



## Harvest-to-Sale Vegetable Handling

Quality produce  
from the field to the table

Laura Frerichs, Loon Organics

Lisa Baker, Bakers' Acres

Joan Olson, Prairie Drifter Farm



This presentation is designed to help growers understand how to get produce from the field to the point of sale at the highest quality, by attending to good handling practices along the whole chain: harvest, cleaning & cooling, sorting & grading, packing, storage, transport, and display.

In this presentation, you will see PHH practices from three small to mid-size vegetable operations with similar markets and crops, but varying practices. You will find that there are many ways to reach the ultimate goal of quality produce based on available infrastructure, land layout, budget constraints and business establishment.



Laura Frerichs with husband, Adam Cullip, co-own and operate Loon Organics, a 40-acre certified organic vegetable farm in Hutchinson, MN. Laura and Adam worked on over five different vegetable and fruit farms across the country before starting their own operation in 2005. Loon Organics grows vegetables and herbs for a 170-member CSA, local retailers, restaurants and the Mill City Farmers Market in Minneapolis. A raise of hands: is everyone familiar with csa? (if not, then define it)



Lisa Baker manages Bakers' Acres, LLC, a 15-acre farm in Avon, MN. Her parents and partner Travis live nearby and help with a variety of roles and responsibilities at the farm. Lisa bought the land in 2010 and has been slowly growing the farm. They currently serve a 50-member CSA and several wholesale/restaurant clients, and the farm also raises a small number of beef and layer hens for direct sale. She and her farm photos in this presentation represent a small, beginning farmer operation.



Joan Olson and her husband Nick own and operate Prairie Drifter Farm, a 33-acre certified organic vegetable operation, in Litchfield, MN with their two kids, Abe and Freya. Joan and Nick worked on four diversified vegetable operations and managed a small CSA and intern program before beginning their business in 2010. Currently, Prairie Drifter Farm serves a 125-member CSA as well as several small restaurants, co-ops and food shelves.

We also raise a small flock of broilers, layers, and pigs each season for direct sales.



## Goal: Quality Produce



So why is PHH so important and what is our ultimate goal? Quality produce!

Quality produce is the goal for every channel farmers sell through: both direct-to-consumer markets (e.g., CSAs, farmers' markets) and wholesale markets (e.g., distributors, co-ops, restaurants, institutions).

## Goal: Risk Reduction



Good post-harvest handling practices are also critical for risk management and reduction. These practices directly impact produce quality and the reputation of the farm, which affects business sustainability. An illness outbreak could destroy a farm.

## Why Improve Post-Harvest Handling?



Improving post-harvest handling will improve food safety and efficiency on your farm, which leads to high-quality and long-lasting produce, which leads to customer satisfaction and building of your business!

As we go through this presentation, consider where your farm is now and practices or infrastructure you may want to improve and/or change. Each farmer that contributed to this presentation is continually striving to improve post-harvest handling practices on their farm – it is a process. Recognize your long-term goals and make a plan for how to reach those goals, but realize it probably will not happen all in one year.

The 4 W's and high-risk crops.

## **FOOD SAFETY**

We're going to begin with some general concepts that you should have in mind before you even start thinking about post-harvest handling procedures. The first of these is food safety and the second is respiration.



## The 4 W's

Four key areas of food safety

- Workers
- Water
- Waste (manure)
- Wildlife

Food Safety and Post-Harvest Handling are totally intertwined. You can't have good post-harvest handling without attention to food safety. In this portion of the presentation, we're going to touch on the 4 Ws (workers, water, waste, and wildlife), an easy way to remember the the high-priority areas of food safety to be aware of on your farm. There are more resources available if you want to go more in-depth with on-farm food safety – Good Agricultural Practices (GAPs) training, food safety plans, etc. are very helpful – see handouts.

We will do an overview of the 4 W's now but these concepts will be revisited in other steps of the post-harvest handling chain.

## Workers (Including you!)



Photo credit: Michele Schermann

- Proper hand washing
- Bathroom facilities
- Not working when ill

Workers have to take responsibility for each of the 3 other W's, so we'll talk about workers first.

Proper hand washing technique is extremely important – for both workers and farmers. Training aides are available online that demonstrate proper technique, and GAPs courses also teach it.

Your farm should have a dedicated hand-washing sink so that workers are not washing hands in produce wash tanks or sinks. Here are two examples. The first at Bakers' Acres is located outside of the bathroom and produce washing areas and uses single-use towels; the second is mobile, and was constructed for about \$20. See your handouts for info on how to build one for your farm. **Having the hand washing area outside of the bathroom allows supervisor to visually verify that workers washed hands (comment: on large farms with porta-potty).**

**Hot water is not required for soap to be effective, but, proper procedures recommend washing hands for at least 20 seconds, and warm water might increase the likelihood that workers follow that procedure.**

Single-use towels for drying are part of GAP standards so germs don't spread through a reusable towel.

Use signage to remind workers of proper hand washing and other sanitation

procedures.

Bathroom facilities need to be located within  $\frac{1}{4}$  mile of the fields.

No one should work with food when they are ill – including you!

## Training Topics: Worker Responsibilities for Safety



### Food Safety

- High-risk eaters
- Special care for high-risk crops
- Reduce risk of physical contamination
- Cell phone use policy
- Designated space for storing personal belongings, smoking
- Using clean tools in the field



### Employee Safety

- Ear protection
- Sun protection
- Avoid heavy lifting when possible
- Awareness of fellow workers
- Machinery/equipment safety

In addition to handwashing training, thorough employee training is necessary in all areas of your food safety and post-harvest handling procedures. Train employees how they can affect and are responsible for food safety from harvest to packing, as well as safety to keep themselves protected from hazards inherent to farming.

Food safety training topics include:

Importance of food safety / risk management (especially compromised populations – pregnant women, young babies, elderly, compromised immune systems).

Knowledge of high-risk crops – we'll talk about this in a few minutes.

How to reduce physical contamination risks (e.g. wearing a hat, pulling long hair back, personal hygiene, clean work clothes).

No cell phone use allowed – if emergency, wash hands after use.

Designated space for personal belongings (clothing, water bottles, no glass) and policies for smoking – if, where and hand washing requirements.

Importance of using clean tools in the field and keeping them clean.

Also train your workers how to protect themselves and their co-workers while working:

Ear protection – where stored and how to use it

Sun protection – hats, long-sleeves

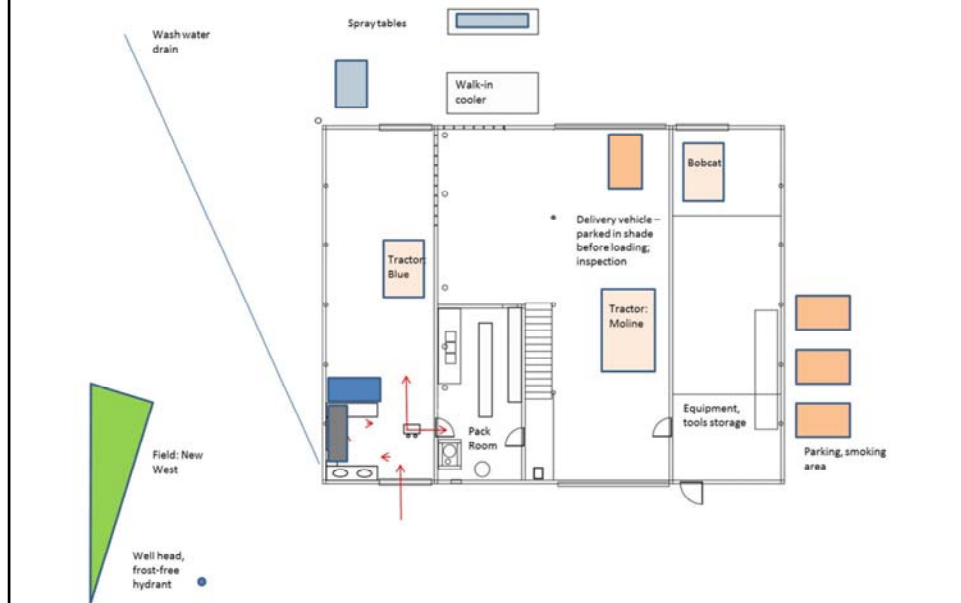
Avoid heavy lifting when possible

Being aware of what others are doing around them in the field and the pack shed – walking while holding knives, slippery floors, where the tractor loader is swinging if turning, etc.

Safe use of machinery and equipment – consider training on proper use of each piece of equipment

To help you with training, we are creating some Employee Training materials, starting with a Training Checklist. It is in progress now, but if you're interested in seeing it, contact us, or check back to the MISA website where we'll post it once it's completed.

## Worker Training – Facility Map



Showing workers a facility map is helpful to train them about designated parking, smoking areas, handwashing sinks, bathroom, where to store personal belongings, break area, etc.



## Water

- Potable water for post-harvest washing, hand washing, and irrigation
- Monitor water tests for changes
  - Quantifiable e. coli vs. absence/presence test
- Crops can uptake pathogens in water through their stem ends; then the pathogen is internal
- The role of temperature



The second of the 4 Ws is Water.

Almost everything you do on the farm involves water. Paying attention to water cleanliness and appropriate use of water is important. You must have potable water for post-harvest processes, handwashing, and irrigation.

Potable water = drinkable water. Most often farms are using water from an on-farm well. With your well you must do a water test to determine if the water is potable. Do this every season before your heavy water use starts so that if you have an issue, you can deal with it before you need to use it on crops. Take care to ensure the quality of your well water by keeping livestock away from the well head (at least 50 feet) and checking the integrity of the well head (e.g. burrowing animals). You need to be especially vigilant when using surface water for irrigation rather than groundwater as the potential for contamination is much higher. You may also be using a municipal water source. In that case, you could access well records from the municipality.

Get regular water tests so you can monitor for changes in your water supply. Start with the Public Health department in your county to find a company to do a well water test. At very least need to test for coliform and nitrate but many test options are available if you have other concerns for your water supply. The e. coli test above shows "Absent." It is better to have e.coli quantified than just a presence/absence

test, and you need to find a lab that will do that.

Starting with clean water is important, but so is the temperature of the water you are using for certain crops. Too-large discrepancy between water temp and the internal temperature of the produce (cold water & warm crop) will accelerate uptake of water by vegetables with a stem end (e.g., melons, zucchini, and tomatoes). This uptake can include pathogens in the water – if pathogens are on outside of produce, this uptake can make them internal, which you cannot wash off and could spread to others in wash tank. So, if you are washing these crops in a tank, the water temp should be no more than 10 degrees cooler than the internal temp of the produce.

On our farm, we do not submerge melons for washing nor cooling because the risk for contamination is too high; if they're dirty, we spray them off. Leafy greens do not have a stem end, so dropping the temperature in increments is not as important.

## Wash Water Sanitizer

- For high-risk crops
- Sanidate and Tsunami for organic producers
- Study: E.coli in leafy greens wash water was reduced 98-100% through use of Sanidate and/or three rinses in water.



*Study source: "Growing for Market" cover article about University of Vermont researchers studying food safety in leafy greens in the summer.*

Sanitizer in your wash water is extra insurance against contaminants; it is not proof against poor field practices. Here are two examples: Sanidate (sourced through several seed/supply companies) and Ecolab's Fruit & Vegetable Wash (the new version of Tsunami). Check OMRI for sanitizer products that are allowed for organic production. Safe handling of concentrated sanitizer is important – it is a concentrated acid. If your employees are applying it, train them on the appropriate use.

The effectiveness of sanitizer drops with increased levels of organic matter in your wash water. You will need to change wash water often during cleaning/cooling process. Using test strips is the safest way to determine your wash water has active levels of sanitizer.

Although small, a University of Vermont Extension study in 2012-2013 found that E.coli rates spiked in warm summer temps and were reduced in wash water by 100% with one rinse with full rate Sanidate 5.0. (compared with single rinse, no sanitizer). Multiple rinses (three was most effective) in wash water (without sanitizer) was also found to reduce E.coli by 98% compared with single rinse.

We typically use sanitizer on the most high-risk crops on our farms:

**Bakers' Acres: leafy greens**

**Loon Organics: salad mix, spinach, arugula, head lettuce, bok choy, kale, chard. We**

found out the hard way that Peracetic Acid (in Sanidate) turns peas rusty!!  
Prairie Drifter Farm: salad mix, spinach, arugula, head lettuce, bok choy, kale, chard

## High Risk Crops

Those eaten raw and in close contact with soil



What do we mean when we say high risk crops? High risk crops include those eaten raw and in close contact with soil. Greens, cantaloupe, etc. require special attention in the post-harvest handling process.

## Greens at Bakers' Acres



Here is an example from Bakers' Acres showing leafy greens through harvest, hydro-cooling/rinsing, drying, packaging and final retail display at a food co-op.

We start by harvesting with clean equipment and clean rubber gloves when it's cold to keep our hands dry and warm. Single-use nitrile gloves are best gloves to use for food safety.

We submerge the looseleaf greens in two different 20-gallon tanks – the first with no sanitizer, the second with sanitizer. The submerged crates have been cleaned and not set on the ground. With clean hands, we swirl the greens several times in both directions, and lift and submerge the crate several times. We repeat the process in the second tank. We typically need to change the tank water within 3 washes if the greens are visibly dirty after harvest.

To dry, the crates are allowed to drip dry for a bit under shade or in the cooler while we process additional crates; we periodically shake and fluff the crates when drip drying. We found that spreading greens out to dry on a screened table led to wilting too quickly and the additional handling caused lots of breakage. This coming year, we will use a 5-gallon salad spinner – the centrifugal force pulls almost all of the water off of the greens, leaving them fluffy and almost dry. The remaining moisture is important to keep humidity inside their bags / packaging.

We hand-fill HDPE bags at 3-5# pounds and package up to 10# in one box.

The last photo shows the looseleaf salad mix on retail display at our local food co-op.



## Greens at Loon Organics



Loon Organics uses a dedicated washing machine to spin-dry greens in dedicated laundry bags. All washing equipment, buckets, screen table is sanitized prior to use. A strainer is used to skim leftover greens from the water to clean out tubs, sometimes we may re-use the water on a 2<sup>nd</sup> batch of greens if it is clean. Sanitizer test strips can be used to verify if the sanitizer is still at active levels for the 2<sup>nd</sup> batch.

## Greens at Prairie Drifter Farm



Prairie Drifter Farm washes leafy greens with a technique similar to Loon Organics. They also use a washing machine and mesh bags in 5-gallon buckets with drain holes for washing/draining greens and a screen table for drying. The washing machine, buckets and mesh bags are dedicated for bulk leafy greens only and all equipment is sanitized at the beginning of each harvest day. Mesh bags are laundered with bleach regularly.

In summary, it's important to pay attention to wash water and your handling processes for high-risk crops to reduce food safety risks as much as possible.

## Waste



- Proper manure handling and application
- NOP Standards:
  - Application 120 days before crop harvest when crop is touching ground (e.g. greens)
  - 90 days before harvest when edible portion of crop does not touch ground (e.g. sweet corn)
  - Incorporate at the time of application



The 3<sup>rd</sup> W is Waste. Waste refers to manure (applied directly or through having livestock graze fallow fields) and/or compost. As part of your farm's soil fertility program, you can use raw manure or composted manure, but you must observe proper time delays between raw manure application and crop harvest. Also, incorporate manure at the time of application to avoid runoff; if manure is allowed to sit on top of your fields, it can create environmental issues as well as the potential to contaminate other fields that could have produce growing in them.

NOP standards –

The NOP time delay standards do not apply to properly composted manure. Our farms source compost from facilities that produce according to safe standards and are tested. If you are doing on-farm composting, make sure you are following standards for safe and complete production of compost. If you do not follow the NOP production criteria for composting, you need to treat it like raw manure.

At Bakers' Acres, we apply raw manure in the fall to fields that will not have leafy greens or root crops in them the following year. On the fields where leafy greens and root crops are planned, as extra insurance against contamination for those high-risk crops, we use certified organic compost instead.

## Wildlife

- Keep wildlife out of fields when able (includes deer, chickens, dogs, etc.)
- Do not harvest produce with visible droppings



The last of the 4 Ws is wildlife. Wildlife refers to any animals that can contaminate your fields with droppings or chewing damage, including domestic animals like your dogs or chickens. To reduce food safety risks, exclude wildlife from fields as best you can.

Deer fences can sometimes be effective by placing two electric single or double wire fences with a 10-foot space between them. Deer are deterred by the space.

Crops with droppings from wildlife should be noted and not harvested. Crops with chewing damage (e.g. deer browse on salad greens) should also not be harvested.

If you have livestock on your farm, follow proper handwashing procedures after doing animal chores, touching animals and/or their droppings. Use separate boots for animal chores and field/harvest activities (e.g. have dedicated boots for animal chores – chore boots should not be worn in production areas or pack shed).

If you allow your chickens, pigs, or cows to browse or graze fields not in production, be sure to treat those fields as if raw manure has been applied and observe proper time delays before harvest.

If you have visitors with pets, ask them to keep them on a leash and not allow them into production fields or the pack shed.

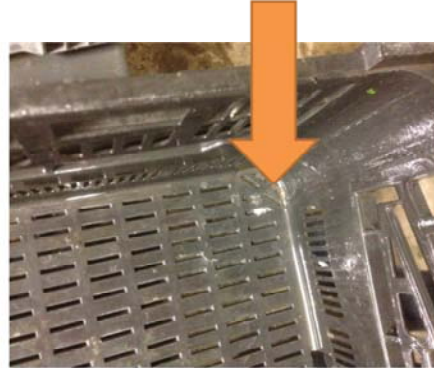
## Field Maps



Use a field map in your food safety documentation to show if you found wildlife contamination and where you marked off areas where harvest should not be done. This is how Bakers' Acres would handle wildlife contamination documentation in our food safety plan.

## Wildlife Management in Pack Shed

- Bird netting
- Don't harvest or touch produce or harvest materials with visible droppings



Wildlife in the pack shed? Having a pest control plan for your pack shed and produce storage areas is also important, to keep out birds, mice, farm animals, etc. Make it uninviting to them.

Use bird netting to prevent birds from perching/nesting above your produce in packing areas.

Set mouse traps in key areas of your wash/pack area and check regularly.

Move pallets frequently.

If you see animal droppings on harvest equipment or in the pack shed, take the time to wash and sanitize the equipment properly.

Store harvest containers upside down so there is less chance for animals to contaminate buckets, harvest crates, etc.

--

Just to recap – the 4 Ws for food safety are? (Workers, Water, Waste, and Wildlife).

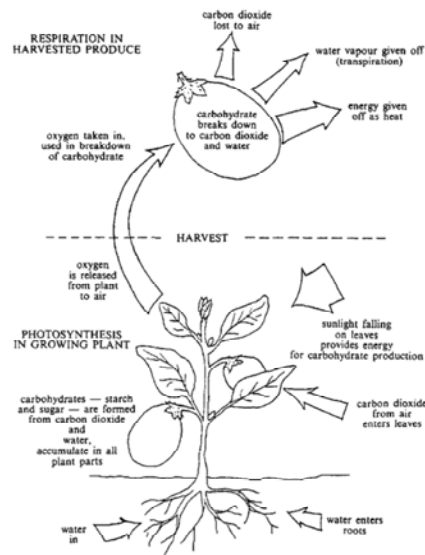


Respiration rates and ways to slow deterioration.

## **RESPIRATION**

The second major concept we will cover before moving on to specific post-harvest handling procedures is respiration. Understanding respiration will help you to slow deterioration of produce from time of harvest, through the cleaning/cooling process, all the way through to storage.

## What is Respiration?



Source: Food and Agriculture Organization

Respiration is a reaction of plant material both in the field and after harvest. In respiration, after a plant is harvested, the plant uses oxygen to break down carbohydrates, proteins, or fats into CO<sub>2</sub>, water and energy (heat). The result, after harvest, includes loss of nutritional value, flavor, salable weight, and overall quality.

## Respiration Categories

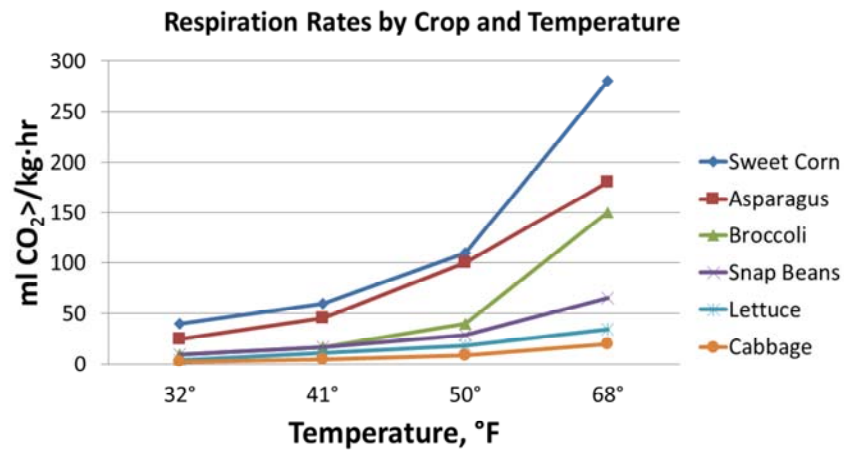
Know each crop's respiration rate to help maintain highest quality and longest shelf-life of produce

<u>High</u>	<u>Moderate/Low</u>	
	Need Refrigeration	Sensitive to Chilling Injury
Asparagus	Apples	Basil
Broccoli	Blueberries	Cucumbers
Green onions	Bulk roots	Eggplant
Kale	Cabbage	Green Beans
Leafy greens	Celery	Melons
Lettuce	Garlic and Onions (once cured)	Okra
Peas	Potatoes	Peppers
Raspberries		Seed Garlic
Spinach		Summer Squash/Zucchini
Sweet corn		Tomatoes
Strawberries		Winter Squash

Each type of produce can be categorized into high, moderate, or low respirators which dictates how you should harvest and handle each item for maximum quality and shelf life. When we refer to the shelf life of a product, that shelf life begins at harvest. It is your job as the producer to extend shelf life to the best of your ability. Understanding the effect of respiration on harvested produce is the first step in slowing deterioration and extending shelf life.

In general, a higher respiration rate equates to a more perishable crop. Respiration rate is also dependent on temperature (higher temperature = higher respiration rate) and handling practices (e.g. bruising due to mishandling can increase respiration rate).

## Slow Respiration by Cooling



Respiration expressed as: ml CO<sub>2</sub>/kg-hr  
Source: UC Davis

You can usually help slow the rate of respiration by controlling the temperature of the product, starting at harvest, or cooling produce immediately after harvest. For high respirator crops, as the temp of the produce increases by just a few degrees, respiration rates increase exponentially.

Note that sweet corn is a high respirator. Farmers often don't think of sweet corn as being so perishable.

Summary: Decreased product temperature --> Decreased respiration rate --> Decreased deterioration rate

## High Respiration Rate = Highly Perishable

Harvest Early When Cool Outside

Cooler air temp outside = cooler internal temp of produce



High-respiration crops are the most perishable, and field heat needs to be removed from them as quickly as possible; they will deteriorate or lose quality if not cooled rapidly.

Start by harvesting high-respiration crops in the cool of the day if possible. A cooler air temp outside means the internal temp of the produce is also cooler (as opposed to the internal temp at midday). It takes less energy and time to cool produce if you start out with it already as cool as possible at the time of harvest.

For example, leafy greens including salad mix, spinach, and swiss chard are high-respiration crops. We prioritize the harvest of leafy greens on harvest days and ensure that they are cooled immediately when they enter the pack shed.

## Hydro-Cool or Ice

To cool internal temp of produce quickly



Many high-respirators will benefit from hydro-cooling or icing to rapidly drop their core temperature.

Hydro-cooling means using water that is colder than the produce to draw out the internal heat. Well water in Minnesota is typically 40-50 degrees. Most small to mid-size farms are using well water for cooling. Larger farms will often have an ice machine for the purpose of cooling. Top icing is especially common for wholesale channels in warmer climates where ground water is as warm as 80 degrees in southern Florida and Texas.

At our farm's, we don't have an ice machine so we hydro-cool most vegetables. The water is also cleaning the produce, removing dirt and bugs – but the main reason for the water is cooling.

A note about water temperature and food safety again: If you're using water tanks to cool produce with stem ends, use several wash tanks and drop the temperature in increments of ten degrees. Tank water should be no more than ten degrees cooler than the internal temp of the produce, otherwise you run the risk of pulling pathogens from the water into the internal and edible portions of the crop.



## Maintain Cold Chain & Humidity

Move to cool storage immediately and prevent moisture loss



After high-respirators are cooled, they need to be refrigerated.

Coolers use circulating cool air to cool product, but this can also dehydrate and cause wilting/limpness. Use covered bins, icing, plastic liners, or pack produce wet to keep humidity in for high-respirators. We always cover leafy greens and berries in plastic to prevent water loss. For shorter term storage (a few hours), sturdier produce like carrots can handle being exposed to air.

In summary, crops with a high respiration rate should be harvested cool and stored cold with adequate packaging to prevent moisture loss and have maximum shelf life.

## Moderate/Low Respiration Rate

Less urgency with harvest, but still need to store some cool



Moderate/low respiration crops are the easiest and most forgiving in terms of harvesting. When prioritizing the order of crop harvest, moderate/low respirators can be harvested later in the day.

For some moderate/low respirators, cool storage is ideal, but they are more tolerant of less-than-ideal conditions. Depending on the crop, they can sometimes stay in good condition for weeks to months outside of refrigeration.

For example, cabbage is a low respiration crop; there is less urgency with harvest. Loon Organics uses an open wagon for harvest of cabbage. However, cabbage still needs to cool down and keep in moisture for long-term storage (months).

There are a couple of categories of moderate/low respirators, some that need refrigeration and some that are sensitive to chilling injury. We will talk about those next.

## Moderate/Low Respirators that Need Refrigeration



- Apples, bulk roots (e.g., carrots, beets, turnips, parsnips, celeriac), cabbage, celery, potatoes
- Garlic and onions once cured (except seed garlic for planting)

Examples of moderate/low respirators that need refrigeration once harvested include:

Apples, bulk roots, cabbage, celery, potatoes, and garlic and onions (once cured).

We'll talk more about specific storage temperatures later.

## Moderate/Low Respirators that are Sensitive to Chilling from Refrigeration

- Basil
- Cucumbers
- Eggplant
- Green Beans
- Melons
- Okra
- Peppers
- Seed Garlic
- Summer Squash/Zucchini
- Tomatoes
- Winter Squash



Some moderate/low respirators are sensitive to chilling injury in storage, especially for long periods of time (over 24 hours and beyond).

At Bakers' Acres, we harvest most of these crops in the evening before delivery or on delivery day and store them on shelves designated to produce in the pack shed. Sometimes they're stored in crates or covered bins; other times they are packed into waxed boxes with liners to help retain moisture.

Prairie Drifter Farm & Loon Organics does this:

Crops that are refrigerated in warmer areas of cooler (cucumbers, green beans, cantaloupe if ripe, peppers, summer squash/zucchini, watermelon if there is room)

Crops that are not refrigerated (unless they have been packed in CSA boxes for short term storage): basil, eggplant, cantaloupe if unripe, watermelon, seed garlic, tomatoes, winter squash

We will talk more about how to handle storage of these products later on in the presentation.

## Green Top Roots vs. Bulk Roots

Very different respiration rates



Greens cause high respiration rate



Remove greens for longer storage

Some respiration nuances to be aware of: If storing with tops, root crops will perish faster due to moisture loss. If you need to store a root crop for a longer period of time, store them topped (with tops removed) and in food-grade plastic liners.

Harvest tips, ways to slow deterioration, and transportation to pack shed

## **HARVEST**

During harvest, there are things you can do before produce even gets to the pack shed to help maintain quality. We're going to talk about a few tips we use on our farms to start with the highest quality product, slow deterioration in the field, increase efficiency, and improve transportation from the field.



## Timing of harvest

### 1. Time of day

- Ambient temperature affects internal temp of produce and respiration rate
- Harvest nightshades, cucurbits, and snap beans dry (no dew) to prevent fungal disease

### 2. Ripeness of produce

- Peak quality & maturity (Broccoli: tight beads, no yellowing; watermelons at maturity)
- Harvest stages (tomatoes)



Start with the highest quality product by harvesting at the right time – both time of day and maturity.

While high respirators should be harvested in the cool of the day, others should be harvested later in the day after dew/moisture has evaporated and produce is dry to prevent fungal disease (e.g. green beans, tomatoes).

Peak quality depends on the crop's ripeness as well. Broccoli should be harvested when its beads are tight and no yellowing has started. Some crops won't ripen further after being picked (ex: watermelons, winter squash). It is important to pick these crops at maturity for optimum flavor and texture.

Tomatoes on the other hand, continue to ripen after harvest and are categorized into "harvest stages". Harvesting stages may be different depending on the buyer for the product. Tomatoes going to a distributor should be less ripe than what you may sell at farmers' market. We will go into more detail with tomatoes because harvest of this crop has a lot of nuances.



## Harvest before completely “vine ripe”

Handle with clean, soft gloves



The tomatoes on the left are at close to the right stage to ship to a wholesale account; they will be red within a few days and at the end of their shelf life in about a week.

The tomatoes on the right are a special order going out the same day, for canning purposes.

The stage of ripeness depends on the customer. Note that tomatoes are harvested and handled in the pack shed with soft harvest gloves which prevents handling injury.

At Bakers' Acres, we harvest tomatoes twice each week, sorting primarily in the field for firm/turners with a hint of green, and those that are overripe or appropriate for canning.

## Harvest heirloom tomatoes at firm stage



Heirloom tomatoes should be harvested at the firm stage, and then stored and shipped in a single layer because they are fragile and bruise easily.

## Harvest Board

A clearly posted harvest board helps to organize and streamline your harvest schedule.

- Harvest date
- Item
- Field name
- Customer
- Quantity needed
- Quantity actually harvested
- Initials of employee responsible

Harvest Date:	FIELD	CUSTOMER	QTY	Act	Initials
10/7-10					
① CSA Pkg					
② 1st Under MW					
③ 2nd Under MW					
Tomatoes - Large	NORTH	CSA			✓
Hokulei Tomps	NORTH	CSA	53		✓
Carrots	South	CSA			✓
Kale - Corgi	South	CSA			✓
Peppers	South	CSA			✓
Eggplant / Peppers	NORTH	CSA			✓
Salad Mix	South	CSA	25		✓
Spinach	South	CSA			✓
Onions	South	CSA			✓
Scallions	South	CSA			✓
Beet Kale	South	CSA			✓
Hard Kale	South	CSA			✓
Broccoli	South	CSA			✓
Bok Choi	South	CSA			✓
Winter Sg	North	CSA			✓
Chickpeas	South	CSA			✓
Kale	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			✓
Butter Beans	South	CSA			✓
Chickpeas	South	CSA			

## Harvest Tips

Tricks that make post-harvest handling easier or result in better quality produce



Number one: Produce should be seen and not heard! Mishandling can result in exterior or interior injury, decreasing shelf life. Produce should also be quiet while transported as well! Take care as you drive through fields and back to the pack shed to minimize jostling.

Leave as much as you can in the field – leaves, roots, non-saleable (e.g. “topped”) parts. It saves time in the pack shed and increases organic matter in your fields.

Keep crops like cabbage and broccoli clean by not letting them touch the ground once harvested and cutting with a clean knife.

Clean product can be field packed to save time. Loon will sometimes field pack cabbage, broccoli, and cauliflower, especially in the fall when it is cool and product doesn’t need to be hydro-cooled. Bring a tote or other box out to the field so you can set your pack boxes off the ground and keep clean. Keep knives, hands, box, and product clean and away from dirt so that boxes can go right in cooler and ready for sale.

Harvesting some crops in small buckets helps you move faster through the row.

Use buckets for harvest instead of crates for particular crops to be easier ergonomically on your worker’s bodies. Prairie Drifter Farm uses buckets for bunched

herbs, bulk basil, cucumbers, zucchini, beans, peas, small peppers, potatoes, bulk roots.

Harvesting heavy crops like pumpkins or squash directly into bins moved with a tractor is easier on workers' bodies. If there are stem ends like on butternut squash, stack/pack them carefully to avoid bruising one another with the stems as much as possible. If you don't have access to a loader, crops such as pumpkins or squash can be harvested onto a wagon or truck.

Wearing rain gear when harvesting wet crops (early morning dew or after a rain) is more comfortable than getting work clothes wet. You can also use rain gear or rubber aprons when washing/spraying crops in the pack shed.

## Harvest Tips

### Tips for bunched crops



Harvest tips for bunched crops –

Bundle rubberbanded/twist-tied crops in the field (either as you move with a crate or on a trailer like Bakers' Acres does with rhubarb). The result is less handling/counting and bruising/breaking later. Rhubarb leaves are easily transported to the compost pile.

Count rubberbands for bunched crops before beginning harvest of those crops. Bring extra bands in case of breakage. Harvest 1 or 2 extra to ensure the proper quantity when you return to the pack shed. No one likes to go back out to a far field to get one more bunch of kale.

As you bunch root crops such as radishes, beets or carrots, lay in piles of five. Once several piles have been made, assign one worker to collect the piles in a harvest crate tipped on its side opposite the sun for shade to collect a set number of bunches (e.g. 25 bunches of radishes per harvest crate).

Keep bunches of chard or kale under arm to minimize trips to tote. (Wear a shirt)

Efficiency: Move logically - right hand for cutting, left hand for moving bin down the row.



## What does an ideal bunch look like?

Packing guidelines vary and may depend on market

- 3-8 beets per bunch
- About 1 lb. leafy greens



Think ahead during harvest about how you're going to pack an item. Counting and bunching in the field saves time and handling injury in the pack shed. Farms will determine bunches for their own CSA but bunch size may be determined by a buyer for wholesale. Blue Rubber bands #33 should go around 3 times. Too tight banding can inhibit water uptake. Train yourselves and employees to be consistent.

Here are a few examples of what different guidelines suggest:

### Beets

"Standard bunches of beets shall be fairly uniform in size and each bunch of beets shall weigh not less than 1 pound and contain at least 3 beets." -USDA AMS

"Beets should be firm and well shaped. Topped beets can be packed loose in 1/2 bu. boxes or 25 lb. bags. Bunched beets (5-8 per bunch) should be packed in a 1 1/9 bu. box or crate with 12 to 24 bunches per box. Temperature: 32 F Relative humidity: 95% Cooling: Hydrocooling." -Penn State Packing Guidelines

"3-5 beets per bunch." -Roxbury Farm

### Kale

"5-6 leaves per bunch." -Roxbury Farm

"The size of the bunch may vary but is generally approximately 0.5 kg (1 lb)." -



Handbook 66

## Ways to Slow Deterioration

In the field, during and immediately after harvest

- Shaded areas, carts, wagons
- Covered bins, especially for greens
- Move produce to the pack shed frequently
- Hydro-cooling in the field



Even when you're harvesting at the cooler time of day, take additional steps to protect produce quality. Find ways to use shade in the field, or use bins with lids to keep sun off of the harvested produce. If you are harvesting in the heat of the day or on a warm, humid morning get produce back to the pack shed for cooling as soon as possible, or bring water out to the field for hydro-cooling.

## Transport from Field to Pack Shed



There are many ways to get produce from the field to the pack shed: wagon, cart, golf cart, trailer, tractor with rack, truck, van. Whichever mode of transport you use, strive to keep the transport smooth to minimize damage to produce.

At Bakers' Acres, the small hand carts we use force us to make frequent trips back to the pack shed, which prevents produce from heating up in the sun and minimizes its exposure to air before it gets cooled/packed in the packshed.

Ideally, on a warm day you should have shade over the produce, especially for longer transport distance from field to pack shed. Covering produce to keep off dust or bird droppings is another good practice.

## Transport from Field to Pack Shed



Golf carts or other vehicles can be modified as harvest vehicles. Loon Organics and Prairie Drifter Farm have modified golf carts by extending the platform to increase volume capacity (pay attention to load capacity of vehicle!). When modifying equipment, you can size it to fit your own harvesting equipment/containers. Consider adding shade over the top.

Cleaning produce, hydro-cooling and air cooling.

## **CLEANING & COOLING**

As you can see, good post-harvest handling practices actually begin in the field. Next, we'll talk about cleaning and cooling produce for storage and distribution.

## Cleaning

- Wash tubs
- Spray hose
- Pressure wash roots (not greens)
- Brush washer
- Barrel washer



*Photo courtesy of Grindstone Farm.*

These slides show some of the tools used for cleaning (always with water), and cooling is a by-product of the cleaning process. In all instances, equipment should be checked and cleaned if necessary at the beginning of each harvest day.

Wash tubs are one of the most common tools for cleaning. If you put crates in water as part of your cleaning, use clean crates that have not been on the ground. Peppers and cucumbers are often submerged, sometimes inside a mesh bag with light agitation.

A pressure washer can be used to clean the root part of hearty root crops such as turnips and carrots, but not the greens. You can increase the distance and between the wand and the produce and easily adjust it by twist-tying the trigger to on and draping the long nozzle over your shoulder. Pressure washer = about \$500 to \$700. Some crops do not need a pressure washer but rather a spray from a hand held sprayer on a hose because their skins are tender (e.g. radishes).

Brush Washer for cucumbers, peppers, melons, squash, potatoes and some root crops. Brush washer = \$1200 to \$1500 for just the basic washer. Add sorting rack, loading rack, extra brushes, \$3200. About \$4000 with roller table.

Barrel washer for bulk root crops. Barrel washer = about \$3000; also there are ways to buy pieces and put it together rather than buying the whole thing. Picture from

Grindstone Farm.

The more expensive mechanical aids are not a requirement for these crops but they do increase efficiency as your operation grows in size. Check the Leopold's Center Post Harvest Handling Decision Tool that Chris Blanchard put together for how many pounds/day justify the cost of these machines. His calculation: Washing 500+ lbs of roots/day justifies a barrel washer.



## Hydro-Cooling & Air-Cooling

- Hydro-cooling is the FAST way to drop temp
- Cooler will then keep it cool



Dropping the core temperature of the produce as rapidly as possible adds a lot of shelf life. Hydro-cooling is a very effective way of dropping that core temperature quickly. In the broccoli and bok choy photos, we are hydro-cooling to drop core temp of product since we don't have an ice machine. Larger vegetable operations would use ice to drop core temps or certain crops, and may even field pack and ice in the field.

Broccoli – 15 minutes to remove field heat; also helps to remove bugs

Leafy greens – minimize length of time in water (no more than 20 minutes through full wash/cool process)

Cabbage, cucumbers, peppers, and winter squash are typically not hydrocooled in the Upper Midwest (as all but cabbage prefer temps above 40 degrees).

Coolers work best when cool product goes in and will be kept cool. Most coolers are considered cooling rooms, or refrigerated storage units that will take a long time to get field heat out and cool high/moderate respirator crops. A cooler is an indispensable tool for produce growers to maintain quality. Coolers were one of the first things we all purchased on our farms and it is one of the best investments you can make on your farm.

This cooler at Bakers' Acres cost \$2700 and we've installed a simple solar light in it. Even though it is painted white to reflect the sun, we will be building a simple lean-to

over it to help improve its ability to stay cool (and reduce the amount of electricity used).

Resource Sheet: Cooling Resources

## Green Beans at Loon Organics

- Harvest dry to prevent fungal disease
- Wash to clean and cool
- Package dry for no quality loss



Some crops are handled differently on farms, both with good end results. Many growers do not wash their green beans, they are packed in pack shed and sent to the cooler.

At Loon Organics, beans are harvested dry, washed to clean and cool (soak for up to 10 min. or so), dried on packing table for 10 minutes (with fan if needed), then packed into individual bags for CSA shares or about 20-25# into a 1 bushel box. They are stored for a short time in the cooler, near the front where its warmer. Chilling injury can happen if stored below 40 degrees for more than a few hours.

Pack shed evolution, drainage, and design/equipment considerations.

## **PACKING AREA INFRASTRUCTURE**

Next we will talk about packing area infrastructure including pack shed evolution, drainage, and design and equipment considerations.

## Pack Shed Evolution

As farms grow and evolve, so do their pack sheds.



Packshed evolution: When starting a farm, chances are you will not have the means to start with your ideal pack shed. Lay out priorities for your pack shed and set goals for improvements each year based on your abilities and finances.

Before Prairie Drifter Farm purchased and moved to their current farm and were renting land, they started with a trailer for supply and tool storage, a pop-up tent/hanging sheets for shade in the field, stacked pallets to keep harvest totes and wash tubs off the ground, and portable screen spray tables for spraying off and drying produce.

Water was brought out to the field using black irrigation pipe and blue layflat hose from a hydrant at the farmstead where they rented land. Produce was stored short-term prior to transporting to their farmers' market in a cold room (A/C run as cold as possible in small room) and packing was done in the farmstead summer kitchen. This was not ideal but covered the bases for the biggest food safety/post-harvest concerns at that location where they could not put money into permanent infrastructure.

## Pack Shed Evolution

As farms grow and evolve, so do their pack sheds.



Currently, Prairie Drifter Farm uses a metal pole shed, which came with the farm they purchased, dedicated to produce washing, packing and storage. They improved the building, which had existing concrete, by adding a wash water drain that can be shoveled and cleaned out, which diverts water outside to a grassy area away from the building.

They also added steel siding to walls in the wash area, overhead lighting and water, a portable hand-washing sink, two coolers, and bird netting over the rafters. They make improvements each year through improved storage, efficiencies, and washing equipment as their budget allows.

## Pack Shed Evolution

As farms grow and evolve, so do their pack sheds.



Outside, covered lean-to



Concrete with better drainage

After buying property, Loon Organics started out their packing area with a lean-to against the barn, then gradually made improvements. The space now has concrete floors, sheet steel on barn walls, and a heavy duty lean-to. Three season low-cost packshed that also meets food safety needs.

One of the most important improvements they wanted to make was drainage control (where is all the water going to go?). They added concrete and a drain so CSA customers didn't have to walk through mud to get to the cooler to pick up their box.



## Drainage

Divert water out of pack shed and fields



Here's what their drainage solution looks like: Slanted concrete in pack shed lean-to directs water into a wooden gutter that goes into a drain at the end of the pack shed. From that drain, drainage tile runs underground to a wetland/wooded area. The wooden frame around the drain is exactly the size of a square-headed shovel that is used to scoop out debris and mud in the drain.

Good drainage in the pack shed is important for food safety – it's been said that adequate drainage is equally or even more important as having adequate water supply. Water pooling in the packing area can harbor & transmit pathogens. Poor drainage contributed to the cause of a listeria outbreak in 2011 associated with cantaloupe.

## Indoor Pack Room

### Pros

- Concrete floor
- Walls for food safety
- Warm air, water

### Cons

- Drainage needs to be converted to fields, not septic
- Small
- Cooler access is through two doorways across the barn and gravel floor



The pack room at Bakers' Acres started as a small enclosed room for food safety with concrete and heated water. The walls have since been covered. The drawback here is that water drains into the septic and needs to be rerouted to the fields not in production. We quickly outgrew the space and the cooler is across the barn.

## Outdoor/Indoor

### Pros

- Adequate space
- Acceptable drainage, but not ideal
- Closer access and no doorways to cooler

### Cons

- Open air, partial walls, partial shade
- Gravel floor
- Unheated



As we increased production, we used a combination of indoor and outdoor washing and packing areas. By packing outside behind the barn, we had adequate space, acceptable drainage sloped away from where we were walking, and closer access to and no doorways to the cooler.

However, we still have improvements we'd like to make. A gravel floor makes using wheel carts difficult. Our planned improvements include concrete, a center floor grated drain, insulated walls, plumbing, proper lighting, etc.

We don't all have a perfect pack shed right from the start; it's a work in progress.

## Pack Shed Elements and Workflow

- Lighting
- Plumbing
- Harvest container storage
- Clearly designated containers for compost and other applications
- Workflow to reduce cross-contamination



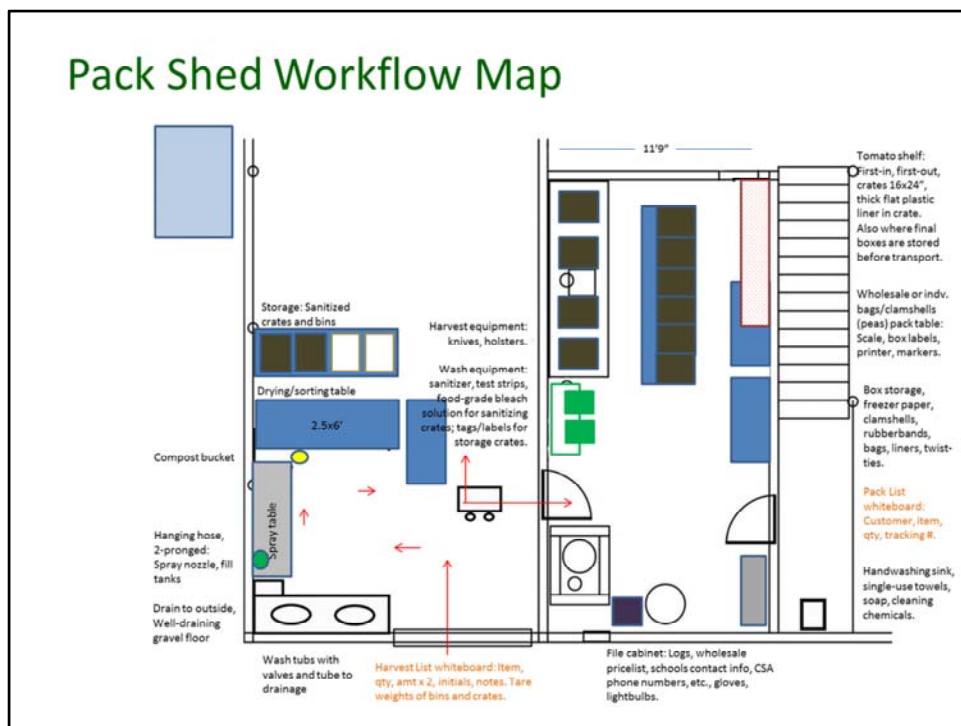
Some essentials when thinking about pack shed design are good lighting, plumbing water sources so that they're food-safe and convenient, designated storage for outdoor and indoor buckets and crates, and clearly labeled containers (e.g. compost).

At Prairie Drifter Farm it was essential to add additional overhead lighting as our indoor pack shed was not bright enough to inspect produce well. We have fully enclosed fluorescent lighting over wash tubs and sorting tables.

We have an overhead water delivery system using Pex tubing for potable water so that hoses are not on the ground. We can fill wash tubs from overhead and can hook our spray hoses and pressure washer in from overhead.

Our harvest crates are designated as field crates and pack shed crates – each application has a different design and color. We harvest only using field crates or buckets and pack shed crates are only used for clean produce in the pack shed.

Because 5-gallon buckets are used for many purposes around the farm, any 5-gallon buckets NOT for harvest are clearly marked with a bright pink X and are labeled with their particular use (chicken feed, irrigation, fencing, compost, etc) to prevent cross-contamination.



A workflow map is helpful for design planning and employee training, showing where each product moves through the pack shed efficiently, paying careful attention to reducing cross-contamination (washed / unwashed produce).

This workflow at Bakers' Acres shows where product comes into the pack shed for washing, where indoor and outdoor crates are stored, where product is dried, where it goes when it moves into the packing area or storage, where the compost bucket is located, water access, the cooler, where the handwashing sink is located, where chemicals are stored, where the harvest board is posted and where packing materials are stored.

## Washable Surfaces



Washable surfaces make packing clean produce easy. Sanitize surfaces that come in contact with produce. Wood can harbor pathogens.

Loon Organics has cleanable steel sheeting on walls behind the wash table, and the wash table itself is cleanable metal. The wash tubs can be emptied and cleaned. The hose hook keeps the hose end clean by keeping it from falling out of the tub onto the floor.

At Bakers' Acres, a stainless steel sink is used for washing early and late season greens indoors. We use a metal spray table as well.



## Movable Work Surfaces and Equipment



Handy but not necessary – have work surfaces and equipment be movable to allow for an evolving pack shed, ease in cleaning, and ease on bodies. At Prairie Drifter Farm, screen tables, wash tub stands, and washing machine for spinning greens are on wheels with an option to lock the wheels. We also use several folding tables as sanitizable surfaces for bagging and packing produce.



## Storage

Safety, order, and efficiency

- Chemical storage
- Rain gear, noise-canceling headphones
- Packing materials



Create a designated space for storing chemicals for sanitizing food contact surfaces – tables, walls, buckets, wash tanks, crates, etc. Designating spaces for packaging materials, safety gear, etc. helps to keep things organized and safe for your employees and your product. Enclosed storage containers keep packaging materials free from rodents.

For packing, it's helpful to start with an efficient layout in the pack shed where you have your boxes, butcher paper, markers, labels, scale – all the things you need for packing – close at hand.

## Pack Shed Ease

Wheels, carts, pallet jacks, hand carts, fork lifts, rollers



Minimize lifting and maximize efficiency with wheels! This usually requires concrete floor—another very worthy investment.

Have brooms or squeegees for cleaning the floor in a designated spot.

Gravity rollers.

## CSA Pack Line

- Assembly line to pack
- Rollers or tables – move CSA boxes or move packer, choice depends on scale



Choose a CSA pack line layout to fit your operation with a positive impact on efficiency, ease of packing, and workflow. At Prairie Drifter Farm, a farm manager is at the beginning of the line and at the end to help ensure each box is packed correctly and to do quality control.

CSA wax boxes are inspected at the beginning of the line for cleanliness and/or signs of damage.

This will not apply if you have a market style CSA. Considerations for a market style CSA will be similar to those of a farm doing a farmers' market.

Continual process, based on quality and buyer preference.

## **SORTING & GRADING**

Sorting and grading is something you do throughout the harvest and post-harvest process to ensure quality product to satisfy your market or buyer.

## Sorting & Grading

At harvest, washing, and packing stages

- Know your customer
- USDA AMS standards
- Options for use of “seconds”
  - Commercial kitchens for freezing and canning
  - Funding from Second Harvest for labor to harvest crops left in the field



How you grade safe produce depends on your buyer.

During harvest, washing and packing, watch for contamination (fecal matter), rot, blemishes, etc. and either discard the produce to the compost pile if it's not salable, or grade it as a second or third and sell it to the appropriate buyer.

If for wholesale, standards are set by the USDA Agricultural Marketing Service (AMS)  
– For example: Available on the internet, the AMS shows snap beans grading with visuals, and an example inspection certificate.

To quote from their site: “Condition = Well Filled pack, Fairly well filled, slack (1/2” below the cover, and movement). Temperature, size and quality = size, shape, cleanness, maturity, sunscald. U.S. FANCY, U.S. NO.1, U.S. NO.2; tolerance level for defects like broken or other damage 10% 13% and 15% respectively, and rot 1%.”

Each piece of information in the AMS tells you what is acceptable grading for that product.

There are some options for seconds including processing and Second Harvest.

## Grading Wholesale to Retailer or Distributor



- Uniformity
- Grade A (Firsts, 1's)
- Maximum shelf life
- Standard packing and packaging

Wholesale usually wants Grade A – very uniform. Some institutional markets may accept less uniformity if their emphasis is on flavor, niche product, and/or using product for processing. A lower grade may mean a lower price for the farmer. Maximum shelf life is needed because it could be 1 week or longer before customer is seeing product, versus direct-sale.

## Grading Wholesale to Restaurants or Farm-to-School



- Open to different grades (B & C size potatoes)
- Seconds or 2's
- Produce for deli/processing can accept 2<sup>nd</sup> quality (pricing should reflect 2nds)
- Some restaurants may demand highest quality only
- Communication

Restaurants, co-op delis, or farm-to-school program sometimes accept more variance in grading – they will usually be processing the product and don't require uniformity. On the other hand, some restaurants might demand the highest quality only. Communicate with your buyer to understand what grading requirements they have.



## Grading Example

### Tomatoes at Loon Organics

Grade A: no cracks or blemishes, not misshapen, similar variety & medium size



Cull tomatoes with open cracks



Canning tomatoes



CSA quality? Your call.

Loon Organics sorts for Grade A tomatoes, culls those with open cracks, and sorts tomatoes suitable for canning customers. We only put top quality tomatoes in CSA boxes, unless maybe during the first tomato harvest of the year if we don't have quite enough to fill all of the boxes.

## Keep Open Cracks on the Farm

Cracks expose fruit to potential pathogens in soil and water



Cull cracked produce in the field, wash area, or while packing. Open cracks are a potential route for pathogens to enter produce. You can't wash off contamination once it's internal. Due to a history of illness related to these crops, tomatoes and melons are now both considered "potentially hazardous" according to the FDA food code.

Keep this produce on the farm, either in the compost pile or for your personal use if the produce is salvageable.

Pack size, packaging, process.

## **PACKING & PACKAGING**

There are a variety of acceptable packing and packaging practices. How you pack and package your produce varies depending on the crop and the customer. Pack sizes, materials, and grading should fit your buyer's needs.

## Standard Pack Sizes

- Use standard pack sizes for wholesale
  - Handbook 66
  - Penn State Produce Packing Guidelines
  - USDA Agricultural Marketing Service (AMS)
- Work with buyer to understand their preferences



Always talk to your buyer; different buyers even in the same class (such as distributors) sometimes have different preferences.

For example, from the **Agriculture Handbook 66** “The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks”:

“Leaf collards, kale, turnip greens, and mustard are commonly bunched using rubberbands or twist ties. The size of the bunch may vary but is generally approximately 0.5 kg (1 lb). Direct packing of loose leaves may be done at the request of the buyer. Head collards are packed loose into cartons with 8 to 16 bunches per container. Waxed fiberboard cartons or wire-bound crates are commonly used (Hurst 1999, Sanders et al. 1999). Spinach leaves, which are smaller and more tender, may be packed loose or bunched, but they require greater care to avoid handling injury (Suslow and Cantwell 2002).”

## Packaging Materials

- Plastic clamshells
- Bio-degradable plastic bags
- Cartons
- Waxed boxes, box sizes
- Waxed freezer/butcher paper
- Box liners
- Twist-ties
- Rubberbands



There is a wide variety of packaging materials used in the industry: Plastic clamshell, waxed boxes, twist-ties, etc. Examples of common practices for wholesale: Pint clamshells for cherry tomatoes, ½ bushel boxes for beans, one-layer tomato boxes for heirlooms, 1 1/9 bushel box for cucumbers.

The packaging materials you choose will depend on the customer.

## Waxed Butcher Paper Over Top of Product

Keep the produce clean, keep moisture in



Waxed paper on the bottom and/or top of product in boxes helps to keep the produce clean and also holds in moisture to reduce wilting. Note: waxed boxes have some insulating properties; if you put cool produce from the cooler into a waxed box, the box will keep it cooler, but the reverse is also true – warm produce put into waxed boxes will stay warmer (which is bad for shelf life).

## Packing & Packaging for Wholesale

Distributors, restaurants, farm-to-school

- Pack in bulk or multiple bunches
- Price by weight or quantity
- Follow standards for bunch and pack sizes



For wholesale, produce is packed in bulk or in multiple bunches. Distributors that are re-selling to retail outlets may have different or very specific expectations for packaging. When in doubt, talk to your buyer, or follow one of the standards for bunch and pack sizes. Pricing varies – sometimes by bunch, sometimes by weight.



## Packaging for Retail

Food co-ops, farmers' markets

- Selling to a consumer, an eater
- What do end consumers like?
- Small store = you help with packaging, display
- Branded packaging helps build loyal customers



For retail sales, you are either selling directly to the eater at a farmers' market, or to a co-op that will sell to the end-consumer. If selling to a smaller grocery store or co-op, you may need to do the retail packaging – putting produce in the bags or boxes preferred by consumers, putting on the twist-ties on bunches, etc. Sometimes using packaging that is branded for your farm can help create customer loyalty and increase sales of your product. Always talk to the co-op buyer about their preferences for packaging.

## Packaging for CSAs

- Direct sale goal is to provide equal-to or better-than value from a store
- Box size considerations
- Reuse packaging
- Minimize damage to produce
- Beauty!



For CSAs, box size varies; listen to feedback from customers on appropriate quantities. Your standard should be to provide equal-to or better-than value from a store.

Many CSAs use  $\frac{3}{4}$  bushel boxes. Some start with  $\frac{1}{2}$  bushel or  $\frac{5}{9}$  bushel and increase to  $\frac{3}{4}$  toward the middle of the season. Others are using heavier-duty reusable plastic containers or reusable cloth bags.

Consider food safety when re-using boxes or crates. Re-use is good in terms of conserving resources but the reused materials also need to be in good condition. You may choose to use a plastic liner inside re-used boxes.

Make sure that you are packing CSA boxes to minimize damage to produce; put heaviest things on the bottom and delicate items on top. Pack to minimize shifting of items during transport.

The aesthetics of the boxes are also important – you want people to say “Wow!” when they open their box.

## Packing: Same Quality, Different Packaging

Wholesale



Retail



CSA



Consumers are used to a certain level of quality in their grocery store's produce section. Your farm can easily equal or surpass that with good post-harvest handling practices, grading, and sorting. Buyer preference determines packaging for different products in different markets, but good quality for any marketing channel means returning business and high retention rates. Notice the packaging differences for broccoli and lettuce depending on the market stream.

Temperature, location, humidity.

## **STORAGE**

Good storage practices including temperature/humidity control, proper location, curing, and length of time in storage help maintain produce quality from your farm both short-term and long-term.

## Storage Temperature & Location

### Cold Storage

#### Cooler

(32-35°)

- Asparagus
- Broccoli
- Carrots and root crops for winter storage
- Greens (lettuce, chard, spinach, kale)
- Green onions
- Onions and garlic after curing
- Peas
- Sweet corn

### Crops Sensitive to Chilling Injury

#### Cooler

(45° and up is ideal)

- Cucumbers
- Eggplant (longer term storage)
- Green Beans
- Melons (Ripe)
- Peppers
- Zucchini/Summer Squash

#### Not refrigerated

(Cool place in pack shed)

- Basil
- Eggplant (1-2 days)
- Melons
- Okra
- Seed Garlic
- Tomatoes
- Winter Squash

There is some flexibility in this list; different farms do different things based on preference, space available, and time held in storage.

35 degrees is a common cooler temperature.

Chilling injury of cold-sensitive crops (okra, cucumbers, zucchini): Damage occurs when these crops get too cold, under 45 degrees typically, and the customer will see the problems a few days later when the produce has come out of storage and warmed up to room temperature.

For example, tomatoes held 10 days at 38 degrees show rotting spots once warmed to room temp, cucumbers after near freezing temps warm up to rot, beans get brown spots. Others: poor flavor, poor ripening.

Beans at our farms do go into the cooler but are stored in the front where it's typically warmer.

Reference your respiration rate handout for proper storage temperatures.

## Storage in Just One Cooler?

- Put sensitive produce in warmer part of cooler (near door or up high on shelves)
- Plastic strips can be put in middle of larger cooler to divide into cooler and warmer areas
- Can use insulated boxes or small hand coolers to keep sensitive product warmer.



Most small farms, just have one cooler available to use. Here are some tips when you need to hold sensitive produce in cooler over 24 hours, to help prevent chilling injury:

Put sensitive produce in warmer part of cooler (near door or up high on shelves)

Create 2 coolers in one: put plastic strips inside cooler to create a warmer and cooler area. (Warmer area will be near door, away from compressor)

Put sensitive produce into an insulated box or small hand cooler to keep it warmer.

## Cooler Storage

- Best used for keeping cool produce cool
- Temperature
- Reduce respiration rate
- Cover with plastic, in covered crates, or in boxes to hold in moisture



In coolers, cover highly perishable, high respirators with plastic before going into the cooler – reduces exposure to the air, keeps vegetables crisp. Sweet corn doesn't need to go in plastic, but it's important to store it cool.



## Cooler Storage

- Right sizing
- Keep product off ground
- Plastic strip doors
- Monitor temperature
- Be mindful of ethylene sensitivity and exposure



Cooler tips: right sizing for your operation, metal/sanitizable racks to keep produce off the ground, plastic strip doors to hold cold in and keep warm air out, monitor temperature. Scaling up: think about what your needs will be in 5 years, don't build too small of a cooler.

Ethylene is a gas caused by ripening produce, which can accelerate decomposing / ripening of other nearby crops. It can be beneficial/detrimental. Inside greenhouses, cold storage rooms, and transportation vehicles, ethylene can accumulate to active levels. To reduce exposure: use ventilation and store at the lowest temperature possible without freezing (e.g., carrots freeze at 29 degrees), minimize time before consumption.

All leafy greens are sensitive to ethylene in the post-harvest environment, which accelerates senescence and leaf yellowing.

## Tomato Storage

- Designated, cool area in pack shed
- Above 45 degrees
- Rodent proof



First-in-first-out



One-layer tomato trays for Heirlooms



Boxes for Slicers/Romas

Store tomatoes in a cool, designated, pest-free area in the pack shed, at 45 degrees or warmer. Use a system for first-in-first-out. Store heirlooms in single-layer trays; slicer/romas can handle stacking a couple of layers high as long as they're not over-ripe.

## Long-Term Root Crop Storage

- Root crops (beets, carrots, radishes, turnips) for winter storage at 32°
- Top roots
- Cleaning may shorten storage life/not cleaning may stain carrots
- In plastic to maintain humidity
- Potatoes at 40°



If you're planning on winter-long sales, your crops need to be stored at appropriate temperatures.

Storage of carrots, other root crops – Top them in the field. Personal preference whether field dirt is removed before or after storage. Not a food safety issue. Soil type may dictate when you clean roots: clay soil will stain carrots after it's dried on the roots. However, cleaning may shorten their long-term shelf life. Keep in plastic to retain humidity and prevent shriveling.

Potatoes: 40°F for long-term storage

## Curing for Onions & Garlic

- Garlic – well ventilated, out of direct sun, 2 weeks, trim and grade once cured
- Onions – dry, well ventilated, 1-2 weeks, clean roughly once cured
- Onions and (non-seed) garlic after curing go into cold storage



Curing is needed after harvest of alliums “to seal the leaf tissue that makes up the bulb against moisture loss and entrance by pathological organisms.” (Chris Blanchard)

There are several options for curing garlic and different farms have different practices. Remember when handling that garlic is very fragile. Approximately 2 weeks of curing at 80 degrees with good air circulation and out of direct sunlight is ideal.

Due to space considerations, Prairie Drifter Farm has cured garlic hanging in bunches of 5 in a dry, well-ventilated shed. Loon Organics cures garlic spread out on the floor of the loft of their barn. Other farms will cure garlic in their greenhouse. If curing garlic in a greenhouse, consider using shade cloth to prevent garlic from overheating or sunscald. Once garlic is cured, the stems should be trimmed and garlic should be graded. Save back bulbs you plan to use for seed.

Onions are typically cured in a greenhouse where they can be protected from rain and dew. It is also a good idea to use shade cloth for curing onions in a greenhouse to prevent sunscald. Once cured, onions should be roughly cleaned to remove stems, and then packed (50# onion bags or 1 1/9 bushel boxes).

Onions are prodigious re-rooters and re-sprouters; curing during high-humidity conditions or exposure to humidity after curing could cause this problem. For example, Lisa, while visiting her parents’ house noticed why they were having such a

hard time curing their onions. Onions were spread out in the house and growing new green shoots already, and it was only late September. The house was very humid and hot, and no air was circulating. We promptly moved them outside where there was a breeze and hot, dry sun for a couple of days.

Onions and garlic: need to be at 32°F post-curing for winter-long storage – cold and DRY.

Seed garlic: don't refrigerate

## Curing for Winter Squash

- Cure winter squash for 1-2 weeks
- Frost risk if curing in the field
- Use greenhouse to keep dry and protected from cold



Some crops like winter squash need a curing step in order to retain maximum quality in long-term storage. Curing process varies per crop and variety, but typically 1-2 weeks.

Loon and Prairie Drifter cure squash inside their greenhouses to reduce the risk of frost damage in the late fall.

See Umass “Harvest and PostHarvest Needs of Fall/Winter Storage Crops” for full info by crop.

## Storage of Winter Squash

- Store at 50-55°
- Off the ground
- In bins
- Careful stacking so stems don't bruise each other
- Pest control



Winter squash: Store at 50-55°F for long-term storage, off the ground in bins or on pallets. Use care when stacking to prevent bruising from stem ends hitting one another. Use and monitor traps for pest control.

At Bakers' Acres, we store winter squash in a cool room and have full quality pumpkins and squash through February.



**TRANSPORT**

## Transporting from the Farm to the Customer

- Keep cool, deliver early if possible, use air conditioning
- Set pick-up timeframes for CSA boxes



If delivering product a distance from the farm and doing so without refrigeration, try to deliver early in a.m., cover cold product out of cooler with blankets to insulate the cold in, use the a.c., don't put produce in an open flat bed truck (very hot and windy), trailers that are insulated and even outfitted with a cooler unit are handy.

Be sure to clean your vehicle before delivery. Keeping a log and scheduling periodic full cleanings are two good tips to ensure your transport vehicle is food-safe.

Bakers' Acres uses a dedicated station wagon and parks it in the shade to cool the vehicle interior before loading boxes. Ideally, we would use a refrigerated truck but our scale doesn't justify it economically or environmentally. We also use an enclosed trailer when deliveries are larger than the capacity of the station wagon. In the trailer, if it's not packed to capacity, we make sure boxes or pumpkins are secured and won't move around during transportation.

Loon Organics uses a white extended cargo van for delivery. We back our van up to our lean-to and bring produce boxes out either on pallets or hand carts to quickly load into van.

Prairie Drifter Farm also uses a cargo van with an insulated floor (rigid foam board topped with plywood). We are able to back our van into the pack shed right next to the cooler for easy and quick loading. As much as possible, produce boxes are stored

on carts in our coolers to easily transport boxes and minimized lifting.

Loading tips: When loading your delivery vehicle, pack boxes strategically to minimize shifting during transport. If you have multiple delivery stops, order your boxes as first in, last out for efficiency during delivery. Take care not to undo flaps on the bottom of wax boxes when sliding boxes into vehicle. Consider bringing a cart with you to move produce from vehicle to delivery site if you have a large quantity of produce to move and no available carts at your delivery site.

Resources for cooling a trailer – see resource handouts.

People grocery shop with their eyes.

## **DISPLAY & POINT-OF-SALE**

Your product presentation and quality make a difference for customer satisfaction.

## Point-of-Sale: Wholesale

### ■ Invoicing and traceability

- Farm name, address and phone number
- Name of certifier if certified organic
- The item and quantity
- Tracking code:  
*SMIX0524LBFNW0525TB* (The item, the date it was harvested, harvester, the field it came from, the date it was packed, and who packed the produce).
- Customer name and address
- The date of shipment



**Loon Organics Farm**  
Laura Fretz & Adam Cullip  
23229 200<sup>th</sup> St. Hutchinson, MN 55350  
Certified Organic by MOSA

**Butternut Squash**  
**40 pounds**

Lot: 1/10/13-23      Zella's Cafe



**Prairie Drifter Farm**  
Nick and Joan Olson  
61369 223<sup>rd</sup> St, Litchfield, MN 55355  
Certified Organic by MOSA

Crop: \_\_\_\_\_  
Harvest Date: \_\_\_\_\_ Field #: \_\_\_\_\_  
Ship Date: \_\_\_\_\_ Qty: \_\_\_\_\_

For any wholesale account, it is important to label boxes and provide tracking information. Use waterproof labels. Ideally, we would use a label printer with waterproof ink as well.

This tracking code means: Salad Mix, harvested May 24 by Lisa Baker, from the Field “New West”, and was packed on May 25 by Tom Baker.

Loon Organics has the date and field number in their label lot #. This combined with the invoice and field records provides tracking information sufficient for their food safety and organic certification needs.

Prairie Drifter Farm uses a standard label and hand-writes information on each label as boxes are packed for storage and transportation.

## Point-of-Sale: Wholesale

Talk to your buyer about their preferences for:

- Pack size
- Packaging and Branding
- Delivery Procedure



Different buyers have different preferences, talk to them about their preferences for pack size and packaging. Small grocers might appreciate tips for keeping produce fresh, like trimming stems, misting, etc. In most cases though, you won't have control over their display.

Know the delivery procedure ahead of time – which door, who signs invoice on receipt, will product temperature be taken upon delivery?

This display is from the St. Joe food co-op.

## Point-of-Sale: Farmers' Markets

- PHD: Pile it High and Deep
- Alternating colors, bountiful, height
- Shade, minimize dehydration
- Clean market materials



People notice a beautiful display, and it makes a difference in how much produce you sell. After doing all the work to grow and harvest and pack, take extra care to build a beautiful display for effective selling. PHD from Chris Blanchard, alternate colors and height, use good signage.

Tips to maintain quality through a long market: use coolers if possible (especially at a fully outdoor market), shade, minimize wind dehydration, mist, display only a portion of the available product, swap out extras to continue looking fresh, use sheets or blankets to cover backstock boxes to help keep moisture and cool in.

Regularly clean market display containers, mist bottles, and linens.

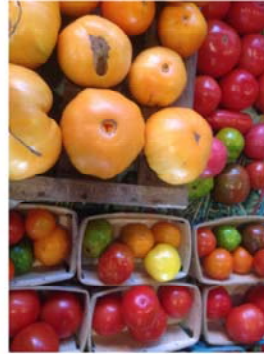


## People Eat with their Eyes

Good signage



Eye candy



People eat with their eyes. Good point-of-sale techniques: Signage and eye candy.

## Point-of-Sale: CSA boxes

- Only first quality
- Size variation is acceptable (unlike wholesale)
- Very clean, very high quality = high retention rate
- Good communication



People should open their CSA box and say WOW! Again this comes back to ultimately building your business through quality farming practices and good post-harvest handling techniques.

Here is an example of a CSA pick-up site: Good signage to instruct customers, welcoming, clean, organized.

## Quality Produce = Happy Farmers & Happy Customers!



Our take away is to think about the post-harvest handling chain on your farm and how it is working (or not working) for you. Is there a crop or two in particular on which you might want to focus and improve your handling? Or perhaps improve part of your infrastructure and efficiency? Even a small investment of time and resources can make a huge impact on your product quality.

Improvements on our farms have been and still are a gradual progression from year-to-year, a process of increasing our knowledge and education, training employees, investing in infrastructure, adding in new tools/systems, etc. Every year we improve a little bit more.

Improving post-harvest handling is important to us as farmers because we work hard to grow, care for, and harvest quality products. We want to ensure that quality product stays that way as long as possible, thereby satisfying our customers and sustaining our businesses. All the while feeding people great, local food in the process.

## Questions?



Lisa Baker  
Bakers' Acres  
[lisa@bakersacresfarm.com](mailto:lisa@bakersacresfarm.com)



Laura Frerichs  
Loon Organics  
[loonorganics@hotmail.com](mailto:loonorganics@hotmail.com)



Joan Olson  
Prairie Drifter Farm  
[priatedrifterfarm@gmail.com](mailto:priatedrifterfarm@gmail.com)

### Editor:

Jane Grimsbo Jewett, Minnesota Institute for Sustainable Agriculture

### Technical Advisors:

Cindy Tong, Department of Horticultural Science,  
University of Minnesota  
Helene Murray, Minnesota Institute for Sustainable  
Agriculture  
Annalisa Hultberg, University of Minnesota  
Jan Joannides, Renewing the Countryside

### Advisors:

Glen Hill, Urban Roots  
Annalisa Hultberg, University of Minnesota  
Jane Jewett, Minnesota Institute for Sustainable  
Agriculture  
Jan Joannides, Renewing the Countryside  
Linda Kingery, Northwest Regional Sustainable  
Development Partnerships  
Erin Meier, Southeast Regional Sustainable Development  
Partnerships  
Helene Murray, Minnesota Institute for Sustainable  
Agriculture  
Joan Olson, Prairie Drifter Farm  
Jake Overgaard, University of Minnesota Extension  
Michele Schermann, University of Minnesota  
Lisa Smiley, Cannon Valley Vineyards  
Courtney Tchida Minnesota Institute for Sustainable  
Agriculture  
Cindy Tong, University of Minnesota  
Caroline van Schaik, Land Stewardship Project  
Dale Woodbeck, Lakewinds Natural Foods  
Vince Xiong, Minnesota Food Association

Acknowledgements. Thanks to authors, photos, advisors.

Questions?

Remind about handouts, if Wholesale Success is for sale, etc.

Surveys.