

## **On-Farm Carrot Storage Trials, winter 2012-2013**

In response to increasing demand for local vegetables through the winter months, growers are expanding their production of root vegetables for winter storage. With that growth has come a corresponding increase in the need for storage facilities. Some growers are choosing to invest in well-insulated, temperature and humidity-controlled storage chambers, while others are converting existing facilities (such as walk-in coolers) to long-term storage use, or utilizing ambient air root cellars.

Optimal storage conditions are known for most crops, but creating a facility that provides ideal conditions can require a large up-front or long-term investment. Less well-studied is how crops store under less than ideal conditions, and what trade-offs exist between crop quality and storage facility expense.

We used Bolero carrots grown at the UMass Research Farm as a model crop to examine how conditions at four on-farm storages affected carrot quality through the winter months. While these case studies cannot fully address the question of trade-offs between quality and cost, they do offer insight into how different storages affect quality and marketability.

### **METHODS**

We fertilized with 100 lbs of chicken manure and 50 lbs of K Mag for two 290' double rows on July 9. We seeded Bolero carrots on July 11 at a rate of 10 per foot. We weeded and thinned carrots in the week of July 30, and weeded again in the week of August 6.

We harvested carrots on November 13 and 14, and topped them in the field. We selected farmer's market-quality carrots free of nicks, scars, or rot. Carrots were placed in the storage facilities the day of harvest, or kept overnight in Bowditch cold storage and placed the next day. Carrots were processed to mimic how carrots were stored on the farm at which they were placed. They were either stored unwashed or were barrel-washed pre-storage. If carrots were stored loose at a farm, we placed ours in 5 lb mesh bags to distinguish them from other carrots, while keeping them open to ambient temperature and humidity. If carrots were stored in perforated plastic at a farm, we placed ours 10 to a bag in perforated plastic bags. We removed one set of bags from the storage each month to sample water loss, Brix score (a measure of sugar content), rubberiness, rot, and other measures of carrot quality. We also brought carrots from on-farm storages to the Amherst farmer's market in January, February, and March. We asked attendees to sample slices of each carrot and rate the carrots based on texture, taste, and appearance. Carrots were rated on a 1-5 scale, with 1 being poor and 5 being excellent.

### *Farm Storage Facilities*

**Farm A: Brookfield Farm** has a 1300 sq ft root cellar, built specifically for storage. The storage is built underground, with cement walls, 4 in of spray foam insulation, and a standard storm door. Passive cooling is provided in the form of PVC pipes built into the walls, and through gaps around the elevator shaft in one corner. There is a hard-wired air intake fan to bring cool air in as necessary.

Carrots are stored unwashed in plastic bulk grain sacks.

**Farm B: Simple Gifts Farm** has a 8' x 8' x 10' tall walk-in cooler. It is a hard-wired three-phase unit, with a compressor, condenser, and fans. Insulation consists of standard refrigeration panels and foamboard in the floor. The farm recently installed a new Cool-Trol system and fans, which allows the system to be more efficient and shut off when not needed. The storage is kept at 38F year-round. Humidity is not actively maintained, but water from wet greens soaks into the plywood and keeps the storage quite humid.

Carrots are barrel-washed and stored in 25 lb perforated bags. In previous years, the farm has sometimes been able to stored carrots successfully into April or May.

**Farm C: Red Fire Farm** has a chamber 21' x 47' x ~7' tall, insulated with 4+ inches of spray foam insulation inside the walls and ceiling. . All chambers are heated and cooled by a geothermal system and cold air from outside. The upper chambers are standard cooler panels. There is a thermostat in the room, but no active monitoring or logging of storage conditions. The chamber is cooled by a geothermal system set to reduce temperatures to 35 F in the winter.

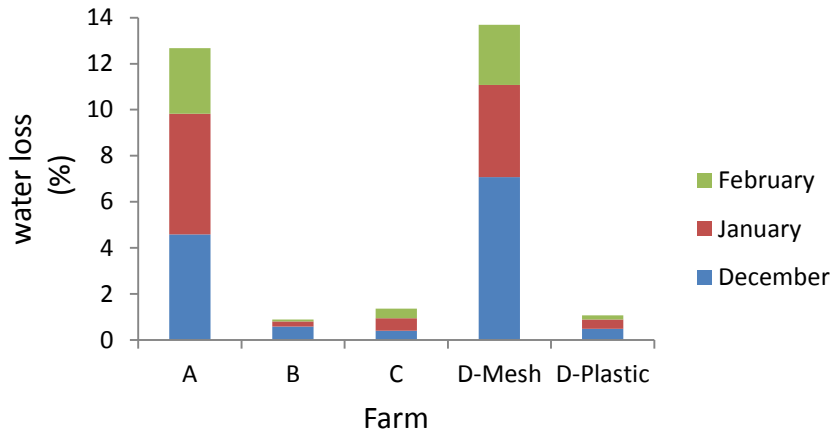
Carrots are stored unwashed in large macro 34 vented bins. The carrots are misted to increase humidity, and shrink-wrapped or simply covered on top with a layer of plastic. Open airflow is allowed through the bottom of the pallet.

**Farm D: Tangerini's Spring Street Farm** has a 320 sq ft space built for high moisture, low temperature storage. The storage is insulated on the roof with foam insulation, flanked by two other coolers, and the back side is insulated by the earth. The cooler is a low velocity unit cooler run on hard-wired electricity. An automated spray system kicks in when the humidity falls too low.

Carrots are stored washed in large bins within 25 lb capacity vented plastic bags. However, the farm has also considered storing washed carrots loose in large bins. At this farm we therefore performed one trial each of perforated and mesh bags. Perforated and mesh bags of carrots were placed on top of pallets containing carrots bagged in perforated plastic.

## RESULTS

**Water loss** – As we expected, water loss from carrots stored in a root cellar was significantly higher than those stored under the temperature-controlled conditions present in the other three storage facilities. Water loss in root cellar carrots averaged 13% over the first three months of storage, as compared to less than 2% in other locations. What was surprisingly, however, was that water loss was also very high for carrots stored in mesh at Farm D in the temperature and humidity-controlled chamber. While carrots stored under these conditions in perforated plastic experienced only 1% water loss, the greater air flow allowed by mesh bags contributed to a greater than 13% water loss in these carrots, under supposedly “ideal” conditions.



**Rubberiness** – Carrots that experience water loss tend to become rubbery, and so it was no surprise that both carrots stored in mesh at Farm D, and carrots stored in the root cellar, had significantly higher levels of rubberiness than the other carrots. For the carrots stored in mesh, this was evident from the first sampling period in December; for the root cellar carrots, rubberiness was higher in January and February, two and three months after the carrots were placed into storage. The majority of carrots stored in mesh at Farm D were sufficiently bendy as to be deemed unmarketable; by February, 80% of these carrots were considered not suitable for sale.

**Sugar content** – We found Brix scores to be higher in the carrots that experienced greater water loss, likely due to the fact that loss of water meant sugars were concentrated in the water that remained. Farm D carrots stored in mesh had the highest Brix scores, followed by carrots stored in the root cellar. Carrots stored in perforated plastic at Farm D had the lowest Brix scores.

**Marketability** – Taste test preferences varied considerably over the course of the storage trial period. In January, after two months of storage, the carrots stored under the closest to ideal conditions – at Farm C and at Farm D in plastic – were the clear favorites, rated significantly higher in terms of appearance and flavor. They also received the highest ratings for texture. 78% and 82% of respondents said they would buy carrots from Farm C and Farm D (plastic), respectively. By contrast, carrots stored in mesh at Farm D and carrots from the root cellar at Farm A received lower scores on appearance, flavor, and texture, and 64% and 58% of respondents said they would buy carrots from Farms C and D (mesh) respectively.

In February, carrots that had experienced water loss again fell to the bottom of the pile in terms of appearance, with Farms A and D (mesh) carrots receiving the lowest scores, and Farm C receiving the highest. We found no significant differences in taste or texture – anecdotally, some people appreciated the crunch and crispness of the carrots that had been stored under ideal conditions, while others noticed the sweetness of the carrots that had experienced greater water loss.

By March, results altered such that carrots that had experienced greater water loss were receiving the highest scores in flavor and texture, with no difference in appearance noted. It appears that at this late date, carrots with a high sugar content were more marketable than those that were well-preserved. 96% of respondents said they would buy the carrots that had been stored in the root cellar.

## DISCUSSION & CONCLUSIONS

*Discussion points – didn't have time to write them up more fully than this.*

Reducing air flow is very important in maintaining humidity. We were surprised to find that when carrots were exposed to the open air under ideal temperature and humidity, they experienced very high water loss. While some air flow is necessary (slits in bins, or perforated plastic bags) to reduce rot, it is important to keep that air flow low or carrots will dry out. At the tail end of the sample period – in late March – we began to see a low level of rot in carrots stored in perforated plastic, as well as a low level of top sprouting, which is indicative of the carrots becoming biologically active (and no longer edible). Perforated plastic bags are a great way to maintain a moist environment, but if you do want to obtain maximum storage life, large bins with plastic over the top may offer a better alternative.

Storing carrots under ideal conditions does a great job of keeping carrots from water loss, and maintaining crunch. A simple solution, like a walk-in cooler, can reduce water loss as well as a specially designed facility.

Storing carrots under less than ideal conditions appears to lead to sweeter carrots. In the early season, when carrots stored under ideal conditions still retain flavor, rubberiness associated with water loss may make drier carrots less marketable. At late season markets, when storage carrots kept under ideal conditions may be tasting flavorless and woody, some degree of softness and sweetness appears to be preferred. However, too much water loss can render carrots unmarketable.

Carrot preferences vary considerably by individual, and every carrot tastes different!