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

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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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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

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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

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Respiration and Shelf Life

- Respiration rate is inversely related to shelf life.

Higher respiration

=> Shorter Shelf Life

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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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Temperature effects on shelf-life

Temperature °C (°F)	Q_{10}	Deterioration	Shelf-Life
0 (32)		1	100
10 (50)	3	3	33
20 (68)	2.5	7.5	13
30 (86)	2	15	7
40 (104)	1.5	22.5	4

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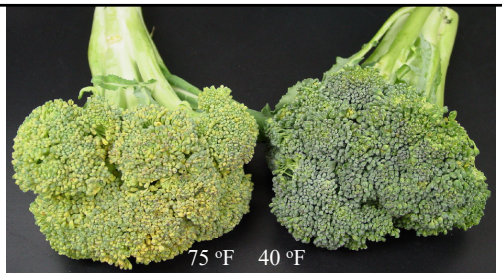

Affect of temperature on the quality of broccoli after just 48 h of storage at either room temperature (75°F) or in the refrigerator (40°F)

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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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Courtesy of Steve Sargent

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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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Stem-end rind breakdown

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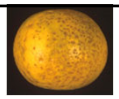
Chilling Injury



- Physiological injury to some commodities when held at temperatures above freezing
- Susceptible crops include:

Avocado	Mango	Sapote
Banana	Olive	Cucumber
Cherimoya	Papaya	Eggplant
Citrus	Passion fruit	Okra
Feijoa	Pineapple	Pepper
Guava	Plantain	Sweet Potato
Jujube	Pomegranate	**Tomato**

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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

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Chilling Injury Symptoms Include

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

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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

Photo courtesy of Steve Sargent

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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 to 100%) can weaken cartons
- Free moisture stimulates pathogen development

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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

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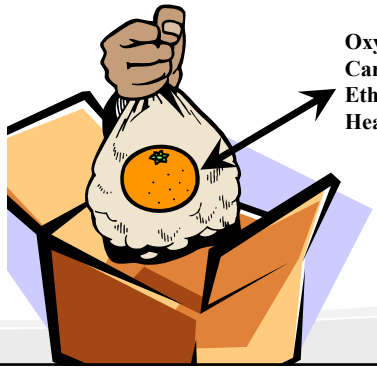

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Modified Atmospheres



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Potential Advantages

- Slows down respiration and other metabolic processes (e.g., ripening & senescence)
- Reduces sensitivity to ethylene (at < 8% O_2 or >1% CO_2
- Reduces development of some physiological disorders (e.g., chilling injury)
- Can inhibit pathogen development
- Can be used to kill insects

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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

Photo courtesy of Steve Sargent

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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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