Postharvest Handling Update for Leafy Vegetables

1. Water relations and texture--broccoli
2. Appearance and Nutritional Quality of Vegetables
3. Fresh-cut Kale and importance of maturity
4. Fresh-cut processing: Compare water-jet with blade cutting

Santa Maria Vegetable Meeting
Sept 17, 2013

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UCDAVIS POSTHARVEST TECHNOLOGY

Water loss is Cumulative

Impacts on Quality

Loss of Salable Weight

Loss Fresh Appearance

- Gloss
- Shrivel
- Pitting, sunken areas

Loss of Texture, Turgidity

Changes in Product Physiology

Critical levels for many products

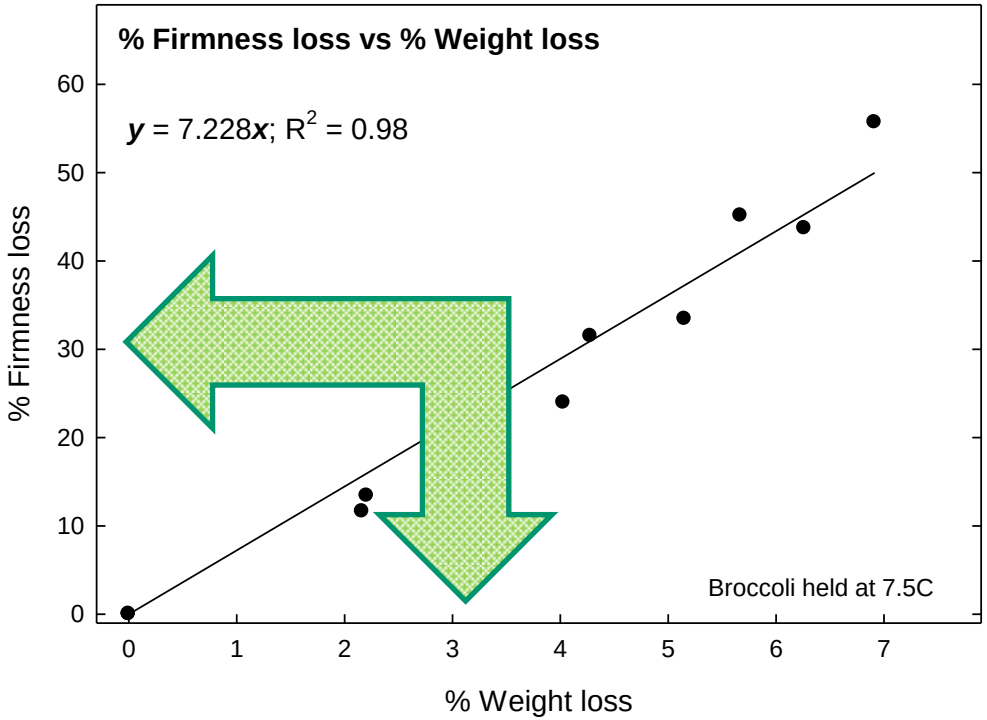
<3% no visual effect, texture

3-5% visual quality affected

>5% shrivel, lose salability

Iceless Broccoli
Temperature-yellowing
Moisture loss-softening

Texture and Water loss



ICELESS BROCCOLI

- Minimize delay from harvest to cooling
- Use plastic liners with holes to reduce water loss
- Keep it cold
- About 3-4% weight loss = soft head

Firmness Testing of Broccoli

Head Firmness

Firmness test of the heads using a 50 mm aluminium flat cylinder probe.

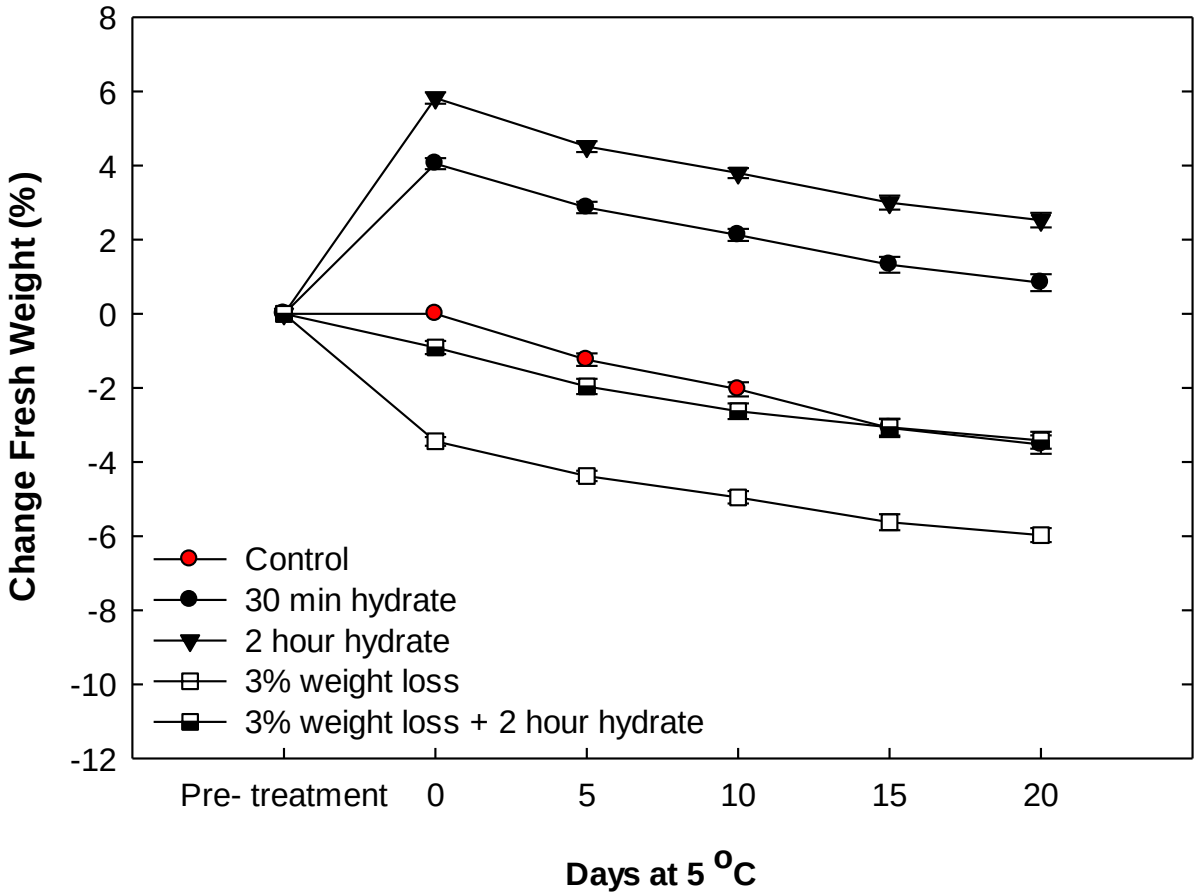
Stem Firmness

Bending of the stems, using a 3 point bending rig.

Broccoli (cv Ironman) harvested into perforated bags and placed immediately in coolers with ice

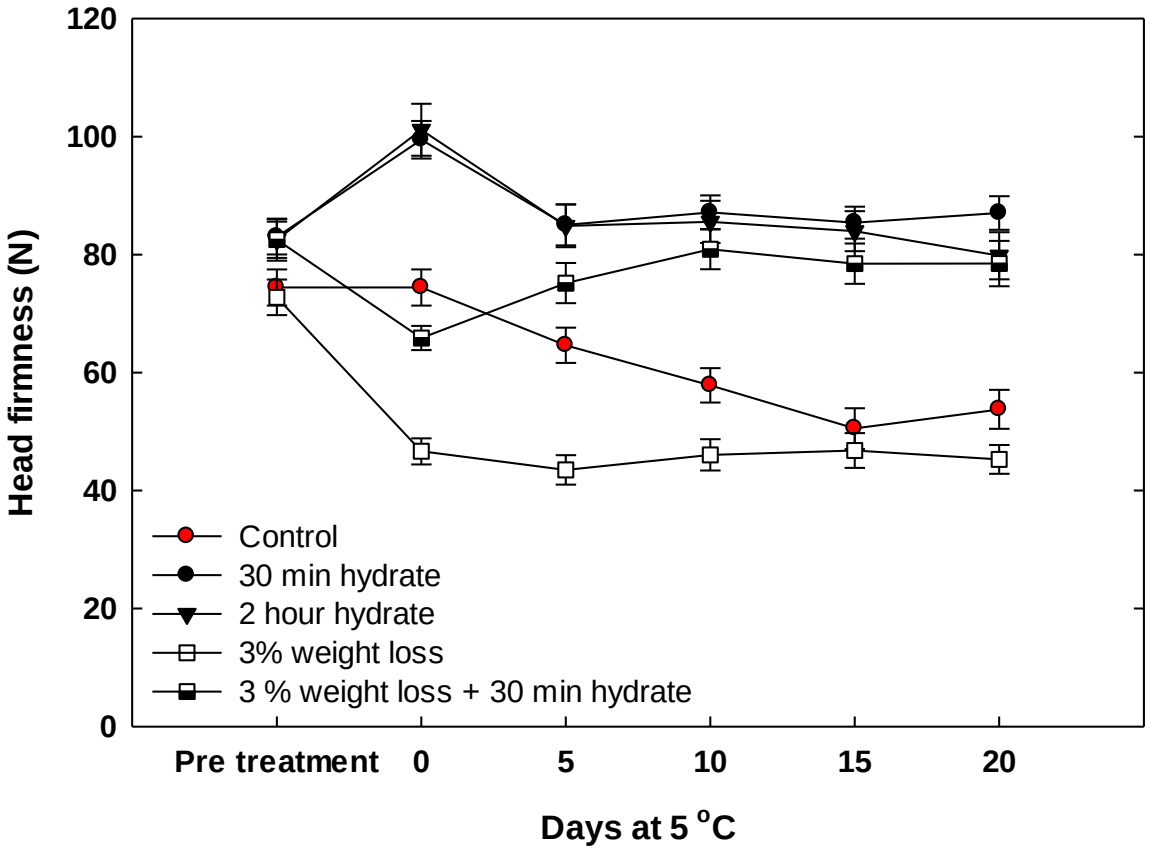
Storage: perforated plastic bags inside waxed carton boxes at 5°C (41°F)

Fresh weight, % change



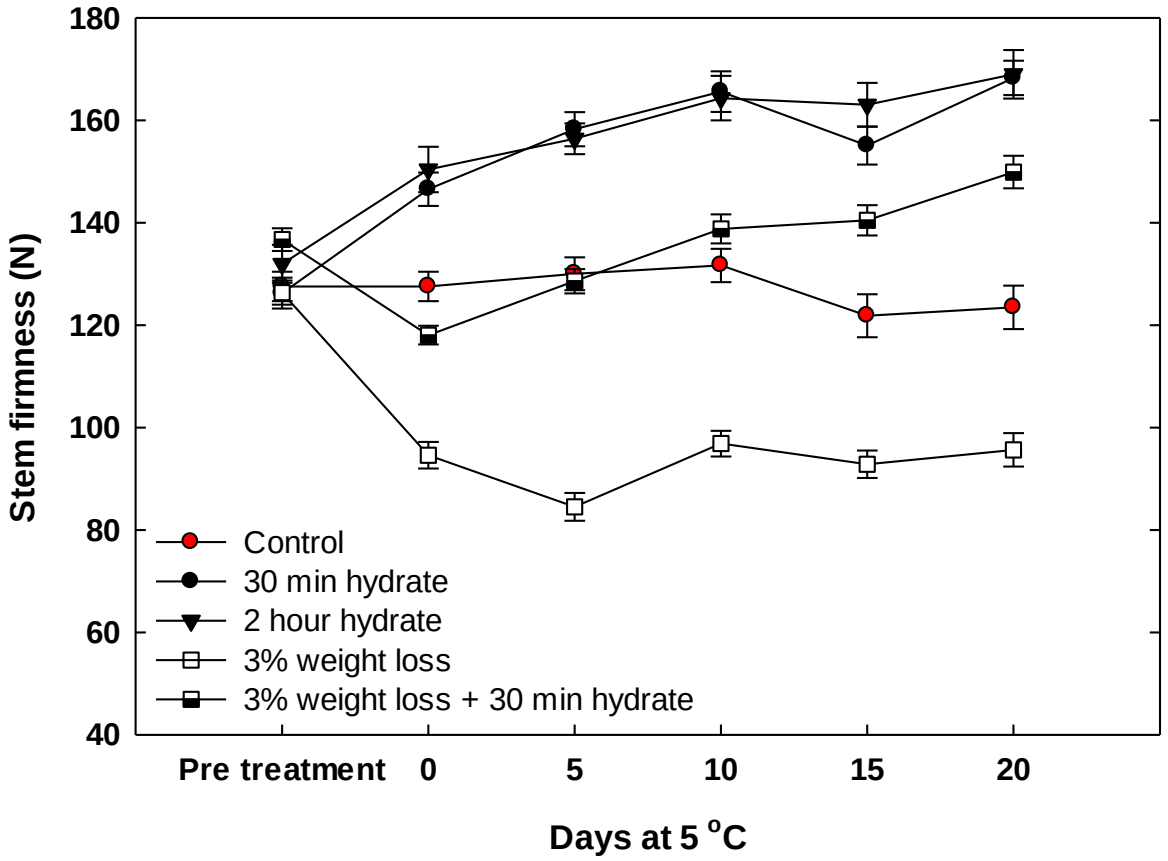
Head Firmness

Storage: perforated plastic bags inside waxed carton boxes at 5°C (41°F)

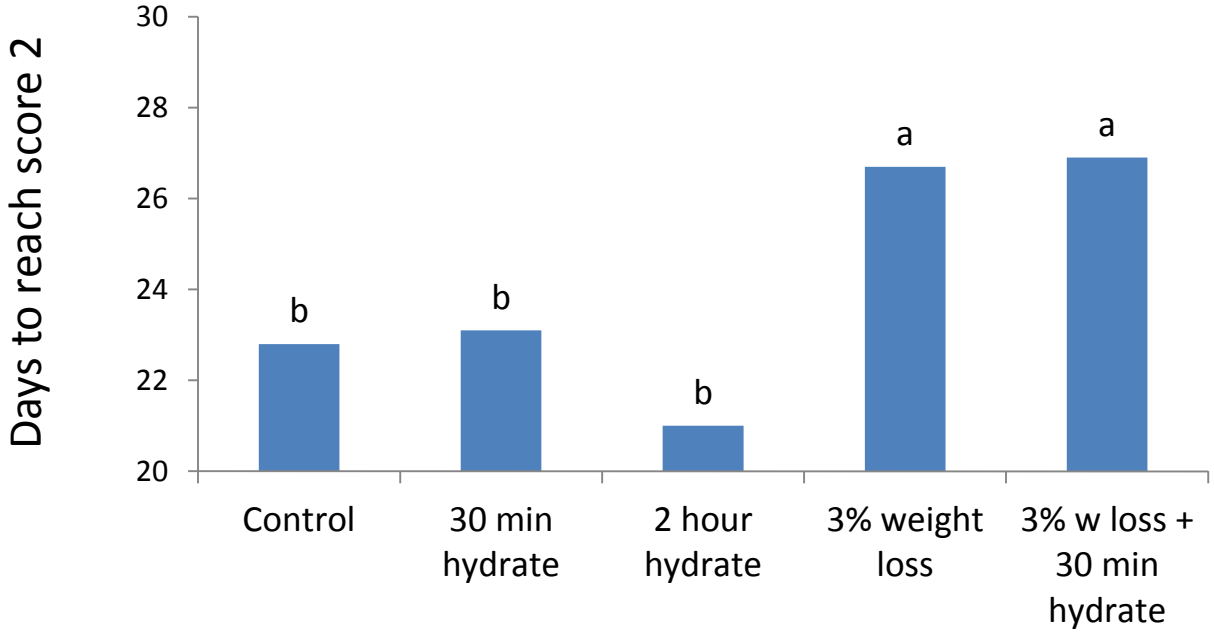


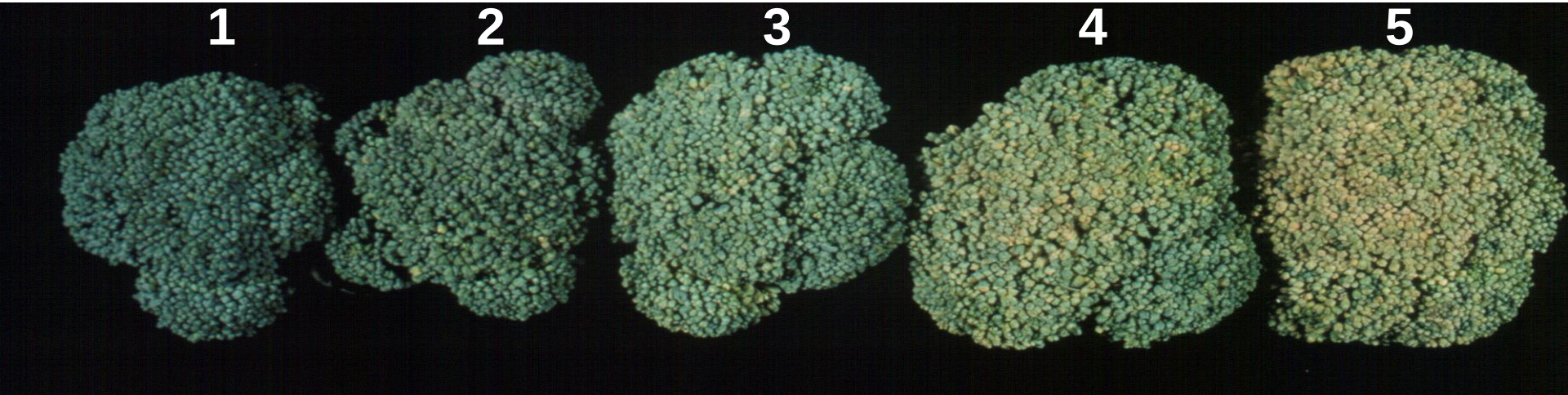
Storage: perforated plastic bags inside waxed carton boxes at 5°C (41°F)

Stem Firmness



Visual Quality and Shelf-life





Broccoli Firmness and Water loss

- 3% weight loss results in noticeable loss of firmness
- Minimize delays to cool
- Use plastic liners to reduce water loss and allow cooling (vacuum, forced air)
- Keep product cold
- Sealed plastic packaging is not necessary to control water loss
- Sealed packaging will create MA which can be beneficial in range of at 3-8% O_2 and 5-12% CO_2

Lucia Kaiser, Shermain Hardesty PIs

WIC Project 2011
Postharvest Quality of Vegetables

Objectives

- Determine whether visual cues for quality are indicative of good nutrient content
- Evaluate a range of leafy and fruit vegetables
- Evaluate a range of potential storage temperatures
- Want to retain a minimum 80% of initial nutrients

Artichoke, Arugula, Asparagus, Bean, Broccoli, Cauliflower, Kale, Snap Pea, Spinach, Zucchini

WIC 2011
Postharvest Quality of Vegetables

- Purchased from wholesaler within 1-2 days of harvest
- Held at 0, 10 or 20°C (32, 50 or 68°F) in unsealed bags
- Evaluated after 0, 4, 8, 12 days; 3 replicates
- **Visual quality** (9=excellent, 1=unusable; 6 is limit of marketability)
- **Decay/deterioration** (1=none, 5=severe)
- **Vitamin C** (total ascorbic acid activity, mg/100g FW)
- **Antioxidant activity** (mg Trolox/100g FW)

Determine time to retain 80% of original content
Is visual appearance (score 6) a good indicator of nutritive value?

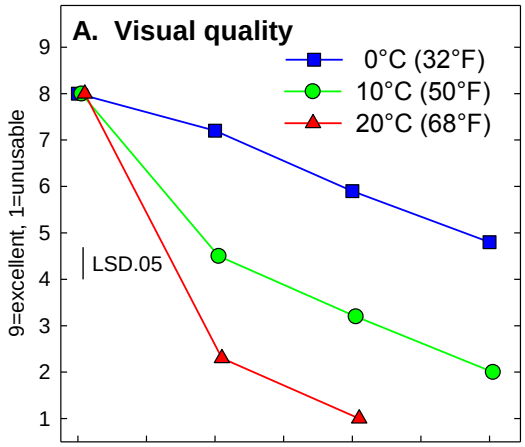
Postharvest Quality of Vegetables Nutritional Value based on Vitamin C and Antioxidant Activity

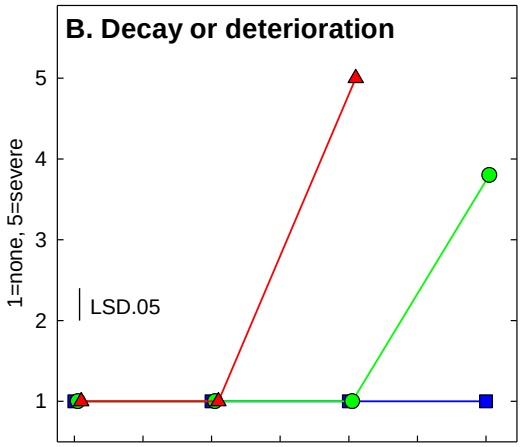
- **Vitamin C**
  - a specific vitamin required by humans
  - 90% of Vitamin C comes from fruits and vegetable
  - needed for cell repair; protects against oxidative stress
  - Is a labile vitamin (degrades easily)
  - Often measured in storage studies of fruits and vegetables
- **Antioxidant activity**
  - With aging, there is increase in oxidative damage of human cells
  - Antioxidants can reverse early stages of oxidation
  - In fruits and vegetables, many constituents provide antioxidant activity (phenols, Vitamin C, Vitamin E, carotenoids and others
  - Various assays can estimate total activity of antioxidant compounds in fruits and vegetables

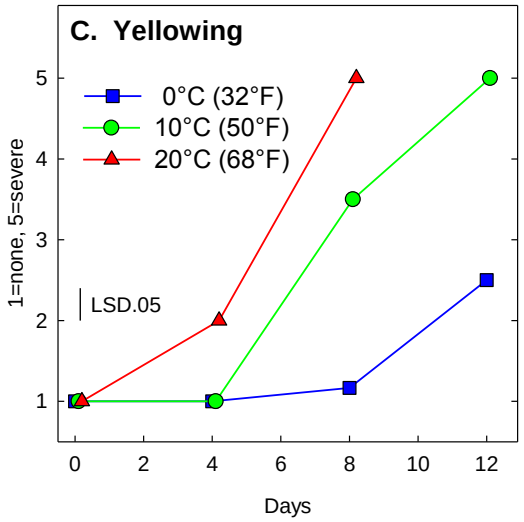
Initial Composition of 10 Vegetables

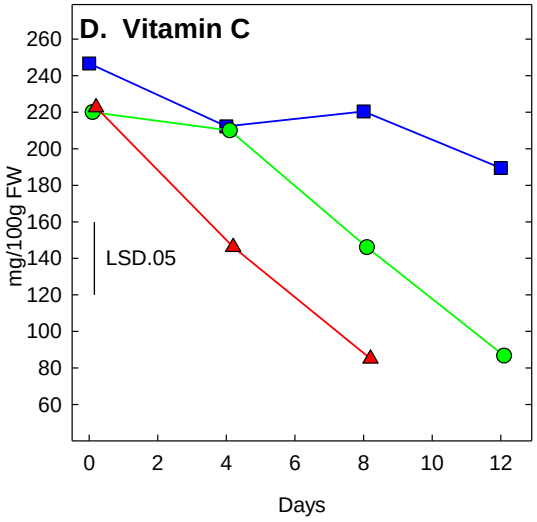
	Vegetable	Dry weight %	Vitamin C mg/100g FW	Antioxidant Activity mg Trolox/100g FW
High phenols	Artichoke	17.2	95.4	347.0
Green Leaf or stem	Arugula	10.2	211.0	160.7
	Broccoli	11.9	193.9	146.4
	Kale	11.6	179.6	157.0
	Spinach	9.8	99.5	169.5
	Asparagus	8.9	39.2	125.1
Immature Fruit vegs	Snap Pea	13.8	105.2	110.5
	Bean, green	10.6	55.1	19.1
	Zucchini	6.7	55.1	11.2
White Veg	Cauliflower	8.0	93.4	41.6
	LSD.05	0.5	12.2	18.4

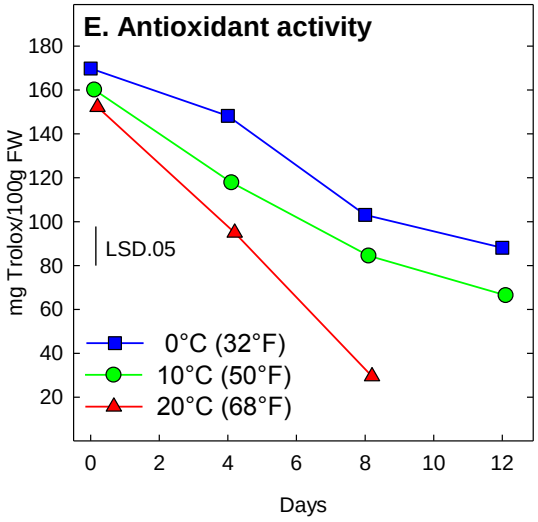
Arugula











- ✓ Arugula (a Brassica) is very responsive to storage temperature
- ✓ Low temperature retained Vitamin C but antioxidants decreased at all temperatures
- ✓ Arugula has high Vitamin C content and high antioxidant activity

Arugula

Temperature	Days to limit of marketability	Days to 80% Vitamin C	Days to 80% Antioxidant activity
0°C (32°F)	8	>12	6.5
10°C (50°F)	3.5	6	3.5
20°C (68°F)	2	2	2

CONCLUSIONS:

Buying **arugula** based on visual appearance would ensure good nutritional quality. Antioxidant activity declines faster than Vitamin C content.

Shelf-life based on visual and nutrient aspects

	Days that remain visually marketable*			Days that retain 80% nutrient value**		
VEGETABLE	**0°C (32°F)**	**10°C (50°F)**	**20°C (68°F)**	**0°C (32°F)**	**10°C (50°F)**	**20°C (68°F)**
Artichoke	9	4	3	12	8	5
Arugula	8	4	2	10	5	2
Asparagus	14	9	5	12	8	3
Bean, green	14	8	5	12	12	10
Broccoli	14	9	4	10	7	4
Cauliflower	8	5	3	12	10	7
Kale	14	8	4	12	10	6
Snap Pea	14	8	5	14	14	10
Spinach	14	7	3	14	10	4
Zucchini	14	12	9	12	12	10
AVERAGE	**12.3**	**7.4**	**4.3**	**12.0**	**9.6**	**6.1**

* Number of days to reach a score of 6 from a 9 to 1 scale, where 9=excellent, 8=very good, 7=good, 6= moderately good and marketable, 5=fair but unmarketable, 4=low, 3=poor, 2=almost unusable and 1=unusable

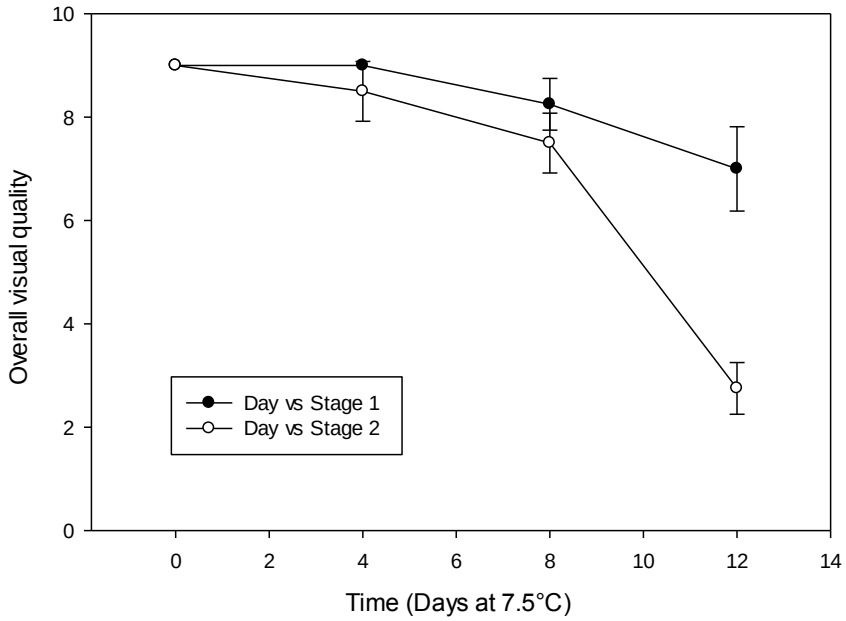
**Number of days to retain 80% Vitamin C and antioxidant activity

Is visual appearance a good indicator of nutritive value? **Generally YES!**

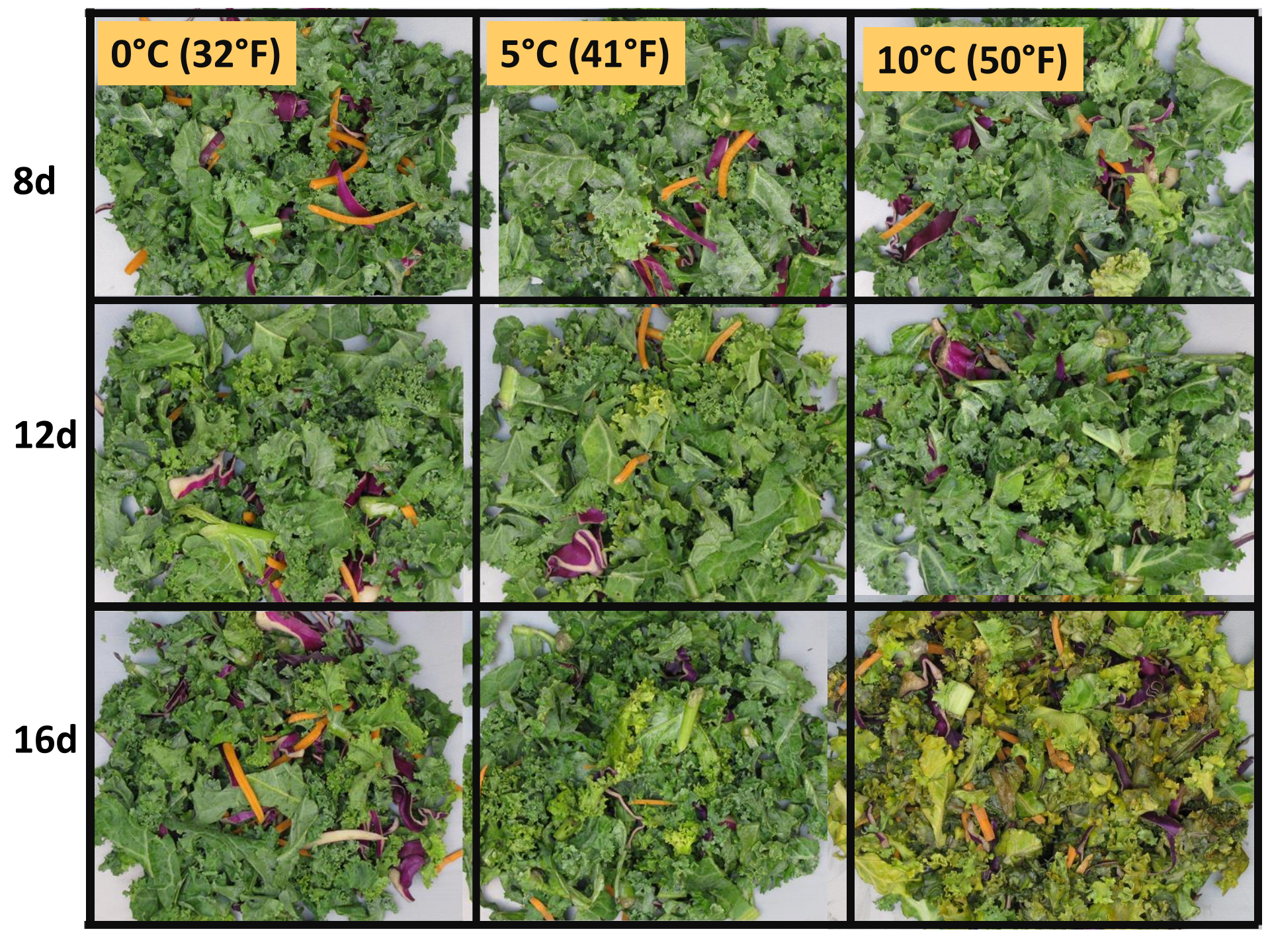
Vegetable	Conclusion
Artichoke	Yes
Arugula	Yes
Asparagus	No
Bean, green	Yes
Broccoli	Partially
Cauliflower	yes
Kale	Yes
Snap Pea	Yes
Spinach	Yes
Zucchini	Yes

Used 80% retention of Vitamin C and Antioxidant Activity at the limit of marketability as criteria to answer the question

Marketability evaluation - Intact leaves



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


0°C (32°F)
5°C (41°F)
10°C (50°F)
8d
12d
16d

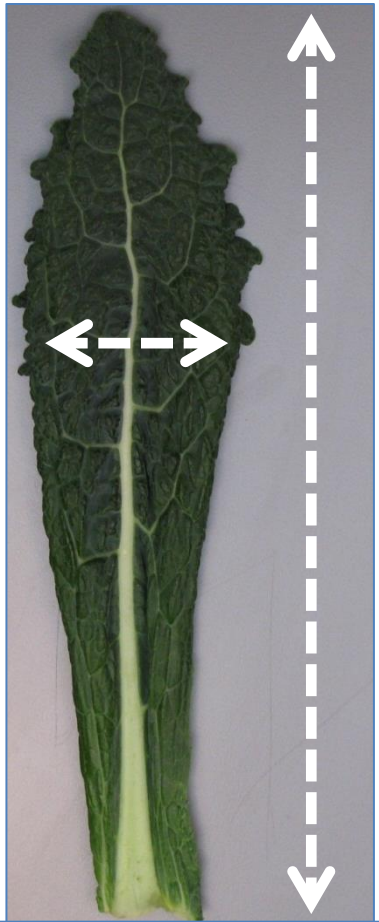
Fresh-cut Kale
Importance of Leaf Maturity

1. Determine the impact of maturity on performance of kale leaves in fresh-cut format at two storage temperatures
2. Determine relationships between composition analyses and indicators of the senescence process

Materials and methods

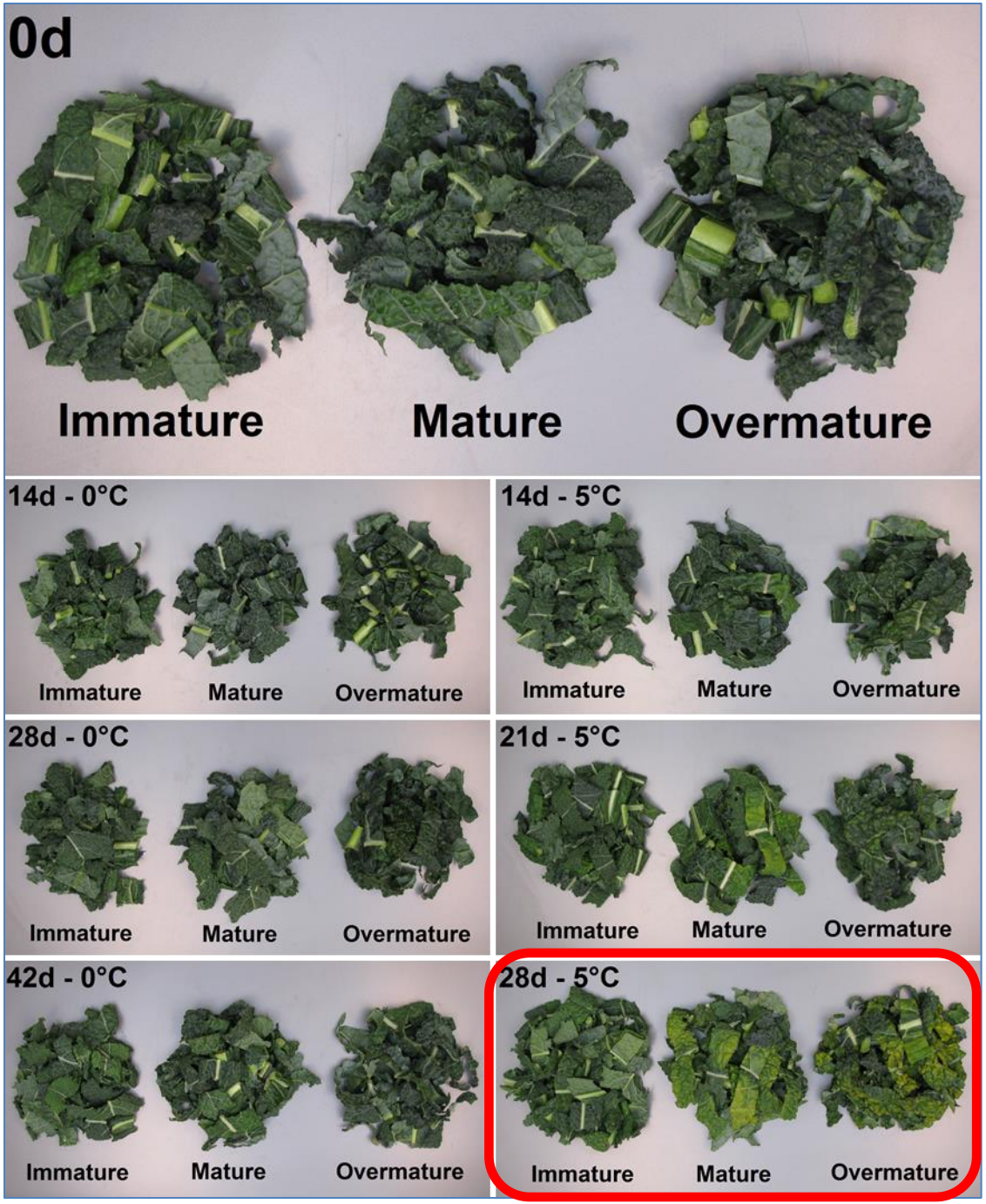
- Kale cv. Lacinato
- Leaves were harvested at three maturity stages based on:
  - Length (petiole included)
  - Width (Point of maximum leaf expansion)
- Unlike other cultivars, color is not a maturity criteria

Criteria	Immature	Mature	Overmature
Length	<20 cm	20-30 cm	>35 cm
Width	<4 cm	4-5 cm	>5 cm



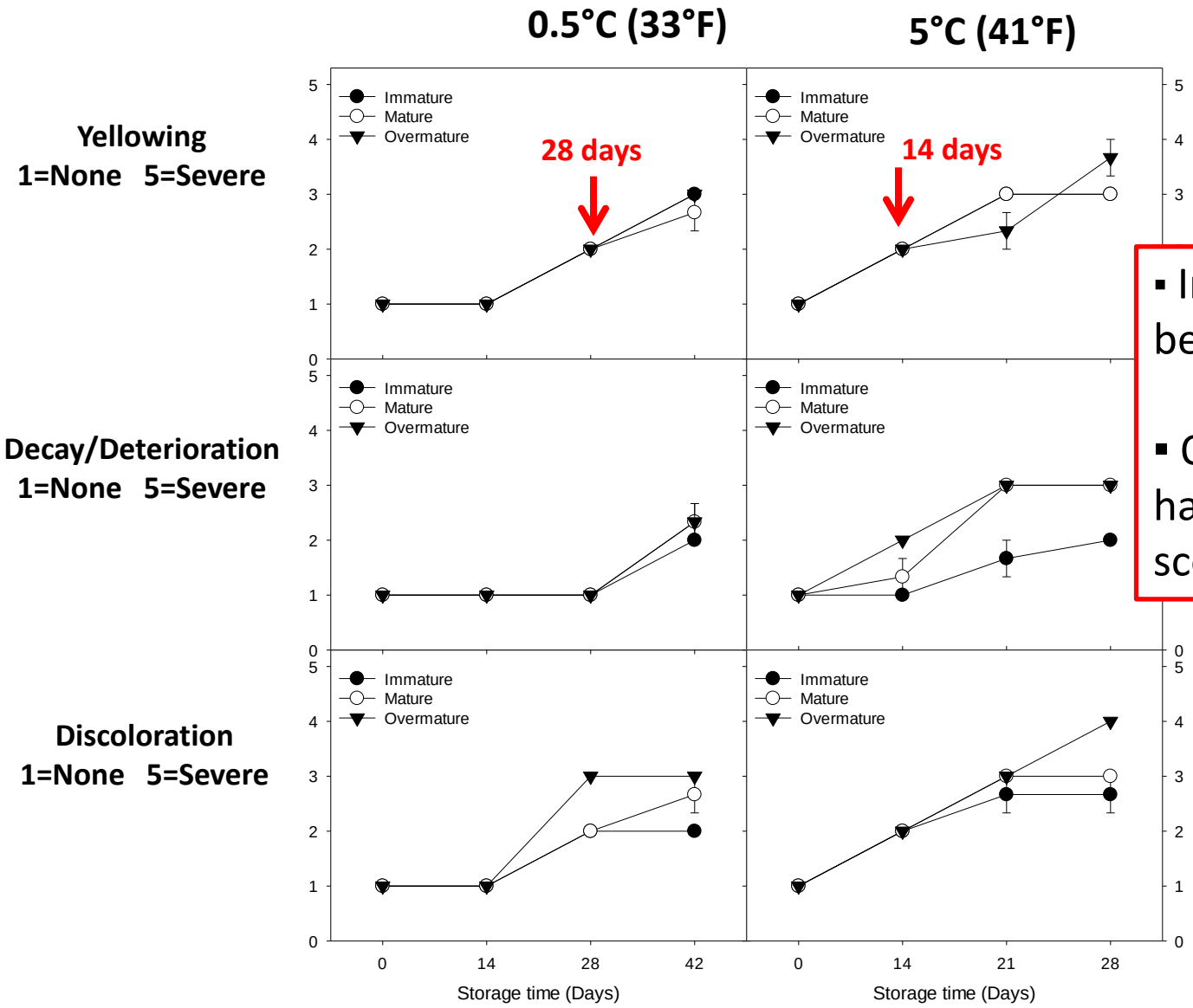
Materials and methods

- Preparation at 7.5°C (45°F)
  - Trim, cut 1 cm strips across midrib
  - Wash chlorinated water (50 ppm NaOCl)
  - Drain, centrifuge
  - Package unsealed plastic PE bas on covered tray at 0.5 and 5°C (33 and 41°F) for up to 42 and 28 days
- Evaluations
  - Marketability assessment (visual quality, defects)
  - Composition (chlorophyll, carotenoids, ammonia, malondialdehyde)



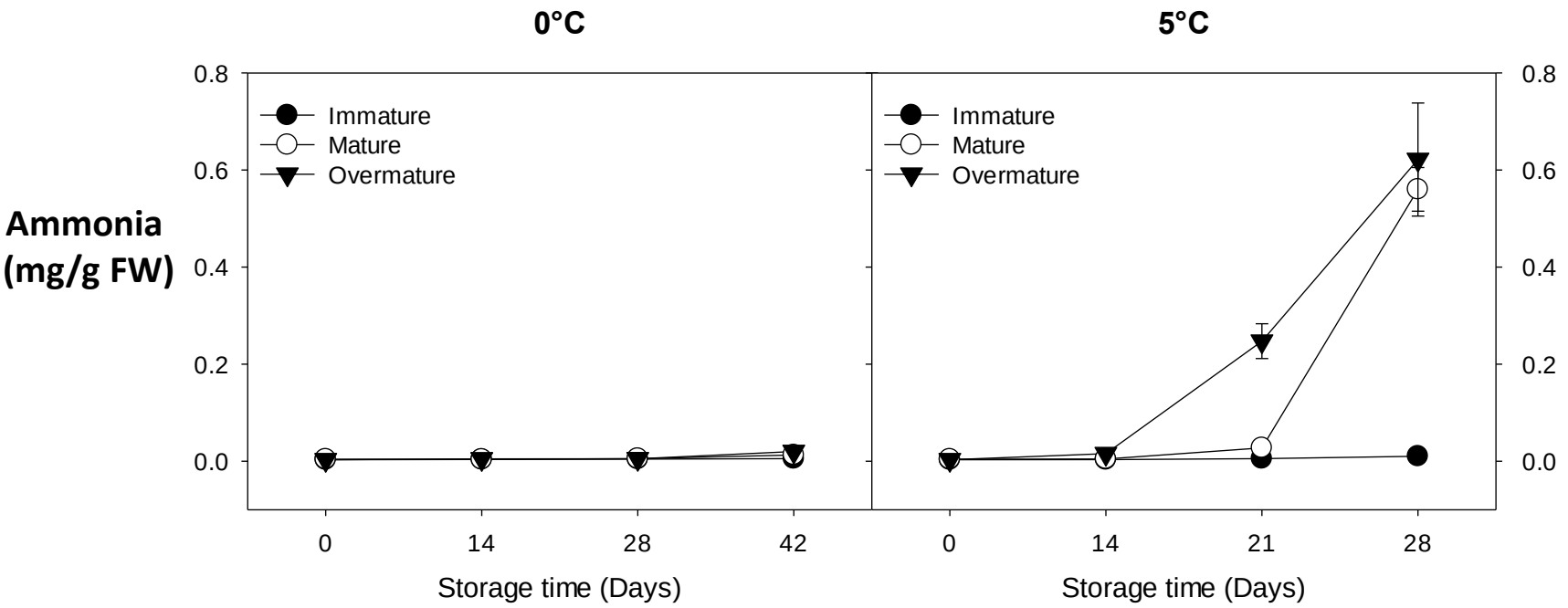
Critical differences in maturity

Marketability evaluations



- Important differences between 0.5 and 5°C
- Overmature leaves had the higher defect scores

Ammonia



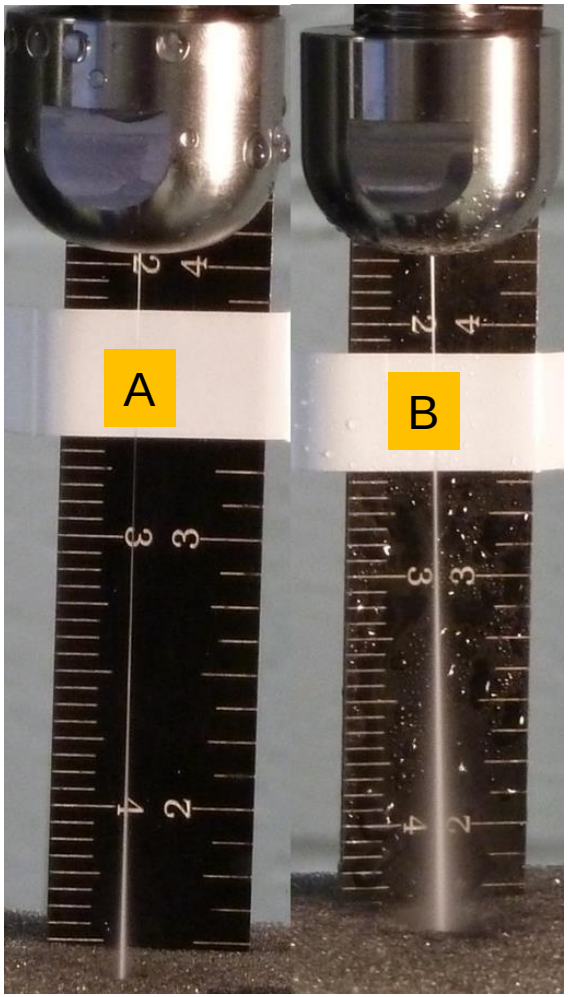
- Ammonia is an indicator of senescence
- Increases as nitrogen compounds are metabolized
- Significant differences due to temperature
- 0°C: No significant differences between maturity stages
- 5°C: Significant increases after day 14. Differences between maturity stages: higher in overmature leaves. Lower in immature leaves.

Ammonia and Leafy & Floral Tissues

- Ammonia can be useful to monitor stressful CA/MA as well as senescence
- Consequences of increases in ammonia
  - Relate to sensory and other quality attributes
  - Relate to physiology and freshness of leafy greens
- Tissue ammonia correlated to ammonia in package atmospheres?
  - Use as a rapid indicator of stress and/or temperature abuse for leafy vegs (broccoli, spinach, asparagus)

Water-jet Cutting Project

- Assessment of performance
- 6 products for fresh-cut
  - Lettuces, 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



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Commercial blade cut

Waterjet cut (sharp nozzle)

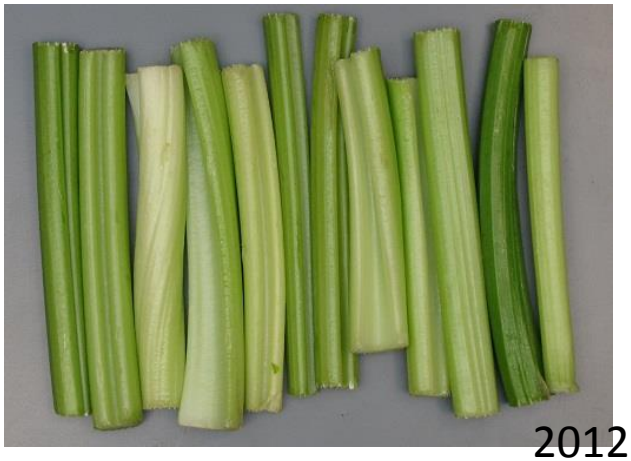
6 days 5°C; no modified atmosphere

2012

Commercial blade cut

Waterjet cut (sharp nozzle)

8 days 5°C; packaged,
no modified atmosphere



2012

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

Used or Dull blade

New or sharp blade

Fuzzy nozzle

Sharp nozzle

Packaged, no MA, 18 days at 2.5°C (36°F)

Test#1 FrEx 2013

Used and sharpened blades

Sharp new blades

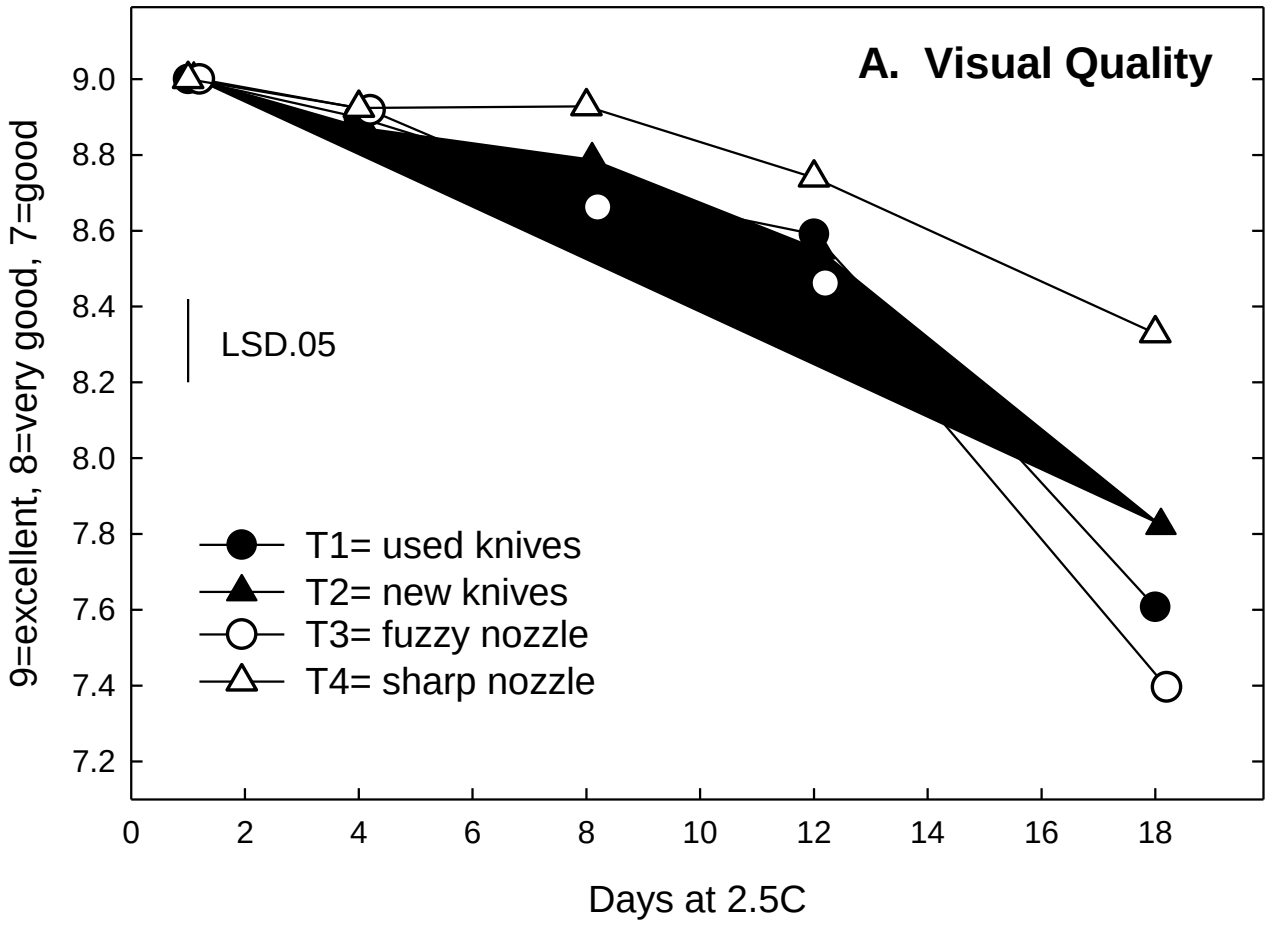
Sharp nozzle
(slow speed, high pressure)

Package, no MA; 8 days at 2.5C in air

Test #2 FrEx 2013

- Overall appearance
- Decay
- Discoloration (pinking or browning)
- Drying or whitening cut edges

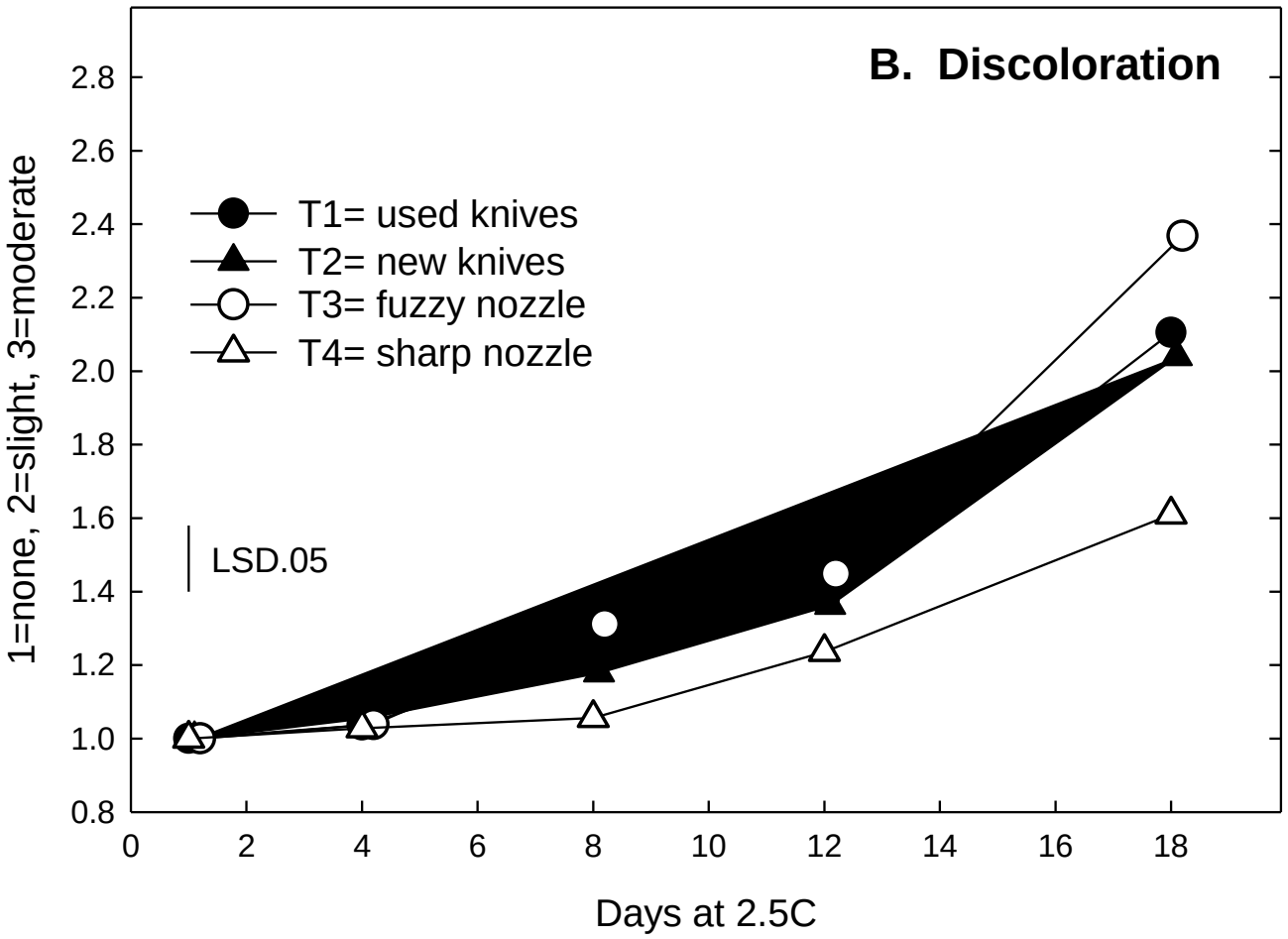
Romaine Lettuce



Data average of 50 pieces per rep per evaluation per treatment, evaluating at both cut ends; 4 reps.

Test#1 FrEx 2013

Romaine Lettuce



Data average of 50 pieces per rep per evaluation per treatment, evaluating at both cut ends; 4 reps.

Test#1 FrEx 2013

Waterjet Cutting

- Quality of some fresh-cut vegetables is better with waterjet cutting than blade cutting (celery, romaine lettuce)
- No differences in microbial (TPC) between waterjet and blade cutting in romaine
- Nozzle type is key component of waterjet technology; pressue and speed play minor roles

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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

Free, content-rich website averages over 3 million views annually,
And encompasses more than 640 pages and 1750 pdf documents.

http://postharvest.ucdavis.edu

Upcoming Workshops at UC Davis

- **Fresh-cut Products: Maintaining Quality and Safety**. Workshop, 18th annual, September 24-26, 2013.
- **Produce Safety: A Science based Framework Workshop**. 1st annual. November 5-7, 2013. This interactive workshop will improve awareness and appreciation of the tools used for effective hazard analysis and quantitative risk assessment.
- **Methods of Measuring Fruit and Vegetable Quality: Color, Flavor, Texture.** January 22, 2014.
- **Fruit Ripening and Retail handling Workshop**. March 25-26, 2014. 20th Annual.
- Postharvest Technology Short Course. 36th annual. June 16-27, 2014. This course will be held June 16-20, 2014 at UC Davis with an optional Field Tour June 23-27.
- **Fresh-cut Products: Maintaining Quality and Safety**. Workshop, 19th annual, September 23-25, 2014.
- **Produce Safety: A Science based Framework Workshop**. 2nd annual. November 4-6, 2014.