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NC GROWING TOGETHER
Connecting Local Foods to Mainstream Markets

ON-FARM INFRASTRUCTURE TOOLKIT

DEVELOPED BY **The Center For Environmental Farming Systems & the Carolina Farm Stewardship Association**
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USDA United States Department of Agriculture National Institute of Food and Agriculture

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NORTH CAROLINA GROWING TOGETHER

NC Growing Together (NCGT) is a multi-year (2013-2018) USDA-funded initiative of the Center for Environmental Farming Systems. NCGT's goal is to bring more locally-produced foods into mainstream grocery and food service markets, strengthening the economics of small to mid-size farm and fishing operations and their communities. This work is accomplished with strategies that work with entities across the supply chain, from producer to end buyer. This includes addressing barriers, such as postharvest handling requirements, that can prevent producers from selling into larger markets. The On-Farm Infrastructure Toolkit was created to address this barrier, and build produce growers' capacity to cool, wash, cure and store produce on-farm.

The Center for Environmental Farming Systems (CEFS) is a partnership of North Carolina State University, North Carolina Agricultural and Technical State University, and the North Carolina Department of Agriculture and Consumer Services. CEFS develops and promotes just and equitable food and farming systems that conserve natural resources, strengthen communities, improve health outcomes, and provide economic opportunities in North Carolina and beyond. For more information, please see www.cefs.ncsu.edu.

CAROLINA FARM STEWARDSHIP ASSOCIATION

The Carolina Farm Stewardship Association (CFSA) is a farmer-driven, membership-based 501(c)(3) non-profit organization that helps people in the Carolinas grow and eat local, organic foods by advocating for fair farm and food policies, building the systems family farms need to thrive, and educating communities about local, organic agriculture. For more information please see www.carolinafarmstewards.org.

CHAPTER ONE

Postharvest Cooling & Washing

Cooling

Postharvest cooling is the process of removing field heat and preparing crops for cold storage. Postharvest cooling is vital for extending the shelf life of produce.[1] Postharvest cooling methods include forced-air, hydro-cooling, vacuum cooling, water spray vacuum, ice, and room cooling. Vacuum and water spray vacuum cooling are expensive and not economically feasible for small-scale fruit and vegetable producers; therefore, they are not covered in this toolkit. However, the concepts used in forced-air, hydro-cooling, ice, and room cooling can be incorporated into cost effective designs applicable to small-scale operations. An overview of each method is discussed in this chapter.

Postharvest cooling should not be confused with longer-term cold storage, which will be discussed later in Chapter Three on page 10.

Forced-Air Cooling

Forced-air cooling consists of pushing or pulling chilled air through stacked containers of produce so that it contacts individual pieces of product. Forced-air cooling is commonly used for tree fruits, berries, melons, and cut flowers. Most commodities can be cooled using forced air, and this process does not require water-resistant packaging. However, disadvantages of forced-air cooling are that it is slower than other methods of cooling (except room cooling), it requires special packaging that promotes air-flow across the product, and it can lead to excessive water loss in some crops.[2]

Photo 1.1 Fifty gallon utility tank, which can be used for hydro-cooling.

Photo 1.2 Modified fifty gallon utility tank to include a float valve.

Photo courtesy of Simeon Farms

Hydro-Cooling

Hydro-cooling is achieved using either water shower or product immersion systems. Hydro-cooling is typically used for leafy vegetables as an alternative to vacuum or water spray vacuum cooling methods. Hydro-cooling water should be kept as cold as possible, be free of decay-causing contamination, and come in contact with as much of the produce's surface as possible.[2] It is important that crops be clean prior to hydro-cooling and that hydro-cooling water be replaced frequently enough to maintain proper sanitation (food safety aspects of hydro-cooling are detailed later in this toolkit). Mechanized hydro-cooling systems may be cost prohibitive for small-scale producers, but some benefits of hydro-cooling can be achieved by simply immersing suitable crops in tubs of ice water as shown in Appendix A on page 21.

Hydro-cooling containers range from 18-gallon plastic totes found at home improvement stores to 50-gallon stock and utility tanks (Photo 1.1) available at farm supply stores. Modifications can be made to these containers, such as the installation of float valves so that filling does not have to be supervised (Photo 1.2). This drain was installed using a cordless drill, hole saw, and common PVC drain kit.

Ice Cooling or Package Icing

Commercial ice making equipment requires a large investment that is likely beyond the financial means of small-scale producers. However, package icing (filling containers packed with produce with crushed ice) can be an effective method to quickly cool product and maintain humidity so that moisture loss is minimized. Proper cooling typically requires product to come into contact with ice; therefore, water-resistant packaging must be used. While not a standalone method of postharvest cooling, access to ice should be considered for use in hydro-cooling and/or top icing (topping off packed containers with loose ice) certain crops during transport. Crops suitable for top icing include sweet corn, broccoli, dark leafy greens, root crops, cantaloupes, and green onions.[1]

Room Cooling

Room cooling consists of exposing harvested crops to a refrigerated environment. The advantages of room cooling are that facility design and operation are relatively simple, crops cooled and stored at similar temperatures require less handling, and there is no need for expensive cooling equipment that is found in more rapid cooling methods. The time required to cool crops using room cooling is longer compared to other postharvest cooling methods and this represents a significant disadvantage, especially when the rate of decay of certain products is greater than the cooling time.[2] Room cooling is different from forced-air cooling since air is not intentionally pushed or pulled through containers of produce. Room cooling should be considered a temporary step in postharvest cooling to remove field heat prior to postharvest washing and not a substitute for long-term cold storage.

1 Slama, Jim and Diffley, Atina. "Wholesale Success: A Farmer's Guide to Food Safety, Selling, Postharvest Handling, and Packing Produce, Fourth Edition." FamilyFarmed, 2013

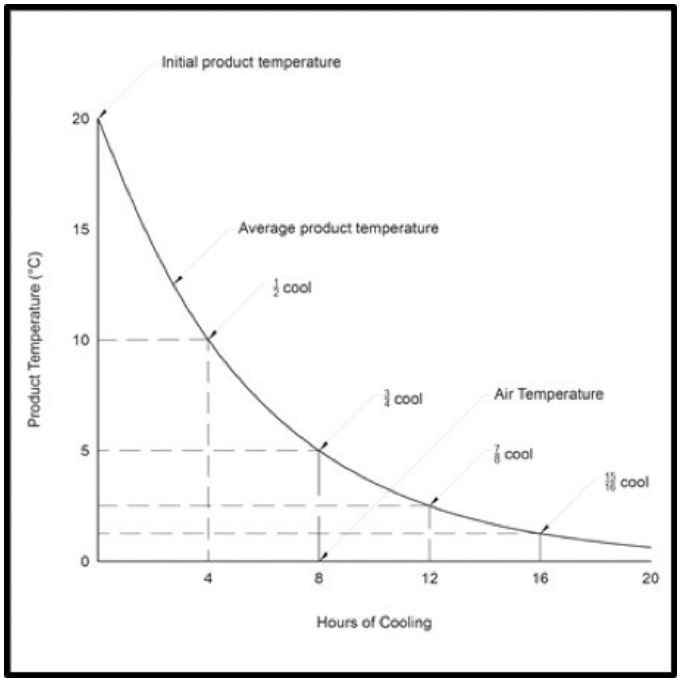
2 Thompson, James F., et al. "Appendix A-1, Commercial Cooling of Fruits, Vegetables, and Flowers, Revised Edition." Agriculture and Natural Resources Publication 21567, University of California, 2002

Concept of Cooling Time

Deciding which postharvest cooling method is appropriate for one's operation will depend ultimately on costs to install and operate/maintain. Other important factors to consider are the speed and efficiency of cooling and concept of half cooling time. The time required to reach the difference between a product's field temperature and ideal holding temperature divided by two is the half cooling time (Figure 1). A general rule of thumb is that 7/8th cooled (87.5%) is the appropriate time to remove produce from pre-cooling and place in cold storage.[3] You can quickly calculate 7/8th cooling time by multiplying half cooling time by three. Knowing 7/8th cooling time is essential for evaluating whether or not a postharvest cooling method is sufficient to achieve the desired shelf life of a product. For example, it takes about four hours for large tree fruits to reach half cooling, therefore, 7/8th cooled is approximately 12 hours.[4]

Cooling methods and time vary depending on the crop type and method used. Fruits and vegetables with a low respiration rate are able to store longer, which allows for the utilization of a longer cooling method (room or forced air cooling). Fruits and vegetables with a high respiration rate have to be stored at very low temperatures in order to maximize shelf life and therefore need to reach 7/8th cooled quickly (forced-air, hydro, or ice cooling). The chart in Appendix A on page 21 provides cooling options for select crops and the estimated amount of time it will take crops to cool using the various cooling options. Selecting the proper method for cooling will ultimately depend on the crop's respiration rate, volume of product, size of exposed surface, and sensitivity to post-harvest water contact.

Figure 1.1 Typical Cooling Time for Perishable Products[4]



Washing

The potential for produce to come into contact with contaminants exists each time it is handled. Reducing the need for postharvest washing minimizes the potential exposure to contamination while minimizing labor costs. Possible ways to reduce the need for washing include the use of mulch and drip irrigation to reduce the occurrence of water splashing dirt on produce. Making sure that harvest tools and picking containers are clean, and that workers maintain proper hygiene can also reduce the need for postharvest washing. If cleaning is required, there are low-cost options; however, different crops will have different washing and drying requirements as shown in Appendix B on page 22.

The Fruit and Vegetable Working Group of the Value Group Partnership Project and the Leopold Center for Sustainable Agriculture designed and published construction details for two wash stations. Vegetable Wash Station Design 1[5] (Figure 1.2) is adequate for most small-scale operations and can be constructed for about $1,000 in materials. The New Entry Sustainable Farming Project[6] modified the design and materials so that the washing station can be certified for GAP operations.

Figure 1.2 Vegetable Wash Station Design 1

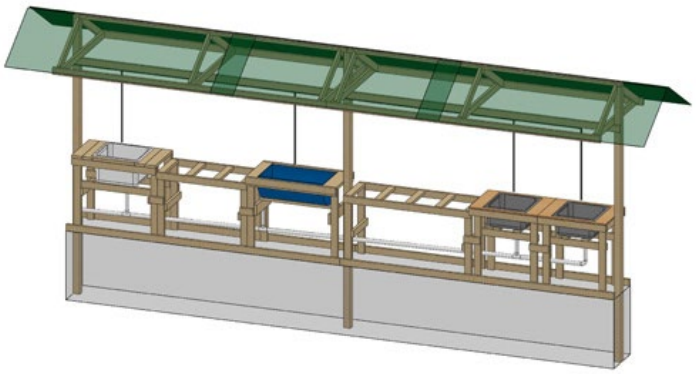


Illustration courtesy of Leopold Center for Sustainable Agriculture

3 Slama, Jim and Diffley, Atina. "Wholesale Success: A Farmer's Guide to Food Safety, Selling, Postharvest Handling, and Packing Produce, Fourth Edition." FamilyFarmed, 2013

4 A. A. Kader (ed.) "Postharvest Technology of Horticultural Crops, 3rdEd." University of California, Division of Agriculture and Natural Resources Publications 3311, 2002.

5 Vegetable Wash Station Design 1: https://www.leopold.iastate.edu/cool_tools/wash_stations1

6 The New Entry Sustainable Farming Project: https://nesfp.org/resources/building-leopold-center-gap-certifiable-vegetable-wash-station-notes-and-modifications

Food Safety Considerations

When building on-farm infrastructure for hydro-cooling fresh produce, it is important to consider food safety, especially if you are seeking GAP Certification. Within the food safety industry, microbial, physical, and chemical contaminations have become primary concerns. With this in mind, carefully consider the materials that you utilize when building your on-farm infrastructure and their effect on obtaining GAP certification. Once produce is harvested, it is important to implement Good Handling Practices.

Wood

Wood is a porous material that harbors bacteria and can be a source of potential microbial contamination. Sanitizing methods are ineffective. It is fine to utilize wood for building any postharvest infrastructure, but is not recommended for any food-contact surfaces. Any wood surfaces that will come into direct contact with produce will need to be covered with a non-porous material or a barrier (clean plastic or double bucket system).

Lighting Fixtures

Adequate lighting during postharvest handling is necessary in order to visually inspect produce for quality control. If you install glass and/or brittle plastic lighting, covers should be installed on lighting fixtures to contain glass or plastic in the event of breakage. Alternatively, silicone coated light bulbs may be used.

Water Risks

Postharvest washing increases the potential risk of microbial contamination because water can infiltrate produce. Therefore potable water (meets safe drinking water standards) must be used when postharvest washing the edible portions of crops. When considering a water source that may be used for cooling produce, keep the following in mind:

- The microbial quality
- Sanitizer use
- Water temperature
- pH
- Immersion time

Microbial Quality & Water Source

In order to ensure the microbial quality of the water, it must be tested. If using municipal water, your municipality can provide you with annual water test results eliminating the need to use a third-party laboratory. If using well water, you will need to have it tested at least annually. It is best to conduct the test just prior to utilizing the water for postharvest activities. It is not recommended that an open water source (pond, lakes, streams) be used for postharvest washing since it would need to be treated and potability verified prior to use.

Sanitizer Use

Commonly used sanitizers include food-grade chlorine, chlorine dioxide, peracetic acid, and hydrogen peroxide. There are several products on the market that are Organic Materials Review Institute (OMRI) approved and labeled for the use of washing fresh produce. However, be sure to get approval from your certifier prior to use. In addition to any NOP annotations or restrictions, labeled instructions for the sanitizer's intended purpose must be followed, including recommended water temperatures and pH. If you prefer not to use chemical sanitizers, ozone or UV light treatments are often considered.

Water Temperature & pH Levels

When hydrocooling or fully submersing produce in water, the water temperature should be no more than 10°F warmer than the internal temperature of the crop to prevent infiltration of water into the crop. Therefore, cooling crops prior to postharvest washing may be critical depending on the temperature of the crop. Infiltration can occur through the stem, or scars on the produce, so it is important to handle the produce properly. Sanitizer labels may also include recommended temperatures and pH levels to ensure its effectiveness. The sanitizer levels and pH must be monitored and recorded at recommended intervals.

Immersion Time Interval

Some fruits and vegetables have a higher risk of infiltration when completely immersed in water, which should be considered when hydrocooling. For example, tomatoes are a high infiltration risk product and complete immersion for greater than two minutes would result in infiltration, even if proper water temperatures are being maintained.

Considerations for Certified Organic Farmers

For certified organic operations, lumber treated with arsenate or other prohibited substances that might come into contact with crops are not allowed. Alternatives to lumber treated with prohibited substances include metal poles/supports, untreated lumber, and lumber treated with allowed substances. Well-designed wash stations should eliminate contact between produce and wood surfaces and surfaces that cannot be sanitized, which is essential for GAP certification. Alternatives to wood include metal, plastic "wood" (Trex), and plastic screen or netting. As with any organic certification question, be sure to contact your organic certifier for approval to use materials prior to construction.

Photo courtesy of Thomas Moore

CASE STUDY

Elma C. Lomax Incubator Farm

Farm Profile

The Elma C. Lomax Farm (Lomax) is a certified organic incubator farm located in Concord, NC. Lomax is a training-ground where beginning farmers can gain access to land and equipment to start their own farm business. The farm is roughly 30 acres with about 10 acres in production, which is split between nine different farmers-in-training. At the farm, vegetable production occurs year-round.

Postharvest Washing & Cooling Infrastructure

The postharvest washing and cooling station is centrally located on the farm and housed underneath an open pole barn structure. The farm's cold storage facility adjoins the postharvest washing and cooling station, which is ideal for preserving produce quality.

Components of the post-harvest washing and cooling station include:

- three (3) triple basin stainless steel sinks
- four (4) 24"x70" stainless steel tables
- ice machine
- 1,600 cubic foot walk-in cooler (10'x20'x8')
- multiple ice chests
- large commercial salad spinner

Station Layout

All of the triple basin stainless steel sinks are lined up together along with a stainless-steel table on one side of the postharvest bay of an open pole barn (Photo 1.3). Opposite of the sinks are the remaining stainless steel tables, lined up side-by-side, and the ice machine. Directly behind the row of stainless steel tables and ice machine is the walk-in cooler, which is located in the central bay of the pole barn. Coolers and ice machines work best in cool environments with low humidity. Thereof, if they are being used in outdoor/open settings, they should be shielded from direct sunlight.

Best Practice

The postharvest washing and cooling station is designed for optimal throughput of produce from field to the cooler. Dirty produce can enter the station from one end and leave clean from another end without much concern for cross contamination. The ice machine is an added benefit to the farmers and used on produce for which top icing is appropriate (the farm does not have hydro-cooling facilities).

Obstacles & Challenges

The main challenge with the postharvest washing and cooling station at Lomax is that so many farmers share it and it can reach capacity fairly quickly during peak harvest time. Additionally, ensuring that every farmer keeps the stations clean and free of debris can sometimes be challenging, especially since the stations are outdoors.

During the winter months, if the water pipes aren't drained daily, they run the risk of breaking from the water freezing inside of them. Every year the farm manager at Lomax can anticipate repairing broken pipes due to freezing at least once or twice during winter months.

CHAPTER TWO

Curing & Storage

Curing

Curing is not needed for fresh vegetables intended for immediate sale; however, curing is used for some fresh market vegetables to prepare them for long-term storage. During curing, vegetables are placed in warm temperatures and moderate relative humidity for a short time to dry and harden their skins prior to being moved to long-term storage. In some vegetables, curing also aids in converting starches to sugars.

Curing can extend the shelf life of certain vegetables and provide small-scale growers with marketable products far beyond the harvest season when the highest prices can be obtained. This chapter will discuss common vegetables suitable for curing that are grown in the southeast. However, several general rules for curing vegetables include:

- Not all vegetables are suitable for curing and some varieties are better than others. For vegetables that require curing, look for varieties labeled for long-term storage.
- Harvest vegetables at maturity; reserve under-ripe or over-ripe vegetables for fresh markets.
- Harvest vegetables after several days of no rain or suspend irrigation several days prior to harvest. Excess moisture can slow the curing process and lead to disease and rot.
- Do not wash vegetables to be cured. Remove excessive soil with a dry brush.
- Select vegetables free from bruises and scratches for curing.
- Remove vegetables from direct sunlight as soon as possible.

Onions, Garlic, & Shallots

Vegetables in the Allium genus should be harvested when the majority of stalks have begun to turn brown, dry, and fall over. This indicates the plants have started to go dormant. Some growers crimp and fold over remaining stalks to terminate growth.

In cooler climates, onions can be cured in the field for several days if no rain is expected. Garlic and shallots can be hung in small bunches to cure. Curing should take place in a warm, well-ventilated space, at 85°F–90°F and 70% relative humidity for two to three weeks or until the necks are dry and tight. If the temperature can be controlled and ventilation is adequate, Alliums can be cured on screened tables or wire racks in shaded greenhouses or high tunnels. Prior to long-term storage, clip tops to one to two inches and brush off any loose dirt and scales, and cull any that did not cure property. After curing, Alliums should be stored in mesh bags at 32°F–50°F with 60% – 70% relative humidity and can be stored for six to eight months.

Sweet Potatoes

Sweet potatoes are highly susceptible to cold injury and should be harvested upon full maturity on a mild day just prior to the first anticipated frost. Remove vines with shears only from rows to be immediately harvested. Use digging forks to expose roots to the surface being careful not to bruise or damage the skins. Roots should not be exposed to temperatures above 90°F or below 55°F for long periods of time but can be left on the surface for a few hours to dry if temperatures are within range. Higher winds will also contribute to faster drying.

Sweet potatoes should be sorted to remove ones with soft bruises or puncture wounds; however, broken off or cleaved surfaces will heal and are okay to cure and store. Culled potatoes should be composted or used in the kitchen immediately. Cure sweet potatoes in crates or flats at 85°F–90°F and 80% – 95% relative humidity for up to 10 days. Sweet potatoes require good ventilation and crates may be stacked in a crisscross pattern or using wooden slats to promote adequate airflow. Some growers cure sweet potatoes in designated areas of pole barns by covering the bays with tarps and using box fans to promote airflow. Shaded greenhouses or high tunnels may be used provided the temperature is not too hot. Again, it is important that the temperature and relative humidity be kept as constant as possible in greenhouses and high tunnels used for curing root crops. Once properly cured, sweet potatoes stored between 55°F–60°F at 85% – 90% relative humidity can last for up to 10 months. If the temperature drops below 55°F to around 40°F for long periods of time (2–3 weeks), chilling injury may occur, which increases the susceptibility to infection by rot-producing organisms. This infection may not be visible for several weeks after the optimal storage temperatures are restored. Additionally, any seed value of the roots may decline.

Potatoes

Potatoes not intended for immediate use should be cured prior to long-term storage. The harvesting time must be considered to achieve optimal storage shelf-life. Potatoes can be harvested when vines have completely died, but waiting an additional two weeks will allow skins to toughen, which is beneficial in storage crops. If there are any remaining living vines, they can be killed by mowing or flame weeding. Removing any crop residue mulch may be needed, especially for mechanical harvesters to work efficiently. Potatoes ready for curing should be dry and excess dirt removed with a soft-bristle brush using gentle pressure in order to avoid external injury to the skin of the potato.

Photos on this page courtesy of Stephen Nix

Cure potatoes for two weeks at 60°F–75°F and 95% relative humidity. Curing below 50°F inhibits the healing process of surface wounds. Potatoes should be cured in the dark, on wire racks or shelves, and in shaded areas. While greenhouses and high tunnels can be utilized to cure root crops, it is extremely important that the temperature and relative humidity be keep as constant as possible, which is difficult during summers in the southeast. Once cured, the temperature should be reduced over a two-week period until the desired storage temperature of 40°F–45°F is reached with an 80% – 90% relative humidity. Potatoes should be inspected and those with bruising or rot should be culled to avoid rapid deterioration of the non-injured crop. Properly cured and stored potatoes can last up to 10 months. Late varieties can typically be stored longer than early varieties.

Potatoes should be inspected regularly once placed into storage and any spouts must be removed if they appear. If sprouting occurs, this may indicate that optimal storage temperatures are not being maintained, usually indicating that temperatures are too high.

Winter Squash & Pie Pumpkins

Provided the fruit is mature and frost is not a concern, winter squash can be left on a dead vine to cure. Winter squash is typically harvested with about two inches of stem remaining; however, for storage, stems will need to be no more than 1 inch in length or removed, depending on buyer specifications. If stored tightly, handle properly and arrange in a manner to not damage the skins of other fruit by the stem. If stems are removed, additional curing is advised.

Cut ends should be exposed to the wind and sun for five to 10 days, or optimal temperature can be simulated indoors using heaters and fans, if necessary. The ideal curing climate is 80°F–85°F at 75% – 80% relative humidity. If curing outside, use tarps or row cover to prevent damage from frost and protect from fluctuating temperatures.

Winter squash should be stored at 50°F–60°F at 50% – 75% relative humidity in crates or bins that promote good ventilation. Properly cured winter squash stored in ideal conditions can last up to 12 months depending on variety. Winter squash should not be stored long-term with root and bulb vegetables as it produces ethylene and can cause sprouting in these crops.

Curing & Storage Facilities

The southeast, and the Carolinas in particular, have many regions with differing climate and geographical characteristics that make a single curing and storage facility applicable to all areas impossible to design. Root cellars are ideal for long-term storage in the mountains, even the piedmont, but not the in the coastal plain. For these reasons, we have not included design specifics or construction plans for a curing and storage facility, but below have included considerations for using existing structures.

- Root cellars can be created by partitioning off and insulating a corner in the basement like the one shown below. The vents shown on the exterior wall allow temperature and relative humidity to be regulated by opening one vent and closing the other. This method works especially well in areas with greater fluctuations between daytime and nighttime temperatures.
- Insulation will likely be required for any long-term storage facility. For an explanation of the different types of insulation and their uses, see Chapter Three on page 10.

Photo 2.1. Design for a passively cooled basement root cellar.

Image courtesy of Mother Earth News

- While some crops can tolerate storage temperatures below 50°F, others cannot and therefore, supplemental heat may be required. Appendix C on page 23 contains recommended temperature and relative humidity for curing and long-term storage of these crops.
- Relative humidity is as important as temperature. How well your storage area is insulated and ventilated will dictate if you need to add moisture with a humidifier or remove it with a dehumidifier (or neither). How well your storage area is insulated and ventilated will dictate which one you need (or neither).
- Air flow is critical to removing air-borne diseases from your storage area and can also help to regulate temperature and relative humidity. The rule of thumb, especially for curing, is that you "turn over" one air volume of your space per day. Calculate the volume of your curing/storage area to determine your air flow needs. Typical 20in, three-speed box fans can move 1,500–2,000 cubic feet per minute, which is sufficient for most spaces. However, if using a high tunnel to cure vegetables, you may need a larger capacity fan to not only move the air, but also lower the temperature inside the tunnel.
- Stored root crops can be susceptible to a wide range of pests, including diseases, insects, and rodents. Preventative measures to control pest damage can be the difference between having a marketable product versus losing an entire season's harvest. Many diseases can be prevented by minimizing injury during harvest, transportation and storage, removing diseased or damaged produce prior to storage, practicing good sanitation, and maintaining proper storage temperatures.

Food Safety

Integrating a pest management program on the interior and exterior of the storage facility will help minimize potential pest and rodent activity. The interior installation of sticky traps (catchment and monitoring tool) or Tincats (with or without sticky traps) placed on each side of all doors leading to the exterior is recommended. Never use rodent poison on the interior of the building where food is stored. On the exterior of the storage facility, bait traps may be utilized following all local, state and federal regulations and should be placed on each side of all exterior doors and at least one trap on the remainding three exterior walls, if applicable. Monitoring for pest activity on a bi-weekly basis on the interior and a monthly basis on the exterior is best practice and required under GAP and Good Handling Practices (GHP). Maintaining at least a 6" parameter between the interior walls and stored product for scheduled monitoring of pest and rodent activity is recommended.

When using drying racks or hanging for curing, for example with garlic and shallots, always ensure that the location is monitored for bird and animal activity. Often curing takes place in structures that are also utilized as a shelter for farm animals. This is not allowed under GAP and may result in an automatic failure during an audit. Airborne bacteria or direct contamination from bird droppings is not only a potential microbial contamination threat, but also may decrease the shelf-life of the stored crop.

If storing indoors, at least once a year the room must be thoroughly washed down with a disinfectant to eliminate any molds or bacteria that will hinder the storage life of future crops. A 10% food-grade chlorine bleach solution can be prepared by adding one cup of bleach to nine cups of water.

Considerations for Certified Organic Farmers

For certified organic operations, lumber treated with arsenate or other prohibited substances that might contact crops, soil or livestock is not allowed. Keep this in mind when you build out the curing facility, specifically if you decided to use wood instead of plastic pallets. Design of the curing facility should eliminate contact between produce and wood surfaces and other porous surfaces that cannot be sanitized, which is essential for GAP certification. This concern can be addressed by allowing the produce to cure in plastic harvest containers or by placing a clean washable barrier between any wood service and the crop. It is important to remember that with any organic certification question, be sure to contact your organic certifier for approval to use materials prior to construction.

CHAPTER THREE

Cold Storage

Time is a resource that always seems to be in short supply for small-scale produce growers. If as the saying goes, "time is money," then more time should be more money. Having cold storage capabilities can provide the produce farmer with both. Cold storage units, or walk-in coolers, provide near ideal conditions for prolonging the shelf-life of most fruits and vegetables. Increasing the shelf life of harvested crops gives the farmer more time to market her/his crops and reduces waste (shrink), both of which should equal more revenues. This chapter is intended to provide small-scale produce farmers with the information and resources they need to design and build a walk-in cooler, and use it to extend the marketable life of fresh fruits and vegetables.

Fresh fruits and vegetables deteriorate (or respire) at different rates. Cooling fresh commodities can reduce rates of respiration by 2–4 times versus typical field heat conditions. Decreasing respiration rates (and water loss) can significantly increase the quality of a crop through its entire shelf life, which is very important to commercial buyers. Appendix D on page 24 provides recommended temperature and relative humidity levels for optimal storage of fresh fruits and vegetables. Keep in mind that some crops are better suited for co-storage than others due to optimal temperate, relative humidity levels, and ethylene sensitivity. See Appendix E on page 27.

Prefabricated Walk-In Coolers vs. the Coolbot®

Prefabricated walk-in coolers are expensive and cost prohibitive for many small-scale produce farmers. Complete units generally start upwards of $5,000 – $6,000, and require professional installation and service. Used units can be found second-hand for much cheaper but still typically need to be installed by a professional and the cooling equipment my not include a warranty.

Photo 3.1 CoolBot® walk in cooler controller.

Photo courtesy of Store It Cold

An alternative to expensive refrigeration units is the CoolBot® technology sold by Store It Cold, LLC. The CoolBot® (Photo 3.1) consists of a small circuit board and sensors that "trick" an off-the-shelf, window-mounted, air conditioning (A/C) unit into cooling to much lower temperatures and for longer periods without freezing up or cycling off. Using the CoolBot® and standard A/C unit, a farmer with basic construction and electrical skills can build a fully functional walk-in cooler capable of cooling to 38°F (3°C) for a fraction of the costs of a prefabricated unit. By comparing maintenance and operating costs over the life of the unit versus a prefabricated unit, the total investment becomes an even more economical option for the small-scale farmer.

Capabilities, installation, and design recommendations presented in this chapter were taken from Store It Cold, LLC (www.storeitcold.com). Any other information or experience related to uses of the CoolBot® are otherwise noted.

Permanent Cold Storage Unit vs. Mobile Cooler

The CoolBot® is typically installed in a permanent walk-in cooler constructed of common building materials or in a commercially-available, tow-behind cargo trailer modified to function as a mobile cooler. Costs to construct a permanent walk-in cooler 8 feet by 8 feet are about $3,800 and the same as those to renovate a mobile trailer 5 feet by 8 feet. In addition to cost, other factors should be considered when deciding which design suits your specific operation and include:

- Mobile cooler units are, well. . .mobile. Portability may be extremely important if you lease farmland and have to relocate your farm. If your markets are a considerable distance from your farm, keeping your produce cold during transport will result in better sales. Appendix F on page 29 provides recommended transit conditions for compatible crops.
- Mobile cooler units can also be taken into the field and used to remove field heat from harvested crops, or serve as long-term cold storage for field-packed produce. Either function minimizes handling, loading, and unloading. Operating a mobile cooler unit while in transport does require a generator, which increases overall costs.
- Double-swinging doors on the rear of the mobile cooling unit are preferable to a single door or tailgate that folds down. Side doors near the front of the trailer are typically not used, so if you can purchase a trailer without the side door, do. It may be virtually impossible to purchase a trailer eight feet or longer without a side door. In this case, the side door should be permanently sealed from the inside to remove cracks where warm air might seep in.
- Mobile cooling units require some metal working skills – owning and/or experience with a welder is an advantage.
- There does not seem to be a consensus as to which is better, a flat front trailer or one that is V-shaped. No real space advantage is gained by using a V-shaped trailer and the metal working is somewhat more involved. The V-shaped trailer might be more aerodynamic while on the road but the V-shape usually eliminates space to store a generator.
- Permanent walk-in coolers can be designed and custom built to fit your operation.
- Construction of a permanent walk-in cooler does not require any specialized equipment – only basic hand tools and basic understanding of carpentry and electrical wiring.
- Regardless of design, location of your cold storage unit is an important consideration. It needs to be conveniently located adjacent to your postharvest wash and pack operations. Permanent walk-in coolers should be located under the north side of a barn or shed and shielded from direct sunlight. Mobile cooler units should be parked under shade while in the field and under a barn or dedicated shed when not actively used.

Table 3.1 Common Insulation Products Used for Cold Storage Units

INSULATION TYPE	MANUFACTURER	PRODUCT NAME	R-VALUE	SIZE	PRICE	USE
Polyisocyanurate	GAF	EnergyGuard	6.1	4ft x 8ft x 1in	$20	Walls, Ceiling
Extruded Polystyrene (XPS)	Owens Corning	Foamular 250	10	4ft x 8ft x 2in	$30	Floor
Expanded Polystyrene (EPS)	Isulfoam	R-Tech	1.93	4ft x 8ft x ½in	$8	Walls
Spray Foam	Touch 'n Foam Professional	System 200	5.48	200 board ft	$333	Walls, Ceiling, Floor
Mineral Wool	Roxul	ComfortBatt	15/23	See Notes	$600/$512	Walls, Ceiling, Floor

Cold Storage Construction

Types of Insulation & R-value

A product's R-value represents the material's resistance to heat flow. Heat flows from hot to cold (or high to low) and the higher a material's R-value, the better it insulates and less energy it takes to cool a space. Store It Cold states that the industry standard for cold storage units is a minimum of R25 of waterproof insulation. It generally takes multiple layers of different insulation products to achieve a total value of R25 or better (Table 3.1).

Rigid foam insulation (polyisocyanurate, XPS, EPS, and spray foam that has dried) and mineral wool are moisture resistant, do not require a vapor barrier, and are ideal for use in coolers.

If using polyisocyanurate, be sure to wear long sleeves and gloves as it can irritate skin. If it contains a foil backing, make sure the foil faces away from the wall, not towards the wall. Rigid foam insulation is available in various thicknesses – be sure to ask for the one that fits your design and budget. DO NOT USE fiberglass insulation (the pink stuff with brown paper backing). It is not moisture resistant and continued exposure to cooling can cause it to sag and quickly develop mold.

Spray foam provides the best sealing properties of all the insulation types and do-it-yourself kits are available at home improvement stores. Applying spray foam to the chassis of a mobile cooler can significantly improve the insulation properties but adds additional costs to the construction. Note that if you plan to insulate the chassis of your mobile cooler, make sure the cooler is secure and all safety precautions are followed. Spray foam is typically marketed and sold by volume, which in construction terms is board feet. One board foot is equal to 144 cubic inches or 0.083 cubic feet. A walk-in wall constructed of 2x4 lumber that is 10 feet long by 8 feet high requires about 241 board feet (20 cubic feet) of spray foam. This cost is considerable when factoring in an entire cooler or one built with 2x6 lumber.

Roxul ComfortBatt is available in two sizes or R-values – R15 fits standard 2x4 construction and R23 standard 2x6 – both assume studs or joists are on 16 inch centers. The price listed is per pallet of insulation or 12 packages. A pallet of R15 covers about 716 square feet and a pallet of R23 about 450 square feet. A walk-in eight feet by 10 feet with 10-foot ceiling contains about 448 square feet of wall, ceiling, and floor area. One pallet of R23 should be adequate for covering all six surfaces (four walls, the ceiling, and the floor), especially when subtracting 20 square feet for a standard 36 inch by 80-inch entry door.

Rigid foam insulation should be installed over studs and joists, not between them. If multiple layers are used, make sure to stagger seams and joints. Seams should be sealed with foil tape and ALL joints and cracks should be filled with an elastic caulk (which does not become brittle when dry) or spray foam (like Great Stuff™ in 16 ounce cans found in home improvement stores). The more air tight your cooler, the more efficient the air conditioner will operate and the lower your energy costs will be.

Wood Deck Floors vs. Concrete Slab

Walk-in coolers intended to store fresh produce will generally need floors constructed with an insulation value of R25, though R30 is better, to achieve a minimum temperature of 38°F (3°C). Floors typically do not require framing and can be constructed by laying 2 – 4 inches of rigid foam on an existing surface. If that existing surface is an untreated wood subfloor, then at least one layer of moisture barrier will be needed between the rigid foam and top layer of plywood (cooler floor). Walls can be constructed directly on top of the plywood as it will distribute the load across the floor.

If designing a new concrete pad specifically for your permanent walk-in cooler, start with a graded surface followed by several inches of gravel. Cover the gravel with a vapor barrier and then 2-4 inches of XPS rigid foam (designed for below-grade use). A 4-inch concrete slab can be poured directly on top of the rigid foam. Be sure to use rebar and fibers to strengthen the concrete and reduce cracking potential. The floor should be sloped slightly so that any water accumulating in the cooler will drain toward the door and outside. Note that it is nearly impossible to insulate the floor of a mobile unit to an insulation value of R30 without significant expense or reducing the interior height by a considerable amount. Using a combination of materials and R12 – R15 materials is more realistic.

Sheathing should be used in the interior of your cooler to protect the insulation from punctures and gouges. Sealed plywood may be sufficient but if intended for use inside of a restaurant, material that can be washed may be required. Similarly, the outside of a permanent walk-in cooler should be sheathed to protect the insulation if in a high-traffic area.

Solid exterior doors that swing to the outside should be used for permanent coolers. Exterior doors that are pre-hung (include frame) measuring 36 inches by 80 inches are available from home improvement stores for about $200 and can be found at salvage warehouses for less. Gluing additional rigid foam to the inside of the door will increase its R-value and modification to the jam may be required if you plan to rinse out your cooler.

Electrical and Wiring

Switches, outlets, light fixtures, and wiring should be rated for exterior use and high moisture environments. Electrical service to your cold storage unit may be as simple as extending the A/C unit power cord to the outside of the cooler. However, if you wish to add a light and additional outlet, or if your A/C unit requires 230 volts, then more advanced electrical knowledge is required. If you do not have electrical wiring experience or are not comfortable wiring your cooler yourself, please seek the assistance of an experienced electrician.

Properly Sizing the A/C Unit

The size of your cooler, the intended use, and how quickly you need to cool your produce will affect the size of A/C unit required (Table 3.2). These requirements assume a cooler ceiling height of eight feet, an insulation value of R25, and that the door is opened no more than six times per hour. If the R-value is less or the door will be opened more than six times per hour, then a larger A/C unit may be needed. Conversely, if the ceiling height is less than eight feet, a smaller unit may be sufficient. Through extensive product testing and consultations, Store It Cold recommends LG brand A/C units for their compatibility with the CoolBot®, and their ease of installation and operation. A/C units must have a digital display to function with the CoolBot®.

Table 3.2 Cooling Requirements for Produce Cooler Sizes

DESIRED TEMPERATURE FOR PRODUCE: 38°F (3°C)	
Cooler Size	BTU Requirements
4ft x 4ft	4,000
6ft x 6ft	8,000
6ft x 8ft	10,000
8ft x 8ft	12,000
8ft x 10ft	15,000
8ft x 12ft	18,000
10ft x 14ft	24,000

Installing the Air Conditioning Unit

The A/C unit should be installed so that the bottom of the unit is at average eye level. This also creates a zone of colder air near the cooler floor that is more ideal for produce with lower cold storage requirements. Installation of plastic curtains at the door may help the cooler retain more cold air when the door is opened. Use of curtains in the interior of the cooler may also help create zones for produce with different storage requirements.

For a rectangular cooler, the A/C should be installed in the shorter wall opposite the door. For example, in an 8 by 10-foot cooler, the door should be installed in one 8-foot wall and the A/C unit in the other. The CoolBot® has to be mounted inside the cooler next to the A/C unit in order to operate correctly and troubleshoot easily. It is important that condensation drains to the outside of the cooler and does not collect and freeze in the A/C unit. Therefore, mount the A/C so that it tilts to the rear or outside of the cooler.

Disclaimer: Use of hand or power tools, and electrical work is inherently dangerous. Be sure to read, understand, and follow all safety rules and precautions. If you are not comfortable completing any tasks, please seek the assistance of someone who is.

Food Safety

It is important that fruits and vegetables be maintained at their optimal temperature, not only to improve shelf-life, but to minimize food safety risks. Wholesale buyers are testing pulp temperatures of product prior to accepting a delivery and may reject a delivery if the product falls outside of these temperature ranges. There are two types of bacteria of concern: 1) pathogenic bacteria responsible for causing food-borne illnesses and 2) spoilage bacteria that causes food to deteriorate more rapidly. Temperatures ranging from 40°F to 140°F create an optimal environment for bacteria growth and can be eliminated with the use of on-farm cold storage. The Center for Environmental Farming System's *Wholesale and Retail Product Specifications: Guidance and Best Practices for Fresh Produce for Small Farms and Food Hubs* provides details on optimal storage temperatures to prevent the growth of bacteria and can be found at https://cefs.ncsu.edu/resources/wholesale-and-retail-product-specifications-guidance-and-best-practices-for-fresh-produce-for-small-farms-and-food-hubs/.

When insulating a cold storage unit utilizing spray foam, it is important to note that spray foam is porous and can be a potential source of microbial contamination. It is recommended that once the spray foam is installed and has dried, it be covered with a non-porous product that is easily washable and can be sanitized effectively.

CASE STUDY

Permanent Walk-in Cooler

Swamp Rabbit Café & Grocery, Greenville, SC

The Swamp Rabbit Café & Grocery (SRCG) opened in 2011 as a café and grocery sourcing meats, produce, dairy, and other goods from over 250 local farmers and food entrepreneurs. Since opening, SRCG has expanded three times and more than doubled their original footprint.

SRCG owners have sought to save money where they can and when faced with the expense of installing a new (or even used) produce cooler, decided to opt for the CoolBot®. Fresh fruits, vegetables, eggs, and milled products are stored around 40°F in their Produce Room, which is open to customers (Photo 3.2).

SRCG is located in a building constructed in the early to mid-1900s. It was originally used as a meat packing operation, however, the original cooler space was not ideal for storing produce. Therefore, insulation was added to existing walls and ceiling to create the Produce Room. Modifications could not be made to the concrete floor to improve its insulation properties.

SRCG's Produce Room is about 150 square feet with a ceiling height of almost eight feet. Solid glass storm doors are located on either side of one corner, providing customers access from two different areas. The A/C unit and the CoolBot® are located in the corner opposite the doors and positioned high in the wall, near the ceiling. Goods are stored on wire shelves, off the concrete floor, for food safety reasons and to promote air circulation (Photo 3.3).

Photo 3.2. Swamp Rabbit Cafe and Grocery's Produce Room, where fresh fruits, vegetables, eggs, and milled products are stored.

Photos on this page and the following page courtesy of Stephen Nix

Given that doors to the Produce Room are opened frequently, much more than the recommended six time or less per hour, the CoolBot® has worked well over the five and a half years in operation. Owners do believe they have replaced the A/C unit once and at times moisture has been an issue since the room is located on the interior of the building.

Photo 3.3. Swamp Rabit Cafe and Grocery's Produce Room with an A/C unit and CoolBot® controller.

CASE STUDY

Mobile Cooler Unit

The Farm Cart, Across SC & Western NC, based in Greenville, SC

The Farm Cart purchases locally grown produce, milk, honey, and other products across South Carolina and parts of North Carolina, and sells mostly direct to chefs but also local food retailers. The Farm Cart now has a refrigerated truck but still uses their mobile cooler unit for pickup at farms and as a stationary walk-in cooler.

The mobile cooler unit is a Pace America trailer measuring 5 feet by 8 feet (Photo 3.4). The plug is located below the A/C unit and can be plugged into a generator or fixed electrical outlet when not on the road or parked at a farmers' market.

The Farm Cart purchased their mobile cooler unit off of craigslist and did not assist in its construction. However, it appears to have been built according to North Carolina State University's Pack N' Cool instructions. While The Farm Cart is pleased with the mobile cooling unit and its functionality, they indicated that the seal around the door could be improved. The Farm Cart also plans to paint the interior plywood so that the unit can be washed out periodically.

Double doors are preferable for mobile cooler use (Photo 3.5). Opening one door does not result in nearly as much cooling loss as having to lower the ramp door each time products are loaded or unloaded. Additional insulation can be added to the door by installing a heavier or thicker gasket around the edge of the doors. (Photo 3.6)

The interior of the mobile cooler has plywood flooring and walls, XPS insulation, an A/C unit, and taped seams (Photo 3.7). The CoolBot® unit is located behind the brown box on the right. Ideally, the A/C unit and the CoolBot® should be installed closer to the ceiling of the cooler. Note that completing the interior of the mobile cooling unit with plywood, caulking all seams/joints, and painting with several coats of quality exterior paint would allow one to mop or wash out the cooler. However, most GAP programs do not allow the use of porous materials, such as wood, inside a cooler where moisture can contribute to the rapid growth of bacteria. RFP wall board, commonly used in restaurant kitchens, and linoleum flooring are acceptable alternatives to plywood.

Photo 3.4 The Farm Cart's mobile cooling unit used to transport and store fresh produce.

Photo 3.5. Mobile cooler with double rear doors.

Photo 3.6. Two inches of XPS affixed to the interior of the door for increased insulation.

Photo 3.7. Interior of the mobile cooler with plywood floor and walls, XPS insulation, an A/C unit and taped sides.

Pack N' Cool: https://plantsforhumanhealth.ncsu.edu/2012/08/20/pack-n-cool/

CHAPTER FOUR

Funding Sources

Access to capital is one of the biggest barriers that small-scale farmers face when trying to expand or enhance their farm's operational output. This chapter describes loan programs and grant opportunities that are available to farmers and ranchers looking to make capital improvements to their business, specifically regarding improvements to post-harvest handling facilities.

Grants

NC Tobacco Trust Fund Commission

The NC Tobacco Trust Fund Commission (TTFC) offers small grants managed by different organizations/institutions to assist with projects that can help with infrastructure investments. *Grants are specific to various regions, and farmers must contact specific grantors to begin the application process. For more information visit:* http://tobaccotrustfund.org/

Cost-Share Program Partners

Energy Conservation Program (E-CAP)

The E-CAP program offers cost share assistance to WNC farmers for energy efficiency or renewable energy projects that increase agricultural output and/or decrease energy costs. Project examples include solar-PV electricity for cold storage rooms, insulating processing rooms and greenhouses, and more.

Area Served: Alexander, Allegheny, Ashe, Avery, Buncombe, Burke, Caldwell, Catawba, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson, Iredell, Jackson, Lincoln, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Swain, Transylvania, Watauga, Wilkes, Yancey

www.mountainvalleysrcd.org

NC AgVentures Grant Program

Cost-share grants to benefit farming operations and increase farm profits.

Area Served: Yadkin, Surry, Rockingham, Stokes, Guilford, Forsyth, Pitt, Nash, Edgecombe, Wilson, Martin, Johnston, Wayne, Greene, Sampson

www.go.ncsu.edu/agfoundation

Agricultural Reinvestment Fund

Cost-share grants to farmers in NC for innovative projects designed to increase farm income and build markets for NC agricultural products.

Area Served: Randolph, Chatham, Alamance, Caswell, Cumberland, Davidson, Davie, Person, Orange, Durham, Granville, Guilford, Vance, Warren, Franklin, Halifax, Northampton, Hertford, Bertie, Chowan

www.rafiusa.org

WNC Agricultural Options Program (aka WNC AgOptions)

Demonstration grants that help family farmers in Western NC diversify and expand their farming operations and replace tobacco-based income.

Area Served: Avery, Burke, Cherokee, Cleveland, Haywood, Jackson, Madison, Mitchell, Eastern Band of Cherokee Indians, Swain, Watauga, Buncombe, Caldwell, Clay, Graham, Henderson, Macon, McDowell, Polk, Rutherford, Transylvania, Yancey

www.wnccommunities.org

USDA Rural Development Value-Added Producer Grant

The Value-Added Producer Grant (VAPG) program provides grants on a competition basis to eligible individuals or entities to create or develop value-added agricultural product. The purpose of this program is to encourage agricultural producers to create and develop value-added producer owned businesses that will help increase farm income and marketing opportunities, create new jobs, contribute to community economic development, and enhance food choices for consumers.

SAMPLE PROJECTS RECEIVING VAPG FUNDS INCLUDE:

- McKaskle Farm in Braggadocio, Missouri, which grows a variety of organic grains, received a planning grant to evaluate the financial feasibility of purchasing equipment to clean, process, and package their products. The VAPG grant allowed McKaskle to examine and evaluate options for scaling up business to sell to more local retailers.
- The Wisconsin Food Hub Cooperative in Madison, Wisconsin received a working capital grant to assist in the startup of a regional fresh produce food hub and packinghouse created to enhance access to wholesale markets for the local farm economy. The food hub plans to aggregate local produce sold under the Wisconsin Farmed brand.

ENTITIES ELIGIBLE TO APPLY FOR VAPG FUNDS INCLUDE:

- individual agricultural producers
- groups of agricultural producers
- majority-controlled producer-based business ventures
- organizations representing agricultural producers
- farmer or rancher cooperatives

Agricultural producers include independent farmers, ranchers, and harvesters, including fishermen and loggers, who engage in the production or harvesting of an agricultural commodity.

THERE ARE TWO TYPES OF GRANTS UNDER VAPG

1. Planning grants to fund economic planning activities such as the development of business plans and feasibility studies (including marketing plans) needed to establish viable marketing opportunities for value-added products; and
2. Working capital grants to fund the operation of a value-added business venture, specifically to pay for eligible expenses related to the processing and/or marketing of the value-added product.

APPLICATION AND FINANCIAL INFORMATION

Grant and matching funds can be used for planning activities or for working capital expenses related to producing and marketing a value-added agricultural product. Examples of planning activities include conducting feasibility studies and developing business plans for processing and marketing the proposed value-added product. Examples of working capital expenses include:

- Processing costs
- Marketing and advertising expenses
- Some inventory and salary expenses

VAPG program Funding: $44 million

Maximum Grant Amount:
$75,000 for planning grants;
$250,000 for working capital grants

Matching Funds Requirements: 50% of total project costs

MORE INFORMATION

http://www.rd.usda.gov/programs-services/value-added-producer-grants

If you have questions, you can contact your nearest Rural Development Office. Additionally, you can reference this guide to walk you through the application process.

Loans

Community Development Financial Institutions (CDFIs)

CDFIs are non-governmental entities, often nonprofits, whose primary mission is to provide funding for small business development and affordable housing in underserved, economically distressed, often rural communities. CDFIs receive funding from federal and state agencies, private foundations, financial institutions, and individuals.

ELIGIBILITY, USES, & RESTRICTIONS

Eligible companies & nonprofits are in the following sectors:

- Local and value-added agriculture
- Renewable energy and energy efficiency
- Sustainable forest products
- Recycling
- Heritage tourism and ecotourism
- Natural products and medicines
- Water conservation and water quality
- Vital community services

Loans can be used to leverage debt from traditional lending institutions. CDFIs often partner with other lenders to provide the unsecured debt needed to complete loan transactions. CDFI funds can be used to purchase equipment, real estate, and technology, and to provide working capital to grow sales through increased inventory, hiring, and marketing.

APPLICATION AND FINANCIAL INFORMATION

Loan amounts typically range from $5,000 to $500,000 and terms depend on use of the capital. Interest rates are tied to the prime rate and are based on the loan purpose, terms of repayment, strength of collateral, and the borrower's credit history.

MORE INFORMATION

www.cdfifund.gov

NORTH CAROLINA CONTACT INFORMATION

Natural Capital Investment Fund
1665 N Fort Myer Drive, Suite 130
Arlington, VA 22209
336-734-6902
http://www.conservationfund.org/what-we-do/natural-capital-investment-fund

Carolina Small Business Development Fund
3128 Highwoods Blvd, Suite 170
Raleigh, NC 27604
919-803-1437
https://carolinasmallbusiness.org/

Self-Help Ventures Fund
301 West Main Street
Durham, NC 27701
800-966-7353
https://www.self-help.org/who-we-are/self-help-family/self-help-ventures-fund

SOUTH CAROLINA CONTACT INFORMATION

CommunityWorks Carolina
107 W Antrim Drive
Greenville, SC 29607
864-235-6331
http://www.communityworkscarolina.org/

SC Community Loan Fund
PO Box 21163
Charleston, SC 29413
843-973-7285
www.sccommunityloanfund.org

USDA Farm Services Direct Farm Ownership and Operating Loan

The purpose of this loan is to provide family farmers and ranchers with the necessary capital to purchase land and assets or finance annual operating expenses. The USDA's Farm Services Agency (FSA) provides the direct farm ownership (DFO) and direct operating loan (DOL) programs to provide financing and assistance to family farms and ranchers to establish farms and ranches that achieve financial success and become self-financing.

ELIGIBILITY, USES, & RESTRICTIONS

Eligible borrowers must be:

- U.S. citizens or U.S. non-citizen national or qualified aliens;
- unable to obtain credit elsewhere through commercial lenders
- have sufficient education, training, or experience;
- have an acceptable credit history; and
- be an owner or operator of a family-sized farm, at loan closing.

A family farm is defined as one in which the farm family provides all of the management and a substantial portion of the total labor.

For DFO loans, an applicant must also have substantially participated in the operation of a farm for at least three of the last 10 years, with flexibility to consider additional experience for at least one of the three years.

LOAN PURPOSES

DFO loans may be used to purchase a farm or ranch, make capital improvements, pay closing costs, and pay for soil and water conservation improvements, including sustainable agriculture practices and systems.

DOLs may be used to pay the costs of reorganizing a farm or ranch, buy livestock or equipment, annual operating expenses, finance conservation costs, pay closing costs, comply with OSHA requirements, pay tuition for borrower training classes, refinance farm related operating loans, and family living expenses.

APPLICATION AND FINANCIAL INFORMATION

Loan application forms are available online but farmers must apply for direct loan assistance in person at an FSA county office or USDA Service Center. FSA officials will meet with the applicant to assess all aspects of the proposed or existing farming or ranching operation to determine if the applicant meets the eligibility requirements. FSA loan programs are funded through the annual agriculture appropriations bill.

MORE INFORMATION

http://www.fsa.usda.gov/programs-and-services/farm-loan-programs/index

FACT SHEETS

https://www.fsa.usda.gov/news-room/fact-sheets/index

FSA'S GUIDE TO FSA FARM LOANS

http://www.fsa.usda.gov/Internet/FSA_File/fsa_br_01_web_booklet.pdf

To find your local FSA regional Service Center or state FSA office select your state from this website: http://offices.sc.egov.usda.gov/locator/app?agency=fsa

USDA Farm Services Guaranteed Farm Ownership and Operating Loan

The purpose of this program is to offer federal guarantees on commercial loans to family farms and ranchers for the purchase of land and assets or finance annual operating expenses. The USDA's Farm Services Agency (FSA) provides the guaranteed farm ownership (GFO) and guaranteed operating loan (GFL) programs to assist family farmers obtain commercial credit to establish or maintain a family farm or ranch.

FSA guarantees against potential loss of the commercial loan at 90 percent of the loss of principal and interest. A 95 percent guarantee is provided in the case of loans to refinance an existing DFO or DOL or for loans made in conjunction with a down payment loan or approved state beginning farmer program loan.

ELIGIBILITY, USES, & RESTRICTIONS

Eligible borrowers must:

- Be a citizen of the U.S. (or legal resident alien)
- Have the legal capacity to incur the obligations of the loan
- Have an acceptable credit history as determined by the lender and FSA
- Have not had a previous FSA loan that resulted in a loss to FSA and not be delinquent on any federal debt
- Be unable to obtain sufficient credit elsewhere without a guarantee at a reasonable rate and terms
- Be the owner or operator of a family farm after the loan is closed
- Not be delinquent on any Federal debt

LOAN PURPOSES

For GOLs, authorized purposes include:

- Payment of costs associated with reorganizing a farm to improve profitability
- Purchase of livestock, equipment, and cooperative stock
- Minor real estate improvements and other farm and home needs
- Payment of annual operating expenses
- Payment of costs for land and water development for conservation or use
- Payment of loan closing costs
- Refinancing of debt incurred for any authorized DOL purpose

For GFOs, authorized purposes include:

- Acquiring or enlarging a farm
- Making capital improvements
- Promoting soil and water conservation and protection
- Payment of loan closing costs
- Refinancing debt incurred for authorized DFO or DOL purposes

APPLICATION AND FINANCIAL INFORMATION

Farmers apply for guaranteed loans as they normally would with local commercial lenders that make agricultural loans in their community. The lender analyses the farmer's business plan and financial condition.

If the farm loan proposal looks realistic, is financially feasible, and there is sufficient collateral, but it cannot be approved because it does not meet the lending institution's loan underwriting standards, the lender may apply for an FSA loan guarantee.

Once an applicant provides all the financial and organizational information to the lender, the lender submits a guaranteed loan application to the local FSA office and the request will be approved or disapproved within 30 days after receipt of a complete application.

The number of guaranteed loans that FSA can provide each year varies depending on the demand for loan guarantees and the amount of guarantee authority approved by Congress, as FSA loan programs are funded through the annual agriculture appropriations bill.

SOURCE

http://www.sare.org/content/download/864/7092/file/building_sust_farms.pdf?inlinedownload=1

MORE INFORMATION

http://www.fsa.usda.gov/programs-and-services/farm-loan-programs/guaranteed-farm-loans/index

FSA'S GUIDE TO FSA FARM LOANS

http://www.fsa.usda.gov/Internet/FSA_File/fsa_br_01_web_booklet.pdf

To find your local FSA regional Service Center or state FSA office select your state from this website: http://offices.sc.egov.usda.gov/locator/app?agency=fsa

USDA Farm Services Farm Storage Facility Loan

For most farmers, on-farm storage is essential to keeping food fresh and safe prior to marketing. The Farm Storage Facility Loan, administered by the USDA's Farm Service Agency, provides low-interest loans for producers to build or upgrade permanent facilities to store commodities, including fruit and vegetable cold storage, washing, packing, and handling buildings and equipment.

ELIGIBILITY, USES, & RESTRICTIONS

The following products are currently eligible for farm storage facility loans:

- Corn, grain sorghum, rice, soybeans, oats, peanuts, wheat, barley or minor oilseeds harvested as whole grain
- Corn, grain sorghum, wheat, oats or barley harvested as other-than-whole grain
- Other grains (triticale, spelt, buckwheat, and rye)
- Hay and renewable biomass
- Pulse crops (lentils, chickpeas, dry peas)
- Fruits (includes nuts) and vegetables
- Honey and maple sap
- Meat, poultry, milk, eggs, cheese, butter, and yogurt
- Aquaculture
- Floriculture and hops

Eligible uses for these types of loans include:

- Grain storage cribs, bins, and silos, and related electrical equipment
- Equipment to maintain, improve, or monitor stored grain quality
- Grain drying equipment
- Hay and biomass storage structures
- Cold storage buildings and equipment
- Packing sheds and handling equipment
- Portable storage structures, portable equipment, and storage and handling trucks

Structures and equipment generally must have an expected useful life of at least 15 years, which includes both new and used equipment. Facilities that are not for the sole use of the borrower(s) are also not eligible.

For fruit and vegetable cold storage facilities, eligible uses include:

- New and used structures suitable for cold storage
- New and used walk-in prefabricated permanently installed coolers
- New and used permanently affixed cooling, circulating and monitoring equipment
- Electrical equipment integral to the proper operation of a cold storage facility
- An addition or modification to an existing storage facility

Additionally, fruit and vegetable producers may use FSFLs for structures and equipment required to get fruits and vegetables washed, treated and packed or otherwise required to maintain the quality of the crop.

Items that can be financed include:

- Baggers
- Batch dryers
- Boxing equipment
- Brush polishers
- Cold dip tanks
- Conveyors
- Drying tunnels
- Food safety-related equipment
- Hoppers
- Hydrocoolers
- Quality graders
- Scales
- Sealants
- Sorting bins/tables
- Vacuums
- Washers
- Waxers
- Weight grader

Eligible cost items include:

- Purchase price and sales tax
- Cost of new materials

- Shipping and delivery
- Site preparation/installation costs
- Off-farm paid labor
- Appraisals and legal fee

FINANCIAL INFORMATION AND APPLICATION

Any farmer with on-farm or mobile storage needs can apply for a USDA Farm Storage Facility Loan as long as they have satisfactory credit, can demonstrate the ability to repay the loan and have proof of crop insurance, NAP coverage, or another risk management option. Loans can be up to $500,000, though there is a streamlined process to apply for a microloan of up to $50,000. A 15% down payment is required for all FSFLs except for microloans, which only require a 5% down payment. Loan terms are for 3, 5, or 7 years (microloans) or 7, 10, or 12 years (all other loans), and the interest rate is fixed by the U.S. Treasury (currently 2.5% as of April 2016).

MORE INFORMATION

Check out NSAC's Grassroots Guide for more information on Farm Storage Facility Loans or contact your local Farm Service Agency (FSA) office for a loan application.

http://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage/index

Farm Credit System

The Farm Credit System was established in 1916 to support rural communities and agriculture with credit and financial services. Each of the nearly 75 independently owned and operated Farm Credit organizations is a cooperative owned by its customers. Farm Credit organizations provide more than $235 billion in loans, leases, and related services.

ELIGIBILITY, USES, AND RESTRICTIONS

The following are eligible for the loan program:

- Agricultural producers of all sizes, commodities, and organic or conventional
- Young (35 years or younger), beginning (less than 10 years of agricultural experience), and small farms (annual sales of $250,000 or less)
- Agricultural cooperatives
- Agribusinesses involved in every aspect of the food chain – production, processing, marketing, and distribution
- Rural infrastructure providers – energy, communications, water, and wastewater providers
- Lending to rural (2,500 persons or less) home owners for first or second homes, recreational land, home construction, and refinancing

LOAN USES

- Real estate and lots
- Homes
- Equipment
- Farm improvements
- Operating expenses
- Automobile and personal loans
- Specialized operations (poultry, dairy, greenhouse/nursery, etc.)

APPLICATION & FINANCIAL INFORMATION

For application and financial information, contact an individual Farm Credit organization agent located in your county.

MORE INFORMATION

https://www.farmcreditnetwork.com/about/overview

NORTH CAROLINA CONTACT INFORMATION

AgCarolina Farm Credit, ACA
4000 Poole Rd, Raleigh, NC 27610
919-250-9500
www.agcarolina.com

Cape Fear Farm Credit, ACA
333 E Russell St, Fayetteville, NC 28301
910-323-9188
www.capefearfarmcredit.com

Carolina Farm Credit, ACA
146 Victory Lane, Statesville, NC 28625
704-873-0276
www.carolinafarmcredit.com

SOUTH CAROLINA CONTACT INFORMATION

ArborOne Farm Credit
800 Woody Jones Blvd, Florence, SC 29501
843-662-1527
www.arborone.com

AgSouth Farm Credit, ACA
101 Northtown Dr, Spartanburg, SC 29303
864-585-6234
www.agsouthfc.com

AgFirst Farm Credit Bank
1901 Main St, Columbia, SC 29201
803-799-5000
www.agfirst.com

Whole Foods Market: Local Producer Loan Program

Whole Foods Market is committed to supporting local products and the people who supply them. Through this commitment the grocery chain is also providing up to $25 million low-interest loans to independent local farmers and food artisans.

ACCORDING TO WHOLE FOODS MARKET, THE PURPOSE OF THE LOCAL PRODUCER LOAN PROGRAM IS:

- strengthen the partnerships between Whole Foods Market and local producers
- work with producers to expand the availability of high-quality local products for our customers
- support the communities where Whole Foods Market does business
- reinforce Whole Foods Market's commitment to environmental stewardship

ELIGIBILITY, USES, AND RESTRICTIONS

In order to be eligible for the loan program producers:

- must meet Whole Foods Market's Quality Standards and standards for animal welfare
- use funds for expansion and capital expenditures (e.g., buy more animals, invest in new equipment and infrastructure, or expand crops), not operating expenses
- have a viable business plan and adequate cash flow to service debt

Due to liquor laws, Whole Foods Market is unable to offer loans to producers of alcoholic beverages.

APPLICATION & FINANCIAL INFORMATION

Whole Foods Market promises a streamlined loan process with fees, interest rates, and paperwork minimized.

- Targeted loan amounts between $1,000 and $100,000 (maximum $25,000 for start-ups)
- Loan amount not to exceed 80% of total project cost
- Low, fixed interest rates (currently between 5% and 9%)
- No penalty for early repayment
- Collateral required
- One-time minimal processing fee covers administrative expenses, including credit report
- Approval and terms dependent on product characteristics, risk assessments and use of proceeds
- Opportunity to apply for additional financing after one year if initial loan is in good standing
- Existing vendor relationship with Whole Foods Market preferred
- Applications accepted on a rolling basis

MORE INFORMATION

For an application, talk to your local Whole Foods Market contact or see: wholefoodsmarket.com/loans. For general information, email LPLP@wholefoods.com.

APPENDIX A

Comparison of Cooling Methods for Common Fruits & Vegetables on Small-Scale Farms[1]

METHOD	ROOM COOLING	FORCED-AIR COOLING	HYDRO-COOLING	ICE COOLING	IDEAL HOLDING TEMPERATURE °F[2]
Cooling Time →	20-100 hours	1-10 hours	0.1-1 hours	0.1-0.3 hours	
Apples	✔	✔	✔		30–31; 38–40[3]
Asparagus			✔	✔	32 (36)[4]
Beans	✔	✔	✔		41–43
Beets, roots	✔				32
Blackberries	✔	✔			31–32
Blueberries	✔	✔			31–32
Broccoli		✔	✔	✔	32
Brussels sprouts			✔	✔	32
Cabbage	✔	✔			32
Carrots, topped	✔			✔	32
Cauliflower			✔		32
Celery				✔	32
Corn, sweet			✔	✔	32
Cucumbers		✔	✔		50–55
Eggplant	✔	✔			50–54
Endive			✔	✔	32
Leafy greens			✔	✔	32–36
Leeks			✔	✔	32
Lettuce, head			✔	✔	32
Onions, green			✔	✔	32
Parsley			✔	✔	32
Pear	✔	✔	✔		29–31
Peas		✔	✔	✔	32–34
Peppers	✔	✔			45–50
Potatoes	✔	✔			50–59; 40–55[5]
Radishes			✔	✔	32
Raspberries	✔	✔			31–32
Rutabagas	✔				32
Spinach			✔	✔	32
Squash, summer	✔	✔			45–50
Strawberries	✔	✔			32
Tomatoes	✔	✔			50–55; 45–50[6]
Turnips	✔		✔	✔	32
Notes	Too slow for most perishable commodities and cooling rates can vary greatly	Cooling rates uniform if properly used; container venting and stacking requirements are critical to be effective	Very fast and uniform cooling in bulk if properly used; daily cleaning and sanitation measures essential; product must tolerate wetting	Requires packaging icing to be effective; limited to commodities that can tolerate water-ice contact; requires water-tolerant shipping containers	

1 Adapted from Slama, Jim and Diffley, Atina. Wholesale Success: A Farmer's Guide to Food Safety, Selling, Postharvest Handling, and Packing Produce, Fourth Edition, FamilyFarmed, 2013.
2 Thompson, James F., et al. Appendix A-1, Commercial Cooling of Fruits, Vegetables, and Flowers, Revised Edition, Agriculture and Natural Resources Publication 21567, University of California, 2002.
3 Apples, nonchilling sensitive varieties 30–31°F; chilling sensitive varieties 38–40°F
4 Chilling injury may occur if held below temperature in parenthesis
5 50–59°F for early, immature potatoes; 40–55°F for late, mature potatoes
6 50–55°F for mature green tomatoes; 45–50°F for firm ripe tomatoes

APPENDIX B

Cleaning Options & Drying Considerations for Common Crops[1]

Crop	Cleaning Options for Small-Scale Farms	Dry Considerations
Baby Salad Greens	Double-wash/rinse in a water tank; after drying, remove sticks, weeds, and bad leaves	Spin dry
	Wash in a baby greens washing/cooling pack line	Spin dry
Beans and Peas	Field pack if clean and cool or if they can be cooled quickly	Picked dry
	Avoid washing if possible; if necessary, batch watch in harvest tote in water tank; 2nd tank rinse	If washing is needed, lay on screen table to air dry; fluff with fingers; do not allow to heat up
Berries	Do not wash	Not applicable
Bok Choy	Tank wash with sanitizer	Drain upside down on screen table
Broccoli, Cauliflower, Cabbage	Harvest clean and pack without further cleaning	None required
	Broccoli and cauliflower can be cleaned in a tank with water and sanitizer	None required
	Cabbage should not be immersed in water; if soiled, trim soiled areas with knife; if washing is necessary, spray soiled areas lightly	Air dry
Cantaloupe or Muskmelon	If it is not muddy, dry brush at harvest with glove or cloth	Not applicable
	Spray wash in harvest; do not immerse in water	Air dry
	Mechanical brush washer	Pack line absorber unit or air dry
Celery	Spray wash	Dry upside down
Bulk Roots and Tubers	Hand method; spray wash on screen table or in harvest tote	Air dry
	Mechanical brush washer is generally best for round vegetables or long rooted crops	Pack line absorber unit
Green-top Bunched Roots	Spray wash on drain table; pressure washer can be used on roots; washer can be used with care on roots only	None required, can be packed wet
Head Lettuce	Field pack if lettuce is clean and cool or if it is clean and can be cooled quickly	None required
	If very dirty, gently spray off the bulk of the soil; wash in water tank; 2nd tank rinse	Drain upside down on screen table
Bunched Herbs	Field pack if clean and cool	None required
	If bunched herbs need to be cooled and or cleaned, tank wash in sanitizer water; if basil, keep water above 55° F	Drain upside down on screen table
Onions, Garlic, Shallots	Trim roots and tops and spray wash for fresh market	Air dry excess moisture
	For storage, cut tops and dry brush after curing	None required
Peppers, Cucumbers	Dry brush with clean glove or cloth at harvest and field pack	None required
	Hand-brush wash in water tank	Air dry while packing
	Wet-brush in pack line	Pack line absorber unit or air dry
	Jacuzzi water bath (peppers)	Air/drain dry while packing
Sweet Corn	Pick clean; no washing needed	None required
Tomatoes	Dry brush with clean glove or cloth at harvest and field pack	None required
	Washing is not recommended; do not immerse in water; if washing is necessary, clean by hand with a wet cloth or in a mechanical pack line using soft brushes	Pack line absorber unit or air dry
Watermelons	Wipe off dirt at harvest	None required
	Wet brush by hand or machine if more washing is needed	Pack line absorber unit or air dry
Winter Squash, Pumpkins	Wipe off dirt at harvest; wet brush by hand or machine if dirty	Pack line absorber unit or air dry
Zucchini, Summer Squash	Dry brush with clean glove or cloth at harvest and field pack	None required
	Washing is not recommended; if washing is necessary, clean by hand or in a mechanical pack line using soft brushes	Pack line absorber unit or air dry

1 Adapted from Slama, Jim and Diffley, Atina. "Wholesale Success: A Farmer's Guide to Food Safety, Selling, Postharvest Handling, and Packing Produce, Fourth Edition." FamilyFarmed, 2013.

APPENDIX C

Recommended Temperature & Relative Humidity for Curing & Storage of Certain Crops[1]

Crop	Curing			Storage		
	Temperature Range	Relative Humidity	Duration (Days)	Temperature Range	Relative Humidity	Duration (Months)
Onion[2]	85°F – 90°F	70%	14 – 21	32°F – 50°F	60% – 70%	6 – 8
Garlic[2]	85°F – 90°F	70%	14 – 21	32°F – 50°F	60% – 70%	6 – 8
Shallot[2]	85°F – 90°F	70%	14 – 21	32°F – 50°F	60% – 70%	6 – 8
Potato[3]	60°F – 75°F	95%	14	40°F – 45°F	80% – 90%	10
Sweet Potato[4]	85°F – 90°F	80% – 95%	10	55°F – 60°F	85% – 90%	10
Winter Squash[4]	80°F – 85°F	75% – 80%	5 – 10	50°F – 60°F	50% – 75%	12
Pie Pumpkins[4]	80°F – 85°F	75% – 80%	5 – 10	50°F – 60°F	50% – 75%	12

1 Adapted from Slama, Jim and Diffley, Atina. "Wholesale Success: A Farmer's Guide to Food Safety, Selling, Postharvest Handling, and Packing Produce, Fourth Edition." FamilyFarmed, 2013.

2 Requires good ventilation during curing process.

3 Needs to be cured and stored in a dark space to prevent greening.

4 Requires ventilation (total volume change of air at least once per day) for disease control..

APPENDIX D

Recommended Temperature & Relative Humidity, & Approximate Storage Life of Fresh Fruits & Vegetables[1]

Vegetable	Storage Conditions		Approximate Storage Life
	Temperature (°F)	Relative Humidity (%)	
Artichoke, globe	32	95 – 100	2 – 3 weeks
Artichoke, Jerusalem	31 – 32	90 – 95	4 months
Asparagus	36	95 – 100	2 – 3 weeks
Bean, fava	32	90 – 95	1 – 2 weeks
Bean, lima	37 – 41	95	5 – 7 days
Bean, snap	40 – 45	95	7 – 10 days
Bean, yardlong	40 – 45	95	7 – 10 days
Beet, bunched	32	98 – 100	10 – 14 days
Beet, topped	32	98 – 100	4 months
Bok choy	32	95 – 100	3 weeks
Broccoli	32	95 – 100	10 – 14 days
Brussels sprouts	32	95 – 100	3 – 5 weeks
Cabbage, Chinese	32	95 – 100	2 – 3 months
Cabbage, early	32	98 – 100	3 – 6 weeks
Cabbage, late	32	95 – 100	5 – 6 months
Carrot, bunched	32	98 – 100	10 – 14 days
Carrot, topped	32	98 – 100	6 – 8 months
Cauliflower	32	95 – 98	3 – 4 weeks
Celeriac	32	98 – 100	6 – 8 months
Celery	32	98 – 100	1 – 2 months
Chard	32	95 – 100	10 – 14 days
Collards	32	95 – 100	10 – 14 days
Cucumber, pickling	40	95 – 100	7 days
Cucumber, slicing	50 – 54	85 – 90	10 – 14 days
Daikon	32 – 34	95 – 100	4 months
Eggplant	50	90 – 95	1 – 2 weeks

1 Adapted from Maynard, Donald N., Hochmuth, George J., and Knott, James Edward. "Knott's Handbook for Vegetable Growers, Fifth Edition." Hoboken, NJ: J. Wiley, 2007.

Vegetable	Storage Conditions		Approximate Storage Life
	Temperature (°F)	Relative Humidity (%)	
Garlic	32	65 – 70	6 – 7 months
Ginger	55	65	6 months
Greens, cool-season	32	95 – 100	10 – 14 days
Greens, warm-season	45 – 50	95 – 100	5 – 7 days
Kale	32	95 – 100	2 – 3 weeks
Kohlrabi	32	98 – 100	2 – 3 months
Leek	32	95 – 100	2 months
Lettuce	32	98 – 100	2 – 3 weeks
Melon, cantaloupe	36 – 41	95	2 – 3 weeks
Melon, honeydew	41 – 50	85 – 90	3 – 4 weeks
Mushroom	32	90	7 – 14 days
Mustard greens	32	90 – 95	7 – 14 days
Okra	45 – 50	90 – 95	7 – 10 days
Onion, dry	32	65 – 70	1 – 8 months
Onion, green	32	95 – 100	3 weeks
Parsley	32	95 – 100	8 – 10 weeks
Parsnip	32	98 – 100	4 – 6 months
Pea	32 – 34	90 – 98	1 – 2 weeks
Pepper, hot	41 – 50	85 – 95	2 – 3 weeks
Pepper, sweet	45 – 50	95 – 98	2 – 3 weeks
Potato, early	50 – 59	90 – 95	10 – 14 days
Potato, late	40 – 54	95 – 98	5 – 10 months
Pumpkin	54 – 59	50 – 70	2 – 3 months
Radish, spring	32	95 – 100	1 – 2 months
Radish, winter	32	95 – 100	2 – 4 months
Rhubarb	32	95 – 100	2 – 4 weeks
Rutabaga	32	98 – 100	4 – 6 months
Shallot	32 – 36	65 – 70	—
Southern pea	40 – 41	95	6 – 8 days
Spinach	32	95 – 100	10 – 14 days
Sprouts, alfalfa	32	95 – 100	7 days
Sprouts, bean	32	95 – 100	7 – 9 days
Squash, summer	45 – 50	95	1 – 2 weeks
Squash, winter	54 – 59	50 – 70	2 – 3 months
Strawberry	32	90 – 95	5 – 7 days
Sweet corn	32	95 – 98	5 – 8 days

Vegetable	Storage Conditions		Approximate Storage Life
	Temperature (°F)	Relative Humidity (%)	
Sweet potato	55 – 59	85 – 95	4 – 7 months
Tomatillo	45 – 55	85 – 90	3 weeks
Tomato, firm ripe	46 – 50	85 – 90	1 – 3 weeks
Tomato, mature green	50 – 55	90 – 95	2 – 5 weeks
Turnip, greens	32	95 – 100	10 – 14 days
Turnip, root	32	95	4 – 5 months

APPENDIX E

Compatible Fresh Fruits & Vegetables During 10-day Storage[1]

Group 1A (32 – 36°F) and 90 – 98% RH				
Vegetables				
Alfalfa sprouts	Cabbage*	Endive*, chicory	Lettuce*	Rhubarb
Amaranth	Carrot*	Escarole*	Mint*	Salsify
Anise*	Cauliflower*	Fennel*	Mushroom*	Scorzonera
Artichoke*	Celeriac	Garlic	Mustard greens*	Shallot*
Asparagus*	Celery*	Green onion*	Pak choi*	Snow pea*
Beans: fava, lima	Chard*	Herbs* (not basil)	Parsley*	Spinach*
Bean sprouts	Chinese cabbage*	Horseradish	Parsnip*	Swiss chard*
Beet	Chinese turnip	Jerusalem artichoke	Pea*	Turnip
Belgian endive*	Collards*	Kailon	Radicchio*	Turnip greens*
Broccoflower*	Corn: sweet, baby	Kale*	Radish	Water chestnut
Broccoli*	Cut vegetables	Kohlrabi	Rutabaga	Watercress*
Brussels sprouts*	Diakon*	Leek*		

Group 1A (32 – 36°F) and 85 – 95% RH				
Fruits and Melons				
Apple	Caimito	Date	Loganberry	Plumcot
Apricot	Cantaloupe	Dewberry	Longan	Pomegranate
Avocado, ripe	Cashew apple	Elderberry	Loquat	Prune
Barbados cherry	Cherry	Fig	Pear: Asian, European	Quince
Blackberry	Coconut	Gooseberry	Persimmon*	Raspberry
Blueberry	Currant	Grape	Plum	Strawberry
Boysenberry	Cut fruits	Kiwifruit*		

1 Adapted from A. A. Kader (ed.) "Postharvest Technology of Horticultural Crops, 3rdEd." University of California, Division of Agriculture and Natural Resources Publications 3311, 2002.

* Products sensitive to ethylene damage; ethylene level should be kept below 1 ppm.

Group 2 (55 – 65°F) and 85 – 95% RH				
Vegetables		Fruits and Melons		
Beans: snap, green, wax	Long bean	Babaco	Juan canary melon	Pepino
Cactus leaves (nopales) *	Malanga*	Calamondin	Lemon*	Pummelo
Calabaza	Pepper: bell, chili	Carambola	Lime*	Tamarillo
Chayote*	Southern pea	Cranberry	Limequat	Tamarind
Cucumber*	Squash: summer*	Custard apple	Mandarin	Tangelo
Eggplant*	Tomatillo	Durian	Olive	Tangerine
Kiwano (horned melon)	Winged bean	Feijoa	Orange	Ugli fruit
		Granadilla	Passion fruit	Watermelon
		Grapefruit*		

Group 3 (55 – 65°F) and 85 – 95% RH				
Vegetables		Fruits and Melons		
Bitter melon	Potato	Atemoya	Honeydew melon	Persian melon
Boniato2	Pumpkin	Banana	Jaboticaba	Plantain
Cassava	Squash: winter*	Breadfruit	Jackfruit	Rambutan
Dry onion	Sweet potato*	Canistel	Mamey Sapote	Sapodilla
Ginger	Taro (dasheen)	Casaba melon	Mango	Sapote
Jicama	Yam	Cherimoya	Mangosteen	Soursop
		Crenshaw melon	Papaya	

APPENDIX F

Recommended Transit Conditions for Compatible Crops[1]

Temp: 55 – 60°F	Temp: 36 – 41°F	Temp: 40 – 45°F	Temp: 40 – 55°F
Relative Humidity: 85 – 95%	Relative Humidity: 90 – 95%	Relative Humidity: About 95%	Relative Humidity: 85 – 90%
Ice: No Contact with Commodity	Ice: Contact Cantaloupe Only	Ice: No Contact with Commodity	Ice: No Contact with Commodity
Avocado	Cranberry	Snap bean	Cucumber
Banana	Lemon	Lychee	Eggplant
Grapefruit (FL before Jan. 1)	Cantaloupe	Okra	Ginger (not with eggplant)
Guava	Orange	Pepper, green (not with bean)	Grapefruit (FL after Jan. 1)
Mango	Tangerine	Pepper, red	Lime
Casaba melon		Summer squash	Potato
Crenshaw melon		Tomato, pink	Pumpkin
Honeydew melon		Watermelon	Watermelon
Persian melon			Winter squash
Olive			
Papaya			
Pineapple (not with avocado)			
Tomato, green			
Tomato, pink			
Watermelon			

1 Adapted from Maynard, Donald N., Hochmuth, George J., and Knott, James Edward. "Knott's Handbook for Vegetable Growers, Fifth Edition." Hoboken, NJ: J. Wiley, 2007.