Maturation and Maturity Indices
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Outline
- Definitions
- Changes during Maturation-Ripening
- Why do we need a Maturity Index?
- What are the Maturity Indices Requirements?
- One or two maturity indices
- Examples
- How to put it to work?

Stages of Fruit Development

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.

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Stages of Fruit Development

Development

Growth

Maturation

Physiological Maturity

Developmental Continuum

Initiation

Growth

Cucumber

Beans

Sweet corn

Sprouts

Maturation

Apple

Banana

Citrus

Pear

Tomato

Peach

Ripening

Senescence

Death
Stages of Fruit Development

**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 for a particular purpose.
Olive Horticultural Maturity

- Spanish Style Pickled Green Olives
- CA-Style Black-Ripe Olives
- CA-Style Green-Ripe Olives
- Greek-Style
- Olive Oil

Olive Oil-Maturity Index

- Immature Fruit: Deep green, firm, bitter, pungent, high polyphenolics, difficult to extract.
- “Veraison”: Green-Yellow-Red Purple close to maximum olive per dry weight and max polyphenolics.
- Black Olive: carotenoid (high), phenolics and chlorophyll down, sweet oil.
What are the Maturity Indices Requirements?

- Simple, easy to carry out
- Objective vs subjective indicators
- Related to minimum quality
- Related to storage life
- Represents a progressive change with maturity
- Permits prediction of maturity from year to year
- Use of inexpensive tools
- Non-destructive

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

California Minimum Maturity Indices for Selected 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
Strawberries must be picked fully-ripe because they do not continue to ripen after harvest.

Maturity Stages of Strawberries

Maturity Index
Harvest Maturity for Fruits: A balancing Act

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

Never ripens  Poor flavor  No repeat buys
Shrivel  Poor shelf-life  Bruises  Too soft  Decay

Nectarine and Peach Ground Color Guides of the California Tree Fruit Agreement (CTFA)
The Easy Ones

Clingstone Peach Maturity

Hue angle have been demonstrated to be good maturity index of clingstone peach. Peaches with a flesh hue angle below 80 degrees are mature.

Maturity and Ripeness Stages of Apricots

CIE hue angle

Cherry Color Categories

Developed by Michigan State University Agricultural Engineering Department. Manufactured by Colorcade Systems, Inc.

Sweet Cherry Maturity Index

Farrell Hul, Michigan State University E. Lansing, MI 48824 (517) 353-4517
Mechanical Pitter Damage

The Good vs. The Bad and Ugly

Fruit Cheek Firmness (lbf.)

Pitting Damage (%)

Prune (Dry Plum)

Maturation

Harvest Maturity
(20-30d)

3-4 pounds and a minimum 16% SSC
The Difficult Ones

For many products, it is necessary to use several indices to accurately determine maturity.

Full Dark Plums and Full Red Nectarines and Peaches

Market life of ‘Blackamber’ plums harvested on four different dates then stored at 0 or 5°C

<table>
<thead>
<tr>
<th>Harvest date</th>
<th>Firmness</th>
<th>SSC</th>
<th>TA</th>
<th>Maximum market life (weeks at 0°C)</th>
<th>Minimum market life (weeks at 5°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/20/02</td>
<td>7.0</td>
<td>10.3</td>
<td>0.78</td>
<td>2.5</td>
<td>&lt;2.4</td>
</tr>
<tr>
<td>6/26/02</td>
<td>5.1</td>
<td>10.8</td>
<td>0.47</td>
<td>5.3</td>
<td>2.4</td>
</tr>
<tr>
<td>7/2/02</td>
<td>4.8</td>
<td>11.7</td>
<td>0.43</td>
<td>5.3</td>
<td>3.3</td>
</tr>
<tr>
<td>7/8/02</td>
<td>2.8</td>
<td>12.3</td>
<td>0.33</td>
<td>5.3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Market life based on chilling injury (CI) determined when >25% of the fruit became mealy1 or leathery2, or had flesh bleeding/browning3 or gel breakdown/translucency4.

‘Blackamber’ plum quality changes during ripening “on the tree” - 2002 season

Maximum Maturity

Critical Bruising Threshold

Quality

Firmness

Harvest
Hauling
Packingline
Transportation
Retail handling

G’s
Developing Tree Ripe Standards


Proposed harvest maturity/quality indices based on firmness and minimum SSC for different plum cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Firmness (lb)</th>
<th>Minimum SSC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackamber</td>
<td>6-8</td>
<td>10-12</td>
</tr>
<tr>
<td>Fortune</td>
<td>6-8</td>
<td>11</td>
</tr>
<tr>
<td>Friar</td>
<td>6-8</td>
<td>11</td>
</tr>
<tr>
<td>Royal D.</td>
<td>6-8</td>
<td>11</td>
</tr>
<tr>
<td>Angeleno</td>
<td>6-8</td>
<td>12</td>
</tr>
<tr>
<td>Betty Anne</td>
<td>6-8</td>
<td>12</td>
</tr>
</tbody>
</table>

*Blackamber plums with TA ≤0.60% after ripening have a high consumer acceptance. If plums have ≥ 12.0% SSC, TA does not play a role.*

Firmness Measurements

Collecting data and using it

Stage of Almond Fruit Development

[Graph showing stages of almond fruit development with various growth metrics such as length, weight, and stages (March, April, May, June, July, August, Sept.).]
**Maturity Stages**

Almond: Hullsplit

Walnut: Hull Dehiscense

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**Gross morphological and physiological changes associated to almond maturation**

<table>
<thead>
<tr>
<th>Maturity class</th>
<th>Dehiscence</th>
<th>Abscission</th>
<th>Desiccation</th>
<th>Change in kernel weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>no change, increasing</td>
</tr>
<tr>
<td>2</td>
<td>separation starting at suture but no visible shell opening</td>
<td>none</td>
<td>none</td>
<td>no change, increasing</td>
</tr>
<tr>
<td>3</td>
<td>splitting up to 5 mm wide</td>
<td>separation zone developing</td>
<td>none</td>
<td>no change, increasing</td>
</tr>
<tr>
<td>4</td>
<td>hull up to two-thirds open; hull turgid and green</td>
<td>separation zone developing</td>
<td>none</td>
<td>no change, no change</td>
</tr>
<tr>
<td>5</td>
<td>hull open to two-thirds or more</td>
<td>separation zone developing</td>
<td>none</td>
<td>no change, no change</td>
</tr>
<tr>
<td>6</td>
<td>fully dehisced almost separate; attached by occasional fibers</td>
<td>starting up to one third dry</td>
<td>loss in moisture</td>
<td>no change</td>
</tr>
<tr>
<td>7</td>
<td>fully dehisced almost separate; attached by occasional fibers</td>
<td>one- to two-thirds dry</td>
<td>loss in moisture</td>
<td>no change</td>
</tr>
<tr>
<td>8</td>
<td>fully dehisced fibers dry</td>
<td>two-thirds or more dry</td>
<td>lowest in moisture</td>
<td>no change</td>
</tr>
</tbody>
</table>

Source: B.K. Brown, W.C. Wicks; and R. Nilu, Department of Plant Pathology, University of California, Davis.

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Stages of hull split: Deep V, unsplit-beginning of splitting with a deep "V" over at least 50% of the suture line, but the hull cannot be squeezed open at the suture.
Navel Orangeworm (*Amyelois transitella*)

The Art

**Almond Harvesting Factors**
- Kernel Ready
- Hull Abscission
- Avoid Navel Orangeworm Attack
- Peduncle abscission
- Equipment Available
- Procession Capacity
# 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.

**Mango maturity indices**

- Fullness of shoulders
- Internal and external color
- Starch content

Makani, Resendes, Gonzales-Moscoso.
Use of Maturity Indices

Limitations

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

Stages of hull split: (c) Split, less than 3/8 inch (1 cm)-a visible opening of the suture less than 3/8 inch at midsuture.

How to put it to work? - The Art!

*Mean fruit shoulder flesh firmness (lbf.) of 50 'Andross' fruit per sector.

14-16% SSC
Stages of hull split: Deep V, split-a deep "V" in the suture, which is not yet visibly separated, but which can be squeezed open by pressing both ends of the hull.