Basic Postharvest Handling Methods

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What is postharvest handling?

By definition: Postharvest = After Harvest

BUT

It is strongly related:

Pre-harvest factors because they strongly influence postharvest quality (quality is set during growth)

Harvest of the crop (e.g., when & how to harvest; maturity standards)

Optimum product quality is determined at **harvest**

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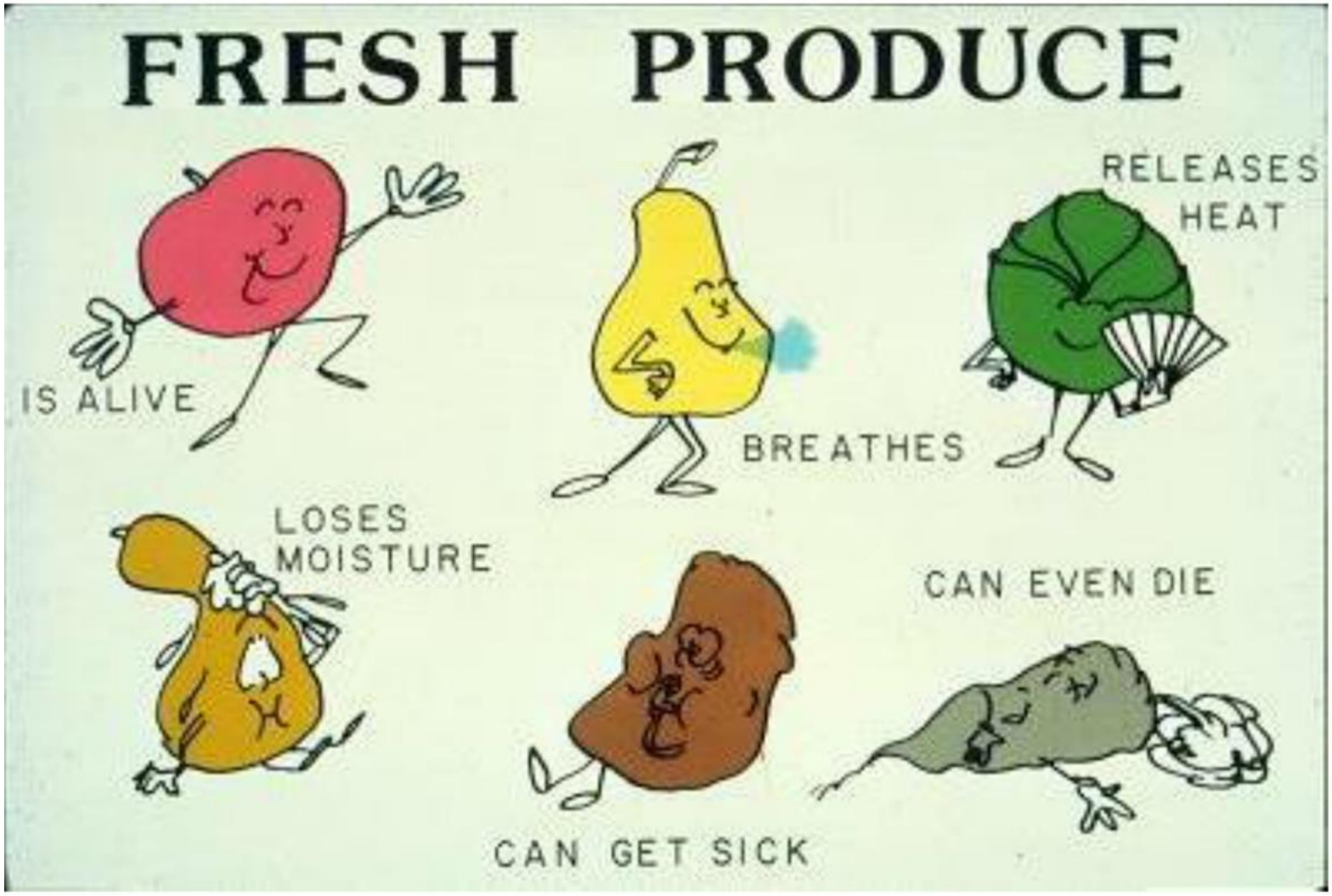
Fruits & Vegetables are ALIVE!



Characteristics of perishable commodities

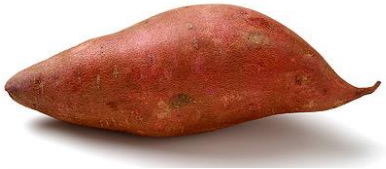
- Living tissues
- High in water content
- Subject to pathological breakdown
- Very diverse in:
  - Morphological structure
  - Composition
  - General physiology

- All different kinds of *plant organs* in various *developmental stages*

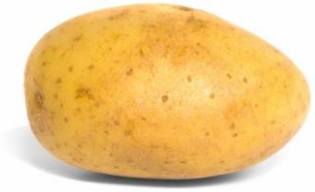
Diversity of Fresh Produce

- Root
  e.g. beet, carrot, radish

- Tuberous Root
  e.g. sweet potato



- Tuber
  e.g. potato



- Bulb
  e.g. garlic, onion

- Flower
  e.g. broccoli, artichoke, cauliflower

Diversity of Fresh Produce

- Leaf

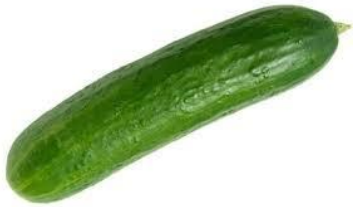
  e.g. spinach, lettuce, kale

- Stem

  e.g. celery, asparagus, rhubarb

- Immature vegetable

  e.g. cucumber, snap beans, eggplant



- Mature vegetable or fruit

  e.g. tomato, apples, citrus

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Factors influencing postharvest loss

Internal factors

- Metabolic rate (respiration)
- Compositional changes
- Morphological changes
- Physiological disorders
- General senescence

Environmental factors

- Temperature
- Humidity
- Physical damage
- Pathogens
- Pests
- Contamination

Fruits & Vegetables are ALIVE!

Ongoing **Metabolic Activity**

RESPIRATION

Energy

$$\text{Sugar} + O_2 \Rightarrow CO_2 + \text{Water}$$

HEAT

Horticultural commodities classified according to respiration rate

(Modified from Kader, 2002)

Class	Range at 41°F (mg CO_2/kg·hr)*	Commodity
Very low	5<	Nuts, dates
Low	5-10	Apple, beet, celery, cranberry, garlic, grape, honeydew melon, onion, potato (mature), sweet potato, watermelon
Moderate	10-20	Apricot, banana, blueberry, cabbage, cantaloupe, carrot (topped), celeriac, cherry, cucumber, fig, gooseberry, lettuce (head), nectarine, olive, peach, pear, pepper, plum, potato (immature), radish (topped), summer squash, tomato
High	20-40	Blackberry, carrot (with tops), cauliflower, leeks, lettuce (leaf), lima bean, radish (with tops), raspberry, strawberry
Very high	40-60	Artichoke, bean sprouts, broccoli, Brussels sprouts, endive, green onions, kale, okra, snap bean
Extremely high	>60	Asparagus, mushroom, parsley, peas, spinach, sweet corn

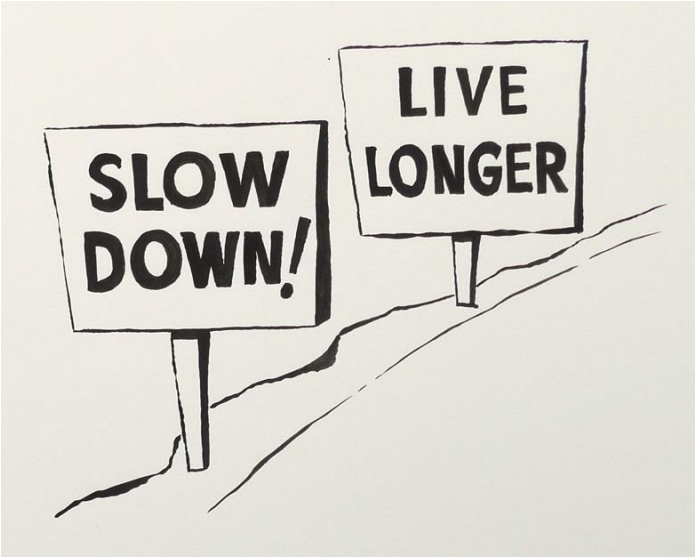
Kader, A. A. (2002). Postharvest technology of horticultural crops, UCANR Publications

Energy/ heat production at various storage temperatures

Btu/ton/day			
Commodity	**32°F**	**41°F**	**70°F**
Blueberries	500 - 2,300	2,000 - 2,700	11,400 - 19,200
Broccoli	4,000 - 4,700	7,600 - 35,200	61,200 - 75,000
Cabbage	1,000 - 1,400	1,700 - 2,700	6,100 -10,800
Muskmelon	- - -	1,900 - 2,200	9,800 -14,200
Strawberries	2,700 - 3,900	3,600 - 7,300	37,200 - 46,400
Sweet Corn	6,600 - 11,300	9,400 - 18,300	59,000 - 68,400

Source: Penn State Extension

FRESH PRODUCE IS AN AGING LIVING TISSUE



Postharvest Handling **GOAL**:

Slow down the aging process!

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Pictures from: poshmark.com/listing/BRANDY-MELVILLE-live-fast-die-young-cycle-tee-560ea2c5bf6df51a6e0009d7 & http://www.newrafael.com/slow-down/

Temperature

Temperature is the most **CRITICAL** factor influencing the postharvest life

Dictates the speed of biological/chemical reactions

- Respiration
- Ethylene Production
- Water loss
- Senescence

Typically, for every 18 °F increase, respiration increases **2 - 4** times

Temperature effect on the quality of broccoli after 48 hours of storage at room temperature (75 °F) or in refrigeration (40 °F)

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Precooling the Produce

- Removing the “field heat” is crucial
- **Field Heat**: Difference between the temperature of the crop at harvest and its optimum storage temperature
- Field heat should be removed rapidly

e.g. Strawberries: 1 hour at field temperature (90 °F) equivalent effect with 1 week at (32 °F)

Precooling the Produce

- Air cooling
  - Room
  - Forced-air
- Hydrocooling
- Ice Cooling
  - Top icing
  - Package icing
- Vacuum Cooling

Maintaining the Cold Chain for Perishables

Harvest

- Protect the product from the sun
- Transport quickly to the packinghouse

Cooling

- Minimize delays before cooling
- Cool the product thoroughly as soon as possible

Temporary Storage

- Store the product at optimum temperature
- Practice first in first out rotation
- Ship to market as soon as possible

Transport to Market

- Use refrigerated loading area
- Cool truck before loading
- Load pallets towards the center of the truck
- Put insulating plastic strips inside door of reefer if truck makes multiple stops
- Avoid delays during transport
- Monitor product temperature during transport

Handling at destination

- Use a refrigerated unloading area
- Measure product temperature
- Move product quickly to the proper storage area
- Transport to retail markets or foodservice operations in refrigerated trucks
- Display at proper temperature range

Handling at home or foodservice outlet

- Store product at proper temperature
- Use the product as soon as possible

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Temperature Related Physiological Disorders

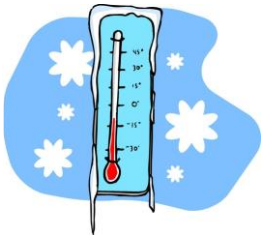
Chilling Injury

- Occurs mainly in tropical and subtropical species when exposed to **low but non-freezing** temperatures

- Chilling injury reduces the quality of the product and shortens shelf life

- Symptoms:
  - Irregular ripening / failure to ripe
  - Pitting
  - Increased susceptibility to decay
  - Brown discoloration
  - Off-flavors
  - Softening

- Symptoms often appear only after the commodity is exposed to warmer temperatures



Picture: http://hottytoddy.com/wp-content/uploads/2015/02/ar123654660968623.jpg

Chilling injury on Caribe chiles

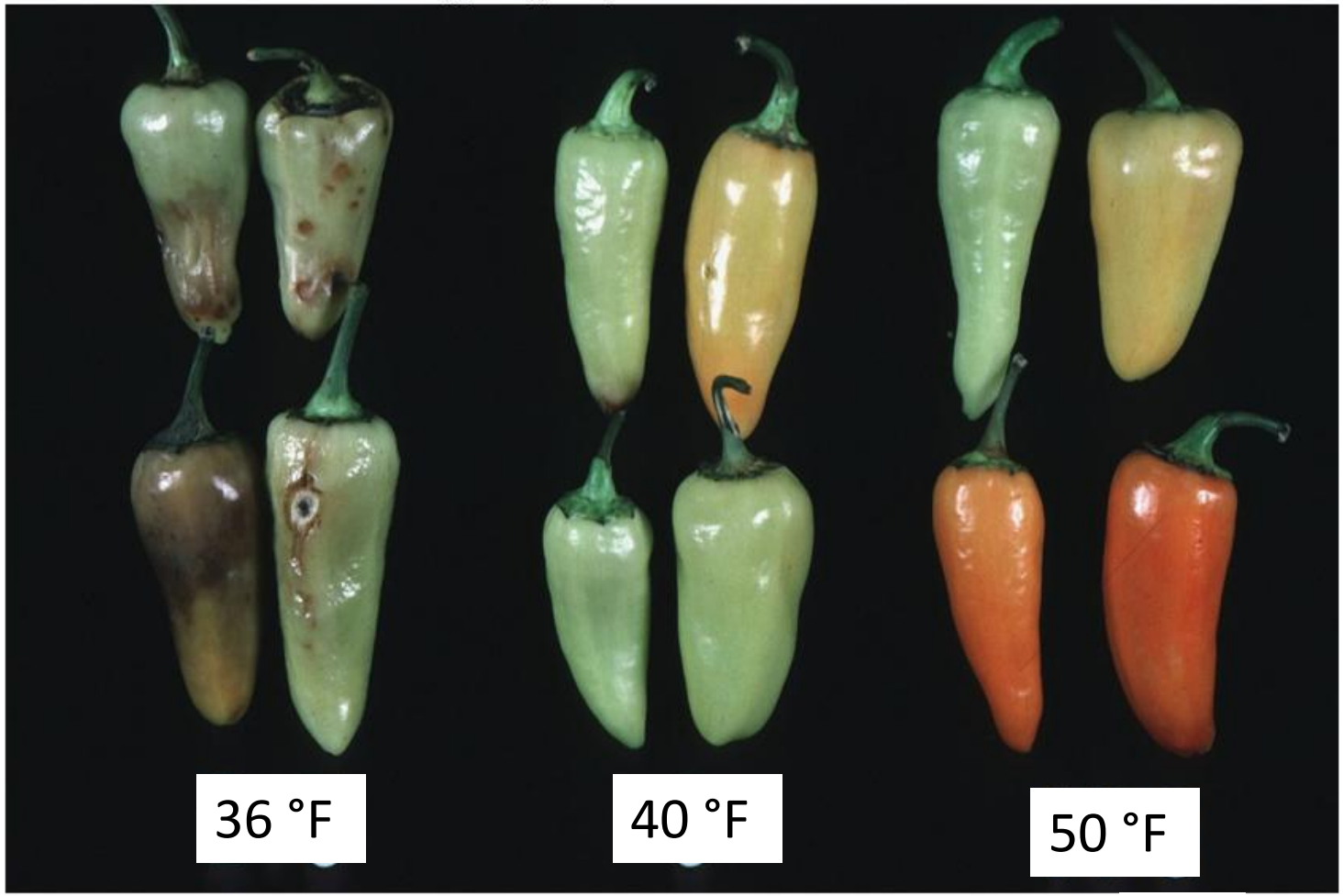


Photo was taken after transferring the chiles to 68°F for 5 days following storage at 36, 40, or 50°F for 30 days.

Picture: http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=12&ds=799

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45 °F

snap bean, eggplant, cucumber, melon, pepper

50 °F

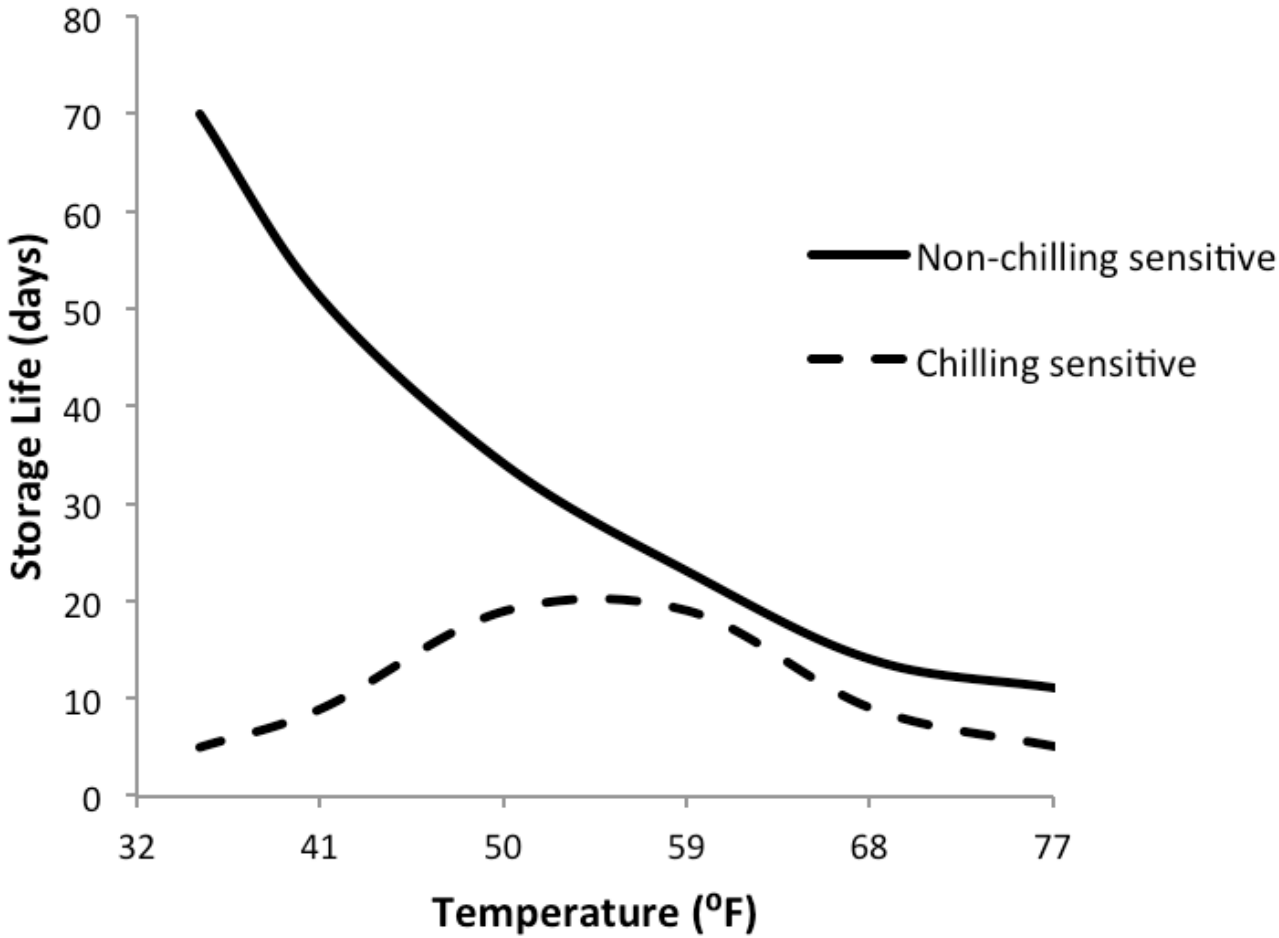
Pumpkin, Squash

Chilling Injury of Tomatoes

45-50 °F: ripe tomatoes

55 °F: mature green tomatoes

The shelf life of chilling and non-chilling sensitive produce



Source: Cornell University extension

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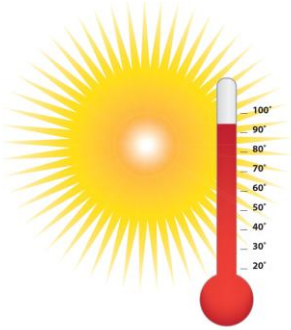
Temperature Related Physiological Disorders

Heat Injury

- Occurs when the crop tissue is heated above the thermal death point of the cells

- Symptoms:
  - Localized bleaching / burning
  - Necrosis
  - General collapse
  - Irregular ripening

Figure 2 - External and internal appearance of 'Paluma' guavas after 156 h of storage at different temperatures.



Pictures: http://sites.psu.edu/siowfa15/wp-content/uploads/sites/29639/2015/09/heat-stroke.jpg & http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90

Storage Temperatures* for Vegetables

Proudly brought to you by Crisp Fruit & Veg

Recommended Storage Temperature 2-5°C	
Fruit Variety	
Artichoke	
Asian Vegetable (Leafy)	
Asian Vegetable (Other)	
Asparagus	
Beans	
Beetroot	
Broccoli	
Brussels Sprouts	
Cabbage	
Carrot	
Cauliflower	
Celery	
Corn	
Fennel	
Herbs	
Kale	
Kohl Rabi	
Leafy Vegetables	
Lettuce	
Mushroom	
Okra	
Parsnip	
Peas	
Pre-Packed Whole Produce	
Pre-Packed Processed Produce	
Radish	
Rhubarb	
Salad Mixes	
Sprouts	
Swede	
Turnip	
Witlop	
6-9°C	
Fruit Variety	
Capsicum	
Chilli	
Choko	
Cucumber	
Eggplant	
Marrow	
Olive	
Green Onions	
Squash	
Zucchini	
13-15 C	
Fruit Variety	
Garlic	
Ginger	
Onions - Other	
Potato	
Pumpkin	
Sweet Potato	
Tomato	

32-36ºF

40-50ºF

55-65ºF

* Recommended Temperature

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Water Loss

- Direct loss of **Salable Weight**

- Important source of **Quality Loss**

  - *Appearance* → wilting, shriveling, accelerated development of injury symptoms
  - *Texture* → loss of crispness, juiciness, etc.
  - *Nutritional quality* → loss of vitamins A & C

% Water loss that results in unmarketable product

- Asparagus 8%
- Cabbage 7%
- Celery 5%
- Lettuce 3%
- Spinach 3%

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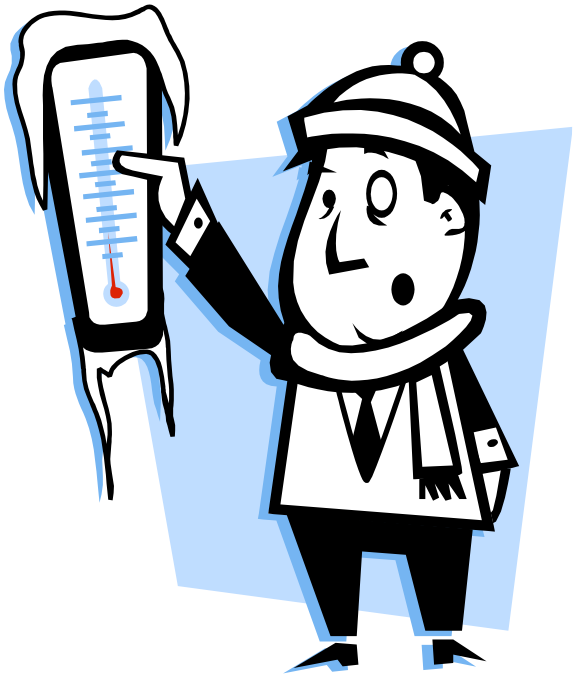
How we prevent water loss

- Control relative humidity
- Lower temperature
- Reduce air movement
- Protective packaging



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Reducing Water Loss

http://www.maryvalleycountryharvest.com/wp-content/uploads/2016/08/dagun-growers-market-34.jpg

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Reducing Water Loss

http://static.progressivemediagroup.com/uploads/imagelibrary/nri/packaging/clients/PerfoTec/perfotec-feb15pr.jpg

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The Commodity & Its Environment

Temperature
Humidity
Oxygen
Carbon Dioxide
Ethylene

Modified Atmosphere

"The practice of changing the composition of the interna atmosphere of a produce bag/tray"

Air: 20.95% O_2 & 0.04% CO_2

MAP typically aims in an atmosphere with:

↓ Reduced O_2
↑ Increased CO_2

} ↓ Respiration Rate ↓ Metabolism

e.g. MAP for Spinach: 3% O_2 & 10% CO_2 at 36°F(Suslow & Cantwe 1998)

Suslow, T.V., Cantwell, M. (1998). " Spinach: Recommendations for Maintaining Postharvest Quality. Perishables Handling #94 ", http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=32&ds=799

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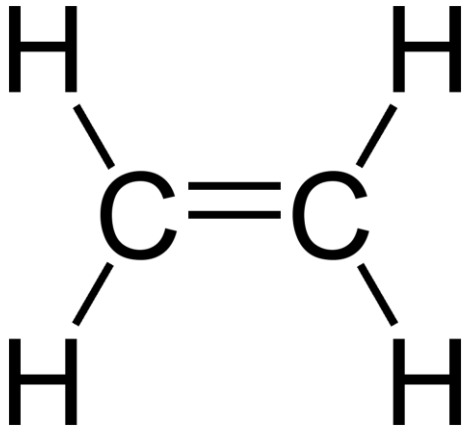
Passive MAP: Atmosphere is modified by product respiration rate & gas permeability of the packaging film

Ethylene & Quality

- Regulates growth & development, senescence
- Different ethylene production patterns amongst commodities
  - Climacteric & non-climacteric crops
- Sensitive & non-sensitive crops
- Beneficial and detrimental effect
- Active at very low concentrations (ppm)
- **Low temperatures** slow down production



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Classification of Horticultural Commodities According to Their Ethylene Production

Class	Production rate at 68°F (µl C_2H_4/kg·hr)	Commodities
Very Low	Less than 0.1	Artichoke, asparagus, cauliflower, cherry, citrus fruits, grape, strawberry, pomegranate, leafy vegetables, root vegetables, potato, most cut flowers
Low	0.1-1.0	Blackberry, blueberry, casaba melon, cranberry, cucumber, eggplant, okra, pepper, pumpkin, raspberry, watermelon
Moderate	1.0-10	Banana, fig, honeydew melon, tomato
High	10-100	Apple, apricot, cantaloupe, kiwifruit (ripe), nectarine, peach, pear, plum
Very High	More than 100	Cherimoya, passion fruit

Kader, A. A. (2002). Postharvest technology of horticultural crops, UCANR Publications

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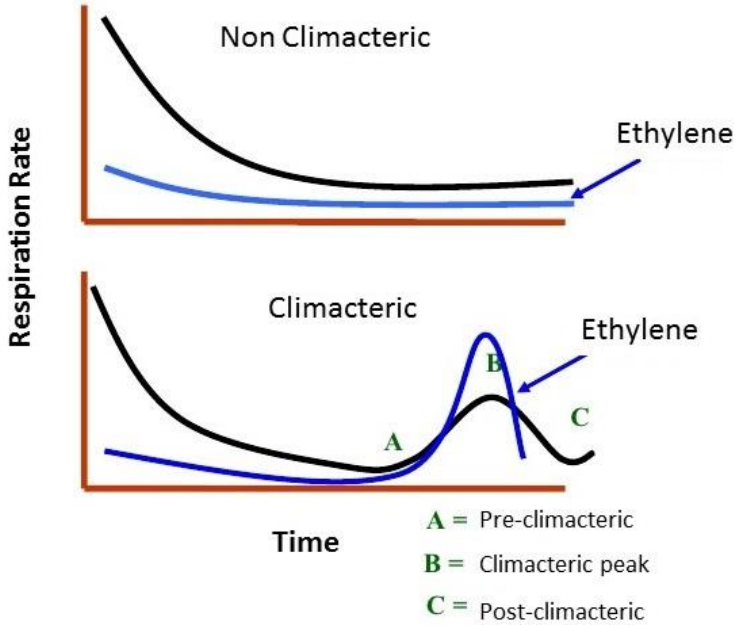
Climacteric & non-climacteric Commodities

- Climacteric crops: peak in CO_2 and ethylene production during ripening

- Non-climacteric: relatively stable CO_2 production rate and negligible amount of ethylene production

Practical application

Harvesting climacteric crops on the onset of ripening & blocking ethylene production up to the time the crops are sold



Climacteric & non-climacteric Commodities

Climacteric crops	Non-climacteric crops
Apple, Apricot, Blueberry, Muskmelon, Nectarine, Peach, Pear, Plum, Tomato	Artichoke, Asparagus, Blackberry, Broccoli, Cabbage, Carrot Cherry, Cranberry, Cucumber, Eggplant, Grape, Lettuce, Pea, Pepper, Raspberry, Spinach, Strawberry, Summer Squash, Watermelon

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Ethylene sensitive

- Leafy Greens
  - e.g. Spinach, Lettuce
- Brassicas
  - e.g. Broccoli, Cabbage
- Root Vegetables
  - e.g. Potato, onion
- Fruits
  - e.g. Apple, pear, cantaloupe
- Flowers
  - e.g. Carnation

Detrimental Effect

Yellowing
Internal Browning
Lignification
Sprouting
Off flavor

Picture: UC Davis Postharvest Technology

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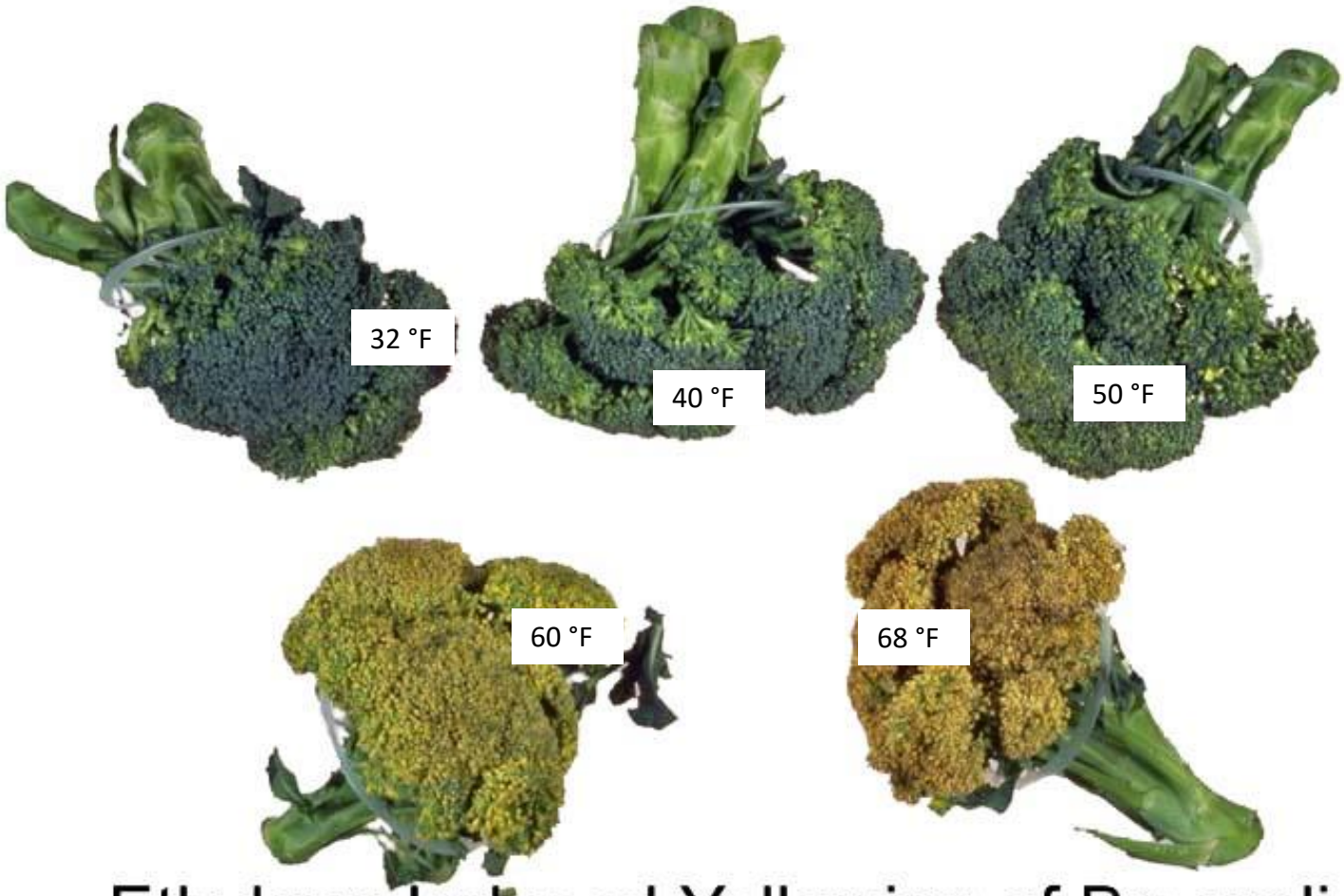

Ethylene Induced Yellowing of Broccoli

Picture: UC Davis Postharvest Technology

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Russet Spotting

Picture: UC Davis Postharvest Technology

Removing Ethylene

- Scrubbers
- Filters/ filtration system
- Separate storage

Physical/Mechanical Damage

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

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Picture: UC Davis Postharvest Technology

Pepper Mechanical Injury

Photos courtesy of Steve Sargent

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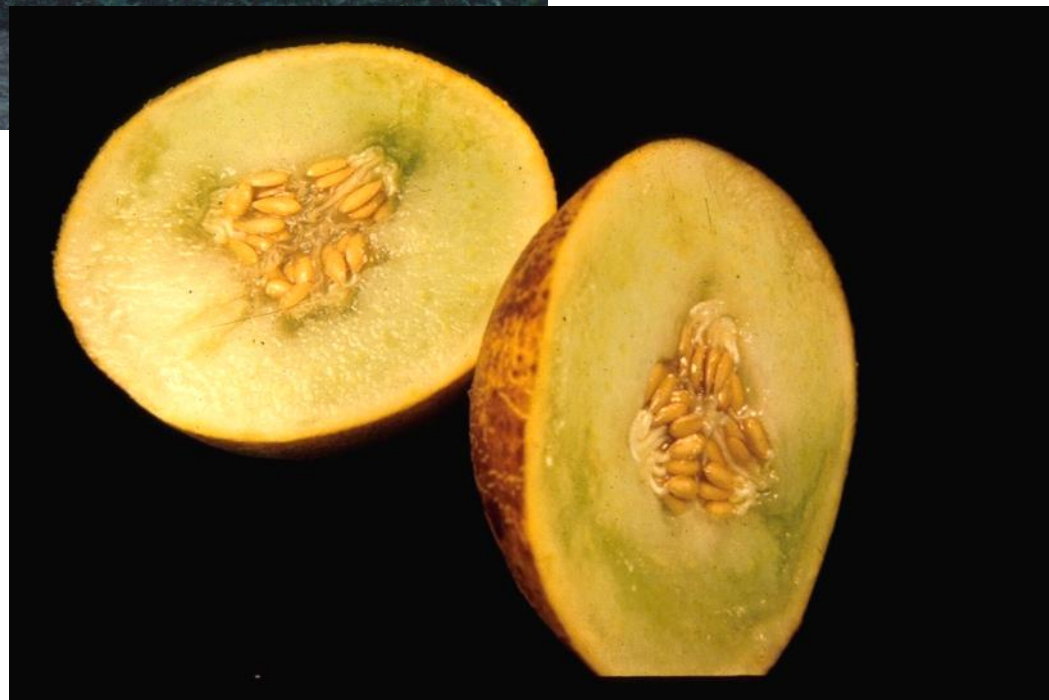
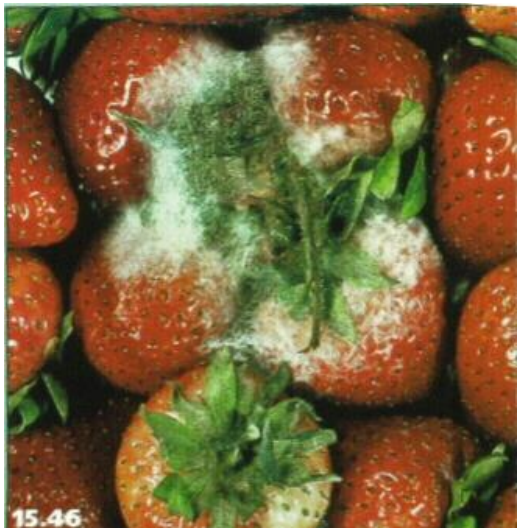
Melon Internal Bruising

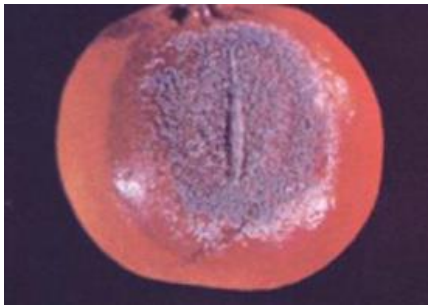


Photos courtesy of Steve Sargent

Pathological Breakdown (decay)



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



Picture: UC Davis Postharvest Technology

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Handling Tips

Harvest

- Pick early in AM
- Harvest at proper maturity
- Gentle & sanitary picking
- Use clean totes/buckets

IF YOU USE HIRED LABOR

TRAIN THE WORKERS

Handling Tips

Harvest

- Do not overfill totes/buckets
- Use sharp & clean tools
- Discard damaged produce
- Pick clean crops
- Shade

IF YOU USE HIRED LABOR

TRAIN THE WORKERS

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Handling Tips

Transportation from the field

- Allow airflow between containers
- Cool down **ASAP**
- Maintain the cold chain
- Shade vehicle
- Grade roads

The “KoolKat”mobile refrigerated unit, of K-state Olathe Horticulture Research and Extension Center

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Handling Tips

Cleaning/shorting

- Remove unmarketable produce as soon as possible
- Clean & Sanitary operation and tools
- Washing can be combined with cooling
  - Keep water clean & cold
- Use appropriate cleaning method
  - Not all commodities should washed

Do Not Wash

Tomatoes
Berries
Green Beans
Cabbage
Peas
Pepper

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Handling Tips

Packing & Storage

- Use appropriate packing material
- Pack produce in same maturity stage
- Do not pack overripe or damaged produce
- Store in the optimum temperature and Humidity
  - 2 cooling rooms available: 1st 32-36°F
    2nd 50-57°F
  - 1 cooling room available: 41°F
    & chilling sensitive kept in a room with AC

Picture: UC Davis Postharvest Technology

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Handling Tips

Packing & Storage

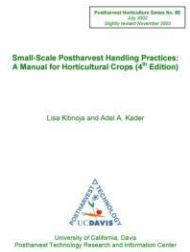
Some crops need curing!

Commodity	Temperature		Relative Humidity	Days
	°C	°F	(%)	
Potato	15-20	59-68	90-95	5-10
Sweetpotato	30-32	86-90	85-90	4-7
Yarns	32-40	90-104	90-100	1-4
Cassava	30-40	86-104	90-95	2-5

Keys To Success In Postharvest Handling Of Fruits and Vegetables

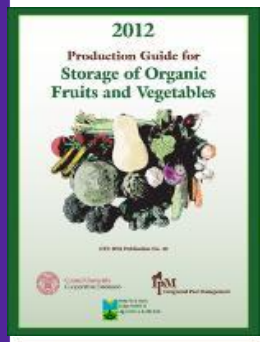
1. Highest Initial Quality/Proper Maturity
2. Minimize rough Handling to Minimize Physical Damage
3. Sorting to remove damaged and diseased produce
4. Management of Environmental Conditions:
   - Temperature
   - Relative Humidity
   - Atmospheric Composition (O_2, CO_2, C_2H_4)
   - Ventilation
5. Proper Sanitation Procedures

Resources



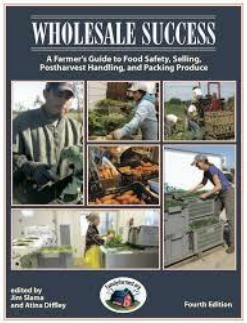
Postharvest Technology Center
http://postharvest.ucdavis.edu/

Small-Scale Postharvest Handling Practices: A manual for Horticultural Crops



Production Guide for Storage of Organic Fruits and Vegetables
https://ecommons.cornell.edu/bitstream/handle/1813/42885/organic-stored-fruit-veg-NYSIPM.pdf?sequence=1

Post Harvest Handling Decision Tool
https://www.leopold.iastate.edu/files/pubs-and-papers/2013-11-post-harvest-handling-decision-tool.pdf



Wholesale Success: A farmers guide to food safety, selling ,postharvest Handling and packaging produce

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Thank you for your attention !

QUESTIONS ?

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