Sensory Quality of Fresh and Fresh-cut Products

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Sensory Evaluation in Postharvest Research

1) Do treatment/packaging that we apply to the fruit change product quality?
2) Are changes measured by instruments meaningful?
3) Are they perceived visually, by odor, taste, texture?
4) How is the new treatment/packaging/cultivar accepted by consumers?
What are the resources?

• Your own lab… 5, 20, 150 employees?
  – Recruiting & training
    • Hidden bias (knowledge of the product/project)
    • Participation and motivation

• Dedicated trained panel?

• Isolated facility or large University?

• Access to supermarket, location of central event…?
Test Environment

- Isolated booths
- Laboratory
- Public event
- Home survey
Plan ahead with the team!

- Experimental objective
- Storage study
- Measurements
- Panelists availability
- Sensory test design
- Number of fruit needed per treatment
Types of Tests

1. **Difference tests** to determine whether there are differences between products
2. **Descriptive panels** to define descriptors, traits
3. **Consumer panels** to indicate how much a product is liked
Difference Tests

- Triangle test
- Duo Trio
- Tetrad
- Simple difference
- Paired comparison
- Difference-from-control

Very useful in R&D product development
Simple to perform
Minimum 20-30 panelists, up to 100-150
Results are tabulated and compared with tables
Triangle Test

Two samples are the same, one is different. Which sample is the odd one?

Presentation order

A, B, A  A, A, B  B, A, A
B, A, B  B, B, A  A, B, B
Triangle Test

- Test is simple
- Well recognized
- Number of panelists: 20 to 40 for difference, 50 to 100 for similarity
- Described in textbooks, tables to interpret results easily available

- *Not recommended for heterogeneous products* (Aust et al., 1985; Harker et al., 2005)
- “results are suspect” (Aust 1985) because “it may measure the difference from fruit-to-fruit, not between treatments” (Harker 2005)
Alternatives to Triangle test

- Aust et al. (1985): Difference-from reference
- Harker et al. (2005):
  - 2-AFC or paired comparison
  - R-index
- Duo-trio with reference
- Paired comparison
- Difference-from-reference
Duo-trio Test

Which sample is the same as the reference?
**Duo-trio Test**

**Constant reference**

A (ref) AB

A (ref) BA

**Balanced reference**

A(ref) AB

B(ref) AB

A(ref) BA

B(ref) BA
**ClO₂ gas to reduce decay**

- **The sachet**
  - Chlorine dioxide wrapped in gas permeable cloth
- **Modifies the internal atmosphere of the packages**
  - Controlled release of ClO₂ reduces the growth of bacteria and molds
  - Maintains the quality of food

*Jan Narciso, Jinhe Bai*
Effect of ClO$_2$ on taste?

- Can panelists perceive/taste the new treatment (sanitizer) on fruit?

  • Duo-trio with constant reference (untreated)
  • 20 panelists
  • 11 correct responses

  → No difference between samples

  → Panelists could not detect the sanitizer

  • Repeated multiple times to confirm results

In front of you are one reference and two unknown samples. Out of the two unknown samples, which is the same as the reference (circle)?

159  845
ClO$_2$ sachets in strawberry clamshells

- Decay reduced
- Weight loss decreased
- Decrease in firmness reduced

Wang et al., 2014. Food Bioprocess Technol. 7:3516-3524
Duo-trio Test

Which sample is the same as the reference?

- For a panelist unfamiliar with sensory evaluation, the duo-trio test is easy to perform because a reference is given.
- Probability of correct guess is 1/2.
- Minimum number of panelists: 20.
**Simple Difference Test**

Is “A” same or different from “B”?

**Presentation order**

- A, B
- B, A
- A, A
- B, B

- Preferred test when samples have lingering taste
- Present one, or two pairs at a time
- The same sample comparison (A,A or B,B) accounts for the “noise”
Grapefruit chilling injury

Grapefruit is prone to chilling injury at storage below 10°C

- Heat treatment 53°C/2 min
- 7 weeks storage, 5°C (chilling) and 10°C
- 7 weeks (10 or 5°C) + 1 week room temp.

Day 1: Simple difference test, 55 panelists

- No difference overall
- When presented +heat/no heat, +heat was perceived sweeter

Mark Ritenour, Jian Li
Overall Difference Tests - Summary

• Used in product development
• Change of one ingredient, sanitation method, packaging,…
• Use before undergoing expensive consumer tests
• Want to know whether there is a difference

YES/NO
Single Attribute Difference Tests

• Is sample A sweeter than B?
• How much sweeter is sample A from B?
• Test more than two products (ranking)
Paired Comparison

Is “A” sweeter than “B”? (one-sided)
Which is sweeter, “A” or “B”? (two-sided)
(results tabulated and compared to critical table values)

Presentation order

A, B
B, A
Example 1: Tangerines

1. Which sample do you prefer?
   - ‘Fallglo’ (seeded)
   - ‘US Early Pride’ (seedless)

2. Select the reason of your choice
   - Sweeter
   - Less sweet
   - More flavor
   - Less flavor
   - …
   - More seeds
   - Less seeds

- 60 total panelists
- 28 preferred ‘Fallglo’
- 32 preferred ‘US Early Pride’

→ No significant difference at \( P<0.05 \)

- ‘Fallglo’ was preferred because of sweeter and more tangerine flavor
- ‘US Early Pride’ preferred because less seeds and juicier

Example 2: Chilled tomato

Chilling (storage at <10 °C) reduces tomato volatiles

Mature green tomato

C2H2 (48 h, 20 °C)

Control (water “vapor”/20 °C)

Methyl salicylate vapor (24 h)

Chilled
5 °C /9 days
20 °C storage

MeSA control
20 °C storage

MeSA + Chilled
5 °C /9 days
20 °C storage

Ripe tomatoes analyzed for volatiles and sensory evaluation

Chilled tomato aroma

✓ 30 panelists
✓ Paired comparison
✓ “which samples has more tomato aroma?”

➢ 19 out of 30 panelists found more tomato odor in MeSA + Chilled
→ significant difference ($P < 0.2$)

## Chilled tomato volatiles

### Table of Volatiles

<table>
<thead>
<tr>
<th>Volatile</th>
<th>Control</th>
<th>Chilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E)-2-pentenal</td>
<td>.00263 a</td>
<td>.00087 c</td>
</tr>
<tr>
<td>Nonanal</td>
<td>.00090 a</td>
<td>.00029 b</td>
</tr>
<tr>
<td>Citral</td>
<td>.0338 a</td>
<td>.0174 b</td>
</tr>
<tr>
<td>6-Methyl-5-hepten-2-one</td>
<td>.255 a</td>
<td>.093 c</td>
</tr>
<tr>
<td>Geranylacetone</td>
<td>.34 a</td>
<td>.13 b</td>
</tr>
<tr>
<td>2-Isobutylthiazole</td>
<td>.0136 a</td>
<td>.0050 c</td>
</tr>
</tbody>
</table>

# Chilled tomato volatiles

<table>
<thead>
<tr>
<th>Volatile</th>
<th>Control</th>
<th>Chilled</th>
<th>MeSA + chilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E)-2-pentenal</td>
<td>.00263 a</td>
<td>.00087 c</td>
<td>.00151 b</td>
</tr>
<tr>
<td>Nonanal</td>
<td>.00090 a</td>
<td>.00029 b</td>
<td>.00072 a</td>
</tr>
<tr>
<td>Citral</td>
<td>.0338 a</td>
<td>.0174 b</td>
<td>.0275 a</td>
</tr>
<tr>
<td>6-Methyl-5-hepten-2-one</td>
<td>.255 a</td>
<td>.093 c</td>
<td>.157 b</td>
</tr>
<tr>
<td>Geranylacetone</td>
<td>.34 a</td>
<td>.13 b</td>
<td>.28 a</td>
</tr>
<tr>
<td>2-Isobutylthiazole</td>
<td>.0136 a</td>
<td>.0050 c</td>
<td>.0079 b</td>
</tr>
</tbody>
</table>

### Chilled tomato volatiles

- MeSA before storage at 5°C minimized volatiles loss due to chilling injury.
- The difference in volatiles b/w Chilled and MeSA+chilled was detectable.


<table>
<thead>
<tr>
<th>Volatile</th>
<th>Odor</th>
<th>Chilled</th>
<th>MeSA + chilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E)-2-pentenal</td>
<td>Green</td>
<td>.00087 c</td>
<td>.00151 b</td>
</tr>
<tr>
<td>Nonanal</td>
<td>Citrus</td>
<td>.00029 b</td>
<td>.00072 a</td>
</tr>
<tr>
<td>Citral</td>
<td>Citrus</td>
<td>.0174 b</td>
<td>.0275 a</td>
</tr>
<tr>
<td>6-Methyl-5-hepten-2-one</td>
<td>Fruity</td>
<td>.093 c</td>
<td>.157 b</td>
</tr>
<tr>
<td>Geranylacetone</td>
<td>Fruity</td>
<td>.13 b</td>
<td>.28 a</td>
</tr>
<tr>
<td>2-Isobutylthiazole</td>
<td>Tomato</td>
<td>.0050 c</td>
<td>.0079 b</td>
</tr>
</tbody>
</table>
Paired Comparison

Is “A” sweeter than “B”?
Which do you prefer, “A” or “B”?

- Easy test for untrained panelist, question well defined
- Gives information on treatment effect for specific attribute
- Can be followed by multiple choice questions to learn more about product preference
Single Attribute Difference Tests

- Is sample A sweeter than B?
- How much sweeter is sample A from B?
- Test more than two products (ranking)
Difference from Reference

• To measure the size of the difference

• Use a scale:
  – 0 = no difference / 10 = extremely different
  – -100 (extremely less) / zero (equal to reference) / +100 (extremely more)

• One of the coded sample is actually the control (noise)

• Can measure overall difference or specific attribute difference
Coated fresh-cut zucchini

- Antioxidants:
  - 0.5% calcium ascorbate + 0.5% ethanol
  - Chitosan + antioxidants
  - Soy Protein isolates + antioxidants
  - Water (control)

Coated fresh-cut zucchini

Difference-from-reference 100 mm line scale

- Less zucchini odor
- Same as Reference
- More zucchini odor

- Less firm/softer
- Same as Reference
- More firm/crunchier

- Less zucchini flavor
- Same as Reference
- More zucchini flavor

- Darker
- Reference
- Lighter
Uncooked coated zucchinis

- **Reference**
- **Antioxidants**
- **Chitosan**
- **Soy Protein**
- **Control**

### Uncooked

- **Zucchini odor**
- **Firmness**
- **Zucchini flavor**
- **Lightness**

- **Antioxidants**
- **Chitosan**
- **Soy Protein**
- **Control**

Legend:
- Antioxidants
- Chitosan
- Soy Protein
- Control

Note: The graph shows comparisons of Zucchini odor, Firmness, Zucchini flavor, and Lightness for different treatments.
Boiled coated zucchinis

Boiled

Zucchini odor
Firmness
Zucchini flavor
Lightness

Antioxidant
Chitosan
Soy Prot
Control
Steamed coated zucchinis

Reference
Antioxidants
Chitosan
Soy Protein
Control

Steamed

Zucchini odor
Firmness
Zucchini flavor
Lightness

Antioxidants
Chitosan
Soy Protein
Control

a
ab
b
b
ab

Reference Antioxidants Chitosan Soy Protein Control
Griddled coated zucchinis

- Griddled Antioxidants
- Chitosan
- Soy Protein
- Control

Reference

Griddled

Zucchini odor

Firmness

Zucchini flavor

Lightness

Antioxidants
Chitosan
Soy Protein
Control

USDA

Chitosan
Soy Protein
Control
Fried coated zucchinis

Reference  Antioxidants  Chitosan  Soy Protein  Control

Fried

Zucchini odor  Firmness  Zucchini flavor

Antioxidants  Chitosan  Soy Protein  Control

Lightness

-20.0  -10.0  0.0  10.0  20.0  30.0  40.0  50.0  60.0

USDA  das
### Firmness of coated zucchinis

Texture analyzed with texture analyzer XT2i
(3 mm probe, insert d=3mm, speed 50 mm/min)

<table>
<thead>
<tr>
<th></th>
<th>Antioxidants</th>
<th>Chitosan</th>
<th>Soy Protein</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uncooked</strong></td>
<td>9.80 a</td>
<td>8.38 ab</td>
<td>7.88 b</td>
<td>8.06 b</td>
</tr>
<tr>
<td><strong>Boiled</strong></td>
<td>0.86 a</td>
<td>0.78 a</td>
<td>0.96 a</td>
<td>0.51 b</td>
</tr>
<tr>
<td><strong>Steamed</strong></td>
<td>1.07 a</td>
<td>0.89 ab</td>
<td>0.93 a</td>
<td>0.67 b</td>
</tr>
<tr>
<td><strong>Griddled</strong></td>
<td>2.47 a</td>
<td>2.61 a</td>
<td>3.10 a</td>
<td>2.64 a</td>
</tr>
<tr>
<td><strong>Fried</strong></td>
<td>0.52 a</td>
<td>0.62 a</td>
<td>0.53 a</td>
<td>0.59 a</td>
</tr>
</tbody>
</table>

Significant differences in a row for the same cooking method by LSD at $P \leq 0.05$
Coatings of fresh-cut zucchini

- Coatings + antioxidants improved color or appearance of fresh-cut zucchini
- Some coatings made cooked slices firmer (Boiled, steamed, griddled)
- Some coatings changed flavor, for better (SPI boiled) or worse (chitosan griddled)

Difference from reference helps when untrained panel is used and/or many samples tested

Single Attribute Difference Tests

• Is sample A sweeter than B?
• How much sweeter is sample A from B?
• Test more than two products (ranking)
Ranking Tests

• When more than two products
• **No more than 5 samples! 3 is best.**
• Panelists do not need training but need to understand attribute(s) to be tested
• Data analyzed with the Friedman test
Coated fresh-cut mangoes

‘Keitt’

Control | Antioxidants* | CMC | Carrageenan

*Antioxidants = Calcium ascorbate, Citric acid, Acetylcysteine

Plotto et al., 2010. J. Sci. Food Agric. 90:2333-2341
Coated fresh-cut mangoes

- Ranking test
- 14 panelists, trained
- Reference standard presented
- Day 1 and Day 5 in storage

Plotto et al., 2010. J. Sci. Food Agric. 90:2333-2341
Grapefruit chilling injury

Grapefruit is prone to chilling injury at storage below 10°C

- Heat treatment 53°C/2 min
- 7 weeks storage, 5°C (chilling) and 10°C
- 7 weeks (10 or 5°C) + 1 week room temp.

**Day 1**: Simple difference test, 55 panelists

**Week 7**: Ranking (Preference, Flavor, Sweetness, Sourness, Bitterness)

**Week 7+1**: Ranking (Preference, Flavor, Sweetness, Sourness, Bitterness)

- 55 panelists
Grapefruit heat treatments

Ranking results at 7 weeks storage and 7 weeks + 1 week room temp.

<table>
<thead>
<tr>
<th>Weeks storage</th>
<th>Heat</th>
<th>Storage Temp</th>
<th>Preference</th>
<th>Sweetness</th>
<th>SSC (°Brix)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>-</td>
<td>10</td>
<td>2.7 b</td>
<td>2.8 bc</td>
<td>8.4 b</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>5</td>
<td>2.7 b</td>
<td>3.0 c</td>
<td>8.3 b</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>10</td>
<td>2.5 a</td>
<td>2.2 ab</td>
<td>9.1 a</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>5</td>
<td>2.1 a</td>
<td>2.0 a</td>
<td>9.0 a</td>
</tr>
<tr>
<td>7 + 1</td>
<td>-</td>
<td>10</td>
<td>2.7 b</td>
<td>2.9 b</td>
<td>8.8 b</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>5</td>
<td>2.8 b</td>
<td>2.9 b</td>
<td>8.6 b</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>10</td>
<td>2.3 ab</td>
<td>2.3 ab</td>
<td>9.4 a</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>5</td>
<td>2.2 a</td>
<td>1.9 a</td>
<td>9.0 ab</td>
</tr>
</tbody>
</table>

Rank is “most” to “least” for each attribute, therefore the lowest number indicates the highest attribute.

- Soursness opposite to sweetness
- No differences in bitterness

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Ranking Tests

• Appropriate when few products are to be compared
• Want to know differences on simple attributes: sweetness, sourness, firmness…
• **No more than 5 samples! 3 is best.**
Trained Panels

• Develop a product profile
• Consensus terminology
• Reference standards
• Common scale
• 10-12 panelists
• Hours of training (24 to 300)
Example 1: Maturity of new tangerine hybrids


Fred Gmitter

- Dec, Jan: too sour but interesting flavor
- End Jan and Feb: very sweet and sour, mix of orange and tangerine flavor
Example 2: Blueberry storage

**Arcadia**

Firmness, Sweetness, Sourness, Blueberry, Green

- H1D01
- H1D08
- H1D15
- H2D01
- H2D08
- H2D15

Distribution of firmness

- 11
- 19
- 115
- 21
- 28
- 215
Example 3: New cultivars evaluation

Trained panel (10 panelists)

Consumer panel (100 pan.)

Winterstar™ Festival Radiance

University of Florida, Charlie Sims

Vance Whitaker
Trained panel

- 12 panelists
- 5 hours training
- Reference standards
- 10 cm line scale

Consumer panel

- 140 panelists
- 9-point hedonic scale

Descriptors

- 6 aroma descriptors
- 6 appearance
- 6 texture
- 3 taste
- 2 aftertaste

✓ “how much do you like the sample?”
Trained panel results

Consumer panel results

Kent, aromatic and sweet

Kent, firm

Tommy, moist and glossy
Sensory Evaluation

Product Development
- Differences between products
- Describe and quantify differences
- Analytical
  - Trained panels
  - Staff “in house” panelists

Consumer Studies
- Preference studies
- Surveys
- Consumption habits
- Behavioral / psychological
  - University panels
  - Mall intercepts
  - Take home products
Collaborators

- Elizabeth Baldwin
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- Jan Narciso
- Greg McCollum
- Jeff Brecht
- Mark Ritenour
- Jim Olmstead
- Vance Whitaker
- Fred Gmitter

Thanks to all the students and visiting scientists!
THANK YOU!!
Questions??