





Precooling Colorado Crops

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INFORMATION SHEET

What is precooling?

The term precooling refers to the removal of heat energy from crops, known as field heat, after they are harvested. Precooling is ideally done immediately after harvest, as many crops begin to degrade rapidly after harvest if kept at high temperatures.

Why is Precooling Beneficial?

(Kader 2002)

Precooling and temperature controlled storage can:

- **Reduce respiration rate** – Don't forget produce is still alive! Reducing the respiration rate will slow down enzymatic processes that cause produce to degrade.
- **Reduce water loss and wilting**
- **Slow the growth of spoilage bacteria** – These bacteria are always present and can cause rapid spoilage at higher temperatures.
- **Slow ripening** – At higher temperatures, ethylene producing produce will ripen quickly, perhaps before it can be consumed.

Importance of Precooling

For highly perishable products, such as strawberries, deterioration at high temperatures occurs quickly. For example, every hour delay in precooling strawberries harvested at 86°F will result in a 10% loss in shelf life (Brosnan 2001). Conversion of sugar to starch in sweet corn occurs 4 times more rapidly at 50°F than at 32°F (Boyette 1990).


Strawberries stored for 5 days at 32°F (left) next to strawberries stored for 5 days at 50°F (right). Courtesy Sensitech™ (2013)

Should all crops be precooled to the same temperature?

Not necessarily. It is important to determine the ideal temperature of the crop you are harvesting and ensure it is not cooled below the optimal temperature. Crops that are damaged by low temperatures can exhibit browning, texture defects, short shelf life, incomplete or failure to ripen, or changes to the flavor and color. These crops are referred to as 'chilling sensitive' crops.

Table 1: Cooling temperatures which may result in chilling injury

Commodity	Temperature °F
Chilling injury will occur below these temperatures	
Asparagus	37
Cantaloupe	39
Cucumber	50
Eggplant	50
Honeydew	50
Peppers	45
Sweet Potato	50
Tomatoes (Pink)	50
Tomato (Green)	55
Watermelon	50

(Adapted from Kader 2002, Thompson 2003)

PRECOOLING METHODS

Precooling produce can be achieved by utilizing one or more of the common methods below.

- Room cooling
- Forced air cooling
- Hydrocooling

Additional methods to precool include vacuum cooling and icing but are not outlined in this fact sheet.

FAST FACTS

26%

Percent of food loss in the United States in 2008 attributed to fruits (9%) and vegetables (17%). Improper postharvest handling contributes greatly to these percentages.

5 years

Estimated amount of time to break even when investing in a mobile forced air cooling unit (Talbot 2002).

FOR MORE INFORMATION

Colorado Farm to Table Food Safety
http://www.farmtotable.colostate.edu/

UC Davis Postharvest Technology
http://ucanr.org/sites/postharvest/

What Colorado crops should be cooled to below 41°F?

The crops listed in Table 2 will best maintain their quality at temperatures just above freezing. Cooling to temperatures below 41°F, and as close to 32°F as possible, will increase their shelf life by days, and in some cases, even weeks.

Note: The range of shelf life listed below for each product can be attributed to the fact that the longest shelf life is obtained at 32°F, and is incrementally shortened as the temperature nears 41°F. Temperatures above 41°F lead to rapid quality loss.

Table 2: Shelf life at refrigerated temperatures

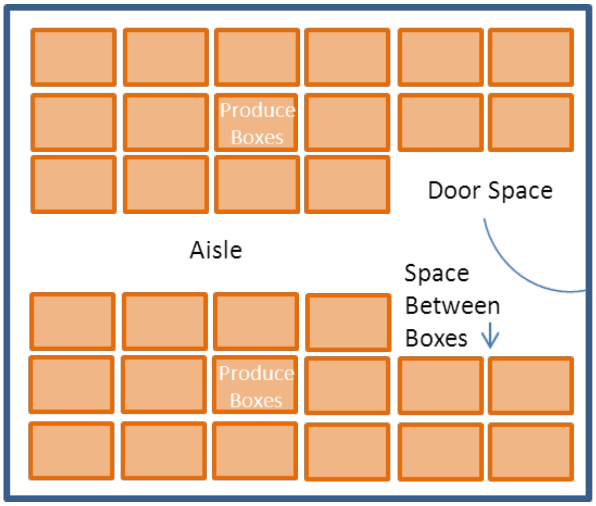
Commodity	Shelf Life* if Stored between 32°F & 41°F
Cabbage	20 days to 3 months
Carrots	2-3 weeks
Lettuce	14 to 28 days
Peaches	30°F to 36°F: 1 to 5 weeks, or greater than 45°F. Do not store between 36°F and 45°F if the cultivar is susceptible to internal breakdown.
Mushrooms	2 to 7 days
Sweet Corn	5 to 8 days
Strawberries	About 1 week

*Shelf Life – The amount of time produce maintains consumer acceptability after harvest. (Adapted From: Kader 2002, Thompson 2003)

Focus On Food Safety

Produce is often harvested at high environmental temperatures, sometimes in excess of 80°F. During the time period between harvest and precooling, it has been shown that spoilage and pathogenic microorganisms can multiply rapidly under certain conditions. Precooling can slow the growth of harmful microorganisms if present and allow for a longer shelf life.

TOP VIEW - ROOM COOLING

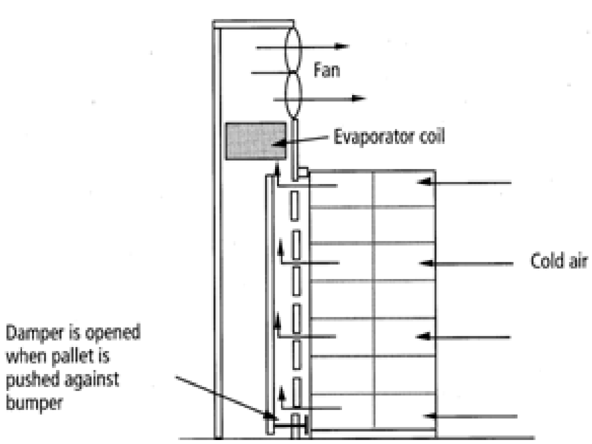


- 25 - 40% of the floor space should be open to allow of space between produce. Allow 4 – 6 inches of space between boxes and walls and at least 1 inch of space between boxes.

FORCED AIR COOLING SCHEMATIC

(Thompson 2002)

- The fan creates a drop in pressure across the pallet, which draws the cold air from the room through the pallet of produce.



- The damper is opened by the pallet being pushed against the wall, creating openings behind the pallet where the air is drawn through.
- As the cold air flows through the pallet, it picks up heat from the produce. The air then flows through the evaporator coils and is cooled again prior to being re-distributed to the cold room.

Pre-Cooling Methods

Room Cooling

(Kitinoja 2002, Boyette 1991)
Room cooling utilizes a standard cold room of any size. These walk-in cold rooms are designed to maintain the temperature of produce, but not necessarily to *rapidly* cool it. There are several factors to take into account when determining how long the produce will need to be in the room cooler prior to reaching the ideal temperature. Factors under the farmer's control are: initial produce temperature, which can be controlled to a degree by harvesting in the cooler hours of the day, packaging (ventilation and size), and amount harvested at one time.

- May take 24 hours or longer to cool produce to its long term storage temperature.
- ❗ It is critical not to pack cold rooms too tightly. 25 - 40% of the floor space must remain open to allow for space between the walls and between produce boxes. If sufficient space is not present, produce will not cool.
- Hot spots can remain in the center of boxes or bins, even when the outside portions of the containers are cooled.
- Fans can be added to room coolers to speed cooling by increasing the airflow.

Forced Air Cooling

(Thompson 2002)
Forced air coolers draw air through packaging resulting in rapid flow of cold air over produce. This increased airflow results in fast removal of heat from produce. Forced air cooling is very versatile and can be used for almost any produce item.

- Forced air can cool produce in less than an hour.
- Because of the risk of drying product out, forced air cooling should only be used as long as necessary to cool produce to the desired temperature. Longer durations will cause excess moisture loss and deterioration in quality.
- For produce susceptible to drying, it is advisable to cool 7/8th of the way to the long term storage temperature, and then place the produce in a room cooler. Combining rapid forced air cooling with a room cooler for storage is an effective strategy to maximize quality.

IS PRECOOLING WORTH THE INVESTMENT?

Poor temperature management throughout the supply chain, from precooling to market, can result in large losses of value.

- In one study of a supply chain for lettuce, a loss in value of $172.50 per 900 cartons was demonstrated due to poor temperature management (Kader 2004).
- Cooling delays for strawberries result in a 10% loss in shelf life for every hour of delay (Brosnan 2001).
- Delays between harvest and precooling for grapes were documented to cause a 15% loss in the value of the commodity (Kader 2004).

In addition to maintaining the value of your crops, many farmers who have invested in pre-cooling methods can choose to charge other farmers to cool produce:

- Pay rates for precooling may vary depending on the technology used. In testing a portable forced air cooler capable of rapid cooling, the University of Florida cited a cooling charge of $0.25 per pound of produce (Talbot 2002).
- Two packing sheds in Colorado charge between $10 and $18 per bin (~900 lbs.) of produce. Bins are placed in room coolers.

FOCUS ON THE FUNDAMENTALS

Harvesting produce during the coolest hours of the day, and utilizing shade for harvested produce awaiting transport from the field, are two very effective methods to extend the shelf life and maintain the quality of your produce (Kitinoja 2010).

Hydrocooling

(Thompson 2002)

Contact with water will increase the rate of spoilage of many produce items and can be affected by pH of the water. Many Colorado crops can contact water without losing quality. Asparagus, broccoli, beets, carrots, cauliflower, celery, cucumbers, cabbage, eggplants, leeks, peas, rhubarb, spinach, summer squash, sweet corn, chard, and cantaloupes are good candidates for hydrocooling.

Many small and medium sized growers will use a batch hydrocooler in which produce is cooled one batch at a time. Cold water is used to remove heat from the produce.

- Produce with small diameters, such as asparagus, may cool in as quickly as 6 minutes.
- Large diameter produce, such as cantaloupe, may take as much as 1 hour to cool.

Produce Safety & Postharvest Water

(Suslow 2001, Ritenour 2002)

Anytime water is utilized in a postharvest process, understanding and managing the quality of water used is critical to the safety of the product. Postharvest water is the single most critical point which can amplify a problem, and spread contamination to entire lots of produce. For all postharvest processes that involve water, the water must start out as being potable, or the equivalent of drinking water. Sanitizers also should be added to the water to prevent the spread of harmful microorganisms. Sanitizers are not added to 'wash' the produce or kill all pathogens, but rather to prevent the spread of microorganisms.

There are many options to sanitize postharvest water including, but not limited to, the addition of chlorine, peroxyacetic acid, and ozone. Chlorine is typically the cheapest and easiest sanitizer to use for postharvest purposes. When managing chlorine levels in the water, pH and turbidity (the amount of solids, leaves, and other organic matter) are two critical areas to monitor to ensure the sanitizer will work properly. A pH between 6 and 7 is recommended for chlorine use. Knowing when to change water in hydrocooling or bulk cooling tanks will also ensure chlorine is not being bound up by organic matter. Be sure to measure and record free chlorine, not total chlorine.

- Depending on the commodity, recommended free chlorine levels are generally between **50 and 200 ppm**.
- For organic growers, up for 4 ppm free chlorine can be used, if followed by a rinse with potable water.

For more resources on sanitizing postharvest water, refer to the resources on page 6.

COOLBOT™

Many farmers are taking advantage of a relatively inexpensive and easy to install technology call 'CoolBot™'. This technology allows you to convert a window air conditioning unit into a walk in cooler or small refrigerated trailer.

CoolBot™ www.storeitcold.com

The CoolBot™ controller costs $299 (2013). Additionally, you'll need to purchase the rest of the materials to build your walk-in room cooler or mobile cooler. Estimates to build small room or mobile coolers range from $2,000 to $4,000, depending on if you are using new or used materials (Perkins-Veazie 2013).

TAKE NOTE!

A common mistake in many produce operations is to over pack transportation vehicles. In order to make the most of your investment in refrigerated equipment, you'll need to use it properly. Be sure to leave adequate space for airflow between the walls and the produce, and do not over pack the trailer.

Low Cost Mobile Cooling Systems

'Traditional' cooling systems may be seen as too expensive for many smaller growers. There are many resources available that outline different types of solutions to fit the needs of your operation.

Small-Scale Refrigerated Trailer

(Perkins-Veazie 2013)
Dr. Penelope Perkins-Veazie of North Carolina State University provides detailed instructions on how to construct a small refrigerated trailer. You can find these instructions in the DIY Postharvest Equipment section of the NC State Extension Website: http://ncfreshproducesafety.ncsu.edu/good-agricultural-practices/postharvest-handling/diy-postharvest-equipment

USDA Portacooler

(Talbot 2002)

A mobile cooler utilizing the principles of forced air outlined on page 3 of this fact sheet was designed by the USDA several years ago. It is slightly more expensive to build than the unit above due to the additional cooling capacity necessary for forced air cooling. The advantage is that it can rapidly cool highly perishable products.

Fixed costs and return on investment of the USDA Portacooler is outlined by Talbot and Fletcher (2002).

Plans for construction of the Portacooler are available here: http://www.bre.umd.edu/portacooler3.htm

SUGGESTED READING AND RESOURCES

Commodity specific postharvest handling information:
http://postharvest.ucdavis.edu

Small-scale refrigerated trailer:
http://ncsu.edu/enterprises/ncfreshproducesafety/refrigeration-units/pack-n-cool/

Postharvest Chlorination:
http://anrcatalog.ucdavis.edu/pdf/8003.pdf
http://edis.ifas.ufl.edu/ch160

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