Susceptibility to low storage temperatures

External Chilling Injury

Internal Chilling Injury

Postharvest Diseases

Body Rot

Stem End Rot

What we know about the avocado fruit

• It is a climacteric fruit showing an increase in respiration and ethylene production during ripening
• Influenced by maturity, time after harvest, temperature and atmosphere

Adapted from Eaks (1978) for ‘Hass’
Field Operations

- Minimum Maturity Standards
  - Dry Weight
- Harvesting Methods
- Bin Holding
- Multiple Harvests per year

California switched to Dry Matter in 80's from oil content

Relationship between dry wet and oil
Also "raised" minimum maturity based on sensory evaluation

Work of Lee et al. (UCR)

Current California Minimum Maturity Standards

<table>
<thead>
<tr>
<th>Variety</th>
<th>Dry Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacon</td>
<td>17.7</td>
</tr>
<tr>
<td>Zulano, Reed</td>
<td>18.7</td>
</tr>
<tr>
<td>Fuerte</td>
<td>19.0</td>
</tr>
<tr>
<td>Hass</td>
<td>20.8</td>
</tr>
<tr>
<td>Pinkerton</td>
<td>21.6</td>
</tr>
<tr>
<td>Lamb Hass</td>
<td>22.8</td>
</tr>
<tr>
<td>Gwen</td>
<td>24.2</td>
</tr>
</tbody>
</table>

Date/Size Maturity Releases

- Industry interest in harvest dates by size and variety
- Model developed to predict the date when dry matter will reach minimum maturity (Ranney et al)
- Date/Size maturity releases allow avocados to move in a uniform manner
- Avocados can still be harvested before the release dates, but they will be tested for minimum maturity standard

Regulated by CA Dept of Food and Ag
'Hass' size and release dates

<table>
<thead>
<tr>
<th>size 40 and larger</th>
<th>size 48</th>
<th>size 60</th>
<th>size 70 and smaller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 28</td>
<td>Dec 12</td>
<td>Jan 2</td>
<td>Jan 16</td>
</tr>
</tbody>
</table>

- Fruit clipped
  - Trees are tall – ladder work and picking poles required
  - Bins moved to receiving area

Bins hold approx. 900 lbs

Considerations in the grove

- Avoid picking when temperatures are high especially with late season fruit
- Avoid picking during or shortly after a rain event – more decay
- Keep fruit in a cool place, out of the sun; high temperatures can impact ripening and increase decay
- Minimize delays from time of harvest to cooling
Packing Operations

- Bins cooled overnight
- Dry dump
- Brushing (waxing)
- Labeling/weight sizing
- Packing
Avocado Storage and Transit

- California fruit marketed within 1 - 2 weeks of harvest; storage at 5°C
- US imports arrivals vary in time after harvest:
  - <5 days (Mexico)
  - 7 - 10 days Dominican Republic
  - 12 - 21 days (Chile)
  - approximately 28 days (New Zealand)
- Fruit from Chile and New Zealand may be shipped in Controlled Atmosphere containers
- Fruit quality has been mixed on longer transit times....
- 1-MCP ?

From US packinghouses often shipped in mixed loads; Imports either in break bulk vessels or CA containers.
Most imported fruit handled by CA packers.
There are problems with fruit arrivals

Relationship between fruit age and unsound fruit

There is a relationship between fruit age and unsound fruit. The equation for this relationship is:

\[ y = 0 + 0.02762 \times \text{exp}(\text{days}/5.203) \]

\[ r^2 = 0.82, n=56, p<0.001 \]

"RIPE FOR TONIGHT"

•Increasing importance for both domestic and imported fruit
•Ethylene treatment can occur at packinghouse, distribution points or specialty handlers
Why Ripen Avocados?

- Increase Uniformity
- Decrease Checkerboarding

Untreated, fruit ripening may range from a few days to even weeks within a carton.

Ripening Management

- Uniform heating and cooling is ABSOLUTELY ESSENTIAL
- Refrigeration needs to control the heat (6000 BTU/pallet)
- Forced air ripening is critical (1000 cfm/pallet)
- Venting (preferably flow through, keep CO₂ below 1%)
- Source of Ethylene - as low as possible; physiologically you only need ~10 ppm)
- Fruit needs to be easily accessible in ripening room for monitoring; especially if fruit is of varying arrival condition or multiple lots of fruit
- Keep good records

Ripening Management

When do you turn off the gas?

- You don’t need the gas until ripe; a short duration treatment will “trigger” ripening
- Fruit may soften but may not color – maturity and other factors involved
- The best way to gauge the rate of softening is with a penetrometer...not your fingertips or buttons “popping”
- Fruit maturity is an important variable

The penetrometer is a tool to judge the relative stage of ripeness
Ethylene dose considerations

- Ethylene concentration
  - >20 ppm; no more than 100 ppm
- Fruit Maturity
  - Less mature; longer treatment
- Time after Harvest
  - With increasing time after harvest; shorter durations needed

How much to apply?

- Short exposures to ethylene can trigger ripening
- Threshold is believed to be around 10 ppm
- Commercial application of 20 - 100 ppm is recommended

Time after harvest

- Ethylene has maximum benefit within 1-2 weeks of harvest
- Imported fruit (i.e. Chile) if conventional shipment will need less time (24 hours or less)
- Imported fruit if CA shipped or 1-MCP treated may need longer treatment times

Source: I. L. Eaks, UC, Riverside
Note the affect of **maturity, storage (3 wks @ 41F)** and **ethylene (50ppm)** on the amount of days to ripe to <1.5 lbf at 68F as well as the variability of the data (checkerboarding)

<table>
<thead>
<tr>
<th>Harvest Date/Storage/Ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 27</td>
</tr>
<tr>
<td>Mar 7</td>
</tr>
<tr>
<td>Apr 18</td>
</tr>
<tr>
<td>Jun 1</td>
</tr>
<tr>
<td>Jul 11</td>
</tr>
<tr>
<td>Aug 24</td>
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</tbody>
</table>

Suggested treatment times for California ‘Hass’ avocados

- **Early season fruit (November – February)** 36 – 72 hours
- **Mid-season fruit (March – June)** 24 – 36 hours
- **Late season fruit (July – October)** 8 - 24 hours

**Management Issues**

- **Temperature**
- **Ventilation/Air exchanges**
  - Careful Monitoring
  - Prompt Movement of fruit
  - What is the proper stage of ripeness?
  - Where do you ripen the fruit?
High Temperature Effects on 'Hass' Fruit Respiration and Ethylene Production (Eaks, 1978)

![Graph showing the relationship between temperature and respiratory rate and ethylene production.]

**Peak respiratory rate and ethylene production. Fruit held continuously at temperature.**

**Temperature Management**

- Efficient warming/cooling of fruit essential
- Airflow essential to maintain proper pulp temperature (68F)

Impact of high temperatures
- Delayed/uneven ripening
- Increased decay

**Ventilation**

- Buildup of carbon dioxide (inhibits ethylene action)
- Airflow essential to maintain proper pulp temperature (68F)

Preliminary data suggests that short durations of high carbon dioxide (up to 3-5%) can be tolerated but need to remember OSHA requirements.
The outcome of “ripe” fruit

Ripe fruit at retail level has greatly increased consumption, HOWEVER…..

• Greater challenge in temperature management
• Fruit sensitivity to damage greatly enhanced
• A problem NO MATTER the source – an opportunity to work with other industries

Example of fruit shriveling
Example of an overripe fruit with stem end rot, body rot and internal rot
Example of a stem end rot
Example of body rots

A. Fruit with no bruising under the peel.
B. Fruit which is very overripe and is exhibiting bruising under the peel.
C. Very ripe fruit compressed by other fruit on display.
B. Example of internal bruising.
C. Very ripe fruit showing severe internal damage.
Considerations for successful avocado ripening

• Temperature management is CRITICAL – Too high; ripening inhibited and increased decay – Too low; ripening is slowed and lose benefit
• Fruit Maturity – More mature; less time
• Time after Harvest – After storage; less time
• Avoids delays in marketing – Minimize fruit handling

Checklist

Quality; don't use stressed fruit
Standardize fruit size and maturity
Uniform warming and cooling
Careful monitoring; don’t overripen

Limitations to avocado postharvest handling

• Fruit maturity and quality at time of ripeness
• Time after harvest (fruit age)
• Stage of ripeness – more difficult to handle “ripe” fruit

Additional information

• California Avocado Commission
  www.avocado.org
• Hass Avocado Board
  avocadocentral.com
• Information on avocados in general from around the world
  www.avocadosource.com