Fruit Ripening and Quality Relationships
Stages of Fruit Development

INITIATION

DEVELOPMENT

DEATH

GROWTH

MATURATION

PHYSIOLOGICAL

MATURETY

RIPENING

SENESCENCE

Development

• The series of processes from the initiation of growth to death of a plant or plant part.

Growth

• The irreversible increase in physical attributes (characteristics) of a developing plant or plant part.
Maturation
• The stage of development leading to the attainment of physiological or horticultural maturity

Physiological maturity
• The stage when a plant or plant part will continue developing even if detached

Horticultural maturity
• The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers

At which maturity stage are most fresh market tomatoes harvested?

A. Physiological maturity
B. Horticultural maturity
Ripening

- The set of processes that occur from the later stages of growth through the early stages of senescence and that results in characteristic aesthetic and/or eating quality, as evidenced by changes in composition, color, texture, or other sensory attributes.
Physiological Changes Accompanying Senescence of Horticultural Crops

**Cellular:**
- Loss of chlorophyll, disassembly of chloroplast structure
- Degradation of cell walls
- Altered membrane composition, loss of fluidity
- Loss of cellular compartmentation, release of vacuolar contents

**Senescence**
- The last stage of development during which degradation of biological components occur.

Stages of Fruit Development

Physiological Changes Accompanying Senescence of Horticultural Crops (cont.)

**Composition:**
- Altered sugar content, and switch to alternative substrates for respiration
- Net loss of RNA
- Increased protease activity, net loss of protein
- Altered amino acid content
Stages of Fruit Development

Physical Changes Accompanying Senescence of Horticultural Crops

Color:
- Loss of green color
- Synthesis of new pigments (carotenoids, flavonoids)

Texture:
- Softening
- Wilting
- Drying

Loss of resistance to pathogens:
- Development of infections
- Lesions

Respiration and ethylene production rates of climacteric and non-climacteric fruits
# Maturity and Ripening

**Group 1:** Fruits that are **not** capable of continuing their ripening process once removed from the plant.

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Loquat</th>
<th>Pomegranate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackberry</td>
<td>Lychee</td>
<td>Prickly pear</td>
</tr>
<tr>
<td>Cherry</td>
<td>Mandarin</td>
<td>Rambutan</td>
</tr>
<tr>
<td>Grape</td>
<td>Muskmelons</td>
<td>Raspberry</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>Orange</td>
<td>Strawberry</td>
</tr>
<tr>
<td>Lemon</td>
<td>Pepper (bell)</td>
<td>Tamarillo</td>
</tr>
<tr>
<td>Lime</td>
<td>Pineapple</td>
<td>Watermelon</td>
</tr>
<tr>
<td>Longan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## California Minimum Maturity Indices for Selected Non-Climacteric Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Minimum maturity indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomegranate</td>
<td>Red juice color and below 1.85% acid in juice</td>
</tr>
<tr>
<td>Grape</td>
<td>14 to 17.5% SS (depending on cultivar and production area) or a SS/A ratio of 20 or higher</td>
</tr>
<tr>
<td>Strawberry</td>
<td>&gt;3/4 of fruit surface showing a pink or red color</td>
</tr>
</tbody>
</table>

SS = soluble solids, A = acidity
Maturity and Ripening

**Group 2:**
Fruits that **can be** harvested before fully ripe, and ripened off the plant

<table>
<thead>
<tr>
<th>Apple</th>
<th>Mango</th>
<th>Persimmon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td>Nectarine</td>
<td>Plum</td>
</tr>
<tr>
<td>Avocado</td>
<td>Papaya</td>
<td>Quince</td>
</tr>
<tr>
<td>Banana</td>
<td>Passion fruit</td>
<td>Sapodilla</td>
</tr>
<tr>
<td>Cherimoya</td>
<td>Peach</td>
<td>Sapote</td>
</tr>
<tr>
<td>Guava</td>
<td>Pear</td>
<td>Tomato</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Pepper (chili)</td>
<td></td>
</tr>
</tbody>
</table>

California Minimum Maturity Indices for Pome Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Minimum maturity indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Starch pattern, above 10.5 to 12.5% SS and below 18 to 23 lb-force firmness (depending on cultivar)</td>
</tr>
<tr>
<td>Pear (Bartlett)</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS</td>
</tr>
<tr>
<td>Persimmon</td>
<td>Yellowish-green to orange color (depending on cultivar)</td>
</tr>
</tbody>
</table>

SS=soluble solids
Quality Attributes of Fruits

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

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.
Sensory Attributes of Foods

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

Flavor

Sensory Attributes of Foods

Appearance

- First attributes perceived
- Shape
- Color
  - Strongly-set expectations
  - Emotional connotations
**Sensory Attributes of Foods: 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**.

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

**5 TASTES**

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**Are taste preferences **innate** or **learned**?**

- **A. Innate** (we are born preferring sweet/salty/umami tastes)
- **B. Learned** (as we grow up, we learn to prefer sweet/salty/umami tastes)
**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>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, cucurbitacins, 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>

**Taste vs. Sugar/Acid Ratio**

<table>
<thead>
<tr>
<th>Acids</th>
<th>Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>Insipid, tasteless</td>
</tr>
<tr>
<td>Moderate to High</td>
<td>Sour, tart</td>
</tr>
</tbody>
</table>

Soluble solids measured by a refractometer = sugars, organic acids, soluble pectins, anthocyanins, phenolic compounds, ascorbic acid...

Need quick methods of measuring total sugars and titratable acidity...
Aroma (or smell or odor) is the sensation perceived when volatile compounds are drawn into the nose.

Are smell/scent preferences innate or learned?

A. Innate (we are born preferring/rejecting certain smells)

B. Learned (as we grow up, we learn to prefer/reject certain smells)
The Aroma of a Strawberry

Over 200 volatile compounds !!

Sensory Attributes of Foods

Texture / Mouthfeel

- Astringency (tannins, calcium oxalate)
- Sense of touch (mechanoreceptors)
Sensory Attributes and Fruit Composition

• All fruit components (sugars, acids, volatiles, etc...) combine to generate a unique sensory experience for the consumer.

• Physical methods can give accurate measurements of fruit composition but it is difficult to relate these measurements to fruit quality without information about sensory perception.

Sensory Methodology

- **Analytical tests**
  - Difference? What is it? How strong is it?
  - Descriptive analysis
  - Trained judges
Sensory Methodology

- **Consumer tests**
  - Preference, liking, purchase intent
  - Attitudes, beliefs
  - Ethnography
  - Untrained consumers

Objective measurements and Quality prediction

- Development on the plant
  - Developmental program
  - Physiological processes (metabolism)
  - Changes in composition
  - Genetic/environmental/cultivation factors

  → Harvesting at maximum potential

- Postharvest Life (?)
  - Altered physiological processes (metabolism)
  - Changes in composition
  - Genetic/environmental/handling factors

  → Attaining and retaining maximum quality
Case study:
Perception of melon quality

- Overall consumer acceptance (and repeat buy) strongly correlated with “Flavor acceptance”

Effect of Maturity and Ripeness on Selected Sensory Attributes
Fruit Volatile Analysis Using an Electronic Nose

Nondestructive Quality Sensing Needs

- Degree of freshness (time since harvest)
- Prior exposure to ethylene (concentration x duration x temperature)
- Prior exposure of chilling-sensitive commodities to chilling conditions (temperature x duration)
- Internal translucency / browning
- Mealiness (lack of juiciness)
- Acidity / nutritional value
- Aroma (volatiles)
Questions?