Fruit Ripening and Quality Relationships

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Stages of Fruit Development

INITIATION DEVELOPMENT DEATH

GROWTH

MATURATION

PHYSIOLOGICAL MATURETY

RIpening

SENSIENCE

John O'Neill

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

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.
Compositional Changes During Pineapple Development

Stages of Fruit Development

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

**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 compartmentalization, release of vacuolar contents

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

**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

- Climacteric Fruits: Ethylene
- Non-Climacteric Fruits: Respiration

Time after Harvest
### 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>Minimum maturity indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackberry</td>
<td>Pomegranate</td>
</tr>
<tr>
<td>Cherry</td>
<td>Lychee</td>
</tr>
<tr>
<td>Grape</td>
<td>Mandarin</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>Muskmelons</td>
</tr>
<tr>
<td>Lemon</td>
<td>Raspberry</td>
</tr>
<tr>
<td>Lime</td>
<td>Pepper (bell)</td>
</tr>
<tr>
<td>Longan</td>
<td>Pineapple</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>Red juice color and below 1.85% acid in juice</td>
</tr>
<tr>
<td>Prickly pear</td>
<td>Rambutan</td>
</tr>
<tr>
<td>Rambutan</td>
<td>Pomegranate</td>
</tr>
<tr>
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<tr>
<td>Prickly pear</td>
<td>Rambutan</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Pineapple</td>
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#### California Minimum Maturity Indices for Selected Non-Climacteric Fruits

<table>
<thead>
<tr>
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<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>Apricot</td>
<td>Nectarine</td>
</tr>
<tr>
<td>Avocado</td>
<td>Papaya</td>
</tr>
<tr>
<td>Banana</td>
<td>Passion fruit</td>
</tr>
<tr>
<td>Cherimoya</td>
<td>Peach</td>
</tr>
<tr>
<td>Guava</td>
<td>Pear</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Pepper (chili)</td>
</tr>
<tr>
<td>Mango</td>
<td>Persimmon</td>
</tr>
<tr>
<td>Persimmon</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS (depending on cultivar)</td>
</tr>
<tr>
<td>Plum</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS (depending on cultivar)</td>
</tr>
<tr>
<td>Quince</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS (depending on cultivar)</td>
</tr>
<tr>
<td>Sapodilla</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS (depending on cultivar)</td>
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### Maturity and Ripeness Stages of Strawberries

Strawberries must be picked fully-ripe because they do not continue to ripen after harvest.

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<td>Persimmon</td>
<td>Yellowish-green to orange color (depending on cultivar)</td>
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### 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
• First attributes perceived
• Shape
• Color
  o Strongly-set expectations
  o Emotional connotations

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)

A rapid method for measuring sugar content in a liquid

• A refractometer measures the refraction of light as it passes through a drop of liquid (it measures the “refractive index” of that liquid).
• The refractive index is directly proportional to the concentration of ALL diluted solutes in the liquid.
• The correct term for fruit juice is:
  TOTAL Soluble Solids (TSS or SSC) = sugars, organic acids, amino acids, soluble pectins, anthocyanins, other phenolic compounds...
Acids  | Sugars
---|---
Low  | Insipid, tasteless | Sweet
Moderate to High  | Sour, tart | Best taste combination

Sensory Attributes of Foods

**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.

The Aroma of a Strawberry

Over 200 volatile compounds !!

**Chemical Irritation**

- Common chemical sense
- Stimulated by chemical irritants
  - Ex: capsaicin, piperin, allicin, glucosinolates, etc...

Innate dislikes (protection)

**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

- **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

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

→ Harvesting at maximum potential

→ Attaining and retaining maximum quality

Sensors for Nondestructive Testing of Produce Quality

- Acoustic impulse transmission
- Aroma sensing technology ("electronic noses")
- Chlorophyll fluorescence
- Electrical and mechanical impedance
- Fruit bounce firmness measurement
- Near infrared (NIR) transmittance
- Nuclear magnetic resonance (NMR) imaging
- X-ray imaging

Volatiles as Objective Markers for Flavor Quality

- Testing a rapid method for volatile analysis for use in commercial setting to monitor flavor quality (pre- and post-harvest)

  - zNose™
  - (Electronic Sensor Technology)

http://www.jove.com/video/3821/
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?