Maturation and Maturity Indices

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Postharvest Technology Short Course, June 2009
Chapter 6 Postharvest Technology Book

Quality:
Attributes or characteristics that give a product value as a food

<table>
<thead>
<tr>
<th>Grower</th>
<th>Handler</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good appearance</td>
<td>Good appearance</td>
<td>Good appearance</td>
</tr>
<tr>
<td>High yield</td>
<td>Shelf-life</td>
<td>Firmness</td>
</tr>
<tr>
<td>Resistant to diseases</td>
<td>Firmness</td>
<td>Flavor</td>
</tr>
<tr>
<td>Easy to harvest</td>
<td></td>
<td>Nutritional value</td>
</tr>
<tr>
<td>Resists damage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Harvesting at the correct maturity is key to satisfying quality expectations

Maturity Indices = Harvest Indices
Importance of Maturity Indices

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

Developmental Continuum

Watada et al., 1984
Initiation

Development

Growth

Maturation

Physiological Maturity

Ripening

Senescence

Watada et al., 1984

Terminology

**PHYSIOLOGICAL MATURITY**

The stage of development when a plant part will continue development even if detached; mature fruits

**HORTICULTURAL MATURITY**

The stage of development when a plant part possesses the necessary characteristics for use by consumers
### Physiological Maturity

**FRUITS**
- Immature
- Mature
- Ripening
- Ripe
- Overripe

### Horticultural Maturity

**VEGETABLES**
- Immature
- Mature
- Overmature

#### Maturity Indices

**Bulb Onions**
Composition of Potato Tubers

<table>
<thead>
<tr>
<th></th>
<th>Weight g</th>
<th>dry wt, %</th>
<th>Starch %</th>
<th>Sugar %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flowering</td>
<td>9</td>
<td>16</td>
<td>64</td>
<td>4.8</td>
</tr>
<tr>
<td>Flowering ends</td>
<td>11</td>
<td>17</td>
<td>66</td>
<td>5.2</td>
</tr>
<tr>
<td>Leaves decline</td>
<td>28</td>
<td>19</td>
<td>72</td>
<td>2.9</td>
</tr>
<tr>
<td>80% leaves dead</td>
<td>33</td>
<td>21</td>
<td>73</td>
<td>0.8</td>
</tr>
<tr>
<td>100% leaves dead</td>
<td>51</td>
<td>20</td>
<td>72</td>
<td>0.7</td>
</tr>
</tbody>
</table>

cv. Irish Cobbler; data from Burton, 1966

Maturity Indices

- **Onions/Garlic**
  - Size
  - Drying and collapse of the “neck”
  - Drying of leaf scales

- **Potatoes**
  - Death of the plant
  - Size of tubers
  - Starch content; specific gravity
  - Periderm development
Maturity Indices

- **Asparagus**
  - Size
  - Apex closed

- **Broccoli/Cauliflower**
  - Size
  - Florets closed

- **Carrot**
  - Size

- **Lettuce, head**
  - Size
  - Firmness, solidity
  - Flavor-sweetness, bitterness

- **Lettuce, Romaine**
  - Size
  - Number of leaves
Checking Iceberg Lettuce Maturity

June 2007
Maturity Indices

- **Beans**
  - Size
  - Seed development
- **Summer Squash**
- **Cucumber**
  - Size
  - External color

**Immature fruit vegetables:** very rapidly developing and changing
Harvest Maturity
Maturity Indices

- **Peppers**
  - Size
  - Color
  - Firmness
  - Seed development

- **Tomato**
  - External and Internal color
  - Development of locules (jelly)
  - Firmness
  - Size
  - Development of cuticle

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**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. Bruised 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

http://www.tomato.org/
http://www.floridatomatoes.org/
Mature-green and Breaker Stages

Checkerboarding

Ripe Grape Tomato

<table>
<thead>
<tr>
<th>Initial Maturity Stage</th>
<th>Weight per fruit, g</th>
<th>Soluble solids, %</th>
<th>Titratable acidity, %</th>
<th>Red color, hue</th>
<th>Firmness, N force</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4.9</td>
<td>5.9</td>
<td>0.59</td>
<td>35.8</td>
<td>11.5</td>
</tr>
<tr>
<td>4</td>
<td>5.7</td>
<td>6.7</td>
<td>0.68</td>
<td>36.3</td>
<td>13.6</td>
</tr>
<tr>
<td>5</td>
<td>5.9</td>
<td>7.5</td>
<td>0.67</td>
<td>37.7</td>
<td>13.7</td>
</tr>
<tr>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>ns</td>
<td>**</td>
</tr>
</tbody>
</table>

Average 7 cvs, Cantwell, Test#2 2003
Maturity Indices

- Nonclimacteric fruits
  (or fruits with no starch reserves)
  - Pineapple
  - Strawberry
  - Citrus
  - Cherry
  - Cactus pear
  - Melons

- Climacteric fruits
  (or fruits with starch reserves)
  - Apples
  - Pears
  - Mango
  - Banana
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

López and Cantwell, 1995

![Fresh-cut Cantaloupe melon Changes in Sugar Content](chart.png)
Honeydew and other melons are more difficult to harvest at the proper stage of ripeness.

Held at 70°F (21°C) to complete color change.

**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></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Shipping green</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>8.5</td>
</tr>
<tr>
<td>¼ color</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>13.7</td>
</tr>
<tr>
<td></td>
<td>12.2</td>
</tr>
<tr>
<td>½ color</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>12.7</td>
</tr>
<tr>
<td>Full color</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>12.6</td>
</tr>
</tbody>
</table>

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

### 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*</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

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### Color of Fruit

<table>
<thead>
<tr>
<th>Color Index</th>
<th>Color of Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pale yellow green</td>
</tr>
<tr>
<td>2</td>
<td>Blotchy pink</td>
</tr>
<tr>
<td>3</td>
<td>Pinkish red</td>
</tr>
<tr>
<td>4</td>
<td>Maroon Red</td>
</tr>
<tr>
<td>5</td>
<td>Dark maroon violet</td>
</tr>
<tr>
<td>6</td>
<td>Violet black</td>
</tr>
</tbody>
</table>

Mangosteen and eating

Quality—maturity issues

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

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Violet black
Dark maroon violet
Pale yellow green
Pinkish red
Maroon Red
Blotchy pink
Violet black
Maturity Indices

- **Nonclimacteric fruits or fruits with no starch reserves**
  - Pineapple
  - Strawberry
  - Cherry
  - Cactus pear
  - Melons

- **Climacteric fruits or fruits with starch reserves**
  - Apples
  - Pears
  - Mango
  - Banana

**Mango maturity indices**
- Fullness of shoulders
- Internal and external color
- Lenticels and hairs on pit
- Starch content; specific gravity
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 considers starch, sugar, firmness

Golden Delicious at Retail Market: How is the maturity in this box?
It is necessary to use several maturity Indices

Maturity Indices
Requirements for establishing

- Simple, easy to carry out
- Objective vs subjective indicators
- Related to quality
- Related to storage life
- Represents a progressive change with maturity
- Permits prediction of maturity from year to year
- Inexpensive
Use of Maturity Indices
Limitations

- Soil conditions, nutrition, irrigation
- Season, climate
- Position on the plant
- Pruning, other cultural practices
- Varieties

Predicting Maturity

- Days from planting to harvest
- Progressive changes in size, composition
- Difficult to do; need new tools and methods
  - Nondestructive firmness measurement, fruits
  - Chlorophyll fluorescence, broccoli; green tissues
  - NIR spectroscopy, sugar concentration in melon
  - MR imaging constituents, internal defects
Harvest Maturity for Fruits: A balancing Act

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

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.