Mature Fruit Vegetables

- **Peppers, Chiles**
- **Tomatoes**
- Winter squash, pumpkins
- Melons

- 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
http://postharvest.ucdavis.edu

Postharvest Handling of Tomatoes

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

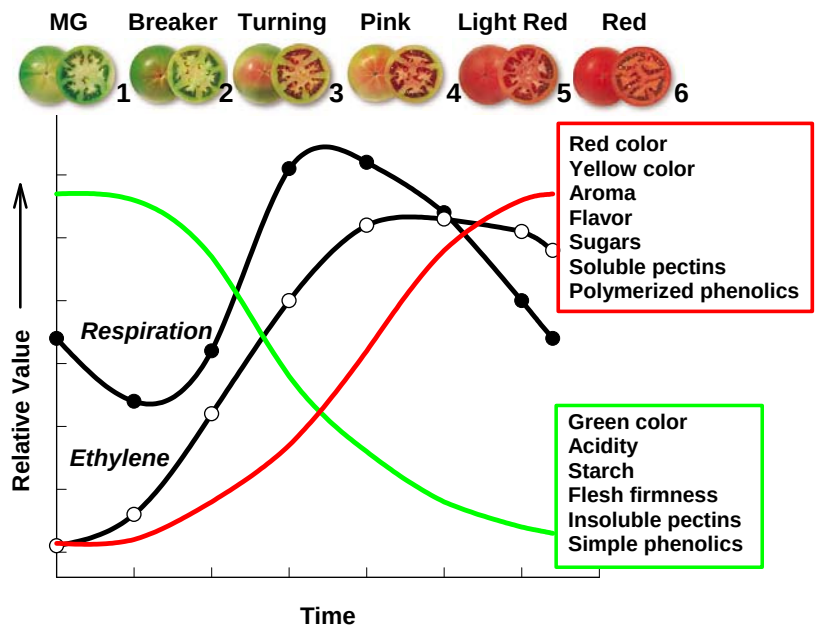
6
RED Red means that more than 90% of the tomato surface, in aggregate, is red

http://www.tomato.org/
http://www.floridatomatoes.org/

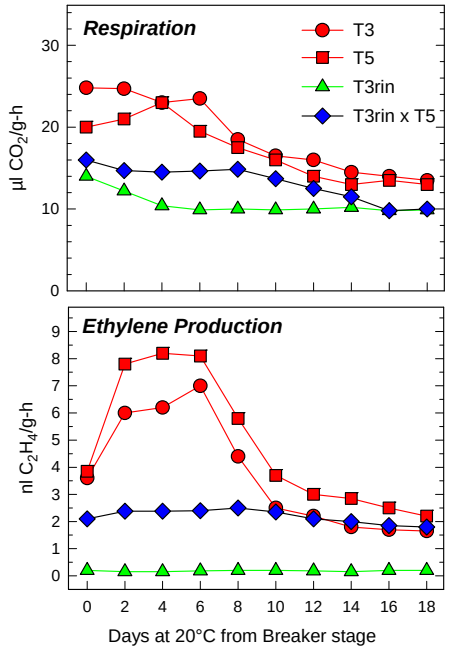
MG1 MG2 MG3 MG4 Br

Checker boarding

Should never be a problem with vine ripe tomatoes!

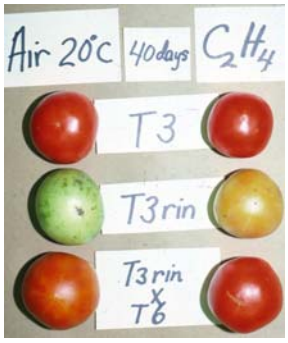


Tomato photos: http://www.tomato.org/food/color.html



Ripening mutants retard the ripening process

Example:
Tomato *rin* mutant



Experimental LSL round tomato variety, 2008

Fruit harvested at different ripeness stages and held 10days at 20°C

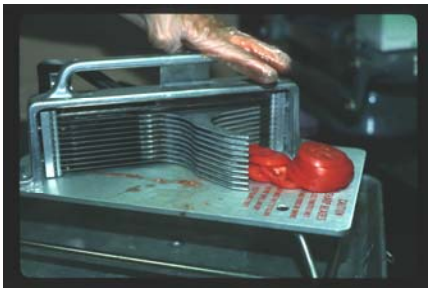
Air **100 ppm Ethylene**

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**

1 Newton = 9.81 kg-force or 4.45 pound-force

Tomato Texture: Slice Integrity



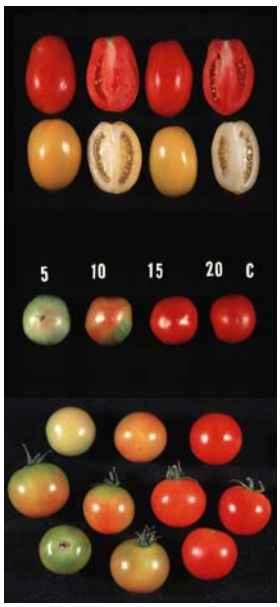
	Juice Loss
Very firm	0-2%
Firm	2-5%
Moderately firm	5-8%
Moderately soft	5-8%
Soft	8-10%
Very soft	>10%

Tomato Color

Carotenoids

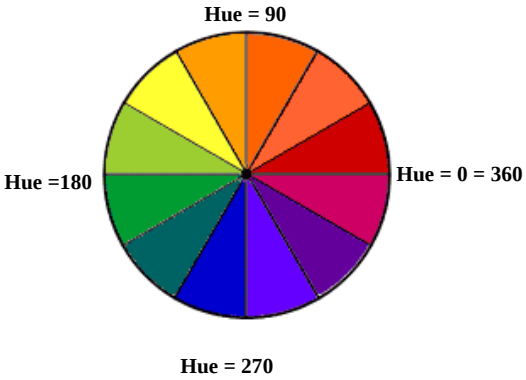
- β– and other carotenes
- Lycopene (90%)

Pigment extraction,
Objective color values



Tomato Color

Simplified Color Wheel



Minolta Color Meter

Good red color in tomatoes:

Hue less than 40

http://www.scribbleskidsart.com/generic.html?pid=84

Typical Objective Color Values for Tomatoes

	L*	a*	b*	chroma	hue
Pink-Orange	49.6	16.6	30.9	35.0	61.8
Orange-Red	46.2	24.3	27.0	36.3	47.9
Red	41.8	26.4	23.1	35.1	41.2
Dark Red	39.6	27.5	20.7	34.4	37.0

Tomato Flavor

Depends on content of:

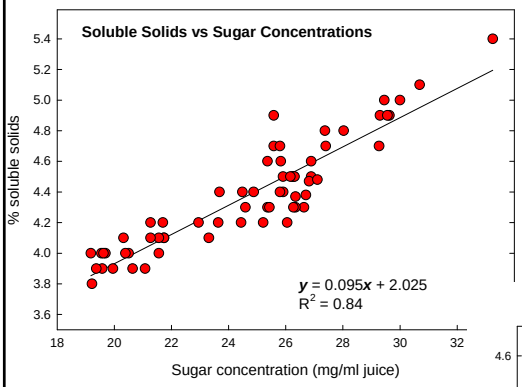
- Sugars (4-6%)
- Acids (0.2-0.6%)
- Aroma volatiles (ppm)

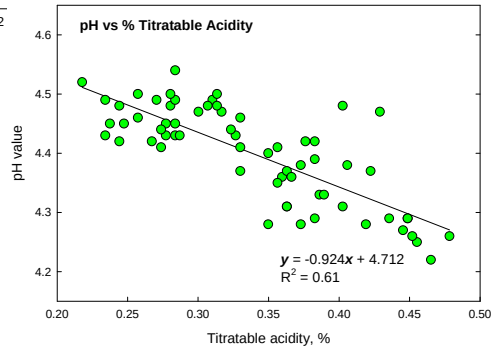
We estimate flavor by measuring sugars (soluble solids) and acids (titratable acidity)

Tomato Type & Composition Group 2

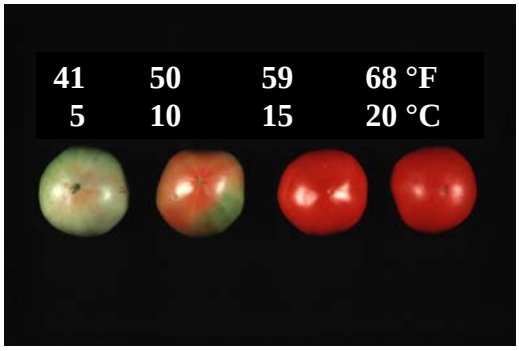
Tomato Type	% Soluble Solids	% Titratable Acidity
Grape	7.55	0.62
Cherry	6.25	0.67
Orange Cluster	4.70	0.44
Round	4.65	0.33
Roma	4.25	0.31
Round Cluster	4.20	0.35

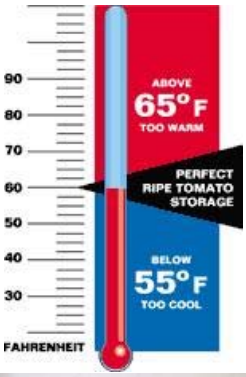
2006 Test#2





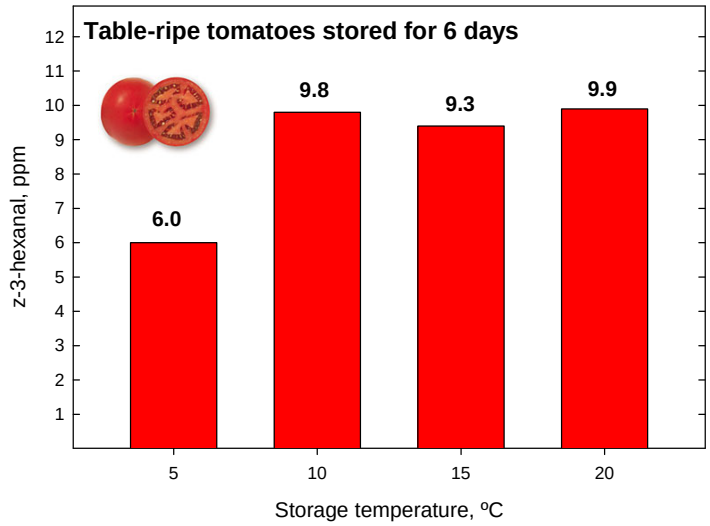
Avoid chilling temperatures for tomatoes





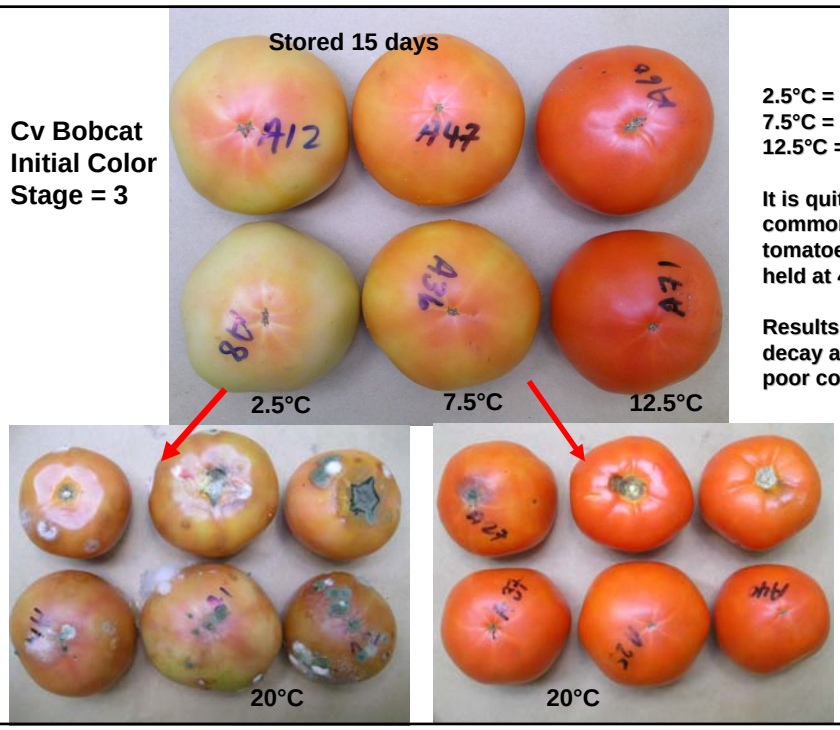
Too low temperature (<10°C <50°F)
Reduces flavor
Affects ability to ripen
Increases decay

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



Cantwell, UC Davis, unpublished

Cv Bobcat
Initial Color
Stage = 3



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

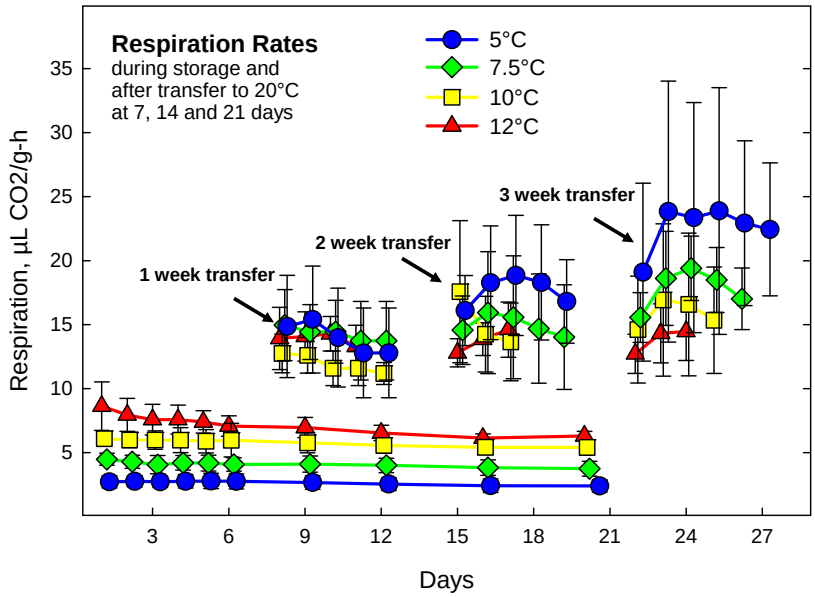
It is quite common that tomatoes are held at 45°F.

Results in decay and poor color.

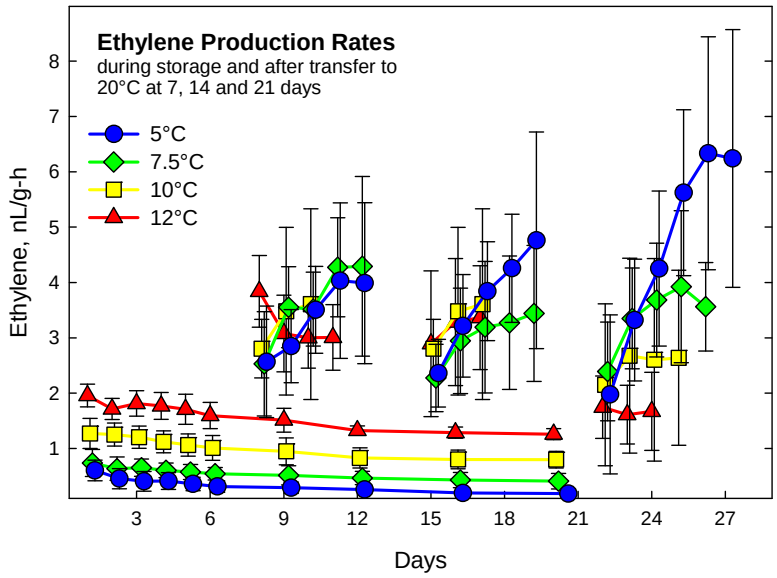
Consequences of Storing Tomatoes Below Recommended Temperatures

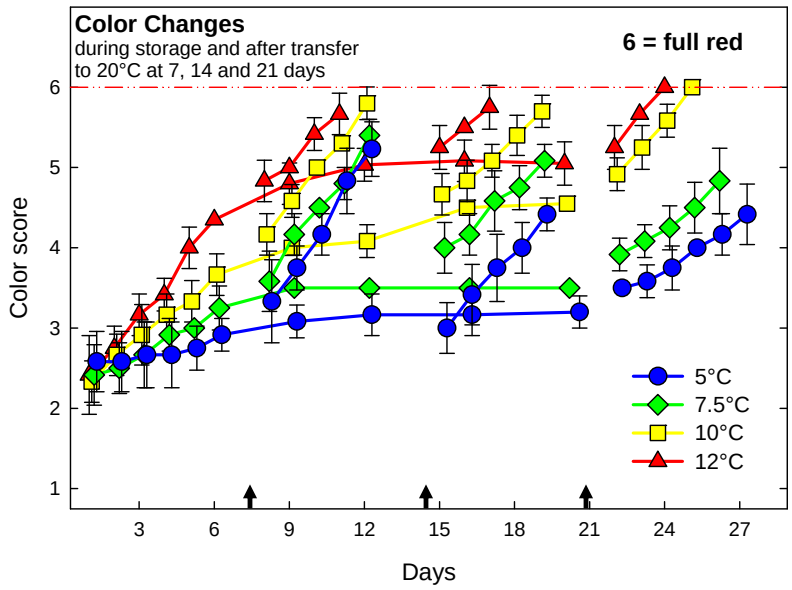
- Round Tomatoes, cv Bobcat, color stage 2-3
- Stored at 5, 7.5, 10 and 12.5C for up to 3 weeks
- Transferred to 20°C to complete ripening
  - maximum 7 days
- Evaluate
  - respiration and ethylene production rates
  - weight loss, decay, firmness, color
  - composition (%SS, acidity, sugars, lycopene, Vitamin C)
- Several experiments on rounds & grape tomatoes

Cantwell, Ara and Hong, 2007



Data average 6 fruit no decay ± standard deviation

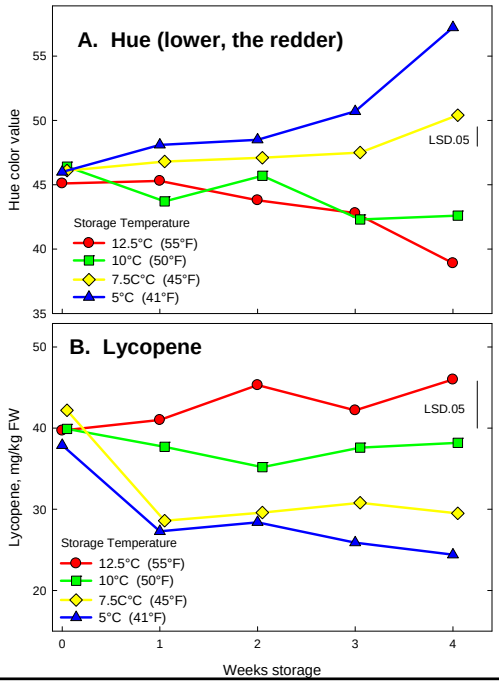

Ethylene Production Rates
during storage and after transfer to
20°C at 7, 14 and 21 days
5°C
7.5°C
10°C
12°C
Ethylene, nL/g-h
Days


Color Changes
during storage and after transfer
to 20°C at 7, 14 and 21 days
6 = full red
5°C
7.5°C
10°C
12°C
Color score
Days

30% color
Fruit stored
At 4 temperatures
For up to 3 weeks.

After storage,
Complete ripening
For 6 days at 20C.

Ara and Cantwell, 2007 Test#2
Cv Bobcat, Initial color = 3



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

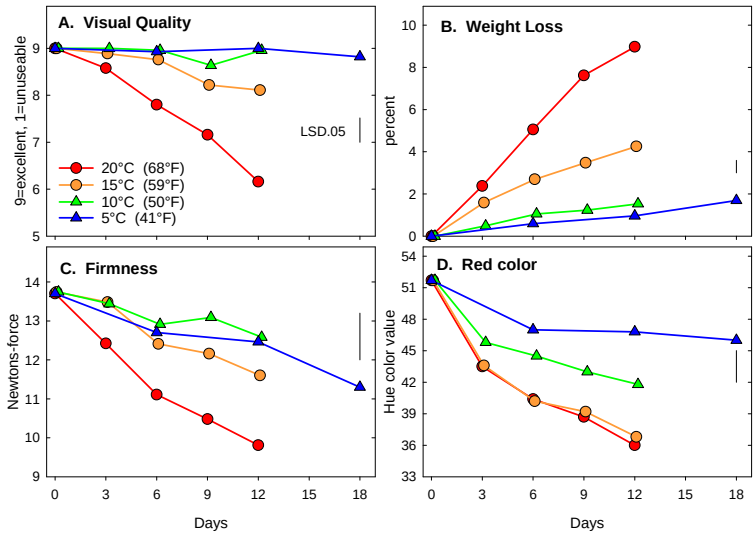
Initial stage = 3

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

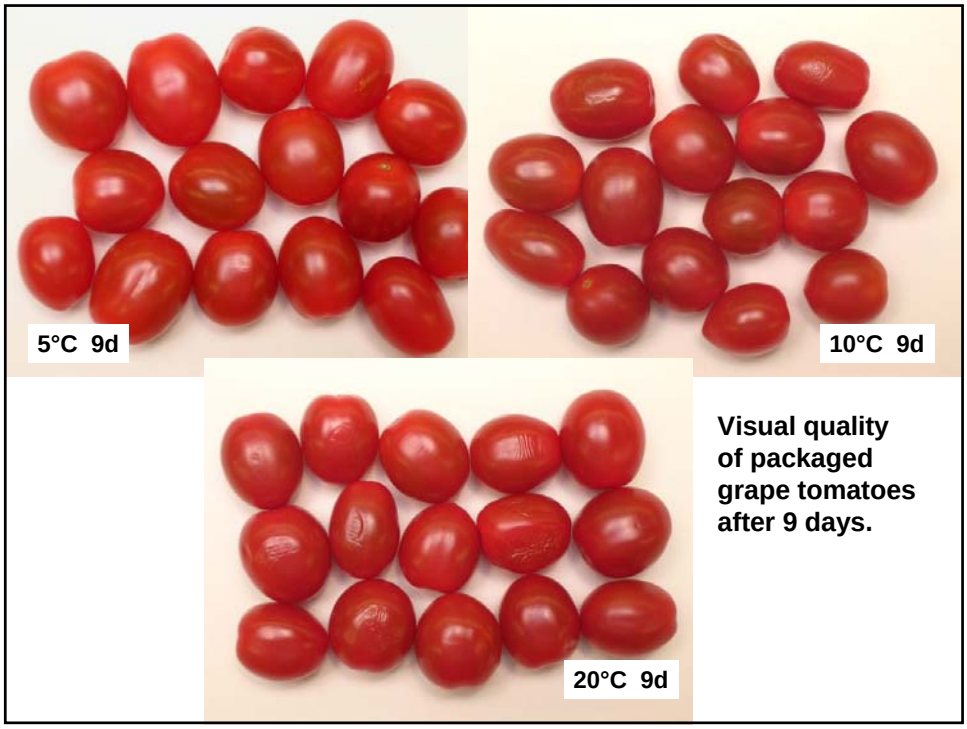
Storage of Tomatoes

- 12.5°C (55°F)
- No lower than 10°C (50°F)
- 2-3 weeks
- Controlled atmospheres
  - 3% O2, <3% CO2
  - Relative humidity ~85%

Storage for grape tomatoes is somewhat different due to water loss



Grape Tomatoes (cv Amsterdam) stored in consumer packaging at 4 temperatures. Cantwell, unpublished, 2004.



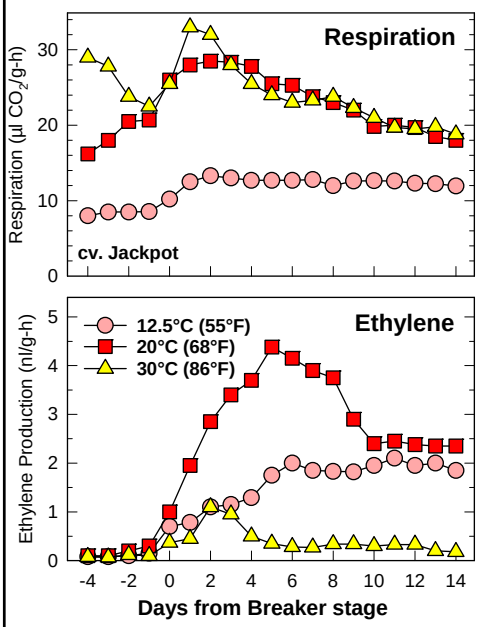
Visual quality of packaged grape tomatoes after 9 days.

Shelf-life/Storage/Ripening Conditions

- ✓ **Temperature and ripening of different tomato types; update conventional tomato chart**
- ✓ **Impact of lower than recommended storage temperature; slight chilling; differences among varieties**
- ✓ **Ripening Temperature and ethylene treatment**
- ✓ **Temperature and RH -Impact on firmness and gloss**

Table 1. Effect of temperature on ripening rates of conventional tomatoes.

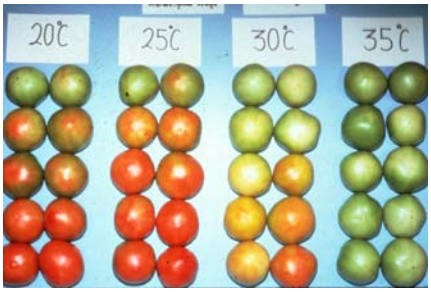
	Days to full red color at indicated temperature					
Ripeness stage	**12.5C 55F**	**15C 59F**	**17.5C 64F**	**20C 68F**	**22.5C 72F**	**25C 77F**
Mature-green	18	15	12	10	8	7
Breaker	16	13	10	8	6	5
Turning	13	10	8	6	4	3
Pink	10	8	6	4	3	2

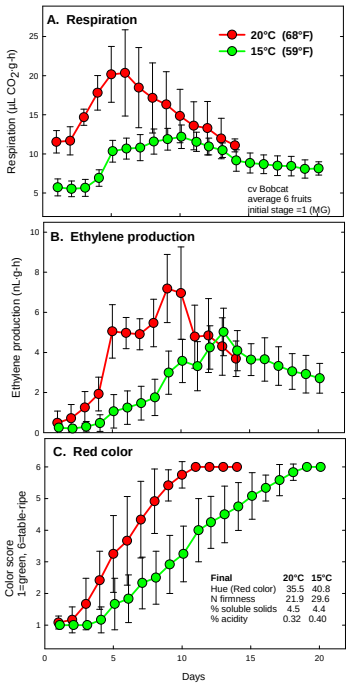


Effect of temperature on Tomato fruit ripening

Good temperature range: 15-25°C (59-77°F)

Best temperature: 20°C (68°F)

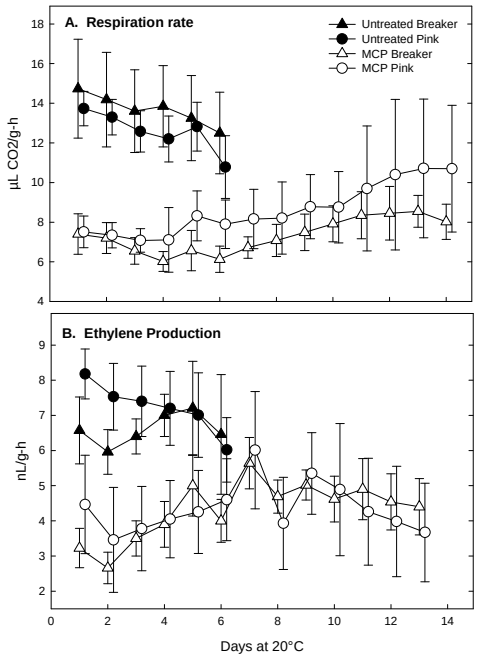




Tomato Ripening & Temperature

15°C allows ripening to continue but at much slower rate than at 20°C

Similar to ripening bananas and other fruits



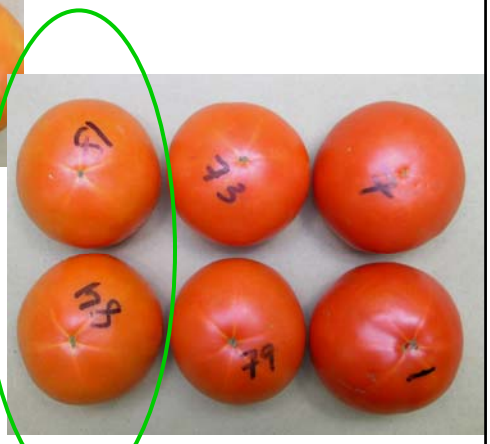
Ripening Tomatoes:

1-MCP treatments decreases respiration and ethylene production rates

Test2, cv Bobcat
1ppm 1-MCP 12h 20°C

cv Bobcat 14 days at 20°C
Treated 12h with 1-MCP
at Breaker stage

100 ppb **300 ppb** **600 ppb**

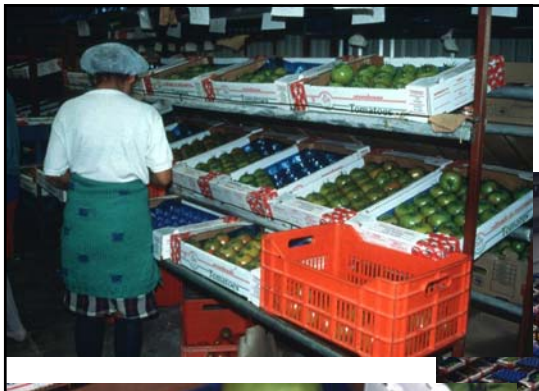


cv Bobcat
14 days from Breaker stage

12.5°C **15°C** **20°C**

Ethylene Treatment for Ripening MG fruit

- Ethylene concentration: 10-100 ppm
- Temperature: 15-25°C (60 to 77°F)
- Relative humidity: 90-95%
- Duration: 24 to 72 hours
- Air circulation: sufficient for distribution of ethylene in ripening room
- Ventilation: sufficient to prevent accumulation of CO2 which reduces effectiveness of ethylene



Vine-ripe Greenhouse Tomato

CTC 2003
Sensory Evaluation Project
Fruit with decay and other defects.

Tomato type	Number fruit evaluated	% decay	% defects	Type of defect
MG ripened Field-grown	480	1.0	11.9	**Poor color, sunburn, too soft**
Pinks Field-grown	360	10.8	8.9	**Poor color, excessively soft**
Hothouse	140	1.5	2.1	**Shrivel, mechanical damage**
TOV	260	0.0	4.0	**Immature fruit, poor color**

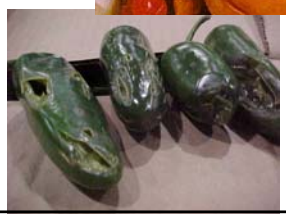
Test#2. Tomatoes packed commercially; VR field fruit not in commercial box

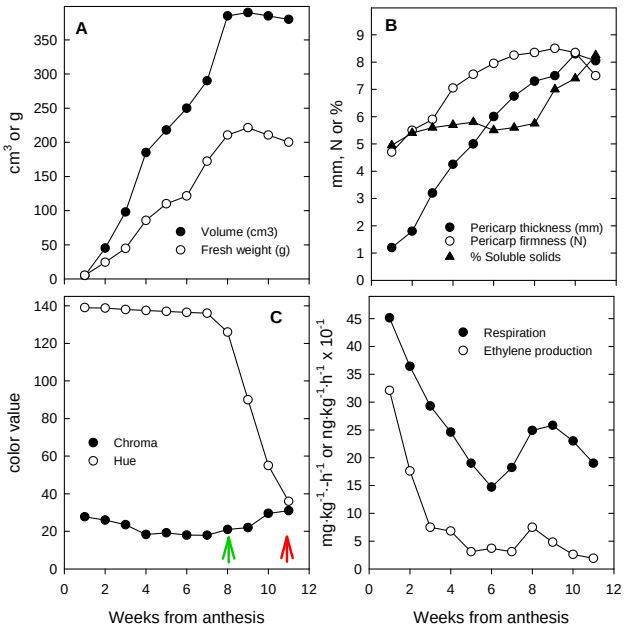
Postharvest Tomato Quality

- Variety
- Maturity at harvest
- Minimize physical injury
- Storage: temperature & duration
- Ripening conditions

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

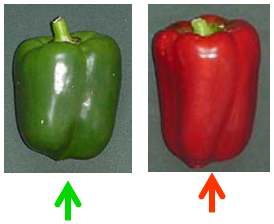




Bell Pepper

(cv. Domino)

Growth & Ripening



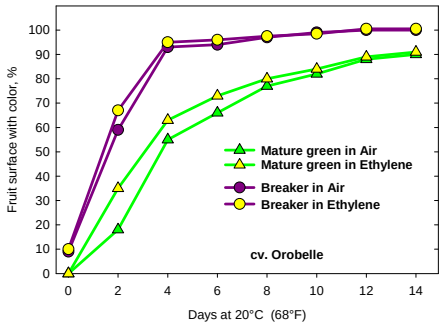
Tadesse et al., 2002. Scientia Hort 93: 91.

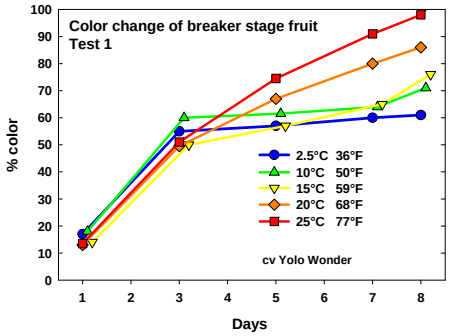
Color changes During ripening Of peppers

1 2 3 4 5 6 7 8 9

Maturity Stages for Anaheim Chiles

- 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





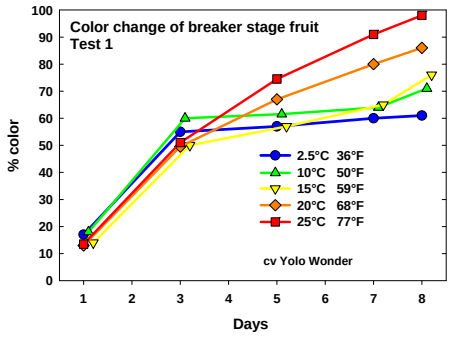
Air 100 ppm Ethylene 3 days at 20°C (68°F)

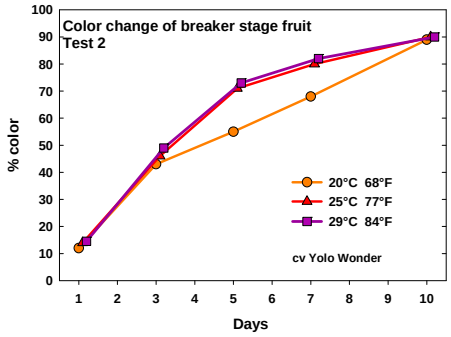
Maturity: Dark Green

Maturity: Light Chocolate

Maturity: Dark Chocolate

From TV Suslow, UC Davis





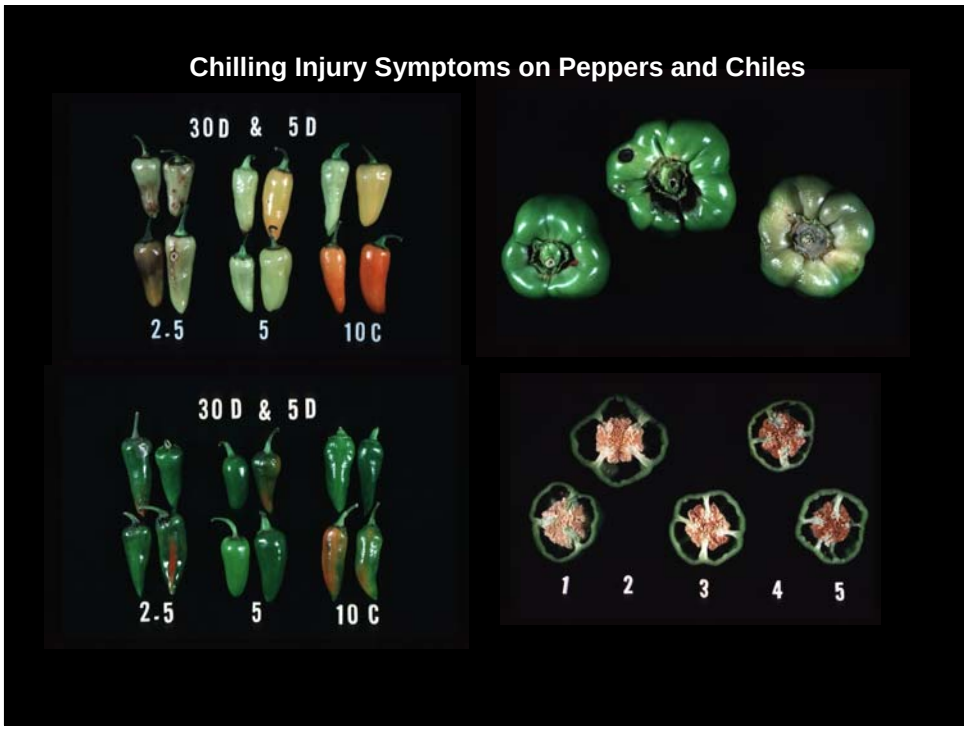
For bell peppers, temperature has the greatest effect on color change or ripening.

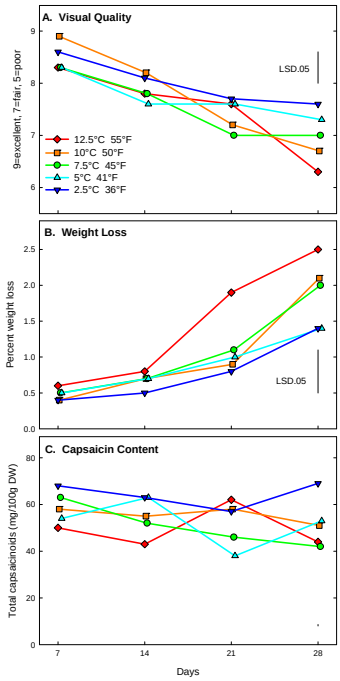
Holding at 25-29°C maximizes rate of color Change—but need High RH to prevent Water loss

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.

Storage Conditions for Peppers

- High RH reduces water loss but may increase superficial decay on stems
- Avoid condensation, will favor bacterial decay on damaged areas
- Temperature: 5-10°C (41-50°F); 7.5°C (45°F) is best
- Shelf-life: 2-3 weeks
- CA not provide much benefit; low O2 retards color change





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

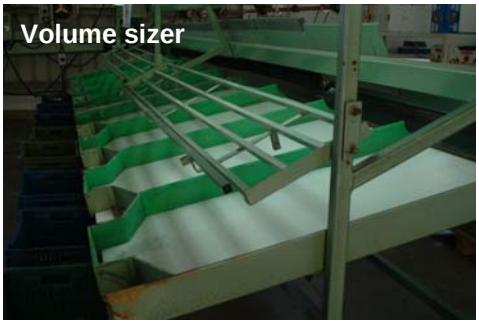
Field Pack Operation

Field Harvest: defect sorting

Plastic totes into refrigerated trailer for transport to packing house

3 productions systems, Mexico
Photos Jose Aguiar, UCR

Peppers transferred to shallow trailer
Gentle dry dump
Singulation for weight sizer
Water spray to remove dust (chlorinated)
Sponge rollers to remove excess water



Effect of Midday Sun Exposure on Visual Quality of Bell Peppers

Storage defects observed on field-grown peppers and chilis

Damage and bacterial decay

Greenhouse pepper defects

Greenhouse Peppers

- Sun exposure not as serious a problem as it is for field grown peppers
- But <u>delays</u> from harvest to packing and cooling lead to water loss and more decay

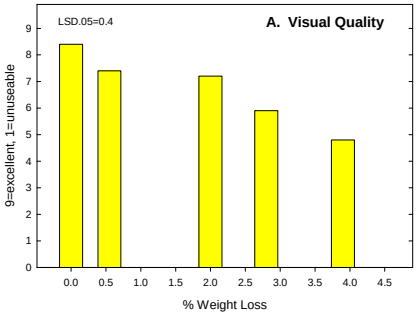
Importance of water loss

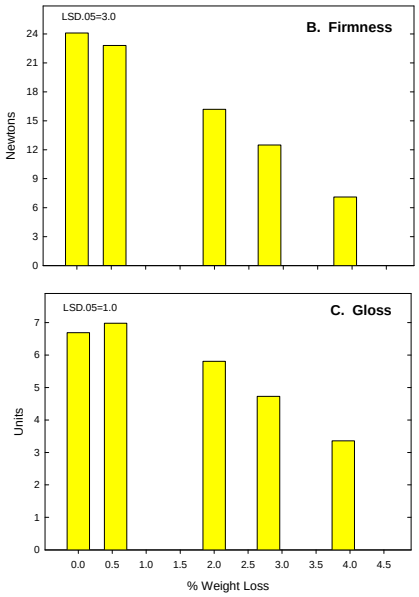
<3% no visual effect, texture
3-5% visual quality affected
>5% shrivel, lose salability

Salable Weight
Fresh Appearance
Texture

Water loss is Cumulative

Delays to cool affect quality of peppers





Delays to cool should be less than:
9 hours at 20-25°C (68-77°F)
6 hours at 37°C (99°F).

Green Bell Peppers, Cantwell and Muy, 2004