

Tomatoes and Tomato Products

Revised 2018

Thermal Properties

	Mature Green		Ripe	
	English	Metric	English	Metric
Moisture, %	93.00	--	94.50	--
Protein, %	1.20	--	0.88	--
Fat, %	0.20	--	0.20	--
Carbohydrate, %	5.10	--	3.92	--
Fiber, %	1.10	--	1.20	--
Ash, %	0.50	--	0.50	--
Specific Heat Above Freezing	0.96 Btu/lb*°F	4.02 kJ/(kg*K)	0.97 Btu/lb*°F	4.08 kJ/(kg*K)
Specific Heat Below Freezing	0.42 Btu/lb*°F	1.77 kJ/(kg*K)	0.43 Btu/lb*°F	1.79 kJ/(kg*K)
Latent Heat of Fusion	134 Btu/lb	311 kJ/kg	135 Btu/lb	313 kJ/kg

Storage Conditions

	Temperature		Storage Period	Relative Humidity or Packaging	Highest Freezing Point	
	°F	°C			°F	°C
Chilled						
Mature Green	55 to 65	13 to 18	2 to 3 weeks	90 to 95%	31.0	- 0.6
Pink	50 to 55	10 to 13	7 to 10 days	90 to 95%	31.1	- 0.5
Ripe	45 to 50	7 to 10	3 to 5 days	90 to 95%	31.1	- 0.5
Frozen						
Chopped, pureed	-10 to 0	-23 to -1.88	6 to 9 months +	Vapor-proof packaging		

Fresh market tomatoes are either harvested while still green (mature-green) or when partially red colored (vine-ripe). Mature-green tomatoes can be reliably identified only upon slicing; the seed coat must have hardened and the locule gel liquefied so that seeds are pushed aside by the knife blade. Long shelf life varieties may be harvested with more color development than conventional or normal ripening types.

The objective in storage after harvest is to control the rate of ripening to extend the marketing period. Tomatoes are sensitive to chilling injury (CI); therefore, the recommended storage temperatures differ depending on the fruit ripeness stage. Storage temperatures below 55°F (12.8°C) cause CI and are

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especially harmful to mature-green tomatoes; these temperatures make the fruit tasteless and susceptible to *Alternaria* decay during subsequent ripening. Increased decay during ripening occurs after about 4-6 days' exposure at 32°F (0°C) or 6-9 days at 40°F (4.4°C).

Both the California Tomato Commission and the Florida Tomato Committee stress that whether tomatoes are mature-green, vine-ripe, or Romas, prolonged exposure to low temperatures robs them of firmness and flavor.

A temperature of 55°F (12.8°C) with 90 to 95% relative humidity (RH) is recommended to slow ripening. At this temperature, most varieties keep in good condition for 2 to 3 weeks and change color very slowly. Above 60°F (15°C), the rate of color change increases quite sharply, and above 70°F (21°C), the rate of ripening and other changes is maximized. Tomatoes held at 65°F (18.3°C) change color rapidly without excessive softening. The optimum temperatures for ripening mature-green tomatoes range from 65 to 68°F (18.3 to 20°C). Temperatures of 77°F (25°C) or higher induce rapid ripening, but reduce firmness and red color development, with the fruit turning orange-red to yellow instead of red; ripening is inhibited above 86°F (30°C).

Mature-green tomatoes are often gassed with ethylene at 68 to 70°F (20 to 21°C) and high humidity to hasten ripening and to attain more uniform ripening. A concentration of 100 to 150 ppm ethylene for 24 to 48 hours is commonly used. Ethylene used to ripen tomatoes can be catalytically generated from ethanol using commercially available units or supplied from compressed gas cylinders. Because mixtures of 3 to 32% ethylene in air are explosive, ethylene for ripening rooms is supplied from compressed cylinders containing a < 3% (<30,000 ppm) ethylene in N₂ mixture.

Cooling tomatoes to 70°F (21°C) or below before the ethylene exposure commences helps ensure uniform ripening. Ethylene treatment is of no value for tomatoes that are already partially pink because they are already producing ethylene. Light is not required for normal postharvest ripening and color development.

Vine-ripe or ethylene-treated tomatoes are often transported at temperatures between 55 and 70°F (12.8 to 21°C) so the fruit can be delivered at a specified ripeness stage. When tomatoes are fully ripe, the holding time can be increased by reducing the temperatures to 45 to 50°F (7.2 to 10°C). However, some softening and loss of flavor will occur with storage in this temperature range; thus, it is generally considered hazardous to hold ripe tomatoes in storage for more than 3 to 5 days. Full red color will not develop below 55°F (12.8°C) or above 85°F (29.4°C).

A temperature of 50 to 55°F (10 to 12.8°C) is recommended for storage and transport of pink-red to firm-red tomatoes produced in greenhouses in order to slow ripening without causing softening and flavor loss.

Very high RH may lead to superficial mold growth on the stem scar and sepals (if present); therefore, an RH of 85 to 90% is best. Superficial mold growth can be stopped by increased air circulation or by using an ozone generator.

There is limited commercial use of low-oxygen atmospheres of 3 to 5% during international transport to extend postharvest life by delaying ripening. Levels of 3 to 5% CO₂ are beneficial for firm ripe fruit but may cause injury in green fruit.

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Diseases and Injuries

Alternaria Rot	<p>Brown to black lesions develop around the stem scar or over the fruit surface. Decayed tissue extends into seed cavities, with gray or olive-green mold eventually appearing on the surface. Rot follows growth cracks, blossom-end rot, faulty-blossom scars, but usually is seen after chilling injury.</p> <p>Control: Hold tomatoes at moderate temperatures and avoid storage below 50°F (10°C). Avoid injuries of any type, particularly chilling injury.</p>
Anthraxnose	<p>Usually attacks ripe tomatoes. Circular, slightly sunken, water-soaked spots, slightly darker, later dark or brownish with cream-colored or pink mold. Warm wet weather favors spread.</p> <p>Control: No warehouse control. Field control.</p>
Bacterial Canker	<p>Very small, shallow, slightly raised white or light brown superficial spots. Later with brown center and white halo.</p> <p>Control: No warehouse control. Field control.</p>
Bacterial Soft Rot	<p>Green fruit are especially susceptible. Water-soaked spots first sharply outlined, later entire fruit becomes soft, watery, colorless and foul-smelling, and bursts readily.</p> <p>Control: Careful handling and prompt removal of excessive field heat. Rot is worse following hot, wet weather. Use clean water and maintain proper sanitizer levels for washing or hydrocooling. Move susceptible tomatoes through ripening process rapidly. Avoid chilling.</p>
Bacterial Spot	<p>Small, shallow, superficial, dark, raised spots first. Later becoming irregular, scabby and dark. It is present at harvest.</p> <p>Control: No warehouse control.</p>
Blossom End Rot	<p>Varies from a superficial brown or dark-green area near blossom end on green tomatoes, later collapsing to become a firm, leathery, sunken and brown to black area.</p> <p>Control: Disease control depends on cultural practices in the field that favor calcium movement into fruits. Should be eliminated during selection and packing.</p>
Buckeye Rot	<p>Decay may resemble a horse chestnut in color, may have concentric rings, or it may be firm grayish-green to brown, with surface uneven and sunken in spots. Often on tomatoes from South following hot, rainy weather. May develop during ripening on tomatoes that appeared sound.</p> <p>Control: Careful culling during grading removes most affected fruit. Do not delay the ripening of suspected tomatoes.</p>
Cladosporium Rot	<p>On green tomatoes, tan or greenish-brown, somewhat leathery and slightly sunken while on ripe fruits, distinctly sunken with greenish-black or shiny black centers and tan or grayish-tan borders. Decaying tissue is shallow, black and spongy, and can be lifted</p>

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	<p>out intact. Surface mold is velvety green. Cladosporium rot follows low temperature injury.</p> <p>Control: Avoid temperatures that cause chilling injury [i.e., below 50°F (10°C)].</p>
Late Blight Rot	<p>Brown to rusty tan blotches at stem end or on sides of fruit. Bacterial soft rot often follows during ripening.</p> <p>Control: No warehouse control. Field control. Do not delay the ripening of suspected tomatoes.</p>
Nailhead Spot	<p>On tomatoes from Mexico, rarely from Florida. Small, circular, slightly sunken, but superficial, grayish-brown to brown spots. Often followed by secondary decay.</p> <p>Control: No warehouse control. Field control. Cull tomatoes with disease spots. Do not delay the ripening of suspected tomatoes.</p>
Rhizopus Rot	<p>Rarely on green tomatoes. Most prevalent on tomatoes shifted repeatedly between 70 and 55°F (21 and 12.8°C) to control rate of ripening. Also serious when ripe tomatoes are held beyond recommended period. Rot is watery, soft, deep penetrating with a fermented odor. Rotted fruit collapse and may develop coarse, white mycelium (“whiskers”) with black spores. Rot spreads from fruit to fruit on contact.</p> <p>Control: Prompt removal of excessive field heat. Handle carefully at all times to avoid bruising and cuts. Ripen tomatoes promptly and avoid delays mentioned above.</p>
Soil Rot	<p>Wet soil conditions favor development on low hanging tomatoes. Small to medium circular, brown spots usually show typical concentric rings or zones of color. Later become brown or reddish-brown and fairly firm, with cream-colored or brown mold growth. Apparently can invade sound skin.</p> <p>Control: Do not delay ripening of suspected tomatoes, especially after wet weather. Only control is to stake tomato plants in field or avoid shipping for 5 days after rain to allow culling after decay develops.</p>
Sour Rot	<p>Symptoms on mature-green tomatoes appear as pale lesions, dull and water-soaked, with sour (vinegar) odor. On ripe fruit, the infected tissue is usually dark, soft, and watery. Symptoms often start at the stem scar and due to wounding.</p> <p>Control: Avoiding mechanical injury is an important preventive measure.</p>
Virus Mottling	<p>Irregular, light-green blotches, streaks or circles on green fruit, fading to red or becoming yellow and brown as fruit ripen.</p> <p>Control: Occurs wherever tomatoes are grown. Symptoms show at harvest. Field control, and careful sorting of fruit when packed.</p>
Watery Rot	<p>Especially on tomatoes from southern states. On green tomatoes, the rot lesions have a dull, greasy, water-soaked to bleached appearance and are quite firm. Decayed fruit have a sour, fermented odor. May show dingy white, scum-like mold growth.</p>

	<p>Control: Remove excessive field heat. Ripen suspected fruit promptly. Avoid chilling injury.</p>
Chilling Injury	<p>Tomatoes injured by low, but non-freezing temperatures fail to develop aroma and color and do not ripen satisfactorily. If seriously injured, they develop Alternaria Rot. For mature-green tomatoes, 1 to 2 days at 32°F (0°C) or 3 to 5 days at 41°F (5°C) will cause chilling injury.</p> <p>Control: Do not hold at temperatures lower than the recommended minimum.</p>
Freezing Injury	<p>Rapid breakdown of tissues in seriously frozen green and ripe tomatoes, becoming watery. Green tomatoes with localized injury may thaw without collapsing, but become shriveled at the affected area. When in frozen state, green and ripe tomatoes appear glassy and dull colored.</p> <p>Control: Do not expose to freezing temperatures of 31°F (-0.6°C) and below.</p>
Sulfur Dioxide Injury	<p>Caused by SO₂ used to control decay in some commodities; very pronounced sinking and drying out of tissues at stem attachment, bleached greenish-tan.</p> <p>Control: Nothing that a warehouseman can do after injury is caused.</p>
Sun Scald	<p>Caused by high heat and intense sunlight in field; irregular water-soaked blisters enlarging to bleached areas, secondary decay invasion.</p> <p>Control: Should be eliminated at time of packing. Nothing that a warehouseman can do.</p>

Frozen Tomatoes

Whole tomatoes do not freeze well because of their high moisture and low solids content, with the possible exception of cherry tomatoes and firm-sliced tomatoes frozen cryogenically. Although these products also lose a certain amount of their turgidity, they are, never the less, acceptable provided they are consumed while they are thawed but still cold. If permitted to reach ambient temperature before serving, they still tend to leak and are no longer of satisfactory quality. Despite attempts to develop and market a cryogenically frozen sliced tomato, it has not proven to be economically feasible.

Chopped or pureed whole tomatoes may be frozen and held for 6 to 9 months at 0°F (-17.8°C) for further processing. Relative humidity is not a factor, since we assume uniform temperatures and vapor proof packaging.

Tomato products, such as purees, sauces, and paste, are widely used as ingredients in frozen products. Pizzas, spaghetti, and a wide range of entrees include such tomato products and have good stability.

Variability in formulation of such products makes impossible a general statement on shelf life. Each formulation to be used should be pre-tested for shelf life before initiating product sales.

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