Causes of Quality & Postharvest Losses

Leafy Vegetables

Lettuces
Spinach
Cabbage
Chard
Broccoli
Celery
Herbs
Endives
Asparagus

- **Water loss**
- **Mechanical damage**
- **Loss of chlorophyll and other nutrients**
- **Respiration rates**
- **Microbial growth**
- **Sensitivity to ethylene**

Marita Cantwell
micantwell@ucdavis.edu;

Effect of Temperature on Deterioration

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

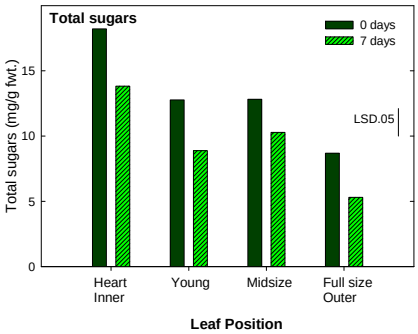
$$Q_{10} = \frac{\text{rate of deterioration at T+10°}}{\text{rate of deterioration at T}}$$

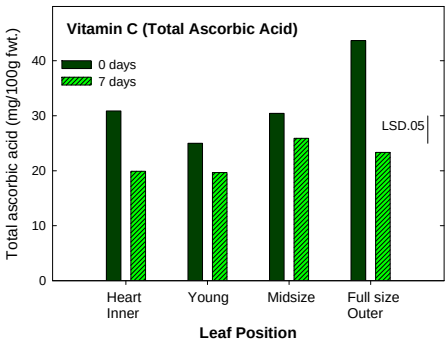
Opportunities related to more nutritious lettuces

Constituent (fresh wt. basis)	**Romaine**	**Iceberg**
Chlorophyll (mg/100 g)	21.5	5.1
Carotenoids (mg/100 g)	5.9	1.6
Sugar (mg/g)	20.4	20.0
Vitamin C (mg/100 g)	23.9	7.5
Phenolics (A_{320})	0.44	0.22

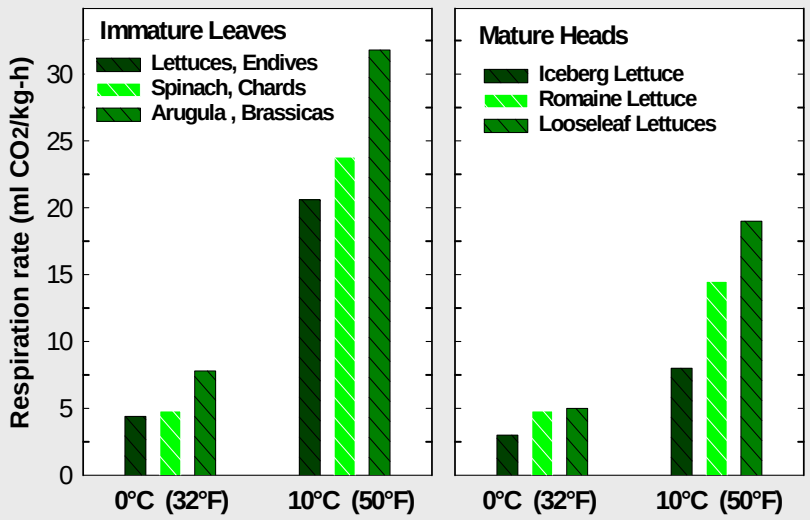
Cantwell and Ermen 2006

Romaine lettuce

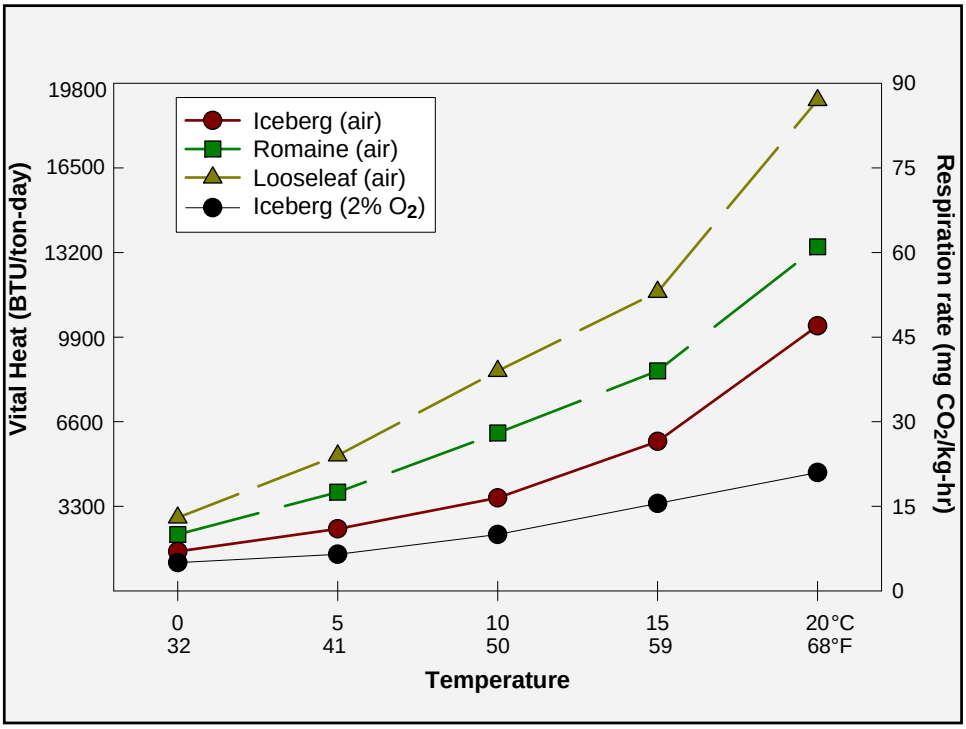




Respiration rates of specialty salad greens and full size lettuces.



From M. Cantwell, UC Davis 1998



Lettuce Maturity

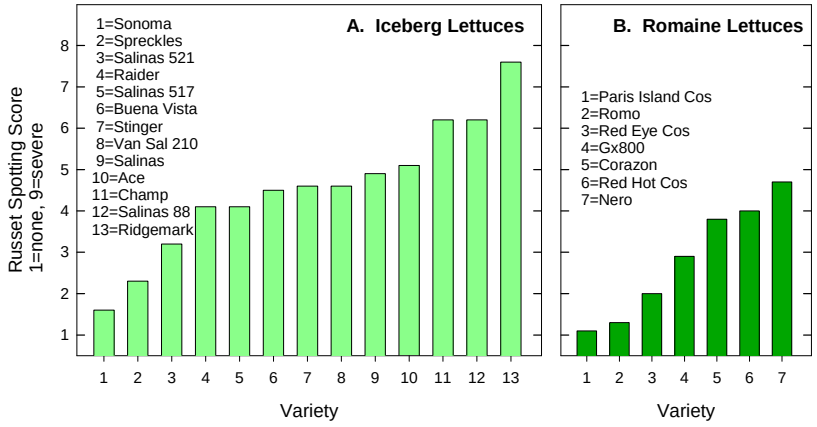
Head firmness
Size, number of leaves

Russet Spotting
Ethylene-induced Disorder on Lettuces

Russet spot scores ~ 1 (none), 3, 6 and 9, respectively.

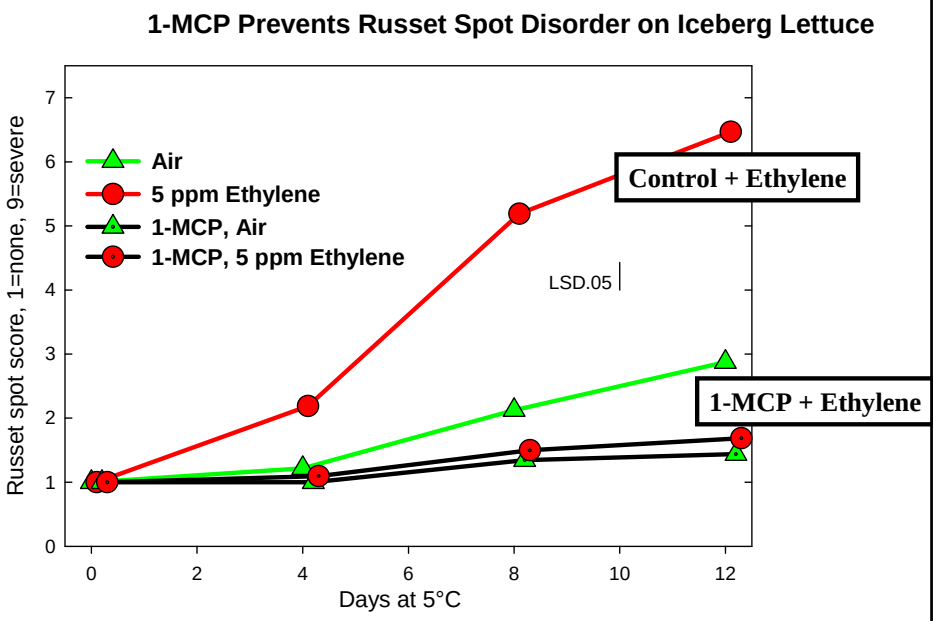
Large differences among varieties in susceptibility

Cantwell, UC Davis, unpublished



Development of Russet Spot Disorder on Iceberg and Romaine Lettuces. Intact heads were stored in 5ppm ethylene at 5°C (1°F) plus 1 week in air.

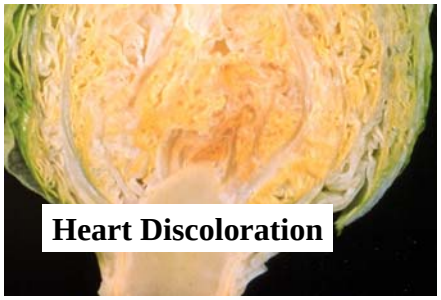
Russet spotting was evaluated on a scale of 1 to 9, where 1=none, 3=slight, 5=moderate, 7=moderately severe and 9=severe.



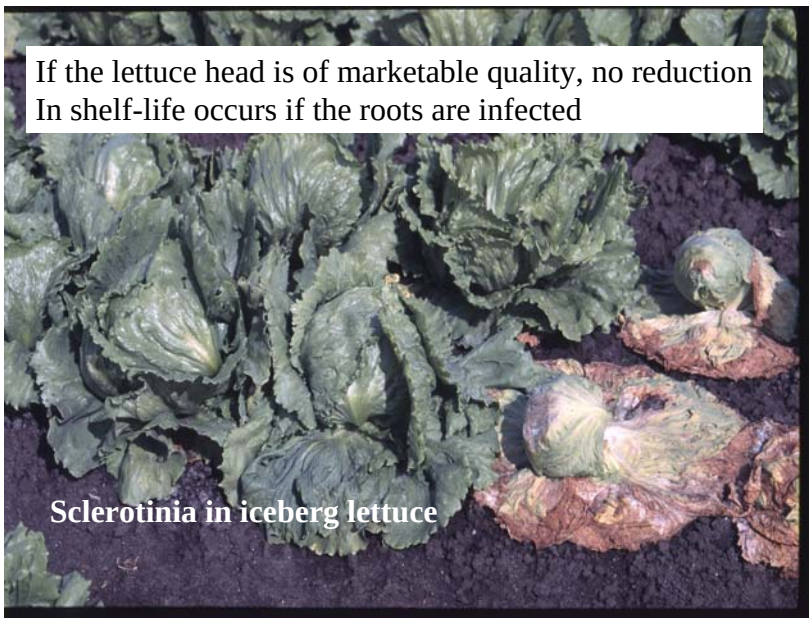
Test#2, midribs; 1000 ppb 1-MCP; Tarraza and Cantwell, Nov 2002

Lettuce disorders

- **Brown stain—CO2**
- **Pink rib –overmature heads**
- **Heart leaf injury– O2/CO2**



Symptoms of Freezing in Lettuce



Lettuce Storage Conditions

- **0°C (32°F) but freezing point is -0.2°C (31.5°F)**
- **Shelf-life:**
  - **0°C (32°F): >4 weeks**
  - **5°F (41°F): ~3 weeks**
- **High relative humidity, avoid free moisture**
- **Controlled atmospheres**
  - **Low O2 beneficial, CO2 >3% damaging**
- **Ethylene sensitive**

Lettuce mobile packing units

Broccoli mobile packing unit

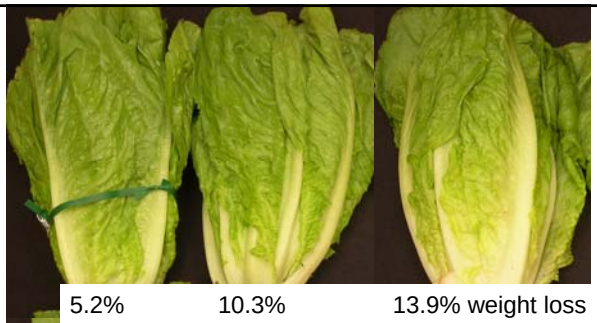
Photos from http://www.ramsayhighlander.com

Field Pack & Palletize
Vacuum Cool

Traditional Packing of Romaine:

- **Do not place cut lettuce on the ground**
- **Waxed cartons rather than crates**

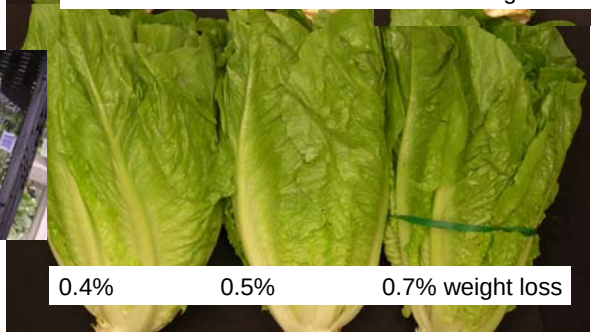
Simple packaging to reduce water loss.
Need to cool product (usually hydrocooling) before packaging or used vented packaging and vacuum cool (romaine lettuces)



8 days

Open

5.2% 10.3% 13.9% weight loss



Bag

0.4% 0.5% 0.7% weight loss

0.5°C (33°F) 5°C (41°F) 10°C (50°F)

Lettuces and other leafy greens in supermarket displays






Spinach Quality Parameters

- Green and uniform color
- Minimum breakage
- No dirt ; Clean and disinfected
- No decay
- Composition
  - nitrates, oxalates
- Shelf-life

Manual harvest of bunched Spinach; vacuum cooled

Note: no longer use slickers, use aprons

Ocean Mist, Salinas, 2006

Mechanical harvest of young spinach for washed and packaged product

http://www.ramsayhighlander.com

Spinach varieties differ in rate of chlorophyll loss during storage

Low temperature is very effective in reducing chlorophyll loss of spinach

Quality categories (leaf damage) for commercial packaged spinach

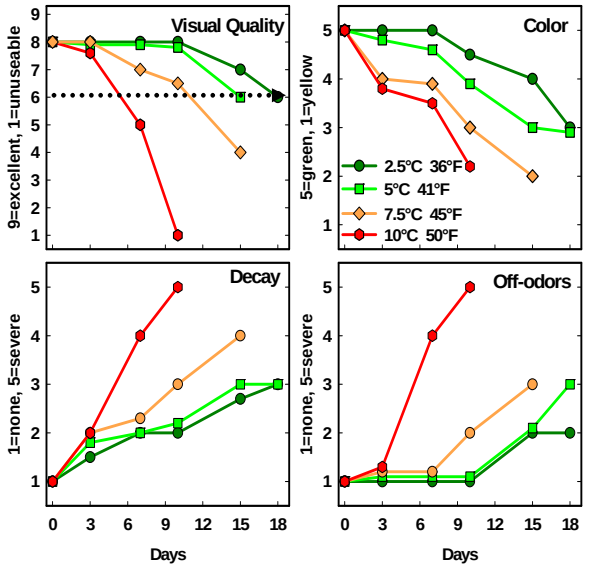
Category number and name		Category Description
1	**No damage**	Intact leaves with no or only minor damage
2	**Slight damage**	Intact or near intact* leaves with 1 notable damaged area (tear, fracture)
3	**Moderate damage**	Intact or near intact* leaves with several damaged areas
4	**Severe damage**	Partial leaves and partial leaves with numerous damaged areas
5	**Leaf Pieces**	Leaf pieces comprised of <25% of leaf area

*Near intact refers to leaves cut at the base with mechanical harvester

DEFECTS ON FIELD-GROWN PACKAGED LEAFY GREENS
DAMAGE FOLLOWED BY DECAY, MOSTLY BACTERIAL
August 2008

Stored 7d 5C

Impact of Temperature on Quality Changes

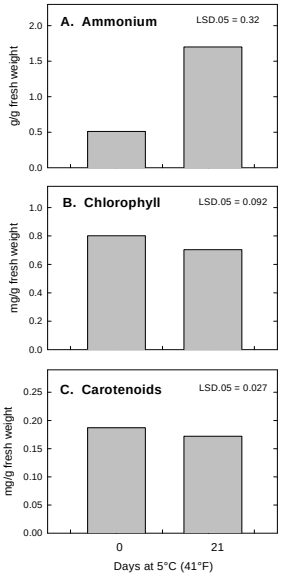


Spinach:

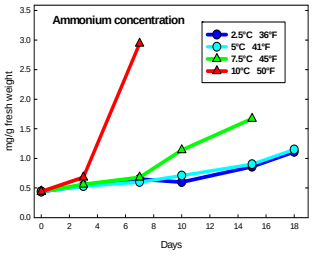
washed and bagged product stored at 4 temperatures

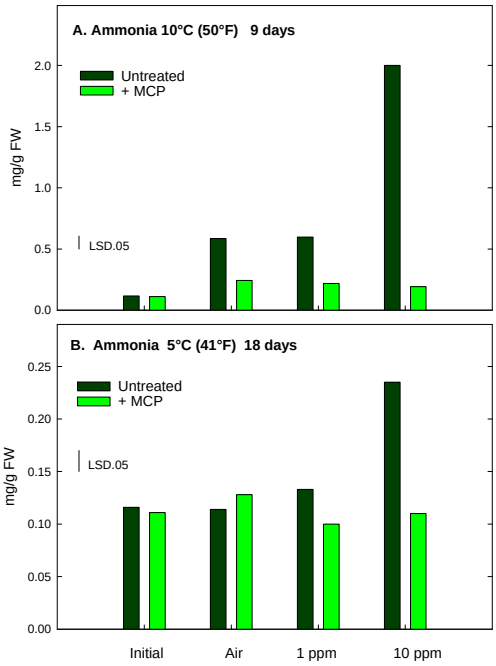
BUT….
Target Temp.
0°C (32°F)

Cantwell, UC Davis



Changes in ammonium, chlorophyll and carotenoid concentrations in spinach after 0 and 21 days in air at 5C (41F). Data averaged from 11spinach cultivars.





Ethylene exposure increases deterioration in leafy vegetables.

A new technology, 1-MCP (SmartFresh™, AgroFresh) blocks ethylene effects.

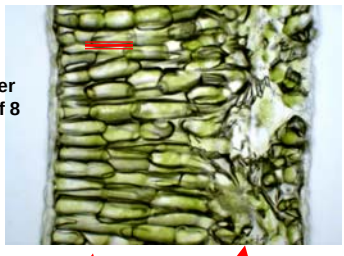
1-MCP treatment maintained low levels of ammonia in spinach, even when stored at 10°C.

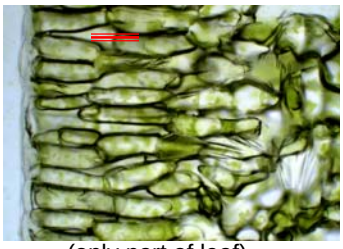
High N results in more fragile leaves; associated with more breakage during harvest, washing, packaging---increased decay and reduced shelf-life

50ppm N (80% nitrate-20%ammonia)

200ppm N (80% nitrate-20%ammonia)

Older Leaf 8





(only part of leaf)

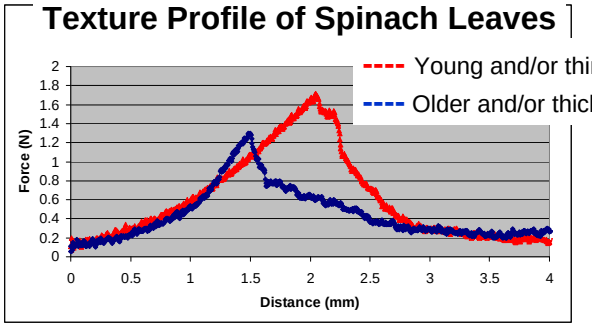
SPINACH GREENHOUSE GROWN

Palisade cells

Spongy mesophyll

Gutierrez and Cantwell 2007

Young less fragile: less ‘crisp’, more force & work to break
Thicker more fragile: ‘crisper’, less force & work to break



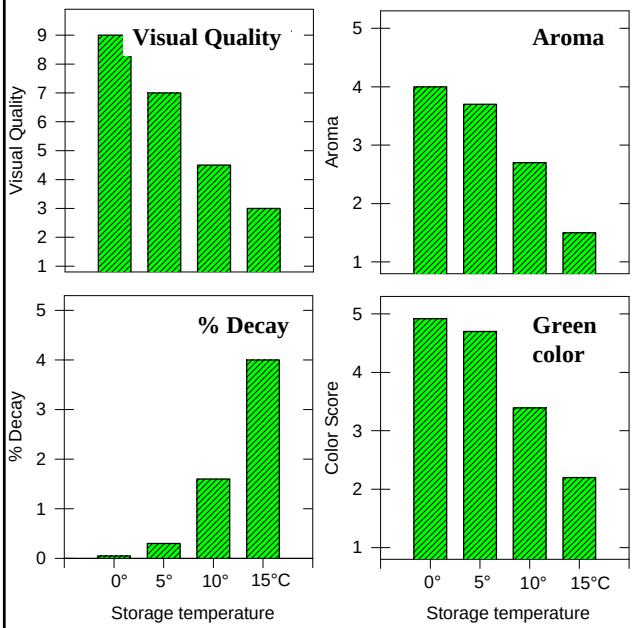
Leaves between plates; punctured with rounded cylindrical probe, 0.95 mm^2

Spinach Storage

- Young and mature spinach leaves respond similarly to storage conditions
- Young leaves have less physical damage
- Excessive N fertilization results in weaker leaves
- Low temperatures are essential for adequate shelf-life
  - 0°C (32°F): 3 weeks
  - 5°C (41°F): 2 weeks
- Modified atmospheres, keep CO2 at 5% or less
- High CO_2 atmospheres stressful to spinach

Storage Conditions for Fresh Herbs

- **0°C (32°F) but freezing point is -0.2°C (31.5°F)**
  - **Shelf-life at 0°C (32°F): 3-4 weeks**
  - **Shelf-life at 5°C (41°F): 2-3 weeks**
  - **Shelf-life based on aroma quality: 1-2 week**
  - **Exception: chilling sensitive basil 12.5°C (55°F) best**
- **High relative humidity, protective packaging, but avoid free moisture condensation**
- **Modified atmospheres can be beneficial**
- **Ethylene sensitive**

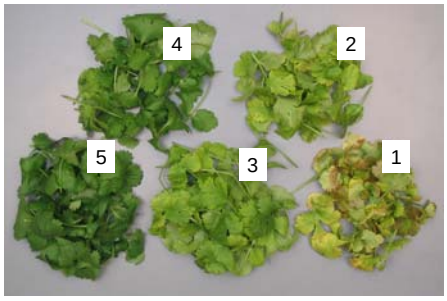


Commercially washed & packaged cilantro 8 days

O2=12-17%
CO2=3-5%

CILANTRO AND ITALIAN PARSLEY LEAVES

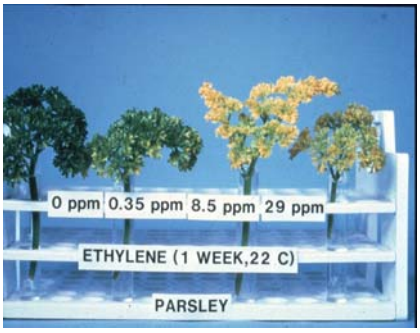
Color scores, color values and pigment concentrations

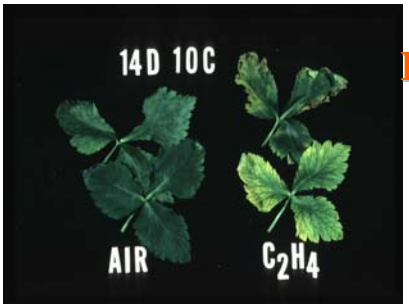


Color Score	5	4	3	2	1
L*	49.5	52.4	62.2	68.1	71.7
Chroma	23.9	28.2	41.5	44.4	46.2
Hue	125.5	125.1	118.3	111.1	108.1
Chlorophyll*	1.77	1.61	0.85	0.60	0.40
Carotenoids*	0.28	0.25	0.17	0.12	0.06

Color Score	5	4	3	2	1
L*	42.4	55.3	62.5	64.0	65.5
Chroma	15.9	30.9	35.9	42.7	43.2
Hue	133.4	120.7	117.7	116.8	109.9
Chlorophyll*	1.79	1.20	0.68	0.49	0.25
Carotenoids*	0.22	0.19	0.15	0.14	0.13

*mg/g FW





Detrimental ethylene effects

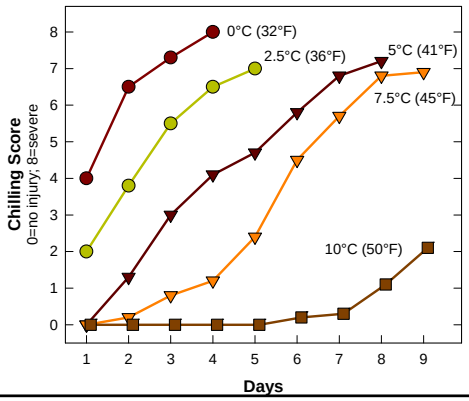
- Yellowing
- Epinasty
- Abscission

Basil
Highly susceptible to water loss
Very chilling sensitive

<u>Situation:</u>
Excellent quality crop
Harvesting late in day
High temperatures, ~30˚C
Low RH, ~50%;
Little protection from ambient
Long delays to packinghouse

What can be done to improve this handling???

Greenhouse Fresh Herb Production
Colombia, Sept 2007
Export to Canada



Basil loses moisture very rapidly

Basil is very chilling sensitive

0°C 32°F **5°C 41°F** **10°C 50°F**

Basil stored 2 days in plastic bags

July 31, 2006