Citrus Degreening

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What is degreening?
The process of exposing “green” citrus fruit with low levels of ethylene to enhance coloration

Chlorophylls
Light harvesting for photosynthesis

Type A-Carotenoids
β-Carotene, Lutein, Zeaxanthin, etc.

Chloroplast

Thylakoids

Photosynthetic carotenoids
Light harvesting
Photoprotection

From K. Inoue, UCD
Chlorophylls

Type A-Carotenoids
= Photosynthetic carotenoids
Light harvesting
Photoprotection

Type B-Carotenoids
= NON-Photosynthetic carotenoids
Fatty acid esters of cis-Violaxanthin, β-Citraurin, etc.

Photoprotection? Attraction? From K. Inoue, UCD

Chlorophylls
Photosynthetic carotenoids
NON-Photosynthetic carotenoids

Thylakoids
Thomson '66

Chloroplast

Ethylene Degreening
What do we regreen?

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

From K. Inoue, UCD
Preharvest Factors Affecting Degreening

- Fruit Maturity, Tree Vigor, and Climatic Effects
- Cultural Practices

- Immature fruit may be poorly colored
- Fruit from trees that are vigorously flushing are more difficult to degreen
- Natural color break needs to have been initiated
  - 7 - 13 C (45 – 55 F) night temperatures
- For best color development in CA valencia orange need (Young and Erickson, 1961)
  - 20°C (68°F) day; 7°C (45°F) night; 12°C (54°F) soil
Preharvest Factors Affecting Degreening

Cultural Practices

- Rootstock
  - Affects tree vigor and may therefore affect color break

- Spray Programs
  - Summer oil insecticide sprays may delay color break
  - Gibberelin application

- Fertilization Practices
  - High Nitrogen which increases tree vigor, thereby affecting color break

Grierson and Newhall (1960)

Ethylene Degreening

Recommended Conditions

- Ethylene: 1-5 ppm
- Temperature:
  - 20-21°C (68-70°F) in CA
  - 28-29°C (82-84°F) in FL
- Humidity: 90-95%
- Ventilation: 1 air exchange/hour
- Carbon Dioxide: reports varies, <1%

The Degreening Atmosphere

- Ethylene
- Temperature
- Humidity
- Air Circulation
- Ventilation and Atmospheric Composition
Results in the destruction of chlorophyll and the development of carotenoids

Will stimulate respiration; with low ethylene levels effect is transitory

May stimulate volatile production

Greater stimulation in green vs yellow lemons (Norman and Craft, 1968)

May enhance decay especially stem end rots as well as anthracnose

Hastens button senescence

Literature for the most part indicates that it is unnecessary to exceed 5 ppm, lower concentrations may be equally effective depending on cultivar

Degreening Atmosphere - Ethylene

Degreening with ethylene induces the conversion of chloroplasts to chromoplast and is dependent on:

- Initial Peel color
- Temperature
- Duration of exposure

Coloration stops when C2H4 is stopped

From I. Eaks

Button discoloration following degreening
Anthracnose (tear staining)

The Degreening Atmosphere - **Humidity**

- Low R.H. may result in soft fruit and loss of size
- Very low humidity may inhibit process
- Low R. H. may accentuate physical blemishes and increase stem end rind breakdown
- **Best results with 90-95%**
**The Degreening Atmosphere - Temperature**

- Degreening temperature varies with growing region
  - 29°C in FL vs. 20-21°C in CA
- High temperatures inhibit carotenoid pigments (>30°C; 86°F)

**The Degreening Atmosphere – Atmospheric Composition**

Good air circulation is required
- to equalize conditions of temperature, humidity, ethylene through entire room
- to uniformly deliver ethylene to every fruit
- to remove unwanted products such as carbon dioxide and volatiles (?) from room

**The Degreening Atmosphere - Air Circulation**

High carbon dioxide can inhibit ethylene
- Threshold values of CO₂ inhibitory effect is unclear
  - 1% - FL orange and grapefruit degreening rooms (Grierson and Newhall, 1960)
  - 2.5%, Shamouti oranges; 5%, lemons (Cohen, 1973) in controlled environment
- Oxygen concentration may have some influence; reports are confusing
Other Factors Affecting Degreening
Packinghouse Treatments

- Bin Drenching
- Washing
  - Increases time for degreening?
- Waxing
  - Inhibits
- Color Sorting
  - Increases efficacy of treatment

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Degreening
- early season navels
- late season valencias

1 - 5 ppm ethylene
68 - 70°F, 90 - 95% RH
<1% CO₂
Degreening

Harvest

Bin Drench

Packinghouse

Degreening

1 to 5 days

TBZ/SBC/Cl₂

Packinghouse

Fungicide application

Source: J. Smilanick

Blue Mold
P. italicum

Penicillium sp.

Green Mold
P. digitatum

Caused by wounding during harvesting and handling

Sporulation - direct loss and necessitates repacking

2 ppm ethylene

No ethylene

Degreening of Mandarins

Mainly early season satsumas harvested before the onset of cool temperatures

Sporulation - direct loss and necessitates repacking

No ethylene

Degreening of Mandarins

Mainly early season satsumas harvested before the onset of cool temperatures
Lemon Degreening

Desert lemons harvested in August - October

Coastal lemons on a more limited basis

Pre - DeGreening

Soak tank
1 to 4 min immersion

Imazalil or Thiabendazole

Fungicides
In Storage WAX

Water rinse

Soak tank

Water brushing

SOPP
Soda Ash
Carbonates
Lime Sulfur
Borax/boric acid

Dryer

Color sorting

Grading, sorting and culling before soak tank

Storage (Coastal Lemons) or Degreening/Packing (Desert Lemons)

Other resource information on degreening

FRESH CITRUS FRUIT 2nd Edition
Florida Science Source, 2006
http://www.ultimatecitrus.com/fssource

Recommendations for Degreening Florida Fresh Citrus
Ritenour et al. 2008
University of Florida Circular 1170
http://postharvest.ifas.ufl.edu
Thank you for your attention