Postharvest Handling of Citrus Fruits
Postharvest deterioration

• Harvested fruit are still living
• Continue to respire
• Loose water but not replaced
• The respiratory rate of the rind is nearly ten times as high as that of vesicles
• Rind- plays a imp. physiological role in the qualitative changes in storage
Postharvest deterioration

- Respiratory rates are stimulated by dropping and bruising
- GFT dropped in 1.2-1.8 M on to hard surface increase in respiratory rate and internal ethylene production.
- Refer. Table 6 in Miller and Wagner 1991 paper.
Postharvest Storage

- Citrus fruits have relatively long postharvest life.
- Loose skinned fruits - Satsuma mandarin and Ponkan easily puff at high humidity.
- Prestorage curing of the fruits also reduces decay and chilling injury during storage.
- Each variety has different optimum conditions for storage (Table 2.6)
Postharvest Storage- Grapefruit

• Store 6-10 weeks
• Wax- with fungicide extends storage life and wax is also desirable to minimize moisture loss during transportation and storage.
• Susceptible to chilling injury below 10C.
Postharvest Storage- Lemons

- Most lemons are ready to consume after harvest, but need conditioning to degreen.
- Conditioning: 13-15.5c, 85-90% R.H.
- Stored for 1-4 months
- Temp: 11-14.4C
- Individually sealed packaging with high density polyethylene (HDPE) film at 13C extends the storage life of “Eureka” lemons
Postharvest Storage - oranges

- Orange quality does not improve during storage
- Stored at 2-7C for 8-12 weeks depending on cultivar and production region
- Pitting and chilling injury below 2-3C
- High temp: blue mold and green mold
- Individually sealed packing with LDPE film reduces fungal rots.
Postharvest Storage- Satsuma mandarins

- Storage life is longer
- Fruit quality can be improved during storage by the reduction of acidity
- Curing is necessary to avoid puffy fruit
- A hot dip treatment (25 or 52°C for 3 min) significantly reduces fungal decay.
Controlled-atmosphere storage

- Research has been done
- Results are promising
- Commercially not used because:
  - Economic reasons
  - Physiological characteristics of fruit
  - Elevated CO$_2$ has no beneficial effect
  - Low O$_2$ stimulates ethanol and acetaldehyde

- Proposed CA conditions for Satsuma
  8-12% O$_2$, 0-2 % CO$_2$ at 1-4 C, 83-90 RH
Physiological Disorders

• Influence quality in the markets
• Causes: Pre- and post-harvest factors
• Preharvest: B, and Cu deficiency, ammoniation, Zebra skin, fruit-splitting, creasing, sun burn, wind scar and freezing
Zebra skin

• Usually occurs in tangerines

• Darkening of areas of the peel over the individual fruit segments

• Drought stress followed by a sudden availability of soil moisture
Zebra skin

• Fruits absorb water and become turgid

• Epidermal cells in the ridges over fruit segments are most exposed and likely to be damaged by harvesting, handling and packline brushes.
Creasing

• Results when crack develops in the albedo causing a crease in the overlaying flavedo
• Most sweet oranges
• Reasons:
  – K deficiency
  – High N
  – Temp during the period of maximum peel growth and development
• Early harvest may solve the problem
Fruit Splitting

- Problem in Fall
- Believed to be a problem of water relations and peel thickness
- Trees take up water from rain or irrigation and fruit expands, bursting the peel in a crack across the bottom
- K and Cu deficiency
- Younger trees more problem than mature trees
Sunburn

- Damage leaves, stems and fruit.
- Leaves: gum spots sometimes like melanose or greasy spot.
- Fruit: shoulders of tree in the southwest quadrant.
- Honey tangerine susceptible
- Drying of exposed portions of the peel, pulp and the juice beneath it.
- Damaged areas will have advanced color break.
Wind Scaring

- By abrasive contact with leaves, twigs, and thorns.
- Injured areas grow with fruit-later become large.
- Damage is cosmetic
- Injury sites are invaded by microorganisms
- Control:
  - Regular pruning
  - Windbreaks
Physiological Disorders

• Postharvest factors:
  – Temp, humidity, gaseous composition, mechanical stress and aging

• Disorders: Puffiness, pitting, chilling injury, granulation, oleocellosis, stem end break down, stylar-end break down, and freezing injury
Postharvest Pitting

- It is characterized by the emergence of clusters of collapsed oil glands that are scattered over the surface of fruits.
- The collapsed regions eventually become bronze and develop more predominantly near the blossom end.
- White grapefruit, Fallglo tangerines, Temple and navel oranges.
Postharvest Pitting

- Increases with fruit size
- Not a phytotoxic burn but triggered by low oxygen within the fruit.
  - High respiration stimulated by high temp storage and low gas exchange rates caused by high shine waxes.
Postharvest Pitting

• Control:
  – Pulp temp should be 50F (10C) or less.
  – Reducing to 40F may increase CI
  – Waxing with coating that have relatively low shine, but high gas permeability has been shown reduce pitting
Chilling Injury (CI)

- Collapse is not targeted oil glands
- A collapse of discrete areas of the peel from sunken darkened lesions which will slowly expand.
- Very early and Very late harvested GRF.
- Low RH enhance CI
- Grapefruit- 4.4 C in FL
- Waxing-Reduce but not eliminate CI
- Thiobendazole (TBZ) or Imazalil
Granulation

- Fruit which is dry or ricey
- Causes:
  - over maturity, sun burn, freezing, lack of water, excessive tree vigor, mite damage, cool, dry and windy conditions
- Keeping trees well irrigated will avoid fruit from drying out.
Oleocellosis (Oil spotting)

• Navel oranges, lemons, and limes mostly affected.
• Oil released from broken peel oil cells in the flavedo.
• Oils are toxic to the surface of the peel and cause necrosis of the surface cells.
• Early morning-highest turgidity following the night when stomates are closed in the leaves and fruit.

Contd.
Oleocellosis (Oil spotting)

- Reduced by:
  - Avoid harvest until the fruit less turgid.
  - A pressure tester used to test turgidity
  - A pressure range of 0-10 lbs is adequate to detect tender peel to resistant peel to oil spotting.
Stem-End Rind Breakdown

• Most often in oranges and Temples.
• Thin skinned fruit are more affected than thick skinned fruit.
• Collapse of rind tissues resulting in sunken brown area which is irregular in shape.
• Narrow ring of unaffected tissue immediately around the stem area which has no stomata.
• N and K imbalance?  Contd.
Stem-End Rind Breakdown

• Moisture loss from fruit after harvest before waxing.
• Control:
  – Reduce interval harvest and waxing
  – Hold fruits at high RH
  – Avoid excessive brushing on the packing line
  » Automatic packingline brush wipe-outs will reduce time on brushes
Stylar-End Breakdown (SEB)

- Common in seedless limes
- First appears as tan water-soaked areas on harvested fruit.
- Pencillium is secondary infection
- Occurs in Summer- confused with yellow tip
- SEB- result of ruptured juice vesicles in the margins of mature, turgid, limes.
- Caused by post harvest solar heating on fruits picked during periods of high turgor pressure.
Stylar-End Breakdown (SEB)

• The liberated juice invades the rind at stylar end
• The acidic juice causes breakdown of chlorophyll in the flavedo.
• Fruits with oil release pressure of 3.0 kg are safe.
• Control:
  – Avoid harvest of large fruit
  – Pick late in morning
  – Careful handling
Blossom-end clearing (BEC)

- Late in the season on high quality thin skinned grapefruit.
- Ruptured juice vesicles in the core of fruit.
- Juice in the center cavity soaks through the peel.
- Higher pulp temp and lower RH increase BEC
- Control: harvest thin skinned earlier and precoring before handling
Rumple of Lemons

- Lemon juice and oil-not affected
- Reported in Sicily as “wrinkle rind”
- FL- later summer as chlorotic rind spot
- Oil glands develop a greenish through tan and brown to black
- May affect 75% of the in some years
- Fully mature large fruit develop this disorder and high N
- Control: Early harvest and reduce N.
Plugging

- Removal of portion of the rind when the fruit is pulled from the stem during harvest
- Loose skinned mandarins is common
- Careful harvesting
- Clipping without protruding stems
- Oranges, grapefruit and tight skinned mandarins- harvest by snapping
Blue Albedo

- Albedo, VB, segment walls and juice sacs have distinct blue color
- Reported in 1944 associated with stubborn
- Excessive fertilizer and high salt
- Excessive rain and lack of drainage
- Blue color is similar to anthocyanin
- Control: Avoid excess fertilizer and provide better drainage
Stylar-End Russetting

- Not common
- stippling or russetting of the stylar ends of the fruits
- Blemish appear to be a linked series of very slightly raised corky lines in a netted pattern.
- Navel orange
- Confused with rust mite
The Degreening Atmosphere

- Ethylene
- Temperature
- Humidity
- Air Circulation
- Ventilation and Atmospheric Composition
Ethylene

• 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 fruits (Norman and Craft, 1968)
Ethylene

• May enhance decay especially stem end rots and anthracnose

• Hastens button senescence

• It is unnecessary to exceed 5 ppm, lower concentrations may be equally effective depending on cultivar
Temperature

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

• Low R.H. may result:
  – soft fruit and loss of size
  – may accentuate physical blemishes and increase stem end rind breakdown

• Very low humidity may degreening inhibit process

• Best results with 90-95%
Air Circulation

• Good air circulation is needed
  – 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
Atmospheric Composition

• 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
Prior Factors Affecting Degreening

• Fruit Maturity, Tree Vigor, and Climatic Effects
• Cultural Practices
• Packinghouse Treatments
• Degreening Room Design
Fruit Maturity, Tree Vigor, and Climatic Effects

- 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 night temperatures
- For best color development in valencia orange need (Young and Erickson, 1961)
  - 20C day; 7C night; 12C soil
Cultural Practices

- Rootstock
  - Affects tree vigor and may therefore affect color break
- Spray Programs
  - Summer oil insecticide sprays may delay color break
    - Gibberellin application contd.
Cultural Practices

• Fertilization Practices
  – High Nitrogen which increases tree vigor, thereby affecting color break
Packinghouse Treatments

- Bin Drenching
- Washing
  - Increases time for degreening?
- Waxing
  - Inhibits degreening
- Color Sorting
  - Increases efficacy of treatment
Postharvest Diseases
Green Mold and Blue Mold

- Green Mold - *Pencillium digitatum* Sacc.
- Blue Mold - *Pencillium italicum* Wehmer.

Fungus enters the fruit only through injury

- Olive-green fungus spores - Green mold
- Bright blue spores

- Later sporulating area is surrounded by a white margin (Wide for green than Blue)

- Pencillium can become resistant fungicides

Ship temp below 4.4C will delay mold dev.
Sour rot (*Geotrichum candidum*)

- Soil borne disease, spread by water and wind
- Mandarins and mature oranges and Grft.
- Mechanical wound or insect damage
- Water soaked areas, clear yellow lesions
- Infection spreads to soft decaying area at 27°C
- Sour odor with decay and attracts fruit flies
- Spread the healthy fruit in packed cartons
Sour rot (*Geotrichum candidum*)

- **Control:**
  - limiting soil contact with fruit
  - limiting injuries
  - Delay harvest until normal turgidity
  - Sanitation with chlorine
  - Hold fruits below 10°C
Stem-End Rot

- *Phomopsis citri* Faw. and
- *Diplodia natalensis* Pole-Evans
- Most destructive fruit decay in FL
- Fungi colonize dead twigs and wood on the tree and dispersed by rain and wind to fruit.
- Diplodia - found in the core, stylar end
- Phomopsis- spreads through core and even rind pattern from the stem end without finger-like projections
Stem-End Rot

- It does not spread from fruit to fruit in packed cartons
- After harvest fungus grows from calyx into the fruit
- Diplodia - early season
- Phomopsis - late season
- Cultural practices to remove dead wood
- Harvesting by snapping
- Ethylene level should be optimum
Quarantine Treatments

• Citrus is a host for many fruit fly species
• A number of our markets have insect quarantine regulations regarding the importation of fruit from infested areas
Quarantine Treatments

• Currently approved quarantine treatments:
  – Cold treatment
  – Methyl Bromide Fumigation
  – Vapor Heat

• High-temperature forced-air (HTFA)
  – Modification of vapor heat
  – Approved for papayas (HI, Belize, Chile), Mex grapefruit and Mex mangos
HTFA Treatments

- Ramped: 35 to 48.5°C
- Stepped: 40°C for 120 min, 45°C for 90 min, 48.5°C
- Constant: 46°C for 230 min