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

- Early Storage Practices:
  - Basket making developed by 7,000 B.C.
  - Underground pits and silos - 9,000 B.C. By Roman times, silos were the major means of long term storage
  - Roman era - modified atmosphere storage of grains
  - Ice refrigeration developed in 1803
  - 1855 & 59, mechanical refrigeration invented
Historical Background

• Early Storage Practices Continued:
  – 1872, ice refrigerated rail cars common
  – 1889 ammonia refrigeration widely used to make ice
  – 1928, mechanical refrigerated displays used in retail stores
  – 1891, first MA studies
  – CA studies begun in 1927
  – 1929, commercial CA storage built in England

• 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

• World population has reached 7.59 billion
• Technological advances have helped us feed much of the world
  – E.g. China, India & Brazil
• Many parts of the world still in need
  – Western style, capitol intensive methods often not suitable for an area
  – Advances have resulted in some problems (e.g. Egypt's Aswan High Dam, Calif. Central Valley)

• 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 (2017):
  – Cereals (durable food goods) = ~3.02 billion MT
  – Fruits, Vegetables, Melons, Roots & Tubers = ~2.76 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

Postharvest Losses

• Only very rough estimates are available
  – 5 to 25% in developed countries
  – 20 to 50% in developing countries
• In the US, a large portion of loss occurs at the consumer level = Waste
• Loss of product = much more that just the cost of the commodity
Other Losses

- Loss of energy & labor (e.g. during packinghouse operations)
- Loss of materials (e.g. packaging)
- Cost of reconditioning
- Cost of waste disposal

Other Losses

- Loss of food value (e.g. nutrients)
- Loss of organoleptic quality
  - Color changes
  - Water loss
  - Carbohydrate changes (e.g. sugar to starch conversion)
  - Volatile changes
  - Breakdown of proteins, cell wall components, softening, etc.

Causes of Postharvest Loss

Internal Factors

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

Causes of Postharvest Loss

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 => 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>
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<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 ➔ Sugar
- Etc.

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

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 affects 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%) can weaken cartons
- Free moisture stimulates pathogen development

Atmospheric Composition
Modified or Controlled Atmospheres
- Altering the normal gas composition surrounding a commodity (e.g. raising or lowering $O_2$ or $CO_2$ concentrations)
- Modified Atmospheres (MA)
  - 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

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
Commercial Considerations

- 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

- 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?