The Principles of Citrus Postharvest Handling

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Overview

• Citrus Postharvest Biology, Pathology and Disease Management
• CA Postharvest Handling Procedures
  - Oranges/Grapefruit
  - Lemons
  - Mandarins

Challenges for the Citrus Handler

• Causes of peel damage poorly understood
• Damage due to low temperature, high temperature, methyl bromide fumigation etc. are often similar
• Interaction of physical damage with other postharvest treatments often difficult to ascertain
• Preharvest environment plays a difficult to quantify but important role

Postharvest Biology, Plant Pathology and Disease Management

Citrus

• Non-climacteric
• Chilling sensitive

Respiratory response of lemons to ethylene at different temperatures

Respiratory response of lemons to ethylene - response typical of nonclimacteric fruit
Storage Temperature Requirements

- Varies with citrus type and variety
- Ranges from approximately 0°C to 15°C

<table>
<thead>
<tr>
<th>Most Cold Tolerant</th>
<th>Least Cold Tolerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kumquats</td>
<td>Oranges</td>
</tr>
<tr>
<td>Mandarin</td>
<td>Limes, Citrons</td>
</tr>
<tr>
<td></td>
<td>Lemons, Grapefruit</td>
</tr>
</tbody>
</table>

Low temperature damage

Membrane Staining in lemons

Peteca

Lemon Disorder
- Develops after harvest
- Curing of lemons allows detection
- Cause unknown

Initiation of Postharvest Citrus Diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Infection Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem-end Rot</td>
<td>Diplodia</td>
<td>Flower, young fruit</td>
</tr>
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<td>Stem-end Rot</td>
<td>Phomopsis</td>
<td>Flower, young fruit</td>
</tr>
<tr>
<td>Stem-end Rot; black rot</td>
<td>Alternaria</td>
<td>Flower, young fruit, navel</td>
</tr>
<tr>
<td>Brown Rot</td>
<td>Phytophthora</td>
<td>Fruit surface</td>
</tr>
<tr>
<td>Botrytis Rot</td>
<td>Botrytis</td>
<td>Flower, young fruit</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Colletotrichum</td>
<td>Fruit surface</td>
</tr>
</tbody>
</table>

Diplodia Stem End Rot

Phomopsis Stem End Rot

Botrytis

Phytophthora Fruit Rot or “Brown Rot”

Anthracnose (tear staining)
**Alternaria**

Lemons occurs in storage controlled by prestorage application of 2,4-D to control "button" abscission

Navel Oranges 
occurs primarily on navel end more severe in "freeze" years

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**Initiation of Postharvest Citrus Diseases**

**Postharvest Infection**

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<tr>
<th>Disease</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Green Mold</td>
<td>Penicillium digitatum</td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Blue Mold</td>
<td>Penicillium italicum</td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Sour Rot</td>
<td>Geotrichum candidum</td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Trichoderma</td>
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</tbody>
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**Caused by wounding during harvesting and handling**

**Sporulation - direct loss and necessitates repacking**

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**Caused by fruit wounds**

Spreads from fruit to fruit

May be a problem in long-term lemon storage

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**Packinghouse practices and treatments reduce decay by:**

- Destroying inoculum on fruit surface
- Inhibiting development of latent infections
- Preventing infection by wound-invading pathogens
- Protecting fruit surface from subsequent infection through wounding
- Inhibiting sporulation and spread from diseased to healthy fruit
Cold Storage and Packinghouse Cleaning Schedule

Fruit dump should be well ventilated and use sanitizer at point of dump

Discard decayed fruit downwind from packing house to minimize contamination

Minimize fruit drops and other points of fruit handling that can cause damage

Maintain tank mixtures/fungicide applicators at optimal conditions

Ambient spore sampling
Important for detection of resistant strains of Penicillium
Care should be taken in the field during harvest to minimize damage to fruit since the consequences of mechanical injury are: increased decay, enhanced water loss, peel breakdown in subsequent handling.

**Impact of Handling Injuries on Postharvest Fruit Quality**

Damage can occur at any time and is cumulative.

Rind oil spotting of desert lemons related to fruit turgor pressure at harvest; more turgid, more damage.
Lemons picked at different times of day then subjected to heat treatment

Note peel damage with early morning harvest

Obenland and Neipp, HortScience, 2005

Ethylene Degreening

- Early season navel oranges
- Re-greened valencia oranges
- Lemons
- Mandarins

- Ethylene: 1-5 ppm
- Temperature: 20 C in CA, 25 C in FL
- Humidity: 90-95%
- Ventilation: 1 air exchange/hour
- Carbon Dioxide: reports varies, <1%

Degreening depends on:
- Peel color
- Temperature
- Preharvest conditions such as GA

Assessing Minimum Maturity

For all citrus (except lemon) maturity standard based on Sugar to Acid Ratio

Orange Harvesting

- 40 to 60 lb picking bag
- Gloves to prevent damage
- Fruit Clipped
- Bulk ~1000 lb bin
- No fruit from ground
- Sanitary Facilities provided
- Fruit transported to PH on day of harvest
Care is taken in the field during harvest to minimize damage to fruit since the consequences of mechanical injury are:
- increased decay
- enhanced water loss
- may result in peel breakdown in handling

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

100 - 200 ppm chlorine spray

Source: J. Smilanick
Cull Fruit for Land Fill or Feed
Flume system for rot removal

Tank Treatments
- optional
- solutions vary

Optional heating
Fruit submersion

High Pressure Washer
California Red Scale
Controlled in field by
- biological control
- chemical control
High Pressure Washer augments field control measures and has allowed for increasing of field “economic threshold”

Scale Removal
Pre Wash
Post Wash
HPW Damage

High Pressure Washer
- 80 - 300 psi depending on level of scale infestation over brush bed
- Water Chlorinated (200 ppm) - may add sodium bicarbonate
- Re-circulating water system; water filtered to remove particulate matter
- Water replenished continuously: completely replaced every 24 hours
- Followed by water rinse (chlorinated)
**Electronic Sorting**

Many orange houses use some sort of electronic grading; trend is increasing.

Useful for sorting fruit by defect, color, weight, freeze damage.

Used in conjunction with manual grading.

Fruit separated electronically as First, Choice, Processed Products.

Reduces manual handling of fruit and potential for damage to fruit.

**Fruit Waxing**

- Replacement of natural wax
- Reduce Water Loss
- Carry Fungicide
- Cosmetic

**Dryer**

Duration: 3 to 5 minutes

90 to 140 F

**Grading for Rots and Processed Products**

Electronically graded fruit that is “too green” or “Processed Products Grade” diverted to bins.

**Fruit Waxing**

pH 8-9

Based on Shellac, Carnuaba or Wood-Rosin or Combination
Post-wax Operations

Final grading for First, Choice, Processed Products and Culls

Electronic Sizing
Stickering of First Grade
Sent to Bulk Accumulation Bins

Box Sealer and Conveyor

Palletization

Short-term Storage

Loading Area isolated from rest of Pack House

Other Packing Options

Bulk bin for Choice Poly or Net Bags

Orange Shipment to Market
A substantial proportion of CA citrus (lemons and oranges) is exported; primarily to Pacific Rim countries

Oranges

• Storage: 3 – 8 C (37 – 46F)

• Storage Duration: up to 3 months under ideal conditions
**Grapefruit**
- Handled similarly to oranges except NO degreening
- Clipped; single harvest
- Maturity: Color (>2/3 fruit surface showing yellow) and SSC/TA ratio of 5.5 or 6 (depending on production area)
- Storage: 6-8 weeks at 12 - 14 C (54 - 57F)

**Mandarins/Clementines**
- More easily damaged than oranges; requires “soft handling”
- Clipped; may size pick
- Maturity: Color (yellow, orange, and/or red) on 75% of fruit surface and SS/TA 6.5 or higher
- Storage: 3-6 weeks at 5 - 8 C (41 - 46 F)

**Puffines**

**Olleocelosis**

**SOPP Damage**

**Peel Damage – Various Causes**
Lemons

- A minimum juice content by volume of 28 or 30% depending on grade
- Clipped
- Multiple harvests based on color and size
- May be stored prior to packing up to 150 days at 10 - 13°C (50 - 56°F)
- After packing and colored may be shipped and stored at 3 - 5°C (37 - 41°F)

Source: J. Smilanick

Additional information

Ultimate Citrus Page
www.ultimatecitrus.com

California Citrus Research Board
www.citrusresearch.org