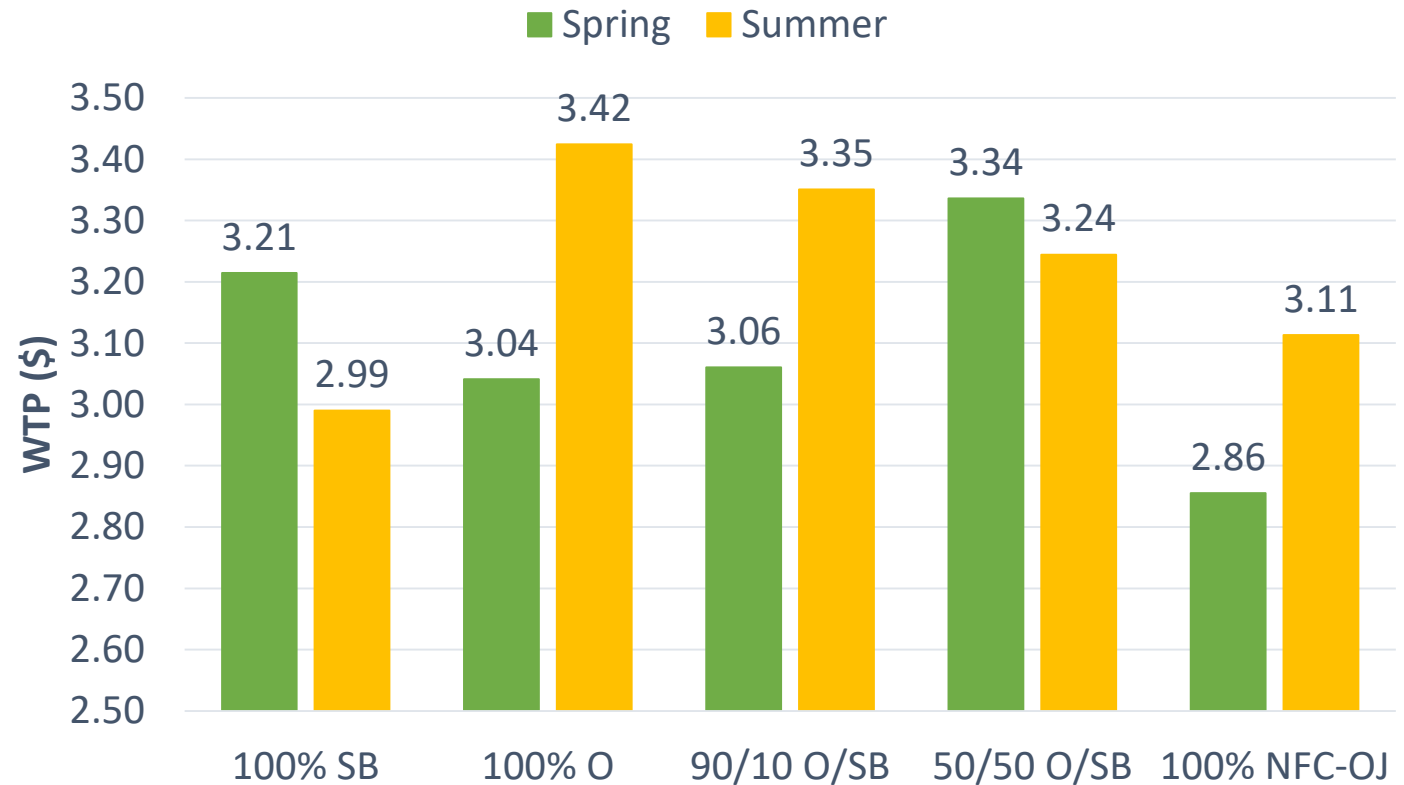


Figure 2. Willingness-to-Pay (WTP) for sample citrus juice blends (52 FL oz)

WTP and Consumption Habits

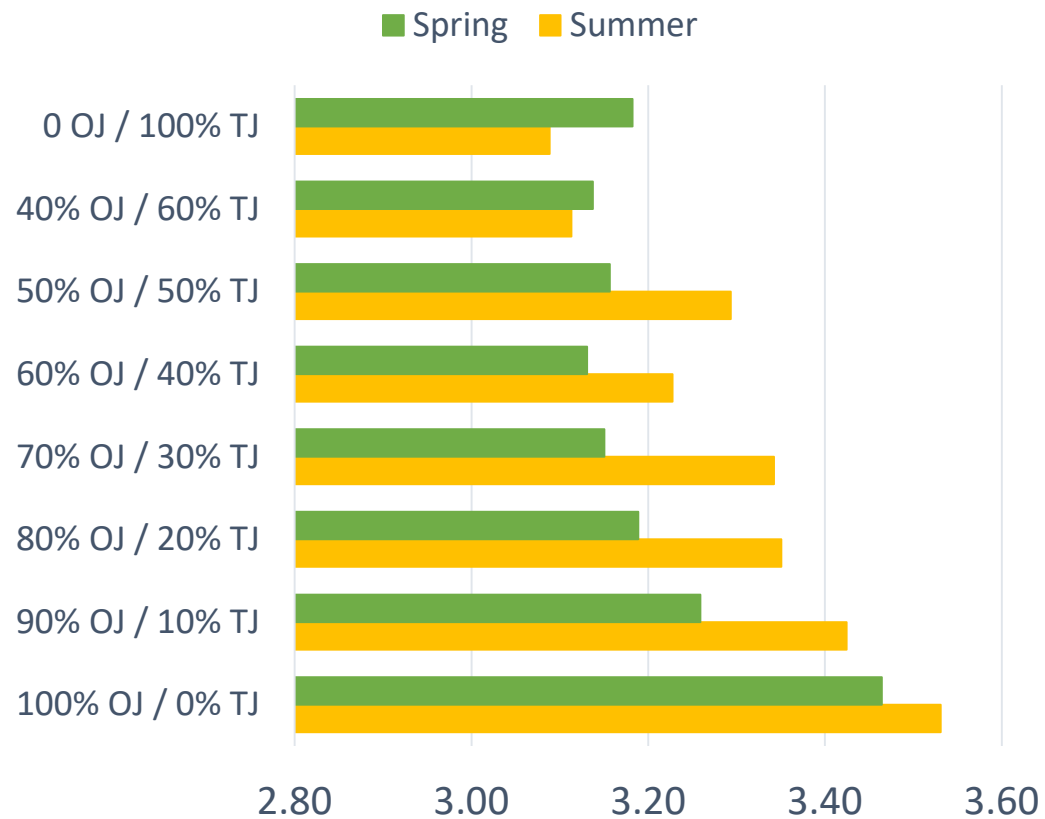


Figure 3. Willingness-To-Pay (WTP) for different citrus juice blends (52 FL oz)

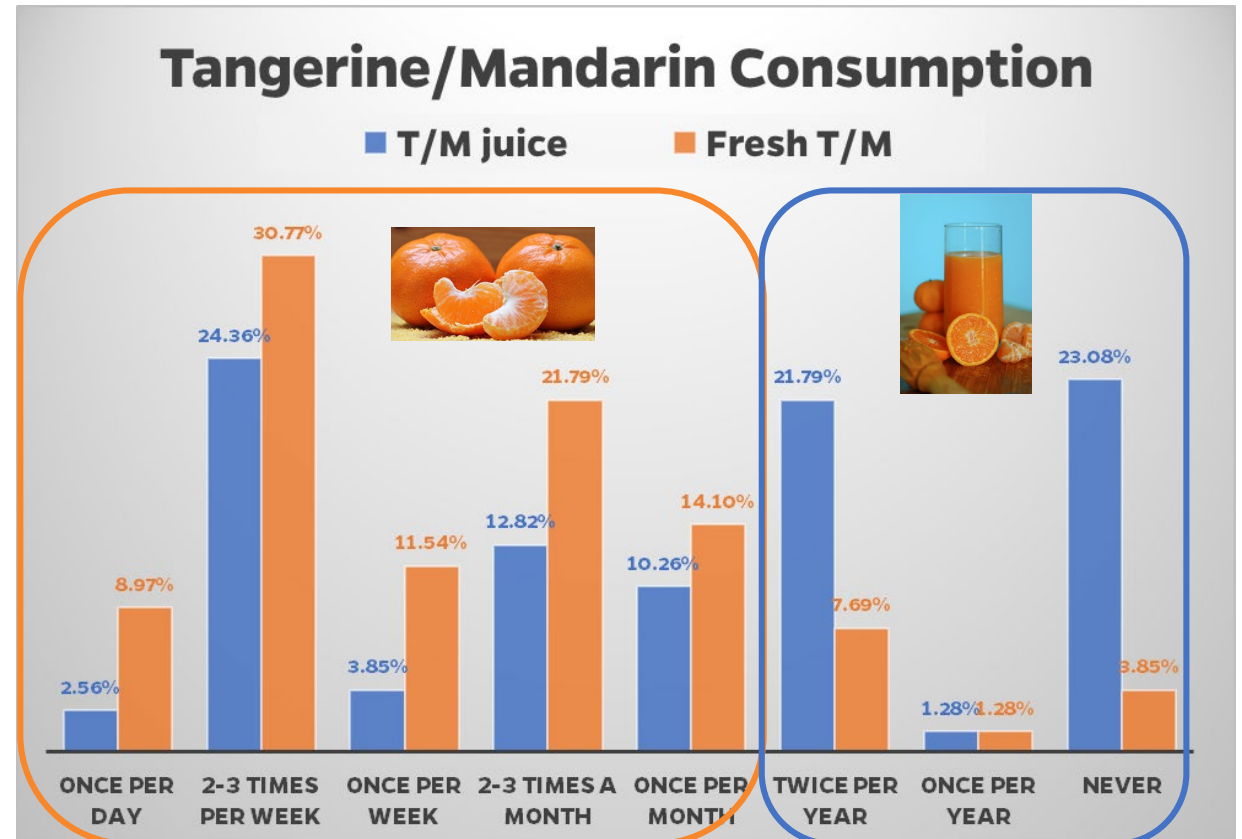


Figure 4. Consumption habits of Tangerine/Mandarin juice

Up to 30% TJ Blending Considered as OJ

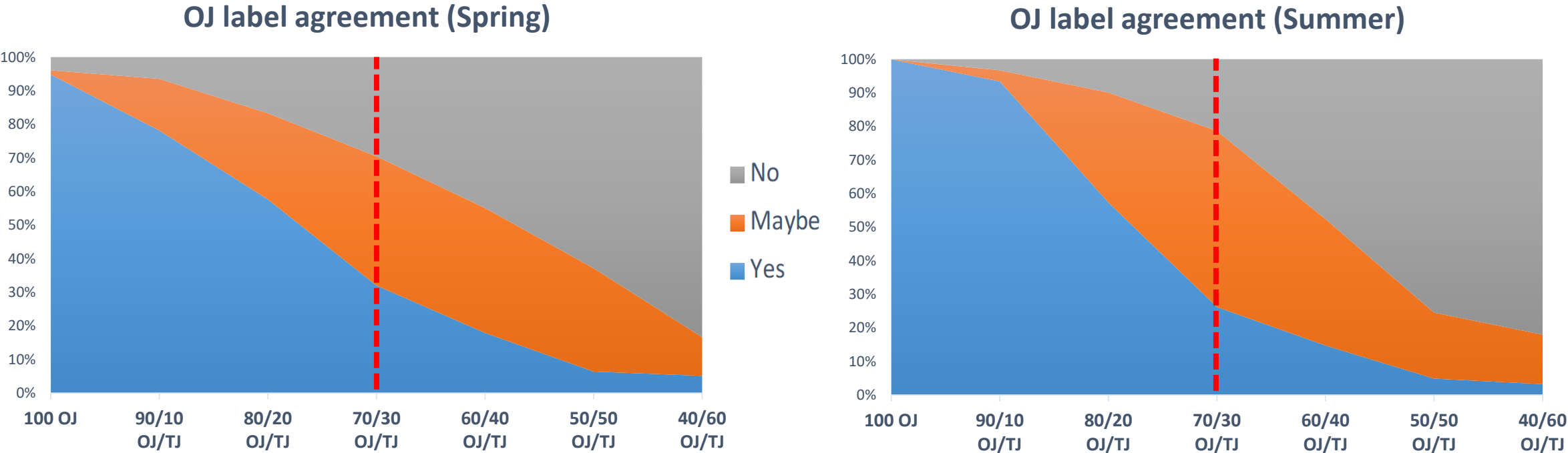
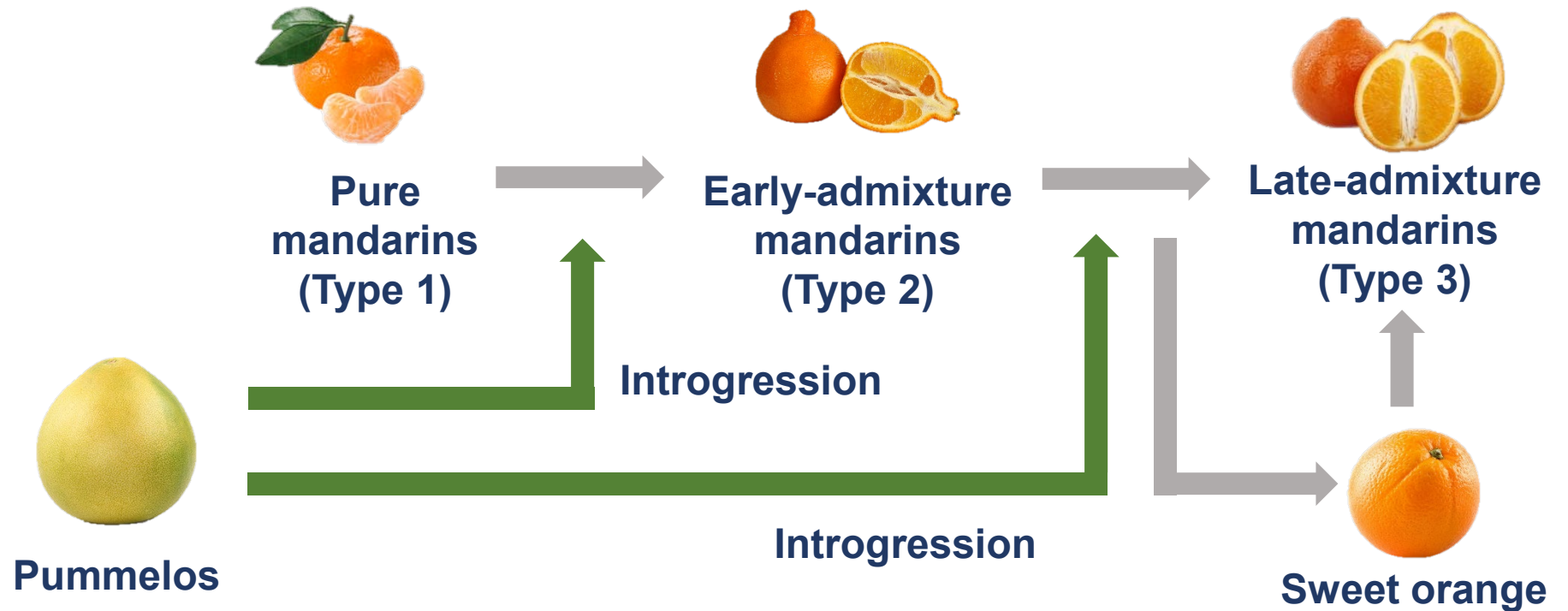


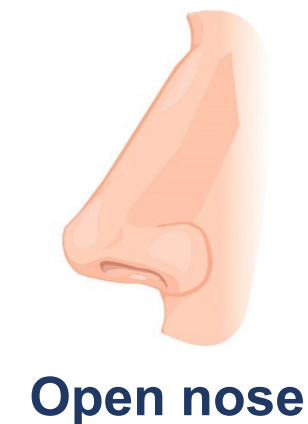
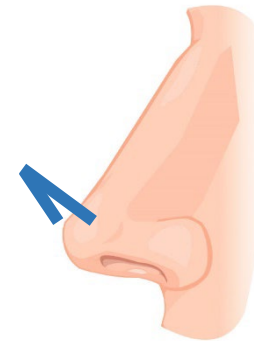
Figure 5. Orange juice label perception on citrus juice blends

Orange and Mandarin Are Genetically Related



(Wu *et al.*, 2018)

Aroma Is the Key



Flavor perception



Which one is orange?

(Feng *et al.*, 2018)

Aroma Is the Key



Orange juice



Mandarin juice

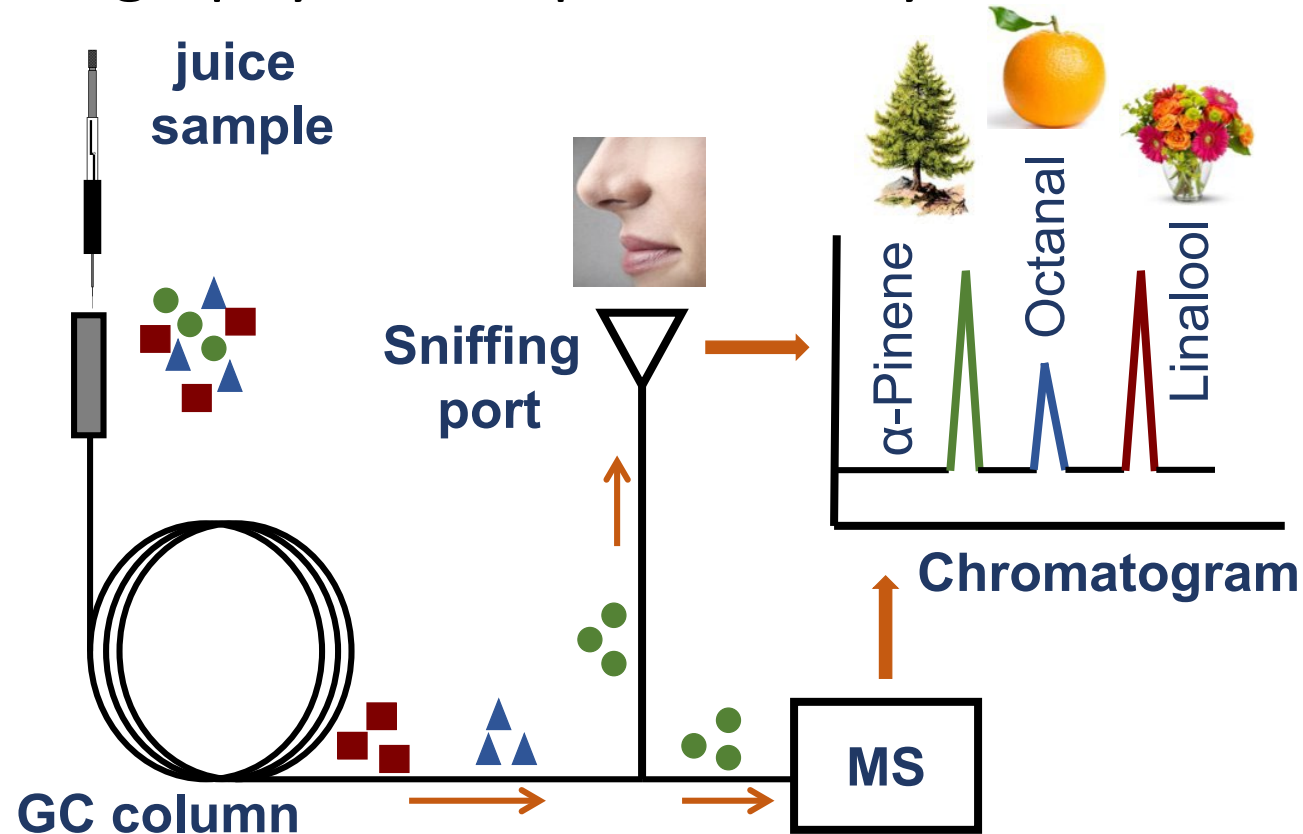


	Close nose	Open nose
Correct answer	6	12
Wrong answer	1	2
I cannot tell	8	1

The aroma played a key role in the differentiation of orange flavor and mandarin flavor

Aroma Identification by GC-MS/O

Gas Chromatography-Mass Spectrometry/Olfactometry

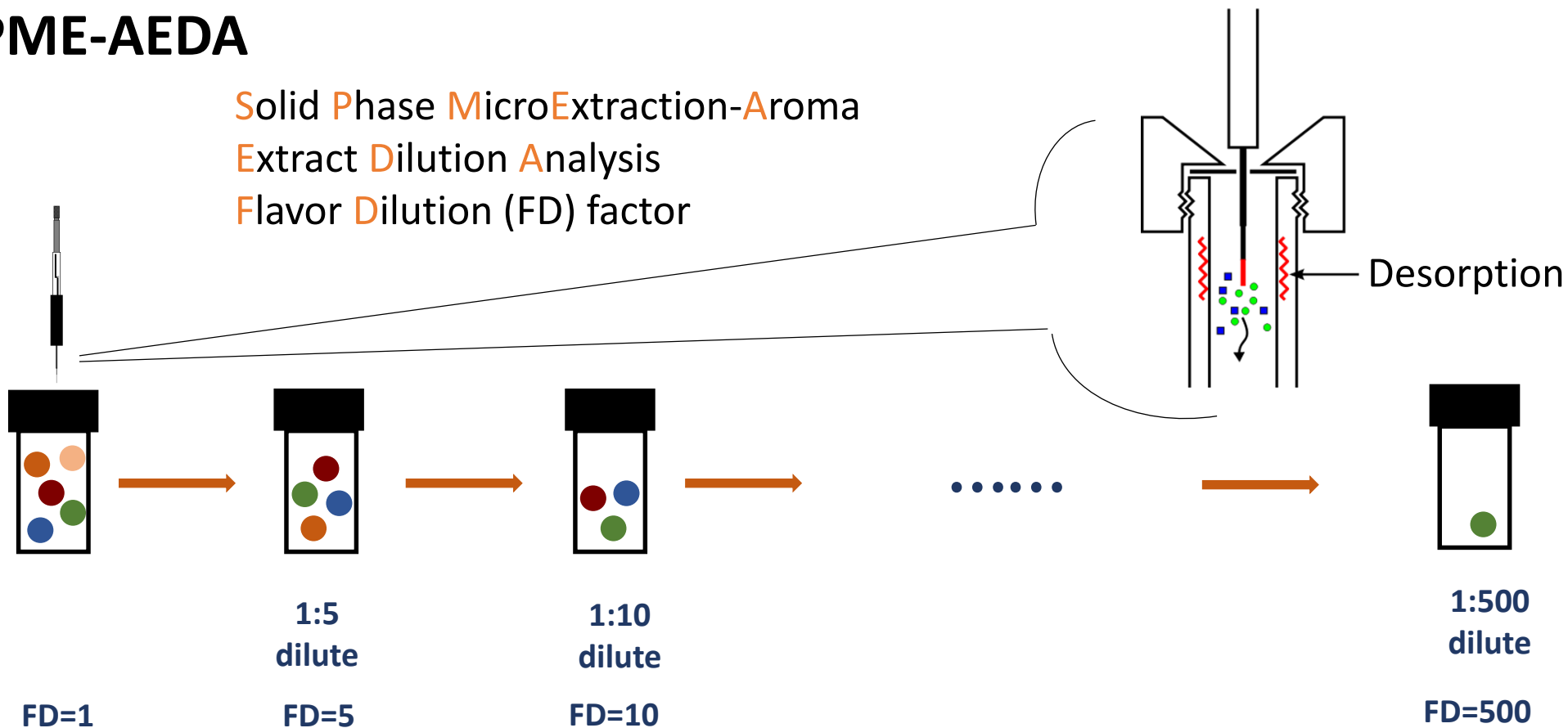


(Feng *et al.*, 2018)

Determine the Most Aroma-Active Compounds

SPME-AEDA

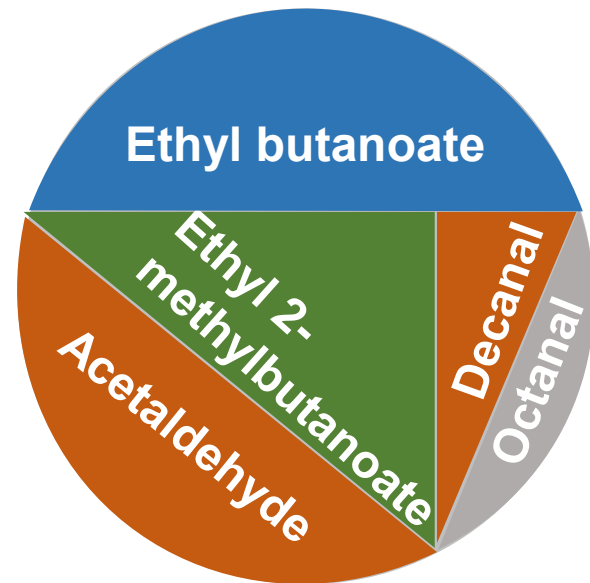
Solid Phase MicroExtraction-Aroma
Extract Dilution Analysis
Flavor Dilution (FD) factor



(Feng *et al.*, 2018)

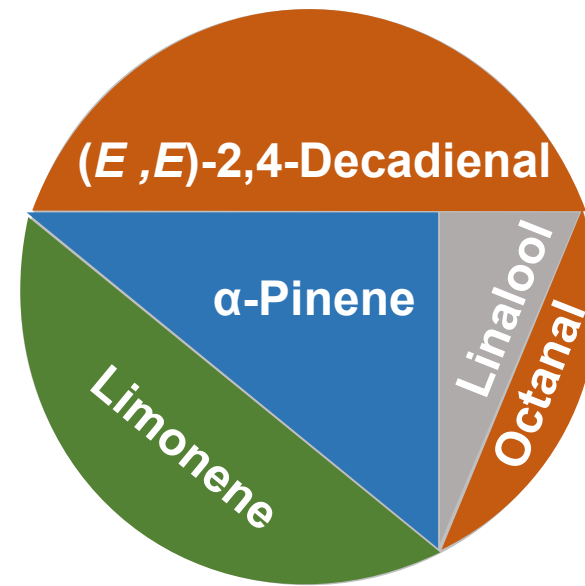
Differences in Key Aroma Profiles

Orange-like aroma



VS.

Mandarin-like aroma

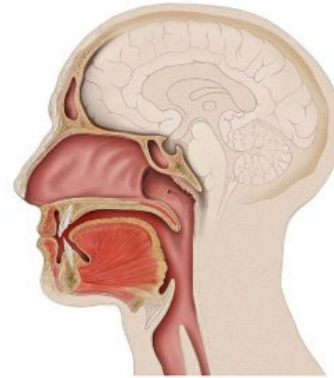


(Feng *et al.*, 2018)

Orange-like Mandarin



Juice of Orange-like Mandarin
(6-2-55)



Flavor perception

Orange
OR

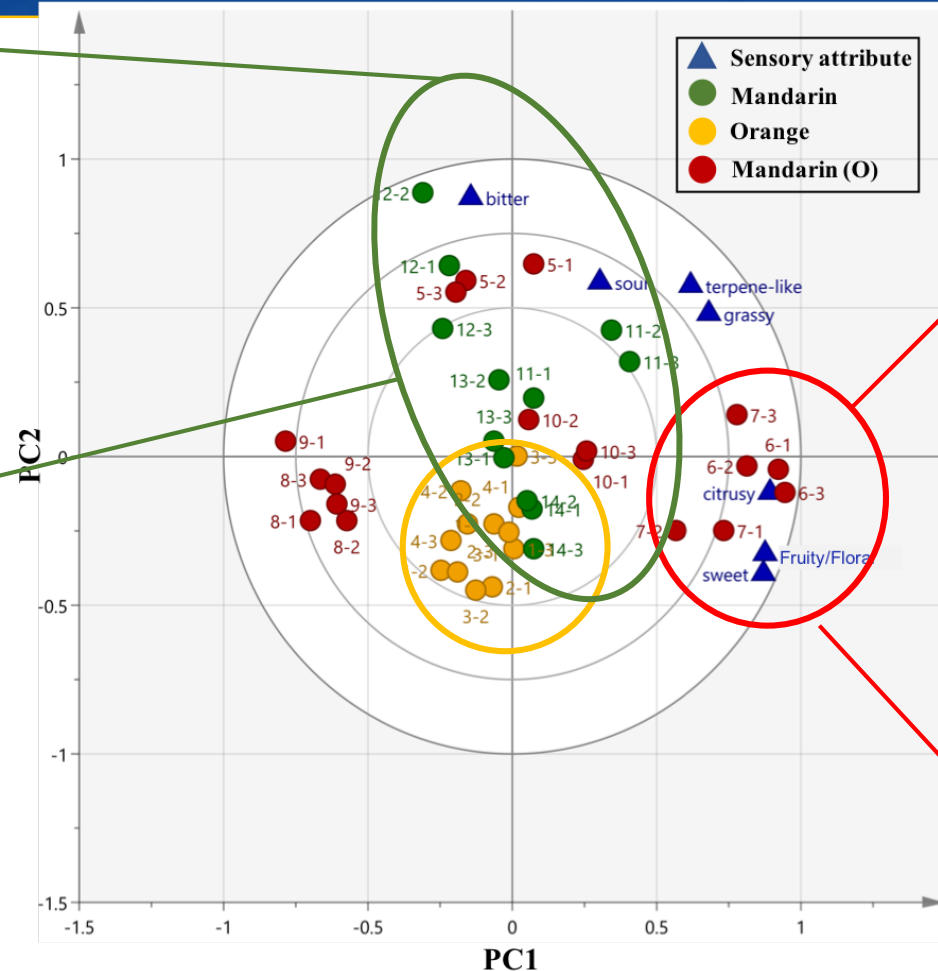
Mandarin

Sensory results	
Orange	11
Mandarin	4
Not sure	1

(Feng *et al.*, 2018)

Sensory Profiles of Citrus Fruits

- Most mandarins are closely grouped together.
- **Bitter** and **sour** attributes are highly correlated with mandarins.



- Some of Orange-like Mandarin (O) are grouped closely with oranges.
- Mandarins (O) are highly correlated with **sweet**, **fruity/floral** and **citrusy** attributes.

Flavor Compounds in Mandarins

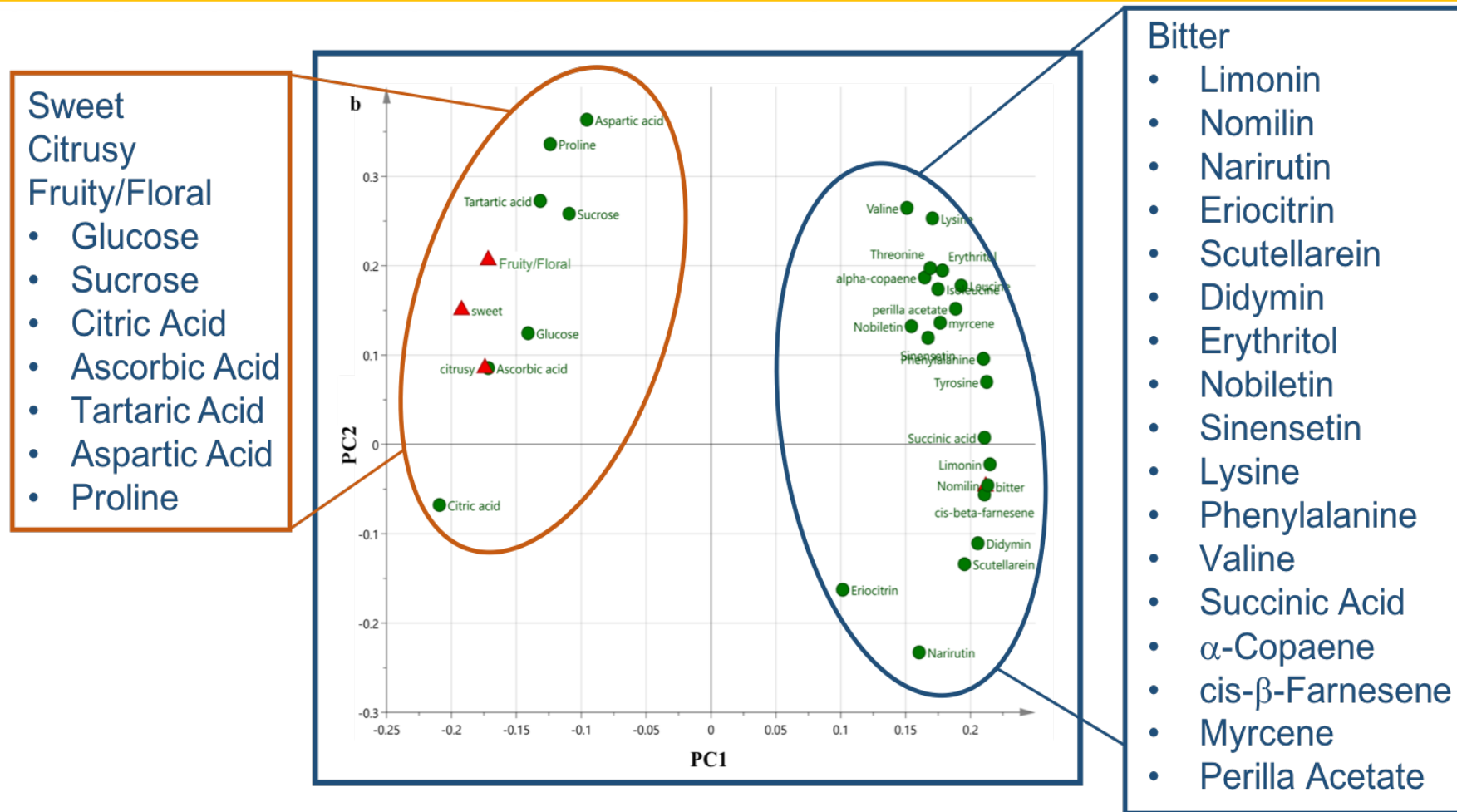


Figure 7. Loading plot of the PCA performed from the sensory attributes and selected chemicals in mandarins

Flavor Compounds in Orange-Like Mandarins

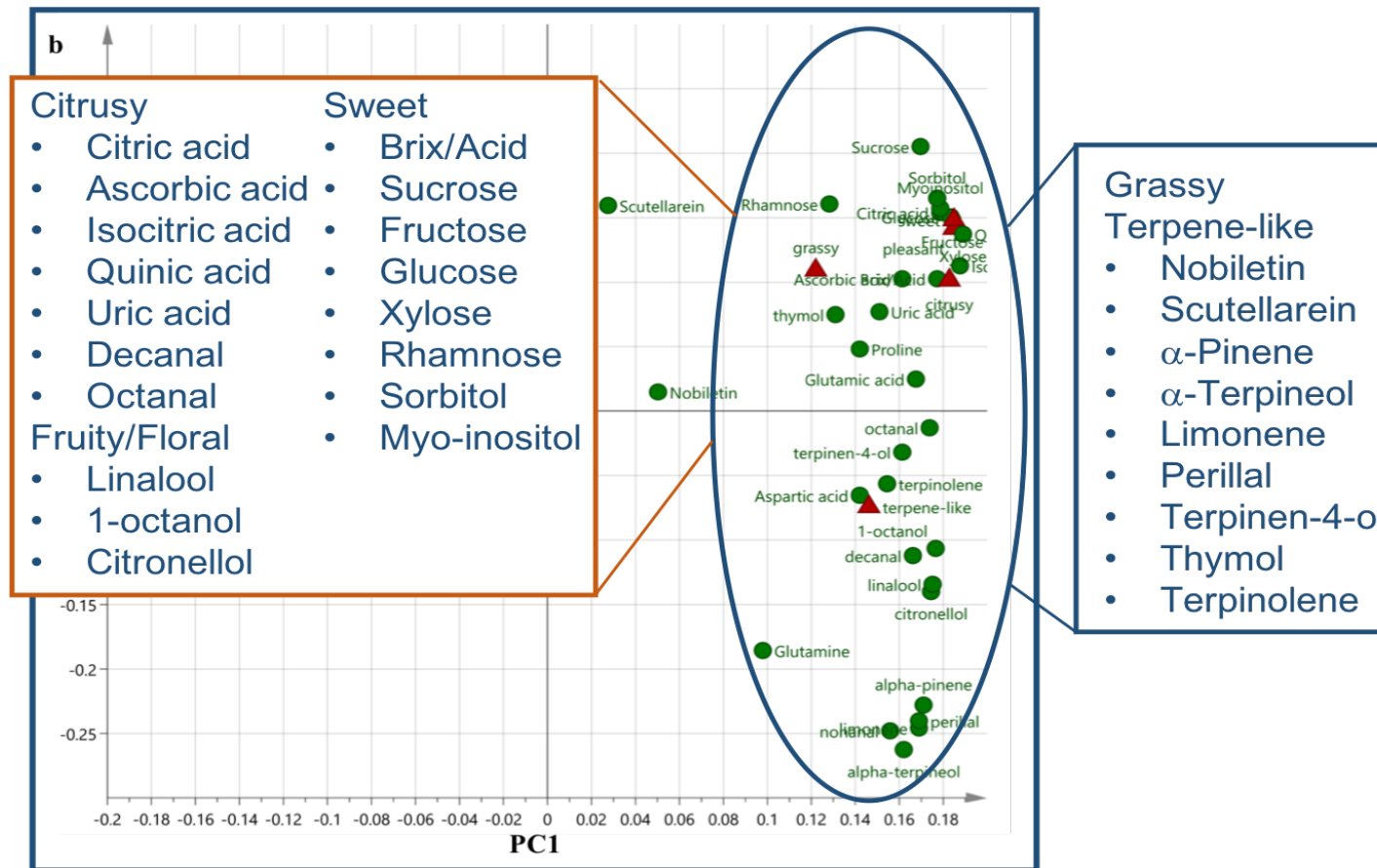
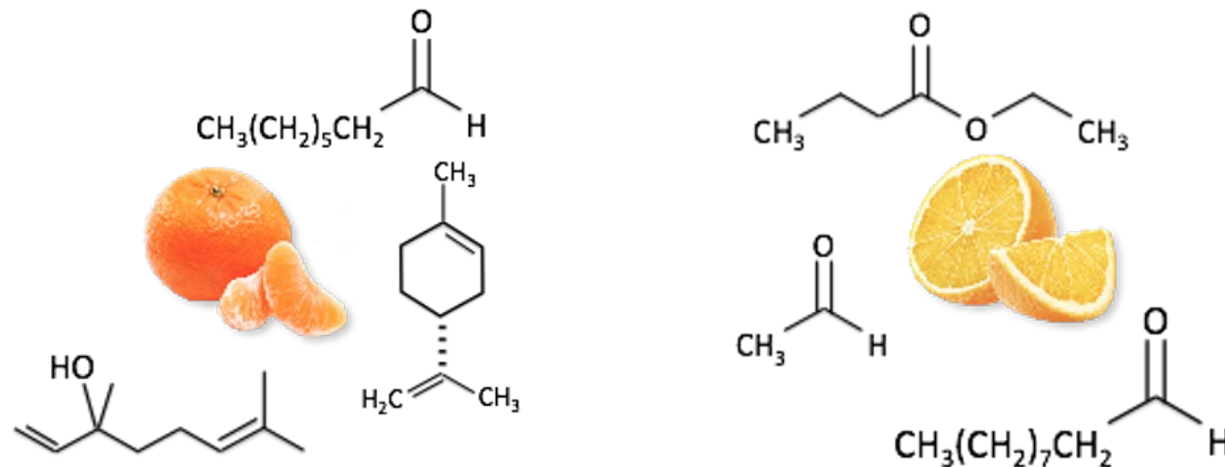


Figure 9. Loading plot of the PCA performed from the sensory attributes and selected chemicals in orange-like mandarins

Potential Use of Mandarins/Mandarin Hybrids



🍊 Improve flavor quality of juice



🍊 Develop consumer-accepted varieties through breeding based on the preferred flavors

The Teams



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Sensory &
Consumer
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A vertical glass filled with orange juice, with a stream of juice being poured into it from the top left. The background is a solid blue color.

ACS Spring 2023 National Meeting

March 26-30, Indianapolis, IN / Virtual

AGFD Symposium: **Citrus Flavor in the Omics Era**

Yu Wang & Anne Plotto co-Organizers





Thank You!

<https://programs.ifas.ufl.edu/scion-guide/>



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