Food Storage Curriculum for Farmers and Processors
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Christopher W. Callahan, UVM Extension, chris.callahan@uvm.edu
http://blog.uvm.edu/cwcallah/crop-storage-resources/

Curricular Overview – 2016 02 09

The following curricular outline was developed with funding support from USDA NE-SARE in response to an identified need for produce storage educational programs in the Northeast. The website above serves as a clearinghouse for additional educational resources include workshop and webinar, videos, handouts and links to other resources.

Educational Topics:

- Importance of Food Storage – Why is food storage important to the region and specific farms and businesses? What competitive advantage can be achieved through improved storage practice?
- Crop Characteristics – How does crop physiology impact how we maintain storage conditions? Why and how do different crops differ in their optimal storage conditions? What production, harvest and postharvest conditions impact storage life and quality? What crops can be stored together and which ones need to be separate? Why do my carrots become bitter and my cabbage become black?
- Energy, Heat and Moisture – How do basic scientific principles factor into storage practices? What is relative humidity and how to we measure and control it? How does a refrigeration system work (and not work?) What are effective means for precooling different crops prior to storage?
- Structures and Materials – How big does my storage space need to be to store a certain amount of each crop? Should I build or buy a cooler? What sort of finish surfaces should I include to make sure my cold room is clean and safe?
- Equipment – What are my options for refrigeration equipment and how do they compare in terms of cost? What are the basic annual maintenance items I should look out for?
- Controls and Monitoring – What are the best thermostats I should consider to ensure precise and accurate temperature control? What are my options for measuring and controlling relative humidity? What are my options for being able to monitor my coolers when I am not physically there?

Key Learning Principles:

1. Know your target conditions. Be informed about what storage conditions are ideal for each of your crops.

2. Provide multiple zones. *May not be multiple rooms.* It is likely that if you are growing a diverse set of crops, you will want multiple zones for storage. This may not mean needing separate rooms as we have found even small rooms can have drastically different temperature and humidity conditions depending on the location of the cooling equipment relative to the location.

3. Informed design, construction and purchase of equipment. It is helpful to know ahead of time how much space you will need by estimating the required, zoned volume from bulk densities and groupings of crops by ideal storage conditions. Smooth cleanable finish surfaces should be planned and budgeted for to provide for longevity and sanitary conditions. There are clear trade-offs between conventional refrigeration systems and lower-cost CoolBot™ systems which should be understood before making a purchase decision.

4. Measure your actual conditions. It is often misleading to depend on the thermostat installed with your refrigeration equipment. It may not be accurate and it may not be measuring the actual location that matters. Investing in one or more digital, calibrated thermometers will enable you to know with certainty the air and pulp temperature anywhere in your system and to make adjustments as needed. Additionally, often a retrofit of a good digital thermostat will improve performance of the refrigeration system in place.

5. Improve crop selection on the way in. Storage is a hotel, not a hospital. Damaged or diseased crops going into storage are not going to improve and they are likely to degrade themselves and neighbors. Rigorous culling and sorting prior to storage and attention to detail during any precooling and curing steps will help to ensure a higher overall quality of stored product.

Learning Objectives:

- The student will know and appreciate that fresh produce is still alive and respiring.
    - Generating heat, water vapor and carbon dioxide.
    - Generating the ripening hormone ethylene.
    - Respiration is temperature dependent and crop specific.
    - Storage is a hotel not a hospital.
- The student will learn about the critical need for establishing and maintaining the "cold chain."
- The student will learn about crop-specific temperature conditions
    - Precooling requirements
    - Chilling and freezing injury potential and limits.
    - Optimal storage temperature
- The student will learn about crop-specific humidity conditions.
    - What humidity is.
    - Importance of high humidity to prevent desiccation
    - Importance of low humidity to prevent plant pathogen development (e.g. molds).
    - How humidity is different from liquid water
- The student will learn about basic storage room construction
    - Materials and practices that can and should be used (structure, insulation, finish).
    - Materials and practices to avoid.
    - Pre-fabricated options.
- The student will learn about basic refrigeration systems
    - How a refrigeration heat pump works.
    - How a common split refrigeration system functions (compressor/condenser, expander/evaporator).
    - How alternative systems work (e.g. CoolBot™, root cellars, outside air exchange).
    - General pro's and con's of different approaches.
    - The impact of refrigeration systems on "micro-climates" in the storage space.
- The student will learn about basic controls and monitoring.
    - Basic information about thermostats, stressing the need for precision and accuracy.
    - Basic information about humidistats, hygrometers and psychrometers, stressing the general lack of reliability in existing items on the market.

It is important to note that this project benefited from the work of other SARE funded projects. Specifically, the work done in the area of adult education theory was particularly helpful. Below are some examples of activities that were integrated into the workshop series to facilitate improved adult learner experience.

Activities (Incorporating Adult Learning Theory)

- Reflection on Motivations - During introductions – Have participants describe their farm, business and organization and reflect on why they are present and what they hope to gain.
- Crop Characteristics – Summary Slide – Simply ask what is common and what is different about common storage crops.
- Crop Characteristics – USDA Handbook 66 – Have students pick a crop, look it up in USDA Handbook 66, read about its optimal handling and storage and summarize back to the group including any unexpected findings.
- Energy, Heat and Moisture – A Cold Glass of Water – Present a picture of a glass of ice water on a hot, humid day. Ask the class to reflect on what is happening the picture.
- Energy, Heat and Moisture – Measuring RH with a Sling Psychrometer – Allow students to use a sling psychrometer to measure the RH of the classroom air. Then send them outside to do it (preferably on a cold, dry day.)
- Structures and Materials – Insulation and Finish Surfaces – Pass around samples of insulation and finish materials for the students to touch and feel. These can also be placed on the desks and tables ahead of class as a tactile opportunity for those who benefit from that.
- Equipment – CoolBot™ Demonstration – A small CoolBot™ cooling system can be constructed and put on rollers. This can be used to demonstrate the basics of refrigeration while also demonstrating this novel approach to using a window air conditioner to provide cooling for small cold rooms.
- Equipment – Outside Air Exchange – A small demonstration panel can be made to show how two thermostats and a fan can be used to provide cooling using outside air on cold winter days.
- Controls and Monitoring – Thermostats – Pass around several examples of thermostats with different features and point out the differences. The outside air exchange panel noted above is also a good way to demonstrate a good thermostat and how they work. Other portable measurement devices can also be demonstrated (e.g. infrared, calibrated insertion thermometers).
- General Experiential Learning – Invite participants to bring pictures and short slide shows of their own storage spaces and projects, even planned projects. Provide time during breaks or at the end of class to allow participants to share what they have done at their own farms or are planning to do. Facilitate group discussion and encourage questions, tying discussion back into course content to reinforce learning.