Maintaining Quality of Winter Vegetables in Storage

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Engineering Storage Facilities for Winter Vegetable Crops
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Expanding **Winter** Harvest and Sales for New England Vegetable Crops

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

**Goal:** help farmers expand vegetable harvest and sales from December-April, and thereby increase winter income

Key components of project

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

• Production for winter increasing
• Mostly commonly grown root crop
• Key winter crop for customers
• Declines rapidly with poor postharvest treatment
• Can be stored 6 months if handled well.
• Model crop for the ‘cold moist’ storage group
What does a carrot need?

- Prevent freeze injury (Freezes at 29.8°F, 1.2°C)
- Prevent water loss and desiccation
- Keep respiration rate low
- Adequate Oxygen (>3%)
- Avoid CO2 buildup (<5%)
- Avoid Ethylene

- No more than brief periods below 30°F
- RH >95% (98-100%) in package and/or room
- Ideal T 32°F (0°C) (7mo), OK at 32-41 °F (0 to 5°C)
- Permeable packaging
- Permeable packaging
- No ethylene producers eg apples
Postharvest affects carrot ‘flavors’

- **Tight packaging** causes low O\textsubscript{2}, high CO\textsubscript{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**
  - Rubberly, shriveled, maybe sweeter

Postharvest affects carrot ‘flavors’

Bruising & shock stimulates ethylene, respiration

- Bitterness (6-methoxymellein)
- Terpene, green, earthy odor or flavor

Wash gently
Minimize bruising
No big drops
Using packaging to increase/modify RH

- Totes
- wrapped bins & pallets
- burlap over pallets
- Perforated plastic bags
On-farm carrot storage 2012-2013

Objective: observe effect of different storage conditions on carrots.

• Grown at UMass: Bolero, seeded July 9, harvested Nov 13-14.
• 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 walls to earth
- 4 in spray foam insulation ceiling
- Active cooling with ambient air, 8” pipe with intake/exhaust fan
- Passive cooling using PVC in walls and through 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.
Farm A: Basement Root Cellar

- In 2012, Nov and Dec were warm
- Root cellar > 40 F thru December
- Higher T = air holds more moisture
- More water drawn out of carrots
- RH higher as T dropped in Jan
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 Perforated 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.
- Replaced pallets of black totes, some shrink-wrapped
- Bins are misted, or covered with plastic or moist burlap.
- Open airflow is allowed through the bottom of the pallet.
- (late winter) carrots moved to walk-ins w/ standard cooler panels.
Farm C (Retrofit Barn Basement)
Temp. Nov 2012 to March 2013

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 insulated, 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.
- Temp and RH set for root crops.
Carrots are washed then packed in 25# capacity, perforated plastic bags and then placed in either Macro bins or stacked on pallets.
%Water Loss by Month in Storage, November to February

- **A - Cellar, Air**: February (5%), January (2%), December (4%)
- **B - Cellar, Geo**: February (0%), January (0%), December (0%)
- **C - Walk-in**: February (0%), January (0%), December (0%)
- **D - Bunk, Mesh**: February (7%), January (3%), December (6%)
- **D - Bunk, Plastic**: February (0%), January (0%), December (0%)
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, wash shortly before market:

- 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)
In summary….

• Carrots are .... more complex than we ever imagined!
• Different types of storage designs work very well
  – Its good to engineer rapid fall cooling
• Quality depends on temperature, RH & packaging
  – packaging matters even at high RH
• Wash timing is 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,
  – Methods of storage
• More results of our project will be posted at:
  
  – [http://extension.umass.edu/vegetable/projects/winter-production-storage-sales](http://extension.umass.edu/vegetable/projects/winter-production-storage-sales)

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Logistics, Storage, Tunnels, and Marketing Presentations & Farmer-to-Farmer discussions

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