The Principles of Citrus Postharvest Handling

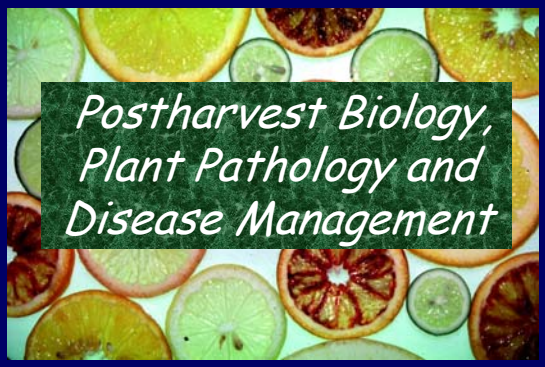
Mary Lu Arpaia
Dept. of Botany and Plant Sciences
UC RIVERSIDE University of California | College of Natural & Agricultural Sciences

Overview

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

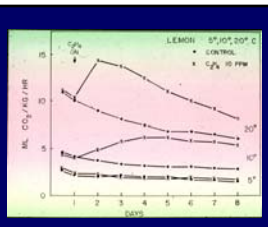
Challenges for the Citrus Handler

- 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



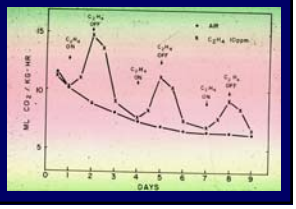
Citrus

- Non-climacteric
- Chilling sensitive



Respiratory response of lemons to ethylene at different temperatures

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

Most Cold Tolerant → *Least Cold Tolerant*

Kumquats *Mandarins* *Oranges* *Lemons, Grapefruit* *Limes, Citrons*

Low temperature damage

Membrane Staining in lemons

External Symptoms

Internal Symptoms

Peteca

Lemon Disorder

Develops after harvest

Curing of lemons allows detection

Cause unknown

Initiation of Postharvest Citrus Diseases
Preharvest Infection

Disease	*Pathogen*	*Infection Site*
Stem-end Rot	*Diplodia*	Flower, young fruit
Stem-end Rot	*Phomopsis*	Flower, young fruit
Stem-end Rot; black rot	*Alternaria*	Flower, young fruit, navel
Brown Rot	*Phytophthora*	Fruit surface
Botrytis Rot	*Botrytis*	Flower, young fruit
Anthracnose	*Colletotrichum*	Fruit surface

Anthracnose (tear staining)

Botrytis

Phytophthora Fruit Rot or "Brown Rot"

Phomopsis Stem End 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

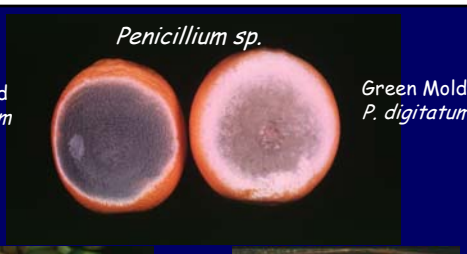
more severe in "freeze" years

Initiation of Postharvest Citrus Diseases
Postharvest Infection

Disease	*Pathogen*	*Infection Site*
Green Mold	*Penicillium digitatum*	Fruit injuries
Blue Mold	*Penicillium italicum*	Fruit injuries
Sour Rot	*Geotrichum*	Fruit injuries
Trichoderma	*Trichoderma*	Fruit injuries

Penicillium sp.

Blue Mold
P. italicum



Green Mold
P. digitatum

Caused by wounding during harvesting and handling

Sporulation - direct loss and necessitates repacking

Sour rot
Geotrichum candidum

Caused by fruit wounds

Spreads from fruit to fruit

May be a problem in long-term lemon storage

Trichoderma sp.

Trichoderma rot

Caused by fruit wounds

May be a problem in long-term lemon storage

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

Cold storage and Packinghouse Cleaning Schedule

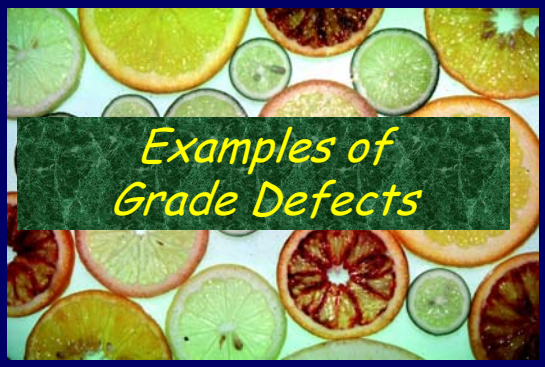
Fruit dump should be well ventilated and use sanitizer at point of dump

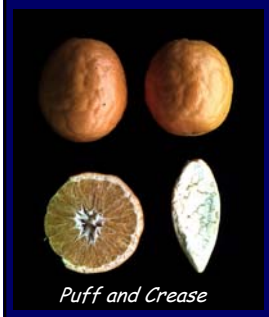
Discard decayed fruit downwind from packing house to minimize contamination

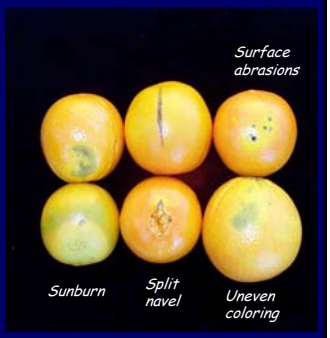
Maintain tank mixtures/fungicidie applicators at optimal conditions

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

Ambient spore sampling

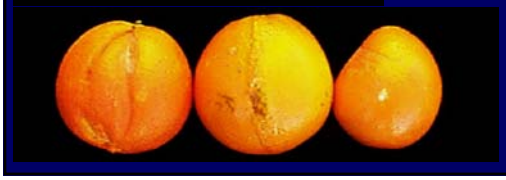






Defects from the field that would be sent to processed products

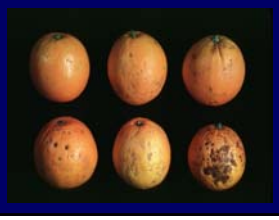
Scarring due to insects, wind, limb rub

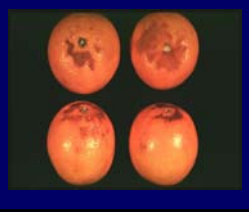


Fruit Shape

Freeze Damage
ice marking or internal damage

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

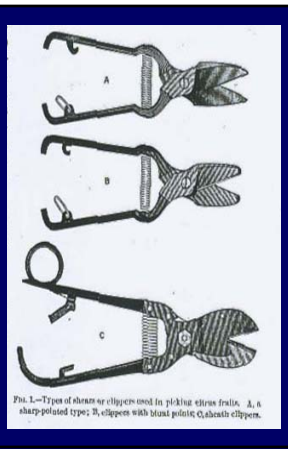
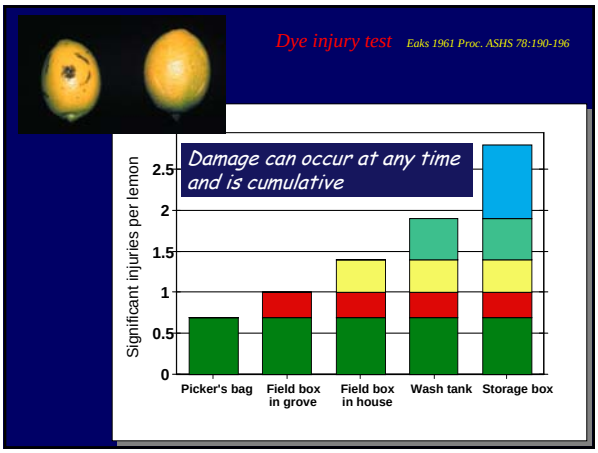
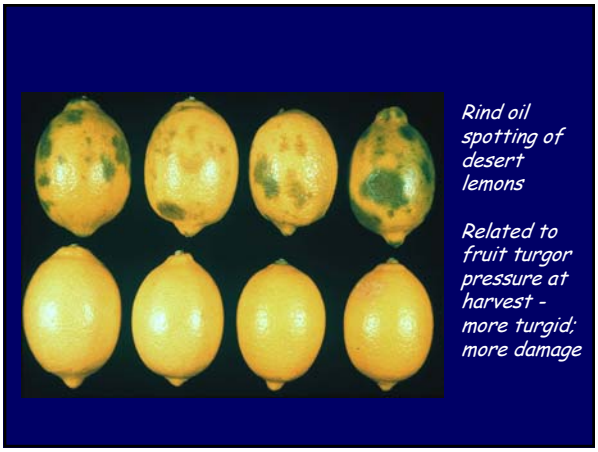


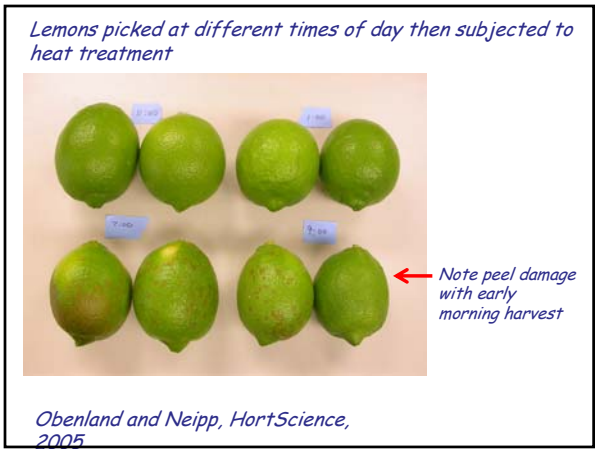
FIG. 1.—Types of shears or clippers used in picking citrus fruits. A, a sharp-pointed type; B, clippers with blunt points; C, sheath clippers.

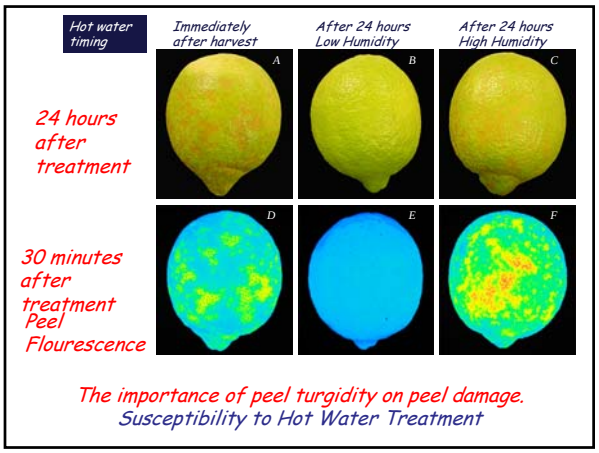
"The most common type of injury was made by … the clippers … many were injured by stem punctures, while others showed scratches from thorns. Other common … injury… were from gravel and twigs in the bottom of boxes and cuts by the finger nails of the pickers."

Powell, 1908 Riverside, California


Dye injury test
Eaks 1961 Proc. ASHS 78:190-196
Damage can occur at any time and is cumulative
Significant injuries per lemon
2.5
2
1.5
1
0.5
0
Picker's bag
Field box in grove
Field box in house
Wash tank
Storage box


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

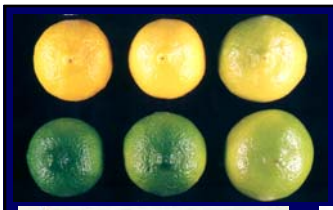


The importance of peel turgidity on peel damage. Susceptibility to Hot Water Treatment

Ethylene Degreening

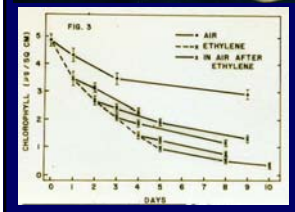
- Early season navel oranges
- Re-greened valencia oranges
- Lemons
- Mandarins

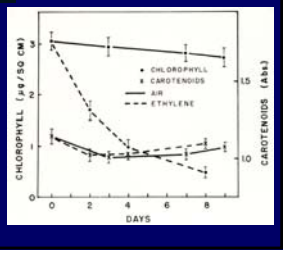
- Ethylene: 1-5 ppm
- Temperature: 20 C in CA; 25 C in FL
- Humidity: 90-95%
- Ventilation: 1 air exchange/hour
- Carbon Dioxide: reports varies, <1%

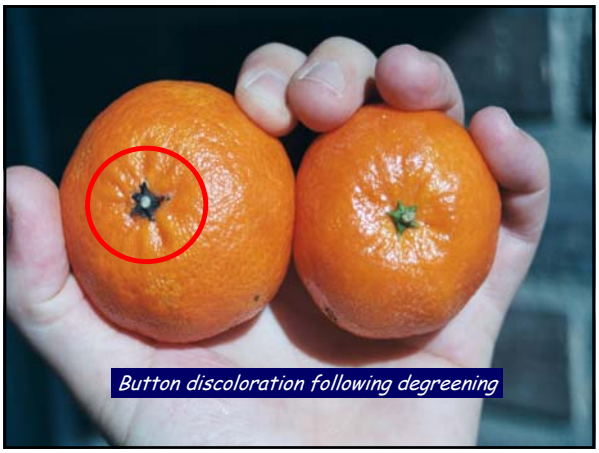


Degreening depends on:

- *Peel color*
- *Temperature*
- *Preharvest conditions such as GA*







Button discoloration following degreening

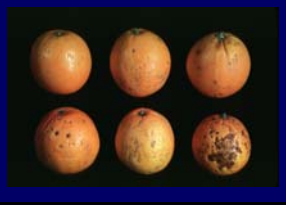
Assessing Minimum Maturity

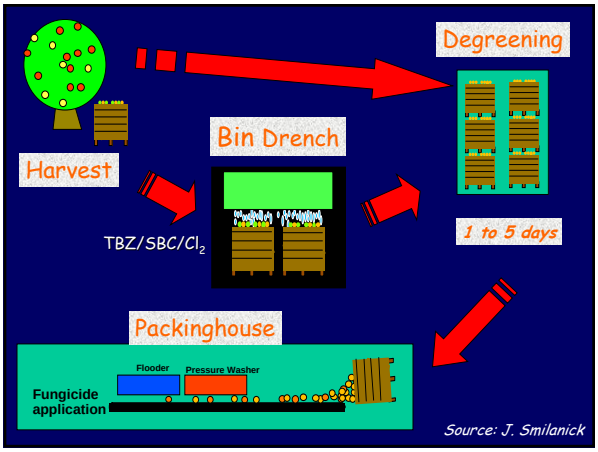
For all citrus (except lemon) maturity standard based on Sugar to Acid Ratio

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

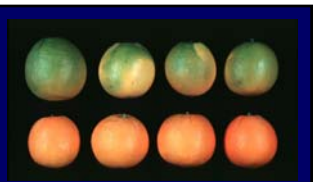
Care is taken in the field during harvest to minimize damage to fruit since the consequences of mechanical injury are:
increased decay
enhanced water loss
may result in peel breakdown in handling

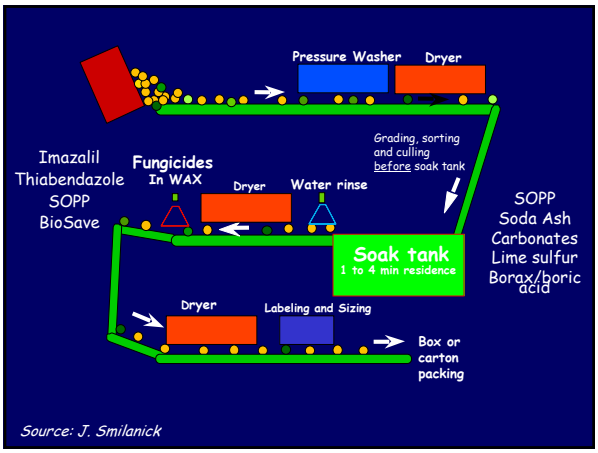


Degreening
-early season navels
-late season valencias

1 - 5 ppm ethylene
68 - 70 F; 90 - 95% RH
<1% CO_2




Pressure Washer
Dryer
Grading, sorting and culling before soak tank
Imazalil
Thiabendazole
SOPP
BioSave
Fungicides In WAX
Dryer
Water rinse
SOPP
Soda Ash
Carbonates
Lime sulfur
Borax/boric acid
Soak tank
1 to 4 min residence
Dryer
Labeling and Sizing
Box or carton packing
Source: J. Smilanick


Exhaust Fan
Bin Dump
Trash Eliminator
100 - 200 ppm chlorine spray


Pregrading for Processed Products and Cull Removal

Fruit for Processed Products

Cull Fruit for Land Fill or Feed

Flume system for rot removal

Tank Treatments

- optional
- solutions vary

Optional heating

Fruit submersion

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

HPW 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 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

Box Sealer and Conveyor

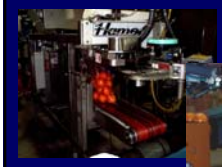
Palletization

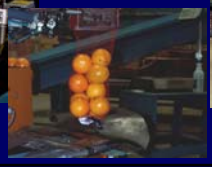
Short-term Storage

Loading Area isolated from rest of Pack House

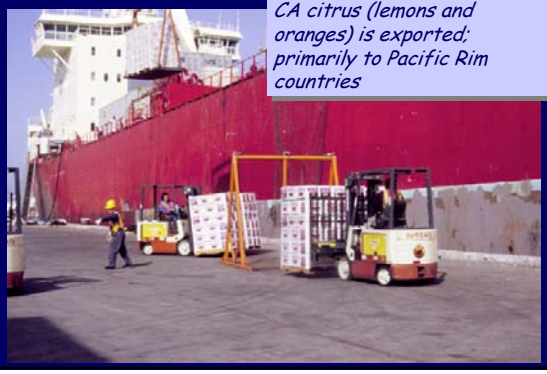
Other Packing Options

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 – 46F)
- Storage Duration: up to 3 months under ideal conditions

Grapefruit

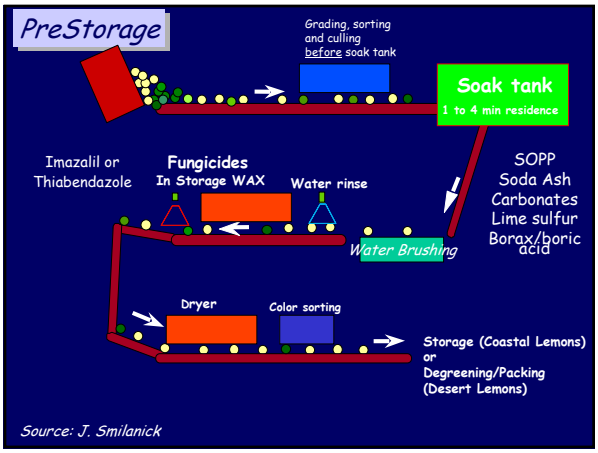
- Handled similarly to oranges except NO degreening
- Clipped; single harvest
- Maturity: Color (>2/3 fruit surface showing yellow) and SSC/TA ratio of 5.5 or 6 (depending on production area)
- Storage: 6 to 8 weeks at 12 – 14 C (54 – 57F)

Mandarins/Clementines

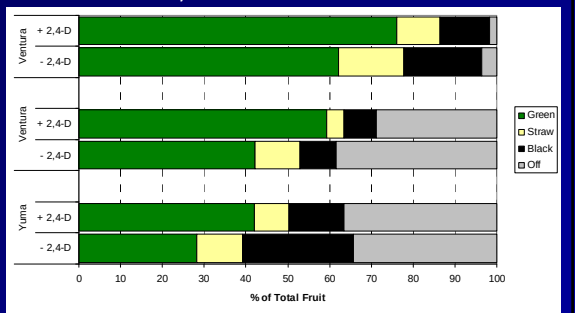
- More easily damaged than oranges; requires "soft handling"
- Clipped; may size pick
- Maturity: Color (yellow, orange, and/or red) on 75% of fruit surface and SS/TA 6.5 or higher
- Storage: 3-6 weeks at 5 - 8 C (41 - 46 F)

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)

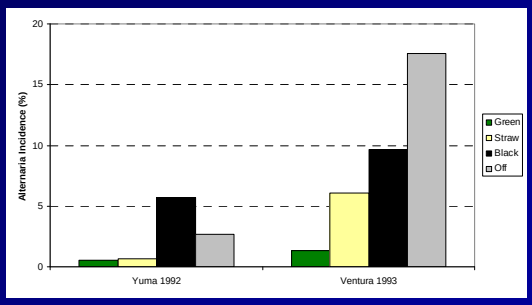


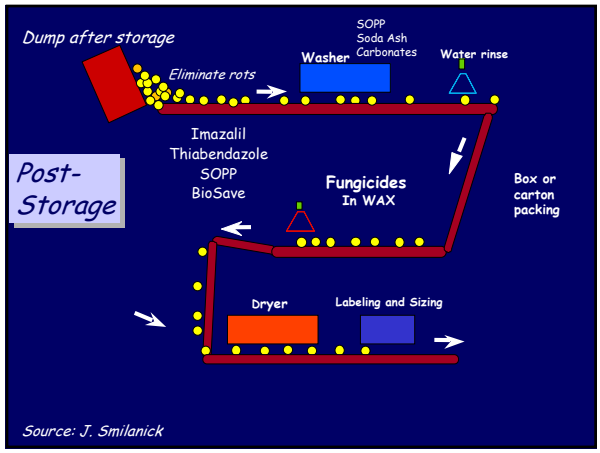
The influence of postharvest 2,4-D on button condition



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

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





Color Sorting

Volume Fill

Storage
Up to 150 days

Additional information

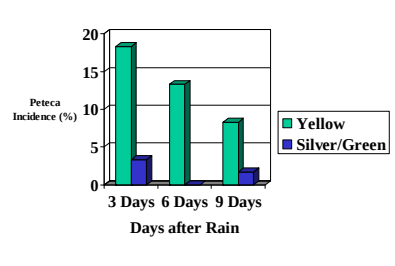
Ultimate Citrus Page
www.ultimatecitrus.com

California Citrus Research Board
www.citrusresearch.org

How preharvest factors may influence fruit quality

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

Peteca, Maturity and Rainfall

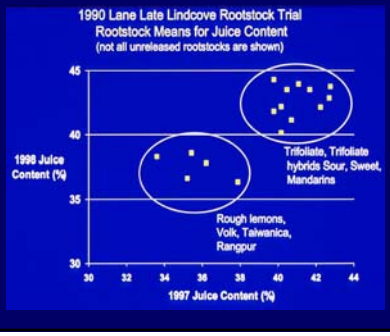


Undurraga M., Olaeta C., Retamales A., Brito P., 2006

Rootstock/Scion Effects:

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

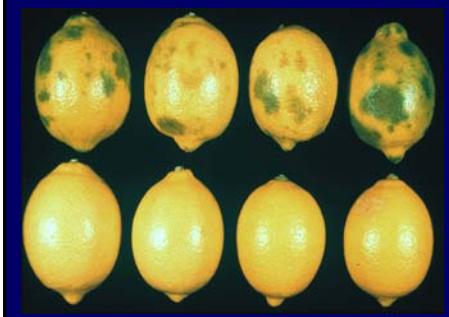
The influence of rootstock on juice content (M. Roose)



Planting design and pruning

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

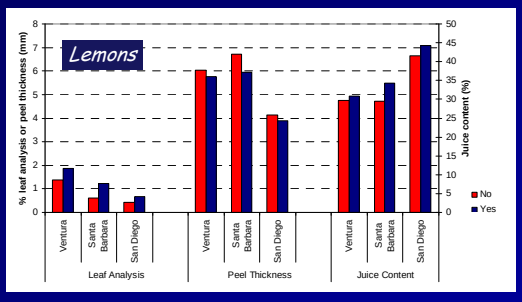
Related to fruit turgor pressure at harvest - more turgid; more damage

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

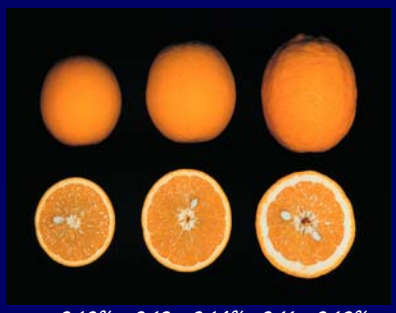
High Nitrogen

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



Potassium can influence peel thickness and juice content

Embelton and Jones, HortScience, 1966

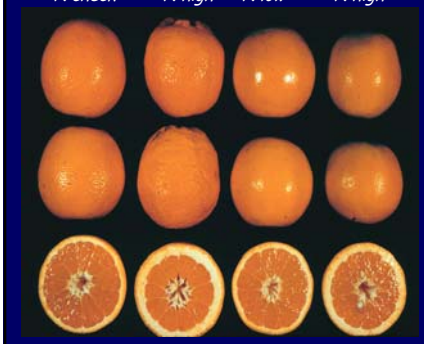


> 0.18% 0.13 - 0.14% 0.11 - 0.12%

Leaf analysis

Effects of phosphorus on valencia orange fruit quality

Aguatibia ranch, 1962



Effects of nitrogen and phosphorus on navel orange fruit quality

Embelton and Jones, 1956 - Yr 6 of 10 yr study