Using sensory evaluation to drive how we handle fresh citrus fruit

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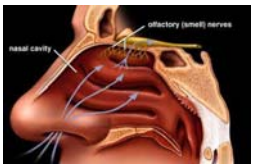
- Why should sensory evaluation be included in postharvest research?
- Changing the minimum maturity standard for California navel oranges
- Examining the impact of storage and the packingline on navel orange eating quality
- Exploring the influence of temperature and other factors on mandarin fruit quality

- Why should sensory evaluation be included in postharvest research?
  - Improve selection of new varieties
  - Improve understanding of how fruit handling strategies may affect eating quality
  - Visual quality ("eye appeal") persists longer than eating and nutritional quality

Flavor perception

Complex integration of human senses involving:

- ***Texture:*** mouth feel
- ***Taste:*** sweet, sour, astringent, salt, MSG
- ***Smell:*** ***volatile aroma components***

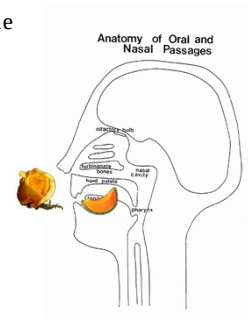


Smell (Olfaction) - sensitivity to substances in gaseous phase - a distant sense

Aroma Volatiles

Aroma (or smell or odor) is the sensation perceived when **volatile compounds** are drawn into the **nose**.

Ripe fruits generally produce tens to hundreds of volatiles. This mixture of volatiles is what we perceive as "aroma".



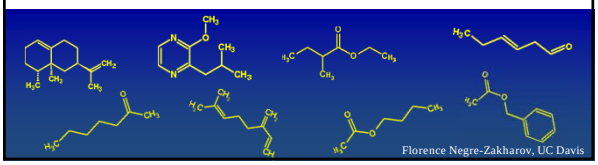
Florence Negre-Zakharov, UC Davis

What is a volatile compound?

• A **small molecule** which has a **high tendency to evaporate**.

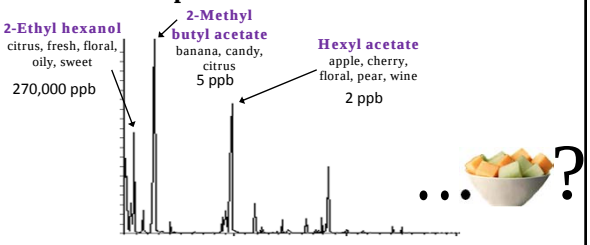
• Volatiles are **naturally produced by plants** (from almost all plant organs) and animals.

• Fruit **aromas** are made up of **complex mixtures of volatile compounds** (strawberry has over 200!).



Aroma Analysis and Product Quality

- **Odor descriptors**



- **Odor thresholds** (minimum concentration of a substance at which a majority of test subjects can detect and identify the substance characteristic odor)

Florence Negre-Zakharov, UC Davis

Responding to the Marketplace:

Providing the consumer with better early-season navel quality

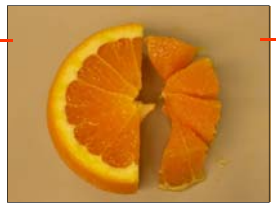
The California Standard

Arpil 1, 2012

What is the minimum taste acceptability for CA navel oranges?

This work was carried out over a 4 year period
We examined several navel strains
We sampled over multiple locations (Year 3)
We utilized commercially handled fruit (Year 4)

Considered alternatives to sugar:acid ratio for predicting eating quality

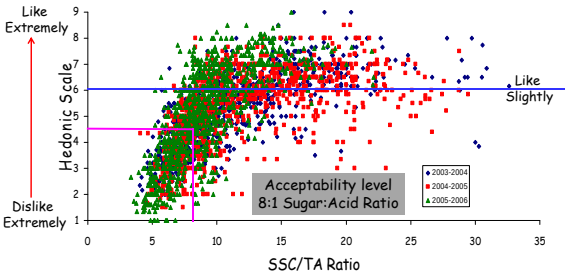


Quality Constituents
% Juice
SSC
TA
Volatiles (pooled)

Making the most of the orange

Sensory Panel
Hedonic Score
Richness
Sweetness
Tartness

Influence of sugar and acid on navel orange flavor



A Sensory-Based Alternative to Brix/Acid Ratio

A new index, BrimA, is proposed as a replacement for Brix/acid ratio to account for the sensory impact of different combinations of sugars and acids in fruit.

Robert R. Jordan, Richard J. Seelye, and V. Andrew McGlone

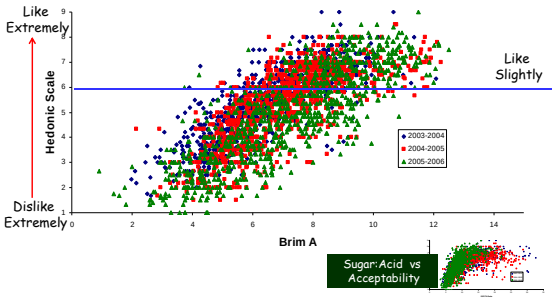
Food Technology (2001) 55(6):36-44

BrimA = SSC – (4*TA)

This measure was believed to better account for the sweetness-reducing effect of the acid

BrimA vs Eating Quality

This data shows that fruit acceptability increases as the BrimA value increases in a linear manner. Each dot is an individual fruit that was tasted. A total of 2630 fruit were tested.



Aroma active compounds are involved in sensory perception

In year 3 we studied the changes in these compounds during fruit maturation

We found 6 compounds (out of 19) significantly correlated with acceptability

Overview of Results

- The relationship of fruit acceptability to SSC/TA is not influenced by strain, location or year
- Should consider increasing the minimum maturity standard of 8:1 SSC/TA to at least 10:1
- Brim A, an alternative to SSC/TA should be considered since it is more closely related to acceptability
- Volatiles were identified that were related to the development of flavor and could possibly act as markers to select better tasting fruit

- 4 tests conducted in Chicago in November and December 2008 at a commercial testing center
- Individual fruit tracked
- 100 consumers per test

The California Standard

California Citrus Mutual

The California Standard

A modification of the BrimA calculation

(SSC – (4 * TA))* 16.5

Minimum score = 90

This will hopefully minimize confusion with the SSC/TA ratio

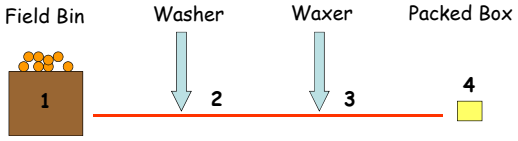
Practical Outcomes

- For minimum maturity, SSC and TA relationship can be a good predictive tool
- The SSC/TA ratio may not be the best relationship to use for citrus
- Brim A, a different way of looking at SSC and TA may be more appropriate
- This forms the basis of the new California minimum maturity standard for navel oranges, the California Standard

Does citrus postharvest handling influence eating quality of navel oranges?

Does the packing line affect fruit flavor?

Packing House Fruit Sampling Scheme



6.4 a	6.1 a	6.1 a	6.0 b

Average Hedonic Score

Does time in storage affect fruit flavor?

Fruit stored at 41F for 0, 3, 6 weeks followed by 4 days at 68 F and 3 days at 54 F

0 wk	3 wk	6 wk
6.4 a	6.2 a	5.7 b

Average Hedonic Score

There were no significant handling x storage interactions

Packing House/Storage Effect on Sensory Characteristics

Test	Storage	Rich	Storage	Tart	Sweet	Hedonic
1	0	103.3a	0	94.8a	111.2a	6.4a
	3	92.0b	3	101.5b	111.4a	6.2a
	6	79.0c	6	96.5a	105.2b	5.7b
2	0	92.8a				
	3	85.9ab				
	6	81.9b				

Richness ↓ w/ storage

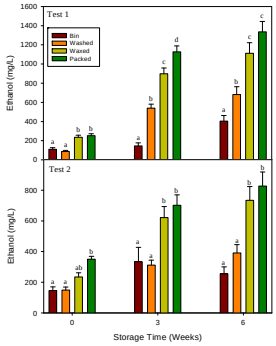
Sweetness ↓ Likeability↓ w/ storage

Step	Rich	Hedonic
Bin	94.1a	6.4a
Washed	90.9ab	6.1a
Waxed	86.2bc	6.1a
Packed	85.8c	6.0b

Richness↓

Likeability↓

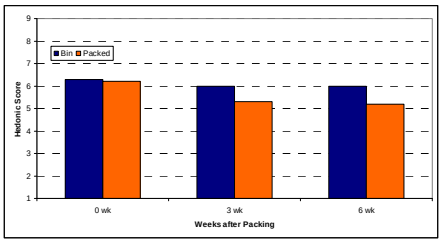
SSC increased with storage
TA decreased with storage
SSC/TA increased



Ethanol accumulated during storage and is influenced by packline handling

We repeated this test and added detection of aroma active compounds

Field Bin — Packed Box



Differences in aroma active compounds were detected due to storage and handling

10 compounds changed significantly due to storage duration

5 compounds changed due to handling

Conclusions

- Storage had a negative effect on fruit flavor
  - SSC/TA↑, Richness rating↓, Hedonic rating↓
- The packing line/waxing had a more modest influence
  - Richness rating↓, Hedonic rating↓
  - Overall each step appeared to have a cumulative effect
- Volatiles may play an important role in the flavor changes

Practical Outcomes

- How we handle fruit in the postharvest environment can influence long term eating quality
- In long term storage, SSC and TA may play a lesser role; changes in aroma active compound may play a more important role
- The impact on eating quality is repeatable across multiple grower lots and multiple tests

Mandarin Orange or Tangerine *Citrus reticulata* Blanco

- Increasing importance to the California industry
- Several new varieties; activity continues looking for new varieties
- Peel is loose and easily separates from flesh so sometimes referred to as “zipper skinned” fruit.
- Mandarins have a hollow core at maturity.
- Can be problematic in postharvest environment

Mandarins often develop off-flavor during storage

Not fresh

Over ripe

Spoiled

Really old

Strange aftertaste

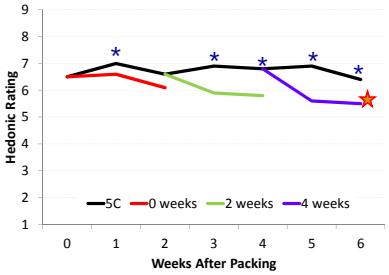
What is the Impact of Warm Temperatures?

Citrus is typically marketed in non-refrigerated cases

Storage Tests

- Continuous 5°C
- 1 and 2 wks 20°C
- 2 wks 5°C + 1 and 2 wks 20°C
- 4 wks 5°C + 1 and 2 wks 20°C

Response to Warm Temperature Storage – W. Murcott Afourer

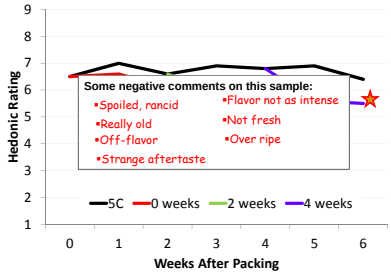


Warm temperature main cause of flavor loss

Time in cold storage influences response

Difference enhanced with greater fruit maturity

Response to Warm Temperature Storage – W. Murcott Afourer



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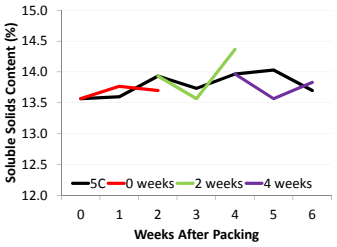
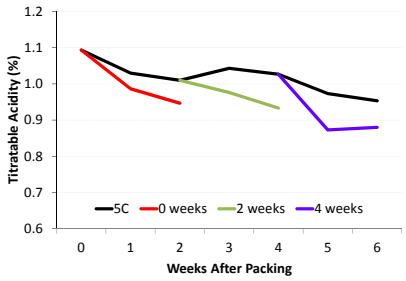
The loss in flavor quality is not explained by changes in soluble solids



No clear effect of temperature on soluble solids

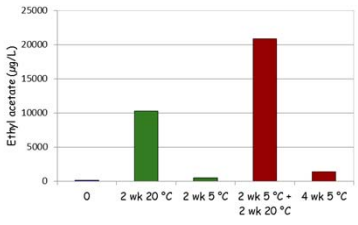
The flavor quality problems are not explained by acidity changes either



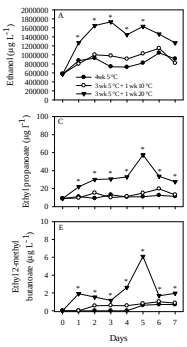
Warm temperature storage causes a loss in acidity

Example of the change in aroma volatiles due to temperature

Ethyl acetate – fruity, pineapple, solvent-like aroma



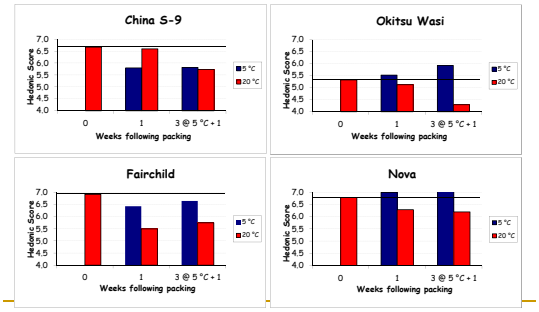
Large increase in ethyl acetate is prevented by cold storage



Subsequent tests showed that an intermediate temperature (50F) did not have the increase in volatiles associated with off-flavors

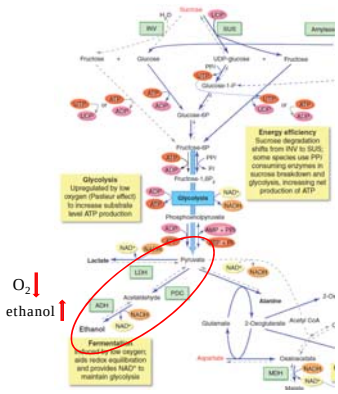
At 68F, increase occurs within 24 hours

Response to warm storage temperature – other mandarin types



What determines off-flavor formation?

Do mandarin varieties differ in off-flavor development in storage and, if so, why?



O_2 ↓
ethanol ↑

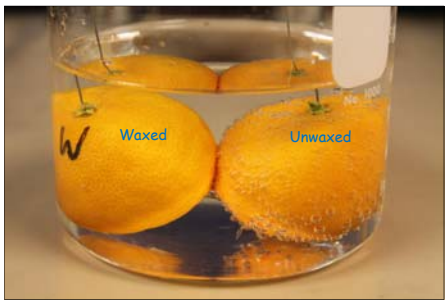
We assayed for ethanol as an attempt to screen for off-flavor susceptibility

- Major product of low oxygen and fermentation
- Substrate for volatile synthesis
- Ethanol easy to measure

Is there variability out there?

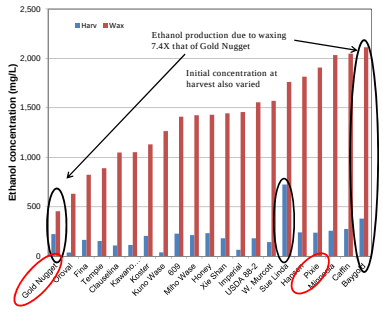
Bailey-Serres et al., 2012

Coatings provide a formidable barrier to gas exchange



UC Lindcove variety collection

The rate of ethanol production as a result of waxing and storage for 1 week at 68 °F varied greatly among the varieties



Is ethanol accumulation predictive of the levels of other compounds (volatiles)important to flavor?

Compound (µg/L)	Storage time (wks) Gold Nugget (low)		Pixie (high)	
Alcohols	0	3	0	3
Ethanol (mg/L)	359	554*	930	3445*
3-Methylbutanol	tr	tr	tr	75*
2-Methyl-1-butanol	tr	tr	tr	44*
Linalool	254	34*	122	60*
4-Terpineol	104	22*	41	24*
Esters				
Ethyl acetate	1753	2922*	487	5812*
Ethyl propanoate	92	201*	36	320*
Ethyl isobutyrate	tr	8*	tr	73*
Ethyl butanoate	18	37*	tr	466*
Ethyl 2-methylbutanoate	tr	6*	tr	209*
3-Methylbutyl acetate	tr	tr	tr	9*
2-Methylbutyl acetate	tr	tr	tr	8*
Octyl acetate	256	60*	185	106
Decyl acetate	102	19*	64	34
Ketones				
1-Penten-3-one	7	7	6	8*
Carvone	tr	12*	15	8
Aldehydes				
Pentanal	9	11*	9	15*
Hexanal	20	24	28	19
E-2-Hexenal	27	21	18	47*
Heptanal	17	16	15	19
Octanal	179	48*	386	66*
E-2-Octenal	tr	tr	8	6
Nonanal	83	44*	106	47
E-2-Nonenal	tr	tr	tr	tr
Decanal	529	38*	223	54*

Ethanol produced much greater for Pixie

Sweet, fruity aromas

Pixie's accumulation of flavor volatiles due to waxing and storage greater than Gold Nugget

Conclusions

1. A great deal of variability exists in the amount of ethanol accumulated as a result of waxing and storage
2. High ethanol accumulators tend to have higher carbon dioxide levels following waxing and storage than low accumulators
3. Ethanol accumulation is linked to the formation of other aroma volatiles that are associated with flavor changes

Future Work

1. Determine relationship of the ethanol accumulation differences and flavor
2. Determine what causes mandarins to be high or low ethanol accumulators
3. Coating effects?

Practical Outcomes

- Mandarins are a more diverse group and there is large differences between varieties
- Visual quality in not indicative of eating quality
- Cold chain crucial to maintain good eating quality
- Loss in acceptability tied to
  - Gas exchange characteristics
  - Changes in ethanol and ester compounds

Our research has been funded by the California Citrus Research Board and the US-IS BARD Program

Thank you for your attention