What is Postharvest Biology?

- A Pragmatic (practical) science
- Primarily deals with Perishable Commodities
- **By definition**: Postharvest = After Harvest
  - Also concerned with preharvest factors (seed source, rootstock, etc.) because they strongly influence postharvest quality. Fruit quality is set during growth.
  - & the harvest of the crop (e.g. when & how to harvest; maturity standards)
- Ultimately, maximum product quality is determined (fixed) at harvest

Postharvest Goals

- Harvest commodities at their **optimum maturity**
- Maintain the commodity’s internal and external **quality** throughout harvest, packing, storage and distribution. Remember, it is **Alive** during this process
- Deliver the commodity to consumers at the **time and in a form (e.g. ripe, cut up, etc.) that they will purchase**

Historical Background

- Early postharvest practices:
  - Dried fruits, vegetables, meats, etc.
  - Fermentation of juices
  - Salting or smoking
  - Canning
- **All these methods KILL the product** => product is easier to transport and store
Historical Background

- Postharvest issues became more important when cities developed (urbanization)
  - The Industrial Revolution (18th century)
  - The Problem: How to deliver (quality) fresh fruits and vegetables from areas of production to areas of consumption
- All fresh produce is alive => A Challenge to Keep Healthy Until Consumed!

World-Wide Perspective

- Food distribution is the main worldwide problems
  - Urbanization expected to continue at a greater rate in developing countries
  - Produce grown in these areas are the least studied
- Worldwide production (2001):
  - Cereals (durable food goods) = ~2.8 billion MT
  - Fruits, Vegetables, Melons, Roots & Tubers = ~2.6 billion MT

Characteristics of Perishable Commodities

- Compared to grains:
  - More subject to deterioration after harvest (shelf life days to months vs. > 1 yr)
  - Relatively larger in size (up to 5 kg vs. < 1 g)
  - Soft textured
  - Higher water content (70 to 90% vs. 10 to 20%)
  - Higher respiration and heat production

Estimated Postharvest Losses (%) of Fresh Produce (A. Kader)

<table>
<thead>
<tr>
<th>Locations</th>
<th>Developed countries</th>
<th>Developing countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>From production to retail sites</td>
<td>2-23 12</td>
<td>5-50 25</td>
</tr>
<tr>
<td>At retail, foodservice, and consumer sites</td>
<td>5-30 20</td>
<td>2-20 10</td>
</tr>
<tr>
<td>Cumulative total</td>
<td>7-53 32</td>
<td>7-70 32</td>
</tr>
</tbody>
</table>

Loss of product = much more than just the cost of the commodity

Causes of Postharvest Loss

Internal Factors

- Respiration (metabolism)
- Compositional changes
- Morphological changes
- Physiological disorders
- General senescence

Environmental Factors

- Temperature
- Physical damage
- Pathogens
- Relative humidity
- Atmospheric composition
- Light
- Gravity
- Rodents and other animals
- Contamination
Fresh Commodities Are Still ALIVE!

- They carry out respiration:
  
  \[ \text{Sugar} + \text{O}_2 \rightarrow \text{CO}_2 + \text{Water} + \text{Energy} + \text{Heat} \]

Respiration and Shelf Life

- Respiration rate is inversely related to shelf life.
- Higher respiration \(\Rightarrow\) Shorter Shelf Life

Respiration & Temperature

- Temperature is the most important factor influencing the postharvest life of a given commodity
  - Dictates the speed of chemical reactions (including respiration)
  - Typically, for every 18 °F (10 °C) increase, respiration increases between 2 and 4 fold

Example

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Shelf-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>33</td>
</tr>
<tr>
<td>68</td>
<td>13</td>
</tr>
<tr>
<td>86</td>
<td>7</td>
</tr>
<tr>
<td>104</td>
<td>4</td>
</tr>
</tbody>
</table>

Compositional Changes

- Water loss
- Nutrients
- Vitamins
- Antioxidants
- Starch \(\leftrightarrow\) Sugar
- Etc.

Affect of temperature on the quality of broccoli after just 48 h of storage at either room temperature (75°F) or in the refrigerator (40°F)
Water Loss

- Besides resulting in direct loss of salable weight, it is also an important source of quality loss
  - Appearance quality - wilting, shriveling, accelerated development of injuries
  - Textural quality - loss of crispness, juiciness, etc.
  - Nutritional quality - e.g. vitamins A & C
- Rate of water loss influenced by:
  - Environmental factors - e.g. relative humidity
  - Anatomical factors - stomates, hairs, etc.

Morphological Changes
(Form & Structure)

- Because horticultural commodities are living (and sometimes still growing) they often continue development in ways that sometimes detract in quality. Changes include:
  - Sprouting (onions, tubers, root crops)
  - Rooting (onions, root crops)
  - Elongation & Curvature (asparagus, gladiolus)
  - Seed Germination (tomato, pepper, grapefruit)

Physiological Disorders

- Definition:
  - "Tissue damage or breakdown not related to pathogens, insects or mechanical damage."

- Temperature
  - High temperature injury, freezing injury, or chilling injury
- Altered atmospheric gas concentrations
  - Low O₂ or Elevated CO₂
- Nutrition
  - E.g. calcium deficiency or boron toxicity
Stem-end rind breakdown

Chilling Injury
- Physiological injury to some commodities when held at temperatures above freezing
- Susceptible crops include:
  - Avocado
  - Banana
  - Cherimoya
  - Citrus
  - Feijoa
  - Guava
  - Jujube
  - Mango
  - Olive
  - Papaya
  - Passion fruit
  - Pineapple
  - Plantain
  - Pomegranate
  - Sapote
  - Cucumber
  - Eggplant
  - Okra
  - Pepper
  - Sweet Potato
  - Tomato

Chilling Injury:
- Occurs mainly in commodities from subtropical & tropical origins
- Injury caused by exposing fruit to temperatures above freezing but below between about 41 to 59 °F (5 to 15 °C)
- Injury becomes more noticeable after transferring to non-chilling temperatures

Chilling Injury Symptoms Include
- Surface pitting
- Discoloration (external/internal)
- Water-soaked areas
- Necrotic areas
- Failure to ripen
- Greater susceptibility to decay
- & others

Causes of Postharvest Loss

Environmental Factors
- Temperature
- Physical damage
- Pathogens
- Relative humidity
- Atmospheric composition
- Light
- Gravity
- Rodents and other animals
- Contamination
Temperature

- Mentioned above with respiration and physiological disorders
- Temperature greatly effects water loss.
- Lower temperature also slows pathogen (human and plant) development.

Physical Damage

- Causes the greatest amount of loss to fresh horticultural products
- Affects (among other things):
  - Respiration, ethylene production, ripening, and other metabolic processes.
  - Pathogen growth and ability to invade tissue
  - Tissue discoloration

Pathology (decay)

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

Relative Humidity

- Higher relative humidity slows water loss from the commodity
- High relative humidities (e.g. 95 to 100%) can weaken cartons
- Free moisture stimulates pathogen development

Atmospheric Composition

Modified or Controlled Atmospheres

- Modified Atmospheres (MA)
  - Altering the normal gas composition surrounding a commodity (e.g. raising or lowering $O_2$ or $CO_2$ concentrations).
  - Passive. The commodity is placed in a gas impermeable container and the crop's respiration consumes (lowers) $O_2$ and gives off (increases) $CO_2$.
- Controlled Atmospheres (CA)
  - Same as MA, except gas concentrations are actively regulated using special equipment.
Modified Atmospheres

Potential Advantages
- Slows down respiration and other metabolic processes (e.g., ripening & senescence)
- Reduces sensitivity to ethylene (at < 8% O₂ or >1% CO₂)
- Reduces development of some physiological disorders (e.g., chilling injury)
- Can inhibit pathogen development
- Can be used to kill insects

Potential Disadvantages
- Can cause or exacerbate some physiological disorders (e.g., black heart in potatoes)
- Can cause irregular ripening
- Can result in off-flavors or odors if anaerobic respiration occurs
- Any MA or CA related injuries stimulate pathogen development
- May delay periderm development and stimulate sprouting in root or tuber crops

Causes of Postharvest Loss
Environmental Factors
- Light
  - Color and morphological changes (e.g., potato greening)
- Gravity
  - Morphological changes (e.g., bending)
- Rodents and other animals
- Contamination (food safety)

Commercial Considerations
- Preharvest factors:
  - Cultivars & Molecular Biology
  - Nutrition & Water effects
  - Weather conditions (temperature, humidity, etc.)
  - Field sanitation (both for decay & human pathogens)

Commercial Considerations
- Harvesting:
  - Is everything ready for arrival of the harvested product?
    - Labor to harvest, grade, pack, ship, etc.
    - Materials to wash, coat, label, pack, ship, etc.
  - Best time to harvest for fresh, processing, storage?
    - Use of harvest aids
Commercial Considerations

• Preliminary grading in the field:
  – Remove unmarketable produce as soon as possible

• Packingline operations:
  – Washing, grading, sorting, sizing, waxing, etc.
  – Each step costs $$. Use only if increases value of the crop

• Packaging:
  – Protects the product, reduces water loss, orients the product, excludes light & communicates information
  – Must be economic, able to support stacking, allow ventilation (cooling), facilitate recycling or disposal at destination markets

• Postharvest Maturation:
  – Ethylene degreening or ripening
  – Curing
Commercial Considerations

• Rapid cooling:
  – Air cooling
  – Room
  – Forced-air
  – Hydrocooling
  – Ice Cooling
    • Top icing
    • Liquid ice injection
  – Vacuum Cooling

• Storage:
  – Only increases the cost of a product
  – Accurate temperature and RH control critical
  – CA or MA storage

• Transportation:
  – Water – inexpensive but slow
  – Rail – more expensive but faster
  – Truck – predominant method. Fast & reliable
  – Air – Fastest, expensive, & inconsistent scheduling and temperature control

• Marketing:
  – Identify markets and qualities desired
  – Entire process should be geared to deliver what the consumer will buy

• Retailing:
  – Educate the retailer how to handle your commodity
  – Continuation of the temperature, RH and sanitation chain
  – Reconditioning?