Basic Postharvest Handling Methods

Kostas Batziakas, Cary Rivard, Eleni Pliakoni
Department of Horticulture and Natural Resources,
Kansas State University
What is postharvest handling?

By definition: Postharvest = After Harvest

**BUT**

It is strongly related:

**Pre-harvest** factors because they strongly influence postharvest quality (quality is set during growth)

**Harvest** of the crop (e.g., when & how to harvest; maturity standards)

Optimum product quality is determined at **harvest**
Fruits & Vegetables are ALIVE!
Characteristics of perishable commodities

- Living tissues
- High in water content
- Subject to pathological breakdown
- Very diverse in:
  - Morphological structure
  - Composition
  - General physiology

- All different kinds of plant organs in various developmental stages
Diversity of Fresh Produce

- **Root**
  e.g. beet, carrot, radish

- **Tuberous Root**
  e.g. sweet potato

- **Tuber**
  e.g. potato

- **Bulb**
  e.g. garlic, onion

- **Flower**
  e.g. broccoli, artichoke, cauliflower
Diversity of Fresh Produce

• Leaf
e.g. spinach, lettuce, kale

• Stem
e.g. celery, asparagus, rhubarb

• Immature vegetable
e.g. cucumber, snap beans, eggplant

• Mature vegetable or fruit
e.g. tomato, apples, citrus
Factors influencing postharvest loss

<table>
<thead>
<tr>
<th>Internal factors</th>
<th>Environmental factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Metabolic rate (respiration)</td>
<td>• Temperature</td>
</tr>
<tr>
<td>• Compositional changes</td>
<td>• Humidity</td>
</tr>
<tr>
<td>• Morphological changes</td>
<td>• Physical damage</td>
</tr>
<tr>
<td>• Physiological disorders</td>
<td>• Pathogens</td>
</tr>
<tr>
<td>• General senescence</td>
<td>• Pests</td>
</tr>
<tr>
<td></td>
<td>• Contamination</td>
</tr>
</tbody>
</table>
Fruits & Vegetables are ALIVE!

Ongoing Metabolic Activity

\[
\text{Sugar} + \text{O}_2 \rightarrow \text{CO}_2 + \text{Water}
\]

Energy

HEAT
Horticultural commodities classified according to respiration rate

(Modified from Kader, 2002)

<table>
<thead>
<tr>
<th>Class</th>
<th>Range at 41°F (mg CO₂/kg·hr)*</th>
<th>Commodity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>5&lt;</td>
<td>Nuts, dates</td>
</tr>
<tr>
<td>Low</td>
<td>5-10</td>
<td>Apple, beet, celery, cranberry, garlic, grape, honeydew melon, onion, potato (mature), sweet potato, watermelon</td>
</tr>
<tr>
<td>Moderate</td>
<td>10-20</td>
<td>Apricot, banana, blueberry, cabbage, cantaloupe, carrot (topped), celeriac, cherry, cucumber, fig, gooseberry, lettuce (head), nectarine, olive, peach, pear, pepper, plum, potato (immature), radish (topped), summer squash, tomato</td>
</tr>
<tr>
<td>High</td>
<td>20-40</td>
<td>Blackberry, carrot (with tops), cauliflower, leeks, lettuce (leaf), lima bean, radish (with tops), raspberry, strawberry</td>
</tr>
<tr>
<td>Very high</td>
<td>40-60</td>
<td>Artichoke, bean sprouts, broccoli, Brussels sprouts, endive, green onions, kale, okra, snap bean</td>
</tr>
<tr>
<td>Extremely high</td>
<td>&gt;60</td>
<td>Asparagus, mushroom, parsley, peas, spinach, sweet corn</td>
</tr>
</tbody>
</table>

### Energy/ heat production at various storage temperatures

<table>
<thead>
<tr>
<th>Commodity</th>
<th>32°F</th>
<th>41°F</th>
<th>70°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blueberries</td>
<td>500 - 2,300</td>
<td>2,000 - 2,700</td>
<td>11,400 - 19,200</td>
</tr>
<tr>
<td>Broccoli</td>
<td>4,000 - 4,700</td>
<td>7,600 - 35,200</td>
<td>61,200 - 75,000</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1,000 - 1,400</td>
<td>1,700 - 2,700</td>
<td>6,100 - 10,800</td>
</tr>
<tr>
<td>Muskmelon</td>
<td>- - -</td>
<td>1,900 - 2,200</td>
<td>9,800 - 14,200</td>
</tr>
<tr>
<td>Strawberries</td>
<td>2,700 - 3,900</td>
<td>3,600 - 7,300</td>
<td>37,200 - 46,400</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>6,600 - 11,300</td>
<td>9,400 - 18,300</td>
<td>59,000 - 68,400</td>
</tr>
</tbody>
</table>

Source: Penn State Extension
FRESH PRODUCE IS AN AGING LIVING TISSUE

Postharvest Handling GOAL:
Slow down the aging process!

Temperature

Temperature is the most **CRITICAL** factor influencing the postharvest life.

Dictates the speed of biological/chemical reactions

- Respiration
- Ethylene Production
- Water loss
- Senescence

Typically, for every 18 °F increase, respiration increases **2 - 4 times**
Temperature effect on the quality of broccoli after 48 hours of storage at room temperature (75 °F) or in refrigeration (40 °F)
Precooling the Produce

• Removing the “field heat” is crucial

• **Field Heat**: Difference between the temperature of the crop at harvest and its optimum storage temperature

• Field heat should be removed rapidly

e.g. Strawberries: 1 hour at field temperature (90 °F) equivalent effect with 1 week at (32 °F)
Precooling the Produce

- Air cooling
  - Room
  - Forced-air
- Hydrocooling
- Ice Cooling
  - Top icing
  - Package icing
- Vacuum Cooling
Maintaining the Cold Chain for Perishables

Harvest
- Protect the product from the sun
- Transport quickly to the packinghouse

Cooling
- Minimize delays before cooling
- Cool the product thoroughly as soon as possible

Temporary Storage
- Store the product at optimum temperature
- Practice first in first out rotation
- Ship to market as soon as possible

Transport to Market
- Use refrigerated loading area
- Cool truck before loading
- Load pallets towards the center of the truck
- Put insulating plastic strips inside door of reefer if truck makes multiple stops
- Avoid delays during transport
- Monitor product temperature during transport

Handling at destination
- Use a refrigerated unloading area
- Measure product temperature
- Move product quickly to the proper storage area
- Transport to retail markets or foodservice operations in refrigerated trucks
- Display at proper temperature range

Handling at home or foodservice outlet
- Store product at proper temperature
- Use the product as soon as possible
Temperature Related Physiological Disorders

Chilling Injury

• Occurs mainly in tropical and subtropical species when exposed to low but non-freezing temperatures

• Chilling injury reduces the quality of the product and shortens shelf life

  – Irregular ripening / failure to ripe
  – Pitting
  – Increased susceptibility to decay
  – Brown discoloration
  – Off-flavors
  – Softening

• Symptoms often appear only after the commodity is exposed to warmer temperatures
Chilling injury on Caribe chiles

Photo was taken after transferring the chiles to 68°F for 5 days following storage at 36, 40, or 50°F for 30 days.

Picture: http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=12&ds=799
45 °F
snap bean, eggplant, cucumber, melon, pepper

50 °F
Pumpkin, Squash

Chilling Injury
Chilling Injury of Tomatoes

45-50 °F: ripe tomatoes
55 °F: mature green tomatoes
The shelf life of chilling and non-chilling sensitive produce

Source: Cornell University extension
Temperature Related Physiological Disorders

Heat Injury

- Occurs when the crop tissue is heated above the thermal death point of the cells

- Symptoms:
  - Localized bleaching / burning
  - Necrosis
  - General collapse
  - Irregular ripening

Figures:

33 °F 50 °F 70 °F 88 °F 105 °F

Water Loss

• Direct loss of **Salable Weight**

• Important source of **Quality Loss**

  – Appearance ➔ wilting, shriveling, accelerated development of injury symptoms
  – Texture ➔ loss of crispness, juiciness, etc.
  – Nutritional quality ➔ loss of vitamins A & C
% Water loss that results in unmarketable product

- Asparagus 8%
- Cabbage 7%
- Celery 5%
- Lettuce 3%
- Spinach 3%
How we prevent water loss

• Control relative humidity

• Lower temperature

• Reduce air movement

• Protective packaging
Reducing Water Loss
Reducing Water Loss
The Commodity & Its Environment

Temperature
Humidity
Oxygen
Carbon Dioxide
Ethylene
Modified Atmosphere

“The practice of changing the composition of the internal atmosphere of a produce bag/tray”

**Air:** 20.95% $O_2$ & 0.04% $CO_2$

MAP typically aims in an atmosphere with:

- Reduced $O_2$
- Increased $CO_2$

$\downarrow$ Respiration Rate $\downarrow$ Metabolism

**e.g. MAP for Spinach:** 3% $O_2$ & 10% $CO_2$ at 36°F(Suslow & Cantwell, 1998)

http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=32&ds=799
Passive MAP: Atmosphere is modified by product respiration rate & gas permeability of the packaging film
Ethylene & Quality

• Regulates growth & development, senescence

• Different ethylene production patterns amongst commodities
  – Climacteric & non-climacteric crops

• Sensitive & non-sensitive crops

• Beneficial and detrimental effect

• Active at very low concentrations (ppm)

• Low temperatures slow down production
<table>
<thead>
<tr>
<th>Class</th>
<th>Production rate at 68°F (μl C₂H₄/kg·hr)</th>
<th>Commodities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Less than 0.1</td>
<td>Artichoke, asparagus, cauliflower, cherry, citrus fruits, grape, strawberry, pomegranate, leafy vegetables, root vegetables, potato, most cut flowers</td>
</tr>
<tr>
<td>Low</td>
<td>0.1-1.0</td>
<td>Blackberry, blueberry, casaba melon, cranberry, cucumber, eggplant, okra, pepper, pumpkin, raspberry, watermelon</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.0-10</td>
<td>Banana, fig, honeydew melon, tomato</td>
</tr>
<tr>
<td>High</td>
<td>10-100</td>
<td>Apple, apricot, cantaloupe, kiwifruit (ripe), nectarine, peach, pear, plum</td>
</tr>
<tr>
<td>Very High</td>
<td>More than 100</td>
<td>Cherimoya, passion fruit</td>
</tr>
</tbody>
</table>

Climacteric & non-climacteric Commodities

- Climacteric crops: peak in CO$_2$ and ethylene production during ripening

- Non-climacteric: relatively stable CO$_2$ production rate and negligible amount of ethylene production

**Practical application**

Harvesting climacteric crops on the onset of ripening & blocking ethylene production up to the time the crops are sold
# Climacteric & non-climacteric Commodities

<table>
<thead>
<tr>
<th>Climacteric crops</th>
<th>Non-climacteric crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple, Apricot, Blueberry, Muskmelon, Nectarine, Peach, Pear, Plum, Tomato</td>
<td>Artichoke, Asparagus, Blackberry, Broccoli, Cabbage, Carrot Cherry, Cranberry, Cucumber, Eggplant, Grape, Lettuce, Pea, Pepper, Raspberry, Spinach, Strawberry, Summer Squash, Watermelon</td>
</tr>
</tbody>
</table>
Ethylene sensitive

- Leafy Greens  
  - e.g. Spinach, Lettuce
- Brassicas  
  - e.g. Broccoli, Cabbage
- Root Vegetables  
  - e.g. Potato, onion
- Fruits  
  - e.g. Apple, pear, cantaloupe
- Flowers  
  - e.g. Carnation

Detrimental Effect  
- Yellowing  
- Internal Browning  
- Lignification  
- Sprouting  
- Off flavor

Picture: UC Davis Postharvest Technology
Ethylene Induced Yellowing of Broccoli
Russet Spotting
Removing Ethylene

- Scrubbers
- Filters/ filtration system
- Separate storage
Physical/Mechanical Damage

- Causes the greatest amount of loss to fresh horticultural products

- Affects:
  - Water loss
  - Respiration, ethylene production, ripening, and other metabolic processes
  - Pathogen growth and ability to invade tissue
  - Tissue discoloration

Picture: UC Davis Postharvest Technology
Pepper Mechanical Injury
Melon Internal Bruising

Photos courtesy of Steve Sargent
Pathological Breakdown (decay)

- Fungi, bacteria & viruses
- Preharvest (latent) and postharvest infections
- Most postharvest infections are a result of breaks in the epidermis of the commodity

Picture: UC Davis Postharvest Technology
Handling Tips

Harvest

• Pick early in AM
• Harvest at proper maturity
• Gentle & sanitary picking
• Use clean totes/buckets

IF YOU USE HIRED LABOR
TRAIN THE WORKERS
Handling Tips

Harvest

- Do not overfill totes/buckets
- Use sharp & clean tools
- Discard damaged produce
- Pick clean crops
- Shade

IF YOU USE HIRED LABOR
TRAIN THE WORKERS
Handling Tips

Transportation from the field

- Allow airflow between containers
- Cool down ASAP
- Maintain the cold chain
- Shade vehicle
- Grade roads

The “KoolKat” mobile refrigerated unit, of K-state Olathe Horticulture Research and Extension Center
Handling Tips

Cleaning/shorting

• Remove unmarketable produce as soon as possible

• Clean & Sanitary operation and tools

• Washing can be combined with cooling
  – Keep water clean & cold

• Use appropriate cleaning method
  – Not all commodities should washed

Do Not Wash
Tomatoes
Berries
Green Beans
Cabbage
Peas
Pepper
Handling Tips

Packing & Storage

• Use appropriate packing material
• Pack produce in same maturity stage
• Do not pack overripe or damaged produce
• Store in the optimum temperature and Humidity
  
  – 2 cooling rooms available: 1st 32-36°F  
  2nd 50-57°F

  – 1 cooling room available: 41°F  
  & chilling sensitive kept in a room with AC
### Handling Tips

#### Packing & Storage

Some crops need curing!

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>°F</td>
<td>(%)</td>
</tr>
<tr>
<td>Potato</td>
<td>15-20</td>
<td>59-68</td>
<td>90-95</td>
</tr>
<tr>
<td>Sweetpotato</td>
<td>30-32</td>
<td>86-90</td>
<td>85-90</td>
</tr>
<tr>
<td>Yarns</td>
<td>32-40</td>
<td>90-104</td>
<td>90-100</td>
</tr>
<tr>
<td>Cassava</td>
<td>30-40</td>
<td>86-104</td>
<td>90-95</td>
</tr>
</tbody>
</table>
Keys To Success In Postharvest Handling Of Fruits and Vegetables

1. Highest Initial Quality/Proper Maturity
2. Minimize rough Handling to Minimize Physical Damage
3. Sorting to remove damaged and diseased produce
4. Management of Environmental Conditions:
   – Temperature
   – Relative Humidity
   – Atmospheric Composition ($O_2$, $CO_2$, $C_2H_4$)
   – Ventilation
5. Proper Sanitation Procedures
Resources

Postharvest Technology Center
http://postharvest.ucdavis.edu/

Small-Scale Postharvest Handling Practices: A manual for Horticultural Crops

Production Guide for Storage of Organic Fruits and Vegetables
https://ecommons.cornell.edu/bitstream/handle/1813/42885/organic-stored-fruit-veg-NYSIPM.pdf?sequence=1

Post Harvest Handling Decision Tool

Wholesale Success: A farmers guide to food safety, selling, postharvest Handling and packaging produce
Thank you for your attention!

QUESTIONS?