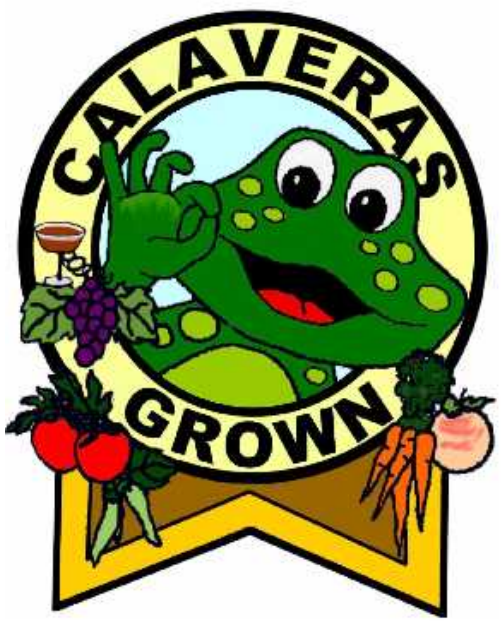
Postharvest Handling Maintaining Quality and Safety for Farmers' and Other Local Markets

Foothill Workshop, July 8, 2011

Marita Cantwell, UC Davis
micantwell@ucdavis.edu
http://postharvest.ucdavis.edu

UCDAVIS POSTHARVEST TECHNOLOGY

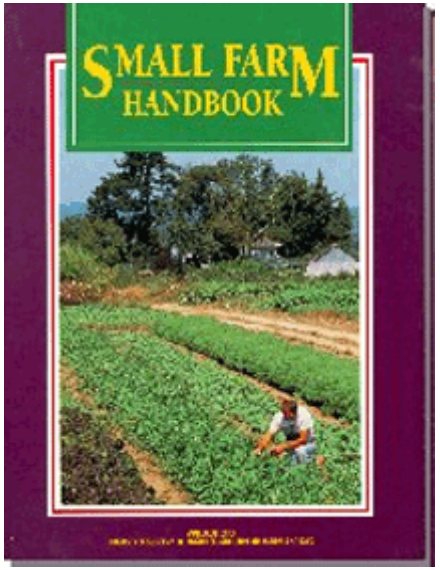
http://www.co.calaveras.ca.us/departments/agriculture.asp



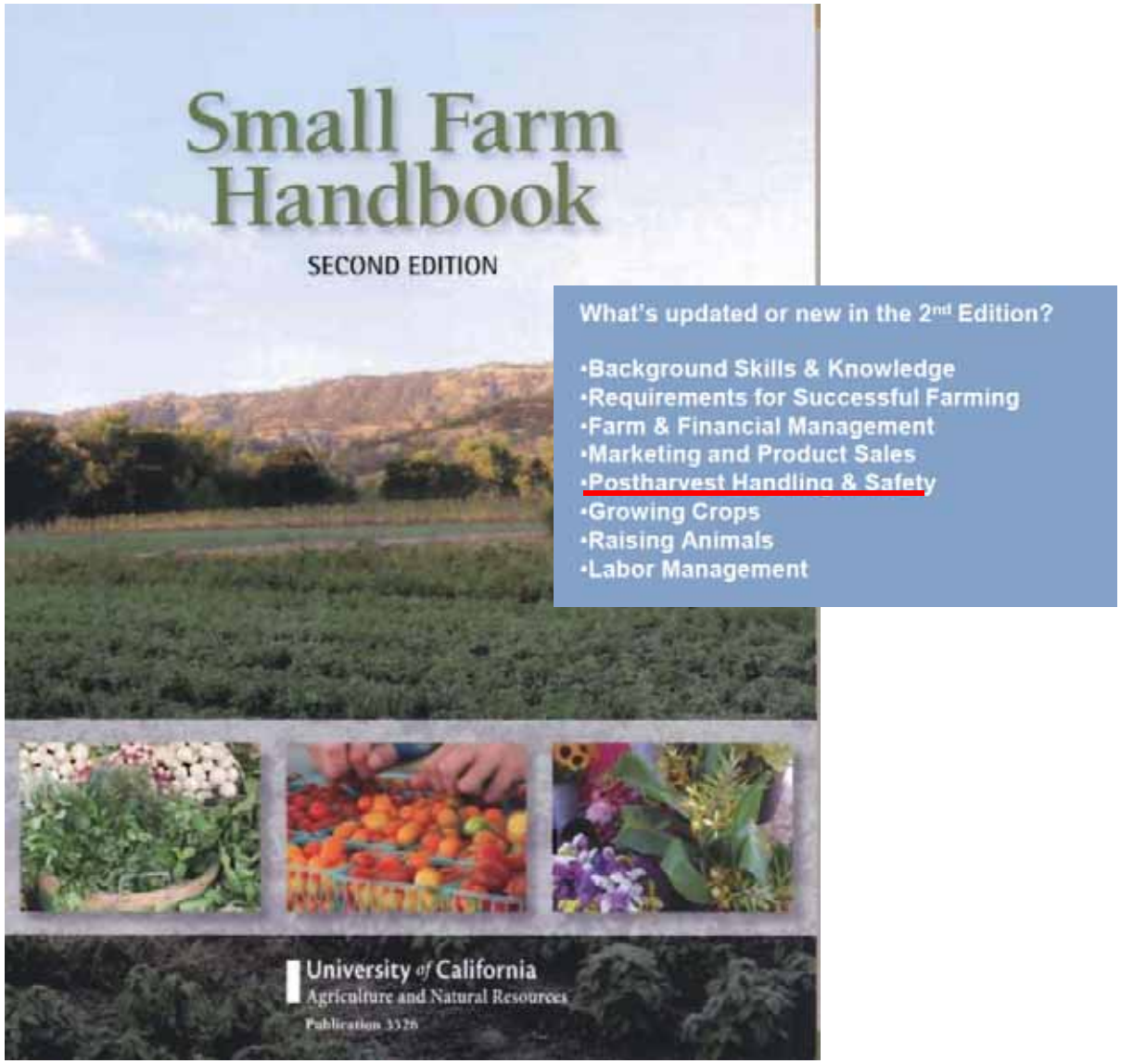
Stretch the Growing Season with Winter Squash
Warm Season Greens Offer Nutrition
Salsas get Boost with Homegrown Herbs
Asparagus Gives an Early Crop
Cool off with Watermelons
Garden Harvest in August
Plant More Carrots Now for Fall and Winter
Plant Lima Beans, Okra, and Brussel Sprouts in May
Protect Vegetables from Early Summer Stress
Cool Fall Weather Brings Sweet Cole Crops
Specialty Greens Provide for Tasty, Nutritious Salads
Grape Arbors-New Interest in an Old Tradition
Growing Pomegranates
Sweeten the Foothill Garden with Blackberries
Strawberries for Your Garden

Ken Churches
UCCE Calaveras County

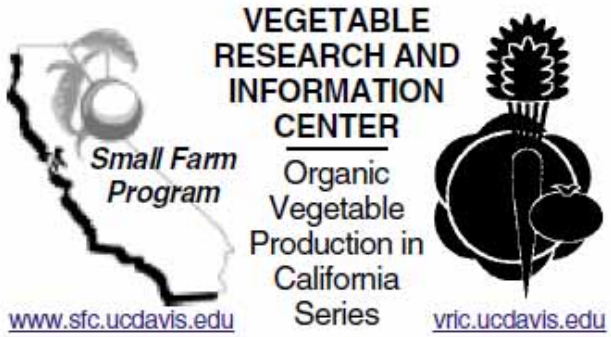
http://ucanr.org/sites/UC_Calaveras/2007_Agricultural_Articles/



Small Farm Handbook
1994



Small Farm Handbook, 2nd ed. 2011
http://anrcatalog.ucdavis.edu
$25



POSTHARVEST HANDLING FOR ORGANIC CROPS

TREVOR SUSLOW,
UC Cooperative Extension
Vegetable Crops Specialist,
UC Davis

Publication 7254; http://ucanr.org/freepubs/docs/7254.pdf
2000, currently being updated: Postharvest Handling for Organic Vegetable Crops

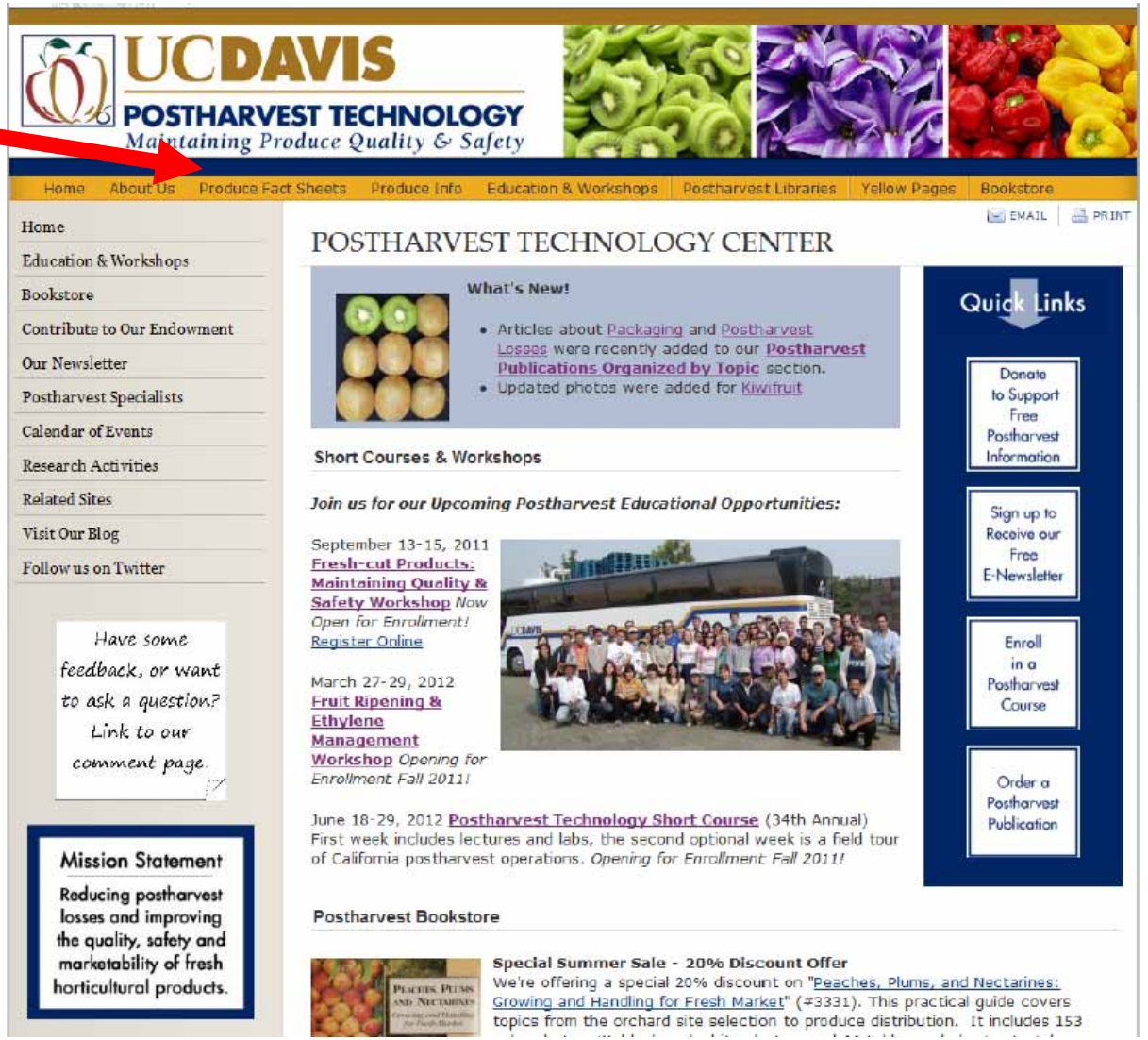
TV Suslow. 2011 Postharvest Handling Considerations for Organic Produce
Pdf of presentation at 2011 Postharvest Technology Short Course
http://ucce.ucdavis.edu/files/datastore/234-2002.pdf

http://postharvest.ucdavis.edu

Produce Facts

- Harvest indices
- Quality indices
- Temperature and RH
- Freezing point/damage
- Respiration rates
- Ethylene production
- Effects of ethylene
- Effects of modified atmospheres
- Physiological disorders
- Postharvest diseases
- Mechanical injury
- PHOTOS

140
Fruits
Vegetables
Flowers



Can print or download

Nopalitos: (Cactus Stems)

Recommendations for Maintaining Postharvest Quality

Marita Cantwell
Department of Plant Sciences, University of California, Davis, CA 95616

Link to Produce Facts Photos

Maturity Indices

Cactus stems or "nopalitos" (in Spanish) are the rapidly-growing succulent stems of the Prickly Pear Cactus (*Opuntia* spp). They are grown in California as a specialty vegetable or imported from Mexico, where they are a traditional vegetable. Cactus stems are harvested based on size, and can be harvested small (<10 cm long) to medium size (<20 cm, about 100g). Overmature nopalitos, thick with lots of spongy white tissue and acidic in flavor, should be avoided.

Quality Indices

Good quality nopalitos are fresh, turgid and a brilliant green color. Nopalitos should be harvested when young and tender and not early in the morning to avoid a high acid content (see special considerations).

Optimum Temperature

Generally nopalitos should be cooled to about 5°C (41°F) to reduce loss of visual appearance due to water loss. The recommended conditions for storage of nopalitos are 5° to 10°C (41°F to 50°F) at high relative humidity. The major factors limiting storage life of nopalitos are decay and dehydration. Nopalitos stored under higher temperatures rapidly loss their brillant shiny appearance, become dull green and may also begin to yellow and curve inward due to water loss. Good quality can be maintained for <2 weeks at 10°C (50°F) and 3 weeks at 5°C (41°F). Some discoloration due to chilling injury occurs if stored longer than 3 weeks at 5°C (41°F).

Optimum Relative Humidity

90-95%

Rates of Respiration

Temperature	5°C (41°F)	10°C (50°F)	15°C (59°F)	20°C (68°F)
ml CO_2/kg·hr	8 - 10	20 - 22	28 - 32	38 - 44

These are average respiration rates for 10 cm nopalitos; respiration rates of 20 cm stems are about 50% lower.

To calculate heat production multiply ml CO_2/kg·hr by 440 to get Btu/ton/day or by 122 to get kcal/metric ton/day.

Rates of Ethylene Production

Ethylene production rates are very low (0.05, 0.10 and 0.20 µ/kg· hr at 5°C (41°F), 10°C (50°F) and 20°C (68°F), respectively.

Responses to Ethylene

Nopalitos are not very sensitive to ethylene exposure, but exposure at warmer temperatures will enhance yellowing.

Responses to Controlled Atmospheres (CA)

No information is available on the potential benefits of modified/controlled atmosphere storage of cactus stems. For diced product, moderate CO_2 (5-10%) atmospheres may be beneficial.

Physiological Disorders

Chilling injury. Nopalitos are chilling sensitive when stored below 10°C (50° F) . However, 3 weeks at 5°C (41°F) may be needed to observe some chilling symptoms. Chilling damage may be manifested as a superficial bronzing or discoloration and increased susceptibility to decay. The onset of chilling injury will depend on storage temperature, maturity and source of product.

Pathological Disorders

Decay at the cut stem end may be a problem if nopalitos are stored for longer than 2 weeks. Decay is usually avoided by insuring that the nopalitos have not been damaged when cut from the plant. Decay can also occur during storage at places where spines have penetrated the surface.

Special Considerations

Cactus stems should be harvested and handled with care to avoid mechanical damage, especially due to spines from one stem penetrating the neighboring stem. Spine damage leads to a rusty-brown discoloration and pathological problems.

Because of the spines, a cleaned and diced product is an attractive option. The cut nopalitos cannot be washed before marketing because it will cause mucilage to exude and increase discoloration of the cut surfaces. Cleaned and diced nopalitos should be stored between 0°(32°F) and 5°C (41°F) and have a shelf-life of about 6 days.

Because the prickly pear plant is a CAM plant (Crassulacean Acid Metabolism) and fixes CO_2 at night as malic acid before converting it to sugars during the day, the acid content of nopalitos may fluctuate greatly and affect their flavor. Therefore it is recommended to harvest the stems after 2-3 hours of sunlight. Small nopalitos however, are not CAM-active. In addition, low storage temperatures 5°C (41°F) maintain acid levels.

Composition of Ripe Grape Tomato Harvested at 3 Stages of Maturity

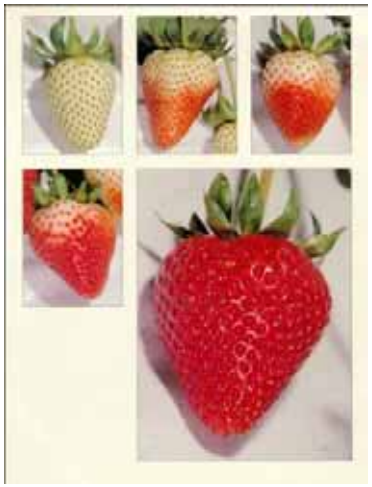
Initial Maturity Stage	Weight fruit, g	Red color, hue	Firmness, N force	Soluble solids, %	Sugars mg/mL	Titratable acidity, %	Vitamin C mg/100mL
3	4.9	36.8	11.5	5.9	27	0.59	96
4	5.7	36.3	13.6	6.7	30	0.68	97
5	5.9	37.7	13.7	7.5	33	0.67	99
LSD.05	0.6	ns	1.5	0.8	3	0.09	ns

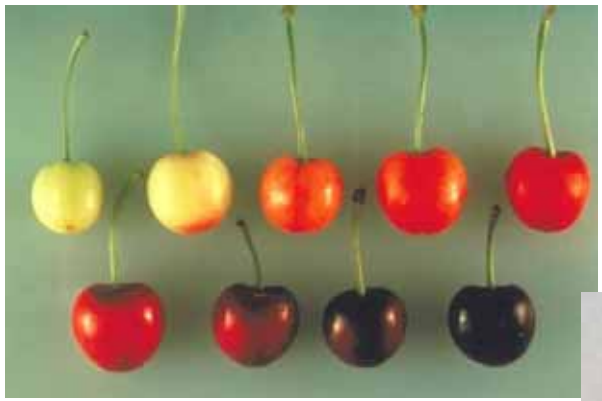
Minimum harvest stage should be Stage 4 (pink-orange)

Average 7 cvs, Cantwell, UC Davis

Postharvest Problem

…Quality is maximized when the product is harvested more mature or ripe, whereas shelf- and storage life are extended if the product is harvested less mature or unripe….



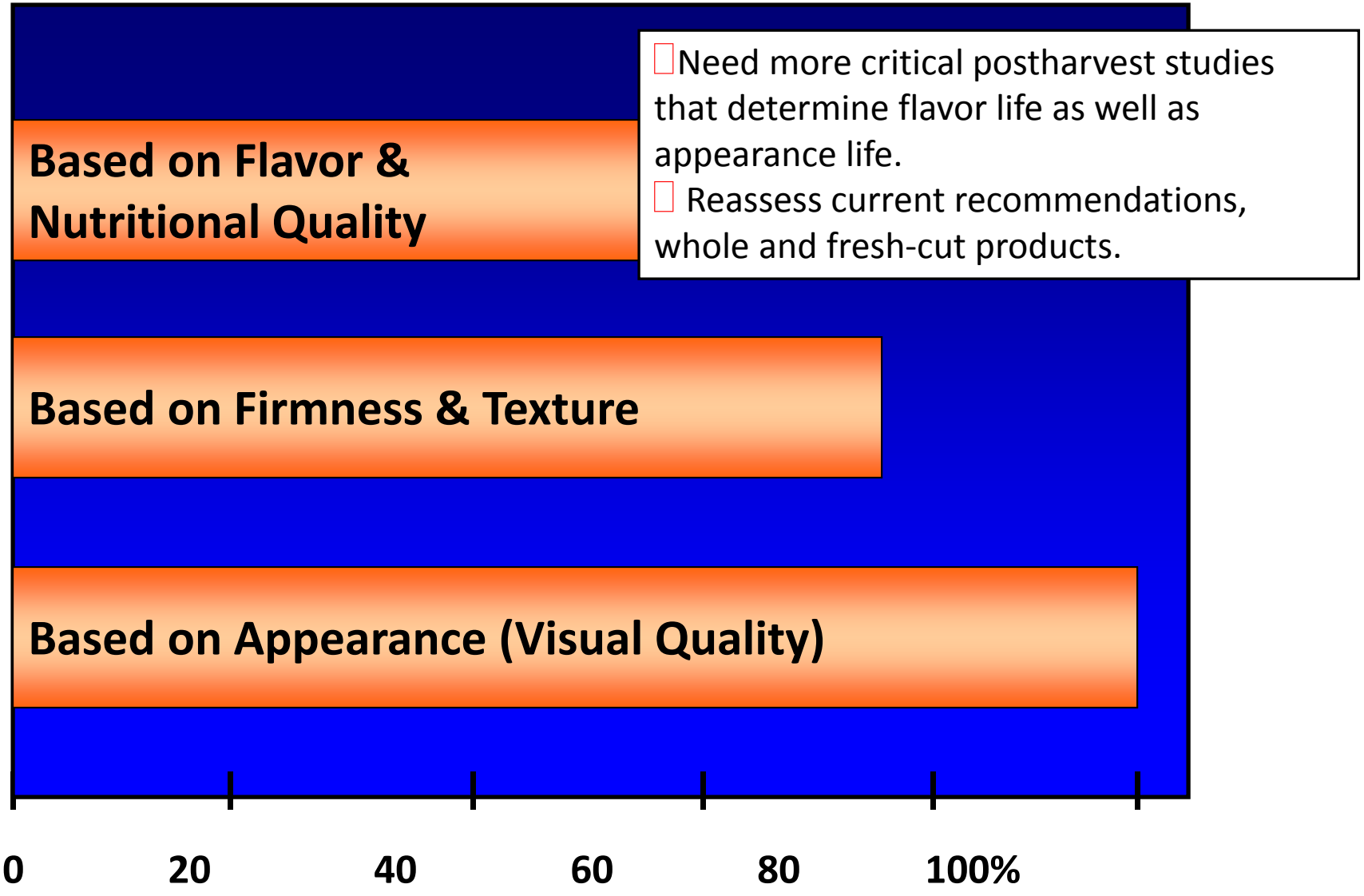


Toivonen, P. 2007. Fruit maturation and ripening and their relationship to quality. Stewart Postharvest Review 2:7.

Flavor and Sugar:Acid Ratio

ACIDS	SUGARS	
	Low	High
Low	Insipid, tasteless	Sweet
Moderate to High	Sour, tart	Best flavor combination

Soluble solids measured by a refractometer = sugars, but also organic acids, soluble pectins, anthocyanins, phenolic compounds, ascorbic acid

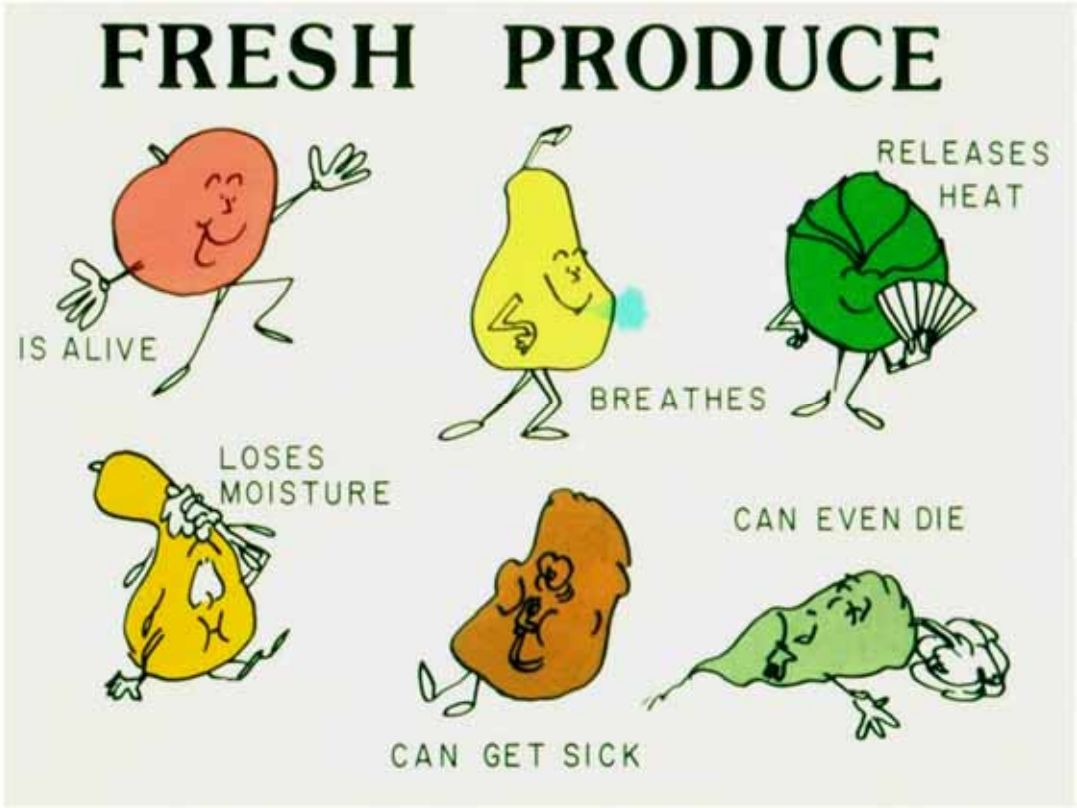


Postharvest Life Under Optimum Conditions

Kader, 2003. A Perspective on Postharvest Horticulture. HortScience 38: 1004

Factors contributing to postharvest losses

- **TIME**
- Temperature
- Water loss
- Damage
- Diseases
- Ethylene
- Continued growth
- Physiological disorders
- Light



Tesco (U.K.)
Fresh & Easy Stores in U.S.
“Farm to Store in 24” program

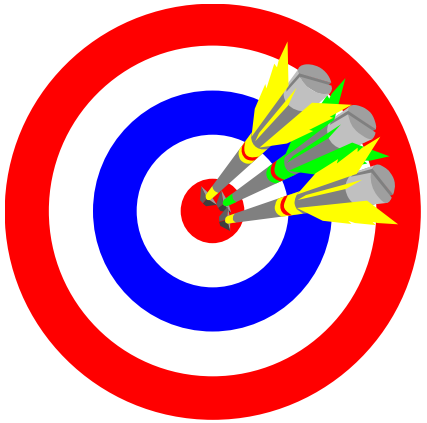
TIME

fresh & easy™
Neighborhood Market

"Getting produce from the farm to the store in 24 hours or less is an incredibly tricky task, which makes it important to partner with strong local growers who share our commitment to quality produce," said Justin Hill, Fresh & Easy's produce manager. "We are working closely with these growers here to put in the extra care required to expand our Farm to Store in 24 offerings whenever we can."

Fresh Produce Deterioration

- **Metabolic changes:**
  - **respiration, ethylene,**
  - **texture, aroma, etc.**
- **Growth and development**
- **Transpiration**
- **Mechanical injury**
- **Physiological disorders**
- **Decay; microbial growth**



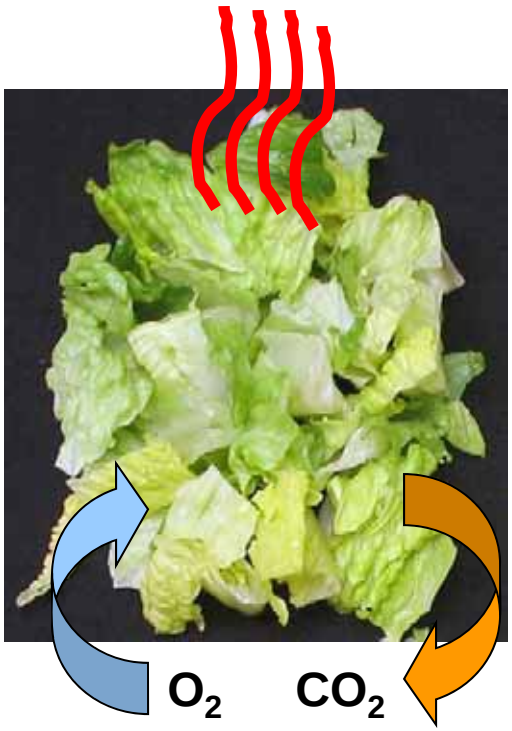
Temperature Affects All Causes of Deterioration

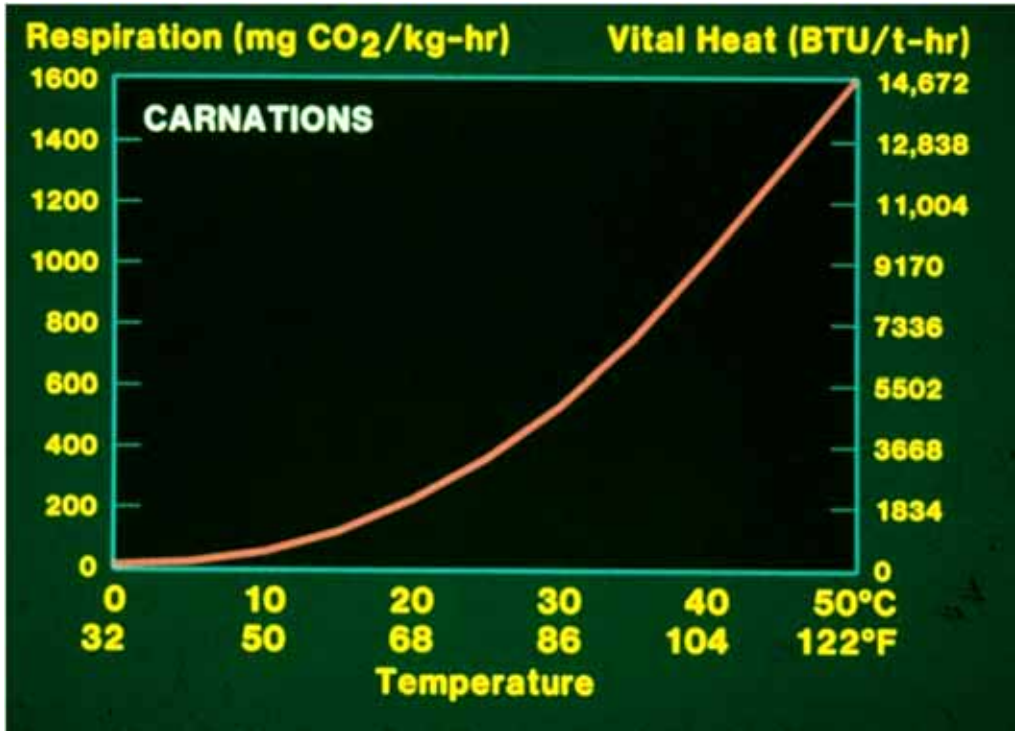
Temperature - why is it important?

- Rate of deterioration α rate of respiration
- Respiration:

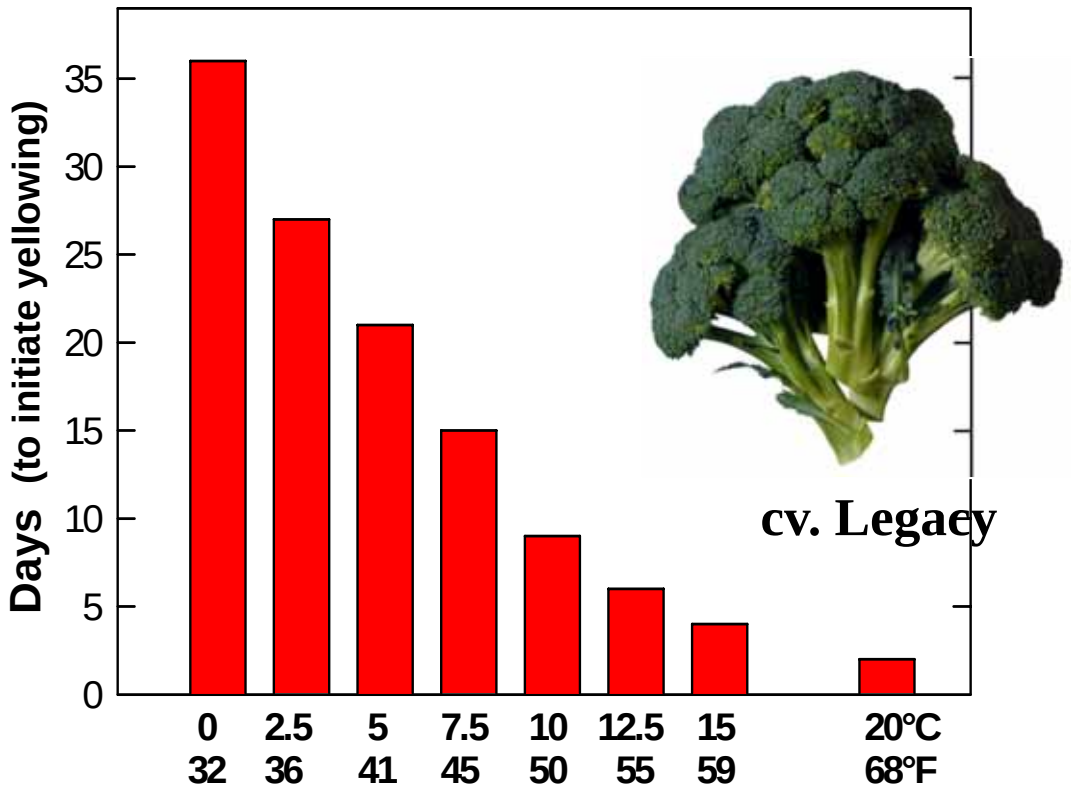
  Sugar + O_2 ➡➡➡ CO_2 + H_20 + Energy (Heat)

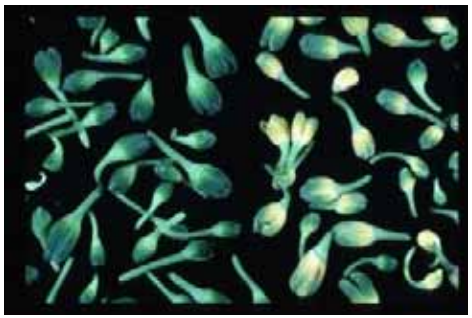
- Respiration increases exponentially with T



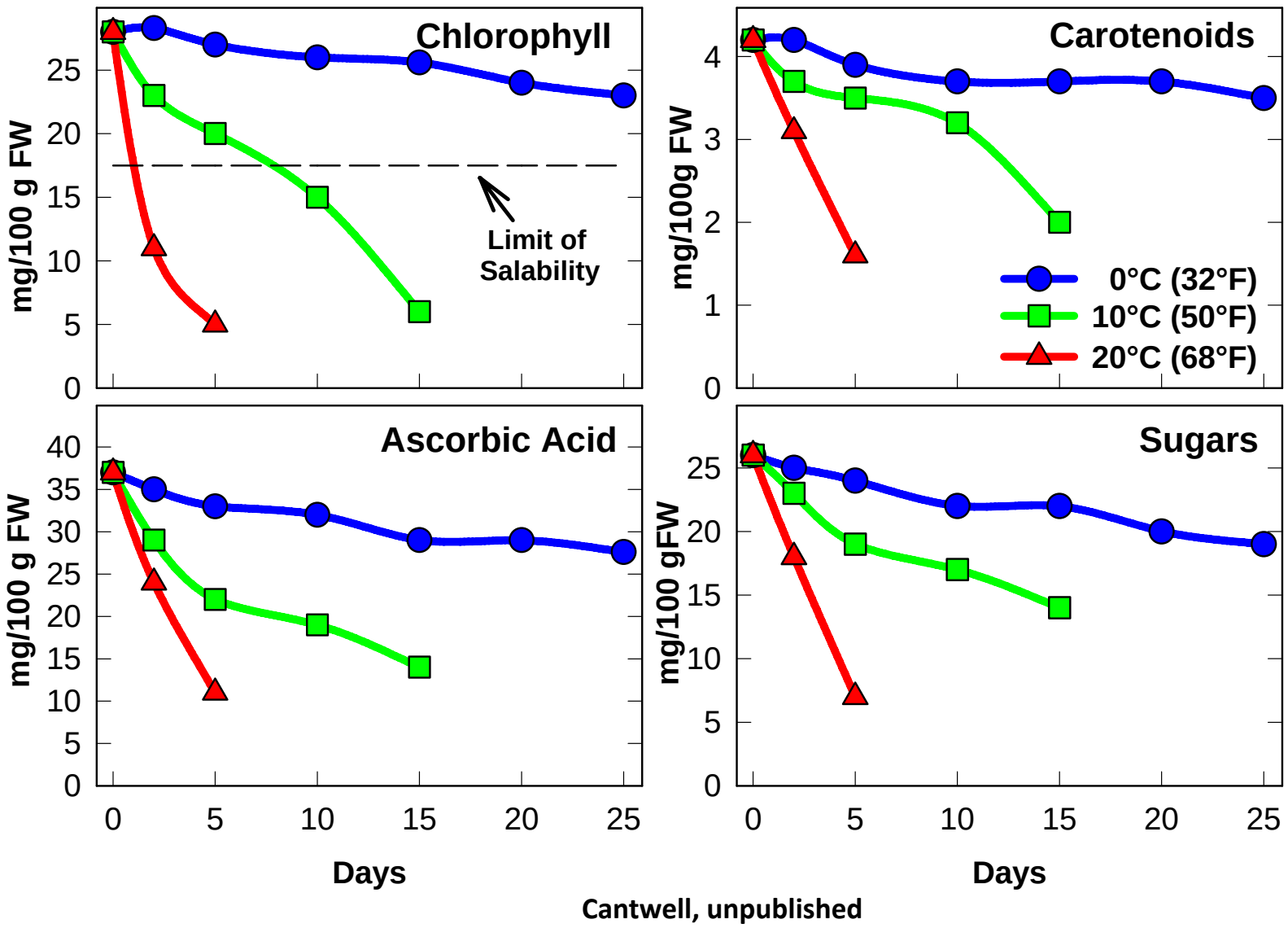


Broccoli Shelf-life & Temperature





Broccoli Compositional Quality and Storage Temperature



Cantwell, unpublished

Importance of Temperature to Maintain Quality

Stored 5 days

Commercial Cooling Methods

- **Room Cooling**
- **Forced Air Cooling**
- **Vacuum Cooling**
- **Hydrocooling**
- **Icing**
- **Cooling in refrigerated transport**

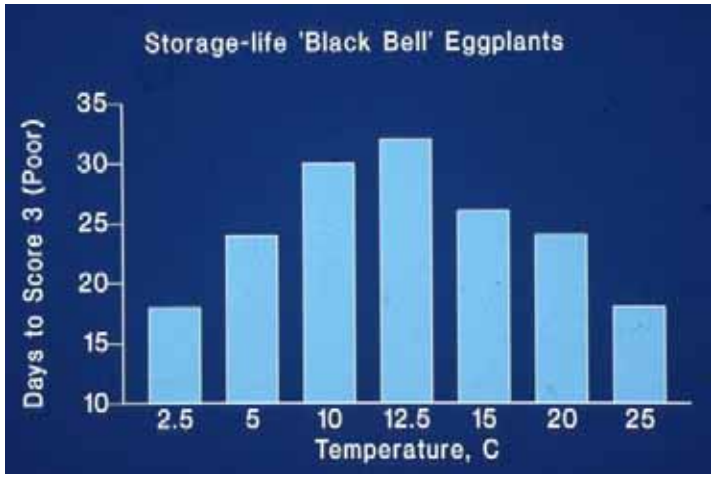
Product requirements
Scale appropriate technology
Conventional, Organic products
Microbial food safety issues

Effect of Temperature on Deterioration

(non-chilling sensitive products)

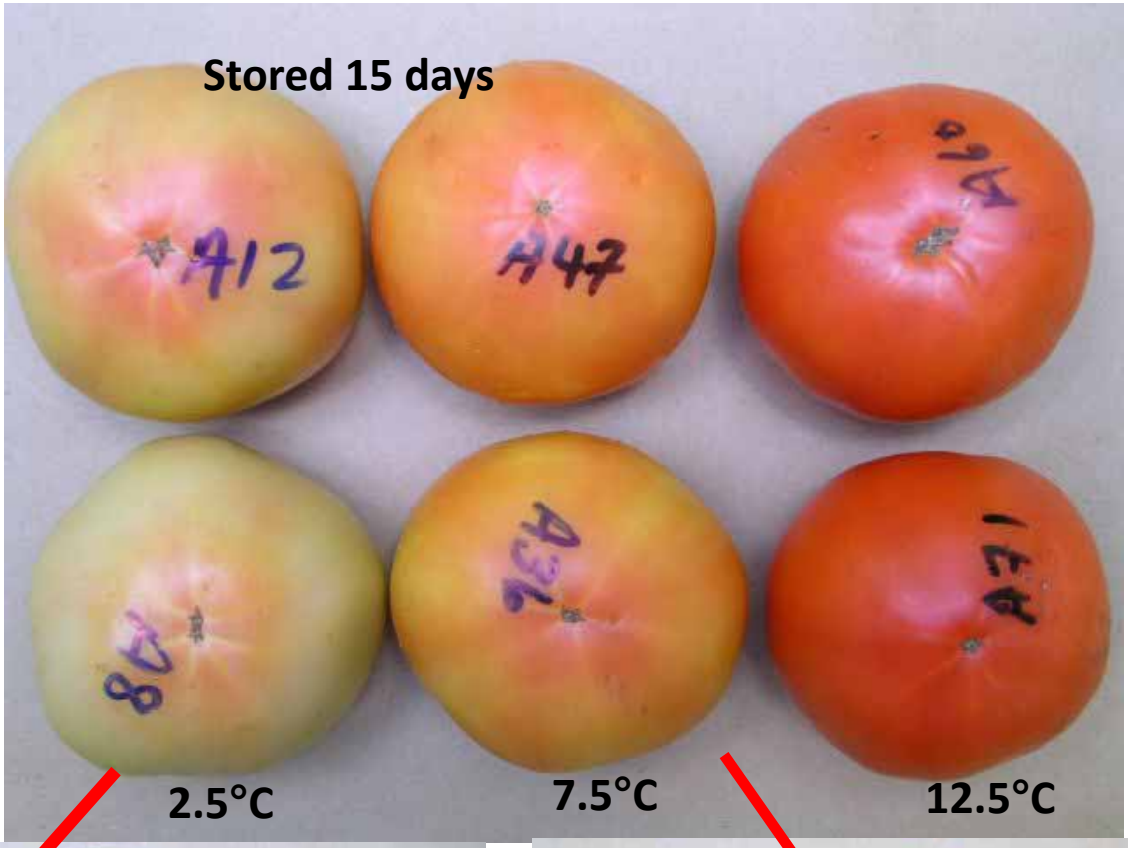
Temp. °F	Temp. °C	Q_{10}	Relative Velocity of Deterioration	Relative Shelf-life	Daily Loss (%)
32	0	--	1.0	100	1
50	10	3.0	3.0	33	3
68	20	2.5	7.5	13	8
86	30	2.0	15.0	7	14
104	40	1.5	22.5	4	25

$$Q_{10} = \frac{\text{rate of deterioration at T+10°}}{\text{rate of deterioration at T}}$$



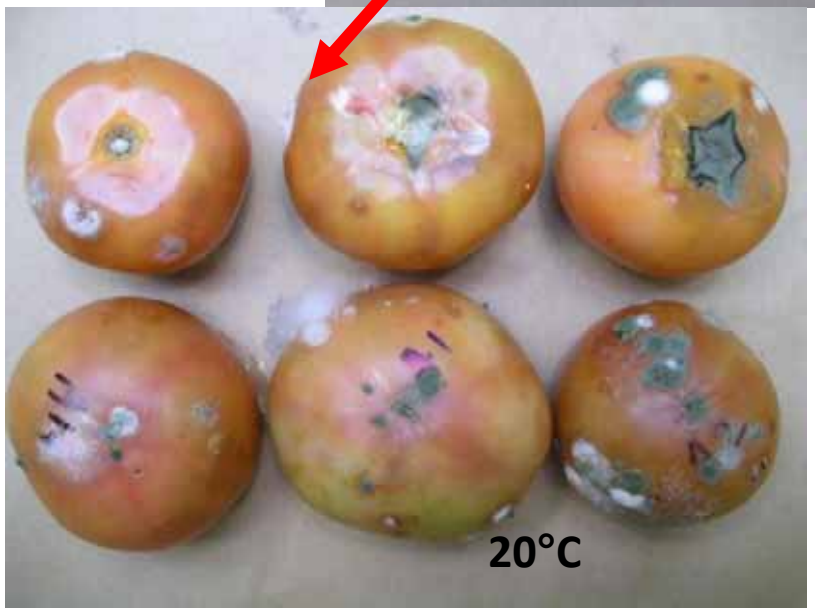
		Days to Visible Chilling Symptoms		
Temperature		Black Bell	Japanese	Chinese
0°C	32°F	1-2	--	2-3
2.5°C	36°F	4-5	5-6	5-6
5°C	41°F	6-7	8-9	10-12
7.5°C	45°F	12	12-14	15-16
10°C	50°F	no chilling	no chilling	no chilling

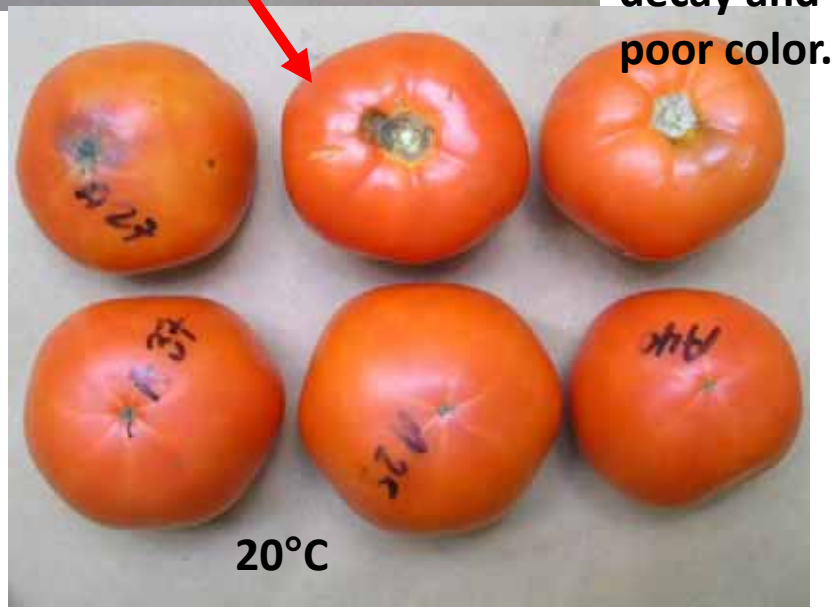
Cv Bobcat
Initial Color
Stage = 3



2.5°C = 36°F
7.5°C = 45°F
12.5°C = 55°F

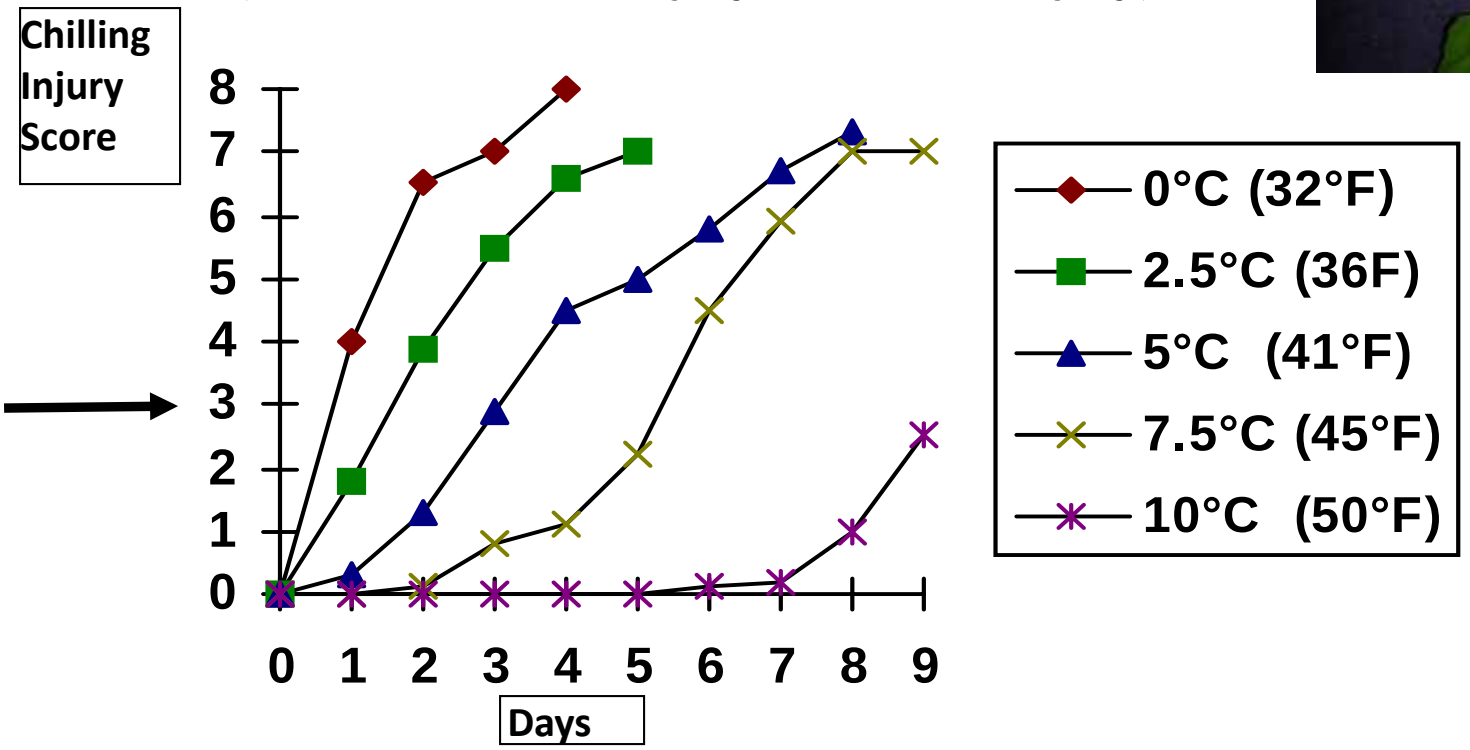
It is quite common that tomatoes are Stored or Transported at 7°C (45°F). This temp. results in decay and poor color.





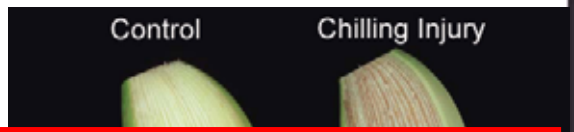
Chilling Injury of Basil: Temperature and Time

Development of Chilling injury on sweet basil stored at different temperatures. A score of 3 was considered the limit for marketability. (A score of 0 = no injury, 8 = severe injury).



Symptoms of chilling injury

- Surface pitting
- Water soaking
- Browning
- Necrosis
- Rots
- Poor flavor
- Poor ripening



Commonly chilling symptoms do not appear until product is transferred from the cold room to a warmer temperature

Transpiration (water loss)

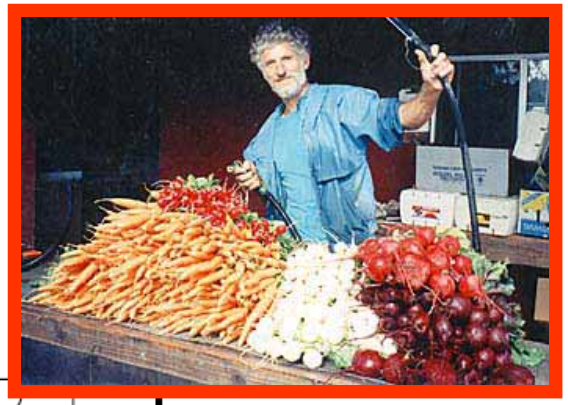
Loss of Salable Weight
Loss Fresh Appearance
Loss of Texture

<3% no visual effect, texture
3-5% visual quality affected
>5% shrivel, lose salability

Water loss is Cumulative

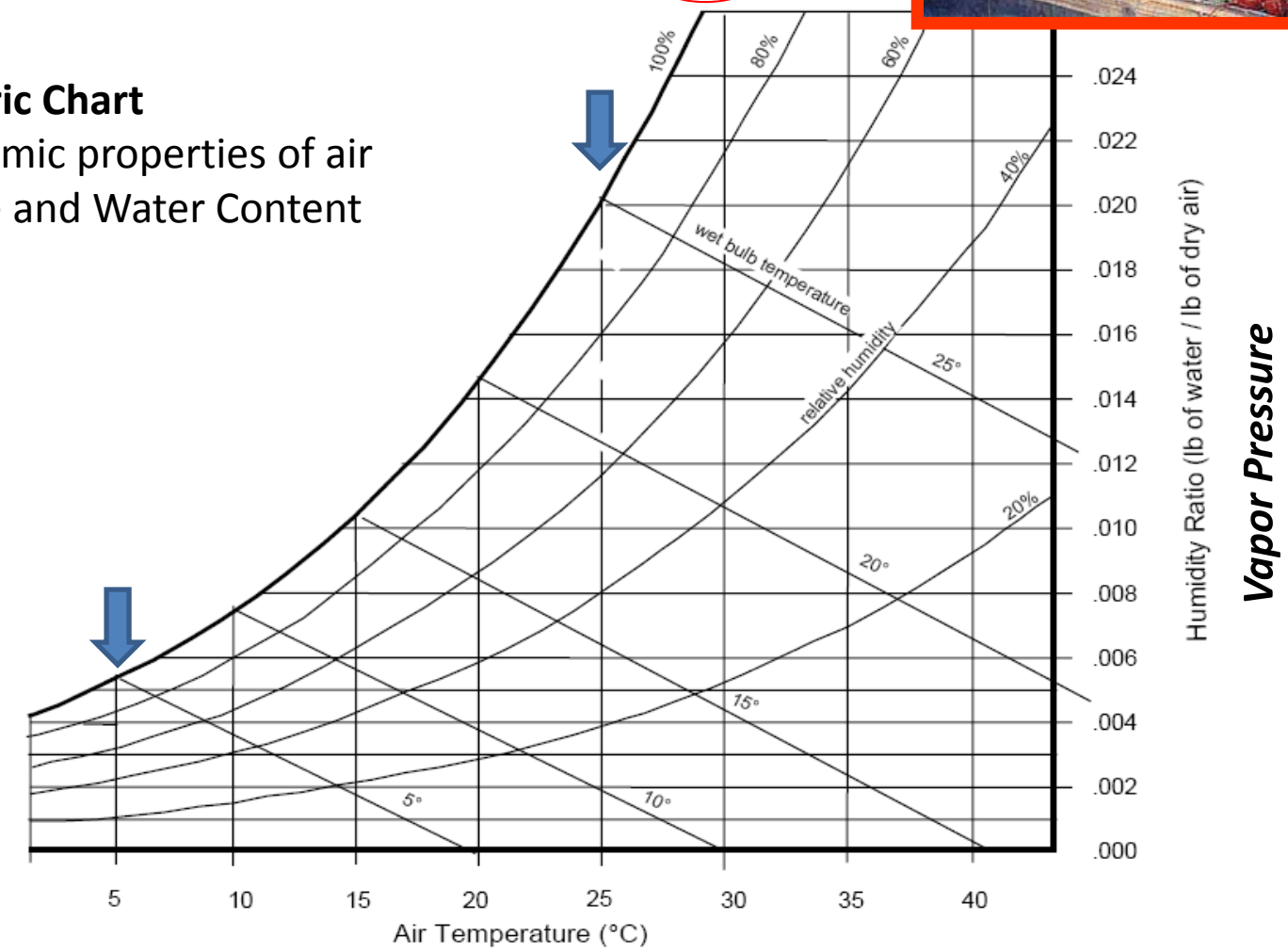
Wt loss (%/day) = product K x VPD

Water loss and temperature

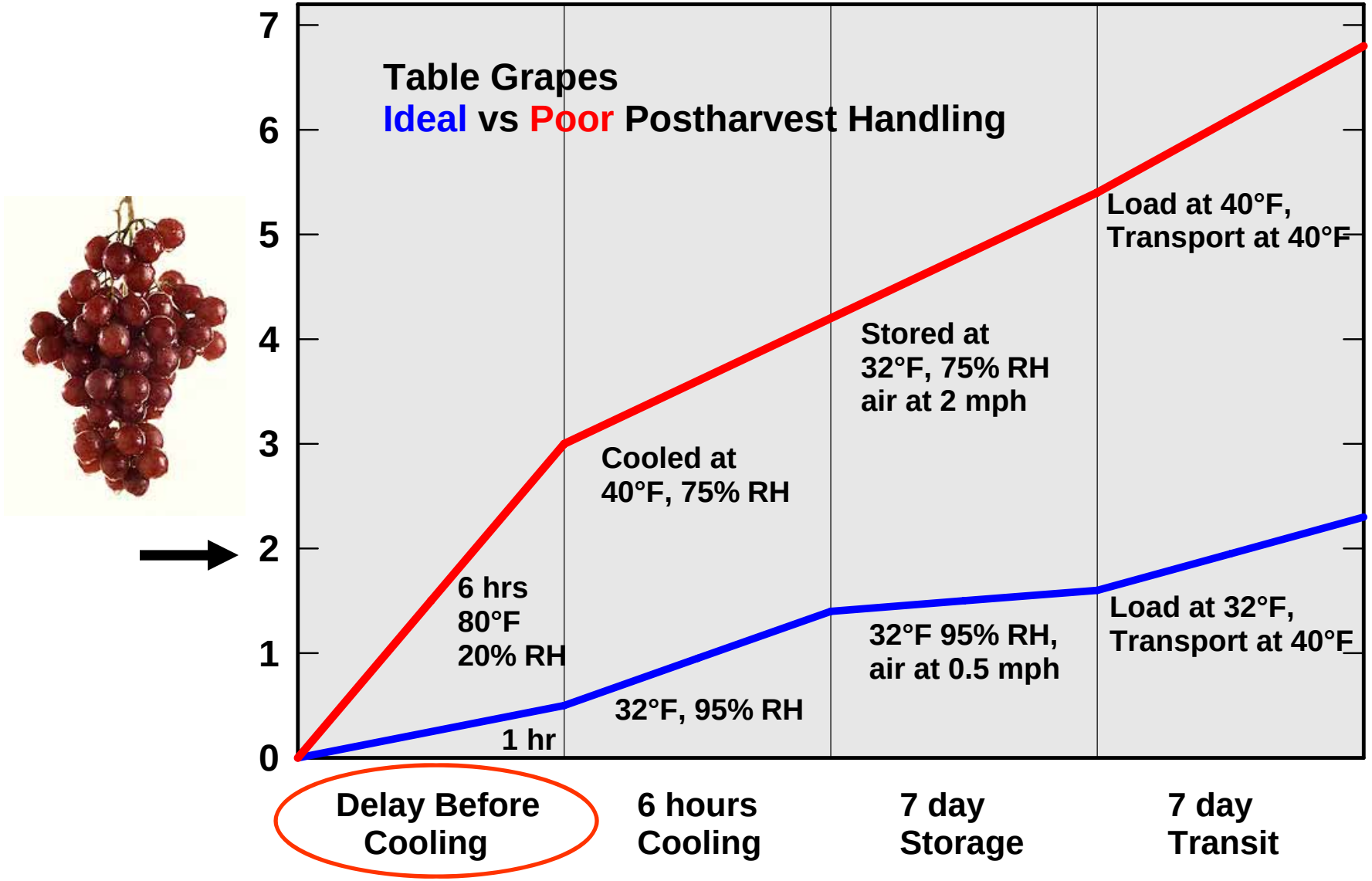


Wt loss (%/day) = product K x VPD

Psychrometric Chart
Thermodynamic properties of air
Temperature and Water Content



Vapor Pressure


% Water Loss
7
6
5
4
3
2
1
0
Table Grapes
Ideal vs Poor Postharvest Handling
Load at 40°F,
Transport at 40°F
Stored at
32°F, 75% RH
air at 2 mph
Cooled at
40°F, 75% RH
6 hrs
80°F
20% RH
32°F 95% RH,
air at 0.5 mph
Load at 32°F,
Transport at 40°F
32°F, 95% RH
1 hr
Delay Before Cooling
6 hours Cooling
7 day Storage
7 day Transit

Packaging to reduce water loss.
Contain, Protect, Inform
RPCs, Paper, Carton, Plastic

Hammock Pack for Ripe Fruit
Thompson & Slaughter, UC Davis

Modified or Controlled Atmospheres

- Reducing oxygen
- Increasing carbon dioxide
- Removing carbon dioxide
- Removing ethylene and other volatiles
- Degree of precision differentiates MA and CA

Composition of Normal Air

78.08%	Nitrogen (N_2)
20.95%	Oxygen (O_2)
0.93%	Argon (Ar)
0.03%	Carbon dioxide (CO_2)
0.0001%	Ethylene (C2H4) (1 ppm)

Temperature Management

- Insures best product quality
- Longest shelf life
- Reduces microbial growth
- Required for MA packaging

Modified Atmospheres

- Can be an important supplement to temperature
- Can retard deterioration
- Can retard discoloration in fresh-cuts products
- Can retard microbial growth

Some uses of MA for fruits and vegetables

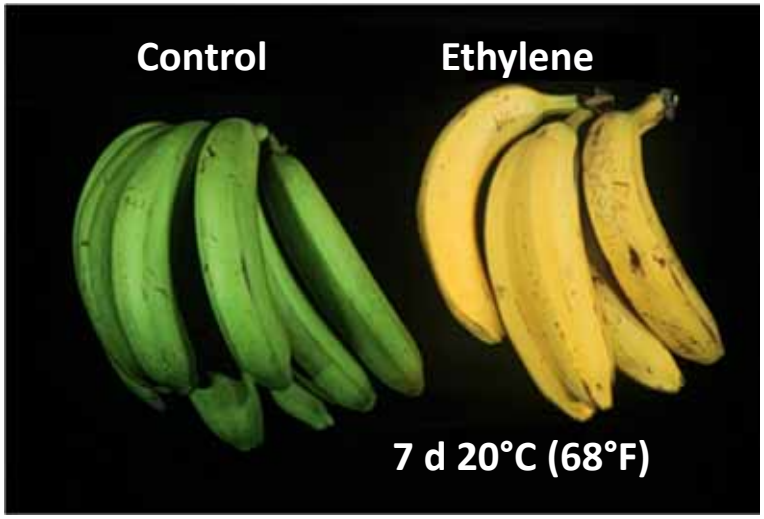
MA for strawberry pallets to control Botrytis

MAP Salad Products

Bag-in-box MA for melons

Ethylene - an important factor

- **Useful:**
  - Accelerates ripening
  - Causes abscission
  - Chlorophyll destruction
- **Problematic:**
  - Accelerates ripening
  - Causes abscission
  - Accelerates senescence



Manage Ethylene

Incompatible products
Low temperature
Minimize exposure time

1. **Avoid**

   Products, forklifts, smoke

2. **Remove**

   Ventilate, oxidize, absorb

3. **Inhibit production and action**

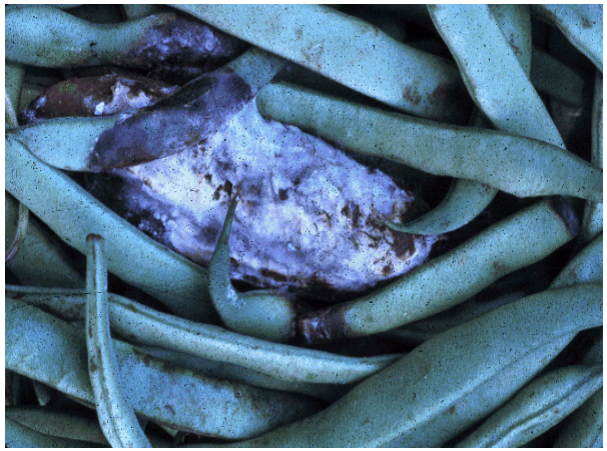
   Low temperature, modified atmospheres, chemical inhibitors, molecular antisense technology

4. **Germplasm selection/engineering**

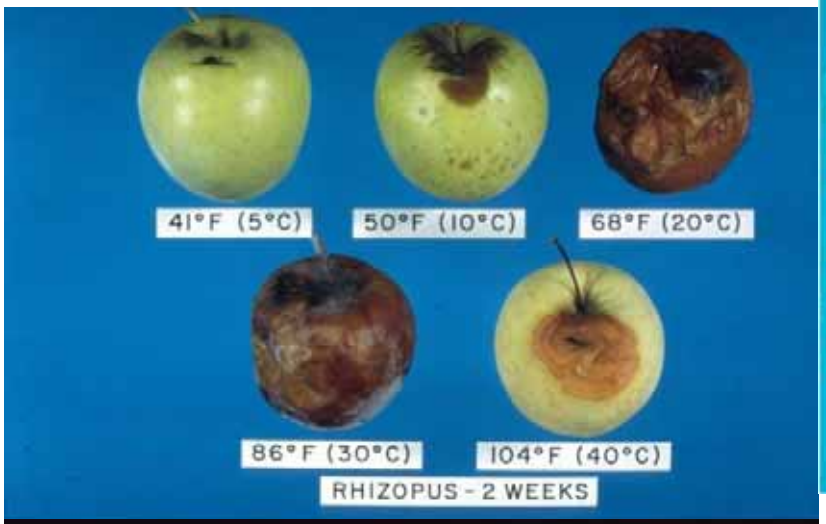
Product Diseases

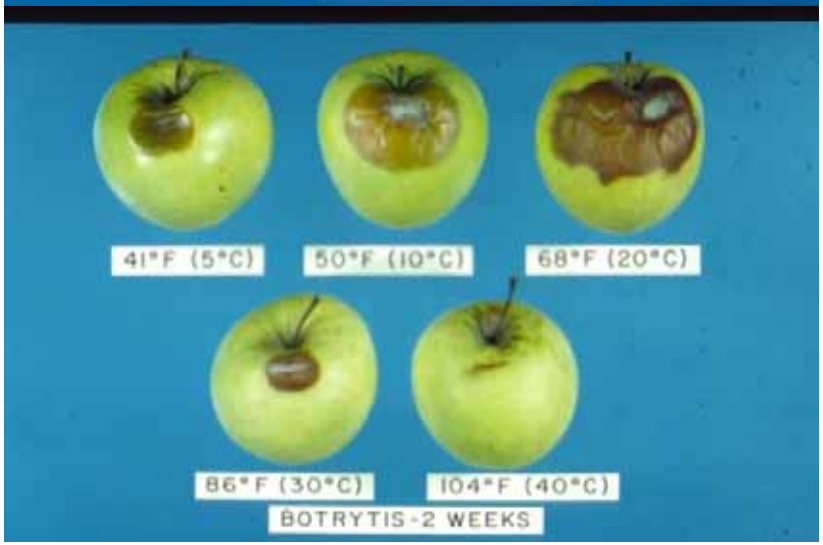
Reduce Physical damage

- Major cause of loss
- Relatively few important genera
  - *Most are weak pathogens and need injury*
- Many products are not infected



Temperature and Postharvest Decay





Carefully transfer to field bin!!

Avoid bruising!

Overcoming damage

- CARE!
  - Careful harvesting
  - Into lined baskets
  - Don’t throw, dump, or drop
  - Avoid rough surfaces
  - Pack gently but securely

Human Diseases: Microbial Food Safety

- Fresh fruits and vegetables can be associated with foodborne illness—contamination and handling errors
- **No kill step** for fresh produce
- Temperature abuse sometimes contributes
  - Bacterial pathogens can multiply on fresh produce
- **Prevention of contamination** throughout the food chain is preferred
  - Sanitation and Hygiene (Clean and Separate)
  - Washing (Clean) and
  - Temperature control important (Chill)



Modified from Linda Harris, UC Davis

Food Safety Issues

Sources of Contamination

Beuchat, 1996

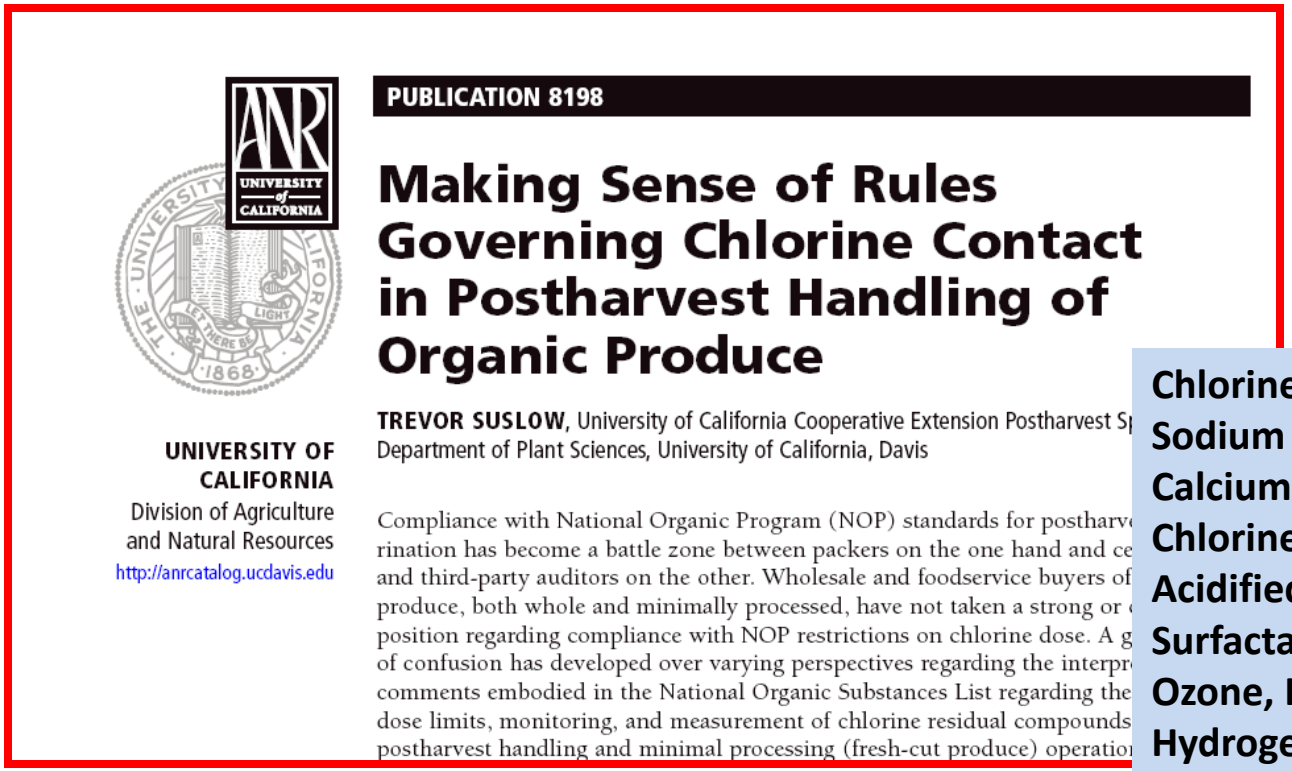
Enteric (Fecal) Pathogens (partial list)

	Pathogen Multiply in Foods	Enteric Source	Infectious Dose	Sequelae
Bacteria	*Salmonella* spp. **YES**	human animals	10 - 100,000	Reactive arthritis
	E. coli O157:H7 **YES**	human animals	10 - 1,000	HUS
	Shigella **YES**	Human	10 - 100	Dysentery
Protozoa	*Cryptosporidium* **NO**	human	<20	Severe

- **Prevention of Contamination is most important**
- **Time and Temperature are Amplifiers of Risk**

From Linda Harris, UC Davis

Use of chlorine or other sanitizers to prevent cross contamination



PUBLICATION 8198

Making Sense of Rules Governing Chlorine Contact in Postharvest Handling of Organic Produce

TREVOR SUSLOW, University of California Cooperative Extension Postharvest Sp
Department of Plant Sciences, University of California, Davis

Compliance with National Organic Program (NOP) standards for postharv
rination has become a battle zone between packers on the one hand and ce
and third-party auditors on the other. Wholesale and foodservice buyers of
produce, both whole and minimally processed, have not taken a strong or
position regarding compliance with NOP restrictions on chlorine dose. A g
of confusion has developed over varying perspectives regarding the interpr
comments embodied in the National Organic Substances List regarding the
dose limits, monitoring, and measurement of chlorine residual compounds
postharvest handling and minimal processing (fresh-cut produce) operatio

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Multiple options for water and surface disinfection.
All can work well,
It depends……

Chlorine gas
Sodium hypochlorite
Calcium hypochlorite
Chlorine dioxide
Acidified sodium chlorite
Surfactants
Ozone, Ionizing radicals
Hydrogen peroxide = Hydrogen dioxide
Organic acids
Peroxyacetic acid, Peroctonoic acid
Calcium oxide
TSP, Bromine, Iodine, Silver, Copper
Ultraviolet Illumination, Energy-wave
Super Critical CO2
Irradiation
Other…….

UC GAPs AND FOOD SAFETY
UCDAVIS

http://ucgaps.ucdavis.edu or http://ucfoodsafety.ucdavis.edu

Basic Handling Steps

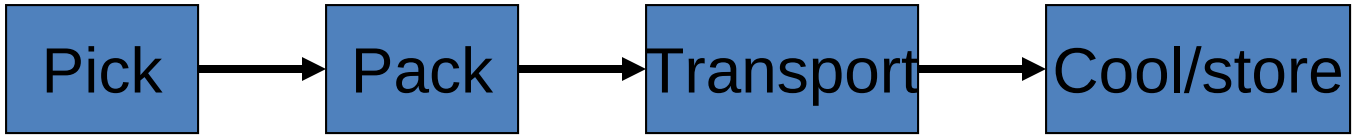
- **Harvest**
- **Sort for defec**
- **Preparation (w**
- **Classify (by color, size)**
- **Pack**
- **Palletize**
- **Cool and temporary storage**

The more the product is directly touched, the more damage occurs to the product.

Therefore get the product into the final shipping container as soon as possible.

Field vs. Shed packing

Field Pack



Shed Pack

‘Ranch Pack’ Peach Handling: Simple, Clean and Careful Handling for High Quality Product

Now packers wear hairnets

Hairnets; gloves
3rd party Inspectors
Forced Air Cooling

10 Basic Postharvest Principles

1) Harvest at correct maturity
2) Reduce physical handling
3) Protect product from sun
4) Keep packingline simple and clean; ensure good worker hygiene
5) Select, classify, and pack carefully
6) Align cartons, strap pallet
7) Cool as soon as possible
8) Know market and product requirements
9) Coordinate efficient & rapid handling
10) Train and compensate workers adequately

Some Postharvest Considerations and Opportunities for Local Produce

- Harvest products near ripe
- Capitalize on Freshness potential
- Harvest and handling carefully to avoid injuries that would lead to decay and favor contamination
- Have scrupulously clean containers, packing areas, and employees
- Harvest when product is cool; cooling and temperature requirements for shelf-life period needed
- Minimize time between harvest and cool conditions
- Minimize use of water; ensure water, worker sanitation
- Use containers, packaging that provide sufficient protection, ventilation
- Value-added opportunities (not all require special infrastructure)
- Expedite handling to consumer
- Consumer needs to handle well and consume promptly

UCDAVIS POSTHARVEST TECHNOLOGY

POSTHARVEST SPECIALISTS

http://postharvest.ucdavis.edu

Mary Lu Arpaia
Subtropical Fruits

Diane Barrett
Processing & Quality

Christine Bruhn
Consumer Issues

Marita Cantwell
Vegetables & Fresh-Cut

Roberta Cook
Marketing & Economics

Carlos Crisosto
Stone Fruits

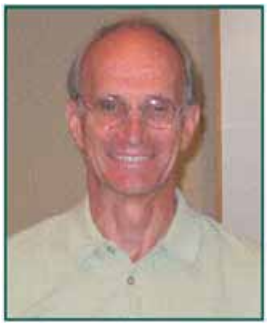
Linda Harris
Food Safety

Adel Kader
Fruit & Nut Quality

Elizabeth Mitcham
MA & IPM Research Faculty Director

Michael Reid
Cut Flowers & Potted Plants

Trevor Suslow
Quality & Microbial Safety



Jim Thompson
Cooling, Transport, Fumigation

California's Great Industries video link; http:californiagrown.org