The Principles of Citrus Postharvest Handling

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Overview

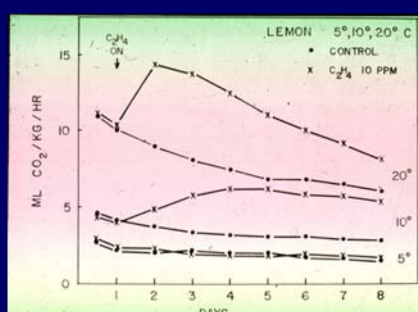
- Citrus Postharvest Biology, Pathology and Disease Management
- CA Postharvest Handling Procedures
  - Oranges/Grapefruit
  - Lemons
  - Mandarins

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

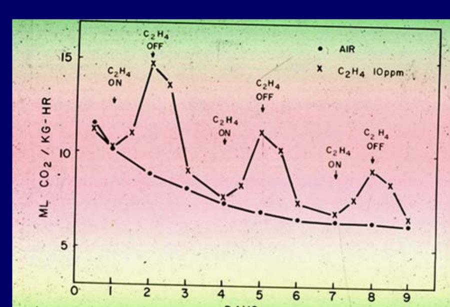
Citrus

- *Non-climacteric*
- *Chilling sensitive*



Respiratory response of lemons to ethylene at different temperatures

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

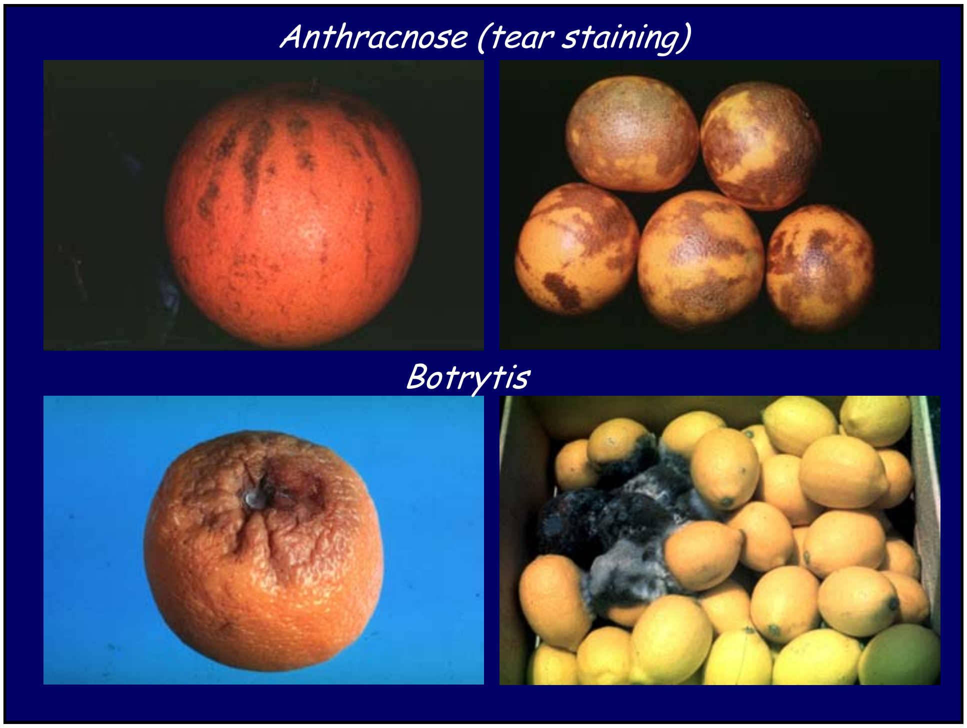
Develops after harvest

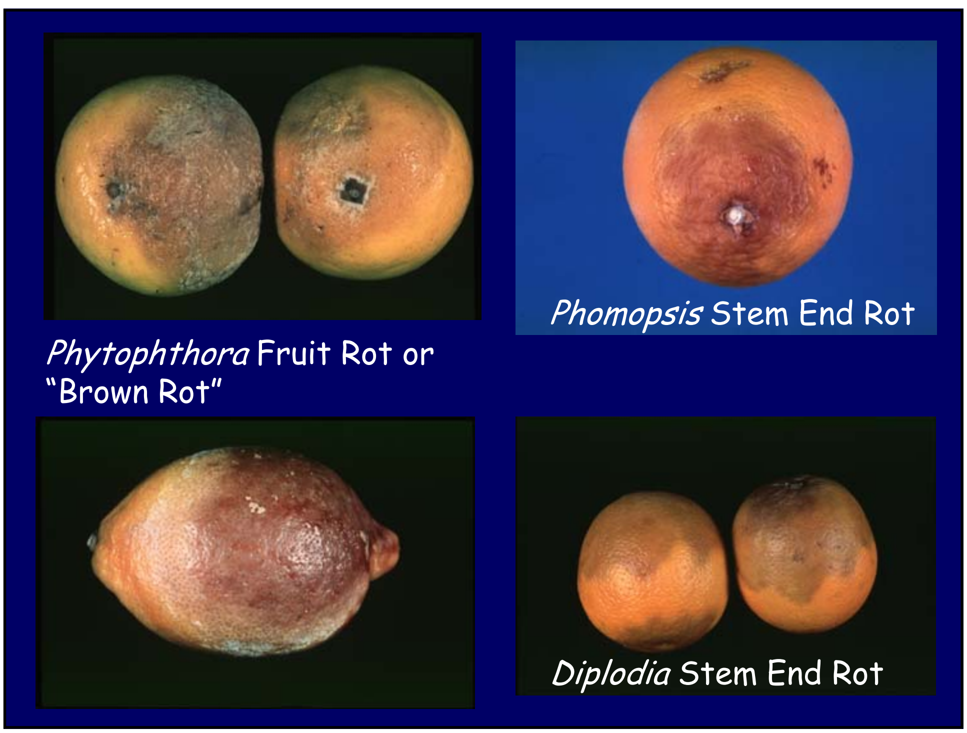
Curing of lemons allows detection

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


Phomopsis Stem End Rot
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

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

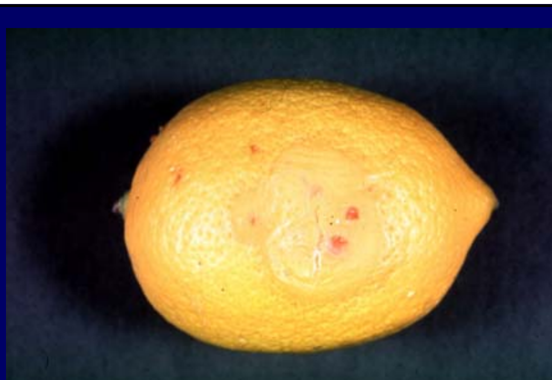
Penicillium sp.

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

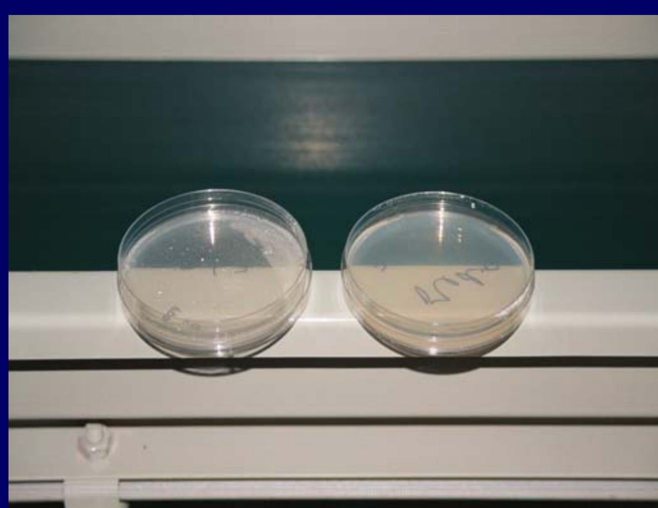
Discard decayed fruit downwind from packing house to minimize contamination

Maintain tank mixtures/fungicide applicators at optimal conditions

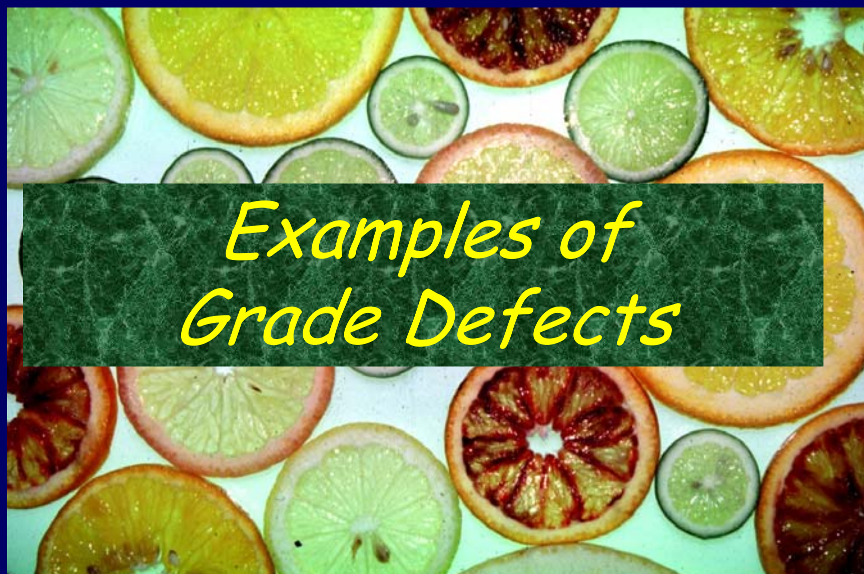
Minimize fruit drops and other points of fruit handling that can cause damage

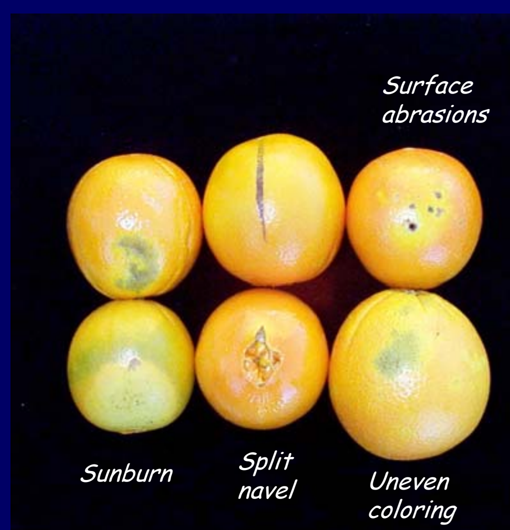
Ambient spore sampling

Important for detection of resistant strains of Penicillium



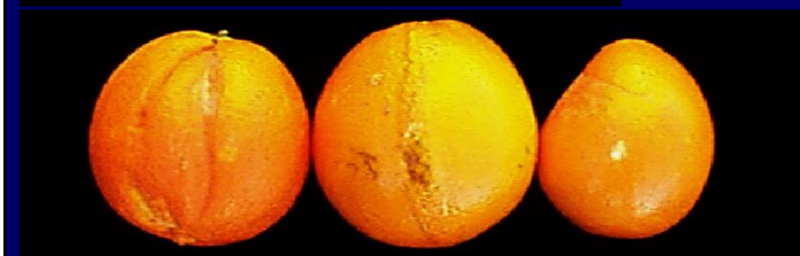
Examples of Grade Defects





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


Postharvest
Handling Practices

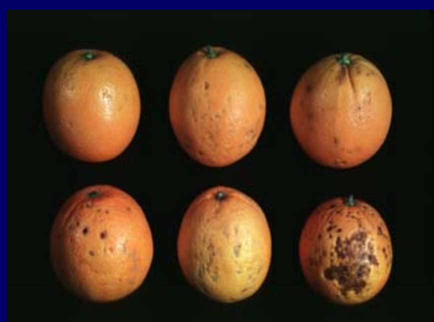

Fruit Handling and Quality

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

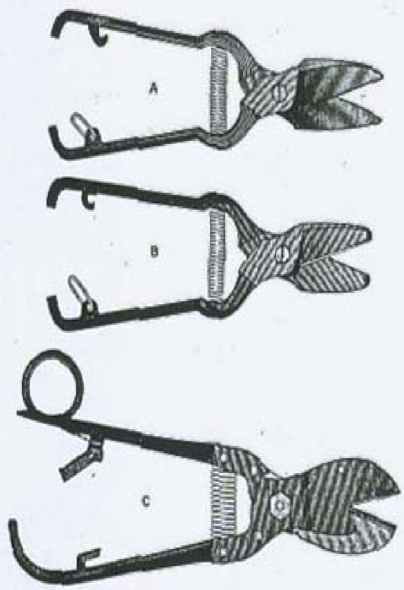
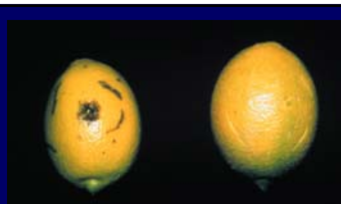


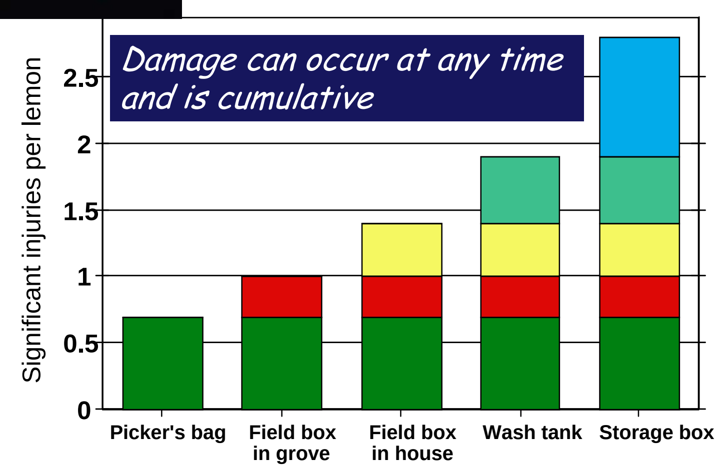
FIG. 1.—Types of shears or clippers used in picking citrus fruits. A, a sharp-pointed type; B, clippers with blunt points; C, sheath clippers.

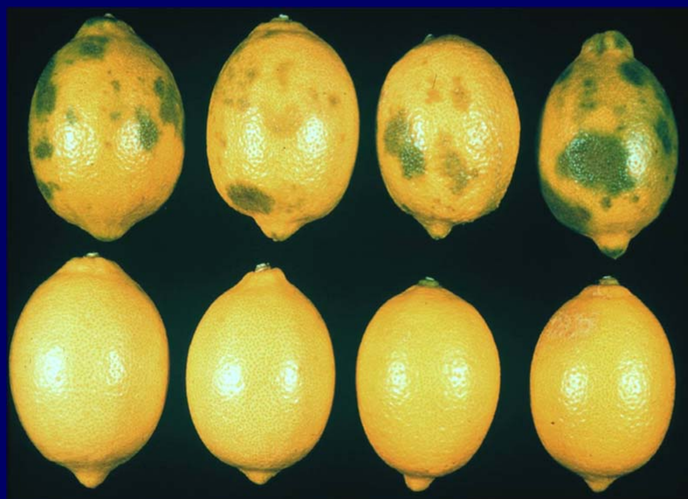
"The most common type of injury was made by … the clippers … many were injured by stem punctures, while others showed scratches from thorns. Other common … injury… were from gravel and twigs in the bottom of boxes and cuts by the finger nails of the pickers."

Powell, 1908 Riverside, California



Dye injury test *Eaks 1961 Proc. ASHS 78:190-196*





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

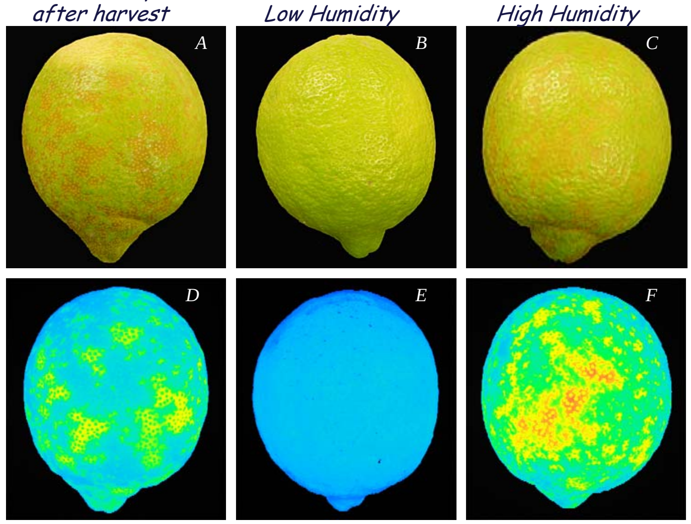
← *Note peel damage with early morning harvest*

Obenland and Neipp, HortScience, 2005

Hot water timing | *Immediately after harvest* | *After 24 hours Low Humidity* | *After 24 hours High Humidity*

24 hours after treatment

30 minutes after treatment
Peel Flourescence



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

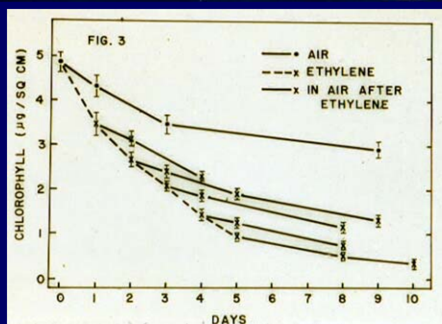
Ethylene Degreening

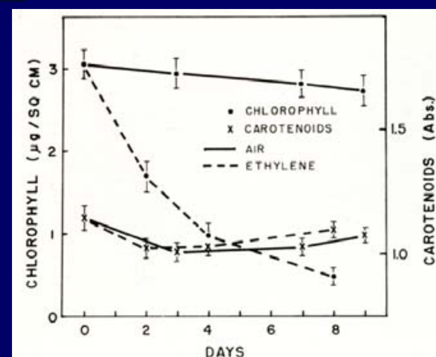
- Early season navel oranges
- Re-greened valencia oranges
- Lemons
- Mandarins

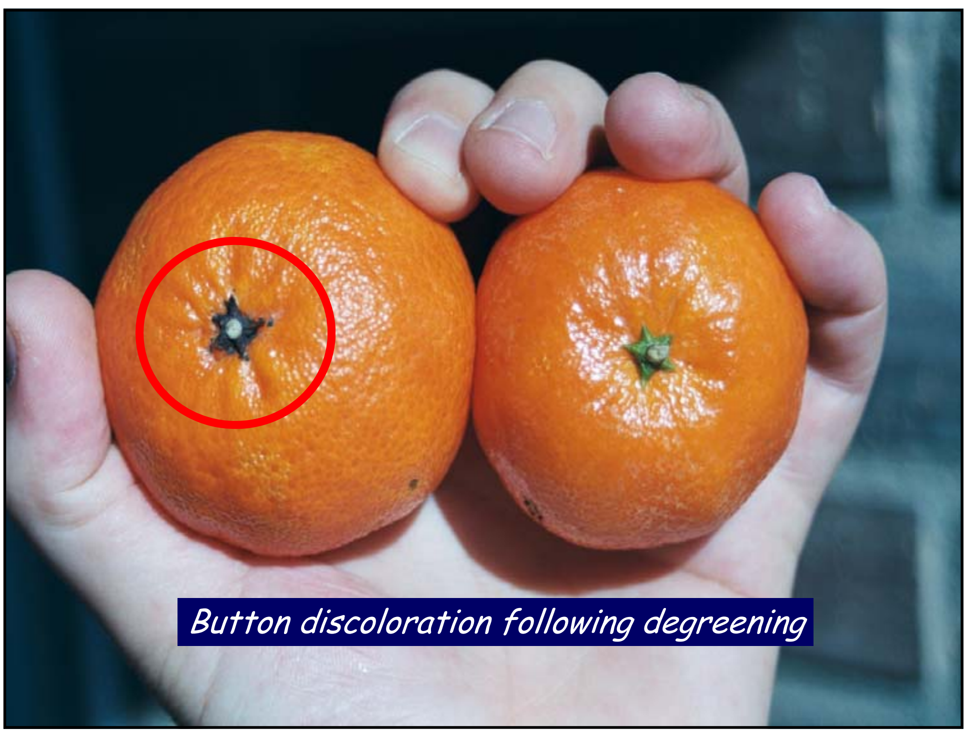
- Ethylene: 1-5 ppm
- Temperature: 20 C in CA; 25 C in FL
- Humidity: 90-95%
- Ventilation: 1 air exchange/hour
- Carbon Dioxide: reports varies, <1%

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 Soluble Solids Content and Titratable Acidity

Orange Harvesting

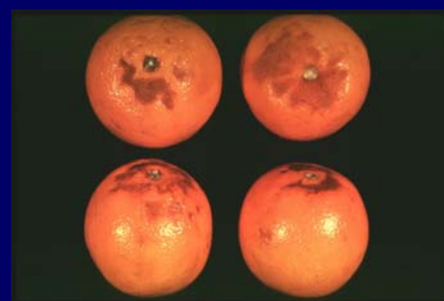
- *40 to 60 lb picking bag*
- *Gloves to prevent damage*
- *Fruit Clipped*
- *Bulk ~1000 lb bin*
- *No fruit from ground*
- *Fruit transported to PH on day of harvest*

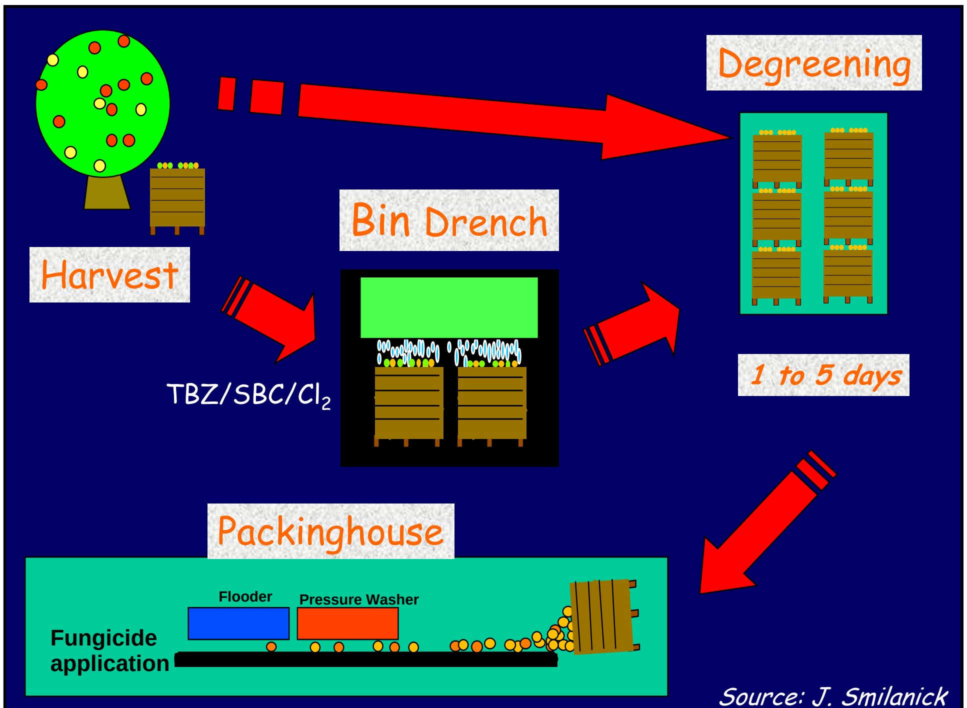
Care is taken in the field during harvest to minimize damage to fruit since the consequences of mechanical injury are:

increased decay

enhanced water loss

may result in peel breakdown in handling

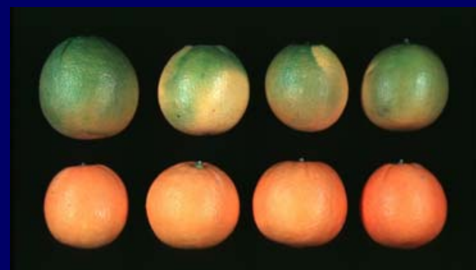


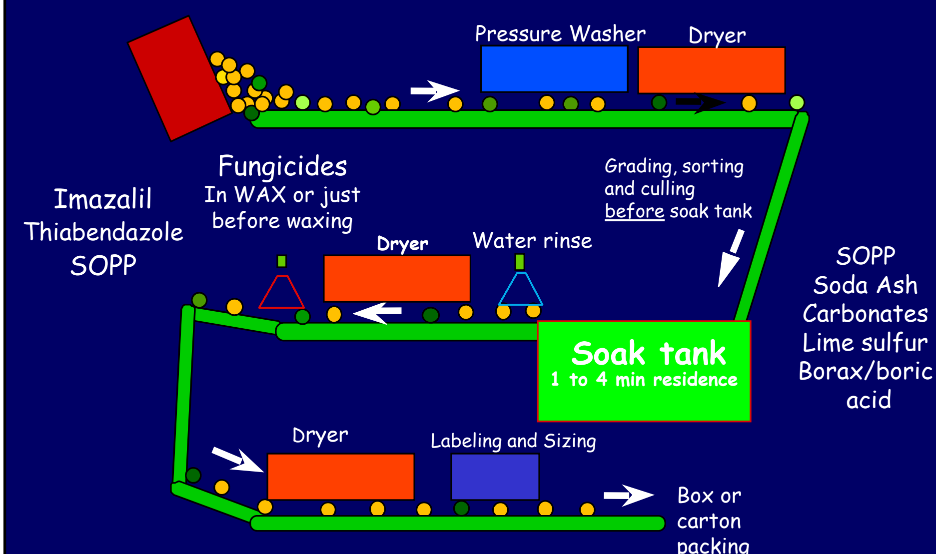


Degreening

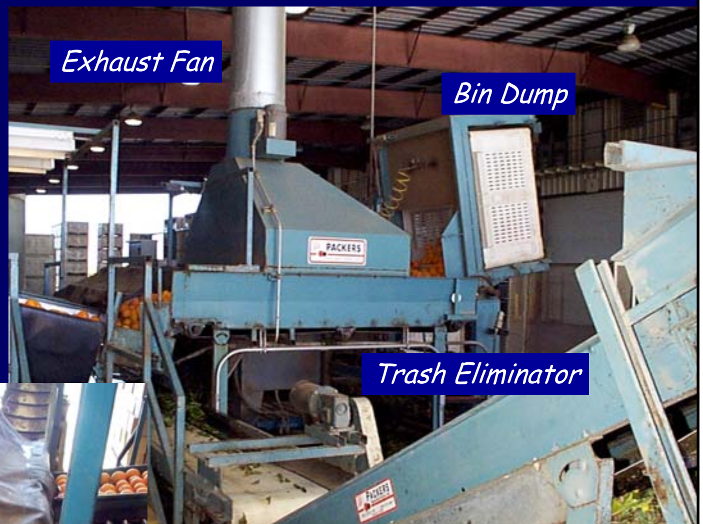
-early season navels
-late season valencias

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





Source: J. Smilanick



100 - 200 ppm chlorine spray

Pregrading for Processed Products and Cull Removal

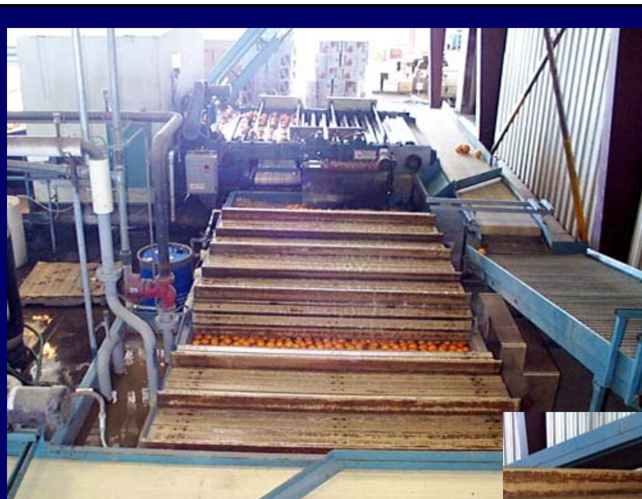
Fruit for Processed Products

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

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)

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

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

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 – 46F)
- Maturity: normally SSC/TA ratio but for CA navels the California Standard
- Storage Duration: up to 3 months under ideal conditions

Background of California Navel Maturity Standards

1915 – California adopted the 8:1 ratio as the minimum maturity standard

1925 – Florida followed California by adopting an 8:1 ratio standard

1949 – Florida raised the minimum orange maturity standard to a 9:1 ratio

1983-1985 – CCM sponsored a consumer study of navel oranges. The study recommended that the ratio should be raise to 9:1.

2003 – California drops B color from the maturity standard

2003-2006 – At CCM's request CRB conducted a three year taste study with University of California researchers. The study concluded that sugar to acid ratios were not the best method of measuring flavor. *Brix minus Acid* was proven to be a much better predictor of flavor.

2008 – CCM received a Specialty Crop Grant to fund a consumer study at Tragon consumer labs in Chicago. This study, using 400 actual consumers, confirmed that *Brix minus Acid* was a much better predictor of consumer acceptance than a simple ratio.

2010 – CCM Board agrees to pursue moving to a *Brix minus Acid* standard for navel oranges and decided to call it the California Standard.

2012 – California Standard adopted for navel oranges

How is the California Standard calculated?

The California Standard is easily converted to a table format, similar to the SSC/TA tables currently in use

It is a slight modification of the BrimA calculation proposed by Jordan et al: BrimA = Brix – (TA*k)

Steps involved in determining the California Standard

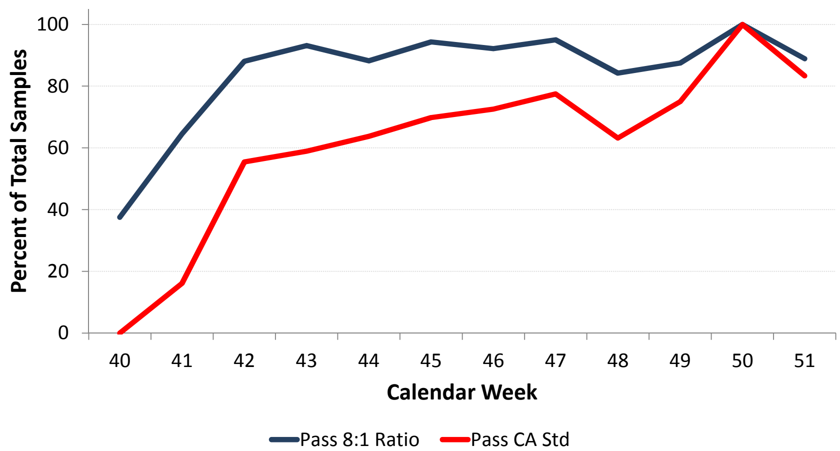
- Juice sample using Boswell Press
- Determine Brix using standard protocols
- Determine Titratable Acidity using standard protocols
- Calculate California Standard

Formula for California Standard:

California Standard = (Brix – (TA * 4)) * 16.5

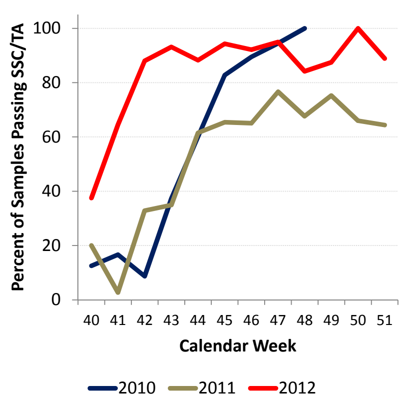
70

Comparing SSC/TA ratio to California Standard 2012

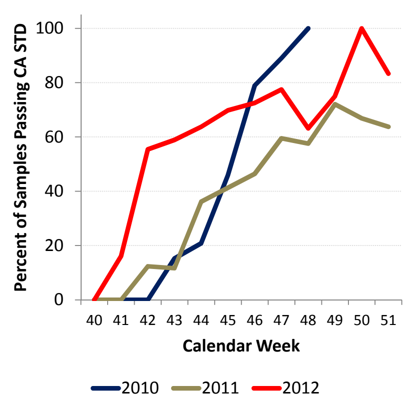


Comparing 2010 – 2012 % Passing

SSC/TA Ratio



CA Standard



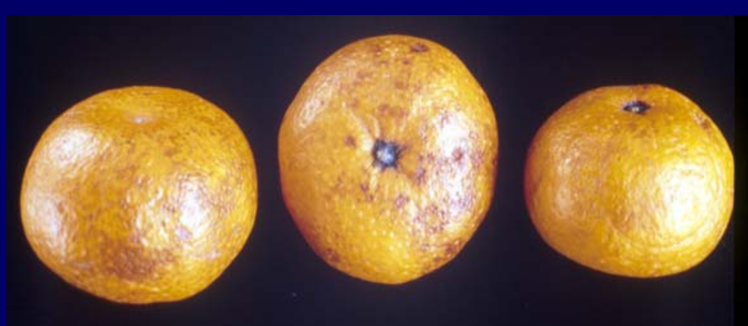
2010: 417 samples; 2011: 3,241 samples; 2012: 636 samples

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)



SOPP Damage



Skin Burns *Skin Wounds* *No Stem end*


Puffines *Olleocellosis*

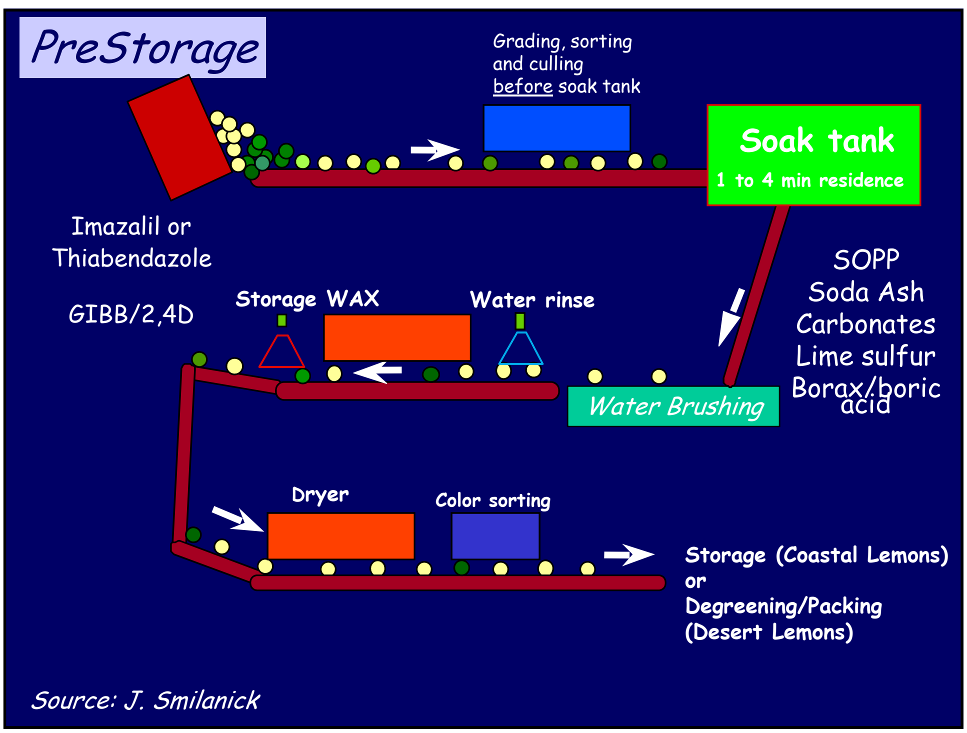
Peel Damage – Various Causes

Rind Breakdown

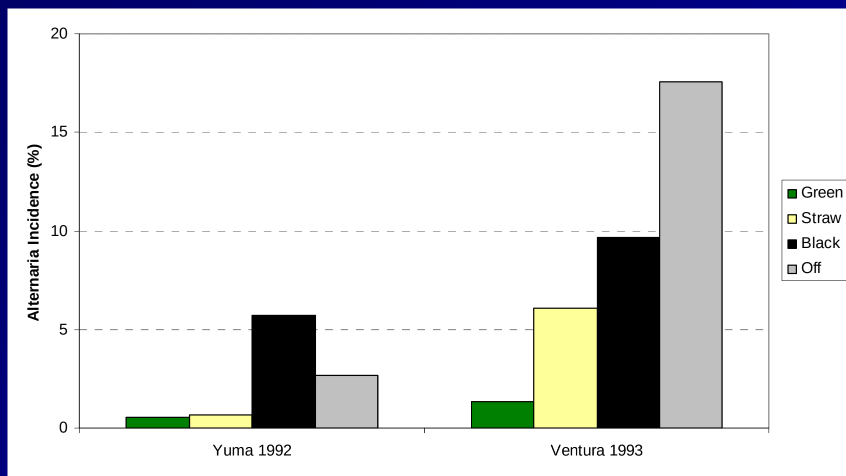
- *Related to long transit times*
- *Associated with high temperatures during shipping?*
- *Lot to lot variability*
- *Pale fruit shows more incidence than dark orange fruit*

Lemons

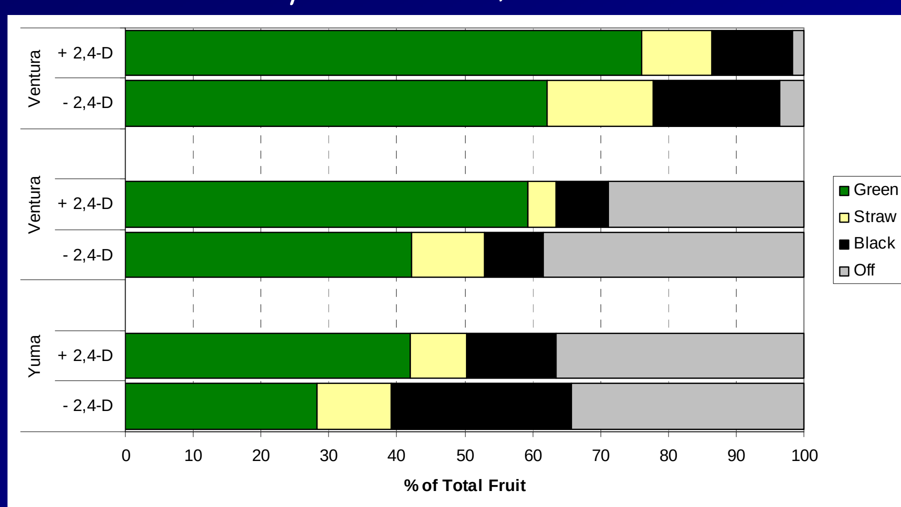
- A minimum juice content by volume of 28 or 30% depending on grade
- Clipped
- Multiple harvests based on color and size
- May be stored prior to packing up to 150 days at 10 – 13 C (50 – 56 F)
- After packing and colored may be shipped and stored at 3 – 5 C (37 – 41 F)



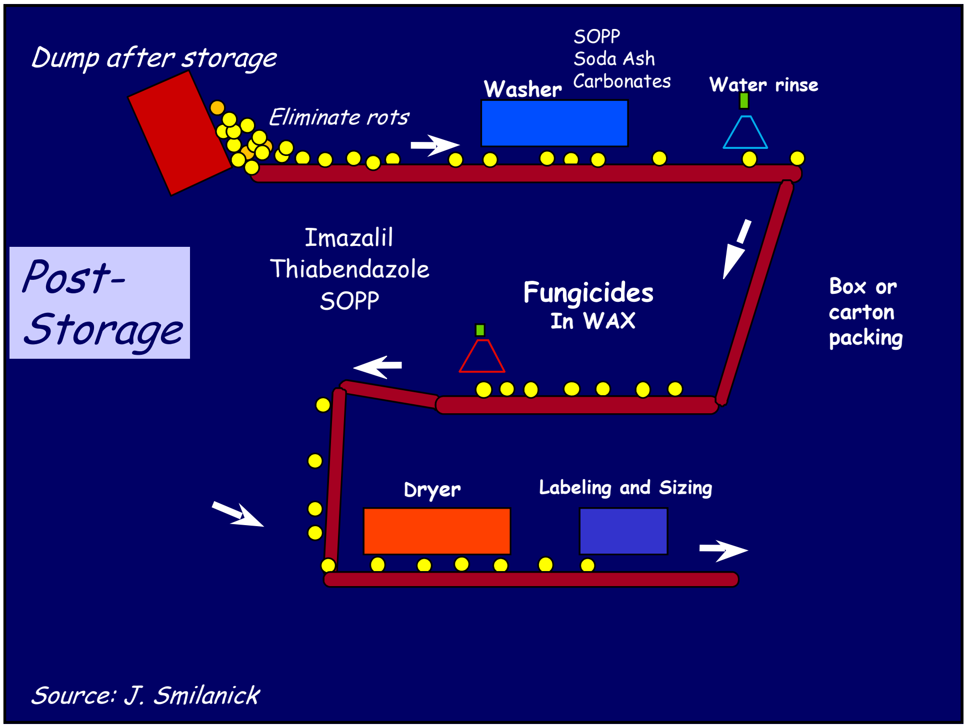
The influence of button condition and % incidence of Alternaria Stem End Rot

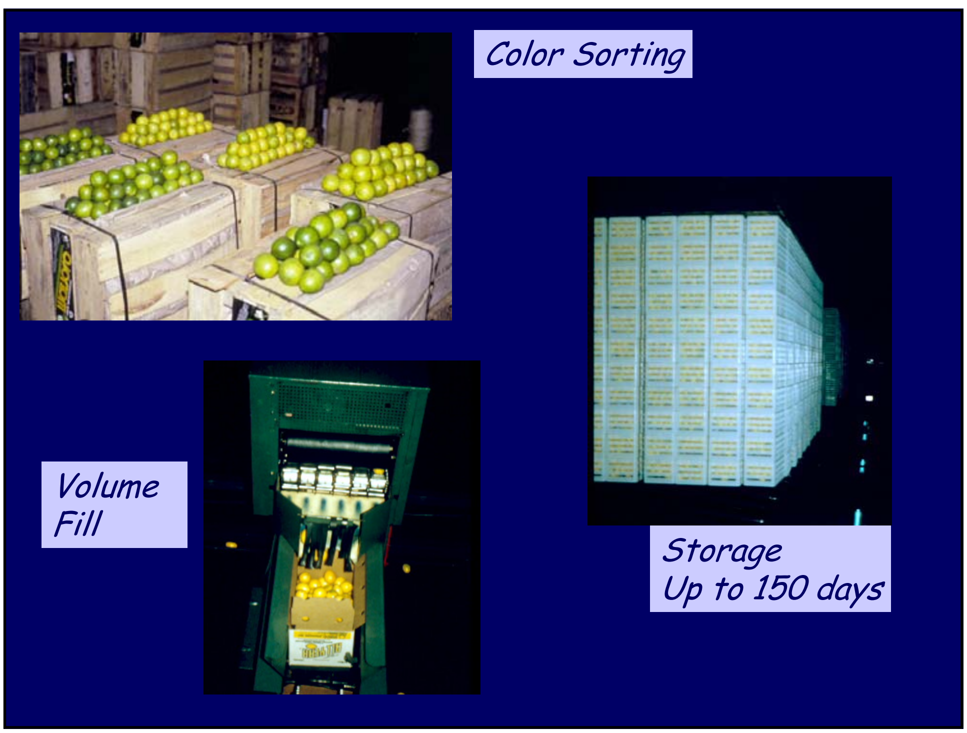


The influence of postharvest 2,4-D on button condition



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


Dump after storage
SOPP
Soda Ash
Carbonates
Washer
Water rinse
Eliminate rots
Imazalil
Thiabendazole
SOPP
Post-
Storage
Fungicides
In WAX
Box or
carton
packing
Dryer
Labeling and Sizing
Source: J. Smilanick


Color Sorting
Volume
Fill
Storage
Up to 150 days

Additional information

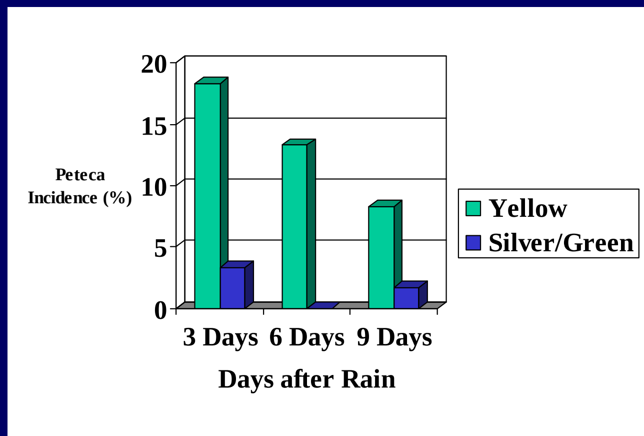
Ultimate Citrus Page
www.ultimatecitrus.com

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

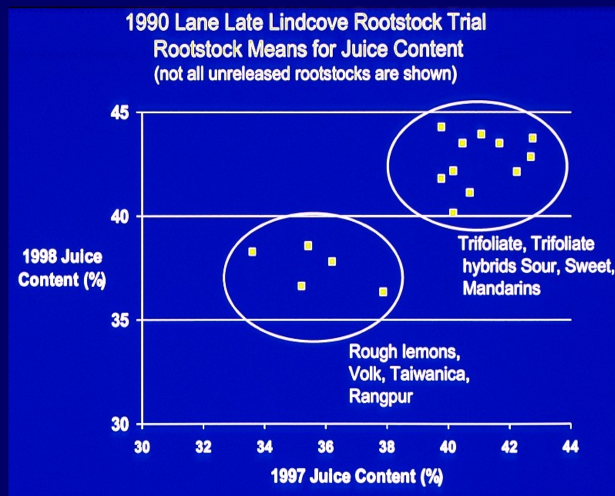


Undurraga M., Olaeta C., Retamales A., Brito P., 2006

Rootstock/Scion Effects:

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

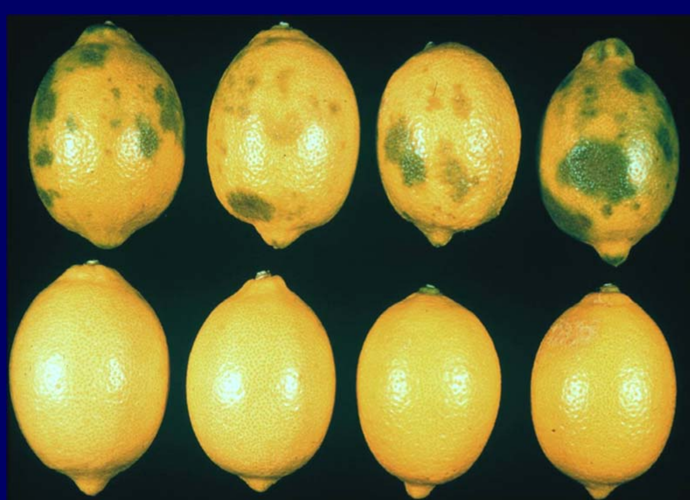
The influence of rootstock on juice content (M. Roose)



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

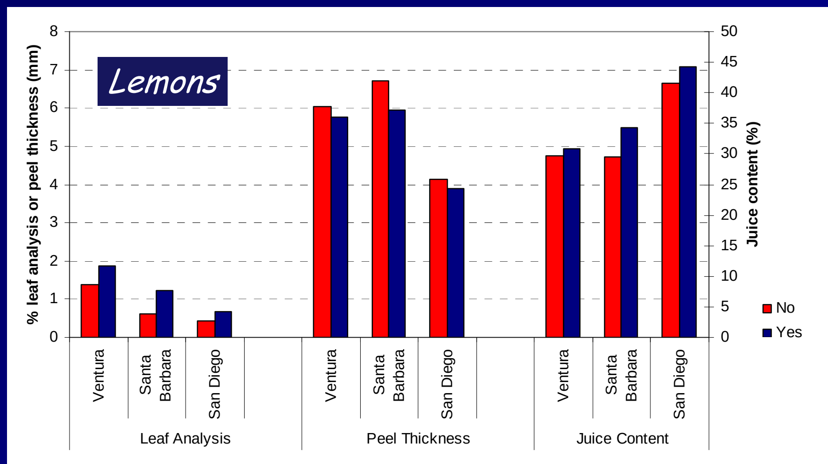
Related to fruit turgor pressure at harvest - more turgid; more damage

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

Effects of phosphorus on valencia orange fruit quality

Aguatibia ranch, 1962

> 0.18% 0.13 - 0.14% 0.11 - 0.12%

Leaf analysis

P low N check | *P low N high* | *P adequate N low* | *P adequate N high*

Effects of nitrogen and phosphorus on navel orange fruit quality

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