From Field to Storage:
High Quality Carrots

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New England Vegetable and Fruit Conference 2013
Expanding **Winter** Harvest and Sales for New England Vegetable Crops

3 year project (2010-2013) funded by USDA/Northeast SARE

Key Elements of Project

- Using low tunnels
- **Winter storage – infrastructure and crops**
  - Winter farmers markets & marketing
  - Farmer to Farmers exchange/educational programs
  - Website

*central goal is to help farmers expand vegetable harvest and sales from December-April, and thereby increasing winter income*
Why study carrots?

- Winter markets are growing
- Key winter crop to keep customers happy
- Most commonly grown root crop
- Declines rapidly with poor postharvest treatment
- Can be stored 6 months if handled well.
- Model crop for the ‘cold moist’ storage group
Respiration:
Sugars + O2 = ‘vital heat’ + CO2
<table>
<thead>
<tr>
<th>What does a carrot need?</th>
<th>How do we provide it?</th>
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<tbody>
<tr>
<td>• Prevent freeze injury (Freezes at 29.8°F, 1.2°C)</td>
<td>• No more than brief periods below 30°F</td>
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<td>• Prevent water loss and desiccation</td>
<td>• RH &gt;95% (98-100%) in package and/or room</td>
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<td>• Keep respiration rate low</td>
<td>• Ideal T 32°F (0°C) (7 mo), OK T 32-41°F (0 to 5°C)(5 mo)</td>
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<td>• Adequate Oxygen (&gt;3%)</td>
<td>• Permeable packaging</td>
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<td>• Avoid CO2 buildup (&lt;5%)</td>
<td>• No apples</td>
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<td>• Avoid Ethylene</td>
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Postharvest affects carrot ‘flavors’

**Bruising & shock** stimulates ethylene, respiration
- Bitterness (6-methoxymellein)
- Terpene, green, earthy odor or flavor

Barrel wash gently
Minimize bruising
**No big drops**
Postharvest affects carrot ‘flavors’

- **Tight packaging** causes low \( O_2 \), high \( CO_2 \) & ethylene
  - Ethanol odor and taste, sickeningly sweet taste
- **High temperatures** (>10 \( C = 50 \) \( F \))
  - All of the above, plus acidic, after-taste
  - Diseases
- **Low humidity affects texture**
  - Rubber, shriveled, maybe sweeter

On-farm carrot storage study 2012-2013

Objective: observe effect of different storage conditions on carrots.

- Carrots placed into each storage same or next day
- Four farms that store all winter, different types of storage
- Matched storage conditions:
  - Washed/unwashed
  - Perf. plastic/mesh/grain bag
- Monthly samples:
  - All bags weighed for waterloss
  - One set taken for Brix, rot etc.
Farm A: Basement Root Cellar

- 1300 sq ft underground root cellar
- Cement floor & walls to earth
- 4 in spray foam insulation ceiling
- Active cooling with ambient air: 8” pipe with intake/exhaust fan
- Passive cooling other openings - PVC pipes, elevator shaft.
Farm A: Basement Root Cellar

- Carrots are stored unwashed in plastic bulk grain sacks.
- Humidity from respiration of vegetables & water on floor if needed.
- CSA pickup site
Farm A

- **Outside:**
  - Nov and Dec were warm
  - nights 25-34, days 40-50
  - below 20 – early Jan.

- Root cellar stayed above 40 until January
- Higher T means air holds more moisture,
  - RH < 90%
Farm B: Walk-in Cooler inside a barn

- Insulated, 8X8X10’ tall
- Thermostat set to 38 F
- Compressor, condenser, and fans
- Cool-Trol system and fans
- Carrots in Perf. Plastic 25lb bags
Farm B: Walk-in Cooler inside a barn

- Temperature consistently in 35-38 °F range
- Dips lower in cold spells
- RH recorded steady >95%
- Carrot bag T more steady than room T
Farm C: Retrofit in Barn Basement

- Chamber 21' x 47' x ~7' tall
- Insulated 4+ inches of spray foam, plywood walls, concrete floor.
- Heated and cooled by an underground geothermal system and cold air from outside,
- Storage temp set to 35 F
Farm C: Retrofit in Barn Basement

• Carrots unwashed in large Macro 34 vented bins.
• Bins are misted, or covered with plastic or moist burlap.
• Open airflow is allowed through the bottom of the pallet.
• RH >95%
• (late winter) carrots moved to large walk-ins w/ standard cooler panels.
Farm C: Retrofit in Barn Basement

Feb-March: Carrots got moved around and a bit lost.
Farm D: Bunker w/ Mister

- 320 sq ft space for high RH, low T root storage.
- Concrete roof not insulate, sides flanked by other coolers, back side is bermed in earth.
- Compressor: low velocity unit
- Automated spray system kicks in when the humidity falls too low.
- RH>95%
Carrots are
• washed,
• packed in 25# capacity,
  perforated plastic bags
• then placed in either Macro bins
  or wrapped pallets.

Farm D: Bunker w/ Mister
% Water Loss by Month in Storage, November to February
Those with high water loss also higher brix

STATS: A & D mesh differ from the other 3

B, C, Dpp no significant difference from each other
Carrot storage case study 2012-2013

Blind Taste tests at Amherst Winter Farmers Market

- Texture
- Taste
- Attractiveness
- Would you buy this carrot?

January: those under ‘ideal’ conditions were rated highest
February: no difference in rating on taste & texture.
  - low water loss: like the crunch
  - high water loss: like the sweetness
March: those with highest water loss (sweeter) rated high on taste & texture
  - 96% said they’d buy the root cellar carrots.
  - Our rating: D-Mesh too rubbery to be marketable
To wash or not to wash?

Reasons to wash in the fall before storage:

• Outdoor wash station is still (almost) comfortable
• More labor on hand
• Sort and grade before storage
• Bag in perf. plastic before storage
• Ready to grab and go to market

Risks:

• Introduce pathogens
• Cause wounding
• Off flavors
To wash or not to wash?

Reasons to store unwashed
• Less time from field to storage
• Shift labor to winter when have more time
• Use indoor washing infrastructure
• Freshly washed at market
• Store in bulk bins
• Better flavor?

Risks:
• Staining
• More surface pathogens
• In bulk bins more open to desiccation
Long-term Storage
Washed vs unwashed
Trial 2011-12

• Seeded 7/26
• Harvested 11/14
• 3 varieties
  – Berlanda
  – Bolero
  – Brest
• Treatments: Hand washed in
  tub or unwashed
• Stored 5 months (Nov 14 to
  May 2) In perforated plastic
Rot was worse on **washed**
Staining was *slightly* worse on **unwashed**
Hand vs barrel washed or unwashed, 2012-13

Postharvest treatments:
- Hand washed
- Barrel washed
- Unwashed

- Stored in perf. plastic bags, UMass cold storage
- Pulled monthly December - April

Washing treatment showed no effect on the following measures of quality:
- Rot
- Staining
- Lenticel dirt
- Water loss

- Slight staining was similar to whitish cast of stored washed carrots.
- Staining may be affected by soil characteristics (see Jerrico Settlers trial)
What influences staining?

Jerrico Settles, Vermont
washed/unwashed study

UMass studies:
fine sandy loam

- Soil type
- Handling
- Temperature
- Pathogens

Staining up to 10% on unwashed carrots
In summary….

- Carrots are .... more complex than we ever imagined!
- Different types of storage designs work very well
  - Need control over fall cooling
- Quality depends on temperature, RH & packaging
  - Need air – but not too much exposure
- Wash timing can be flexible.
  - but results vary, compare on your own farm & soil type
- Flavor and texture can be tricky
  - get feedback from your customers
- Spread your risk
  - Plant and harvest dates, varieties (try new ones!)
  - Methods of storage
• More results of our project will be posted at:
  – http://extension.umass.edu/vegetable/projects/winter-production-storage-sales
• Thanks to: Amanda Brown, Zara Dowling, Danya Teitelbaum, Andrew Cavanagh, Sarah Berquist, Drew Hamilton, Becky Sideman, Lisa McKeag, Susan Scheufele, Susan Han, Dan Kaplan, Laura & Charlie Tangerini, Ryan Voiland, Jeremy Barker-Plotkin.
• And to Farmers pioneering new/old winter storage methods
What’s next?

UMass Produce Storage Project

• Survey: baseline current practices -- and what are the needs?
• What is current energy use and how could storages be more energy efficient?
• How to get the most out of ambient air
• Contact Luke Doody, ldoody@eco.umass.edu
  – Fill out the survey and get a free energy analysis for your storage!
What’s next?

  • Farmers, Engineers. N. Connecticut

• March 6, 2014, Winter Growing and Marketing
  – Publick House, Sturbridge, MA
  • Logistics, Storage, Tunnels, and Marketing

Contact: umassvegetable@umext.umass.edu