Flavor and Aroma Biology

Perception of Quality

- Our sensory systems are responsible for generating an internal representation of the outside world, including its chemical (taste and olfaction) and physical (mechanical, sound, vision and temperature) features.
- When evaluating the quality of the foods we eat, we use the complete array of our sensory system (chemical and physical senses) and integrate this information to formulate a judgment.
- From an evolution standpoint, chemical senses are the most primal of the senses.

Sensory Attributes of Foods

- Appearance
- Taste
- Odor/smell/aroma
- Irritation/pain
- Texture/mouthfeel
- Temperature

Outline

- Introduction to our sensory system and the perception of flavor
- Relationships between fruit composition and flavor perception
- Fruit biology and development of flavor components (influence of genetic and environmental factors)

Perception of Quality

- Varies depending on protagonist in PH chain
- Consumer-centric “quality” ultimately drives marketability and sales
- Overall consumer acceptance (and repeat buy) strongly correlated with “Flavor acceptance”

Taste

- Our sense of taste is in charge of evaluating the nutritious content of food and preventing the ingestion of toxic substances.
- Taste is a sensation perceived in the mouth, more specifically on the tongue. We have innate likes and dislikes for it.

- Sweet
- Salty
- Bitter
- Sour (acidic)
- Umami (protein – savory)

5 TASTE MODALITIES
Fruit Composition and Taste

<table>
<thead>
<tr>
<th>Quality</th>
<th>Class of compound</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>Sugars</td>
<td>Sucrose, fructose, glucose</td>
</tr>
<tr>
<td></td>
<td>Some proteins</td>
<td>Monellin, thaumatin</td>
</tr>
<tr>
<td>Sour</td>
<td>Acids</td>
<td>Citric acid, malic acid, tartaric acid</td>
</tr>
<tr>
<td>Bitter</td>
<td>Alkaloids, Phenolics, Terpenoids, some proteins</td>
<td>Naringin, eucalyptus, limonoids</td>
</tr>
<tr>
<td>Salty</td>
<td>Ions</td>
<td>Sodium, calcium</td>
</tr>
<tr>
<td>Umami</td>
<td>Amino acids</td>
<td>Glutamate, aspartate</td>
</tr>
</tbody>
</table>

Texture and Mouthfeel

- Astringency (tannins, calcium oxalate)
- Sense of touch (mechanoreceptors)

Aroma

- Aroma (or smell or odor) is the sensation perceived when volatile compounds are drawn into the nose.
- We have learned likes and dislikes for it.

Taste and Aroma

- Taste and aroma are very closely linked.
- If you want to only TASTE something, you need to pinch your nose to avoid perceiving the volatiles in foods or drinks.

What is a volatile compound?

- A small molecule which has a high tendency to evaporate.
- Volatiles are naturally produced by plants (flowers, fruits, vegetables, herbs...) and animals. They can also be made artificially (by chemical reactions designed for their production).
What does a volatile compound smell like?

- Each single volatile compound has a distinct smell.

\[ \beta\text{-ionone} \]

Floral, woody, sweet, fruity, berry, green

\[ \text{Dimethyl disulfide} \]

Sulfurous, vegetable, cabbage, onion

\[ \text{Myrcene} \]

Peppery, spicy

“Character-impact” volatiles

Vanillin

2-isobutyl 3-methoxypyrazine

Accessibility of Character-impact Aroma Components

Complexity of Fruit Aromas

- A natural aroma, smell or odor is typically made up of tens or sometimes hundreds of different volatile compounds.

- A mixture of volatile compounds is not perceived as “the sum of its parts”: volatiles interact to create a unique, distinct, aroma.

The aroma of a strawberry...

Over 200 volatile compounds!!

GC olfactometry is used to help determine which volatiles contribute to flavor

Tomato GC Olfactometry chromatogram

Elizabeth Baldwin, USDA/ARS
• We have different sensitivity levels for different volatiles.

• Some volatiles, like furaneol, can be detected by our olfactory system at extremely low levels; while others, like acetic acid (vinegar!), we can detect only at higher levels.

• Even though acetic acid is much more abundant than furaneol in strawberries, it is furaneol that is more important for determining the characteristic aroma of the strawberry (because of its low odor threshold value).

Odor Thresholds
What the nose knows...

Studying Fruit Flavor
What kinds of flavor compounds are present in fruits?

How do plants produce these flavor compounds?

How do internal and external factors influence the production of these compounds?

Define commodity- and variety-specific compositional characteristics that can be related to sensory attributes

Develop varieties with novel flavor properties based on knowledge of genetic determinants of volatile formation

Control fruit flavor quality throughout production and postharvest handling

Flavor Development: Diversity and Complexity

Genetic factors
Pathways, hormones, regulatory mechanisms...

Climatic factors
Temperature, light, atmospheric gases...

Agricultural factors
Soil type, irrigation, fertilization...

Taste Development
Sugars

• Starch accumulation is an important factor for determining the final sugar content of many fruits.

• In tomato, cultivars that accumulate higher levels of starch in young fruits eventually contain more soluble sugars at the ripe stage.

Aroma Development
Volatiles

How are aroma volatiles made in plants?

• There are more than 2,000 volatiles known to date in plants. About 900 different volatiles have been reported in fruits and vegetables.

• Research has identified genes involved in the synthesis of less than 10% of all volatiles known.
Alcohol Acyl Transferase: a gene involved in fruit aroma formation

\[ R_1-\text{OH} + S \xrightarrow{\text{AAT}} R_2-\text{O-S-CoA} \xrightarrow{\text{Acyl-CoA Volatile Ester (Aroma)}} R_1-\text{O-S-CoA} + R_2-\text{O} \]

Aroma Development Volatiles

How is aroma (volatile) production controlled in fruits/vegetables?

- In climacteric fruits, ethylene plays an important role in triggering aroma formation during fruit ripening.

Regulation of Aroma Formation

Figure 4. Phenotype of wild-type (WT) and antisense ACC oxidase (AS) Solanum lycopersicum cv. moneymaker 36 days after pollination and stored for 10 days at 25°C. Ayub et al., 1996

Regulation of Aroma Formation

Aroma Biology

What are the impacts of cultivation practices and postharvest storage on aroma formation?

- Pre-harvest factors
  - Supply of carbon (sugars) to the fruit, water stress, light, temperature, plant diseases...

Aroma Biology

- Postharvest factors
  - Temperature
    - Cold slows down metabolism (less volatiles made).
    - Cold slows down evaporation of volatiles from fruit surface.
  - Ethylene
    - In climacteric fruits, aroma cannot form without ethylene.
  - Modified or controlled atmosphere
    - MA or CA alters plant metabolism – risk of anaerobic metabolism which can cause off-odors.
An example of the impact of temperature on flavor...mandarins

- Warm temperature main cause of flavor loss
- Time in cold storage influences response

Some taste panel comments on warm temp fruit
- Spoiled, rancid
- Really old
- Off-flavor
- Strange aftertaste
- Over ripe
- Not fresh
- Over ripe
- Warm temperature main cause of flavor loss
- Time in cold storage influences response

Effect of modified atmosphere as a result of surface coating on mandarin ethanol concentration

Harvest Coating + 68°F 1 week

Is there hope?...

Quality-oriented practices
- Understand the physiology of commodity, select cultivars with optimum flavor quality.
- Harvest at maximum flavor potential (riper) to attain (and retain) maximum flavor quality.

More Research needed...
- Improving techniques to slow down metabolism when fruits already start to ripen.
- Developing rapid, non-destructive methods for objective flavor quality determination (beyond “Brix”…)

Questions?