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SP-214

Tomato Production Guide for Florida: Harvest and Handling[1]

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Maturity at Harvest

The United States Department of Agriculture Grade Standards for Fresh Tomatoes recognizes six official color designations: green, breaker, turning, pink, light red, and red (Table 1). The Florida tomato industry is based primarily on harvesting tomatoes at the green stage. Problems arise in determining maturity at harvest because it is difficult to distinguish immature-green tomatoes from mature-green tomatoes. If tomatoes are harvested before the mature-green stage, they will fail to ripen normally.

Table 1. U.S.D.A. tomato ripeness classification.

Ripeness Stage	Description of Tomato Surface
1 (Green)	Surface is completely green.
2 (Breaker)	Definite break in tan, pink or red color, up to 10% of surface.
3 (Turning)	10 to 30% tan, pink or red color.
4 (Pink)	30 to 60% pink or red color.
5 (Light Red)	60 to 90% pink or red color.
6 (Red)	More than 90% red color.

All of the following have been used as external indicators of maturity in green-picked tomatoes:

1) size - attainment of a minimum size which varies with cultivar;

2) shape - well rounded, not angular;

3) color - some cultivars turn whitish green and others show cream-colored streaks at the blossom end;

4) surface - having a waxy gloss and a skin not torn by scraping indicates a more developed cuticle;

5) stem scar - the presence of brown corky tissue on the stem scar in some cultivars.

A fruit's internal appearance is a much better indicator of maturity in the green stage, but this is a destructive test. A representative sample of fruit can be cut and classified based on their internal appearance (Table 2). This information can then be used as an index to the maturity of the crop for scheduling harvest.

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Table 2. Maturity classes of green tomatoes.

Class	Internal appearance	Average number of days to reach the 'breaker' stage during 68°F (20°C) storage.
M-1 Immature-green	No jelly-like material in any of the locules; seeds are cut by a sharp knife upon slicing the fruit.	Will not ripen normally.
M-2 Partially mature-green	Jelly-like material formed in at least one, but in less than all the locules; seeds are well developed.	6 to 10
M-3 Typical mature-green	Jelly-like matrix in all locules; seeds are not cut by a sharp knife upon slicing the fruit.	2 to 5
M-4 Advanced mature-green	Typical mature-green with some internal red coloration.	1

In actual practice Florida growers use a combination of these factors to determine when the crop is ready to harvest. Most delay harvest until a small percentage of fruits are showing color in the field. Then pickers are instructed to harvest fruits larger than some minimum size and at a certain height in the plant.

Harvesting Systems

Currently all fresh market tomatoes are harvested by hand in Florida. Pickers place the fruits into plastic buckets which hold 40 to 50 pounds of tomatoes. In most areas, pickers carry the filled buckets to field trucks and empty fruit into pallet bins or gondolas. Pallet bins hold between 800 and 1200 pounds of fruit. and gondolas hold between 16,000 and 24,000 pounds of fruit. The pickers may have to walk as much as 50 yards to empty their buckets.

Once the field trucks with the pallet bins or gondolas have been filled, they are transported to the packinghouse. While awaiting unloading, fruit should be kept in a shaded area to minimize heating. Fruit held in the sun for an hour on a hot, sunny day can be as much as 25°F (14°C) hotter than fruit held in the shade.

Packinghouse Operations

Most tomato packinghouses are large, sophisticated, high volume operations. Upon transfer to the packing line, tomatoes are washed, presized, waxed, sorted and graded, sized, packed into shipping containers, and unitized for shipment while in the packinghouse.

Dumping and washing. Water dump tanks are routinely used for receiving tomatoes at the packinghouse. In Florida, pallet bins are emptied into the dump tank while tomatoes are water flumed from gondolas into the dump tank. In each case, tomatoes in the dump tank are flumed to an elevator where they are spray washed and conveyed to the packing lines.

Serious losses due to decay occur periodically in tomato shipments during transit or at destination. Florida research has shown that poor dump tank and wash water management practices can be major contributors to decay problems. Bacteria and fungi present on the fruit when harvested can be spread to uncontaminated tomatoes in the water. Organisms that cause bacterial soft rot *Erwinia carotovora*, sour rot or watery rot *Geotrichum candidum*, Rhizopus rot *Rhizopus stolonifera*, and gray mold *Botrytis cinerea* can inoculate the fruit during dump tank and washing procedures. Decay of inoculated fruit after packaging can spread to other fruit during marketing and increase product losses.

The following is a summary of the suggested dump tank management practices to eliminate these problems:

1) Minimize the depth to which tomatoes are submerged when dumped, to less than 24 inches if possible.

2) Maintain a single layer of tomatoes in the dump tank.

3) Minimize the time tomatoes spend in the dump tank, less than two minutes if possible. Never leave tomatoes standing in the water during packinghouse crew breaks. Modify dump tanks to eliminate "dead" spots.

4) Chlorinate dump tank and wash water to maintain a free chlorine concentration of 100 to 150 parts per million (mg/L). Check concentration frequently (at least twice a day) with a DPD test kit. Chlorine may be added to the water as CL_2 gas or the liquid and dry formulations of calcium or sodium hypochlorite labeled for such use.

5) Adjust water pH to about 7.0 (neutral).

6) Maintain the dump tank water temperature 10°F higher than highest fruit pulp temperatures. Water heating requirements can be minimized by keeping harvested fruit in the shade. Temperatures should be monitored with a thermometer.

7) These management practices represent **additive** control efforts - not alternative methods. Use of a **single** control parameter (like chlorination) has not proved to be sufficient to prevent postharvest decay during disease-favorable conditions.

Presizing. Following washing, undersized tomatoes are eliminated by use of a perforated belt sizer. Smaller tomatoes drop through the belt and are conveyed to the cull chute. This step eliminates undersized fruit and prevents them from congesting the packinghouse operations which follow.

Waxing. Most Florida tomatoes are waxed prior to packing with a food grade wax labeled for use on tomatoes. Waxing serves to reduce water loss during marketing, but it is done primarily to improve the luster of tomatoes.

Sorting and grading and sizing. In most packinghouses these operations are very labor-intensive, often involving more than one hundred people. One of the first steps involves separating green fruit from fruit showing any red color (U.S.D.A. color stages two and above). From this point on, stage one fruit continue on the main packing line, while stage two and above fruit are handled on a smaller but similar line.

Following color sorting, fruit are hand-separated into grades according to U.S.D.A. standards for grades of fresh tomatoes as modified by the Florida Tomato Committee under authority of the Federal Marketing Order. Grades are U.S. No. 1, U.S. Combination, U.S. No. 2, and U.S. No. 3. When not more than 15 percent of tomatoes in any lot fail to meet the requirements of U.S. No. 1 grade and not more than one-third of this 15 percent (five percent) are comprised of defects causing very serious damage, including not more than one percent of tomatoes that are soft or affected by decay, such tomatoes may be shipped and designated as at least 85 percent U.S. No. 1 grade.

Sizing. Following sorting and grading, tomatoes move to the mechanical sizers. Next, there is a series of continuous belts with increasingly larger round holes corresponding to the maximum allowable diameter for a given size. Electronic sorters are becoming more feasible as computing speed increases. These systems utilize several images per fruit to measure reflectance color, diameter and weight. Tomatoes of a desired color stage and size are transferred to the appropriate conveyor for packing. Most packinghouses have another presizer just in front of the sizer to insure that under-sized fruits are removed. Fruits are then sized into progressively larger size classifications as defined by the U.S.D.A. Grade Standard (Table 3) or by the Florida Tomato Committee. The United States Dept. of Agriculture allows the minimum size of tomatoes shipped out of the regulated area, (as defined in the Florida Tomato Marketing Order) to 2 8/32 (57 mm) inches in diameter. This regulation reduces the number of low quality immature-green fruits which are marketed.

Table 3. U.S.D.A. size standards for tomatoes[z].

	Equatorial Diameter			
	Inches		Millimeters	
Size	Minimum	Maximum	Minimum	Maximum
Medium	2 9/32	2 17/32	58	64
Large	2 17/32	2 28/32	64	73
Extra large	2 28/32	3 15/32	73	88

[z]Current size designations for the regulated production areas in Florida may be obtained from the Florida Tomato Committee, Orlando FL.

Packing. Sized and graded fruits are conveyed to automatic fillers. Fruits are jumble-packed into fibreboard containers until they are filled to the designated net weight (25 lb for stage one and 20 lb for stage two and above). Filled containers are conveyed through automatic labeling wheels which stamp the size on the carton. Grades are usually designated by different brand names or shipping labels. Empty containers are mechanically fed to the fillers through chutes which deliver cartons from a make-up area where the blanks are machine-run and hot-melt glued together. While being conveyed to the unitization area, the filled cartons are automatically lidded.

Containers and unitization. Tomato shipping containers are constructed from corrugated fibreboard. For mature-green tomatoes, the container must hold a net weight of 25 pounds, but the dimensions of the container are not regulated. Most Florida shippers pack into a standard size carton which facilitates international transport and export. The outside dimensions of the lid are 40 centimeters long x 30 centimeters wide (15 3/4 inches x 11 3/4 inches). These cartons stack 10 to a layer on a standard 40 inch x 48 inch (100 cm x 120 cm) pallet.

The stacking may be done by hand or by automatic palletizing equipment. The pallet load is secured by adding glue to the top of the lid of each container. From this point onward the tomatoes are handled as palletized, 2000 pound units with fork lift trucks rather than as individual, 25 lb cartons. Stage one tomatoes are moved to ripening rooms for ripening initiation treatments, or they are shipped without treatment, depending on the customer requirements.

Ripening Treatment

Almost all Florida tomato packinghouses are equipped with storage facilities for initiating ripening with ethylene treatments. Most of the ripening rooms have 40, 60, 80, or 100 pallet capacities. These rooms have precise controls to maintain optimum ripening initiation conditions of 68°F (20°C) and 85 to 95 percent relative humidity (RH). As mentioned, tomatoes harvested at stage one may range from M1 to M4 internal maturity. Exposure to ethylene gas (C_2H_4) under controlled conditions will reduce the time required to reach stage two resulting in a more uniformly ripening load. It is advisable to treat stage one tomatoes with ethylene immediately after packing. Our studies have shown that delays of more than one day will counteract the effects of ethylene, necessitating longer treatment times.

A number of methods are available for introducing ethylene gas in the ripening room, but the catalytic generator and flow-through systems are most popular. The catalytic generator system of introduction involves generating ethylene *in situ* by a catalytic process which converts a liquid concentrate to C_2H_4 gas within the ripening room. Ripening room operators simply have to plug in the generator, add the concentrate, and turn the generator on.

The flow-through system involves dispensing ethylene from compressed cylinders equipped with a pressure regulator and flow meters. This system supplies a constant, ripening-effective blend of ethylene and fresh outside air which passes over the tomatoes and out an exhaust port in the room. The constant air exchange prevents carbon dioxide from

building up to ripening inhibitory levels more than two percent and eliminates the need for periodic aeration. Current recommendations for tomato ripening suggest 150 parts per million C_2H_4 as the optimum concentration.

An inexpensive portable method for measuring ethylene is provided by gas detection kits, available from speciality gas companies, which consist of a piston-type volumetric pump into which direct-reading detector tubes are inserted. With these kits, ethylene levels (ranging from 0.1 to 800 parts per million) can be measured.

Storage Conditions

The tomato fruit's susceptibility to chilling injury dictates that optimum storage conditions for tomatoes are within a relatively narrow range. As already mentioned, optimum conditions for tomato ripening are 68°F (20°C) and 85 to 95 percent RH. Above 85°F, tomato fruit develop more orange than red pigments and this is undesirable for U.S. markets. Those wishing to delay tomato ripening or hold tomatoes at a certain stage of ripeness can do so by lowering the temperature below 68°F (20°C), but no lower than 55°F (12°C). Below 55°F (12°C), chilling injury may occur and chilled fruits never ripen to full color and flavor, and are susceptible to *Alternaria* decay. It has been known for over 50 years that tomato quality is adversely affected by temperatures below 50°F. Handlers and consumers must be made aware that storage of ripening tomatoes below 55°F (12°C) will greatly reduce final quality. This includes storage in home refrigerators which maintain temperatures at 41°F (5°C) or lower. Fully ripe (eating-ripe) fruit may be stored below 50°F for a short period if consumed immediately upon transfer to a higher temperature.