Produce Handling, Safety and Nutritional Quality Considerations

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How postharvest biology and handling is related with the local food system

Demand of local food:

- Farm-level value of local food sales totaled about $11.8 billion 2017
- 8% of U.S farms sold food directly at local food market channels
- Primarily fruits and vegetables mainly

- Market value of agricultural products sold directly at Californian local market totaled $4.3 billion in 2017, which is accounted about 35 % of the U. S total sale

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What is the growth of local production we are referring to?

- 147,307 farms engaged in local food systems
- >5% of all U.S farms
- Several local food markets channels have experience growth since 2006

Since 2006:

- Farmers markets have grown by 180%
- regional food hubs have grown by 288%
- school district participation in farm to school programs has increased by 430%
- 2019 to 2020, sales at farmers markets and restaurants/grocery stores increased by **11 and 13%**

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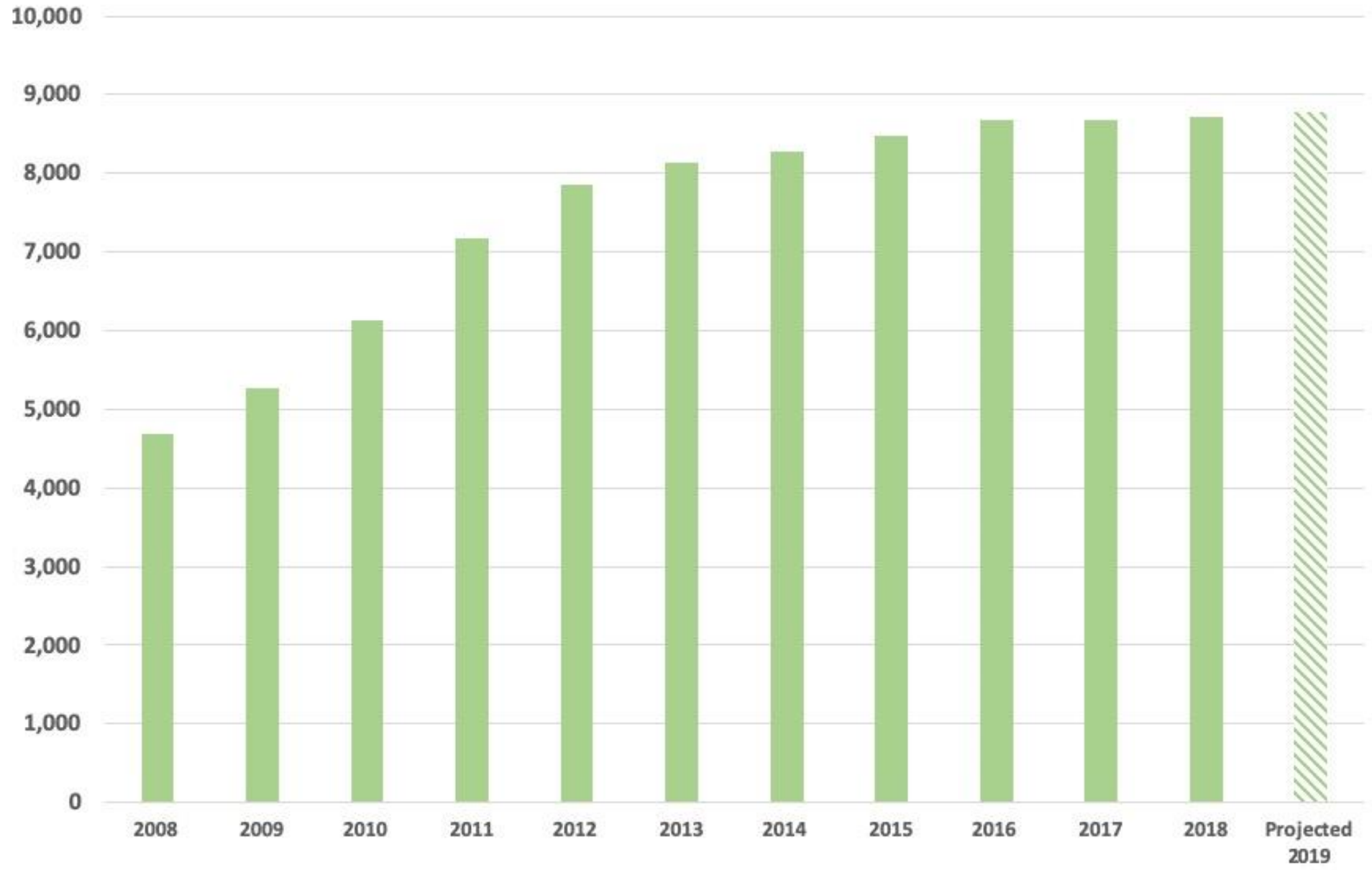
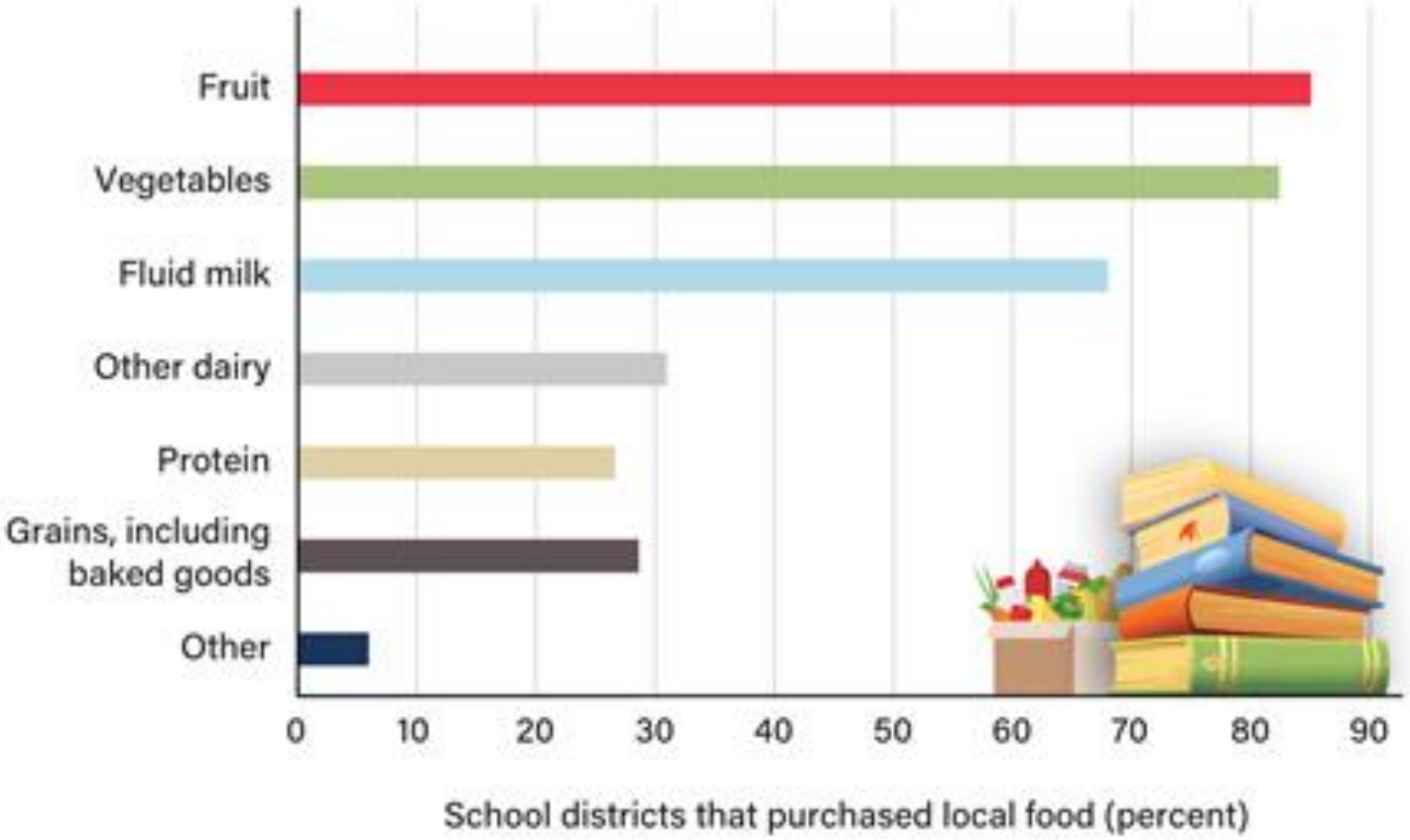
Number of Farmers' Markets in the Nation



Percent of school districts that purchased local food, by type, school year 2018–19

USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE



Notes: Percentages sum to more than 100 percent because respondents were allowed to identify multiple foods. School district is used interchangeably with the formal term, "school food authority," which often but does not always correspond with school district. Respondents were restricted to school districts participating in farm to school activities that indicated they purchased any local food during school year 2018–19.

Source: USDA, Economic Research Service using data from the 2019 USDA Farm to School Census, USDA Food and Nutrition Service.

What postharvest biology means and why it is important?

- A pragmatic (practical) science
- Primarily deals with perishable commodities
- By definition: Postharvest = After Harvest

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What Postharvest handling means?

- 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)
- Ultimately, maximum product quality is determined at harvest

What are the main objective of post-harvest handling?

- Maintain the quality
- Reduce losses

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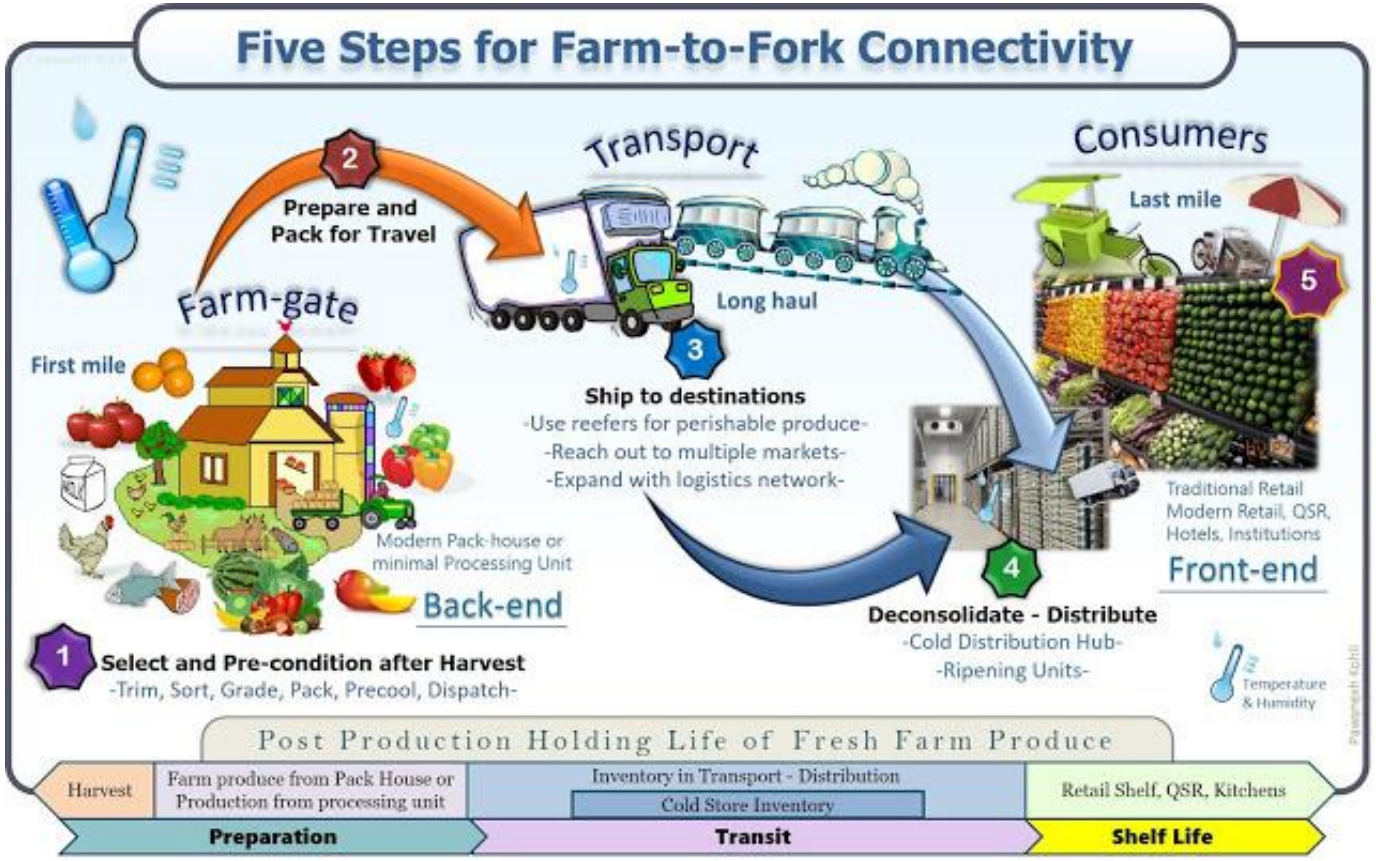
What happens after crops are harvested?



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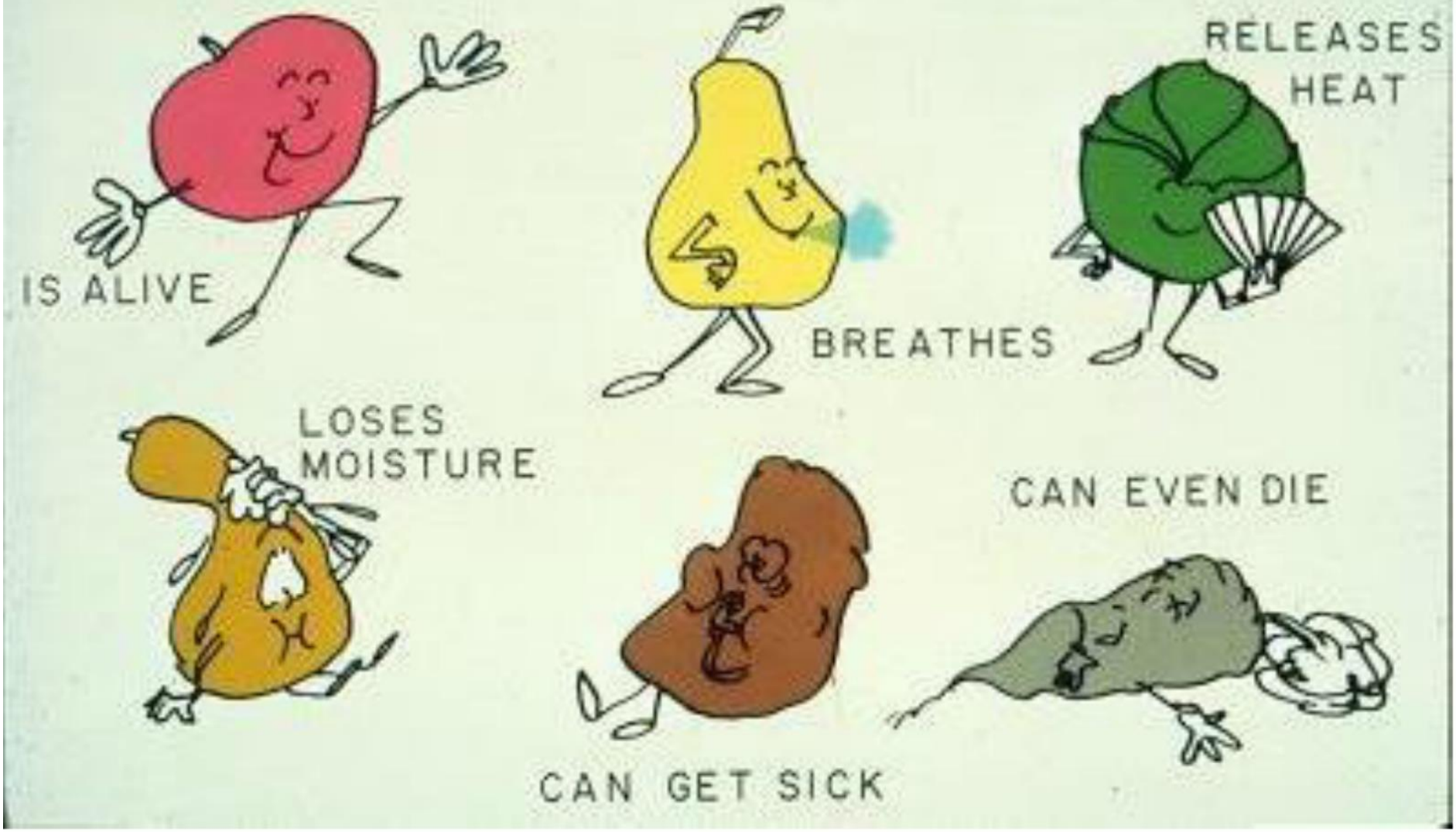
FRESH PRODUCE



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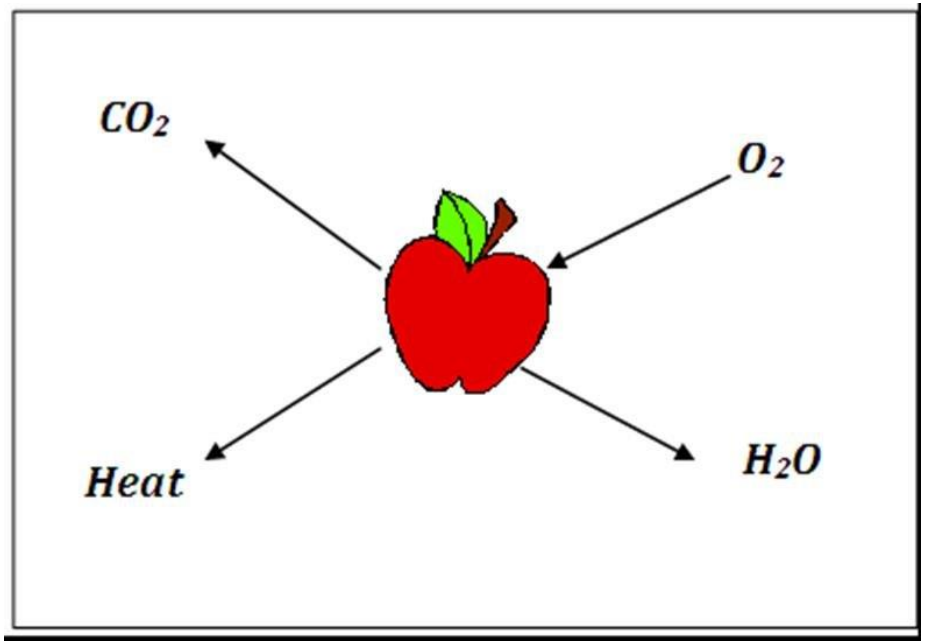
- **Are the fruits and vegetables alive after harvest?**
- -It breathes,
- - They releases heat
- -Loss moisture
- -Can get sick
- -Finally die



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What are the characteristics of fresh produce/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

Name the parts?

- Onion-Modified leaves
- Lettuce-leaves
- Broccoli-A stalk and immature flower
- Peach-Fruit
- Peas –Seeds

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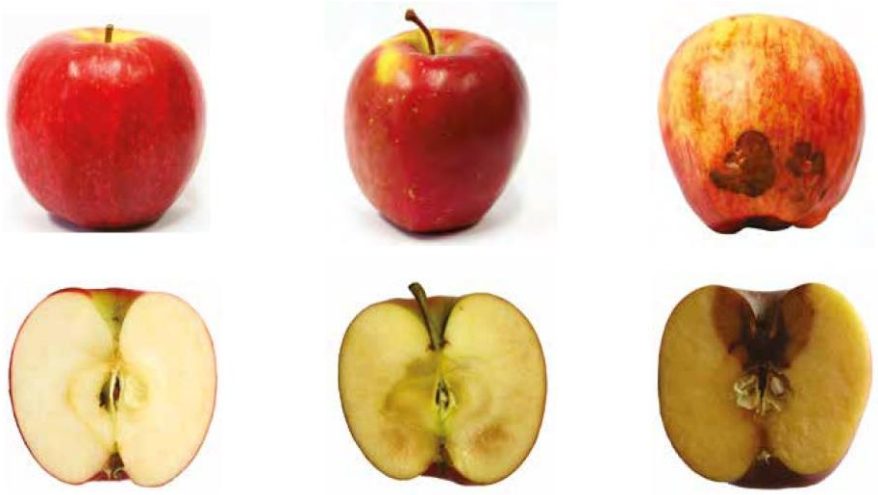
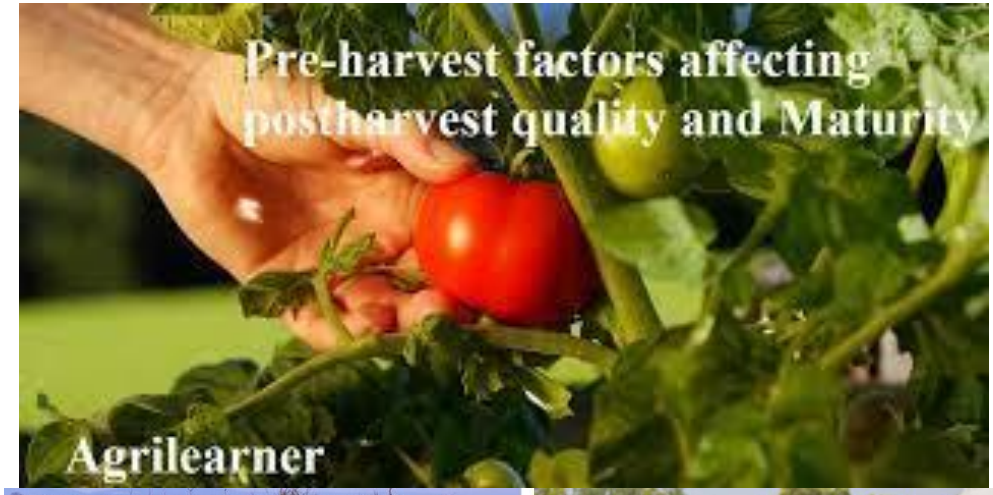
- **What factors influence postharvest loss?**
- There are two kinds of factors influence the postharvest loss-
- **Internal factors**
- Metabolic rate (respiration)
- Compositional changes
- Morphological changes
- Physiological disorders
- General senescence



Environmental factors

- Changes in temperature
- Physical damage
- Pathogens
- Humidity
- Rodents
- Contamination



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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

The main goal of postharvest handling is to make the produce take it easy and slow down that aging process

- **Temperature:**
- Temperature is the most CRITICAL factor influencing the postharvest life
- Dictates the speed of biological/chemical reactions
  - Respiration
  - Senescence
  - Ethylene Production
  - Water loss
- Typically, for every 18 °F increase, respiration increases 2 - 4 times

- 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

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Temporary storage:

Store the product at optimum temperature

Practice first in first out rotation

Ship to market as soon as possible

Handling at Home or Food service outlet:

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

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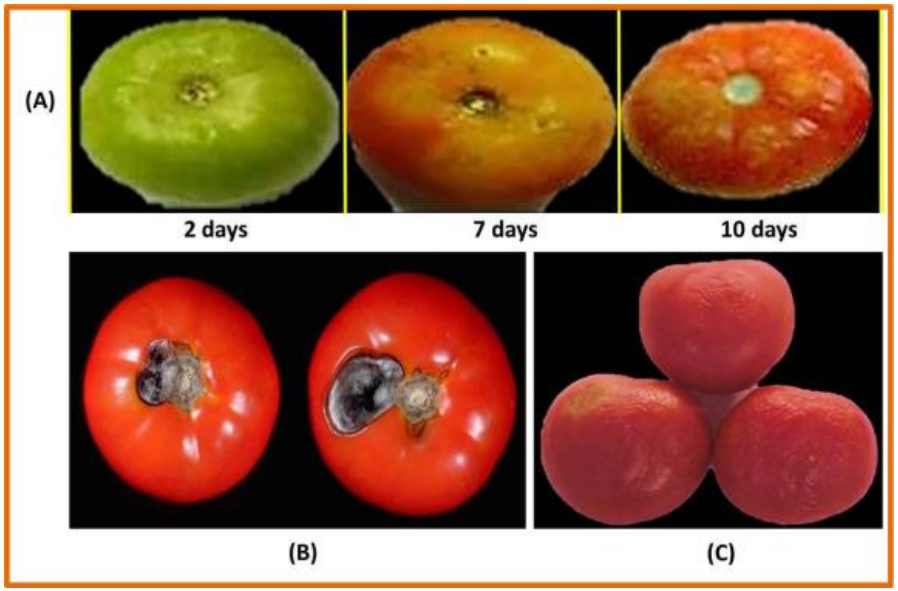
Temperature Related Physiological Disorders:

- Chilling Injury
- Occurs mainly in tropical and subtropical species when exposed to **low but non-freezing temperatures < 10 °C (50 °F)**
- 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



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- **What is the relationship of temperature with chilling and non-chilling products?**
- Chilling sensitive products have shorter shelf life in storage and it is the longest in moderate temperatures. **Mostly the tropical and sub tropical crops**
- Non chilling sensitive commodities will last longer in storage when held in lower temperatures and as temperature is increasing self-life is decreasing.

Examples: **carrots, sweet corn, cantaloupes, escarole, lettuce, spinach, radishes, broccoli, green onions**)

Storage temperature

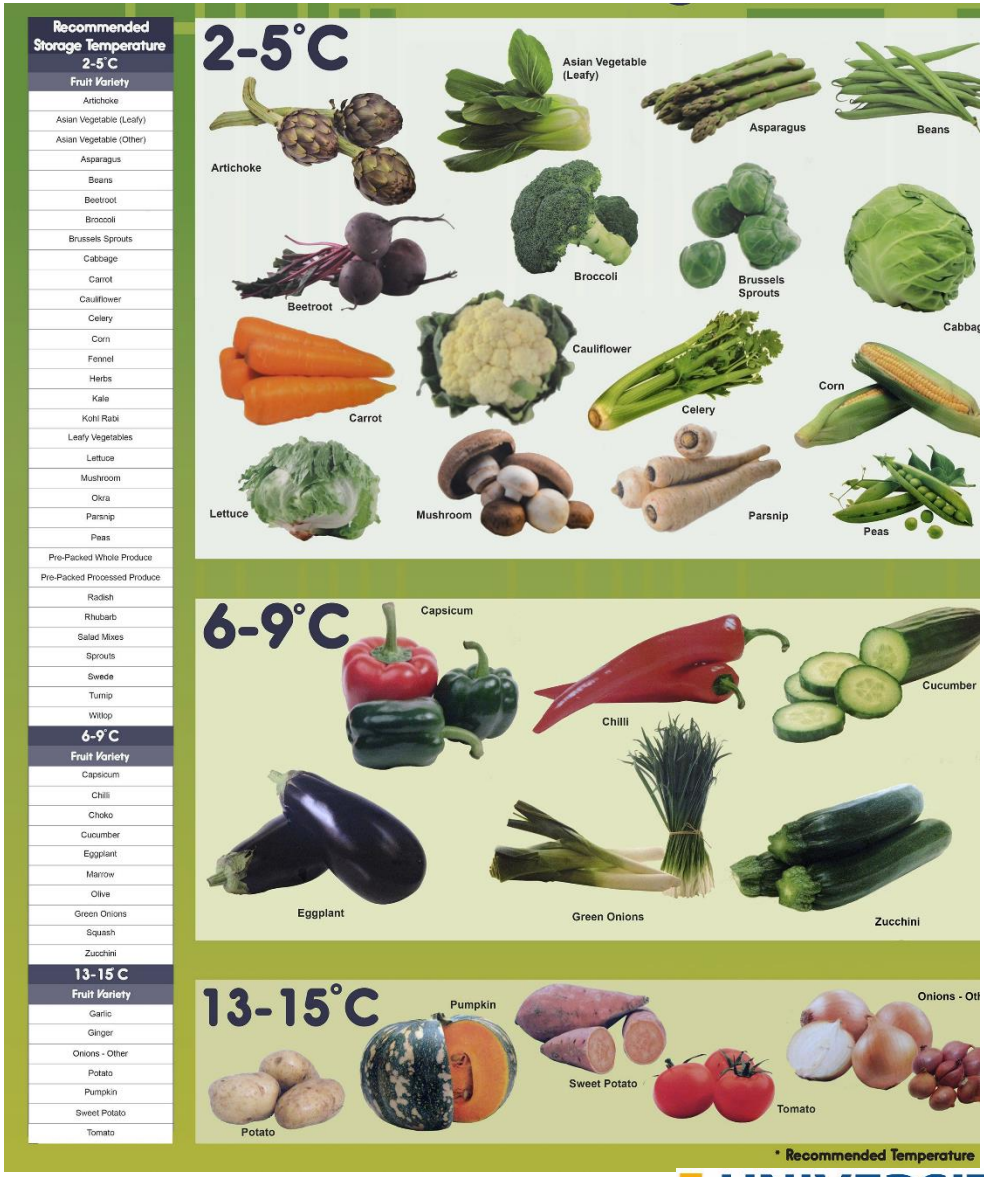

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Table 2. Cumulative losses in vitamin C *due to fresh storage or processing and storage, followed by home cooking in all cases. Adapted from Rickman et al. (2007a).*

Vegetable	Initial concentration (g/kg)	Refrigerated storage time before processing and cooking (days)	Loss after cooking (% wet weight)			Reference
			Fresh	Frozen	Canned	
Broccoli[a]	1.23	21	5	35[b]	–	Howard et al. (1999)
	1.80	21	38	62[b]	–	Howard et al. (1999)
Carrots[a]	0.043	7	42	12[b]	81[b]	Howard et al. (1999)
	0.039	7	+50[c]	56[b]	95[b]	Howard et al. (1999)
Green beans	0.152	21	37	20[b]	–	Howard et al. (1999)
	0.163[d]	0	23	48[e]	68[e]	Weits et al. (1970)
Green peas	0.40[d]	0	28	66[e]	77[e]	Weits et al. (1970)
	0.354	1–2	61	70[f]	85[f]	Fellers and Stepat (1935)
Spinach	0.28[d]	0	64	81[e]	67[e]	Weits et al. (1970)

[a]*Authors repeated analysis in two consecutive years, results indicated separately.*
[b]*Stored for 12 mo prior to cooking.*
[c]*Authors reported increase in vitamin C with fresh storage.*
[d]*Authors did not provide values. Values taken from USDA (2005).*
[e]*Stored for 6 mo prior to cooking.*
[f]*Authors did not indicate storage time before cooking.*

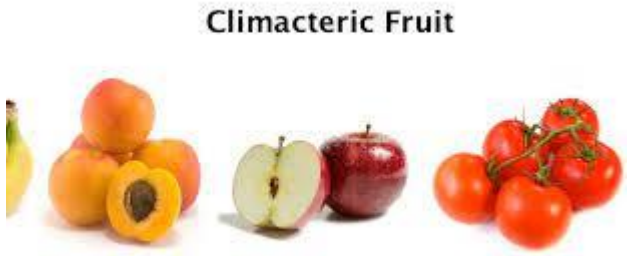
Factors affecting the commodity in the environment:

- Temperature
- Humidity
- Oxygen
- Carbon Dioxide ,Ethylene

- **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

What is climacteric & non-climacteric crops?

- **Climacteric**: **Climacteric fruits** are **defined** as **fruits** that enter '**climacteric** phase' after harvest i.e. they continue to ripen. During the ripening process the **fruits** emit ethylene along with increased rate of respiration.
- **Examples of climacteric fruits** are apples, apricots, avocados, bananas, blackberries, kiwi, plums, peaches, pears, tomatoes.



- **Non-climacteric**, which cannot **ripen** once removed from the plant
- **Examples** of non-**climacteric fruits** are citrus, grapes, cherries, raspberries, strawberries and cashews.
- Commodities that are producing very low amounts of ethylene for instance cherries and strawberries while 10 to 100 times higher in apples and peaches.

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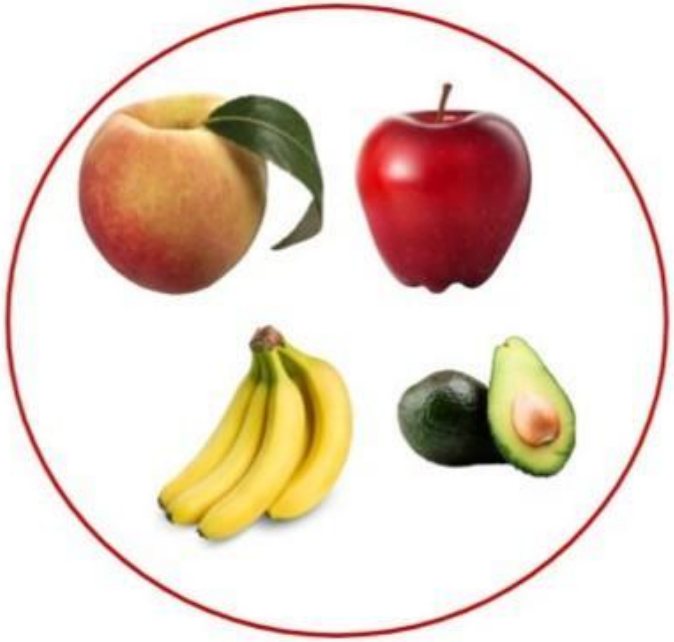
Climacteric Fruits



Non-Climacteric Fruits

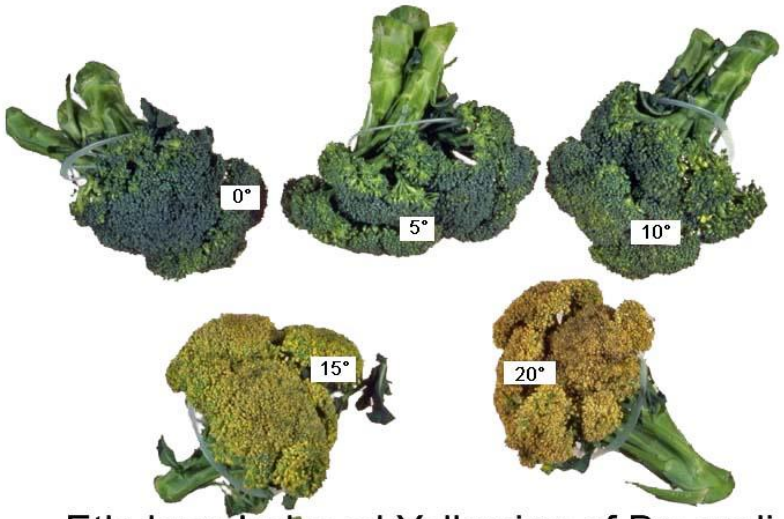
Classification of Horticultural Commodities According to Their Ethylene Production

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

Practical application:

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

- **Ethylene sensitivity:**
- The ethylene sensitive crops will be damaged on the presence of ethylene.
- The symptoms include: Yellowing, Internal Browning, Lignification, Sprouting, and off flavor development.



Ethylene Induced Yellowing of Broccoli

Ethylene sensitive commodities include:

Leafy Greens e.g. Spinach,

Lettuce Brassicas e.g. Broccoli, Cabbage

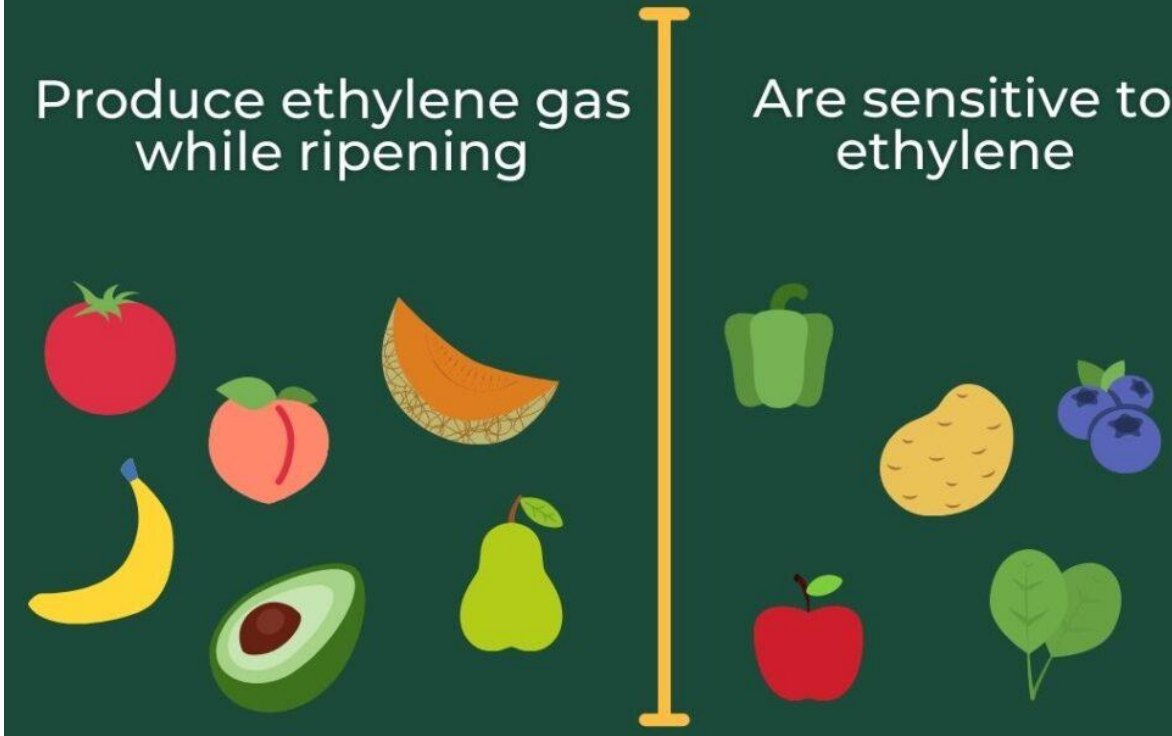
Root Vegetables e.g. Potato, onion

Fruits e.g. Apple, pear, cantaloupe

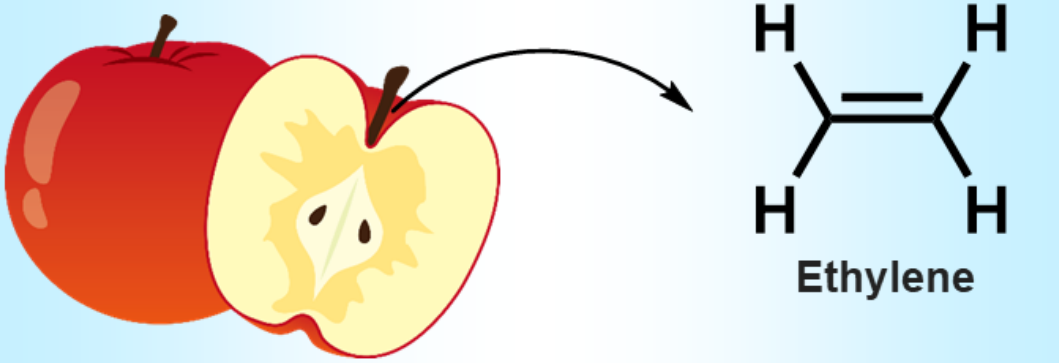
Flowers e.g. Carnation

Store separately

Keep foods that produce more ethylene gas separate from those that don't to reduce premature spoilage



Apples produce ethylene that promotes fruits ripening



Ethylene

- **Handling Tips during harvest:**
- Some handling tips.
- During harvest:
- Pick early in AM for reducing the field heat
- Harvest at proper maturity
- Perform Gentle & sanitary picking.
- Use always clean totes/buckets for avoiding contamination.

- Never overfill totes/buckets this will damage the crop
- Use sharp & clean tools
- Discard damaged produce
- Pick clean crops
- Always keep the totes in shade
- In case of hired labor, always train the worker in order to perform the job correctly!

- **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: Set 1st 32-36°F and 2nd 50-57°F

Mature Fruit Vegetables

Tomatoes

Peppers, Chiles

- Maturity at harvest critical for quality
- Chilling sensitive, but variable in sensitivity
- Ethylene can control ripening
- Moderate respiration rates; can be stored

Marita Cantwell, UC Davis
micantwell@ucdavis.edu

UCDAVIS POSTHARVEST TECHNOLOGY

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Tomato Quality Attributes

- **Size, shape**
- **Condition**
  - no damage
  - no decay
- **Texture**
  - Firmness, mealiness, juiciness, slice integrity
- **Color**
  - Red color and lycopene content
- **Flavor and Composition**
  - Sugars
  - Acids
  - Aroma volatiles
  - Vitamins

Maturity & Ripening Stages

VR

1 

GREEN The tomato surface is completely green. The shade of green may vary from light to dark.

2 

BREAKERS There is a definite break of color from green to bruised fruit Tannish-yellow, pink or red or 10% or less of the tomato surface.

3 

TURNING Tannish-yellow, pink or red color shows on over 10% but not more than 30% of the tomato surface.

4 

PINK Pink or red color shows on over 30% but not more than 90% of the tomato surface.

5 

LIGHT RED Pinkish-red or red color shows on over 60% but red color covers not more than 90% of the tomato surface

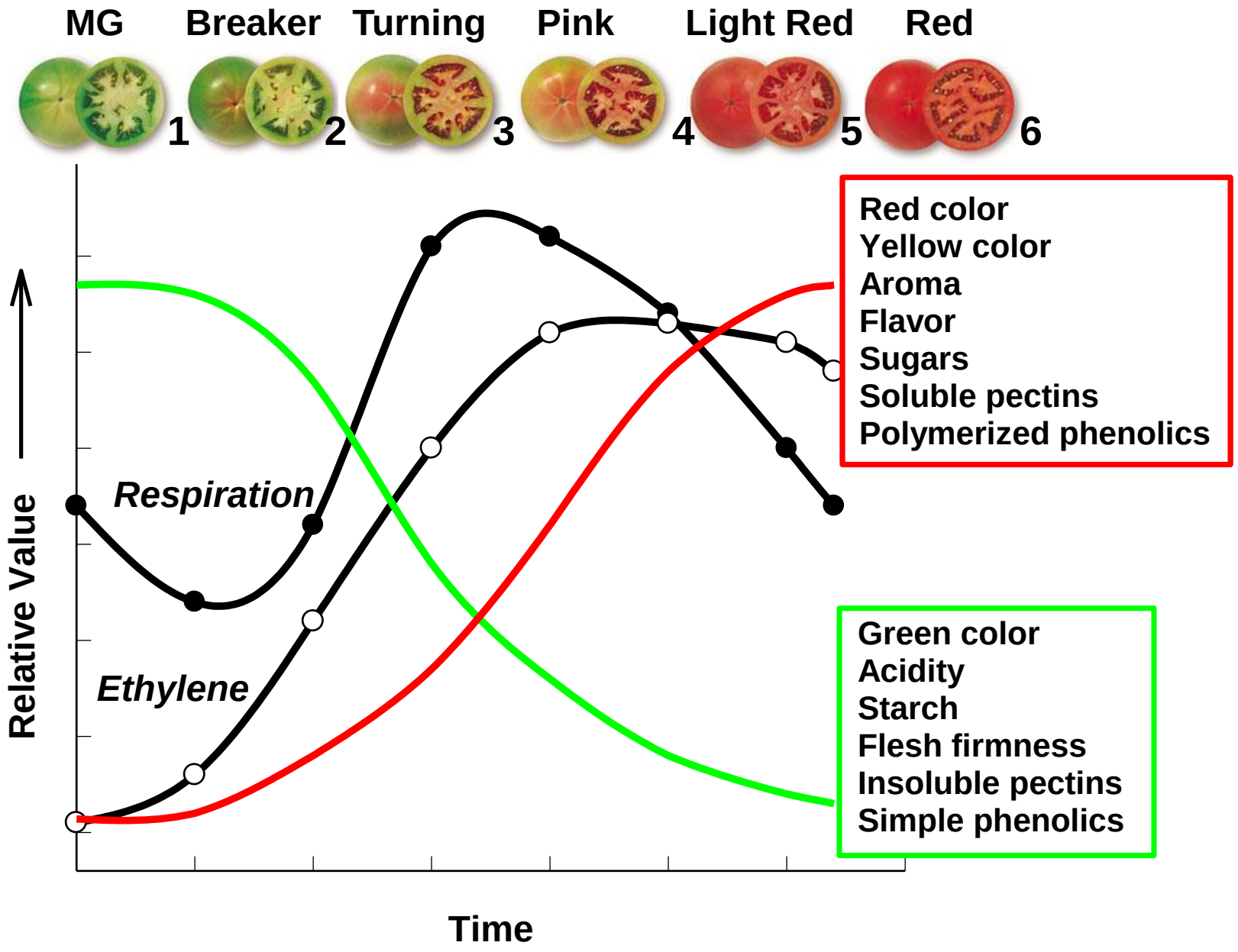
6 

RED Red means that more than 90% of the tomato surface, in aggregate, is red

Tomato mature-green & breaker stages

PROBLEMATIC!

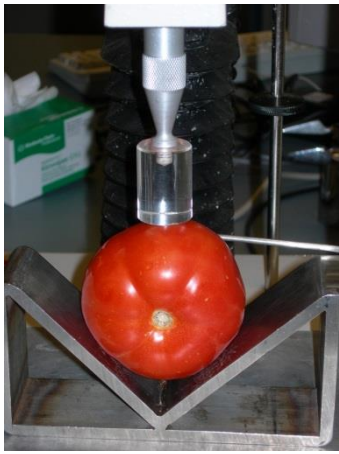
Immature MG1 MG2 MG3 Br



Tomato photos: http://www.tomato.org/food/color.html

Firmness Classes for Tomatoes

Firmness Class	Description	Firmness Newtons force to compress 5 mm
Very firm	yields slightly to considerable finger pressure	**30-50**
Firm	yields slightly to moderate finger pressure	**20-30**
Moderately firm	--	**15-20**
Moderately soft	yields readily to moderate finger pressure	**10-15**
Soft	yields to slight finger pressure	**10**
Very soft	yields very readily to slight finger pressure	**5**



Other Textural Characteristics

- **Slice Integrity**
- **Mealiness**

1kg-f= 9.81Newton; 1 lb-f = 4.45 Newton

Small handy equipment for firmness and maturity detection

Penetrometer

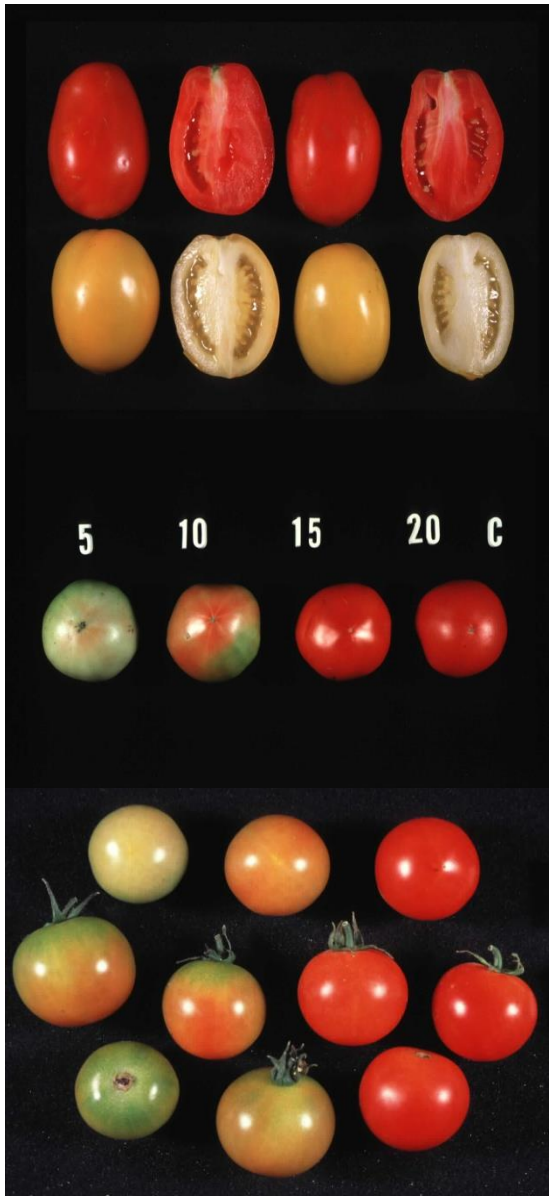
Refractometer

Tomato Color

Carotenoids

- β– and other carotenes
- Lycopene (90%)

Pigment extraction,
Objective color values



Tomato Color

2	3	4	5	6

Hue	95	78	62	48	40
Lycopene	0.3	4.0	8.6	16.8	32.7

Lycopene in the pericarp, mg/kg FW

Tomato Flavor

Depends on content of:

- ✓ Sugars (4-8%)
- ✓ Acids (0.2-0.8%)
- ✓ Aroma volatiles (ppm)

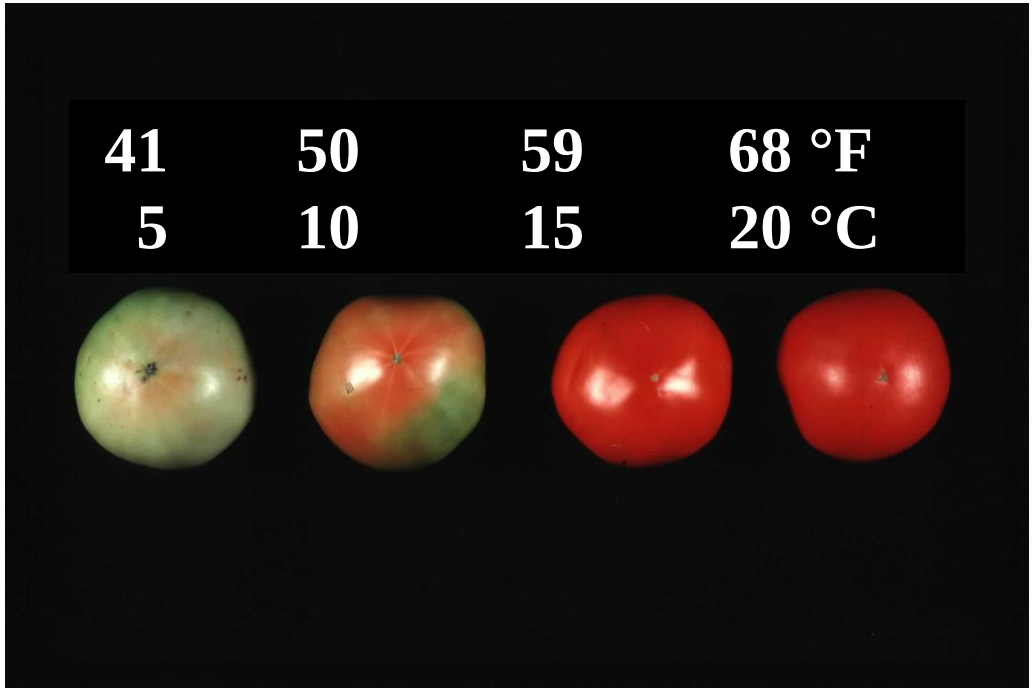
We estimate flavor by measuring sugars (soluble solids) and acids (titratable acidity)

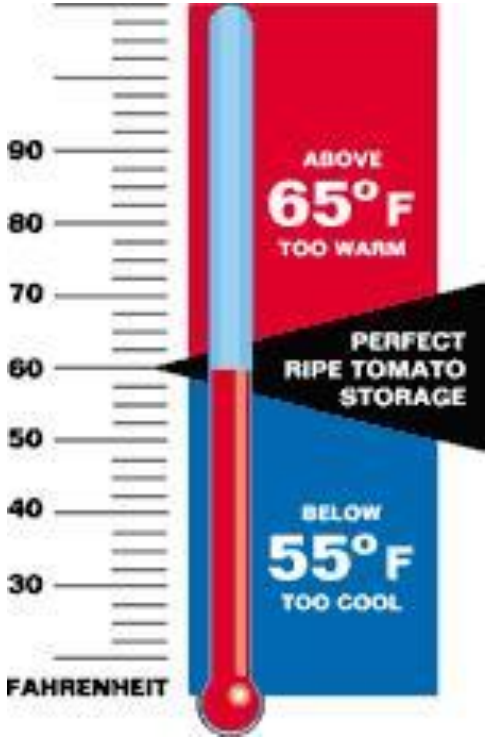
Tomato Storage and Handling

- Variety and maturity at harvest
- Minimize physical injury
- Storage conditions
  - 12.5°C , No lower than 10°C
  - 2-3 weeks
  - Low O2 retards ripening; CO2 is damaging
  - 1-MCP retards ripening
- 85% Relative humidity
- Ripening conditions
  - Temperature 15-20°C
  - High humidity
  - If MG fruit, 100 ppm ethylene

Note. Grape tomatoes are very susceptible to water loss; use clamshells to retard water loss at 12-15C. They will tolerate about 2 weeks at 5°C

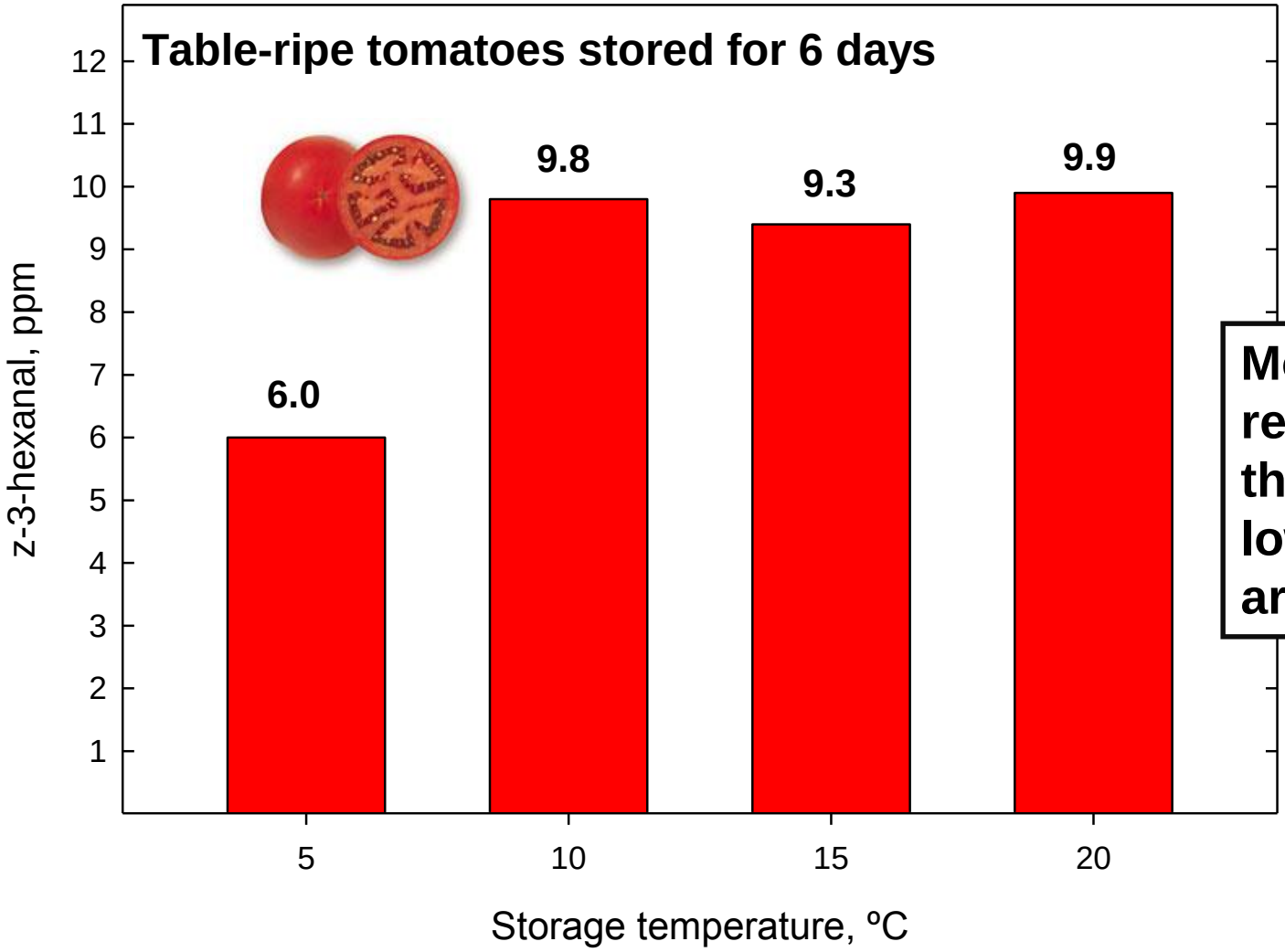
Avoid chilling temperatures for tomatoes





Too low temperature (<10°C <50°F)
Reduces flavor
Affects ability to ripen
Increases decay

Low temperatures reduce aroma volatiles
z-3 hexanal as example of important volatile



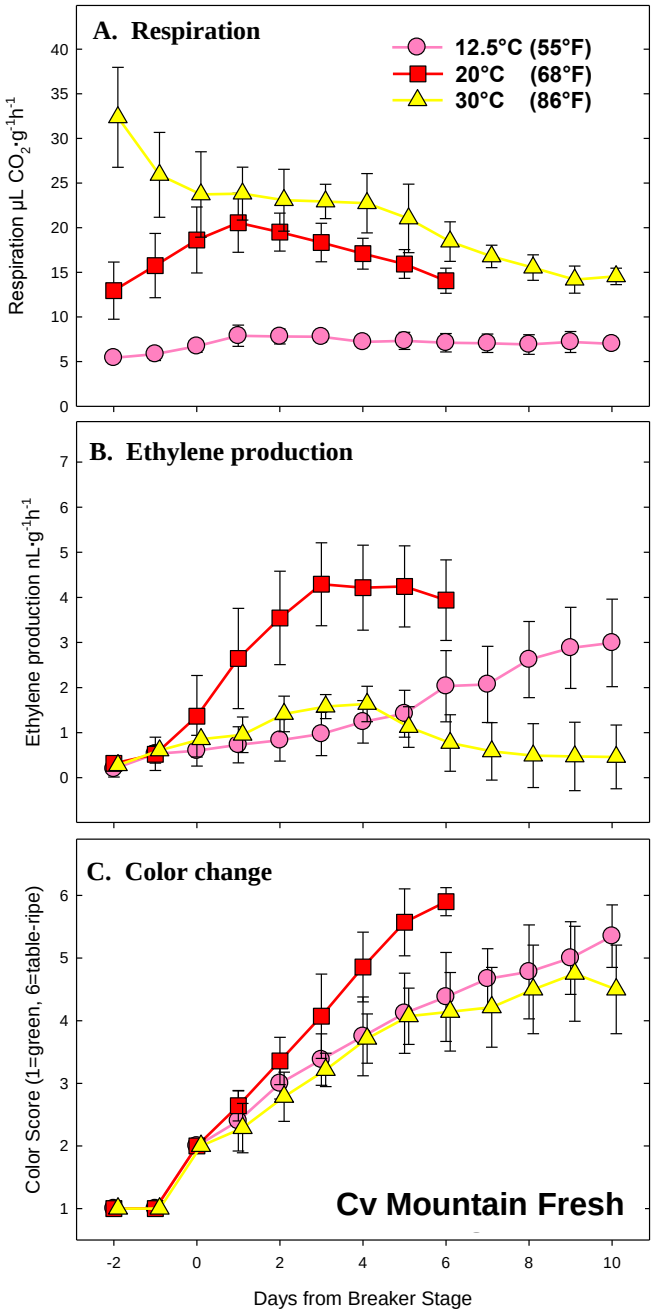
More recent research shows that 10°C is too low for good aroma profile

Cantwell, UC Davis, unpublished

Round Tomato (cv Bobcat) stored 4 weeks + 2 days

Initial stage = 3

10°C (50°F) **7.5°C (45°F)** **5°C (41°F)**



Impact of Temperature on Tomato Ripening Respiration, Ethylene and Color

Avoid Ripening above 20°C

Ripened from Breaker Stage

12.5°C (55°F) 20°C (68°F) 30°C (86°F)

Ripened from Mature-green Stage

12.5°C (55°F) 20°C (68°F) 30°C (86°F)

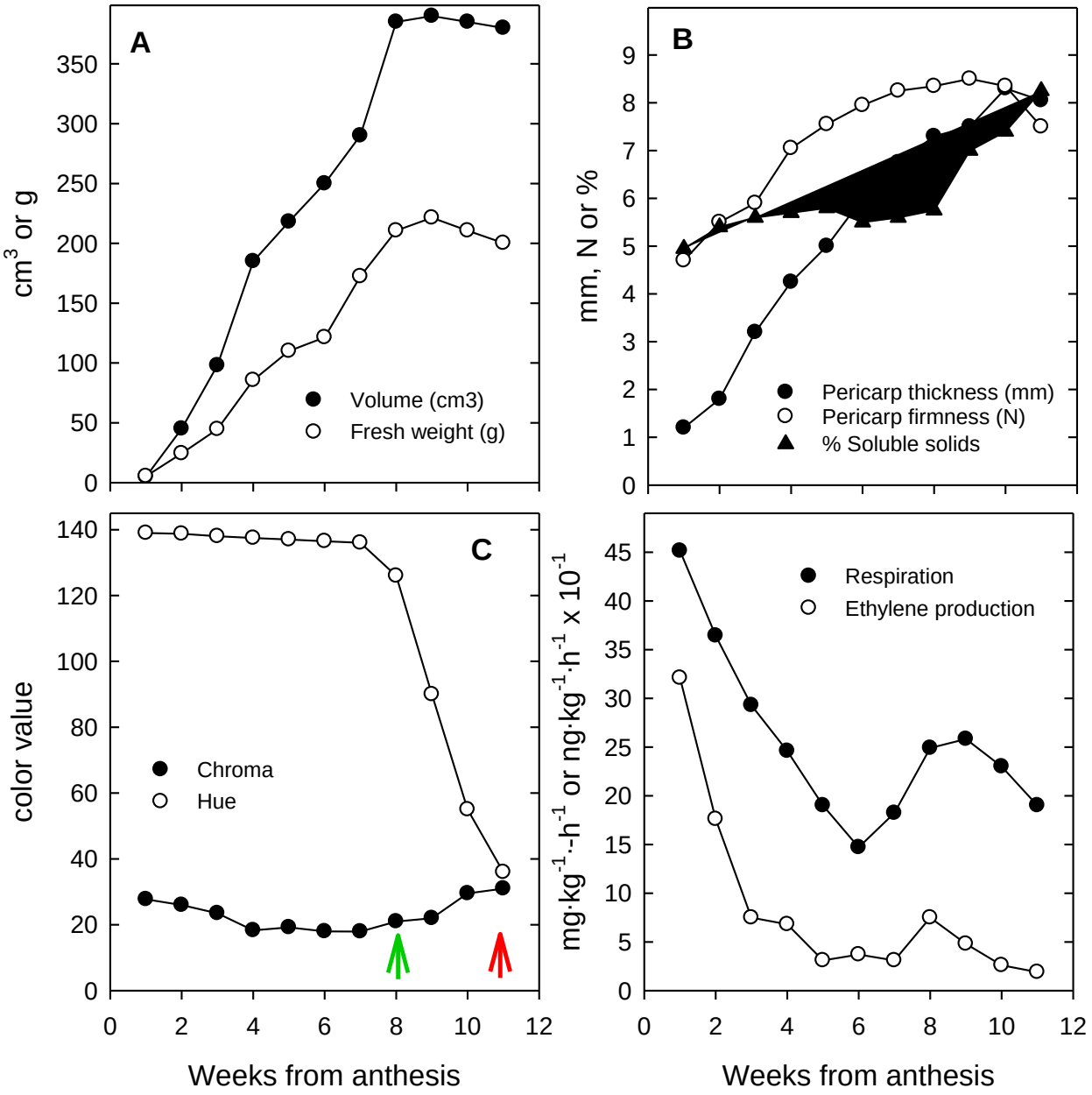
Quality Criteria for Marketing Chiles and Peppers

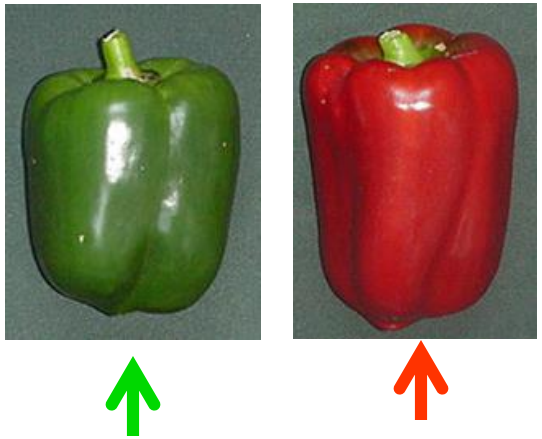
- Shape, size and color typical of cultivar
- Bright glossy appearance;
- Green stem & calyx
- No decay, damage, defects
- Firm, little water loss
- Flavor and pungency typical of cultivar

Bell Pepper

(cv. Domino)

Growth & Ripening

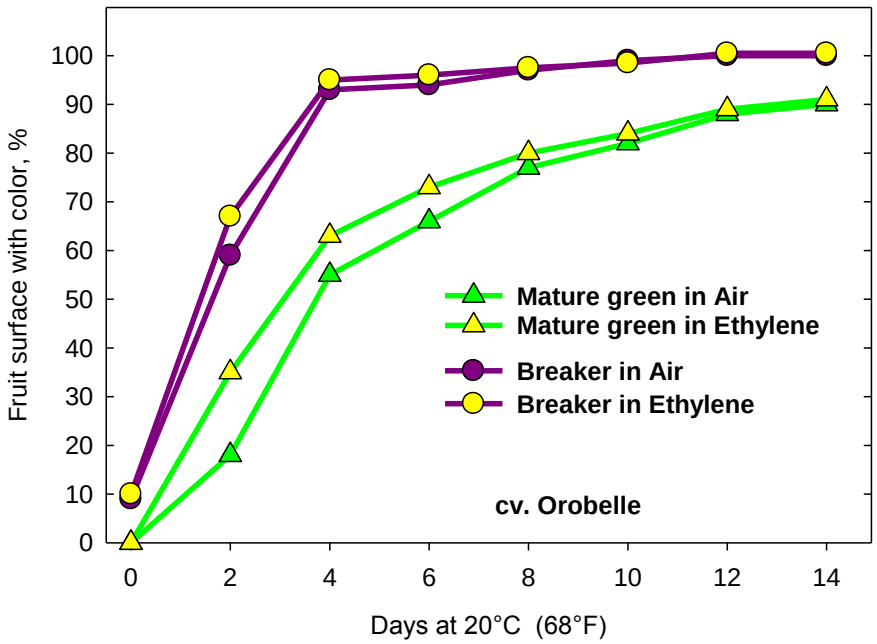


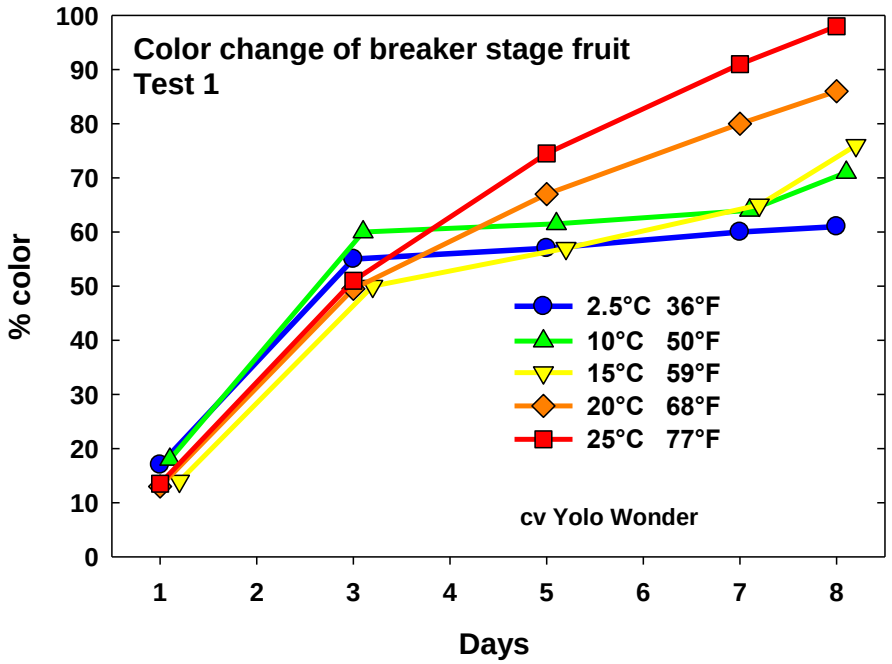


Tadesse et al., 2002.
Scientia Hort 93: 91.

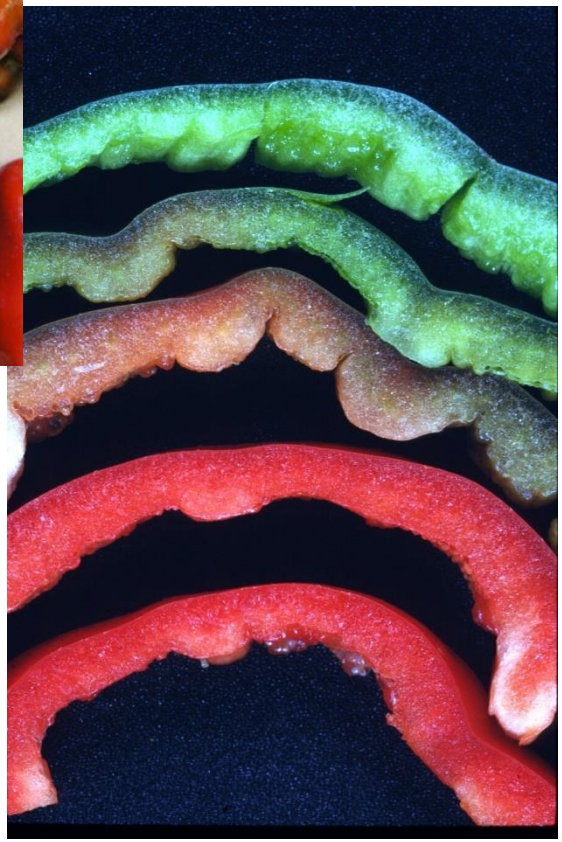
Color changes
During ripening
Of peppers

- ❑ **Bell peppers generally do not respond to ethylene**
- ❑ **Temperature has the greatest effect on color change or ripening.**
- ❑ **Holding at 25-29°C (77-84°F) maximizes rate of color change**

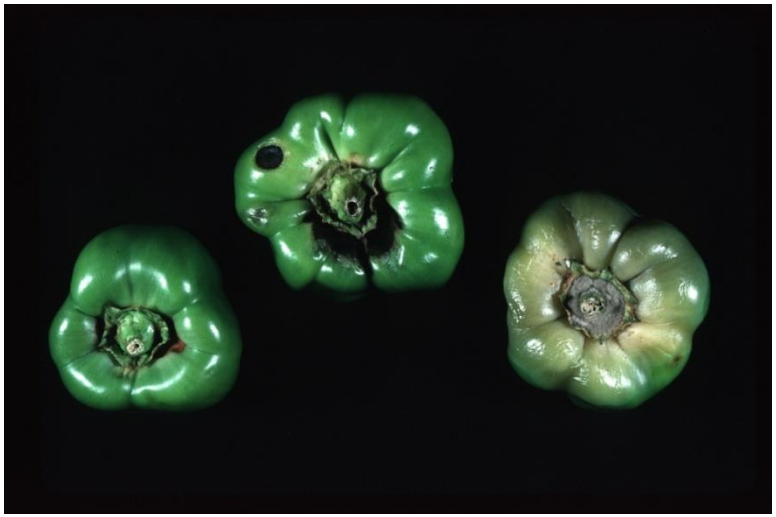


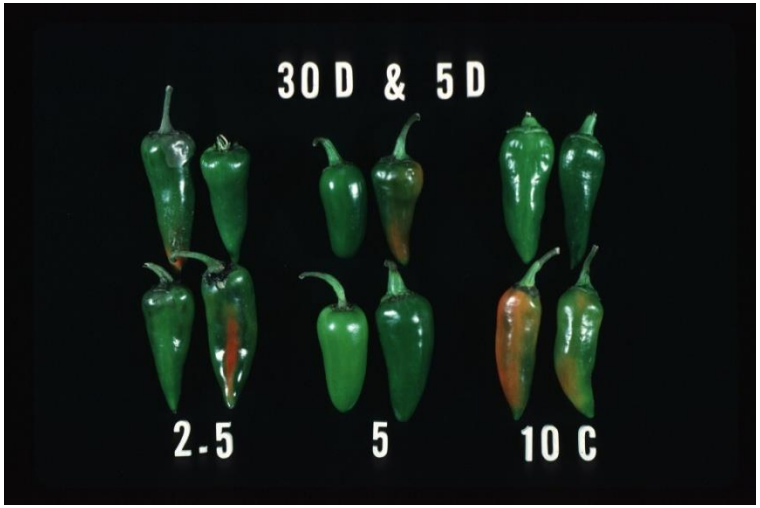


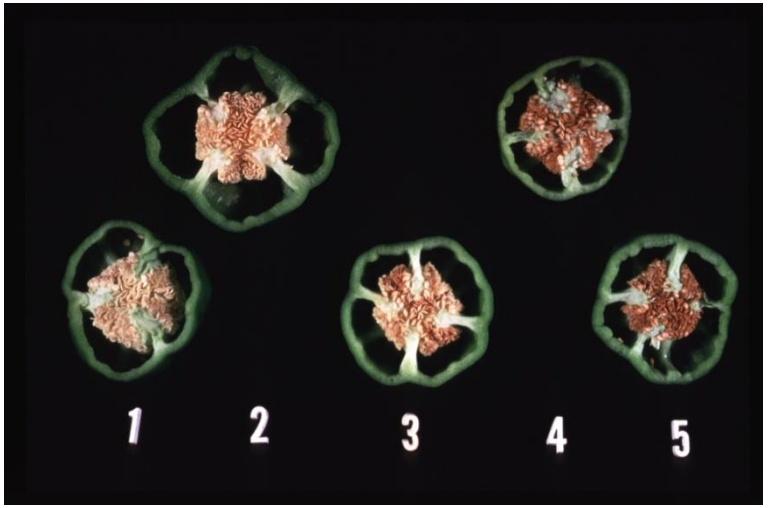
To maximize quality and shelf-life of colored peppers, harvest at no more than 80-90% color; color change continues after harvest even under typical storage temperatures.



Chilling Injury Symptoms on Peppers and Chiles





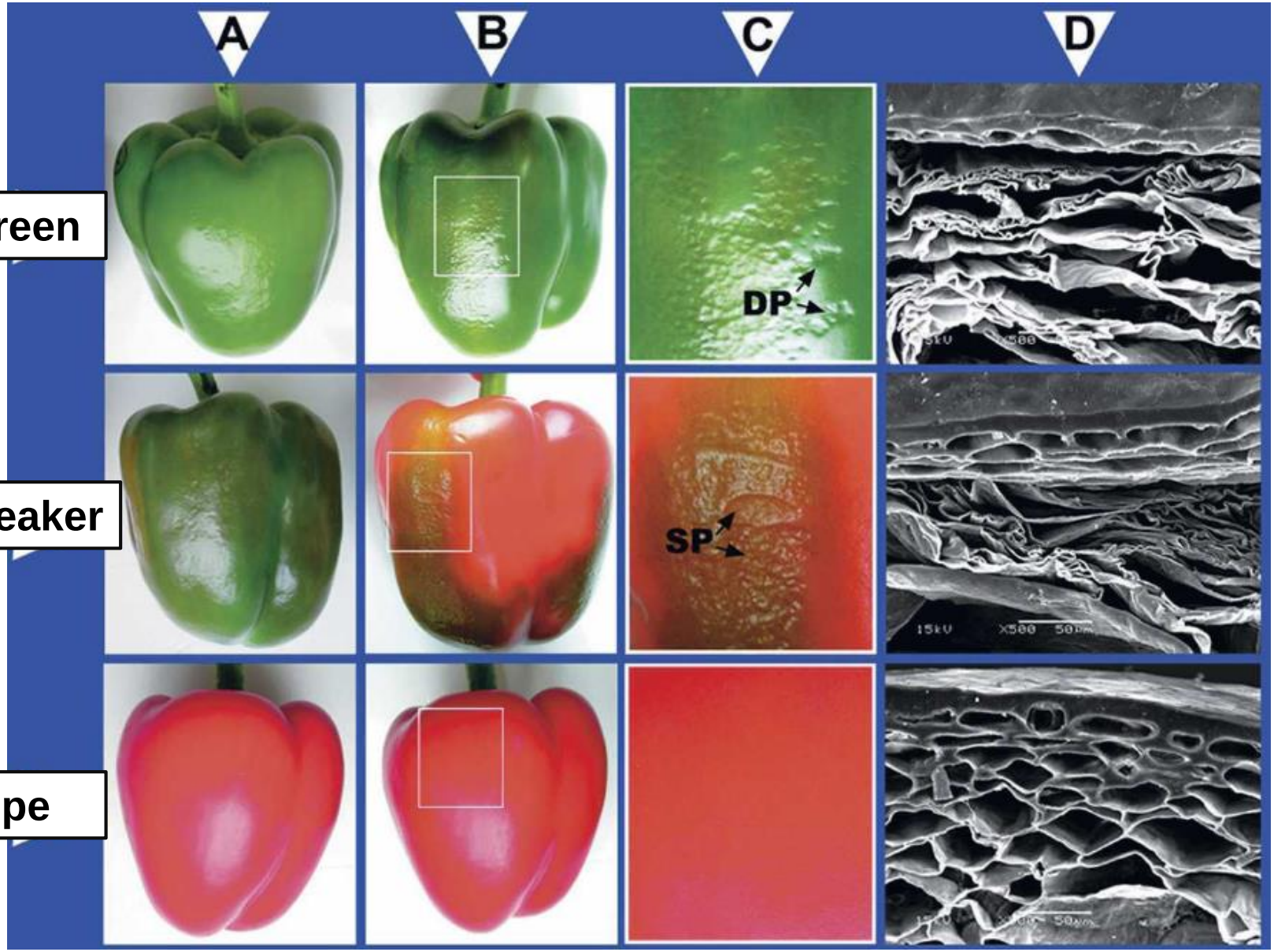


Quality of mature-green and red peppers (cv Galaxy) stored in air or controlled atmospheres at 5°C. Peppers evaluated after 1 day at 5°C.

	Visual Quality			Decay		
GREEN PEPPERS	10	15	20 days	10	15	20 days
Air	6.7	6.5	1.8	1.0	1.5	3.8
Air + 5% CO2	6.7	6.7	5.7	1.0	1.2	2.5
Air + 10% CO2	7.3	6.2	1.7	1.0	1.2	1.9
3% O2	6.2	6.0	1.8	1.2	1.3	3.3
3% O2 + 5% CO2	8.2	6.7	6.0	1.0	1.0	1.8
3% O2 + 10% CO2	7.0	6.2	1.5	1.0	1.0	1.4
RED PEPPERS						
Air	7.3	6.8	6.6	1.3	1.2	1.5
Air + 5% CO2	7.8	7.8	7.7	1.0	1.0	1.7
Air + 10% CO2	7.8	8.0	6.7	1.0	1.0	1.2
3% O2	8.5	7.0	6.5	1.0	1.5	2.0
3% O2 + 5% CO2	8.1	7.8	7.6	1.0	1.1	1.0
3% O2 + 10% CO2	8.2	8.0	6.0	1.0	1.0	2.0
LSD.05	0.8			0.6		

Visual quality, 9 to 1, 9=excellent, 1=unusable; 6 limit for marketability
Decay, 1 to 5, 1=none, 5 severe

Cantwell, UC Davis



Ripe peppers are more chilling tolerant than green peppers

Lim et al., 2007. HortScience 42:1659; 14d 1°C (A) +2d 20°C (B)

Storage Temperatures for Peppers

5-10°C is recommended

Higher water loss at 10°C or above

7.5°C is probably best, but 5°C is common

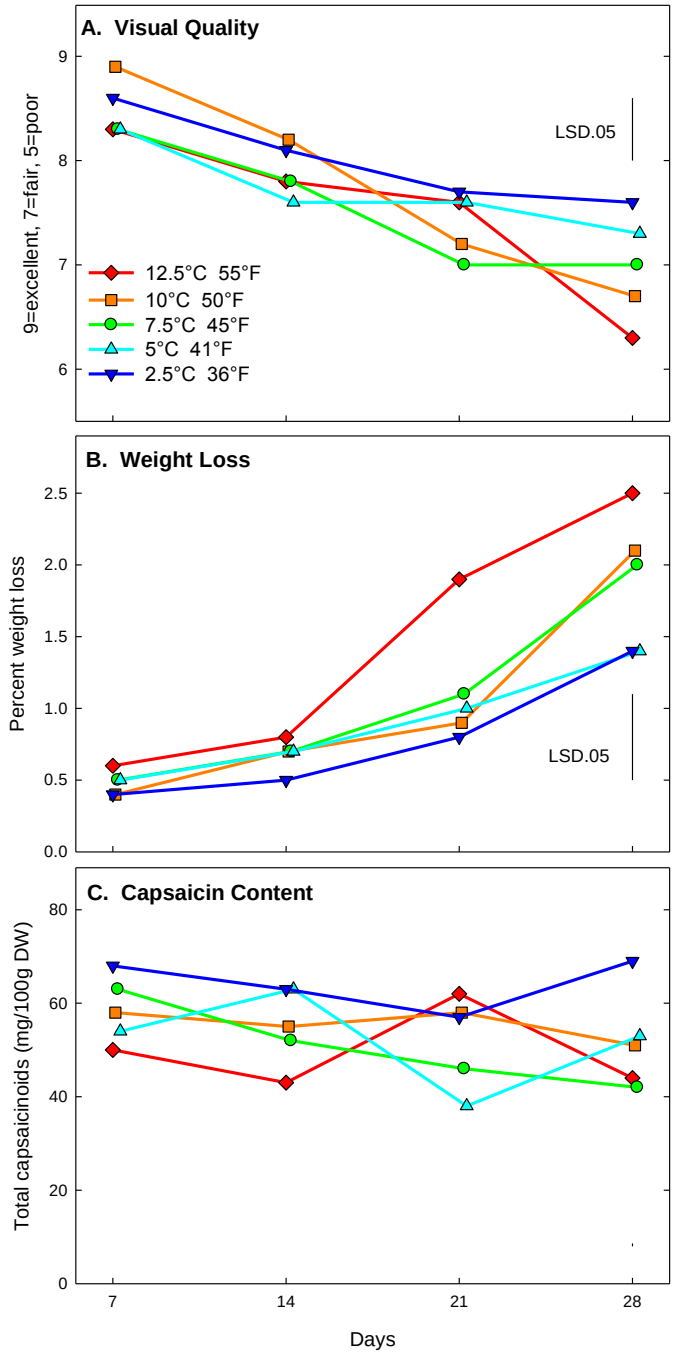
Quality of bell peppers stored at 5 or 7.5°C for 14 days. Peppers were transferred to 20°C for 3 days before evaluation. Average 8 varieties. Data from Bayogan and Cantwell, 2010.

Storage condition	Weight Loss, %	Firmness N	Visual Quality	Shrivel	Surface Pitting	Decay	Calyx Blemish	Seed Discolora-tion
3d 20°C	2.93c	19.6a	8.2a	1.1c	1.0b	1.0c	1.0b	1.0c
14d 5°C +3d 20°C	4.14b	18.4b	6.9b	1.8b	1.6a	1.2a	2.1a	2.5a
14d 7.5°C +3d 20°C	5.15a	15.1c	7.1b	2.6a	1.0b	1.2b	2.1a	2.1b

Visual quality scored on 9 to 1 scale, where 9=excellent, 1=unusable.
Defects scored on 1 to 5 scale, where 1=none and 5=severe.
Peppers stored in commercial carton boxes.

Cv Magnum 45

Cantwell, UC Davis, 2012



Jalapeño Peppers
stored at 5 temperatures
for up to 4 weeks
(evaluated without transfer)

No significant changes in capsaicin content of Jalapeño peppers with time or storage temperature--**in chiles of marketable quality**

Similar results with **Habanero** and **Serrano** chiles—no significant Changes in capsaicin content

Resources?

https://postharvest.ucdavis.edu/

https://cals.cornell.edu/produce-safety-alliance/training/train-trainer-course

https://cals.cornell.edu/national-good-agricultural-practices-program

Question?

Survey Link for feedback

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