Avocado Postharvest Handling

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Persea americana Mill.

Family: Lauraceae
3 horticultural races
- Mexican
- Guatemalan
- West Indian (Antillean)
Avocado

- Most leading avocado producing countries produce Guat/Mx race avocados
- More tropical areas produce West Indian Race avocados
- Leading cultivar worldwide: HASS

California Avocado Cultivars

- Bacon
- Fuerte
- Gwen
- Hass
- Lamb Hass
- Pinkerton
- Reed
- Zutano
Hass Seasonality

<table>
<thead>
<tr>
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<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
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<tbody>
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<td>California</td>
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Susceptibility to low storage temperatures

- External Chilling Injury
- Internal Chilling Injury
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)
Date/Size Maturity Releases
- 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.

<table>
<thead>
<tr>
<th>Dry Matter (%)</th>
<th>Variety</th>
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<tr>
<td>17.7</td>
<td>Bacon</td>
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<tr>
<td>18.7</td>
<td>Zutano, Reed</td>
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<tr>
<td>19.0</td>
<td>Fuerte</td>
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<tr>
<td>20.8</td>
<td>Hass</td>
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<tr>
<td>21.6</td>
<td>Pinkerton</td>
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<tr>
<td>22.8</td>
<td>Lamb Hass, GEM, Harvest</td>
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<tr>
<td>24.2</td>
<td>Gwen</td>
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</tbody>
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Dry matter determination in California
- 5-fruit bulk sample
- Core sample from middle of fruit
- Microwave drying to constant weight
- NIR for the future????
### 'Hass' size and release dates

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

The link between the preharvest environment and fruit quality

Quality does NOT improve after harvest

Increasing body of evidence that many factors influence PH fruit quality and decay development

- Mineral nutrition, most notably N, Ca
- Rootstock via mineral distribution
- Canopy management strategies
- Plant growth regulators such as Sunny and Cultar
- Weather conditions just prior to harvest
- Fruit position on the tree

All contribute to fruit quality; interact with each other
Important to understand interaction with fruit maturity
Packing Operations

• Bins cooled overnight
• Dry dump
• Brushing (waxing)
• Labeling/weight sizing
• Packing
Tray Pack

Volume Fill

Bagging

RPC

Shrink Wrapped

...and all combinations
Box weights calibrated and final quality inspection

Palletization

From US packinghouses often shipped in mixed loads; Imports either in break bulk vessels or CA containers

Physical damage and chilling

Damage is cumulative; worse if turgid or wet fruit are harvested

Lenticel damage

External chilling

Source: Hofman, Cutting, Dixon, Pak
Physical damage and chilling

Source: Hofman, Cutting, Dixon, Pak
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 - 28 days (Peru/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 ?

Can you successfully cold-treat avocado?

The fruit will respond positively to intermediate low temperature conditioning.

Work published by Hofman et al (2003) PBT and Woolf et al (2003) PBT demonstrated that following several days at 6-8°C will provide protection against peel damage during subsequent low temperature storage.

Success of conditioning is dependent on temperature (don’t want softening) and duration.

Temperature Range: 5-10°C
Duration: 3-5 days
Challenges in avocado postharvest handling

- Fruit maturity
- Fruit age - time to ship
- Cooling
- Ethylene exclusion
- Controlled Atmosphere
- 1-MCP
- Stage of ripeness when presented to the end user

Ethylene - hastens deterioration

- Ethylene contamination
  - Softening
  - Physiological disorders
- Use of CA
  - High CO₂ counteracts ethylene
  - Slows softening
- Use of 1-MCP
  - Can slow softening
  - Development of disorders
  - Risks – overdose fruit; ripening
There are problems with fruit arrivals

Relationship between fruit age and unsound fruit

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

\[ r^2 = 0.82, n = 50, p < 0.001 \]

Dixon, Pak and Cutting
"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
Why will avocados respond to ethylene?

- 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'

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

Source: I. L. Eaks, UC, Riverside
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

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”

_The penetrometer is a tool to judge the relative stage of ripeness_
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

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
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).

### 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
**California ‘Hass’ Avocado**

**Relationship between dry matter and final peel color**

Final Peel Color = 3.06261 - 0.00264DW + 0.0020DW²

where DW = Dry weight

R² = 0.621 ***

**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)

Temperature Management

- Efficient warming/cooling of fruit essential
- Airflow essential to maintain proper pulp temperature (20C, 68F) and CO₂ < 1%

Impact of high temperatures
- Delayed/uneven ripening
- Increased decay
Ripening temperature influences final peel color


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
Postripening Management

- **Temperature** and softening rate
- Know your customer
- Chilling injury susceptibility
- Move fruit as quickly as possible to end user
- Periodically visit your end user to assess fruit quality and how you are doing

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 rotting.

Example of a stem end rot

Example of body rots

A. Very ripe fruit compressed by other fruit on display.
B. Example of internal bruising.
C. Very ripe fruit showing severe internal damage.

A. Fruit with no bruising under the peel.
B. Fruit which is very overripe and is exhibiting bruising under the peel.
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

**CONSUMER/MARKET Education**

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**
Trends for the future

• 1-MCP
  – Prestorage/preshipment
  – Post-ethylene to slow ripening
• Alternative packaging for conditioned fruit
  – Protecting the fruit during transportation
  – Protecting the fruit from the consumer
• Ripening closer to end user
• Alternative storage methodologies and understanding O₂ and CO₂ requirements

• Gene sequencing of avocado will open new doors for research

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