Fruit Preparation for Consumers

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Stages of Fruit Development

Ripening

• The set of processes that occur from the later stages of growth and development through the early stages of senescence that results in characteristic aesthetic and/or eating quality, as evidenced by changes in biochemical composition, color, texture, or other sensory attributes.

Relative Values

- Red color
- Yellow color
- Aroma
- Flavor
- Sugars
- Soluble pectins
- Polymerized tannins
- Green color
- Acidity
- Starches
- Flesh firmness
- Insoluble pectins
- Unpolymerized tannins

Time
Maturity and Ripening

Group 1: Non Climacteric
Fruits that are not capable of continuing their ripening process once removed from the plant.

<table>
<thead>
<tr>
<th>Fruit Species</th>
<th>Acceptance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature Figs</td>
<td>70</td>
</tr>
<tr>
<td>Ripe Figs</td>
<td>90</td>
</tr>
<tr>
<td>Mature Peaches</td>
<td>80</td>
</tr>
<tr>
<td>Ripe Peaches</td>
<td>85</td>
</tr>
<tr>
<td>Mature Kiwi</td>
<td>75</td>
</tr>
<tr>
<td>Ripe Kiwi</td>
<td>85</td>
</tr>
</tbody>
</table>

Group 1

- Raspberry
- Cherry
- Blueberry
Group 2: Climacteric Fruits: Fruits that can be harvested and ripened off the plant

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Apple</th>
<th>Mango</th>
<th>Persimmon</th>
<th>Apricot</th>
<th>Nectarine</th>
<th>Plum</th>
<th>Avocado</th>
<th>Papaya</th>
<th>Quince</th>
<th>Banana</th>
<th>Passion fruit</th>
<th>Sapodilla</th>
<th>Cherimoya</th>
<th>Peach</th>
<th>Sapote</th>
<th>Guava</th>
<th>Pear</th>
<th>Tomato</th>
<th>Kiwifruit</th>
<th>Pepper (chili)</th>
</tr>
</thead>
</table>

Ripening Conditions for Some Commonly Ripened Fruit

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Exposure time (hours)</th>
<th>Range of ripening temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>8-48</td>
<td>15-20ºC / 59-68ºF</td>
</tr>
<tr>
<td>Banana</td>
<td>24-48</td>
<td>14-18ºC / 58-65ºF</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>6-24</td>
<td>0-25ºC / 32-77ºF</td>
</tr>
<tr>
<td>Mango</td>
<td>24-48</td>
<td>20-25ºC / 68-77ºF</td>
</tr>
<tr>
<td>Pear</td>
<td>24-48</td>
<td>20-25ºC / 68-77ºF</td>
</tr>
<tr>
<td>Tomato</td>
<td>24-72</td>
<td>18-20ºC / 65-68ºF</td>
</tr>
</tbody>
</table>

1 Shorter duration for more mature fruit
2 Faster ripening rate at higher temperatures

How to apply Ethylene?

Ethylene is Required to Induce Banana Ripening

CONTROL

C_{2}H_{4} TREATED

AFTER 7 DAYS AT 20ºC
Note the 5-Fold Increase in Respiration Rate (Carbon dioxide production) as Bananas Ripen from Stage 1 or 2 to Stage 4.

From A. Kader

Carbon dioxide reduces efficacy of ethylene in inducing fruit ripening

Chilling Injury Symptoms

Bronzing of Fingers (dull color)
Discoloration on inner side of peel
Other symptoms: failure to ripen; flesh browning (in severe cases)
Exposing mature-green bananas for:
• 1 hour at 50°F
• 5 hours at 53°F
• 24 hours at 54°F
• 72 hours at 55°F

Ripening Conditions for Bananas
(Sophisticated)

Fruit temperature: 14 to 18°C (58-65°F)
Relative humidity: 90-95%
Ethylene concentration: 100-150ppm
Duration of ethylene: 24-48 hours
Carbon dioxide: Adequate air exchange to prevent CO₂ above 1%

Ripening Facilities

Citrus degreening
Conventional
Forced air

STONE FRUIT RIPENING (Easy)

Mealiness
Lack of Flavor
Flesh Browning
Uneven Ripening

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**Stone Fruit Transport**

- Stone fruit temperature measured upon arrival at the retail warehouse after 3 days truck shipment, 1996

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Nectarine (n=103)</th>
<th>Peach (n=102)</th>
<th>Plum (n=87)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;35</td>
<td>14.7</td>
<td>5.9</td>
<td>4.6</td>
</tr>
<tr>
<td>35-50</td>
<td>69.9</td>
<td><strong>79.4</strong></td>
<td>71.4</td>
</tr>
<tr>
<td>&gt;50</td>
<td>15.7</td>
<td>14.7</td>
<td>24.0</td>
</tr>
</tbody>
</table>
**Peach Delayed Cooling**

- **0°C 20 Days**
  - (43% Mealy)
  - (0% Mealy)

- **5°C 20 Days**
  - (100% Mealy)
  - (0% Mealy)

- **20°C 48 Hours + 0°C 20 Days**


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**Product Flow Through the Preconditioning Process**

- **Arrival**
  - Precooling
    - Hydrocooling
    - Forced air
    - Room Cooling

- **Cold Storage**

- **Move**

- **Holding/Partial Preconditioning**

- **Warm Packing**

- **Forced Air Cooling**

- **Preconditioning**

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**What is degreening?**

The process of exposing “green” citrus fruit with low levels of ethylene to enhance coloration.

- Early season navel oranges
- Re-greened Valencia oranges
- Lemons
- Mandarins
Chlorophylls
Photosynthetic carotenoids

NON-Photosynthetic carotenoids

Thylakoids
Chloroplast

Chromoplast

Degreening
- early season navels
- late season valencias
1 - 5 ppm ethylene
68 - 70 F; 90 - 95% RH
<1% CO₂

Degreening with ethylene induces the conversion of chloroplasts to chromoplast and is dependent on:
- Initial Peel color
- Temperature
- Duration of exposure

From K. Inoue, UCD
Coloration stops when C₂H₄ is stopped

From I. Eaks

Astringency Removal
PCA=Pollination-constant astringent
PVA= Pollination-variable astringent
PCNA= Pollination-constant non-astringent
PVNA= Pollination-variable non-astringent

Fuyu and Hachiya are the two main cultivars in California.

(PCNA) (PCA)
A closer look at astringency

- Astringency in persimmons is caused by water-soluble tannins.
- Tannins are polymers of Pro-Anthocyanidins (PAs) with high molecular weight (~1.38 x 10^4 Da on average in persimmon).
- PAs consist of flavan-3-ol units that are synthesized via the general phylpropanoid pathway (the same pathway that produces flavonols and anthocyanin pigments).

![Chemical structures of (-)-epicatechin and (+)-catechin](image)

Tanaka et al., 1994

Astringency Removal

Astringent Removal

Carbon Dioxide
**Lemon Degreening**

*Desert lemons harvested in August - October*

*Coastal lemons on a more limited basis*

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**Cell wall of flowering plants**

- Cellulose
- Matrix glycans
- Pectins
- Structural proteins
PME & ENDOPG IN CELL WALL METABOLISM

endoPG
Depolymerizes
demethylated pectin

PME
Demethylesterifies
methylated pectin

Decreased intercellular cohesion

Softening

Enzyme Changes During Ripening

COLD STORAGE + RIPENING -> MEALY FRUIT

COLD STORAGE

ethylene
endoPG

Cells clump together
Cells do not break apart easily
Cell walls adsorb water

Decreased intercellular cohesion
Softening

Peach Market Life

Increase in market life of preconditioned peaches during 48h at 68°F compared to untreated (no cooling delay) based on development of chilling injury during storage at 32° or 41°F.

<table>
<thead>
<tr>
<th>Change in delayed cooling treatment</th>
<th>Change in maximum market life at 32°F (weeks)</th>
<th>Change in minimum market life at 41°F (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elegant Lady</td>
<td>0</td>
<td>1 +</td>
</tr>
<tr>
<td>Summer Lady</td>
<td>1 +</td>
<td>2 +</td>
</tr>
<tr>
<td>O’Henry</td>
<td>1 +</td>
<td>1 +</td>
</tr>
<tr>
<td>Zee Lady</td>
<td>0</td>
<td>1 +</td>
</tr>
<tr>
<td>Ryan Sun</td>
<td>2 +</td>
<td>2 +</td>
</tr>
</tbody>
</table>

From K. Inoue, UCD