Postharvest Storage

Webinar

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CULTIVATING HEALTHY COMMUNITIES

Outline

- Postharvest Basics
- 4 Crop Case Studies
- Systems & Monitoring




If you needed to store these vegetables for 6 months…

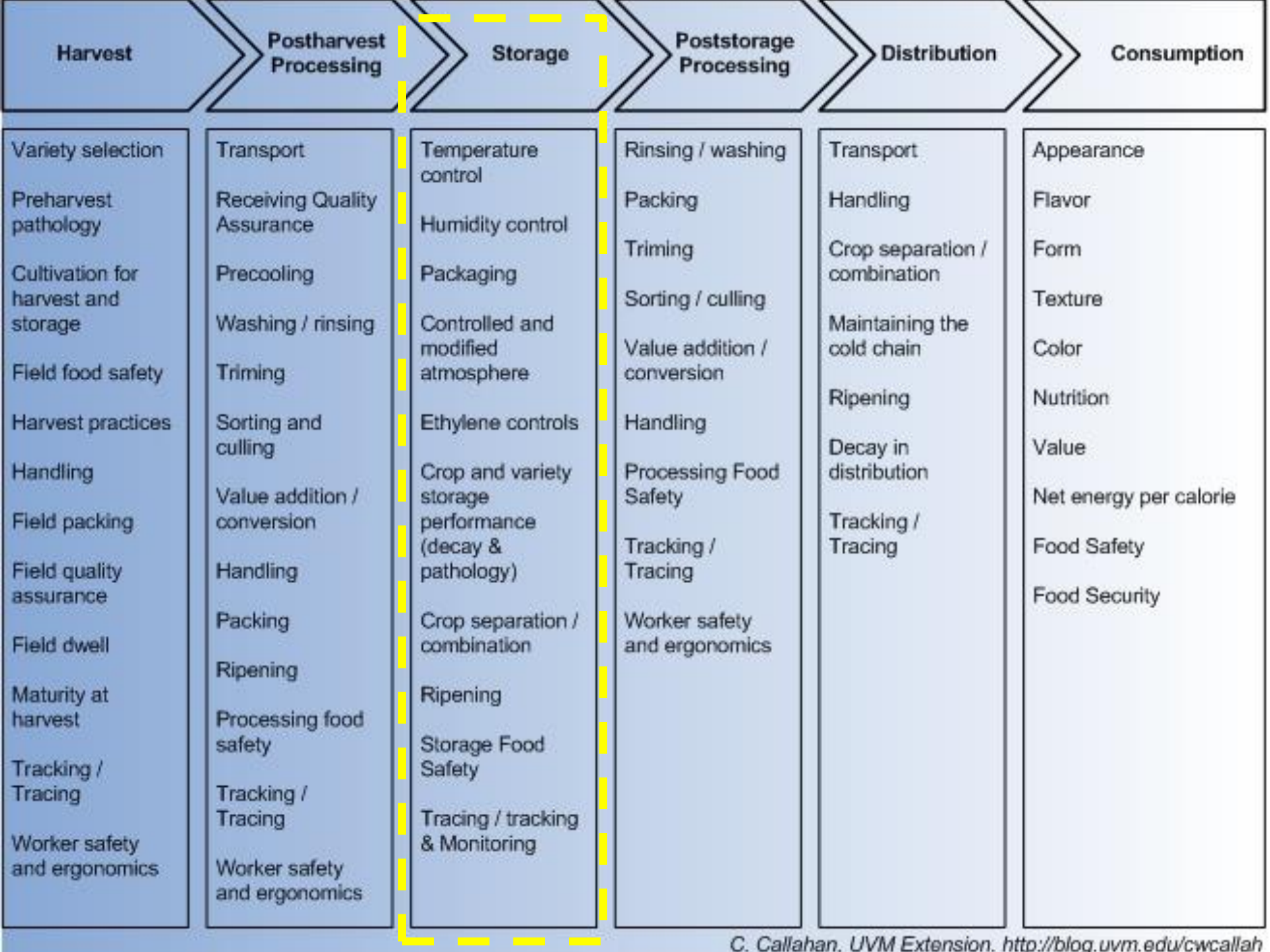




…What would you worry about? What specific things should you pay attention to? What is common about these vegetables and what is different?

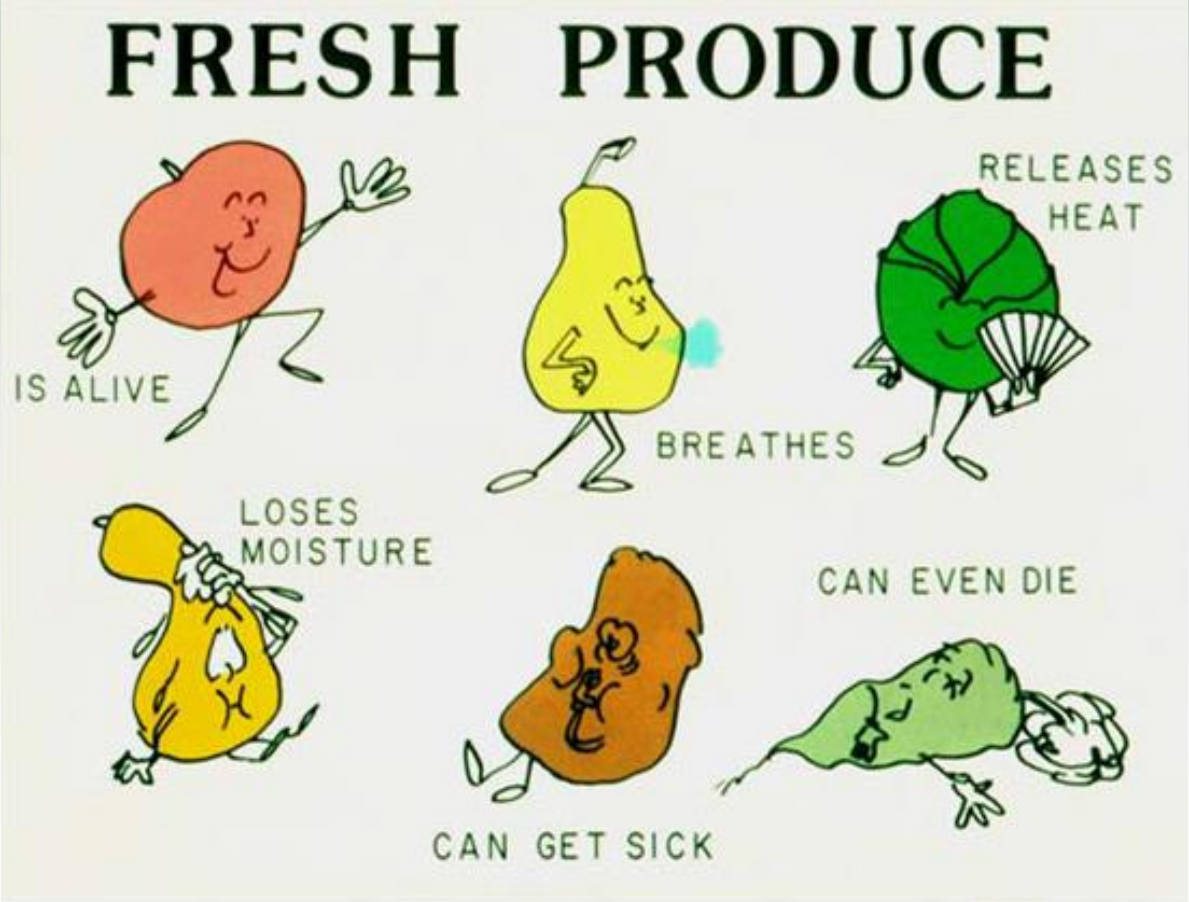
You Grew It... Now what?

- 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


Harvest
Postharvest Processing
Storage
Poststorage Processing
Distribution
Consumption
Variety selection
Preharvest pathology
Cultivation for harvest and storage
Field food safety
Harvest practices
Handling
Field packing
Field quality assurance
Field dwell
Maturity at harvest
Tracking / Tracing
Worker safety and ergonomics
Transport
Receiving Quality Assurance
Precooling
Washing / rinsing
Triming
Sorting and culling
Value addition / conversion
Handling
Packing
Ripening
Processing food safety
Tracking / Tracing
Worker safety and ergonomics
Temperature control
Humidity control
Packaging
Controlled and modified atmosphere
Ethylene controls
Crop and variety storage performance (decay & pathology)
Crop separation / combination
Ripening
Storage Food Safety
Tracing / tracking & Monitoring
Rinsing / washing
Packing
Triming
Sorting / culling
Value addition / conversion
Handling
Processing Food Safety
Tracking / Tracing
Worker safety and ergonomics
Transport
Handling
Crop separation / combination
Maintaining the cold chain
Ripening
Decay in distribution
Tracking / Tracing
Appearance
Flavor
Form
Texture
Color
Nutrition
Value
Net energy per calorie
Food Safety
Food Security
C. Callahan, UVM Extension, http://blog.uvm.edu/cwcallah

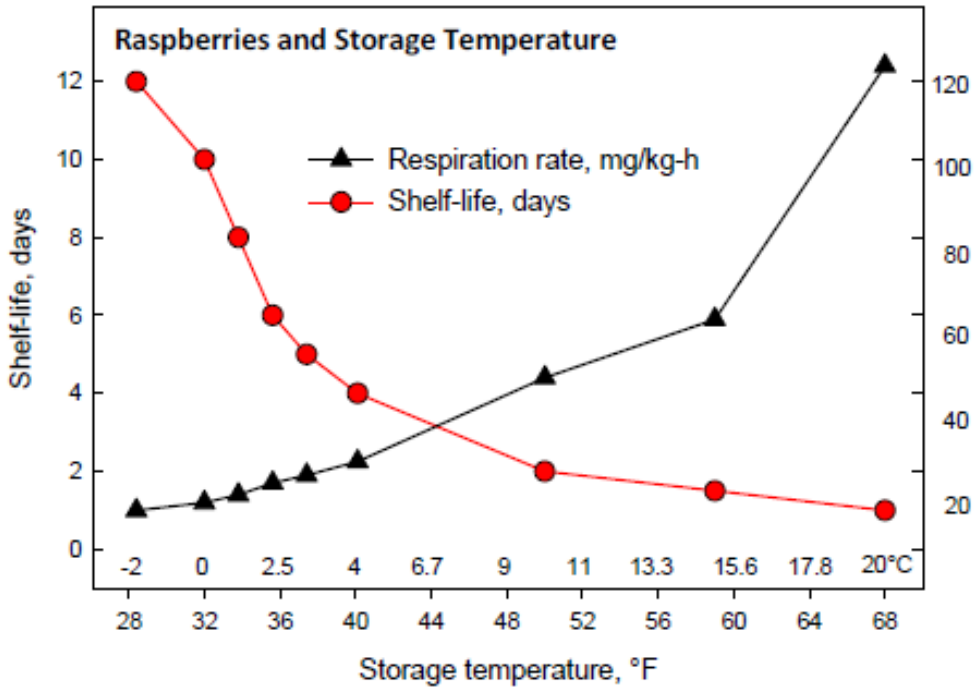
Storage Characteristics of Food

- 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?

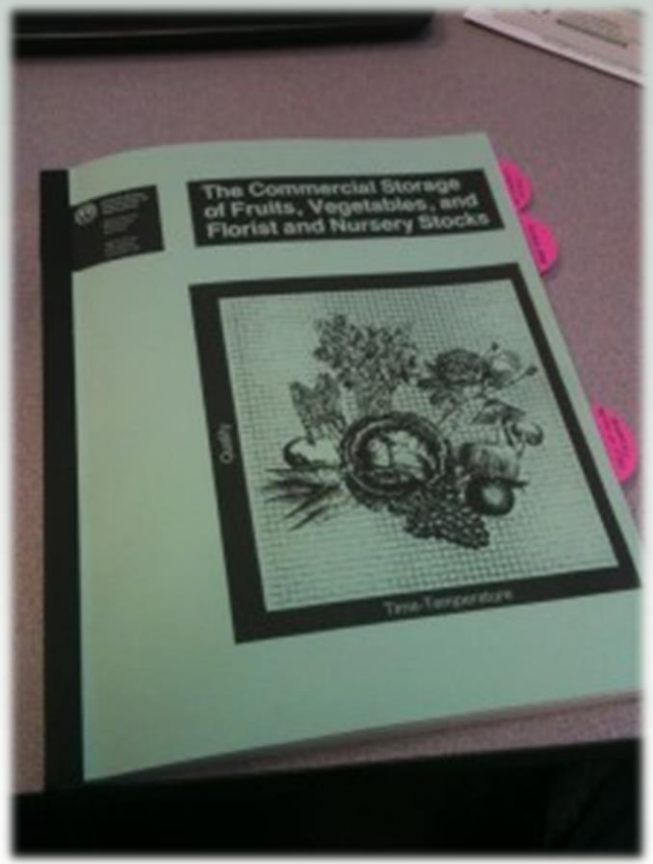
- Ethylene
  - C2H4
  - Produced in stored produce (at various rates)
    - plant hormone
    - physiologically active at very low concentrations
      - (0.1 to 10ppm)
  - Stored produce is variably sensitive to Ethylene
    - Bittering effect
    - Premature decay

Storage is a hotel.


Not a hospital.

And each crop is different

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



USDA Handbook 66 – "The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks"
http://www.ba.ars.usda.gov/hb66

Storage Crops – Case Studies





Crop	Units	Carrot	Onion	Potato	Cabbage	Squash
Storage Density	lb/ft^3	22	20	42	17	35
Temp	ºF	32–34	32	36-40	32	50
RH	%	98 – 100	65 – 70	99 – 100	98 – 100	50-70
Duration	Months	7 – 9	6 – 9	Up to 12	3 – 6	1-3
Resp. rate at temp	$\frac{\text{mg } CO_2}{\text{kg - hr}}$	10-20	3 (cured)	6 – 18 (cured)	4 – 6	100
	$\frac{\text{BTU}}{\text{ton-hr}}$	138	28	110	46	917
Ethylene Prod. Rate	$\frac{\text{uL}}{\text{kg-hr}}$	< 0.1	< 0.1	< 0.1	< 0.1	Trace
Ethylene Sensitivity	$\frac{\text{uL}}{\text{L}}$	High ~ 0.2	Low > 1500-2000	Low	High ~ 1.0	Low

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Zoned Storage

- Zoned by temperature and relative humidity
- Also consider ethylene production and sensitivity
- Low cost – perforated bags, vapor barrier walls, greenhouse poly, moist burlap
- 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


“Cold” Storage or “Warm” Storage?

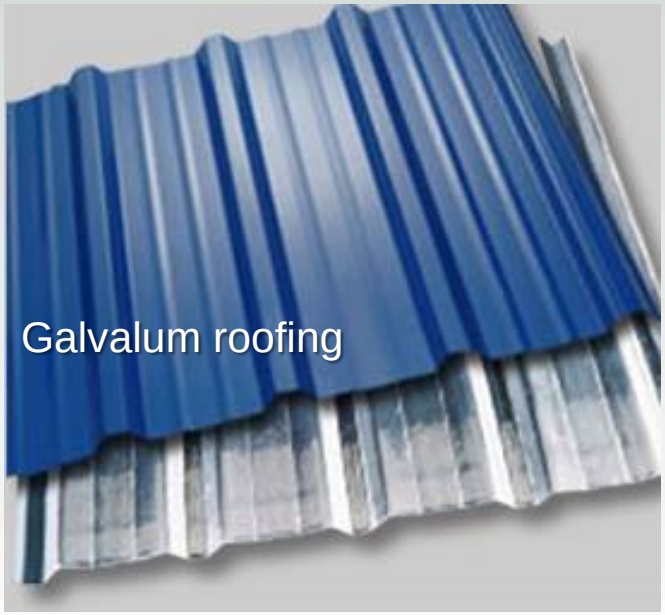

Elliston Root Cellar, Newfoundland - 1610

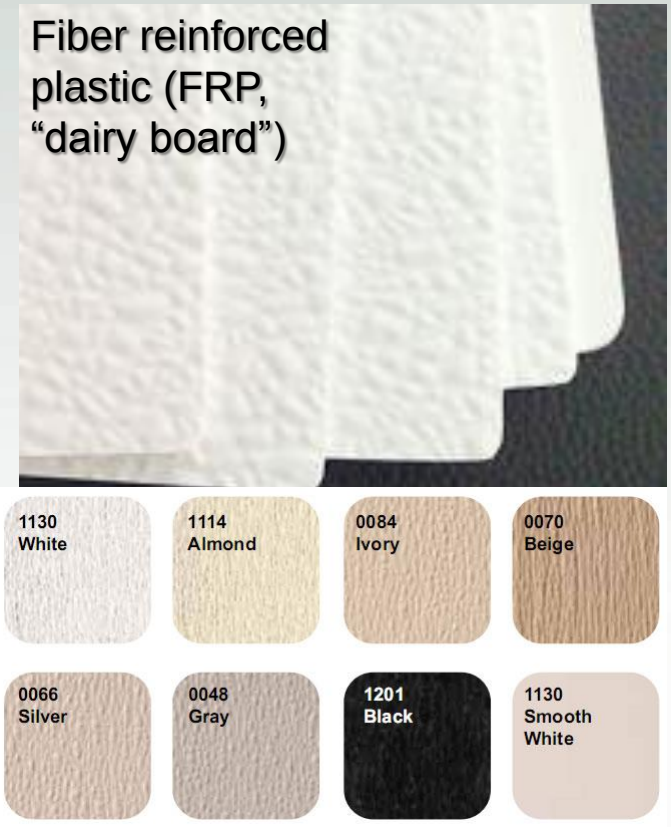
Structure and Materials

- Sound
- Durable
- Moisture tolerance
- Reusable?
- Portable?

Finish/Inside Materials

“Smooth and cleanable”





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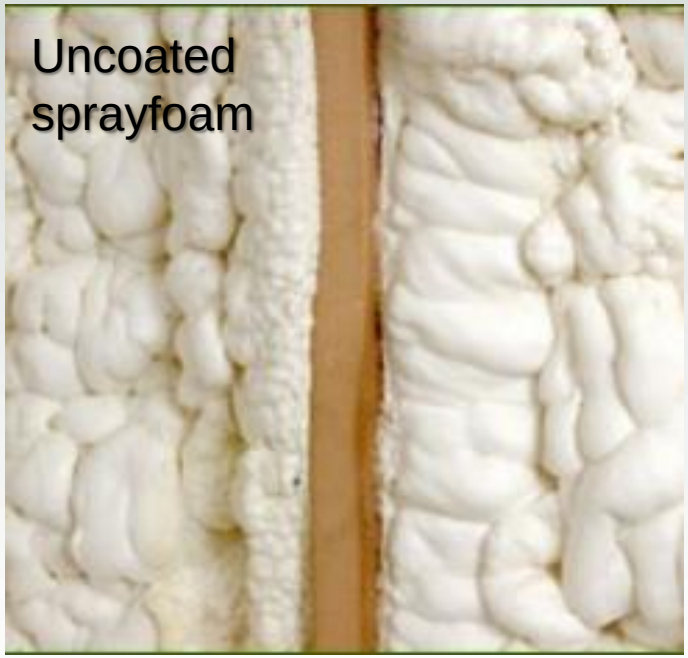
Cost Summary of Finish Materials

Finish Material Options	$/sqft
FRP (Smooth) on 3/8 CDX Plywood	2.48
FRP (Textured) on 3/8 CDX Plywood	2.62
1/4" Lauan on 3/8 CDX Ply, Painted	1.60
Araucoply/Selex 3/8", Painted	1.35

Structure and Materials

Practices to avoid



Doors and Sealing

- Check door seals and latches - adjustable

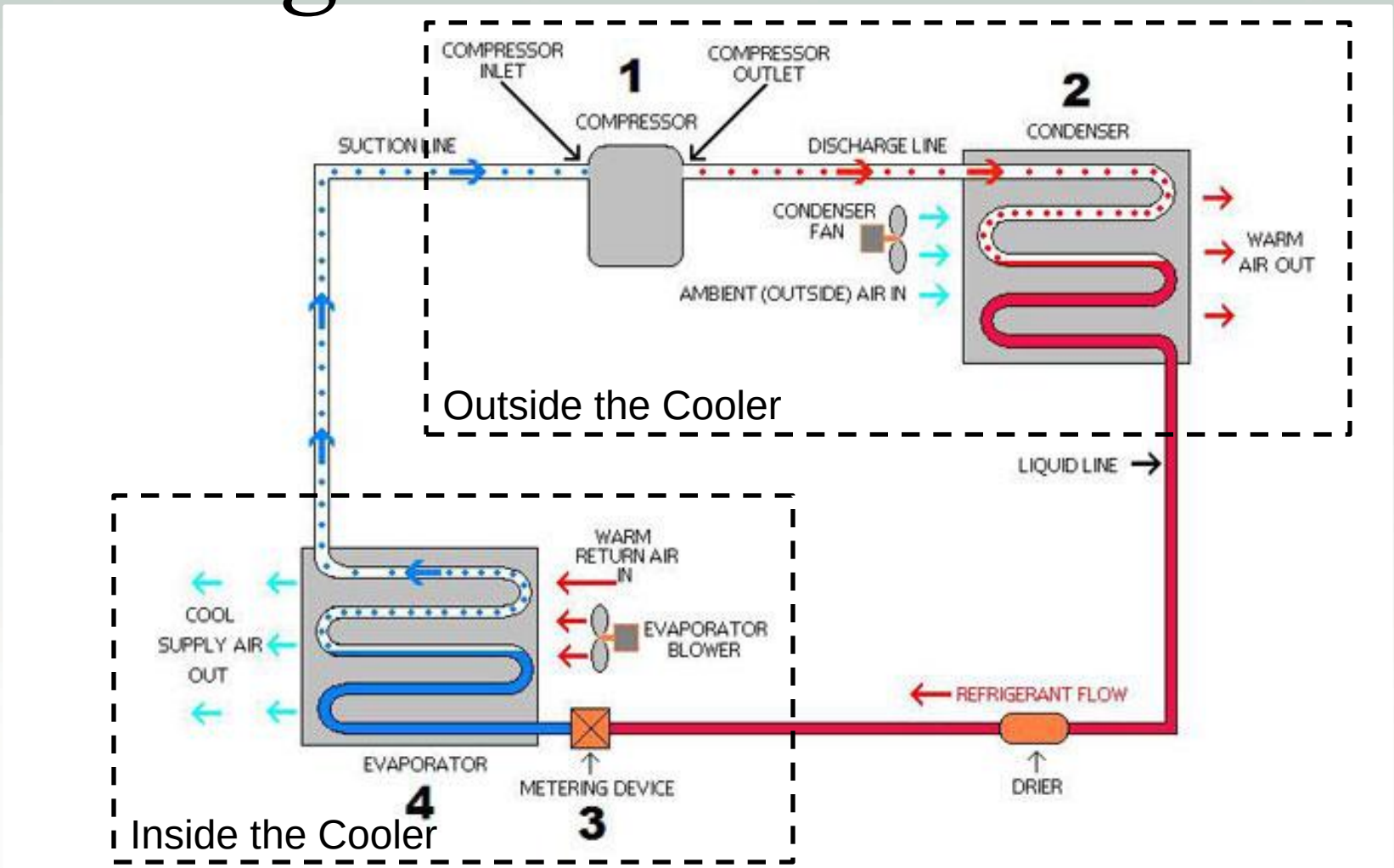
Structure and Materials

- Sealing –
  - daylight test
  - (or dog/cat test).

Rodent & Pest Control

- New construction vs. Retrofit
- Bait & traps
  - OMRI approved D3 rodenticide
  - Must have strict schedule for checking traps!
- Tight envelope excludes pests
  - Wire mesh / hardware cloth
- Some storage bins help exclude rodents
- Cement curb

Refrigeration



Refrigeration

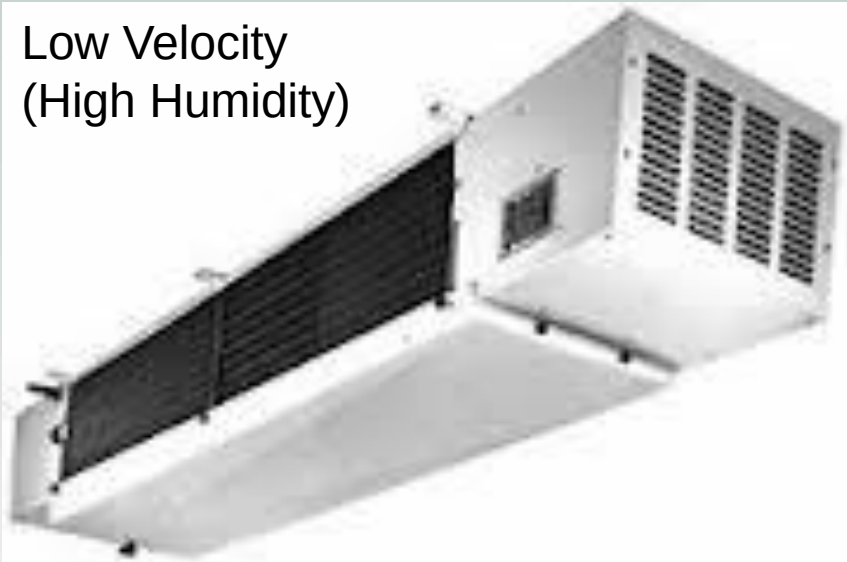
Evaporator Unit

Compressor / Condenser Unit

Evaporator Options

Standard

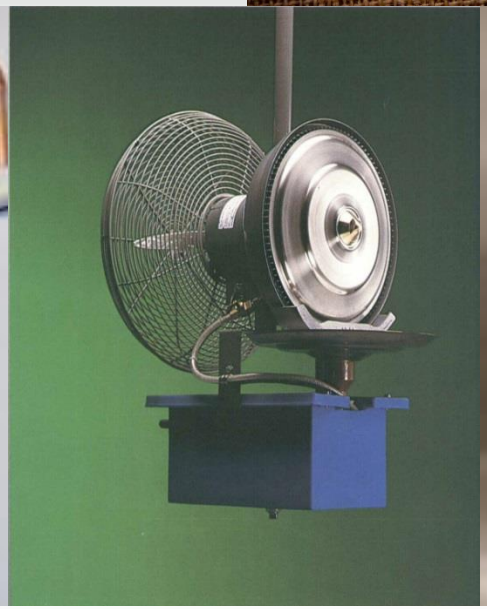
Low Velocity
(High Humidity)



Plates

Humidification

- Generally required for root veg storage



Humidification

Dayton – Humidifier
Control 20-90%, $60

Standard room humidifier, refills are manual. $30

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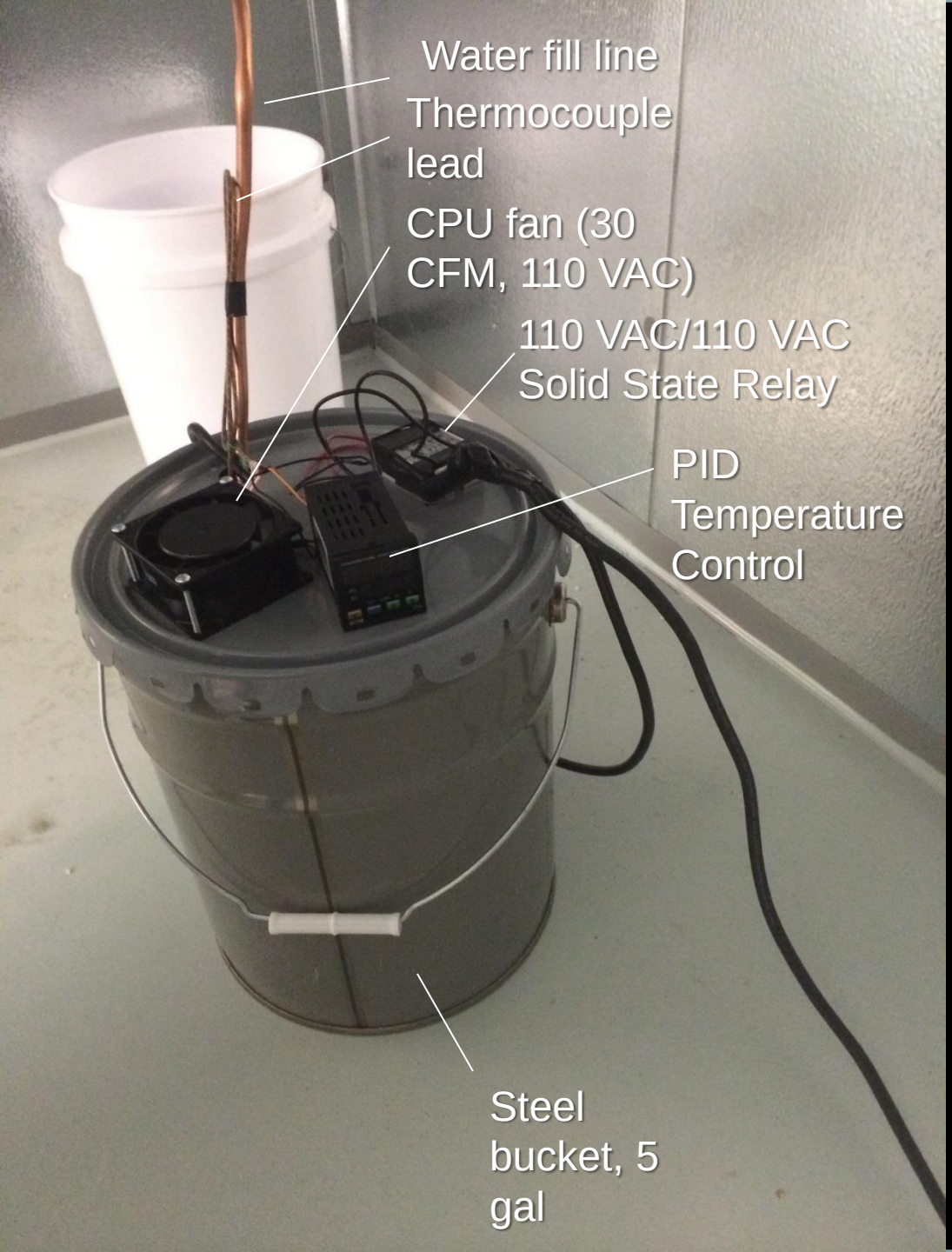
Humidification

Trion Duct Humidifier
$285

Atomizing type
Auto-fill

6 gal per day

www.qasupplies.com



DIY Autofill Bucket Humidifier
5 gal per day at 33 F room temp
Evaporative type
Open source design
Parts ~$155

www.FarmHack.net

http://farmhack.net/tools/auto-fill-high-output-temperature-controlled-humidifier#wiki

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 ºF

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

CoolBot vs. Conventional

- 2009 NYSERDA Study
  http://storeitcold.com/coolbot%20Report%20May09.pdf
- 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)

Controls - Thermostats

- Control a load based on temperature

"remote bulb" allows measurement inside, adjustment outside of 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

Humidity Sensors

- Humidity: 10 to 99% RH
- Temperature: 14 to 140°F (-10 to 60°C)
- Accuracy: **±5%RH**; ±1.8°F, ±1°C

Sling Psychrometers

QA Supplies
Bacharach Heavy Duty Sling
Psychrometer - $155
www.qasupplies.com

Ben Meadows
Weksler Sling
Psychrometer - $68
www.benmeadows.com

Containers

- Storage bins/pallet sizing
- Consider: Wood vs. Plastic, Maneuverability, Stackability, Airflow & circulation


Photo Credit: Brookfield Farm


Photo Credit: MacroPlastics


Photo Credit: Monte Package Company


Photo Credit: Orbis

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

USB Data Loggers

DATA-Q www.dataq.com

EL-USB-2+ USB Data Logger
Measures ambient temperature and humidity
Higher accuracy than EL-USB-2
Automatically calculates dew point
-35 to +80 °C (-31 to +176 °F) temp measurement range
±0.3 °C (±0.6 °F) overall temp accuracy
0-100% RH measurement range
±2.0% overall RH accuracy (20-80%RH)
2 User-programmable temp alarm thresholds
2 User-programmable RH alarm thresholds

5 minute readings = 56 days storage
1 minute readings = 11 days storage
Download data to computer

$125 (RH +/-2%)

$99 (RH +/-3%)

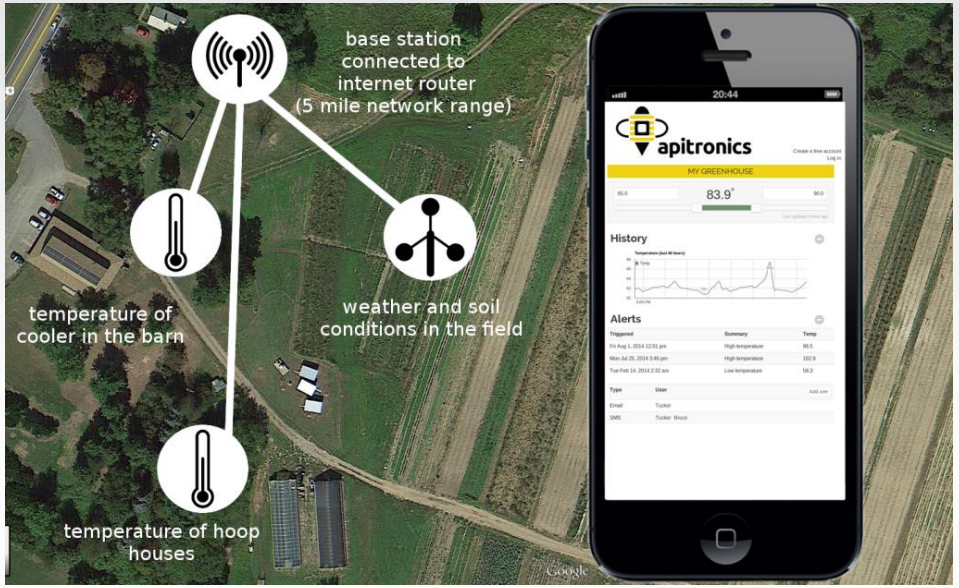
$82 (RH +/-3%)

Apitronics

Base (Hive): $111
Sensors (Bees): $205-240

All wireless

www.apitronics.com

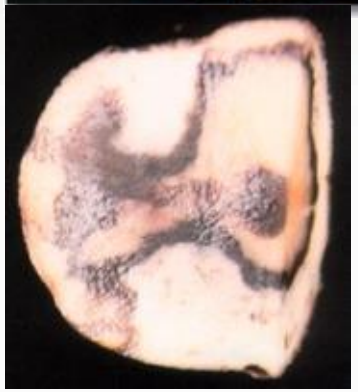


Scouting

- 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

Rhizopus Soft Rot on Sweet Potatoes

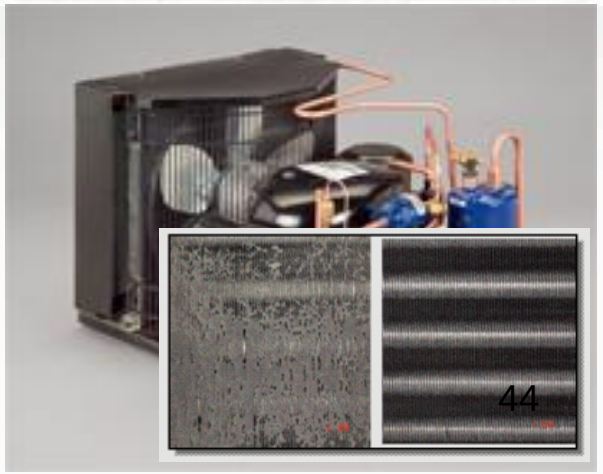
Potato Affected by Fusarium Dry Rot



Potato Affected by Soft Rot

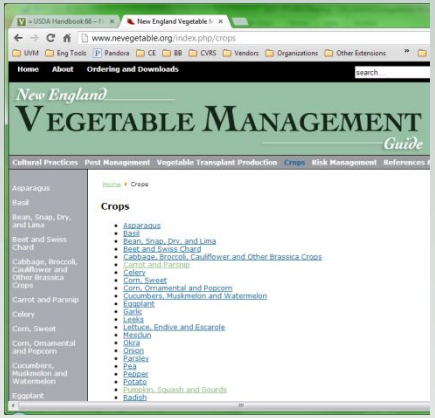
Cooler Audit

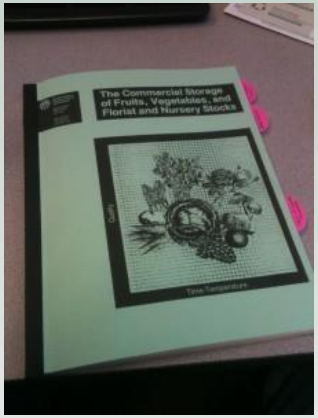
- Envelope (“The Box”)
  - All doors close tightly
  - All seals are sealing
  - Signs of degradation
  - Signs of mold
  - Air circulation inside
- Mechanicals (“The Chiller”)
  - Noise is energy
  - Condenser coil is clean and clear
  - Annual refrigeration tuning

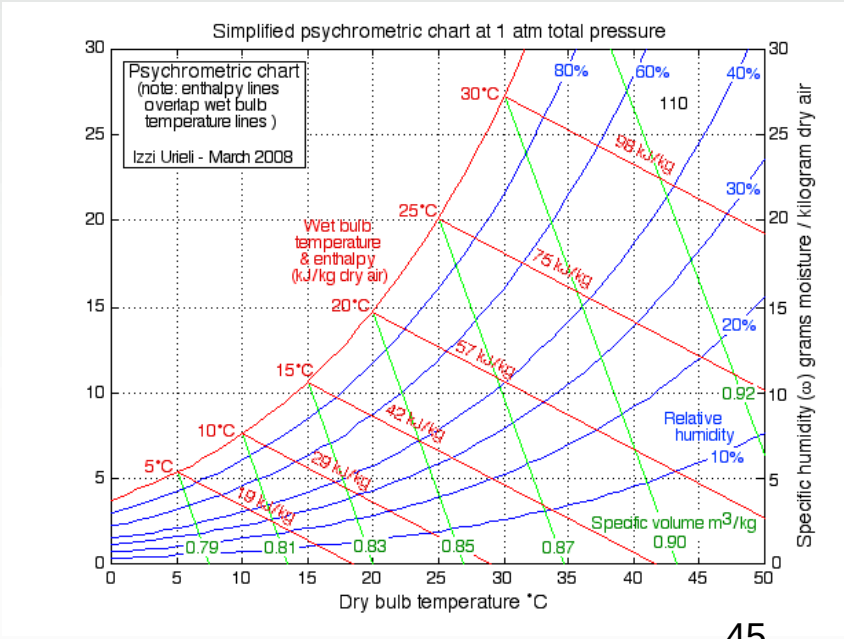


Technical References

- UVM Extension Ag Engineering Blog
  - http://blog.uvm.edu/cwcallah/
- USDA HB 66
  - http://www.ba.ars.usda.gov/hb66/contents.html
- NE Vegetable Management Guide
  - http://nevegetable.org/
- UC Davis Post Harvest Website
  - http://postharvest.ucdavis.edu
- Psychrometric Charts and Calculators
  - http://www.sugartech.co.za/psychro/index.php







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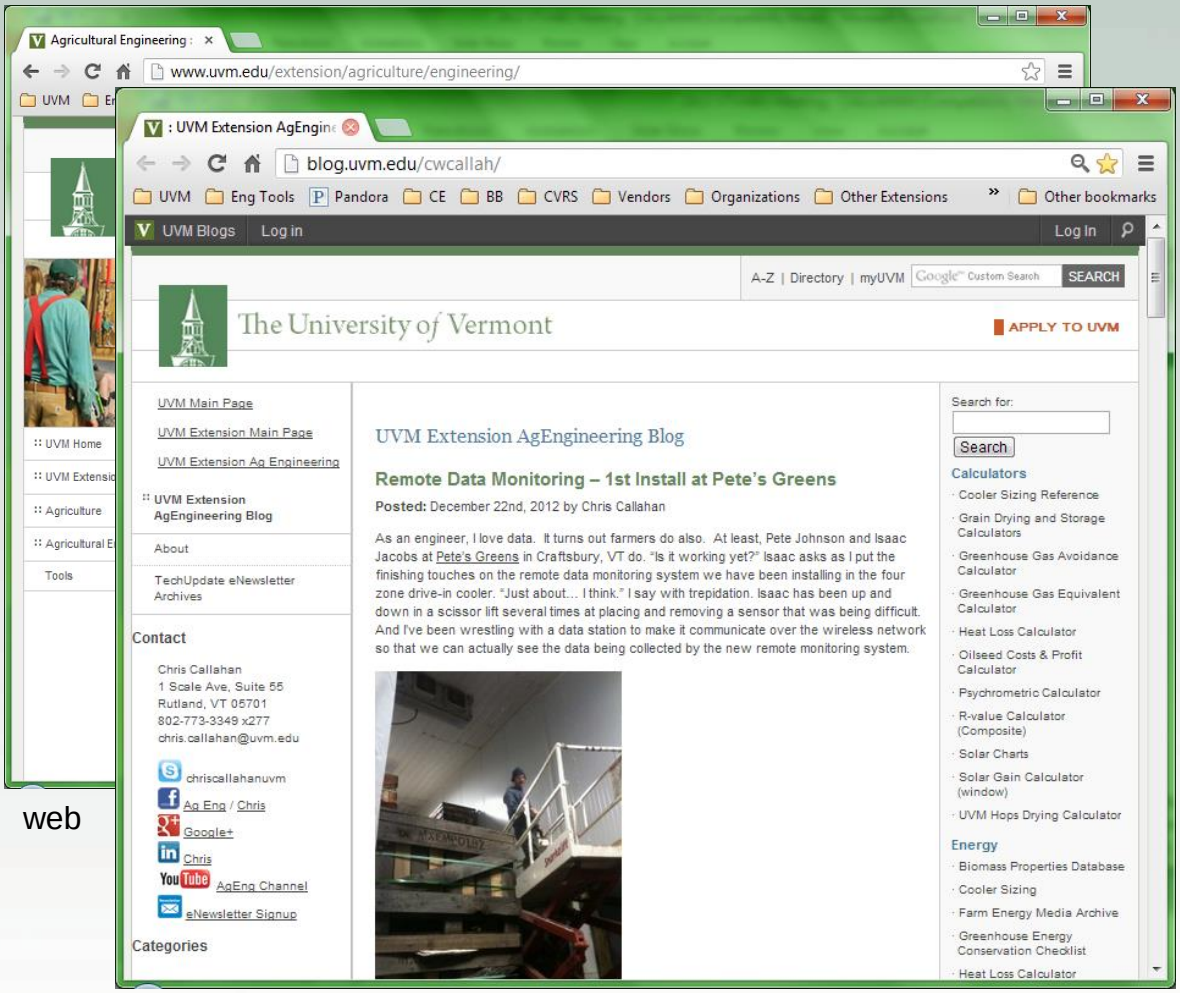

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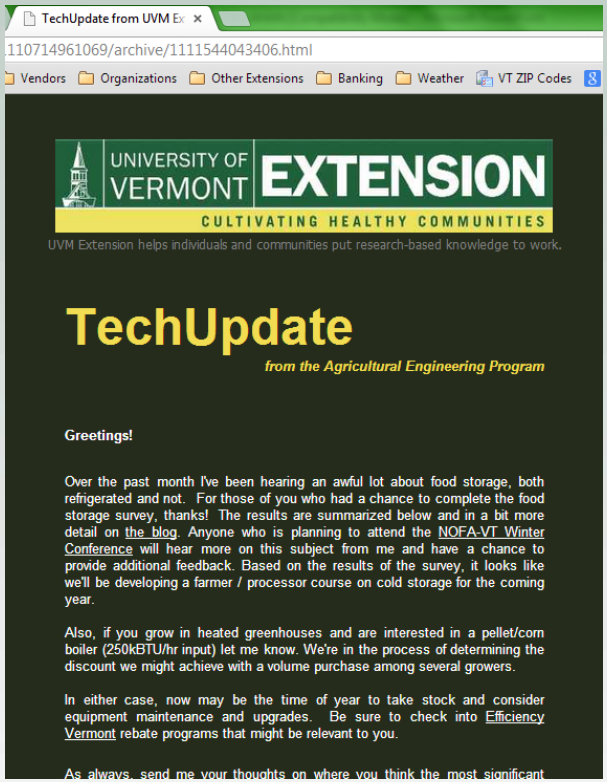

eNewsletter

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