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
Citrus

• Non-climacteric
• Chilling sensitive

Respiratory response of lemons to ethylene at different temperatures
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>Limes, Citrons</td>
</tr>
<tr>
<td>Mandarins</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

**Preharvest Infection**

<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>

### Anthracnose (tear staining)

### Botrytis

### Phytophthora Fruit Rot or "Brown Rot"

### Diplodia Stem End Rot
**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>
<td>Green Mold</td>
<td><em>Penicillium digitatum</em></td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Blue Mold</td>
<td><em>Penicillium italicum</em></td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Sour Rot</td>
<td><em>Geotrichum</em></td>
<td>Fruit injuries</td>
</tr>
<tr>
<td>Trichoderma</td>
<td><em>Trichoderma</em></td>
<td>Fruit injuries</td>
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</tbody>
</table>

Caused by wounding during harvesting and handling
Sporulation - direct loss and necessitates repacking
<table>
<thead>
<tr>
<th>Packinghouse practices and treatments reduce decay by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destroying inoculum on fruit surface</td>
</tr>
<tr>
<td>Inhibiting development of latent infections</td>
</tr>
<tr>
<td>Preventing infection by wound-invading pathogens</td>
</tr>
<tr>
<td>Protecting fruit surface from subsequent infection</td>
</tr>
<tr>
<td>through wounding</td>
</tr>
<tr>
<td>Inhibiting sporulation and spread from diseased to</td>
</tr>
<tr>
<td>healthy fruit</td>
</tr>
</tbody>
</table>
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.
Maintain tank mixtures/fungicide applicators at optimal conditions.

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

Ambient spore sampling.
Examples of Grade Defects

Defects from the field that would be sent to processed products:

- Puff and Crease
- Sunburn
- Split navel
- Uneven coloring
- Surface abrasions
- Scarring due to insects, wind, limb rub
- Fruit Shape
Freeze Damage
ice marking or internal damage

Postharvest Handling Practices

Fruit Handling and Quality
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

“The most common type of injury was made by ... the clippers ... many were injured by stem punctures, while others showed scratches from thorns. Other common ... injury ... were from gravel and twigs in the bottom of boxes and cuts by the finger nails of the pickers.”

Powell, 1908 Riverside, California
Dye injury test  Lah 1961 Proc. ASHS 78:190-196

Significant injuries per lemon

Damage can occur at any time and is cumulative

- Picker’s bag
- Field box in grove
- Field box in house
- Wash tank
- Storage box

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

Obenland and Neipp, HortScience, 2005

Note peel damage with early morning harvest
The importance of peel turgidity on peel damage.

Susceptibility to Hot Water Treatment

<table>
<thead>
<tr>
<th>Hot water timing</th>
<th>Immediately after harvest</th>
<th>After 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low humidity</td>
<td>High humidity</td>
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</table>

24 hours after treatment

30 minutes after treatment Peel Flourescence

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
Button discoloration following degreening

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
Pressure Washer

Imazalil
Thiabendazole
SOPP
BioSave

Fungicides

Soak tank
1 to 4 min residence

Dryer

Pressurizing
Grading, sorting
Situating soak tank

Dryer

Water rinse

Labeling and stringing

Box or carton packing

Source: J. Smilanick

Imazalil
Thiabendazole
SOPP
BioSave

Exhaust Fan

bin Dump

Trash Eliminator

100 - 200 ppm chlorine spray

Pregrading for processed products and cull removal
Tank Treatments

- Options for tank mixtures
  - Sodium Carbonate (3%) @ ~105 F, pH 10.5
  - Sodium Bicarbonate (3%) w/ chlorine (200 ppm) @ 68 - 80F, pH 8.0
  - Borax/Boric Acid (4%/2%) @ 105 F, pH 10 - 11
  - Lime Sulfur (3%) @ 105 F, pH 10 (registered in 1998)

- Avg. duration 1.5 - 2 minutes (4 min. max.)
- Generally heated at night to ~140F, changed ~ 2 wks,
- ~30% orange houses; <20% grapefruit houses
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

High Pressure Washer Damage

Pre Wash

Post Wash
High Pressure Washer

- 80 - 300 psi depending on level of scale infestation over brush bed
- Water Chlorinated (200 ppm)
- Trend towards adding sodium bicarbonate in wash water
- Re-circulating water system; water filtered to remove particulate matter
- Water replenished continuously, completely replaced every 24 hours
- Followed by water rinse (chlorinated)

Grading area to remove rats

Water Elimination

Grading for Rots and Processed Products
Electronic Sorting
- 25% of 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

Electronically graded fruit that is "too green" or "Processed Products Grade" diverted to bins

Fruit Waxing
- Replacement of natural wax
- Reduce Water Loss
- Carry Fungicide
- Cosmetic
**Fruit Waxing**

pH 8-9
Based on Shellac, Carnuaba or Wood-Rosin or Combination

**Dryer**
Duration: 3 to 5 minutes
90 to 140°F

**Post-wax Operations**

Final grading for First, Choice, Processed Products and Culls
Electronic Sizing
Stickering of First Grade
Sent to Bulk Accumulation Bins

**Pattern Packing**

Packing by Hand
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

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 - 46°F)
- 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 to 8 weeks at 12 - 14 °C (54 - 57°F)

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)
**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)
The influence of postharvest 2,4-D on button condition

Harvesting care is important. Damaged buttons are more prone to develop Alternaria.

The influence of button condition and % incidence of Alternaria Stem End Rot

Dump after storage:

Source: J. Smilanick
How preharvest factors may influence fruit quality

- Development and maturation
- Physical effects on quality and packout
- Susceptibility to physiological and pathological breakdown

Additional information

Ultimate Citrus Page
www.ultimatecitrus.com

California Citrus Research Board
www.citrusresearch.org
Peteca, Maturity and Rainfall

Undurraga M., Olaeta C., Retamales A., Brito P., 2006

Rootstock/Scion Effects:

- Production
  - number of fruit
  - fruit size
- Fruit composition
  - SSC, TA
  - Rind thickness
  - Rind Oil content
- Postharvest Disorders
  - Rindstain

The influence of rootstock on juice content (M. Roose)
Irrigation

- Frequency and amount may influence fruit number and size
- Good irrigation practices especially important during bloom and Stage 1 growth
- May play a role in navel end splitting
- May influence SSC and juice content
- Fruit turgidity (internal water pressure) is important in oleocellosis

Rind oil spotting of desert lemons

Related to fruit turgor pressure at harvest - more turgid: more damage
Plant Nutrition

- Nitrogen (N) fertilization (rate and timing) likely has the greatest impact on citrus quality
- Adequate P and K are required for high fruit quality particularly the rind

High Nitrogen

- Delayed coloring
- Thicker rind
- Coarser rind
- Increased staining of navel orange
- Increased valencia re-greening

Potassium can influence peel thickness and juice content

Embuelton and Jones, HortScience, 1966
Effects of phosphorus on valencia orange fruit quality
Aguatibia ranch, 1962

Leaf analysis

> 0.18%  0.13 - 0.14%  0.11 - 0.12%

Effects of nitrogen and phosphorus on navel orange fruit quality
Embelton and Jones, 1956 - Yr 6 of 10 yr study