Principles of Postharvest Horticulture

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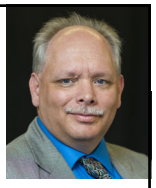
Postharvest Deterioration and Losses



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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

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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

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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

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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

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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
  - 1819, first MA studies
  - CA studies begun in 1927
  - 1929, commercial CA storage built in England

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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!

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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)

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

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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

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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

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Other Losses

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

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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.

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Causes of Postharvest Loss

Internal Factors

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

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Causes of Postharvest Loss

Environmental Factors

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

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Fresh Commodities Are Still ALIVE!

- They carry out respiration:

Sugar + O_2 =>

CO_2 + Water + Energy + 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

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Example

Temperature (°F)	Shelf-Life
32	100
50	33
68	13
86	7
104	4

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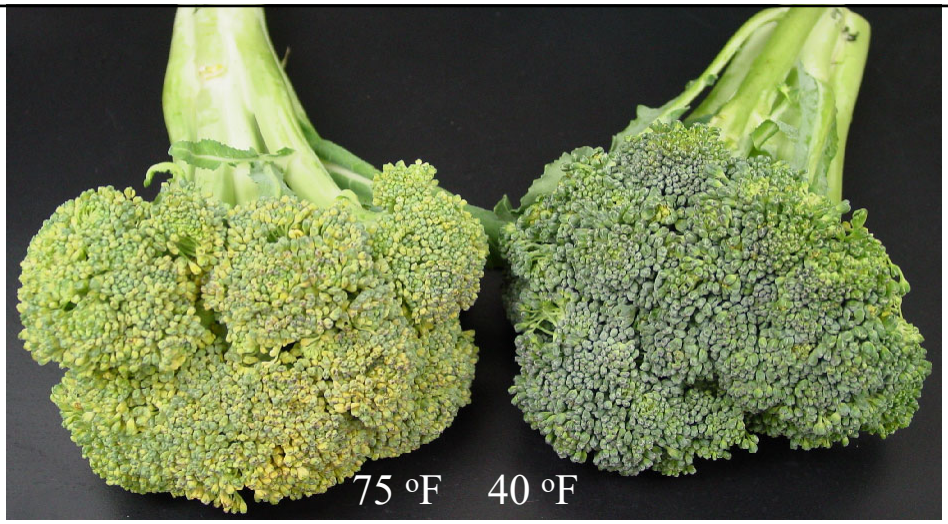

Affect of temperature on the quality of broccoli after just 48 h of storage at either room temperature (75°F) or in the refrigerator (40°F)

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Compositional Changes

- Water loss
- Nutrients
- Vitamins
- Antioxidants
- Starch ⇔ Sugar
- Etc.

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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.

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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)

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Physiological Disorders

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

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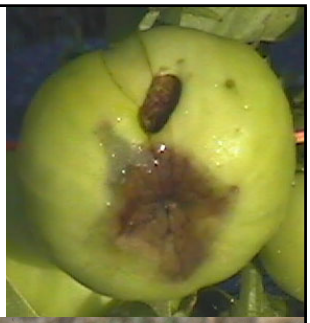
Physiological Disorders

- Temperature
  - High temperature injury, freezing injury, or chilling injury
- Altered atmospheric gas concentrations
  - Low O_2 or Elevated CO_2
- Nutrition
  - E.g. calcium deficiency or boron toxicity



Photos courtesy of Steve Sargent

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Causes of Postharvest Loss

Environmental Factors

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

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Temperature

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

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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

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Pathology (decay)

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

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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

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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

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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)

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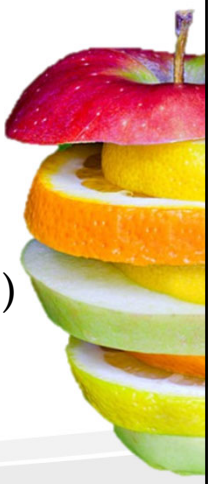
Commercial Considerations

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



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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

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Commercial Considerations

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

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Commercial Considerations

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

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Commercial Considerations

- 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

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Commercial Considerations

- Postharvest Maturation:
  - Ethylene degreening or ripening
  - Curing

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Commercial Considerations

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

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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?

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