Postharvest Losses, Physiology and Quality of Horticultural Crops

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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

Characteristics of Perishable Commodities
• Compared to grains:
  – More subject to deterioration after harvest (shelf life days to months vs. > 1yr)
  – 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

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

  \[ \Rightarrow \text{Shorter Shelf Life} \]

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

Temperature effects on shelf-life

<table>
<thead>
<tr>
<th>Temperature °C (°F)</th>
<th>Q_m</th>
<th>Deterioration</th>
<th>Shelf-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (32)</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>10 (50)</td>
<td>3</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>20 (68)</td>
<td>2.5</td>
<td>7.5</td>
<td>13</td>
</tr>
<tr>
<td>30 (86)</td>
<td>2</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>40 (104)</td>
<td>1.5</td>
<td>22.5</td>
<td>4</td>
</tr>
</tbody>
</table>

Compositional Changes

- Water loss
- Nutrients
- Vitamins
- Antioxidants
- Starch ⇔ 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
(Structure & Form)

- 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

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

- 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
Commercial Considerations

- **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

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Commercial Considerations

- **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?