Fruit Maturity, Ripening and Quality

• Maturity at harvest very important to determine final fruit quality and storage life
• With few exceptions, fruits reach best eating quality when allowed to ripen on the tree
• Most currently used maturity indices are a compromise between those indices that ensure best eating quality and those that provide needed flexibility in marketing.

Adel Kader
UC Davis

Postharvest Paradox

...Quality is maximized when the product is harvested more mature or ripe, whereas shelf- and storage life are extended if the product is harvested less mature or unripe.


Harvest Maturity for Fruits: A balancing Act

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

<table>
<thead>
<tr>
<th>Stone fruit</th>
<th>Solution is educational</th>
<th>Solution is technological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bananas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pears</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiwifruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mango</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Harvest Maturity and Fruit Quality

Martina Cantwell
Dept. Plant Sciences, UC Davis
mcantwell@ucdavis.edu

Fruit Ripening and Ethylene Management Workshop
Feb 25-26, 2010

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

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

Maturity and Ripeness Stages of Cherries

California strawberries and cherries at NTUC Distribution Center
Singapore, May 16, 2008
Strawberries from Oxnard; Cherries from Lodi

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>

Composition of Ripe Grape Tomato
Harvested at 3 Stages of Maturity

<table>
<thead>
<tr>
<th>Initial Maturity Stage</th>
<th>Weight, g</th>
<th>Red color, N force</th>
<th>Firmness, %</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>36.8</td>
<td>11.5</td>
<td>5.9</td>
<td>27</td>
<td>0.59</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>5.7</td>
<td>36.3</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 0.05</td>
<td>0.6</td>
<td>ns</td>
<td>1.5</td>
<td>0.6</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
Evolution of some physical, chemical and physiological parameters during fruit development and ripening on the tree of 'Golden Globe' Plum.

Watada et al., 1984


Developmental Continuum

Initiation

Development

Growth

Maturation

Physiological Maturity

Ripening

Senescence

Watada et al., 1984

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

Watada et al., 1984


Development & Ripening of Honeydew Melons Harvested at Different Stages

Physiology after harvest

Stage

Ripeness

C_{2}H_{4} ppm

Soluble Solids %

Firmness*

Firmness*

Pounds

0

0.6

9.0

42

9.4

1 ▲

2.4

10.8

38

8.6

2 ▲

4.0

12.4

38

8.5

3

16.3

12.3

25

5.7

cv. Morning Ice

▲ = typical commercial maturity

* Maximum rupture force with 8 mm probe

Cantwell, UC Davis

Honeydew Melons

Fruit Characteristics at 4 Stages of Ripeness

Honeydew and Orange Flesh Melons

Maturity and Ripeness Classes

- Class 0: Immature
- 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

Mr Tay, Hupco Ltd., Importer, Singapore, 15May2008
Papaya (Exotica2), slow ripening cultivar
PH treatment with Ethrel
2 days after treatment,
Differences in maturity accentuated

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

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

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

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/SS²/Starch score)

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
Mangosteen and eating quality—maturity issues

<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>Maroon violet</td>
</tr>
<tr>
<td>6</td>
<td>Violet black</td>
</tr>
</tbody>
</table>

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 and selection are well trained to ID correct maturity/ripeness.
- As consumers, take back fruit with poor eating quality.