



Making Your Crops Last: Tips and Tricks for Harvesting, Cooling and Storing Produce

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Quality cannot be improved after harvest, only maintained.

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High quality produce results from:

- Sound production practices
- Proper handling during harvest
- Appropriate postharvest handling & storage

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Quality starts with variety selection:

- Firmness
- Uniformity
- Disease & pest resistance
- Shelf-life
- Flavor



Match the variety to your market & needs!

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Environmental factors that affect quality:

- Soil type
- Temperature
- Frost
- Rainy weather at harvest

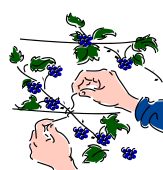


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Cultural practices that affect quality:

- Plastic vs. bareground
- Trellising
- High tunnels
- Tools and equipment
- Irrigation practices
- Postharvest handling



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Postharvest handling

- Respiration
- Transpiration
- Temperature
- Relative humidity



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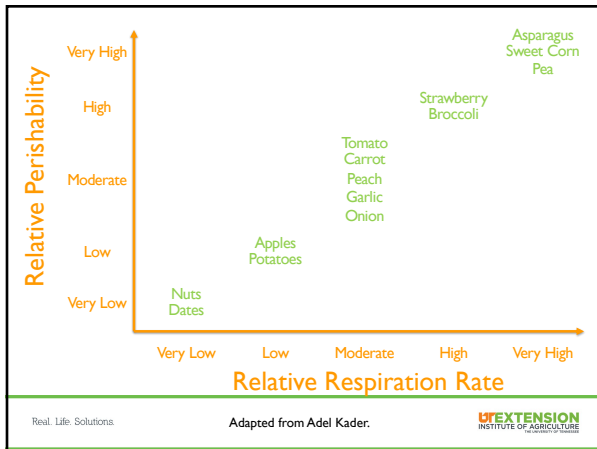
Respiration

- Process by which food reserves are oxidized to produce energy to keep the fruit or vegetable alive
- Results in deterioration (loss of nutrients, changes in texture and flavor, weight loss)
- Respiration rates vary by commodity
- Once harvested, the clock is ticking!

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Adapted from Adel Kader.

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Transpiration

- The process of losing water to the environment
- After harvest, produce can no longer obtain water through the roots of the plant
- Water loss causes wilting, shriveling and softening, as well as loss of weight, crispiness, juiciness, nutritional quality and flavor

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Temperature

- Most important factor in maintaining quality!
- Remove or prevent field heat as much as possible
- Remember fruits and vegetables are ALIVE:
 - Heat increases water loss and respiration and reduces storage life and quality
 - The higher the storage temperature, the shorter the shelf-life



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Relative Humidity

- Measure of degree to which the air is saturated with water vapor
- Rate of water loss depends on:
 1. The relative humidity difference between the intercellular structure and the surrounding air
 2. The surface characteristics of the produce
- For most vegetable crops, high RH (80-95%) = longer shelf-life, but can encourage disease
- Cool temps and sanitation can help prevent disease
- Buckets of water and humidifiers can increase RH

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When is it time to harvest?

- Most crops are harvested based on size and maturity
- Many crops will have better quality and shelf-life if picked *slightly* immature



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When is it time to harvest?

- Too early = insufficient size, poor sugar content and vitamins
- Too late = too much fiber, conversion of sugars into starches, decrease in plant productivity, potential to attract pests

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Ripeness & Maturity

Pick immature

- Green bell pepper
- Cucumber
- Summer squash
- Snapbeans
- Sweet pea
- Okra
- Eggplant
- Sweet corn

Pick mature (vine ripe)

- Tomatoes
- Red peppers
- Muskmelon
- Cantaloupe
- Watermelon
- Winter squash
- Pumpkin
- Dry beans

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Don't Harvest Until You Need Them!

- Root crops (carrots, beets, turnips) can be left in the ground through winter, if mulched 1-2" thick.
 - Not if soil freezes solid!
 - Cool temps also improve the flavor of these crops.



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Harvest tips

- Harvest in the morning hours
- But... harvest dry...
- Keep produce out of the sun!
- Handle with care- bruising reduces quality
- Move to cold storage ASAP
- Don't mingle damaged produce with high quality produce
- Use clean and sanitized harvest bins
- Handle no more than necessary (field pack)



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Field Packing

- Reduce steps in handling chain = reduce potential damage (impact, compression and abrasion)
- Good for soft fruits, leafy crops (berries, lettuce, spinach)
- Reduce contact of container with soil
- A small cart can reduce the amount of bending & lifting for the picker



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Shade and Mobility

- Golf carts
- Hand carts
- Trailers
- Lightweight stands
- Pop-up tents



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Pre-Cooling

- **Room cooling:** an insulated room equipped with refrigeration
- **Forced-air cooling:** fans used in a cooling room to pull cool air through packages of produce
- **Hydrocooling:** showering produce with chilled water (not suitable for all vegetables)
- **Top or liquid icing:** crushed ice is added to the container on top of the produce (good for sweet corn and broccoli)
- **Vacuum cooling:** produce is cooled in a vacuum, which forces water to evaporate and remove heat (good for leafy crops)



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Room Cooling

- Cold rooms will prolong shelf-life from hours to weeks
- Want large enough to handle projected back ups of product
- Can be used or new walk-in cold rooms
- Can DIY by adapting old shipping containers, railway cars or building cold rooms and using cool bot



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Asparagus
Beets
Broccoli
Cantaloupes
Carrots
Cauliflower
Green Onions
Leafy Greens
Radishes
Spinach
Sweet Corn
Watermelon

Damaged by direct
contact with ice

Strawberries
Blueberries
Raspberries
Tomatoes
Squash
Green Beans
Cucumbers
Garlic
Okra
Bulb Onions
Romaine Lettuce
Herbs



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Chilling Injury

- Some vegetables best stored between 45-55 °F
- Both time + temperature determine extent of injury
- Highly sensitive crops: basil, cucumbers, eggplant, pumpkins, summer squash, okra and sweet potatoes
- Moderately sensitive crops: snap beans, muskmelon, peppers, winter squash and tomatoes



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Chilling injury symptoms:

- Pitting or skin blemishes
- Internal discoloration
- Failure to ripen
- Susceptible to decay



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Washing

- Washing prior to marketing is essential for many vegetables
- Need a plentiful source of clean water
- Change water often
- Brushing may be necessary for root crops (potatoes, beets, carrots)
- Thoroughly drain leafy greens before bagging/storing- better yet, don't get them wet!
- Don't wash damaged or diseased produce
- Water should have a sanitizer

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Bacteria can enter the stem scar with improper handling or wash water management

Fruit pulp must be <10 °F warmer than water temperature to prevent infiltration.



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Crops NOT to wash before market:

- Berries
- Spinach (unless overly dirty)
- Basil
- Summer squash



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How long will they last?



Storage of Fresh Produce

Storing produce at the proper temperature is critical to obtaining the longest shelf-life. Table 1 provides the optimal storage temperature and shelf-life for each commodity. If a crop is stored at higher than ideal temperatures, the shelf-life will be reduced. Similarly, if a crop is stored at a lower than ideal temperature, freezing or chilling injury could compromise the shelf-life.

Table 1. Fruit and vegetable storage conditions and shelf-life.

Crop	Ideal Storage Temperature (°F)	Shelf-Life at Ideal Storage Temperature
Apples	30-40	1-12 months
Asparagus	32-35	2-3 weeks
Beans, Butter/Lima	37-41	5-7 days
Beans, Snap	40-45	7-10 days
Beets, Topped	32	4-6 months
Blackberries	31-32	2-3 days
Blueberries	31-32	1-2 weeks
Boysenberries	31-32	2-3 days
Broccoli	32	10-14 days
Brussels sprouts	32	3-5 weeks

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Storage Temperatures

Cooler #1 (at 32 °F)

- Asparagus
- Beets
- Carrots
- Crucifers
- Lettuce
- Ripe muskmelon
- Onion
- Parsley
- Spinach
- Radishes
- Sweet corn

Cooler #2 (at 50 °F)

- Green beans
- Cucumbers
- Eggplant
- Sweet peppers
- Potatoes
- Pumpkins
- Summer squash
- Ripe tomatoes
- Watermelon
- Winter squash

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Curing...

- Thickens the skin, reduces moisture loss and provides better protection against insects and microbes

Onions & Garlic: leave roots and leaves attached, protect from sun and rain in well-ventilated area, cure for 2 weeks at 80-90 °F, tops can be cut off after curing, onions may be cured in the field

Potatoes: 5-10 days at 59-68 °F & 90-95% RH

Sweetpotatoes: 4-7 days at 86-90 °F & 85-90% RH

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Ethylene

- Promotes ripening and susceptibility to disease
- Damaged and diseased crops produce high levels of ethylene
- Don't store ethylene producers with sensitive crops!



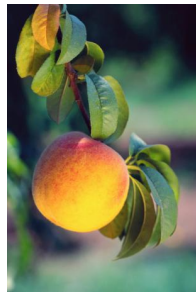
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Ethylene producers:

- Apples
- Apricots
- Avocados
- Ripening bananas
- Cantaloupe and honeydew
- Peaches
- Pears
- Persimmons
- Plums
- Quinces
- Tomatoes



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Ethylene sensitive:

- Asparagus
- Snapbeans
- Broccoli
- Brussels sprouts
- Cabbage
- Carrots
- Celery
- Cucumbers
- Eggplant
- Lettuce
- Sweet potatoes
- Okra
- Bell peppers
- Summer squash
- Spinach



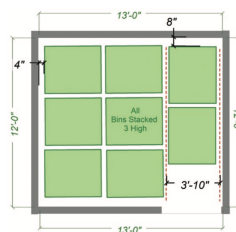
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Designing Your Storage Space

- What will you be storing? And for how long?
- Can you compartmentalize for different storage needs?
- Plan for the most product you will have to store at one time- think winter storage!
- Think about product flow in to and out of the space
- Think about accessibility- can you back your truck up to it?



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Design Features to Consider:

- Climate control systems with cooling, heating and humidity control
- Air intake and circulation (maintain at least 8" between bins and end walls, 4" between bins and side walls, and 12" between bins and ceiling)
- Plans to handle bins or pallets- forklift, pallet jack
- Insulation- expanded polystyrene (EPS) foam board, mineral wool batts and closed-cell spray foam (avoid fiberglass batts!)
- Concrete slab for moving, cleaning and strength and a floor drain!

From Growing for Market Designing and building a storage facility.

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Design Features to Consider:

- Vapor barrier to help prevent excessive condensation
 - Usually places outside the insulation for summer coolers, just under the exterior covering
 - Inside the insulation and just behind the wall panel for winter storage
 - If using for both, especially in our hot, humid summers, look into REMOTE (Residential Exterior Membrane Outside Insulation TEchnique)
 - Do **not** do both- vapor barrier on inside and outside of insulation- or you will trap moisture inside your walls!

From *Growing for Market* Designing and building a storage facility.

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Acknowledgements + Resources

- Small-Scale Postharvest Handling Practices, Kitinoja, L. & Kader, A.A., 1994, University of California, Davis, CA
- Cornell University, National GAPs Program: <https://gaps.cornell.edu>
- ATTRA Postharvest Handling of Fruits and Vegetables: <https://attra.ncat.org/product/postharvest-handling-of-fruits-and-vegetables/>
- Locally Grown Produce Series: Storage of Fresh Produce: <https://extension.tennessee.edu/publications/Documents/SP768-F.pdf>
- UC Davis Postharvest Produce Fact Sheets: http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/
- Growing for Market- Designing and building a storage facility (subscription required): <https://www.growingformarket.com>

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More Resources

- CoolBot: <https://www.storeitcold.com>
- NCSU Pack N' Cool: <https://plantsforhumanhealth.ncsu.edu/2012/08/20/pack-n-cool/>
- Low Cost Cold Storage, John Wilhoit: https://ag.purdue.edu/extension/Documents/SmallFarms%20Documents/SFC%202016%20Presentations/CoolingEquipment_Wilhoit_SFC_2016.pdf
- NCSU Cool and Ship: <https://content.ces.ncsu.edu/cool-and-ship-a-low-cost-portable-forced-air-cooling-unit>
- USDA PortaCooler: <https://ncfreshproducesafety.ces.ncsu.edu/wp-content/uploads/2014/03/Portacooler-USDA.pdf?fwf=no>
- REMOTE Walls: <http://cchrc.org/remote-walls/>

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Thank you!
Questions?

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