Water Loss and Postharvest Quality

Key messages:
- Minimize delay from harvest to cooling
- Use appropriate packaging to reduce water loss
- Use low temperatures throughout distribution

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Fresh Produce and Water Loss

- Fresh produce contains 65% (garlic) to 95% (lettuce) water; water content for most products is 85-90%
- Harvested products begin to lose moisture immediately upon cutting from the plant
- Water loss is also called transpiration
- Water loss = weight loss (except if dry matter loss occurs in storage)
- Water loss is water vapor movement from product to the environment
- Water loss is affected mainly by packaging, temperature, relative humidity and airflow as well as product characteristics.

Water Loss is Cumulative

Impacts on Quality
- Loss of Salable Weight
- Loss of Fresh Appearance
- Gloss
- Shriveling
- 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

Water Loss and Fruit Physiology

Water Loss and Fruit Ripening
Water loss during initial phase of ripening affects rates of ripening
- Water loss is a stress and caused increased synthesis of ethylene
- Therefore minimize water loss during initial 72 hours after harvest

<table>
<thead>
<tr>
<th>Stage when induced water loss</th>
<th>Total % Water loss</th>
<th>Days to ripen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-climacteric</td>
<td>5.6</td>
<td>14.1</td>
</tr>
<tr>
<td>Climacteric</td>
<td>5.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Post-climacteric</td>
<td>5.2</td>
<td>17.0</td>
</tr>
</tbody>
</table>

- Early season fruit
- Induced water loss 20°C, 20% RH
- Control, 20°C 95% RH lost only 1.3% weight; 16.4 days to ripen
- Decay was less on fruit from treatments with induced water loss than on control fruit.

Fruit
100% RH in air spaces
Assume 25°C 100% RH

Environment

Skin/epidermis

Temperature
Relative Humidity < 100%
Assume 25°C with 40% RH

Handling at harvest is critical for water loss management

Basil
Highly susceptible to water loss
Very chilling sensitive

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

Water loss is Cumulative

Weight loss of Tuscan melons held for different periods at 37°C (99°F)
before cooling, storage and shelf-life.

<table>
<thead>
<tr>
<th>Cooling delay</th>
<th>% weight loss before cool</th>
<th>% weight loss storage 40°F 90%RH</th>
<th>% weight loss shelf-life 35°C 10%RH</th>
<th>Total Weight loss</th>
<th>Suture browning score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 h delay</td>
<td>0.00</td>
<td>2.14</td>
<td>0.95</td>
<td>3.08</td>
<td>0.7</td>
</tr>
<tr>
<td>4 h delay</td>
<td>0.38</td>
<td>1.95</td>
<td>0.96</td>
<td>3.29</td>
<td>1.5</td>
</tr>
<tr>
<td>8 h delay</td>
<td>0.83</td>
<td>1.90</td>
<td>0.76</td>
<td>3.66</td>
<td>2.5</td>
</tr>
<tr>
<td>12 h delay</td>
<td>1.19</td>
<td>1.62</td>
<td>0.76</td>
<td>3.54</td>
<td>3.0</td>
</tr>
<tr>
<td>16 h delay</td>
<td>1.50</td>
<td>1.32</td>
<td>0.65</td>
<td>3.53</td>
<td>3.0</td>
</tr>
<tr>
<td>20 h delay</td>
<td>1.90</td>
<td>1.35</td>
<td>0.64</td>
<td>3.95</td>
<td>4.0</td>
</tr>
<tr>
<td>24 h delay</td>
<td>2.30</td>
<td>1.41</td>
<td>0.71</td>
<td>4.43</td>
<td>4.7</td>
</tr>
<tr>
<td>48 h delay</td>
<td>3.20</td>
<td>1.42</td>
<td>0.70</td>
<td>4.90</td>
<td>5.8</td>
</tr>
<tr>
<td>72 h delay</td>
<td>4.20</td>
<td>1.42</td>
<td>0.70</td>
<td>6.50</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Suture browning Tuscan melons

Water loss and temperature

Wt loss (%/day) = product K x VPD

Psychrometric Chart
Thermodynamic properties of air
Temperature and Water Content
VPD increases exponentially with rising temperature
VPD increases linearly with falling humidity

Storage conditions

Environment
Temperature
Relative Humidity
is <100%
Air velocity

Table Grapes
Ideal vs Poor Postharvest Handling

<table>
<thead>
<tr>
<th>Delay Before Cooling</th>
<th>6 hours Cooling</th>
<th>7 day Storage</th>
<th>7 day Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>From G. Mitchell, UC Davis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table Grapes
Ideal vs Poor Postharvest Handling

% Water Loss

From G. Mitchell, UC Davis

Delays to cool of Tuscan Melons; fruit held at 37°C (99°F)

<table>
<thead>
<tr>
<th>Delays to cool of Tuscan Melons</th>
<th>Weight loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 h</td>
<td>0.0%</td>
</tr>
<tr>
<td>8 h</td>
<td>0.8%</td>
</tr>
<tr>
<td>16 h</td>
<td>1.5%</td>
</tr>
<tr>
<td>24 h</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

Cantwell, Marita “Water Loss”
Postharvest Technology of Horticultural Crops Short Course 2015
(c) Postharvest Technology Center, UC Davis
Melon visual quality after delays to cool, storage at 10d 5°C + 4d 20°C

Total Weight loss

Litchi Browning:
Water loss is a major contributor: 8% water loss for peel browning.
Mechanical damage, senescence, improper storage temperature, and postharvest pathogens also contribute.

Predicted postharvest moisture loss from litchi with idealized handling.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Temp. (°C)</th>
<th>RH (%)</th>
<th>Wind speed (m s⁻¹)</th>
<th>Duration (h)</th>
<th>Predicted moisture loss (%)</th>
<th>Cumulative moisture loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td>30</td>
<td>65</td>
<td>1.5</td>
<td>3</td>
<td>1.87</td>
<td>1.87</td>
</tr>
<tr>
<td>Pre-cooling</td>
<td>5</td>
<td>75</td>
<td>1</td>
<td>5</td>
<td>0.38</td>
<td>2.25</td>
</tr>
<tr>
<td>Storage</td>
<td>5</td>
<td>75</td>
<td>0</td>
<td>5</td>
<td>0.06</td>
<td>2.31</td>
</tr>
<tr>
<td>Transport</td>
<td>7</td>
<td>66</td>
<td>0</td>
<td>12</td>
<td>0.23</td>
<td>2.54</td>
</tr>
<tr>
<td>Wholesale</td>
<td>5</td>
<td>75</td>
<td>0</td>
<td>3</td>
<td>0.04</td>
<td>2.58</td>
</tr>
<tr>
<td>Wholesale display</td>
<td>25</td>
<td>22</td>
<td>0</td>
<td>2</td>
<td>0.27</td>
<td>2.85</td>
</tr>
<tr>
<td>Retail</td>
<td>20</td>
<td>50</td>
<td>0.5</td>
<td>6</td>
<td>0.90</td>
<td>3.79</td>
</tr>
</tbody>
</table>


% Weight loss vs % Firmness loss

y = 7.228x² + 0.08

% Firmness loss vs % Weight loss

Broccoli head firmness and water loss
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 and would reject it.

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Wind speed and weight loss

Litchi
~8% weight loss = desiccation browning

Role of cultivar in postharvest quality loss
Example: Grape tomatoes and weight loss

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Shrivels *</th>
<th>% weight loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahern 299</td>
<td>3.5</td>
<td>13.2</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>3.2</td>
<td>15.2</td>
</tr>
<tr>
<td>Harris LI-34</td>
<td>4.6</td>
<td>15.6</td>
</tr>
<tr>
<td>Hazera 1319</td>
<td>4.3</td>
<td>18.0</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>2.4</td>
<td>11.8</td>
</tr>
<tr>
<td>TC 1260</td>
<td>3.6</td>
<td>14.9</td>
</tr>
</tbody>
</table>

LSD 0.05
0.6 1.5

*Shrivels score -1-5 scale, 1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe

Example Results

Average weight loss over time

Average firmness loss

Example: Grape tomatoes and weight loss
12days 20C 50%RH

Cantwell, UC Davis
Simple packaging to reduce water loss. Need to cool product before packaging (room or hydrocool) or used vented packaging and vacuum cool (romaine lettuces).
Water Loss and Postharvest Quality

- Water loss occurs through natural pores and damaged areas
- Environmental conditions at harvest cause high water loss
- Harvest when cool
- Protect and shade in the field
- Reduce delays from harvest to start cooling
- Cool efficiently, then reduce air flow over product
- Temperature, RH, air flow during storage and transport
- Use protective packaging
- Protective treatments in some cases (waxes, coatings)
- Weight loss is cumulative, store only as long as necessary
- Problem conditions are at the beginning and end of the cold chain

REFERENCES


