Postharvest Handling for Quality and Freshness

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Transitions...UF/IFAS Extension’s role
What went wrong with this shipment???
Goal of Postharvest Technology

Minimize Losses in Postharvest Quality by Retarding Senescence and Decay

Worker removing unsalable produce at a supermarket:
Estimated Postharvest Losses of Fresh Produce in the USA

Current research has largely neglected system-wide produce losses but the estimates developed by the landmark study by NSF-RANN 35 years ago are believed by most industry experts to remain valid. That research developed broad ranges of losses at each stage of the distribution system but taken together reached as high as 16% of all fresh produce, which converts to more than $17 billion in 2009.

<table>
<thead>
<tr>
<th>Distribution Activity</th>
<th>Losses %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>2.80 – 5.00</td>
</tr>
<tr>
<td>Wholesaling</td>
<td>2.50 – 5.03</td>
</tr>
<tr>
<td>Retailing</td>
<td>2.74 – 6.58</td>
</tr>
<tr>
<td>System Losses</td>
<td>9.04 – 16.61</td>
</tr>
</tbody>
</table>

Percentage losses are based upon dollar values of losses in each phase of distribution as a percentage of the wholesale value of products entering the distribution system.

From: R. Cook, cited by Kader
Postharvest Losses of Fresh Produce

• Quantitative losses
• Qualitative losses
  – Loss of acceptability by consumers
  – Loss of caloric and nutritive value
  – Loss of edibility

From, A. Kader
POSTHARVEST PHYSIOLOGY

• Processes that affect produce quality
  – Respiratory activity
  – Ethylene production/sensitivity
  – Chilling sensitivity
  – Texture
  – Moisture loss susceptibility
  – Decay susceptibility
Fruits and Vegetables are Very Diverse

- Different morphological structures
- Composition
- Postharvest physiology
Postharvest Physiology

• Postharvest life is dependent upon:
  – Fruit and vegetable crop – each has different potential postharvest life
  – Quality at harvest
  – Maintaining quality after harvest starts with temperature control
Temperature Effects on Fruits and Vegetables:

• **Respiration Rate** – *For each 18°F (10°C) of cooling* it decreases by 1/2 to 2/3, increasing postharvest life by 2- to 3-fold

• **Ripening** – optimal at 68-75°F; lower temperatures extend postharvest life

• **Chilling injury** – Crops of tropical and subtropical origin are injured above freezing & below 41 to 59°F (5 to 15°C)
Temperature Effects on Respiration

- **Optimal Temperature for Respiration:**
  - Peaks from 77 to 86°F (25 to 30°C)

- **Freezing Point:**
  - 28 to 31.8°F (-2 to -0.1°C)

- **Thermal Death:**
  - 113 to 122°F (45 to 50°C)
Respiration

\[(\text{CH}_2\text{O})_6 + 6 \text{ O}_2 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + 673 \text{ Kcal}\]

Sugar + Oxygen → Carbon + Water + Heat
dioxide       energy

By Slowing Respiration, Postharvest Life is Extended
Respiration & Perishability

- Actively growing crops (leafy, stem, floral, immature fruit) have high metabolism
  - Very little stored energy reserves
  - Short postharvest life

- Mature crops (fruits, roots, tubers) have lower metabolism
  - Have starch, sugar and/or acid reserves
  - Longer postharvest life
Kader 2002.
Temperature Effects

Kader 2002.
Ethylene

- Ethylene:
  - Natural plant hormone – $\text{C}_2\text{H}_4$
  - Accelerates respiration and metabolism
  - Promotes ripening & senescence
  - Promotes development of abscission layer
  - Promotes chlorophyll metabolism (degreening in citrus)
Fruit Ripening

Kader 2002.
Climacteric Ripening Pattern – avocado

M. Pereira

Days after harvest (20°C)

- CO₂
- Ethylene

Ethylene evolution rate (uL C₂H₄.Kg⁻¹.h⁻¹)

Respiration rate (mg CO₂.Kg⁻¹.h⁻¹)
Nonclimacteric Ripening Pattern – carambola

Respiration Rate of Carambola at 20°C

Days after harvest at breaker stage

O. Warren
Ethylene:
commercial treatments

- **Avocado (‘Hass’ type)**
  - 10 to 100 ppm @ 63-68F (17-20C); 12 to 72 hr depending on harvest time

- **Banana**
  - 1,000 ppm @ 57-64F (14-18C); 4 to 8 days

- **Tomato**
  - 50 ppm @ 68-72F (20-22C); 1 to 3 days

- **Citrus degreening (non-climacteric)**
  - 5 ppm @ 82-85F (28-29C); 1 to 3 days (Florida)
Tomato Ripeness Stages

Tomato is typically harvested at mature-green stage (1)
U.S.D.A. Grade Standards

COLOR CLASSIFICATION REQUIREMENTS IN TOMATOES

1. "Green" means that the surface of the tomato is completely green in color. The shade of green color may vary from light to dark.

2. "Breakers" means that there is a definite break in color from green to tannish-yellow, pink or red on not more than 10 percent of the surface.

3. "Turning" means that more than 10 percent but not more than 30 percent of the surface, in the aggregate, shows a definite change in color from green to tannish-yellow, pink, red, or a combination thereof.

4. "Pink" means that more than 30 percent but not more than 60 percent of the surface, in the aggregate, shows pink or red color.

5. "Light red" means that more than 60 percent of the surface, in the aggregate, shows pinkish-red or red. Provided, that not more than 90 percent of the surface is red color; and,

6. "Red" means that more than 90 percent of the surface, in the aggregate, shows red color.

The above photographs are only guides illustrating the shade and percentage of surface color specified for each of the color terms. These photographs do not necessarily depict absolute limits of minimum or maximum shades and/or percentage of color required for each term.
Harvest Maturity: papaya
Harvest Maturity

Can be harvested at “color-break stage”
Nutritional Disorders

Blossom-end rot
Environmental Disorders

Gray Wall: Low light, wet weather conditions

Above: at harvest;
Right: after ripening
Brown heart / hollow heart in potato

Cool temperatures (<55F; 13C) during tuber formation
Temperature Management: Cool it fast & keep it cool!

- Lowering the temperature as quickly after harvest as possible:
  - Slows respiration and metabolism
  - Retains higher nutrient levels
  - Slows water loss
  - Inhibits microbial growth (< 41°F; 5°C)
    - Reduces decay
    - Minimizes food safety problems
Optimal Product Temperature

• There is an optimal postharvest temperature for every product
  – Optimal temperature = Lowest safe temperature to minimize metabolism

• The ideal postharvest temperature often depends on the geographical origin of the crop

• There is also an optimal ripening temperature for fruits for best quality
Temperature Effects on Horticultural Crops

- Temperate products should be kept at 32-37°F (0 to 3°C)
- Tropical/subtropical products should be kept at higher temperatures to avoid chilling injury
- All products are harmed by exposure to excessively high or low temperatures

Source: Postharvest Technology Center, U.C. Davis
Chilling Injury

• Three factors:
  1) Sensitivity of the crop
     • Most sensitive (13-15°C): e.g., banana, pineapple, sweetpotato
     • Moderately sensitive (8-12°C): e.g., avocado, grapefruit, cucumber, peppers
     • Less sensitive (4-7°C): e.g., oranges, tangerines, beans, muskmelons
  2) Exposure temperature
  3) Exposure time
Chilling Injury in the Field
Chilling Injury in the Field - avocado

‘Booth 8’; exposed to 0°C (Jan 2010)
Mango Chilling Injury

EXPERIMENT
6/30/99

CONTROL 10 MIN
2 WKS @ 3C+4D@20C

J.K. Brecht
Non-uniform ripening: guava
Thermal injury in mango
Freezing Injury
Sprouting
QUALITY MAINTENANCE: Harvest & Handling

Two primary concerns:

• Minimize mechanical injury

• Cool rapidly
Injuries Increase Respiration

- Mature-green tomatoes were dropped 12 inches

- Respiration and ethylene production increased and remained higher throughout ripening
Types of Mechanical Injury

**Bruises**
- **Impact:** Drops
- **Compression:** Excessive weight
- **E.g., for bell pepper:**
  - Avoid over-fertilizing
  - Harvest above 60°F (15°C)
  - Peppers softer in warmer seasons

**Cuts, Punctures, Abrasion**
Impact Bruises
Impact Injury
Accelerated ripening; decay
Abrasion at harvest
Abrasion at harvest/ apparent during storage
Harvest & Packing Operations

- **Field containers, packing area**
- **Minimize drop heights** (e.g., < 10 cm; 4 in. tomato)
- **Pad impact surfaces**
- **Keep all surfaces clean**
Harvest & Packing Operations
Harvest & Packing Operations

Other treatments include:

- **Washing/drying**
- **Waxing to reduce abrasions & water loss – e.g., cucumber**
- **Pack in specialized containers**
These containers look nice, but what about shipping quality??
Field Pack

Strawberries grown in the Dover FL area
Pony reefers were used to transport the strawberries to northern markets. These were actually two crates one built into the other. The outside crate held a layer of ice, and the inside crate held the fruit. Dec. 1926.

(Photo courtesy of GCREC-Dover, also called the Strawberry Lab.)
Wirebound Wooden Crate vs. Corrugated Carton
Reusable Plastic Containers (RPC’s)
Display Carton
Temperature Management begins in the field

Strawberries waiting to be transported to be cooled
Cooling Principles

• **Determine optimal conditions**
  – *Storage temperature; relative humidity*
  – *Cooling method; atmosphere*

• **Rapid Cool within a few hours of harvest** *(7/8 Cooling)*

• **Cool efficiently**
Cooling delays can lower postharvest quality

Strawberries cooled within 2 or 4 hours had better quality after 1 week of storage than those with a 6-hour delay to cooling

• Significantly softer, more shriveled, less attractive color
• Lower SSC, acidity, and Vitamin C levels

Nunes et al., 1995
Cooling rate is determined by the 3 T’s:

- **Time** of exposure to the cooling medium
  - Longer = cooler

- **Temperature** of the cooling medium
  - Lower = faster

- **Turbulence** (contact & mixing)
  - More = faster, more uniform
In-room Cooling & Packing
Forced-air cooling tunnel: Blower/chiller unit
Forced-air cooling:
Forming the tunnel with 2 rows of pallets
Cold room air is pulled through cartons to block openings at pallet bases.
In-room

Portable Forced-air coolers

Small truck retrofit
Immersion Hydrocooling - lychees
Package Icing
Vacuum Cooling
Once cooled, keep it cool!

Load and unload directly from the cold room
Maintaining the “Cold Chain” during Shipping

Properly load the refrigerated trailer; keep pallets away from sidewalls.
In Summary: Quality Maintenance

- Consider crop physiology
- Minimize mechanical injury
- Cool quickly and thoroughly