EXTENSION
UtahStateUniversity

Vegetable IPM Advisory

UTAH PESTS

Pest and Production Update, Utah State University Extension, **September 17, 2014**

Harvest and Postharvest Considerations

Temperature:

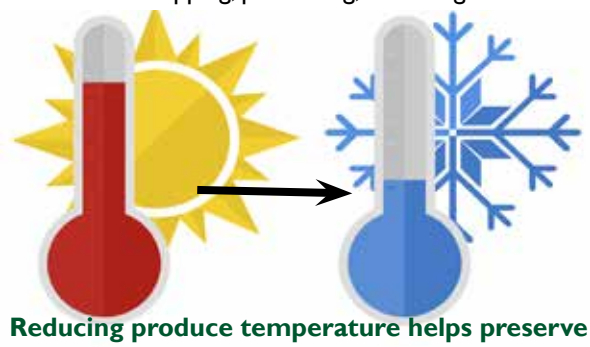
Temperature is the single most important factor in maintaining quality after harvest. Refrigerated storage is often used to keep temperatures at levels that help slow elements of deterioration in perishable crops such as:

- Aging due to ripening, softening, and textural and color changes.
- Undesirable metabolic changes and respiratory heat production.
- Moisture loss and the wilting that results.
- Spoilage due to invasion by bacteria, fungi, and yeasts.
- Undesirable growth, such as sprouting of potatoes.

Of these, the most important function of refrigeration is to control the crop's respiration rate. Respiration generates heat as sugars, fats, and proteins in the cells of the crop. The loss of these stored food reserves through respiration means decreased food value, loss of flavor, loss of salable weight, and more rapid deterioration.

For refrigeration to be effective in postponing deterioration, it is important that the temperature in cold storage rooms be kept as constant as possible. Exposure to alternating cold and warm temperatures may result in moisture accumulation on the surface of produce (sweating), which may hasten decay. Storage rooms should be well insulated and adequately refrigerated, and should allow for air circulation to prevent temperature variation.

Pre-cooling is the first step in good temperature management. The field heat (heat the product holds from the sun and ambient temperature) of a freshly harvested crop is usually high, and should be removed as quickly as possible before shipping, processing, or storage.



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Reducing produce temperature helps preserve market and storage quality.

Rapid pre-cooling to the product's lowest safe temperature (see table 2) is most critical for crops with inherently high respiration rates. These include artichokes, brussels sprouts, green onions, snap beans, asparagus, broccoli, mushrooms, peas, and sweet corn. Crops with low respiration rates include garlic, onions, potatoes (mature), and sweet potatoes. There are several methods that can be used to pre-cool your produce.

Cooling Methods:

Room Cooling

Room cooling is a relatively low cost but very slow method of cooling when electricity for mechanical refrigeration is available. When using room cooling, produce is simply loaded into a cold room, and cold air is allowed to circulate among the cartons, sacks, bins or bulk load. This cooling method is best suited to less perishable commodities such as potatoes, onions, and winter squash since highly perishable crops will deteriorate too much before being adequately cooled. The design and operation of cold rooms are fairly simple and no special equipment is required.

Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org

Fans inside cooling rooms are used to cool produce quickly to reduce damage caused by respirating fruit.

Forced-air Cooling

Fans are used in conjunction with a cooling room to pull cool air through packages of produce. Although the cooling rate depends on the air temperature and the rate of air flow, this method is usually 75–90% faster than room cooling. Fans should be equipped with a thermostat that automatically shuts them off as soon as the desired product temperature is reached.

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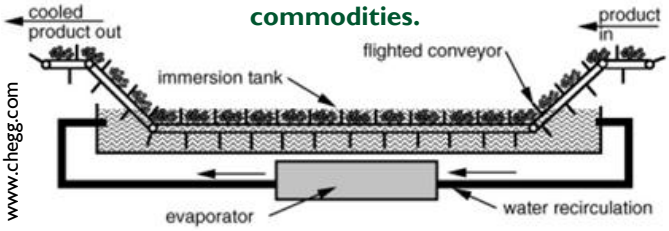
Hydro-Cooling

Even faster than forced-air cooling is hydro-cooling, where water-tolerant produce is either immersed or showered with icy cold water. Immersion hydro-coolers usually take longer to cool produce than shower type coolers. Produce to be hydro-cooled can be spread out in a single or multiple layers; left in open field bins or be packed in vented plastic or wooden boxes. Containers need to be vented on the top to allow water to flow into the container and around the produce.

This method can serve as a means of cleaning at the same time as cooling and can also reduce water loss and wilting. It's a good idea to sort produce before cooling so you don't waste money by cooling culls.

Hydro-cooling works well for produce such as radishes, sweet corn, root crops, and celery, but does not work well for potatoes to be stored, sweet potatoes, bulb onions, garlic or other commodities that cannot tolerate wetting.

Shower (above) and immersion (below) hydro-coolers can be used to cool sweet corn and other commodities.



Icing

Crushed or flaked ice for package icing can be applied directly or as a slurry in water (liquid ice).
The ice must come into direct contact with the produce in order to cool. The use of ice to cool produce provides a high relative humidity environment around the product and can reduce the rate of water loss in commodities sensitive to moisture loss.

Table 1: Icing Produce

Good to Ice	*NOT Good to Ice*
• Artichokes	• Tomatoes
• Asparagus	• Squash
• Beets	• Green beans
• Broccoli	• Cucumbers
• Cabbages	• Garlic
• Carrots	• Okra
• Cauliflower	• Bulb onions
• Daikon	• Romaine lettuce
• Endive	• Herbs
• Green onions	
• Leafy greens (lettuce, parsley, spinach)	
• Radishes	
• Sweet corn	

Chilling Injury

While cooling is very important, care must be taken to avoid chilling injury in sensitive crops. Many vegetables and fruits store best at temperatures just above freezing, while others are injured by low temperatures and will store best at 45 to 55 °F. Both time and temperature are involved in chilling injury. Damage may occur in a short time if temperatures are considerably below the danger threshold, but some crops can withstand temperatures a few degrees into the danger zone for a longer time.

Crops such as basil, cucumbers, eggplants, pumpkins, summer squash, okra, and sweet potatoes are highly sensitive to chilling injury. Moderately sensitive crops are snap beans, peppers, winter squash, and tomatoes. These crops may look sound when removed from low temperature storage, but after a few days of warmer temperatures, chilling symptoms become evident.

The various symptoms of chilling injury include failure to ripen (tomatoes), development of pitting or sunken areas (cucumbers), brown discoloration of tissues (eggplant), increased susceptibility to decay (cucumbers, tomatoes, zucchini, and beans), and lack of flavor development (tomatoes).

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Table 2: Lowest Safe Temperature

Commodity	°C	°F	Chilling Injury Symptoms
Asparagus	(0-2)	(32-36)	dull, grayish, limp tips
Beans (lima)	(2-4)	(35-40)	rusty brown specks, spots
Cucumbers	7	45	pitting, watersoaking, decay
Eggplants	7	45	surface scald, alternaria rot, blackening of seeds
Okra	7	45	discoloration, water-soaked areas, pitting, decay
Peppers (sweet)	7	45	sheet pitting, alternaria rot, darkening of seed
Potatoes	3	38	sweetening, mahogany browning
Pumpkins, squashes	10	50	decay, alternaria rot
Sweet potatoes	13	55	Decay, pitting, internal browning
Tomatoes (ripe)	(7-10)	(45-50)	water soaking, softening, decay
Tomatoes (mature-green)	13	55	poor color when ripe, alternaria rot

Moisture/Relative Humidity:

While temperature is the primary concern in the storage of vegetables, relative humidity (RH) is also important. Loss of water from produce is often associated with a loss of quality because wilting and shriveling can cause textural changes and be visually undesirable. Water loss can also result in loss of salable weight and reduced profit. Leafy crops tend to lose water the most rapidly. Water loss of 3 to 6% is generally enough to cause a noticeable loss of quality and value.

Most fruit and vegetable crops retain better quality at high relative humidity (80 to 95%), but at this humidity, disease growth is encouraged. Maintaining high relative humidity in storage is also complicated by the fact that refrigeration removes moisture.

DOs and DON'Ts *(Temperature and Humidity)*

- Cool produce as soon as possible after harvest.
- Cool using appropriate methods for each commodity (consider water tolerance, time required to reach 7/8ths cooling, and susceptibility to desiccation).
- Harvest during the coolest part of the day if possible.
- Provide shade over harvested produce, packing areas, buildings used for cooling and storage, and for transport vehicles.
- Design buildings to reduce storage temperatures. Buildings with overhangs on the side of the sun provide shade and using light colors on buildings will reflect light (and heat) and reduce heat load.
- Use high pressure sodium lights in packing and cooling facilities. These lights produce less heat and use less energy than incandescent bulbs.
- Cool before loading produce into refrigerated trucks (these trailers are designed only to maintain cool temperatures).
- To reduce water loss, increase RH and reduce temperature.
- Increase RH by using mists, sprays, or by wetting the floor.
- Use proper containers, suited to the method used for cooling (waxed cartons or wooden boxes for hydro-cooling or icing, boxes with aligned side vents for forced air cooling).
- Use forced-air coolers inside a cold room to speed cooling and decrease water loss and decay rate.
- Use high quality insulation in coolers, storage rooms and transport vehicles to reduce incoming environmental heat load.

IPM:

The first line of defense against insects and diseases is good management during production. The second defense is careful harvesting and preparation for market. Since most diseases can't gain a good start without easy entry through cuts, bruises or injuries, harvest and postharvest care of produce can make a big difference.

It's best to harvest your produce at the proper maturity which differs among commodities (see table 3). Under-mature and over-ripe produce is often more susceptible to

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diseases and insect damage than produce at prime maturity. As produce ripens, the flesh and skin softens and offers less protection against pests.

Monitoring pest levels using traps and lures during production will help reduce pest problems after harvest.

High humidity in the storage environment is important for maintenance of high quality produce, but if there is free water on the surface of commodities it can enhance germination and penetration by pathogens. Certain fungi and bacteria, in their germination phase, are susceptible to cold and infections can be reduced by treating produce with a few days of storage at the coldest temperature the commodity can withstand without incurring damage. Cold treatments can also control some insect pests. For produce packed before cold storage treatment, package vents should be screened to prevent the spread of insects during handling.

On the other hand, brief hot water dips or forced-air heating can also be effective, for reducing postharvest insects and microbial loads on crops such as sweet potatoes and tomatoes. Whenever heat is used with fresh produce, clean, cool water showers or forced cold air should be provided to help return fruits to their optimum temperature as soon as possible after completion of the treatment. Storing commodities in the proper conditions will help reduce or eliminate pests and diseases from destroying the produce.

DOs and DON'Ts *(IPM)*

- Consider the entire system (production, harvest, postharvest and marketing) when developing pest management strategies.
- Use cultivars offering some natural resistance to the pests you expect to have to deal with in your region.
- Plant only good quality, clean seed or stock.
- Use appropriate cultural practices (proper planting density, fertilization, irrigation, pH modification, weeding, pruning, thinning, and ventilation/air movement through the canopy) during production to ensure healthy produce which are more resistant diseases and pest attacks.
- Monitor fields to determine actual pest levels before implementing pest controls.
- Use a combination of appropriate pest control methods (physical, biological, and chemical) during production and postharvest.
- Keep fields free of debris and diseased produce.
- Avoid damage during harvest by handling produce gently.
- Harvest at the proper maturity for produce to have the maximum resistance against pests.
- Use sharp, clean tools for harvest and trimming processes.
- Sort and remove any damaged, decayed, over-mature or under-ripe produce.
- Wash or clean produce to remove soil and debris and to reduce the amount of inoculum on surfaces.
- Avoid over-use of liners that constrict air flow in the package and contribute to condensation (free moisture) and poor cooling efficiency.
- Avoid ethylene damage to sensitive commodities by using ethylene scrubbers and avoiding mixed lots of produce in storage.
- Keep produce at its lowest safe temperature for maximum pest management.
- Keep leafy vegetables, carrots, and cool season vegetables at very high relative humidity (98-100%) to reduce incidence of decay.
- Store onions and garlic at low humidity to reduce decay (60-70% RH).

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Table 3: Harvest Timing

Commodity	Maturity indices or characteristics
Asparagus	cut when spears are 9" long; width is not a maturity indicator
Basil	before night temperatures drop below 50° F
Beans (green)	pods are filled but not bulging, seeds are immature
Beets	adequate size, highest quality beets are less than 2"
Broccoli	adequate diameter, compact, all florets should be closed
Brussel sprouts	buds that are 1 to 2" in diameter
Cabbage	firm head
Carrots	Immature, when roots have reached adequate size, have uniform taper
Cauliflower	mature curds at least 6" in diameter, compact
Celery	90 to 120 days after transplanting
Corn (Sweet)	silks dried, kernels immature, "milky" when squeezed, tight, green husk
Cucumber	immature, glossy skin, 55 to 60 days from planting, before seeds fully mature
Eggplant	immature, glossy skin, 6 to 8 inches long, before seeds fully mature
Garlic	well-filled bulbs, tops dry down, undercut bulbs and cure
Lettuce (bibb, romaine)	adequate size, 60 to 70 days
Lettuce (head)	compact head, not too firm
Lettuce (leaf)	adequate size leaves, 50 to 60 days
Okra	4 to 7 days after flower has opened (pods 2 to 4" long), not fibrous, tips of pods pliable
Onion (green)	minimum of 6 " tall
Onion (dry bulbs)	when 10 to 20% of tops fall over (withhold irrigation, undercut and cure)
Peas (edible pod)	5 to 7 days after flowering, pods slim, immature and very small
Peas (green)	pods well filled but not faded in color
Peppers	fruit size and color reached (depends on cultivar and intended market)
Potatoes	harvest before vines die completely, cure to heal surface wounds
Spinach	adequate size (35-45 days after planting), young or mid-maturity, or cut outer leaves and then again in 3 to 4 weeks
Squash (summer)	immature, glossy skin, 3 to 5 days after flowering, before seeds mature
Squash (winter)	rind hard, before hard frost
Sweet Potatoes	adequate size of roots, before first frost
Tomatoes	seeds fully developed, gel formation advanced in at least on locule (seeds not cut when fruit is sliced)

CAUTION:
The above suggested number of days to maturity, from flowering, or from planting can be variable depending on variety, growing conditions, (temperature, moisture, soil, etc.) and other factors. Maturity indicators and characteristics mentioned above are provided only to serve as a guide.

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Food Safety

Food Safety:

Pathogens may not be seen with the naked eye, so it's important to take precautions when handling and consuming produce.

While produce quality can be judged by outward appearance such as color, turgidity, and aroma; food safety cannot. It is impossible to determine if produce is safe to consume by simple visual inspections.

Careful detail to production, harvest, and post-harvest methods are extremely important to ensure the prevention of contaminating fresh produce by physical hazards, harmful chemicals and human pathogens.

Table 4: Harvest and Postharvest Hazards

Physical Hazards	*Chemical Hazards*
• Fasteners (staples, nails, screws, bolts) • Pieces of glass • Wood splinters	• Pesticides, fungicides, herbicides, rodenticides • Machine lubricants from forklifts or packing line equipment • Heavy metals (Lead, Mercury. Arsenic) • Industrial toxins • Compounds used to clean and sanitize equipment

DOs AND DON'Ts *(Food Safety)*

- Grazing animals, feedlots or other sources of fecal contamination should NOT be present on or adjacent to production land.
- Prior land use should be investigated to assure that toxic compounds such as pesticides or heavy metals are NOT present at dangerous levels in production soil.
- Fertilizers should have no detectable levels of human pathogens.
- Irrigation water should have no detectable human pathogens, or unacceptable levels of pesticide residues, heavy metals or toxic compounds.
- Maintain a safe period between applications and produce harvest.
- Keep harvested produce up off the bare soil.
- Avoid exposure to moist soil. There is an increased risk of infection.
- Provide field latrine and hand wash stations for field workers and then monitor and enforce good personnel hygiene practices.
- Use only clean and sanitary field containers.
- Continuously monitor chlorine concentrations and pH of hydro-cooling or wash water.
- Clean and sanitize equipment (field tools, containers, packing lines, air coolers, cold storage rooms, transport trucks etc.) on a frequent and scheduled basis.
- Only use cleaning compounds and sanitizers that are approved for food contact surfaces.
- Use transportation that is dedicated to hauling only produce. Do NOT use trucks which have been used to transport live animals.

For more detailed information on harvest and post-harvest care see UC Davis Postharvest Technology for Fruit & Vegetable Produce Marketers at

http://postharvest.ucdavis.edu/libraries/PHTechMarketers/

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