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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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.

http://postharvest.ucdavis.edu
2012 Short Courses & Workshops

- 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

**Trial #1, 2010**

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

Cantwell, UC Davis
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 ± standard error.

1 lb-force = 4.45 N; 1 kg-force = 9.81 N
Relative Water Content (RWC) is calculated as follows:

\[ RWC = \frac{\text{fresh weight} - \text{dry weight}}{\text{turgid weight} - \text{dry weight}} \]
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.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shelf-life 5°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>22.8</td>
</tr>
<tr>
<td>2. 30 min hydrate</td>
<td>23.1</td>
</tr>
<tr>
<td>3. 4 hr hydrate</td>
<td>21.0</td>
</tr>
<tr>
<td>4. 3% weight loss</td>
<td>26.7</td>
</tr>
<tr>
<td>5. 3% weight loss + 30 min hydrate</td>
<td>26.9</td>
</tr>
</tbody>
</table>

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
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

Cantwell, UC Davis
Spinach

- 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

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

Off odors - persistent

Ammonia

Tissue pH

LSD values: LSD = 0.2 for Off odors-immediate, LSD = 0.3 for Off odors-persistent, LSD = 4 for Ammonia, LSD = 0.02 for Tissue 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
Romaine April 16, 2011; 4 days 5°C; 7, 12, dull, sharp
#7 (sharp, slow)  
#12 (fuzzy, fast)  
Dull knife  
Sharp knife
<table>
<thead>
<tr>
<th></th>
<th>Knife</th>
<th></th>
<th>Waterjet</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual quality (9-1)</td>
<td>6,9</td>
<td>Visual quality (9-1)</td>
<td>5,2</td>
<td></td>
</tr>
<tr>
<td>Whitening (1-5)</td>
<td>2,1</td>
<td>Whitening (1-5)</td>
<td>3,6</td>
<td></td>
</tr>
<tr>
<td>Browning (1-5)</td>
<td>1</td>
<td>Browning (1-5)</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

4 days
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