

Vegetable Meeting

Food Safety and Postharvest Handling of Vegetables

Santa Maria, Sept 25, 2012

Postharvest Handling Considerations

Brassicas and Leafy Vegetables:

1. Broccoli Iceless: Water loss and firmness
2. Kale: Maturity and shelf-life
3. Spinach: Off odors and temperature and atmospheres
4. Water-jet Cutting for fresh-cut products

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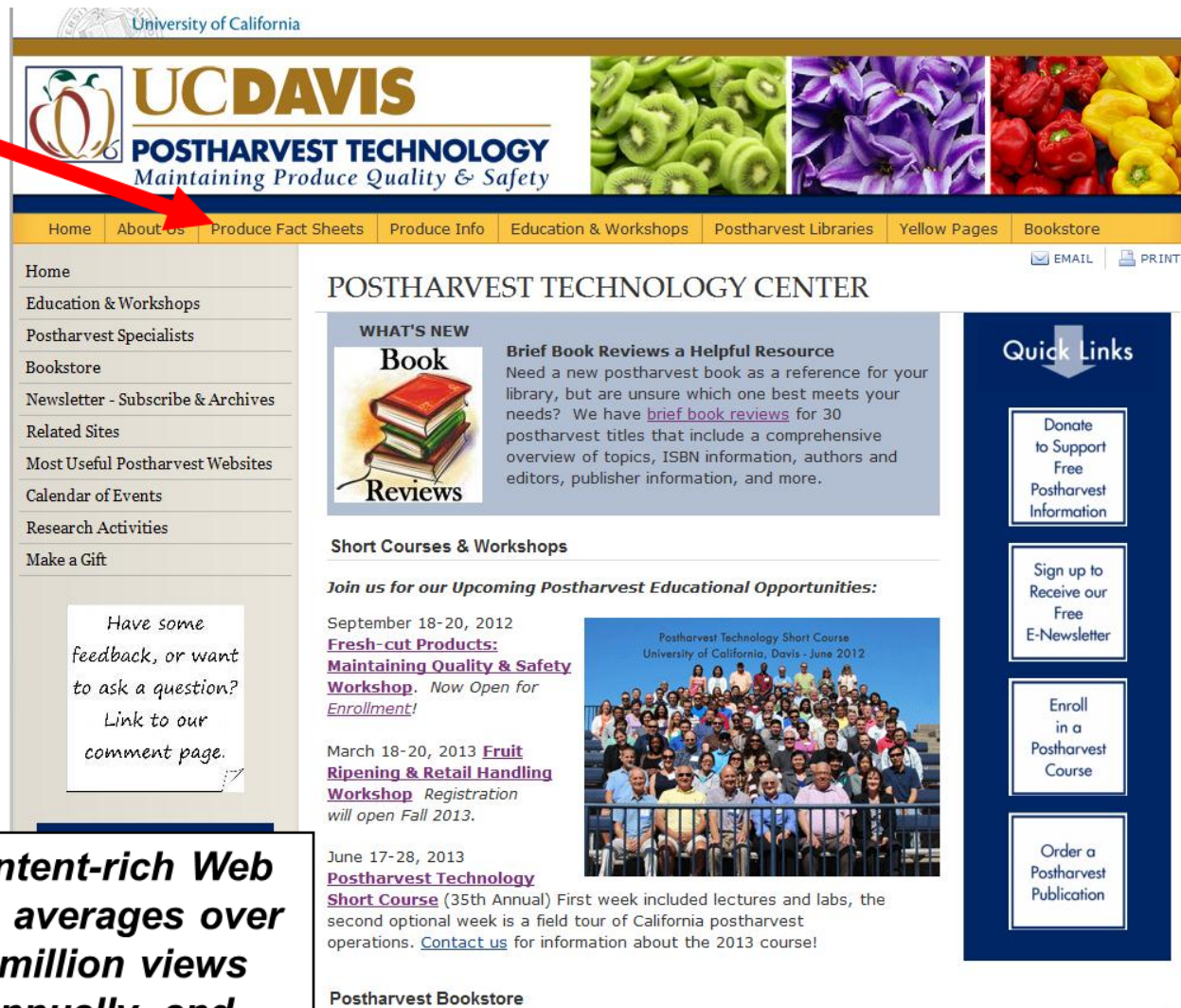
<http://postharvest.ucdavis.edu>

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

Content-rich Web Site averages over 3 million views annually, and encompasses more than 600 pages and 750 documents.



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Maintaining Produce Quality & Safety

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September 18-20, 2012
Fresh-cut Products: Maintaining Quality & Safety Workshop. Now Open for [Enrollment!](#)

March 18-20, 2013 **Fruit Ripening & Retail Handling Workshop** Registration will open Fall 2013.

June 17-28, 2013
Postharvest Technology Short Course (35th Annual) First week included lectures and labs, the second optional week is a field tour of California postharvest operations. [Contact us](#) for information about the 2013 course!

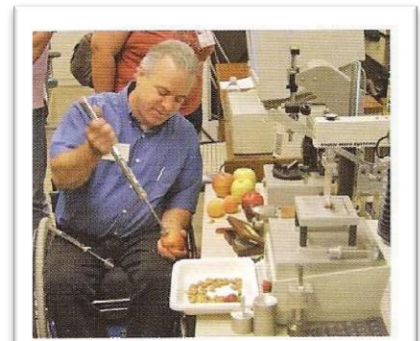
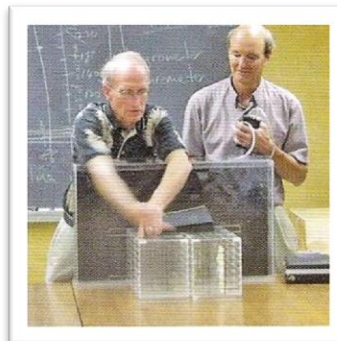
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- Fruit Ripening & Retail Handling Workshop Mar. 27-29
- UC GAPs Skills for On-Farm Assessments Workshop April 2-3
- Postharvest Technology Short Course (lectures/labs) June 18-22
- Postharvest Technology Short Course (field tour) June 25-29
- Fresh-cut Products: Maintaining Quality & Safety workshop Sept. 18-20
- UC GAPs Skills for On-Farm Assessments Workshop Nov. 5-6

<http://postharvest.ucdavis.edu/Education/>



Causes of Quality & Postharvest Losses

Leafy Vegetables



Lettuces

Spinach



Cabbage

Chard

Broccoli



Celery



Herbs

Endives



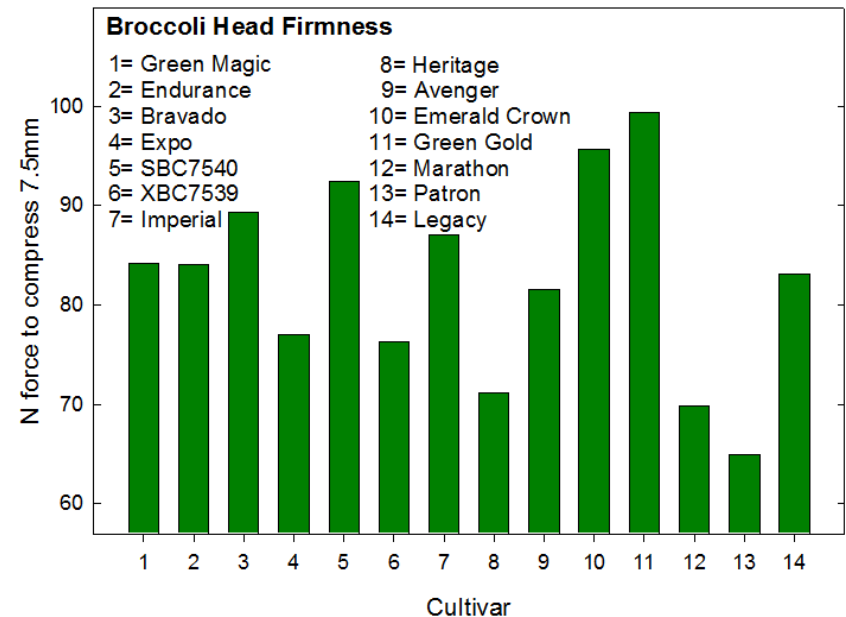
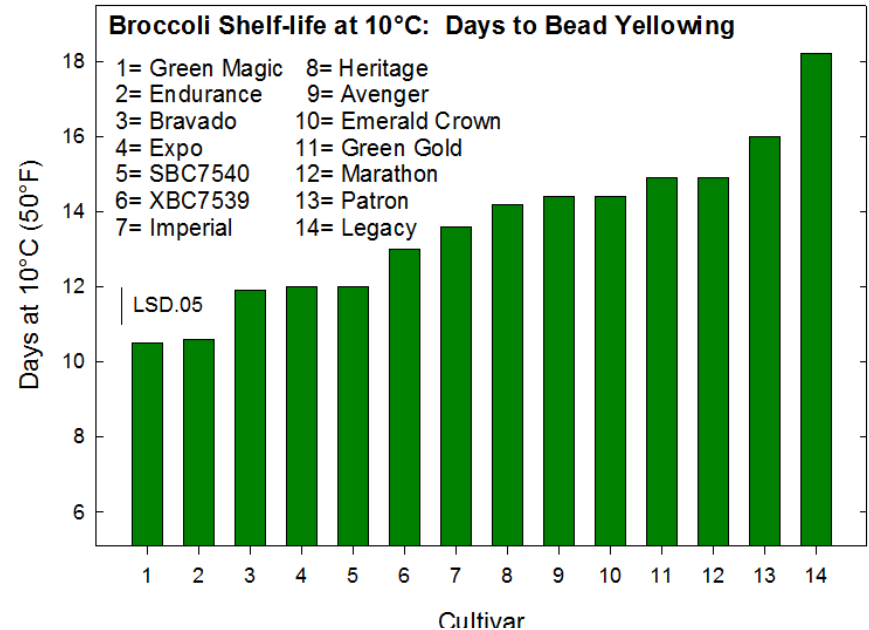
Asparagus

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

Almost all leafy & green vegetables require low storage temperature

Broccoli Quality and Variety Evaluations

- Head Size, floret uniformity
- Floret/Head Color
- Head Firmness, Stem Texture
- Water loss and firmness loss
- Decay susceptibility
- Discoloration cut ends
- Shelf-life
- Composition
 - % dry weight
 - Sugars
 - Vitamin C
 - Pigments
 - Glucosinolates (glucoraphanin)
 - Antioxidant activity





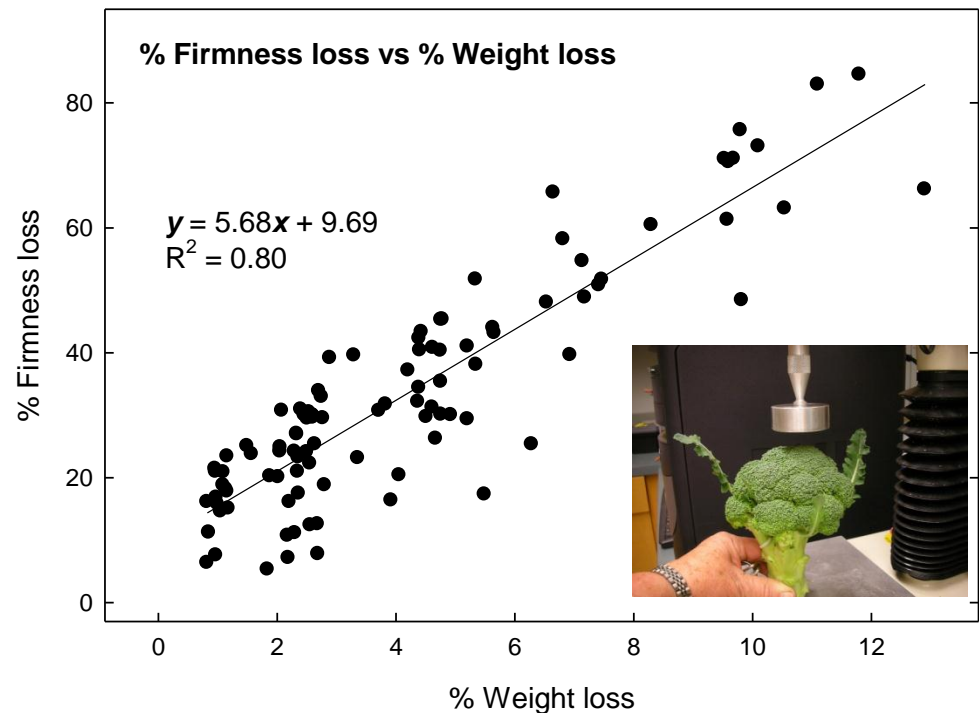
Iceless Broccoli

Temperature-yellowing

Moisture loss-softening



About 4% weight loss results in 30% decrease in firmness and this is likely the point at which a buyer would consider the head soft.

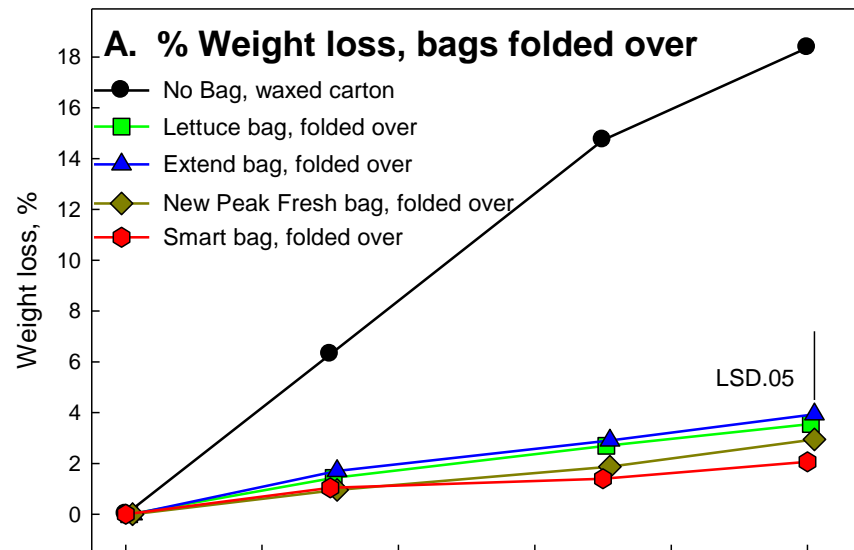


- ✓ Minimize delays to cool
- ✓ Use plastic liners to reduce water loss
- ✓ Keep product cold

Firmness and Water Loss of Crowns of Broccoli Cultivars

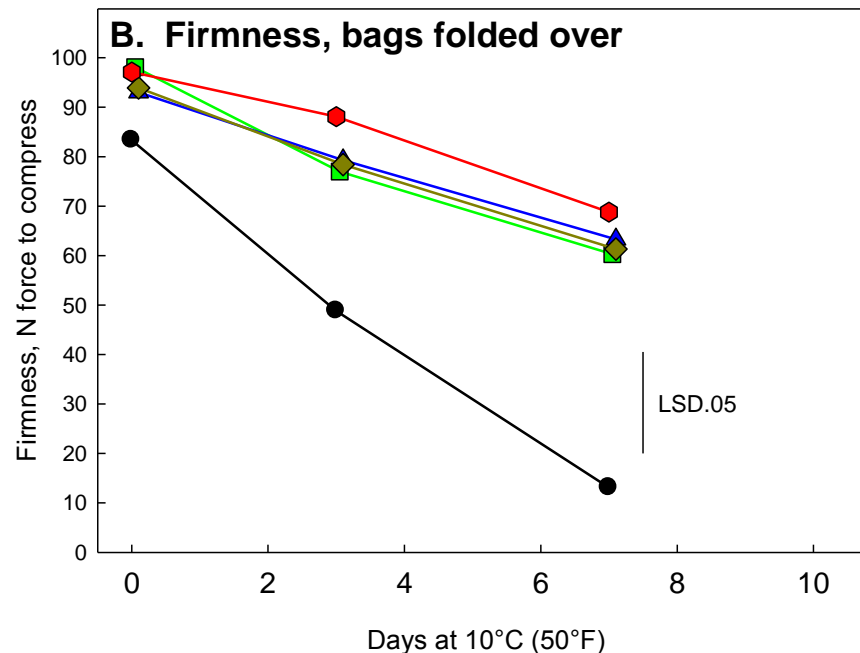
Cultivar	Crown weight, g	Initial Firmness N	% weight loss 20h 15C 70%RH	Final Firmness N	% firmness loss
1	215.5	52.8	5.27	33.0	38.3
2	198.9	63.5	5.24	38.7	39.3
3	200.3	60.0	3.62	48.2	20.6
4	187.5	63.8	3.73	49.2	24.7
5	195.8	58.1	3.66	45.3	21.6
6	181.5	75.6	3.57	62.4	17.9
7	197.2	96.6	3.73	87.0	9.9
8	222.7	113.3	4.80	82.7	28.0
9	227.5	71.5	5.30	53.3	23.9
Average	203.0	72.8	4.32	55.5	24.9
LSD.05	ns	17.2	0.79	16.3	10.8





Broccoli weight loss and firmness loss can be minimized with plastic liners.

Simple perforated PE lettuce or basil liners perform as well as more expensive plastic films.



Head Firmness

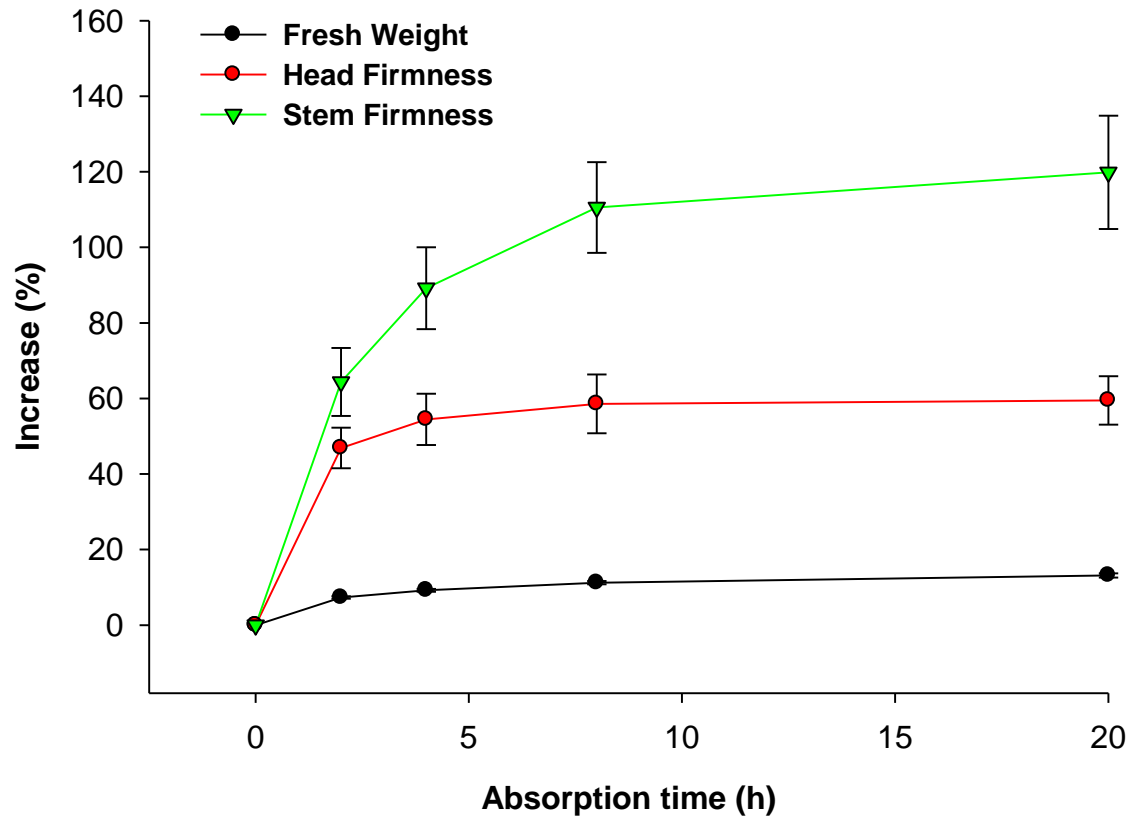


Stem Firmness

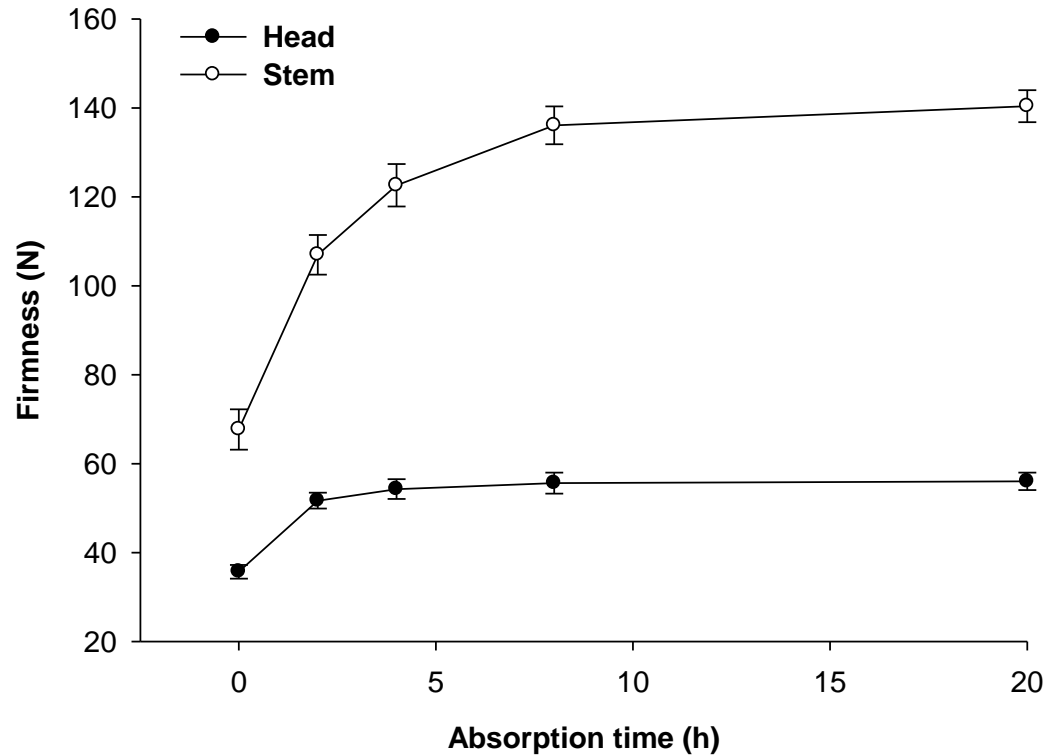


Texture of broccoli heads using a TAXT2i texture analyzer (Stable Micro Systems Ltd).
(A) Firmness test of the heads using a 50 mm flat cylinder probe.
(B) Bending measurement of the stems, using a 3 point bending rig.

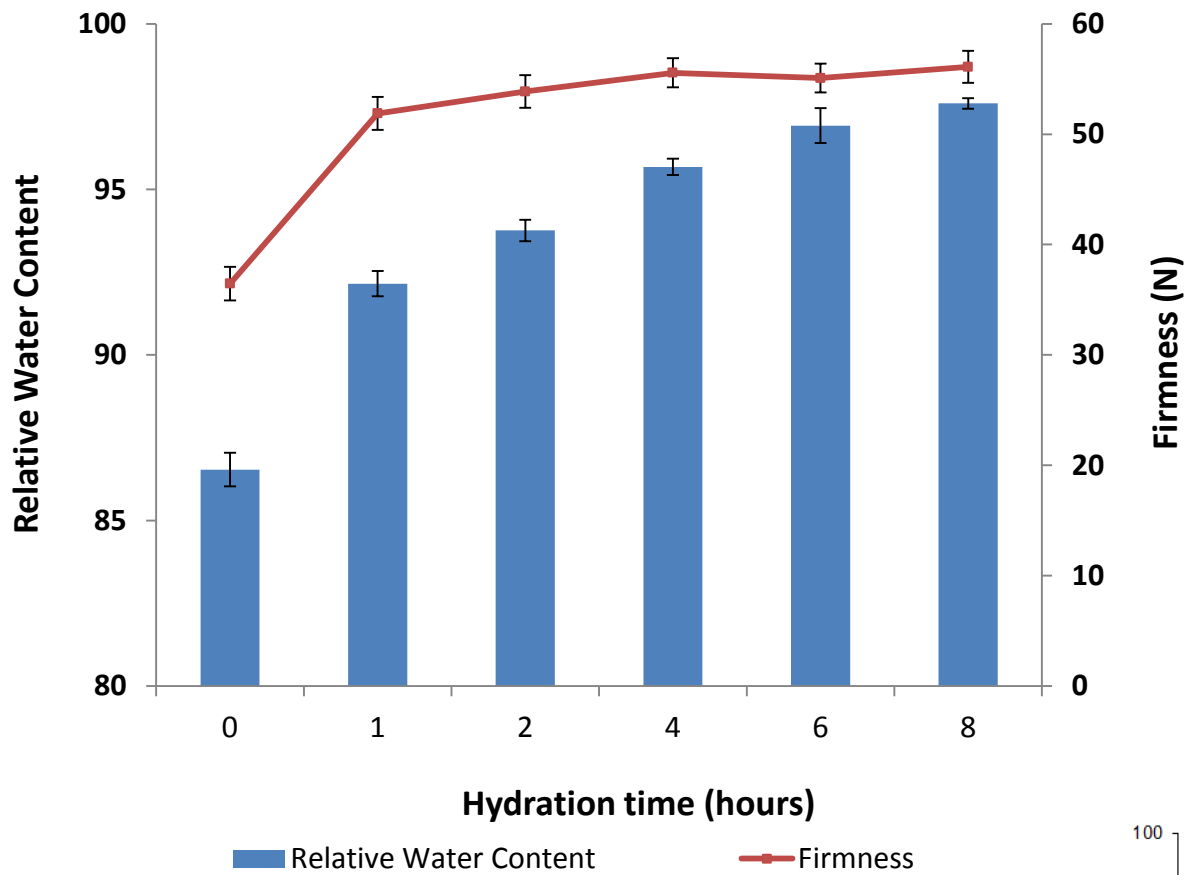
Relative changes in fresh weight and firmness of broccoli heads during rehydration.



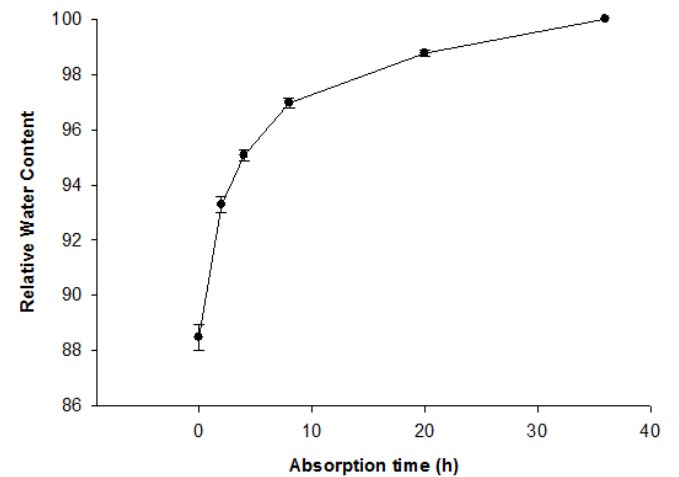
Changes in firmness of stems and heads of broccoli during 20 hours of rehydration at 5°C (41°F). Each data point is the mean of 15 heads \pm standard error.



1 lb-force = 4.45 N; ; 1 kg-force = 9.81 N



$$RWC = \frac{\text{fresh weight} - \text{dry weight}}{\text{turgid weight} - \text{dry weight}}$$



Water relations of Broccoli: Impact on Firmness and Other Quality Aspects

Treatments

1. Control (as harvested)
2. Hydrate heads 30 min in 5°C water
3. Hydrate heads 4 hr in 5°C water
4. Dehydrate heads 3% weight
5. Dehydrate 3% + rehydrate 30 min

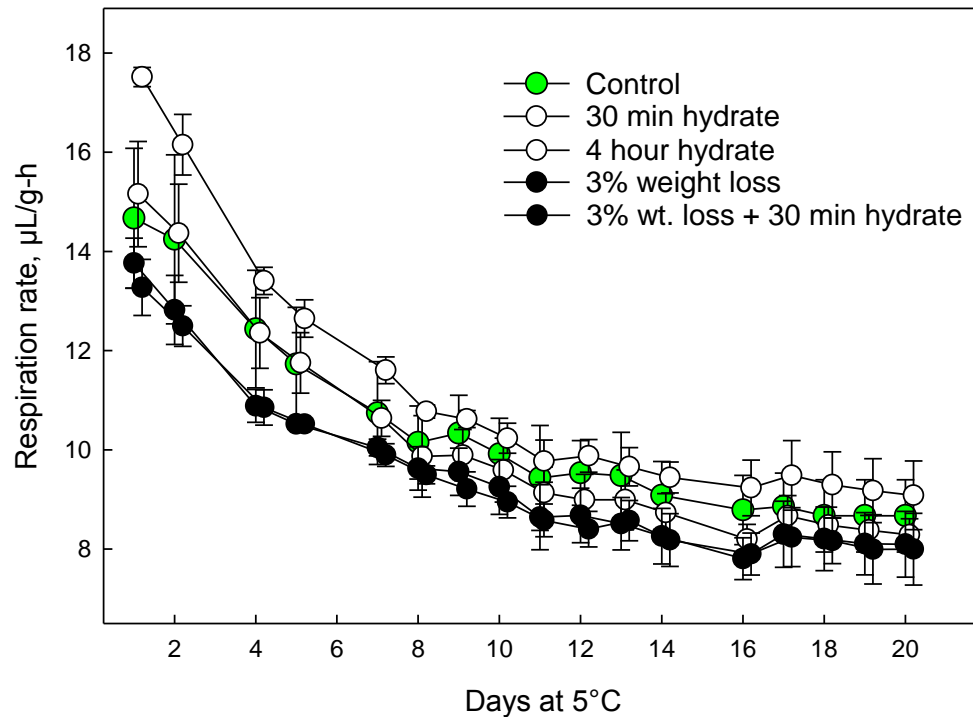
Measurements

Shelf-life (days to yellowing at 5°C)

Fresh weight changes

Firmness (head and stem) changes

Respiration rates



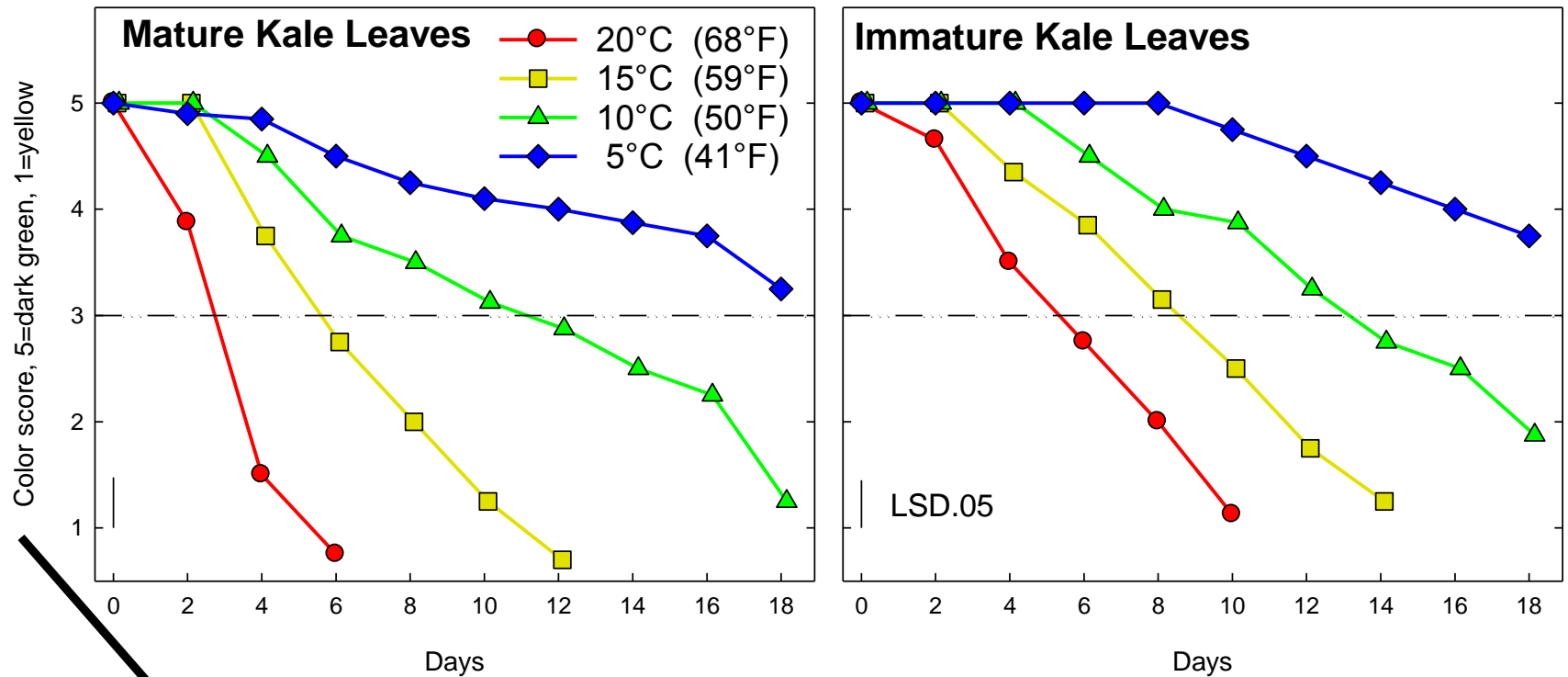
Water loss and water gain do have an effect on broccoli respiration rates and shelf-life

Treatment	Shelf-life 5°C
1. Control	22.8
2. 30 min hydrate	23.1
3. 4 hr hydrate	21.0
4. 3% weight loss	26.7
5. 3% weight loss + 30 min hydrate	26.9
LSD.05	2.6

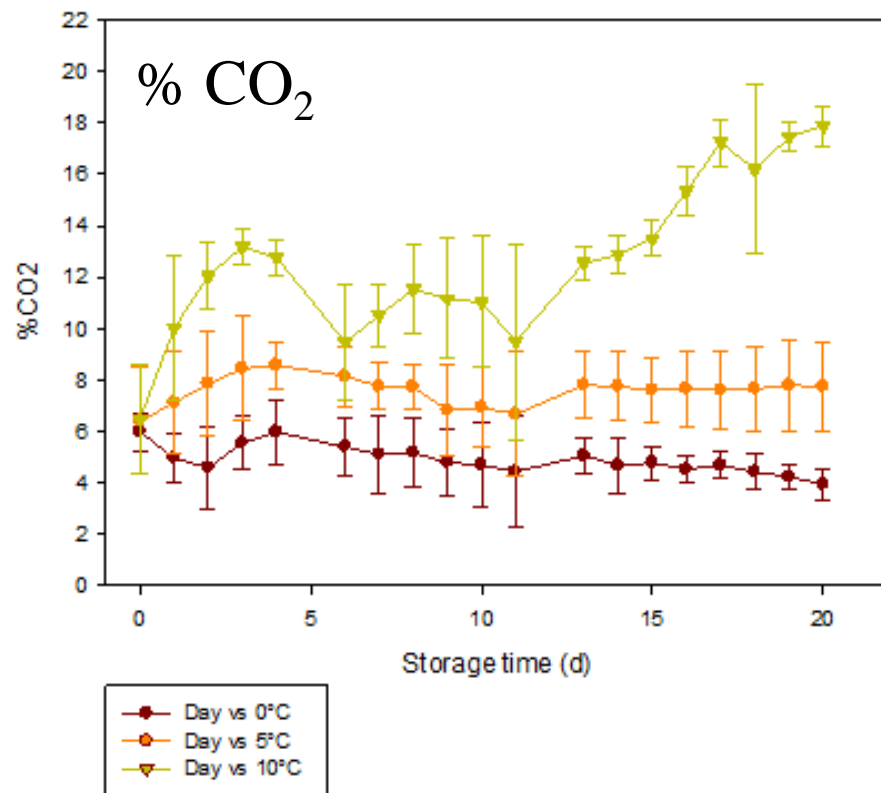
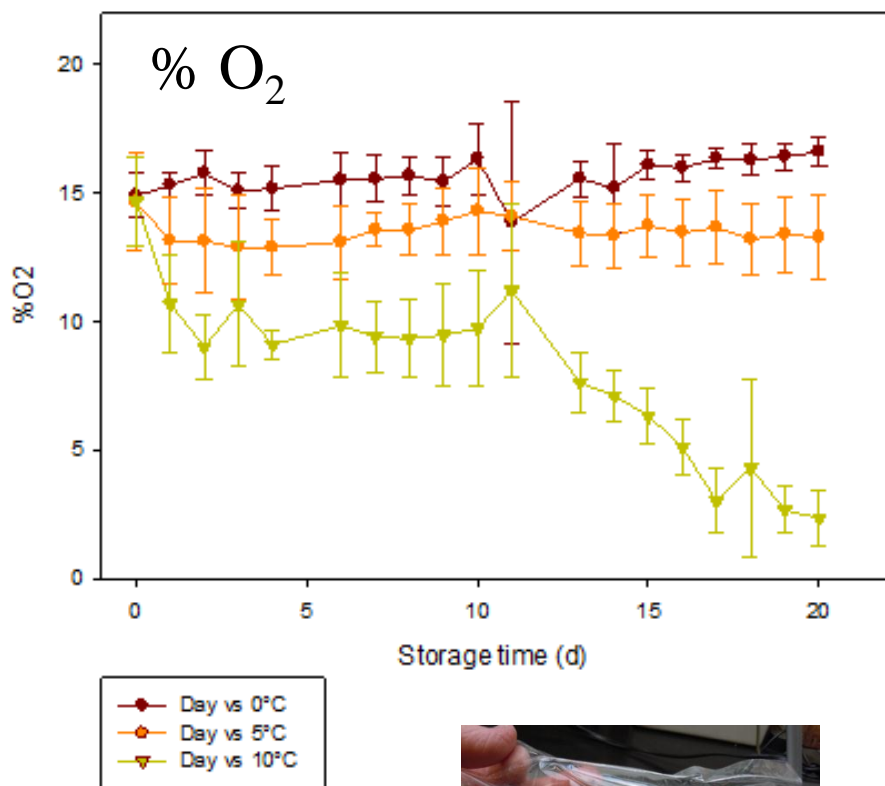
cv Ironman

Melo and Cantwell, 2012

Loss of green color by **mature** and **immature** Kale leaves stored at 4 temperatures for up to 18 days.



Gas composition (CO_2 and O_2) of packages of fresh-cut kale at different temperatures



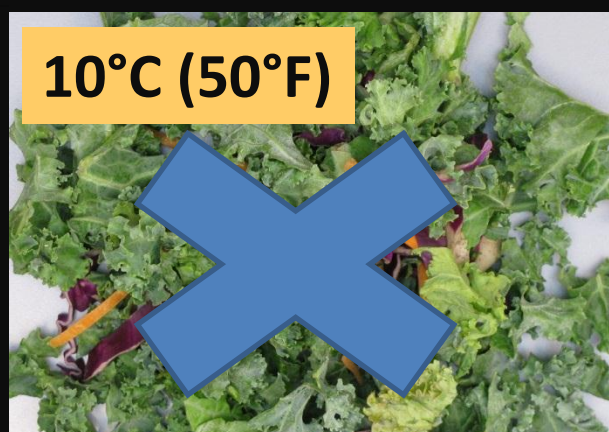
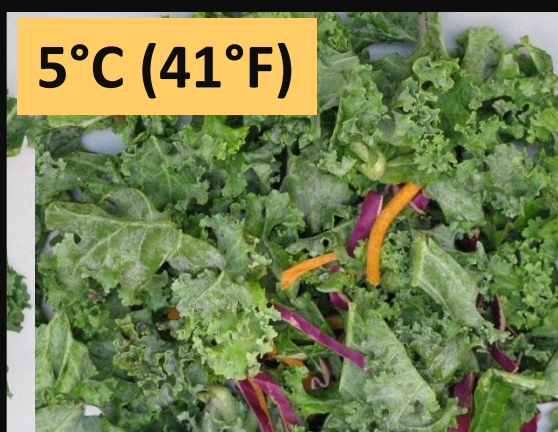
Kale shreds in microperforated bag

0°C (32°F)

5°C (41°F)

10°C (50°F)

8d



12d



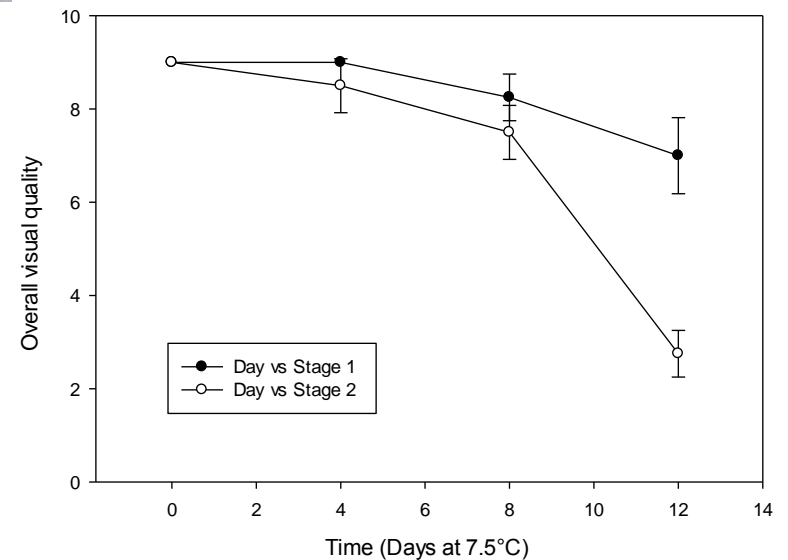
16d

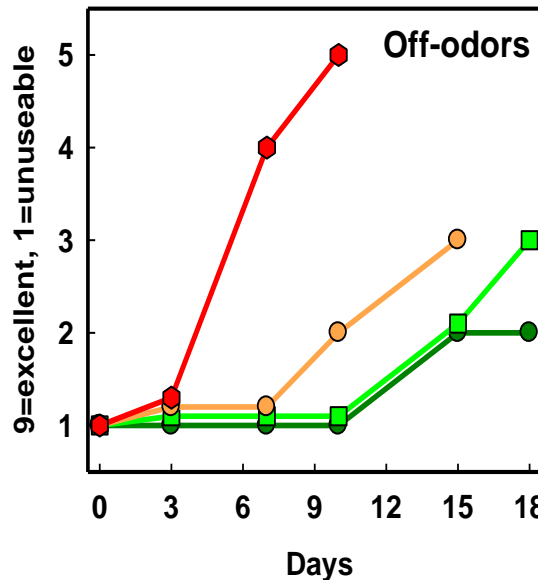
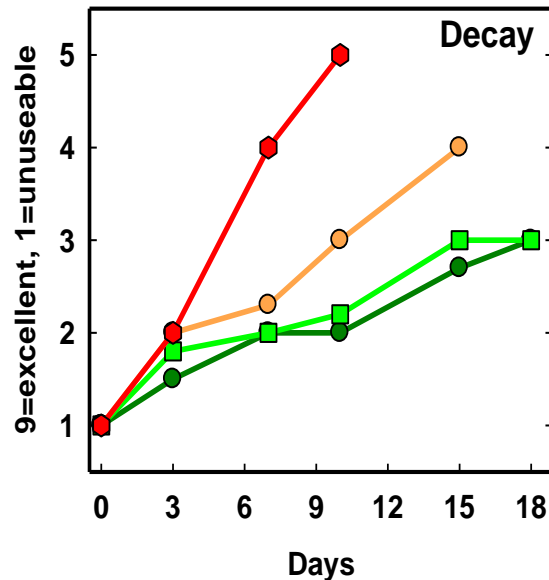
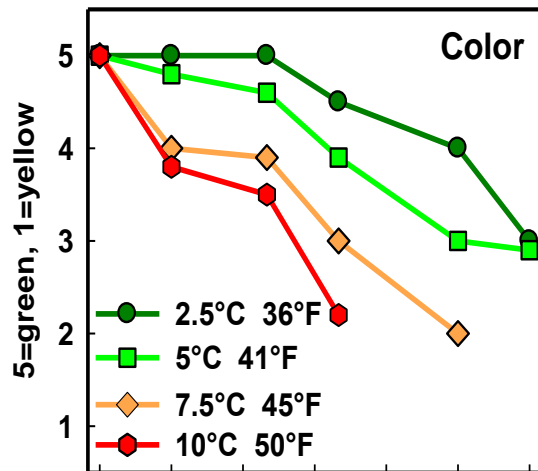
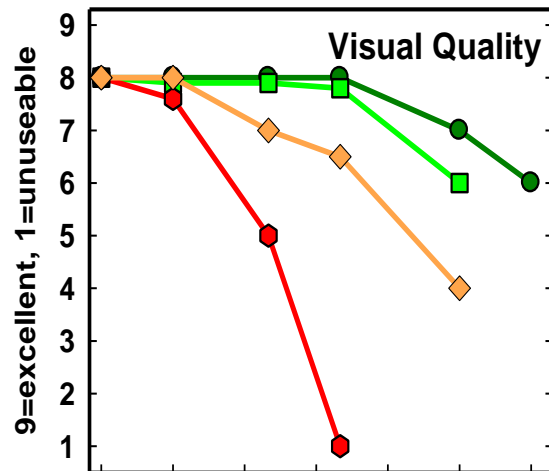




Marketability evaluation - Intact leaves

How important is leaf maturity for quality and shelf-life of kale products





Changes in Spinach quality:

washed and bagged
product stored at 4
temperatures



Spinach

10 days

0°C (32°F)

Category 1 and 3



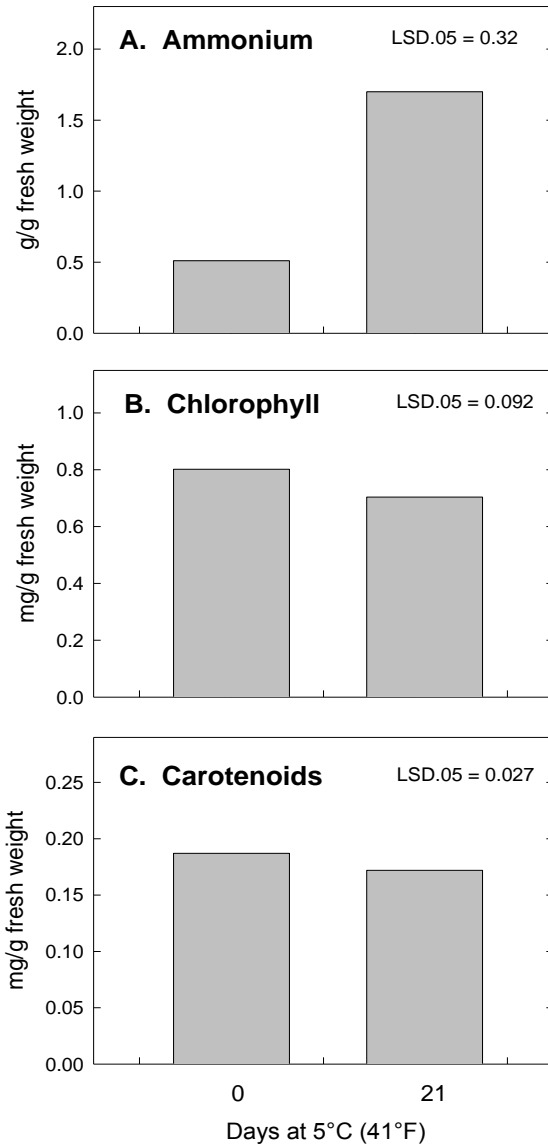
5°C (41°F)

Category 1, 3 and 4

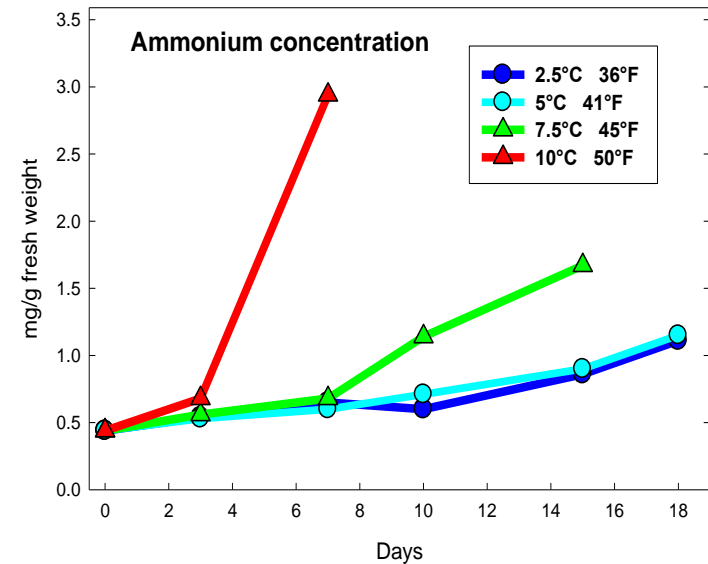


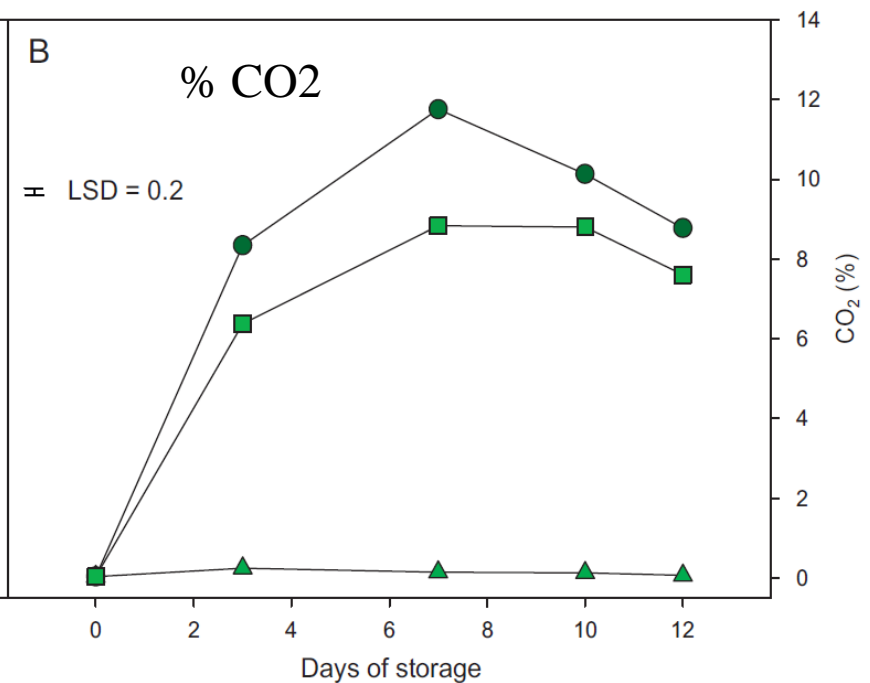
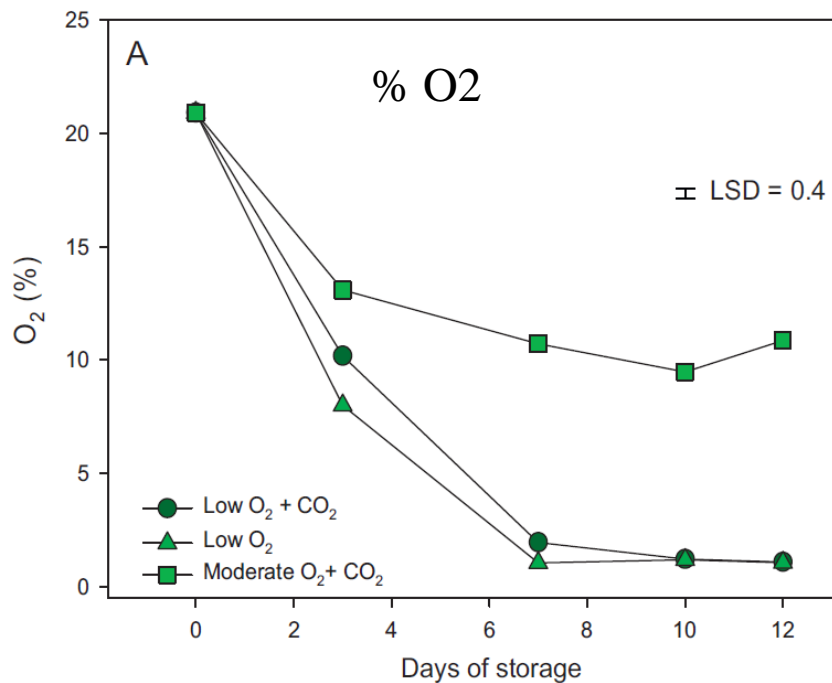
10°C (50°F)

Category 1 and 3



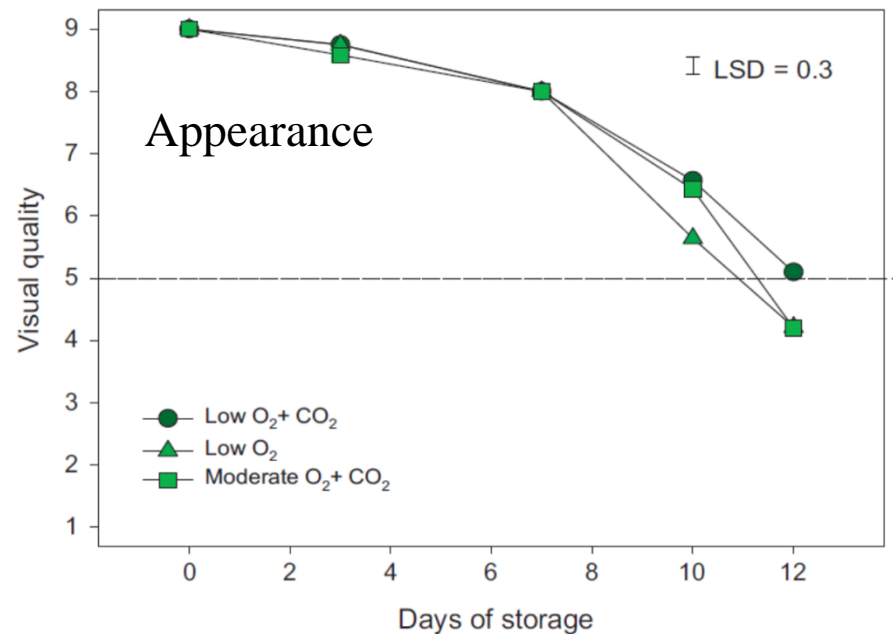
Ammonia is toxic to plant cells;
Changes in ammonia greater than
other compositional changes

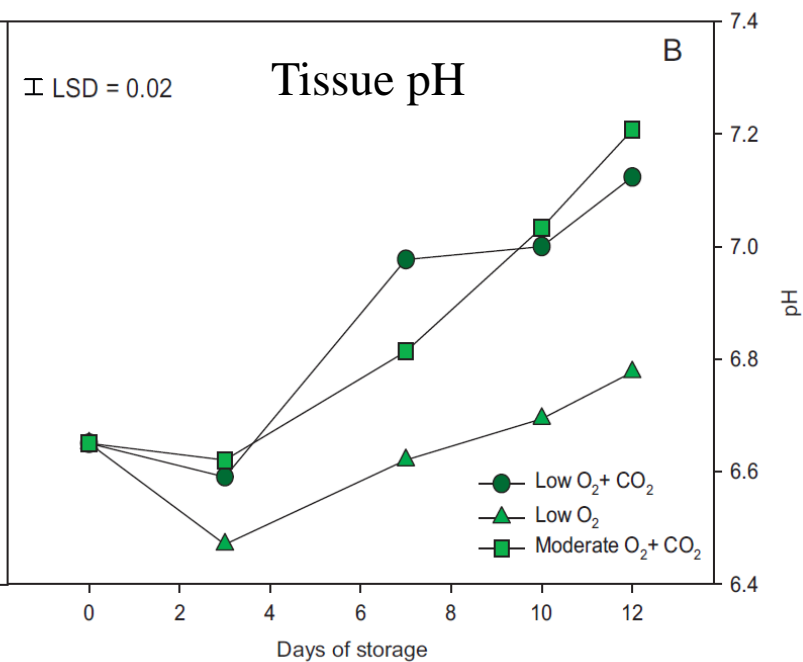
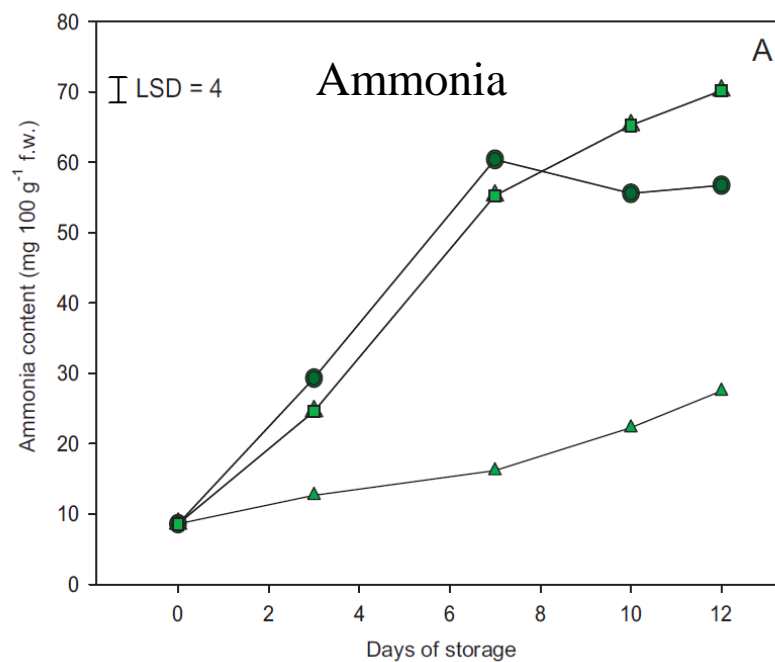
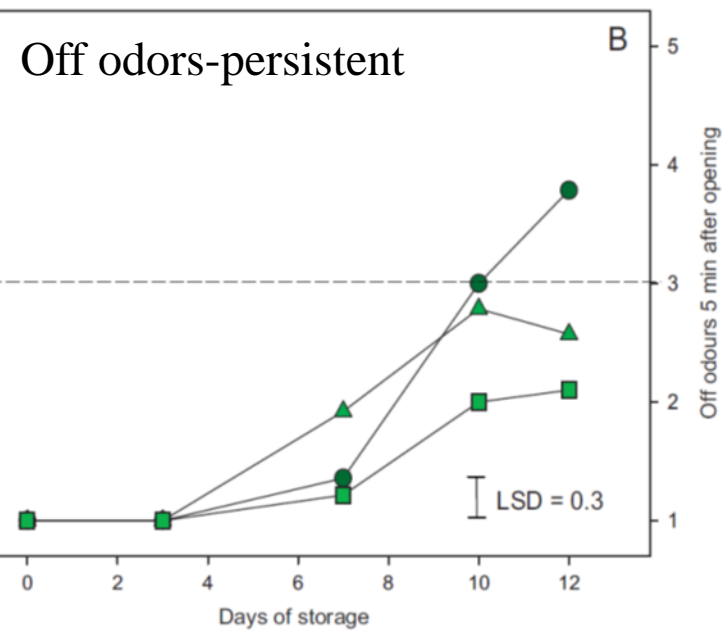
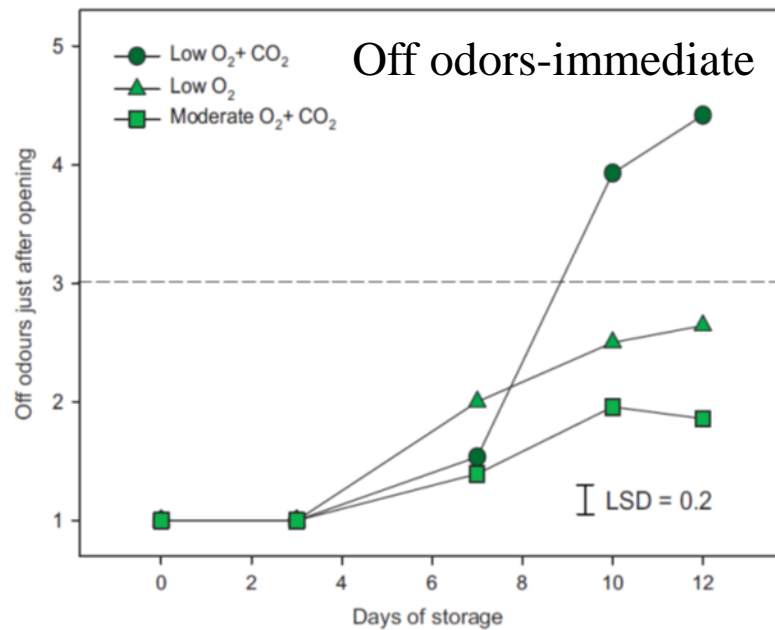




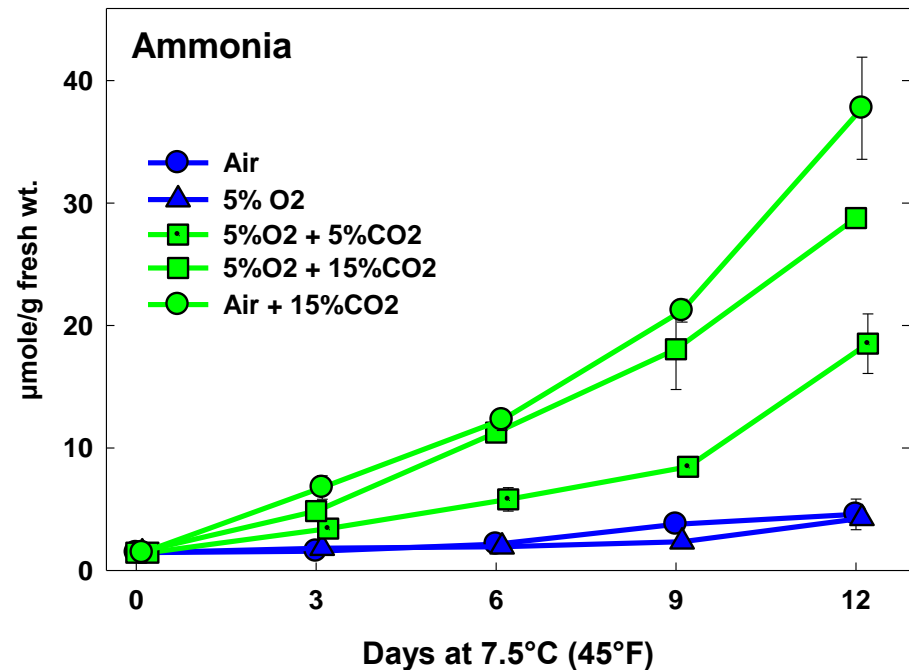
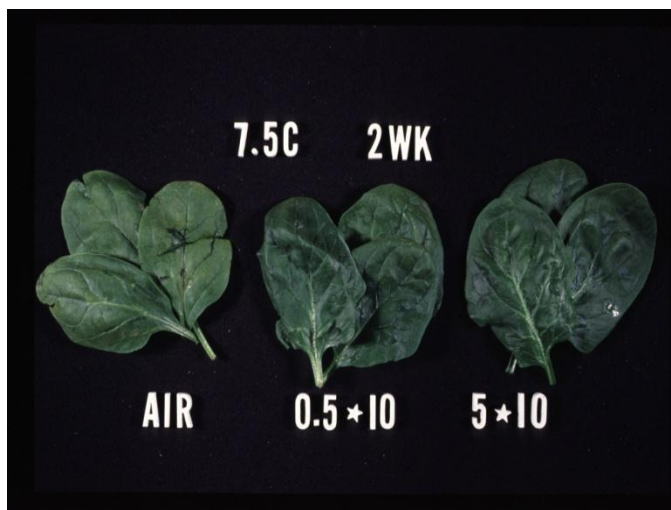
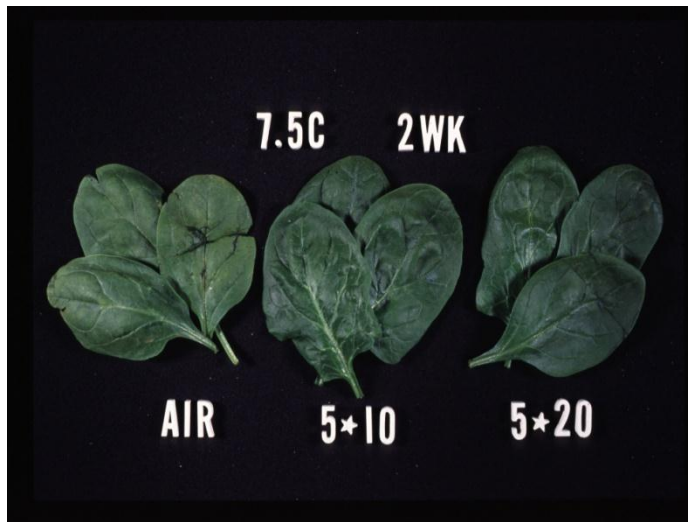
Off-odor development in MAP
Spinach is an unresolved problem.
J.A. Tudela et al, 2013. PH Biol Tech 75:75-85

7°C; color, texture electrolyte leakage,
anatomy, protein, chlorophyll, carotenoids,
sugars, microbiology, ammonia, pH





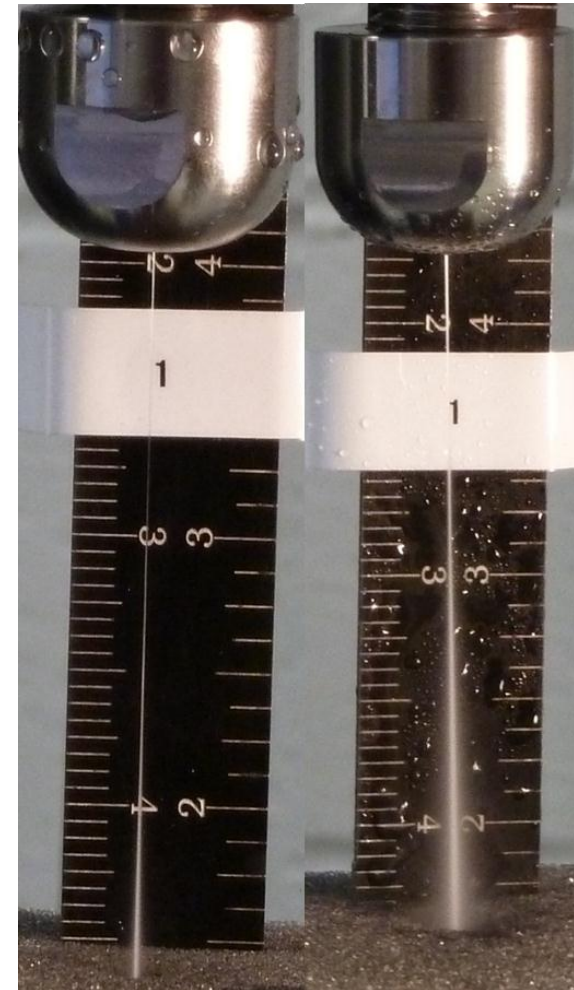
Controlled atmospheres may maintain visual quality of spinach, but may cause undesirable increases in ammonia



Best atmosphere for spinach:
5% O₂ + 5% CO₂

Water-jet Cutting Project

- Third party assessment of performance
- 6 products for fresh-cut
 - romaine, iceberg, celery, cabbage, broccoli
- 2 types of **orifices** (sharp, fuzzy)
- 3 **pressures** (35, 45, 55K PSI)
- 3 traverse **speeds**
- Cut surface appearance
- Shelf-life and quality commercially cut product and waterjet cut products





Best WJ



Worst WJ



Dull Knife

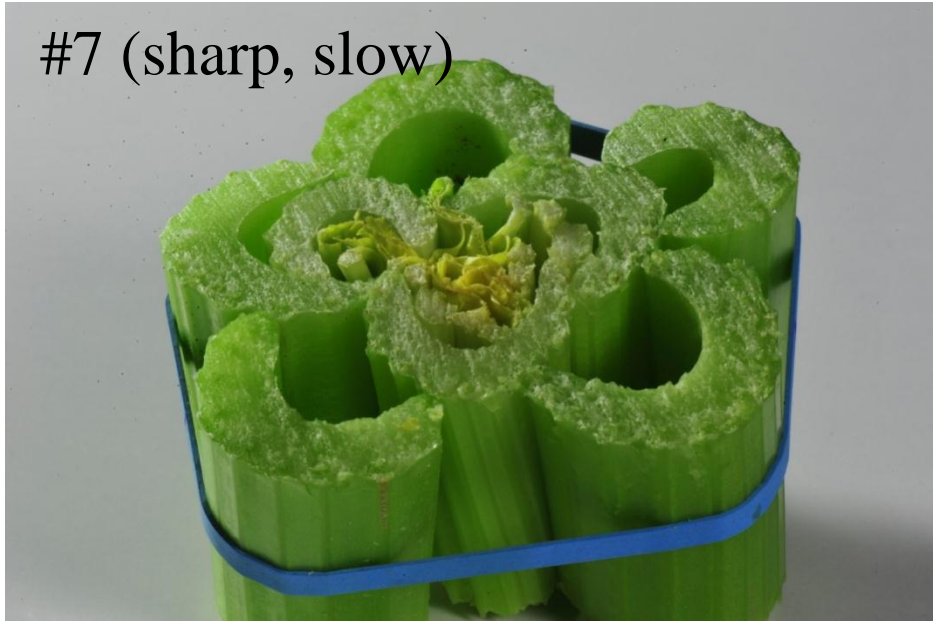


Sharp Knife

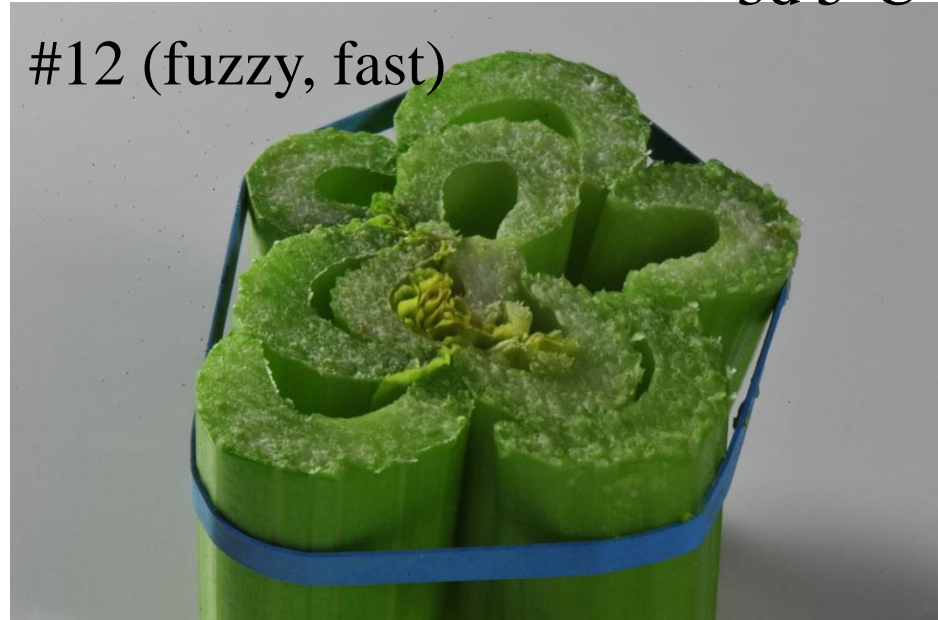
Romaine April 16, 2011; 4 days 5°C; 7, 12, dull, sharp

3d 5°C

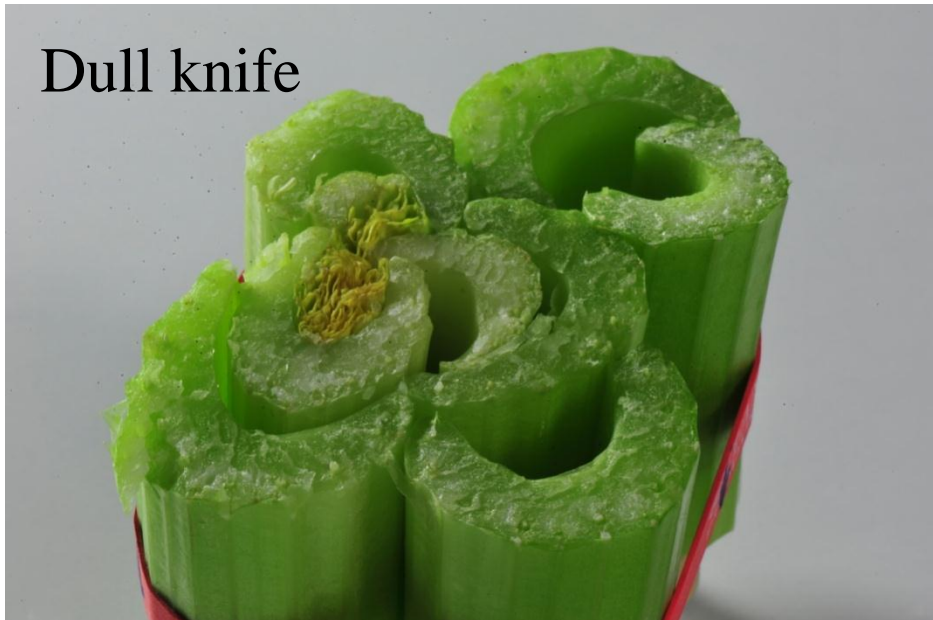
#7 (sharp, slow)



#12 (fuzzy, fast)



Dull knife



Sharp knife



4 days



Knife

Waterjet

Visual quality (9-1)

6,9

Visual quality (9-1)

5,2

Whitening (1-5)

2,1

Whitening (1-5)

3,6

Browning (1-5)

1

Browning (1-5)

1

Commercially-cut (left) and water-jet cut (right) celery stalks, packaged and held 8 days at 5°C.



Marketable quality, decay, microbiology, color, texture, physiology, electrolyte leakage, Microscopy, other techniques to objectively evaluate cutting technologies

Sharp vs Dull knife; 3 days air 5°C



- Sharp vs dull effect on product quality
- Guidelines for knife sharpness?
- Sharp knives make a difference but how to quantify the effect and blade quality

Postharvest Challenges for Vegetables

- *Key link between production and marketing*
- ***Maintain** quality and safety of the product*
- *Achieve shelf-life required to meet marketing needs*

1. Adhere to basic handling principles
2. Improve temperature management; Cold Chain
3. Ensure hygiene and microbial food safety
4. Increased use of modified atmospheres
5. Control detrimental ethylene effects
6. Improve sensory & nutritional quality
7. Increased product diversity; fresh-cut
8. Streamline handling and distribution