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Guide for Maintaining the Quality and Safety of Organic Vegetables and Melons During Harvest and Handling Operations[1]

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Total farm-gate receipts for major vegetable crops grown in the United States were about $10.4 billion in 2008. Florida-grown fresh vegetables and watermelons provide significant revenues to the state and were valued at $1.55 billion that year, a 6% increase over 2007 and ranking our state second in the country (USDA/NASS, 2009). The annual growth rate for the U.S. organic food sector has been about 20% during the past 10 years, for a total of $13.4 billion in 2006 (Haumann, 2008). Organic fruits and vegetables accounted for 39% of this amount, or $5.4 billion. The leading organic fruits and vegetables in the U.S. are: tomato, carrot, peach, squash, leafy vegetables, apple, potato and banana. Prices for organically grown produce were higher than those for conventionally grown produce. For example, in 2003, the wholesale price for organic carrot was 153% higher than that for conventionally grown carrot (Oberholtzer et al., 2005). However, as organically grown vegetables become more available in coming years, these price differences are expected to decline.

Florida remains a leading state in organic vegetable and melon production despite the constant challenges growers face from subtropical weather events and pests, increased regulatory requirements, and encroachment by development. The quality of fresh Florida produce is important to consumers and critical to the success of our industry. Maintaining high quality from harvest to table requires an understanding of proper handling techniques and practices as well as common sense. Without a well thought-out plan, unnecessary postharvest losses can eventually make an organic vegetable or melon operation financially infeasible.

This publication highlights practical guidelines to assist growers and handlers of organic vegetables and melons to minimize losses during harvest and handling operations. Differences in recommendations between crops grown using organic methods and conventional production methods are noted.

What Is Quality?

Many factors contribute to vegetable quality, and visual appearance is generally the first factor that we use to assess quality. The shape of a fruit or vegetable, its color, and the uniformity and intensity of shading are of paramount importance in crops as different as summer squash, spinach and mushroom.

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Vegetables should also be free of obvious defects, including cuts, bruises, decay or shriveling. Firm texture (crispness) is important in many crops, including carrot, snap bean, celery, greens, lettuce and bell pepper, while aroma plays a key role when consumers shop for crops like melons and tomato.

Vegetable perishability varies greatly depending upon the crop. For example, high-respiring crops such as sweetcorn, peas and broccoli, have a very short postharvest life (or, shelf life) of less than 24 hours under ambient temperatures. At the other end of the spectrum are low-respiring crops like potato, winter squash and onion that can be stored for much longer periods. A wide variety of crops, including leafy vegetables, strawberry and cucumber, are susceptible to shriveling because their vulnerable physical structures readily lose moisture. Reducing the pulp temperature soon after harvest maintains appearance longer by lowering the respiration rate and the rate of water loss. Protecting fresh vegetables and melons from physical injury and from infection by decay organisms is also a priority.

The USDA/AMS has approved grade standards for most vegetables and melons that are used for commercial marketing. These standards specify quality parameters for each crop and include grade classifications, size, color, cleanliness, and tolerances for shape, defects and decay, and are available online (USDA/AMS, 2008). Growers must follow these standards when packing according to specific grades.

A significant proportion of consumers have also come to expect sweetness in certain crops. In the mid-1990s there was a remarkable shift to the virtually exclusive production of supersweet sweetcorn based on varieties developed by the UF/IFAS breeding program. Other specialty items that have grown in sales volume during this period include grape tomatoes and sweet onions. Specific melon and seedless watermelon varieties with higher sugar concentrations are also gaining in the marketplace. The UF/IFAS tomato, strawberry, blueberry and peach breeding program have released several varieties with excellent flavor. Since consumers must wait until after purchase to test for flavor, in-store samplings are a proven method for increasing sales, particularly for newer or ethnic vegetables. A poor flavor experience decreases the likelihood of a repeat sale.

Vegetables and melons are also purchased because of their nutritional and antioxidant contributions to the diet. The "Five-a-Day" campaign encourages the daily consumption of five portions of fruits and vegetables. It is sponsored by the U.S. Centers for Disease Control and Prevention and promoted by several produce industry organizations and governmental agencies. Numerous crop marketing organizations have financed nutritional research on their crops and use the resulting data in their promotional programs. Growers selling to local produce markets have also taken advantage of these materials.

Consumers are also concerned about the production and sale of wholesome crops. This includes crops that are free of chemical and hazardous contaminants and whose growers and handlers have taken precautions to avoid cross-contamination by human pathogens. Most growers have implemented Good Agricultural Practices (GAPs) during production and harvest, and handlers have implemented Best Management Practices (BMPs) in handling, packing and shipping operations. Adherence to these programs is assured through annual third-party audits. When a grower or handler "bends the rules" the risk to individual operations and to the industry is considerable: contaminated crops could be sold and could cause a disease outbreak. Outbreaks that are traced back to a particular farm lead to a forced shutdown of that operation until the cause is determined and corrected - a costly result. Further details related to food safety programs are available (Goodrich-Schneider et al., 2006).

An interesting twist on consumers' assessment of produce quality relates to the influence of price and their purchasing decisions. Studies have shown that as price decreases, consumers become somewhat more tolerant of defects in appearance.

The National Organic Program Related to Fresh Vegetables and Melons

The U.S. Department of Agriculture/Agriculture Marketing Service has established national standards for certification of organic crops including vegetables and melons: http://www.ams.usda.gov/nop/indexIE.htm. These certification standards apply to growers and/or handlers having annual gross revenues over $5,000. Qualifying operations must develop an organic system plan that details the "sequence of practices and procedures resulting in an operation that complies with every applicable provision in the regulations." This plan must be certified by an accredited certifying agent before the crop can be labeled as organic.

A valid system plan must include the following components, found in Subpart C: Organic Production and Handling Requirements:

"(1) A description of practices and procedures to be performed and maintained, including the frequency with which they will be performed;

(2) A list of each substance to be used as a production or handling input, indicating its composition, source, location(s) where it will be used, and documentation of commercial availability, as applicable;

(3) A description of the monitoring practices and procedures to be performed and maintained, including the frequency with which they will be performed, to verify that the plan is effectively implemented;

(4) A description of the recordkeeping system implemented to comply with the requirements established in §205.103;

(5) A description of the management practices and physical barriers established to prevent commingling of organic and nonorganic products on a split operation and to prevent contact of organic production and handling operations and products with prohibited substances; and

(6) Additional information deemed necessary by the certifying agent to evaluate compliance with the regulations"

Complete details of this organic system plan can be found at the Electronic Code of Federal Regulations (eCFR) under Agriculture (Title 7) for the National Organic Program (Part 205). http://ecfr.gpoaccess.gov

The most current National List of Allowed and Prohibited Substances is published in the NOP sections 205.600 to 205.606.

The Organic Foods Production Act of 1990 further establishes for handlers that:

- No synthetic ingredient or sulfites may be added to the fresh crops during handling.
- No packaging materials, bags, bins, storage containers may be used that contain or were in contact with synthetic fungicides, or preservatives.
- All water used must meet the requirements of the Safe Drinking Water Act. (U.S.E.P.A., 1996).

Documentation is a critical component of any agricultural operation. All standard operating procedures (SOPs) are identified in sequential order. Recordkeeping logs verify that these procedures are, in fact, routinely adhered to during all phases of the operation and serve to show that "due diligence" is maintained at all times.

Harvest Operations

The main factors for maintaining quality from the point of harvest forward are:

- Harvest at proper maturity for the intended market.
- Minimize mechanical injuries.
- Maintain sanitation procedures.

Harvest is the beginning of a series of critical operations in the production cycle. All the investment of time, money and energy necessary to grow a crop can be quickly lost from this point on. To avoid

significant losses, growers must pick the crop at proper maturity and handle properly. Initial preparations include:

- Establish the market(s) and know the quality expectations of the buyers.
- Maintain the cleanliness of picking containers.
- Set up product transport to and from the field(s).
- Secure adequate labor for the harvest season.

Organic growers must be particularly vigilant to avoid cross-contamination, beginning with the organic fertilizers and soil amendments applied during the production cycle. For example, compost applied to the field must be properly made in order to kill human pathogens present in the raw material (see eCFR 205.203). If composting is not complete or thorough, surviving pathogens will be spread in the field with the likelihood of contacting and contaminating the harvested crop. Max Teplitski's E. coli and Salmonella on animal farms: sources, survival and management (2006) (http://edis.ifas.ufl.edu/SS458) provides detailed information on composting.

Crops that are picked and field-packed should always be placed into clean containers. Although used containers (including wirebound crates and corrugated cartons) are less expensive than new containers, they should not be used as picking or shipping containers unless they can be cleaned and sanitized. Plant residues in the container can be sources of pathogens that can contaminate the freshly harvested crop and promote postharvest decay. Whenever possible, picking containers and bins should not be placed directly on the ground since they can transfer significant amounts of soil and debris into the packing area. Field crews must be trained and constantly supervised in proper harvest and personal hygiene techniques; portable restroom facilities and handwashing stations must readily available in the field (Ritenour et al., 2007).

Once harvested, the crop should be shaded to minimize accumulation of field heat and quickly transported to the packinghouse or shed. It is important to remember that each time the harvested crop is handled, the opportunity exists for mechanical injury to occur; therefore, workers must use care during container filling, handling, stacking and unstacking.

Handling and Packing Operations

To maintain quality during handling:

- Sort, clean, grade and pack with care.
- Use appropriate containers according to the market.
- Apply proper cooling to retard senescence and ripening.
- Clean all contact surfaces every day.

Vegetables brought to a packinghouse or a packing area must be carefully transferred from the picking container to the packing line or grade table for sorting. Smaller-volume operations should use tables with painted or plastic surfaces that can be easily cleaned and sanitized; higher-volume operations generally employ a mechanized packing line. Both types of packing methods should be properly designed to handle the crops with minimal drop distances and low impacts. During sorting, handlers remove culls for disposal and then classify in-grade fruit according to appropriate grade standards.

Sanitation is critical during all handling and washing operations to minimize the risk of spreading human pathogens from contaminated to non-contaminated vegetables. Maintaining sanitary conditions is even more challenging for organic crops due to the limited number of approved sanitizers. As at harvest, worker hygiene is critical at this stage of handling. Studies have shown that properly washed hands are as hygienic as plastic gloves. For more information on personal hygiene, see "Good Worker Health and Hygiene Practices: Training Manual for Produce Handlers," http://edis.ifas.ufl.edu/FY743, Simonne et al. (2005). All surfaces that contact the crop—picking containers, benches, cutting/trimming tools, and reused containers—must be regularly cleaned and sanitized. Thoroughly brushing contact

surfaces with soapy water and rinsing them with potable water effectively removes debris and pathogens and eliminates their build-up over time.

Often, vegetables are washed before sale. Fresh vegetables should not be wiped with a reused cloth because microorganisms accumulate readily on cloth and can be transferred from fruit to fruit. Tanks or tubs are commonly used to wash vegetables, but this reused water presents challenges for organic operations. Postharvest fungi and bacteria can wash off vegetable surfaces into the water, and these can survive to inoculate other vegetables as they are immersed. The best method for cleaning most organic vegetables is to carefully brush them under running, potable water.

Detergents should not be added to wash water since, as surfactants, they favor the uptake of the water though openings in the vegetable. Any decay and/or human pathogens present in the water can also enter the crop, a process called internalization. Once inside the vegetable, these microbes are protected from being washed off or killed by sanitizers. Further, detergents that contain synthetic surfactants are prohibited for contact with organic crops.

Wash/rinse water can contain chlorine (eCFR 205.601) as long as it meets state and federal standards for drinking water, which is a maximum of 4 parts per million of free chlorine, measured at discharge (U.S. E.P.A., 1996). Maximum sanitizing effectiveness of chlorine is achieved by adjusting the water pH to the range of 6.5 to 7.5; citric acid is approved for this purpose. Details regarding chlorine mixing can be found at Sargent et al. (2007).

Ozone is an effective alternative to chlorine, particularly to sanitize water used in once-over applications. White vinegar (acetic acid) was found to effectively sanitize iceberg lettuce: a 35% solution achieved a 5-log reduction of E. coli after a 5-minute, agitated soaking (Vijayakumar and Wolf-Hall, 2002). Other sanitizers approved for use with organic crops include calcium chloride, sodium chloride, hydrogen peroxide and peroxyacetic acid (Suslow, 2000).

The natural wax layers on produce can be supplemented by applying food-grade coatings. Coatings reduce water loss during handling and storage and add sheen to the crop. Cucumber and tomato are examples of vegetables that benefit from postharvest coatings. Carnauba wax and wood resin wax are permitted on organic crops.

Packing is another key step to protect fruits and vegetables. An effective shipping container protects the crop from bruising or other injury and is compatible with the cooling method that will be used. It must be strong enough to support the weight of stacked (palletized) containers during storage and shipping while providing adequate ventilation for cooling. Many vegetables are packed by count into a container that has specific dimensions. The most commonly used carton contains 1 and 1/9 bushels. Grape tomatoes and other small crops are usually packed by weight. Melons are normally packed in a single layer in a corrugated carton or in bulk bins that contain about 800 to 1,000 pounds. Some crops (e.g., summer squash and tomato) should be dried before packing to minimize development of decay. Leafy vegetables and sweetcorn are examples of crops that can be packed wet as long as they are quickly cooled. The shipping container must be resistant to contact with moisture whenever wet vegetables are packed. For conventionally grown vegetables, corrugated fiberboard cartons are typically impregnated with paraffin wax for resistance to water. However, paraffin wax is not approved for direct contact with organic crops.

Organic growers and handlers have several options for shipping containers, depending upon the use. For single-use shipping containers, options include:

- Dry vegetables, then pack into corrugated fiberboard cartons.
- Watermelons and cantaloupe can also be packed in bulk bins.
- Place a plastic liner in the container prior to packing.
- Pack into consumer-size plastic bags or rigid clamshells and place in the container.

For reusable shipping containers, options include:

- Purchase plastic lugs for internal use or with repeat customers.
- Rent returnable plastic containers (RPCs) for single shipments to distant markets.
- Place plastic bags or clamshells in RPC master containers.

The use of pallets significantly increases handling efficiency and reduces mechanical injury. The U.S. grocery industry has adopted a standard pallet size of 40 x 48 inches (100 x 120 cm). In order to make the most of pallet space, each layer of shipping containers should completely cover the pallet surface. The container base dimensions (or footprint) should be selected to stack 5, 8, or 10 containers per pallet layer. This reduces the number of container sizes required and increases worker comfort by reducing the weight per container.

Cooling, Storage and Shipping Operations

Following packing the containers should be transferred to a storage area. Removal of field heat is a key component of a successful crop, and rapid cooling (or, precooling) involves removing most of the field heat within a few hours of harvest. The amount of field heat removed is based on the recommended final storage temperature. Studies have shown that for every 20°F (11°C) decrease in pulp temperature, the postharvest life (or shelf life) of a given crop increases two to three times. For example, cooling freshly harvested snap beans from 85 to 45°F (30 to 7°C), drops the pulp temperature by 40°F (23°C). This should extend postharvest life from 1 day to more than 9 days. For best quality and energy efficiency, once cooled, the crop must be kept cool, maintaining the "cold chain" during subsequent operations. Temperature fluctuations quickly lower quality by hastening shriveling and promoting decay. For a more detailed explanation of fresh produce handling, cooling methods and storage temperatures, see Sargent et al., "Handling, Cooling and Sanitation Techniques for Maintaining Postharvest Quality," http://edis.ifas.ufl.edu/pdffiles/CV/CV11500.pdf (2007).

Note: Be sure to check with your certification agency prior to using any compounds or materials discussed in this document.

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