Harvest Maturity and Fruit Quality

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California orange on plane returning from Indonesia PH workshop
Nov 19, 2007

Relationship between sugar/acid ratio and sensory panelist’s response to the question about Willingness to Buy navel oranges

<table>
<thead>
<tr>
<th>Sampling week</th>
<th>% samples below sugar/acid Ratio of 8.1*</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 14-18</td>
<td>39</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>Nov 28-Dec 2</td>
<td>27</td>
<td>53</td>
<td>47</td>
</tr>
<tr>
<td>Dec 12-16</td>
<td>13</td>
<td>63</td>
<td>37</td>
</tr>
</tbody>
</table>

*from California A grade standard
Source: Ivans and Feree, 1987

Importance of Maturity Indices

- Sensory and Nutritional Quality
- Use—Fresh market or Processed
- Adequate shelf-life
- Facilitate marketing—standards
- Productivity

Evolution of some physical, chemical and physiological parameters during fruit development and ripening on the tree of ‘Golden Globe’ Plum.

Watada et al., 1984

Terminology

**PHYSIOLOGICAL MATURITY**
The stage of development when a fruit will continue development even if detached; mature fruits

**HORTICULTURAL MATURITY**
The stage of development when a fruit possesses the necessary characteristics for use by consumers

**Group 1** Non-climacteric Fruits
Fruits that are not capable of continuing ripening process (physiological changes) once removed from the plant.

| Blackberry | Loquat | Pomegranate |
| Cherry     | Litchi | Prickly Pear |
| Grape      | Mandarin | Rambutan |
| Grapefruit | Muskmelons | Raspberry |
| Lemon      | Orange | Strawberry |
| Lime       | Pepper (Bell) | Tamarillo |
| Longan     | Pineapple | Watermelon |

*No increase in sugar content; Changes in firmness, external color, and aroma may occur*

**Group 1. Non-Climacteric Fruits**
Conditioning
Color change may occur
Softening may occur
No increase in sugar
Decrease in acidity
Ethylene can be used to de-green

**Group 2. Climacteric Fruits**
Ripening
Color change
Softening often substantial
Starch to sugar conversion
Decrease in acidity
Large increase in metabolism
Ethylene used to trigger ripening

**Composition of Ripe Strawberry**
Harvested at different stages. Held at 70°F (21°C) to complete color change.

<table>
<thead>
<tr>
<th>Maturity</th>
<th>% SS</th>
<th>% Acid</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% color</td>
<td>4.28</td>
<td>0.80</td>
<td>5.35</td>
</tr>
<tr>
<td>50% color</td>
<td>4.56</td>
<td>0.79</td>
<td>5.77</td>
</tr>
<tr>
<td>75% color</td>
<td>4.98</td>
<td>0.68</td>
<td>7.32</td>
</tr>
<tr>
<td>100% color</td>
<td>5.48</td>
<td>0.59</td>
<td>9.28</td>
</tr>
</tbody>
</table>
**Pineapple Stored at 7°C (44°F)**

<table>
<thead>
<tr>
<th>Maturity</th>
<th>% Soluble solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>days</td>
<td>0</td>
</tr>
<tr>
<td>Shipping green</td>
<td>6.9</td>
</tr>
<tr>
<td>¼ color</td>
<td>13.6</td>
</tr>
<tr>
<td>½ color</td>
<td>13.6</td>
</tr>
<tr>
<td>Full color</td>
<td>15.4</td>
</tr>
</tbody>
</table>

**Cantaloupe Maturity/Ripeness**

- Fruit begins to separate from stem
- Abscission zone; “slip”
- External color between net
- Net well developed with wax
- Subtending leaf dries up
- Internal color, firmness, soluble solids

The “slip” is a very useful attribute & applicable to old & new cantaloupe varieties.

**Fresh-cut Cantaloupe melon**

- Changes in Sugar Content

| Sugar loss in fresh-cut cantaloupe may be considerable, but Soluble solids do not change much; Sugar loss typically is not as extreme as in this example.

**Typical loss over 10 days at 5°C (41°F):**

- S.S. 0-10%
- Sugars 10-20%
Honeydew and other melons
Cut off the vine are more
difficult to harvest at a specific
stage of ripeness

Honeydew and Orange Flesh Melons
Maturity and Ripeness Classes

- **Class 0: Immature**
  - Ground color greenish-white; peel fuzzy; no aroma;
  - 10% soluble solids; flesh crisp, melon splits when cut;
  - minimum commercial harvest maturity

- **Class 1: Mature, but Unripe**
  - Ground color greenish-white; peel fuzzy; no aroma;
  - 10% soluble solids; flesh crisp, melon splits when cut;
  - minimum commercial harvest maturity

- **Class 2: Mature, Ripening**
  - Ground color white; begins to develop surface wax;
  - pulp crisp, melon splits

**Minimum for Good Eating**

**Group 2** Climacteric Fruits ‡ has significant amount of starch
Fruits that can be harvested and ripened off the plant.

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

*Except for avocado, banana, mango and pear, these fruits attain best flavor if ripened on the plant. Many of these fruits have large increases in sugar during ripening.

**Indicators of Harvest Maturity**

**APPLES**

- Days from full bloom
- Time/temp (heat units) from anthesis
- Days from harvest to onset of ethylene production
- Ground color
- Soluble solids content (SSC)
- Flesh firmness and SSC
  - Starch disappearance pattern
  - Internal ethylene concentration
  - Changes in firmness or starch content
  - Streif index (Firmness/SS*Starch score)
Apple Maturity: starch index

Apply the iodine solution** to the cut surface
Drain away any excess, and rate the fruit after 2 min.
Starch-iodine reaction is temperature-dependent
Starch pattern is variety-specific.

Rating system is a scale of 1 to 6, as follows:
1 = full starch (all blue-black)
2 = clear of stain in seed cavity and halfway to vascular area
3 = clear through the area including vascular bundles
4 = half of flesh clear
5 = starch just under skin
6 = free of starch (no stain)

** Preparation of Iodine-Potassium Iodide (I₂KI) Solution for Starch Staining: Dissolve 58.1 g of potassium iodide (KI) in about 150 ml of distilled water, then add 14.5 g iodine (I₂) and mix well until completely dissolved. Then complete the final volume to 2 liters with distilled water. Store in a brown bottle or aluminum foil covered bottle.

Golden Delicious at Retail Market: How is the maturity in this box?

Maturity and ripeness stages of Manila mango

Mango Maturity Indices
- Fullness of shoulders
- External color dark to lighter green
- Internal color-white to yellow
- Lenticles and hairs on pit
- Starch content-specific gravity

Group 2* Climacteric Fruits ▼ has significant amount of starch

Fruits that can be harvested and ripened off the plant:
- Apple ▼
- Mango ▼
- Pepper (chili)
- Apricot
- Mangosteen
- Persimmon ▼
- Avocado
- Nectarine
- Plum
- Banana ▼
- Papaya
- Quince ▼
- Cherimoya ▼
- Passion fruit
- Sapodilla ▼ (chico)
- Guava ▼
- Peach
- Sapotes ▼
- Kiwifruit ▼
- Pear ▼
- Tomato

*Except for avocado, banana, mango and pear, these fruits attain best flavor if ripened on the plant. Many of these fruits have large increases in sugar during ripening.

Maturity & Ripening Stages

GREEN The tomato surface is completely green. The shade of green may vary from light to dark.

BREAKERS There is a definite break of color from green to blushed fruit. Tannish-yellow, pink or red or 10% or less of the tomato surface.

TURNING Tannish-yellow, pink or red color shows on over 10% but not more than 30% of the tomato surface.

PINK Pink or red color shows on over 30% but not more than 90% of the tomato surface.

LIGHT RED Pinkish-red or red color shows on over 60% but red color covers not more than 90% of the tomato surface.

RED Red means that more than 90% of the tomato surface, in aggregate, is red.

May 10, 2008
From YK Chan
MAFC, MY
Checker boarding
Should never be a problem with vine ripe tomatoes!

Composition of Ripe Grape Tomato Harvested at 3 Stages of Maturity

<table>
<thead>
<tr>
<th>Initial Maturity Stage</th>
<th>Weight fruit, g</th>
<th>Red color, hue</th>
<th>Firmness, N force</th>
<th>Soluble solids, %</th>
<th>Sugars mg/mL</th>
<th>Titratable acidity, %</th>
<th>Vitamin C mg/100mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4.9</td>
<td>38.8</td>
<td>11.5</td>
<td>5.9</td>
<td>27</td>
<td>0.59</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>5.7</td>
<td>38.3</td>
<td>13.6</td>
<td>6.7</td>
<td>30</td>
<td>0.68</td>
<td>97</td>
</tr>
<tr>
<td>5</td>
<td>5.9</td>
<td>37.7</td>
<td>13.7</td>
<td>7.5</td>
<td>33</td>
<td>0.67</td>
<td>99</td>
</tr>
<tr>
<td>LSD.05</td>
<td>0.6</td>
<td>ns</td>
<td>1.5</td>
<td>0.8</td>
<td>3</td>
<td>0.09</td>
<td>ns</td>
</tr>
</tbody>
</table>

Minimum harvest stage should be Stage 4 (pink-orange)

Average 7 cvs. Cantwell, 2003

Maturity and Fruit Quality
- Know the consequences of harvesting at different stages of maturity/ripeness on final eating quality.
- Make sure workers involved in harvest, selection are well trained to ID correct maturity/ripeness.

On behalf of all consumers, please, please! As a consumer, take back poor eating fruit!
Harvest Maturity for Fruits: A balancing Act

Too often we err on the side of shelf-life at the expense of good eating quality.