Postharvest Storage

New Farmer Webinar

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Outline

• Postharvest Basics
• 4 Crop Case Studies
• Systems & Monitoring
You Grew It... Now what?

- By the time you harvest, most costs are sunk.
- Lasting quality depends on good storage.
- Profitability is directly related to waste.
- Market and season expansion
Storage Characteristics of Food

- Respiration & Metabolism
- Temperature
- Humidity
- Ethylene
- Food Safety
- Pathology
Postharvest Basics

• Stored crops are still alive.
• Metabolism continues after harvest (respiration).
• …and it is highly dependent on temperature.
What happens in storage?

- **Chilling / Freeze Injury**
  - Tissue damage
  - Variable over body of plant
  - Min temp not same as freezing temp

- **Desiccation / Drying Damage**
  - Cool or cold air
  - Heat from respiration
  - Moisture (H2O) available at surface of produce
  - Need humidity (H2O) in air, “RH” or relative humidity
What happens in storage?

- **Ethylene**
  - C2H4
  - Produced in stored produce (at various rates)
    - plant hormone
    - physiologically active at very low concentrations
      - (0.1 to 10ppm)
  - Stored produce is variably sensitive to Ethylene
    - Bittering effect
    - Premature decay
And each crop is different

- Recommended storage conditions
  - Temperature
  - Relative humidity
- Ethylene production rate
- Ethylene sensitivity
- Chilling/Freezing Injury
- Variety differences


[http://www.ba.ars.usda.gov/hb66](http://www.ba.ars.usda.gov/hb66)
# 4 Crops – Case Studies

<table>
<thead>
<tr>
<th>Crop</th>
<th>Units</th>
<th>Carrot</th>
<th>Onion</th>
<th>Potato</th>
<th>Cabbage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Density</td>
<td>lb/ft³</td>
<td>22</td>
<td>20</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>Temp</td>
<td>°F</td>
<td>32 – 34</td>
<td>32</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>RH</td>
<td>%</td>
<td>98 – 100</td>
<td>65 – 70</td>
<td>99 – 100</td>
<td>98 – 100</td>
</tr>
<tr>
<td>Duration</td>
<td>Months</td>
<td>7 – 9</td>
<td>6 – 9</td>
<td>Up to 12</td>
<td>3 – 6</td>
</tr>
<tr>
<td>Resp. rate at temp</td>
<td>mg CO₂ kg - hr</td>
<td>10-20</td>
<td>3 (cured)</td>
<td>6 – 18 (cured)</td>
<td>4 – 6</td>
</tr>
<tr>
<td></td>
<td>BTU</td>
<td>138</td>
<td>28</td>
<td>110</td>
<td>46</td>
</tr>
<tr>
<td>Ethylene Prod. Rate</td>
<td>uL kg-hr</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Ethylene Sensitivity</td>
<td>uL L</td>
<td>High ~ 0.2</td>
<td>Low &gt; 1500-2000</td>
<td>Low</td>
<td>High ~ 1.0</td>
</tr>
</tbody>
</table>
Zoned Storage

- Zoned by temperature and relative humidity
- Also consider ethylene production and sensitivity
- Low cost – perforated bags, vapor barrier walls
- Higher cost – dedicated structures
- Could also be useful to have a zone dedicated to precooling / removal of field heat.
Removing Heat

• Root Cellar
  – Essentially a cool sink with high humidity

• Air Exchange
  – Exchanging cool outside air with warm inside air using fans and thermostat controls

• Cooler
  – Mechanical refrigeration to “pump” heat out

Adding Heat

• For higher temperature crops
  – Electric, propane, biomass/pellet heaters
Refrigeration

Outside the Cooler

Inside the Cooler
Evaporator Options

Standard

Low Velocity (High Humidity)

Plates
CoolBots™

• Adapt an air conditioner for use as a refrigeration system.

• Air conditioners are basically “packaged” refrigeration systems run at higher temperature.

• Build a “good box” first.
CoolBots™

• Pro’s
  – Low initial cost
  – Easy to retrofit into existing spaces with basic construction
  – Potential efficiency benefit

• Con’s
  – Slow to “pull down” temperature
  – Slow to recover from rises in temp
  – Can not freeze, only cools down to 35 °F

www.storeitcold.com – Has loads of info and is very clear.
CoolBot vs. Conventional

• 2009 NYSERDA Study

• 8’x10’ storage room - Albany, NY conditions

• Cooled to 35 F
  – with evap fan controls
    • Conventional is 74 kWhr/yr more efficient ($10/yr)
  – without evap fan controls
    • CoolBot is 230 kWhr/yr more efficient ($30/yr)

• Coolbot cost $750 (net of cold room)

• Conventional cost $4,400 (net of cold room)
Adding Humidity
• Crops will add some humidity as they respire
• Moist slabs
• Moist burlap / cloth blankets
• Should be cleaned regularly
• Foggers / Nozzles

Removing Humidity
• Outside air exchange can be very effective
  – Small fan with ducting
Controls - Thermostats

• Control a load based on temperature
Measure and Monitor

• “The measured variable improves.”

• Temperature **AND** Relative Humidity

• Don’t assume you have the conditions you want. **Measure.**

• **Low tech** – wall sensors, daily checks, log book

• **High tech** – remote monitoring, email alerts

• Calibration and certification
Scouting

• Daily checks for spoilage, sprouting
• Have different people perform the task
• When pulling stored crops, check other bins
• Check for spoilage, sprouting
• Use all five senses
• “Scout” the mechanicals also
Cooler Audit

• Envelope (“The Box”)
  – All doors close tightly
  – All seals are sealing
  – Signs of degradation
  – Signs of mold
  – Air circulation inside

• Mechanicals (“The Chiller”)
  – Noise is energy
  – Condenser coil is clean and clear
  – Annual refrigeration tuning
Technical References

- UVM Extension Ag Engineering Blog
  - [http://blog.uvm.edu/cwcallah/](http://blog.uvm.edu/cwcallah/)
- USDA HB 66
- NE Vegetable Management Guide
  - [http://nevegetable.org/](http://nevegetable.org/)
- UC Davis Post Harvest Website
  - [http://postharvest.ucdavis.edu](http://postharvest.ucdavis.edu)
- Psychrometric Charts and Calculators