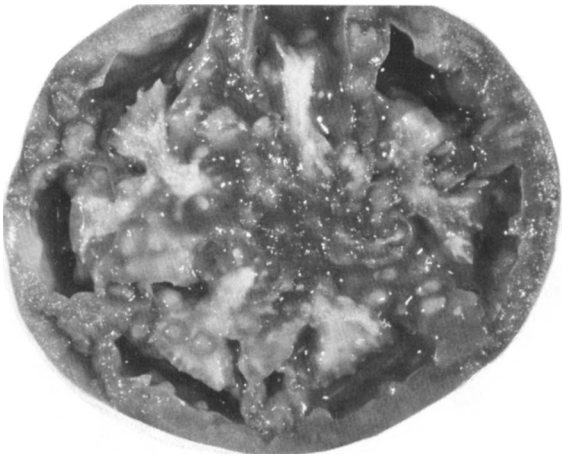

Disorganized gel, water-soaking, and cracked fruit wall tissue resulting from impacts and vibrations during commercial marketing of vine-ripened tomatoes.

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Damage to fresh tomatoes can be reduced

Physical damage, which has a major effect on fruit quality and market loss of fresh market tomatoes, can occur throughout the distribution system between field and consumer. As part of an effort to improve retail quality of fresh tomatoes, studies were conducted to identify the type and amount of physical damage, factors that render fruits more susceptible to injury, and symptom development as related to temperature, storage, and fruit maturity.

Symptoms and possible causes

To identify the physical damage that occurs before shipment to market, a survey covering most California shipping districts was conducted in 1974. Packed cartons of "mature-green" and flats of "pink" tomatoes were obtained at random from packinghouses and sorted for visible damage. Each affected fruit was classified according to the most severe defect shown. Fruit defects varied considerably among individual containers and packing sheds surveyed.

The survey revealed several distinct types of damage and indicated the likely causes. Cuts and punctures result from sharp points and edges, such as fruits with stems, fingernails, or rough containers. Scuffs and abrasions occur when the fruit surface is rubbed away by friction against dirt or sand, packing line belts, other fruits, or container surfaces. Shoulder scars result from scuffs or abrasions on the shoulder of the fruit.

Bruises can be caused by impacts against other surfaces or by vibrations during transit. External symptoms include tissue softening, water-soaking, or cracked fruit walls. Often bruise damage is not detected until the fruit is cut and internal tissue examined. Water-soaked tissue and whitish to greenish, shrunken and disorganized gel are internal symptoms of damage. Deformation is a localized, permanently flattened area, resulting from pressure on the tomato during transport or storage.

Occurrence and severity

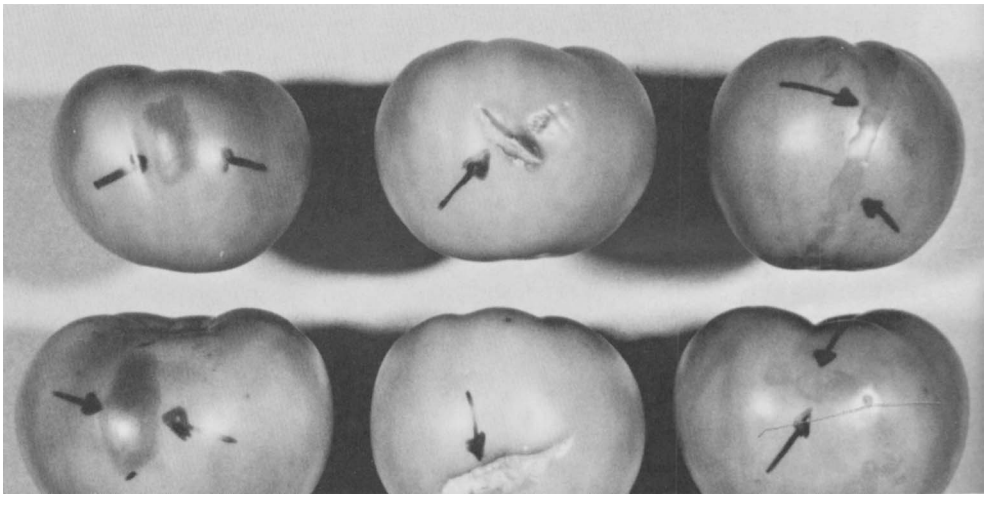
Cartons of mature-green tomatoes were sorted initially and then held for simulated transit and storage periods at the Mann Laboratory, University of California, Davis. After each holding period, fruits were scored for the most serious defect.

Figure 1 shows that 55 percent of the mature-green tomatoes sorted at shipping point had some type of mechanical injury. This increased to 78 percent after simulated transit, primarily because symptoms developed from injuries initially present. Increases in bruise and deformation categories were primarily due to development of deformations during fruit ripening.

After ripening at 68° F for 7 days, 69 percent of the fruit showed mechanical injuries. This apparent reduction occurred because some damage was reclassified as shrivel and decay. Decay incidence was directly related to the initial degree of surface injuries (cuts, punctures, abrasions, scuffing, and shoulder scars), which contributed more than twice as much as bruising and deformation to the final percentage of unmarketable fruits. Total percentage of unmarketable fruit increased from 2 to 30 percent over the 17-day period (fig. 1).

In 1975 transit tests were conducted in California to determine the cause and magnitude of physical damage in marketing "vine-ripened" tomatoes. A representative pallet of commercially packed pinks (color 2-3, XL size) was selected at shipping point (Oceanside), carefully scored, and then repacked. After truck shipment, fruit from the same pallet was scored at the distribution center (Sacramento), upon arrival at the retail market (Davis), and after retail display. Retail cullage was collected and scored. Only test fruit was used in the bulk retail display. After 20 store hours, fruit remaining in display bins was evaluated.

The severity and extent of defects



Bruises, cuts, and abrasions found in commercially packed cartons of mature-green tomatoes sorted at shipping point.

increased with each step in the handling system (fig. 2). Total fruit classified as unmarketable increased from 11 percent at shipping point to 17 percent at retail. Bruising, the primary defect, accounted for 59 and 63 percent of all unmarketable fruit at shipping point and retail, respectively. Sixty-two percent of those fruits considered unmarketable at retail had defects at shipping point. This included fruit with preharvest defects (puffy, misshapen, growth cracks) and some damaged during packinghouse operations but not sorted out. These defects became more apparent after transit and in some cases were followed by decay. Puffy, misshapen fruit were structurally weak and thus more susceptible to bruising.

Discrepancies (fig. 2) in percent fruit judged unmarketable before retail display and actual cullage by produce personnel at retail were not due to sorting methods. Consumer purchase of some fruits with severe defects accounted for the lower retail cullage. Although this resulted in a higher percentage sold, it could influence repeat purchases by consumers who bought fruit with severe defects.

Laboratory tests

Because commercially packed tomatoes are subject to variations in handling and environment, the surveys could not identify the factors that specifically influenced physical damage. Effects of temperature, storage, handling practices, ripeness stage, and other factors on fruit damage susceptibility and symptom development were studied under laboratory conditions.

Locally grown tomatoes (cv. Cal Ace) were harvested and sorted for freedom from damage. Uniform amounts of abrasions and scuffs were inflicted by rolling fruit on fine-grade sandpaper glued to the bottom of a padded tray. A laboratory shaker was used to standardize motion of the tray. Impact bruises were inflicted by dropping tomatoes from a uniform height onto a hard surface. Unless otherwise specified, treated tomatoes were held at 59° F for 10 to 14 days for observations and measurements.

Scuffs and abrasions. Symptom development of scuffs (cuticle removed) varied with ripeness stage. Scuffed immature-green and partially mature-green fruit developed a brownish, callus-like blistering over the injured area. Fully mature-green fruit developed no blisters, but the affected skin area failed to develop normal color. Injured areas appeared bleached on ripened fruit. Tomatoes scuffed at breaker stage showed similar symptoms. Scuffing rarely occurred on fruit riper than breakers. Immature greens were most susceptible, followed by mature greens, breakers, and pink tomatoes. Two days were required for scuffing symptoms to develop fully.

Scuffs and abrasions increased water loss during storage. Localized shrivel around damaged areas magnified symptom development. As severity of scuffs and abrasion increased, the percentage of water lost and severity of fruit shrivel increased. Immature-green fruit lost more water, shriveled more, and developed more severe symptoms than corresponding mature greens.

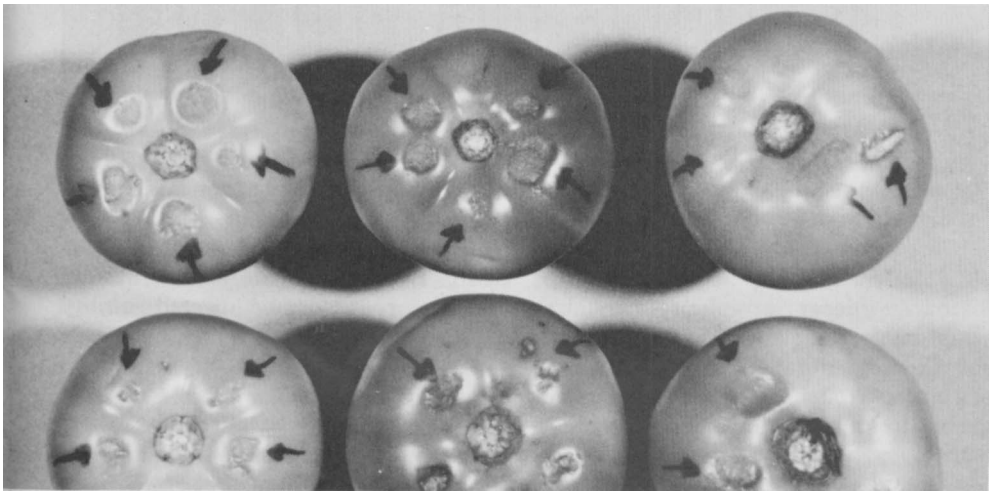
Cold mature-green tomatoes have often been considered more susceptible to scuffs and abrasions than warm fruits. However, our laboratory tests detected no relation between susceptibility to damage and pulp temperature (41°, 59°, or 86° F) at time of damage. Moisture condensed on cold fruit in the field can cause dirt and sand to adhere to the fruit surface during harvest, resulting in more scuff and abrasion damage.

Pulp temperature immediately following scuff and abrasion damage did have a significant effect. Symptoms developed faster at warmer storage temperatures (86° F) because of increased rates of surface browning and localized water loss.

Impact bruises. Susceptibility to impact bruising increased with ripeness stage at harvest. Fruits harvested partially ripe (breakers and light pinks) developed more visible, severe bruising symptoms (softening, water-soaked appearance, and internal damage) than did mature greens when subjected to similar impact treatments. External bruise symptoms on mature greens were nonexistent or became less apparent as the fruit ripened. Bruise symptoms did not disappear on fruit damaged at ripeness stages beyond breaker. In all impact-bruised fruit, internal tissue often became water-soaked; gel was shrunken, disorganized, and discolored.

No pronounced difference in external symptom development could be detected among mature-green fruit impact bruised at 41°, 59°, and 86° F. However, fruit impact bruised at 41° F pulp temperature did have more cracks in radial wall tissue. Temperature during a two-day holding period after treatment had no effect on impact damage.

Impact bruising of mature-green tomatoes increases ethylene production and respiration within one day of impact. Increased ethylene production and possibly other physiological changes seem to create a condition conducive to faster ripening of damaged fruit. Ripened, impact-damaged, mature-green tomatoes have significantly less titratable acidity (citric acid) and slightly lower (non-significant) ascorbic acid content than do undamaged tomatoes. These compositional changes are sufficient to alter nutritive and taste characteristics.



Shoulder scars on commercially packed, mature-green tomatoes at shipping point.

Conclusions

Much of the physical damage that adversely affects retail quality occurs before shipment. Unfortunately, identification of damage early in market channels is difficult, because it may not be

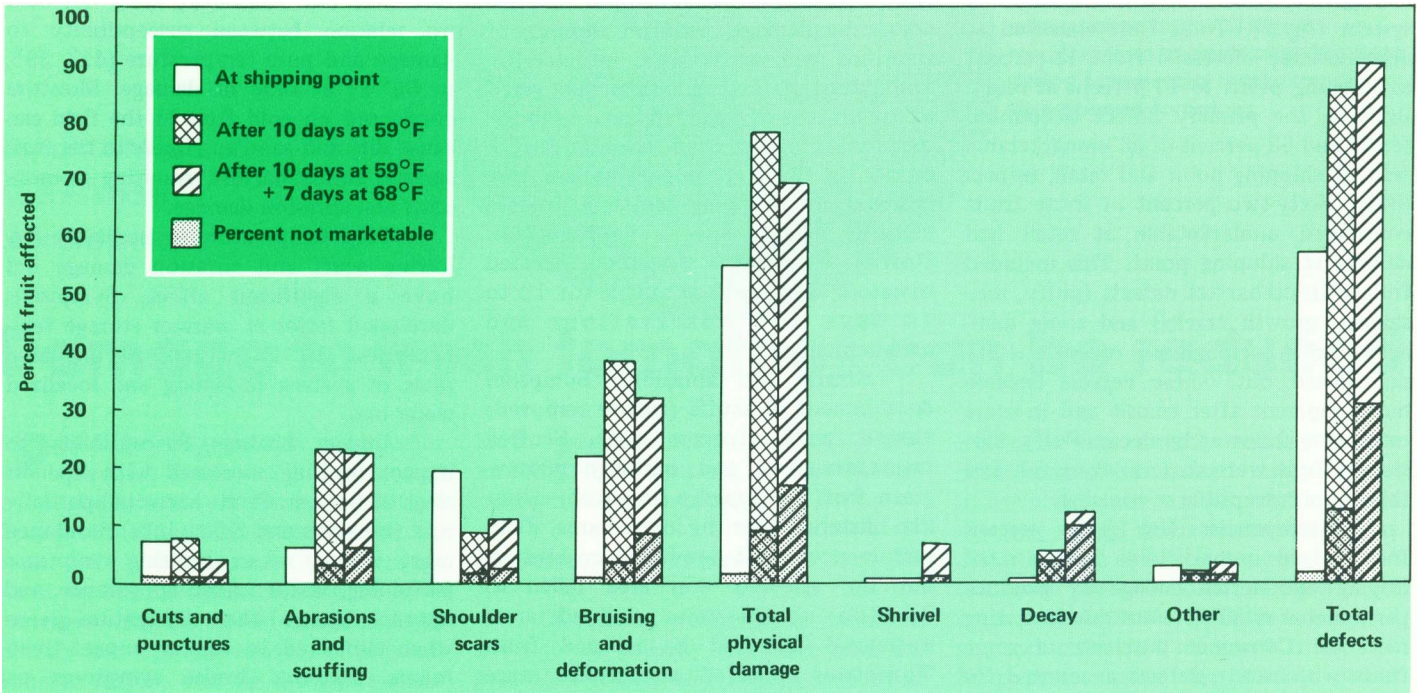


Fig. 1. Incidence and severity of various types of physical damage and other defects on fruits commercially packed as mature greens. Based on survey conducted during 1974 involving 2,241 fruits (large, 6x6 size).

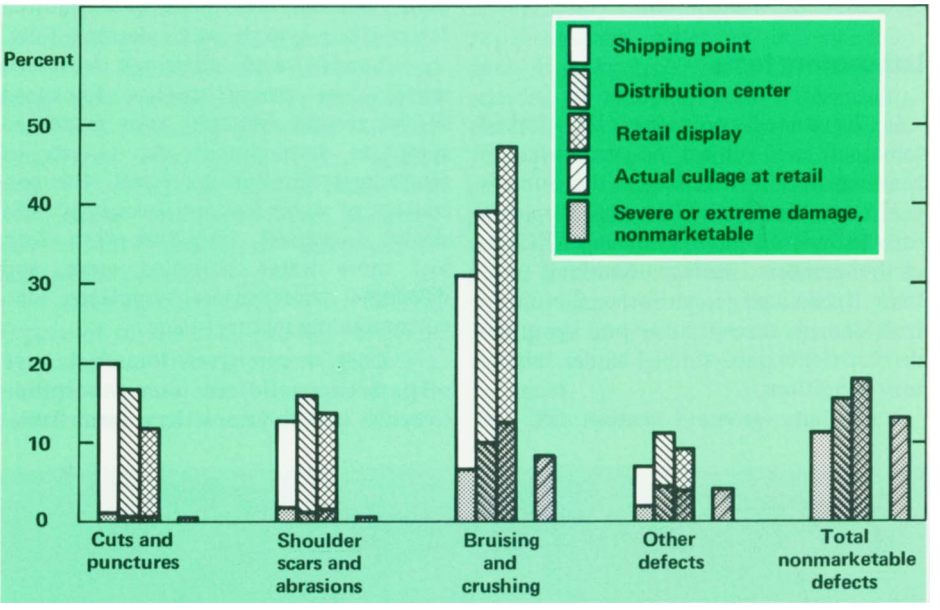


Fig. 2. Incidence and magnitude of defects during handling and retail marketing of place-packed, extra-large, pink (color 2-3) tomatoes (means of three test shipments from Oceanside to Davis, California).

visible immediately. The following suggestions can help lower damage and decay during handling of fresh tomatoes.

- Careful handling cannot be overemphasized. Properly trained and managed harvest and packinghouse crews should be aware of damage inflicted by fingernails, dirt, and rough handling during sorting. Proper produce handling at all market points is a management responsibility.
- Containers and packing lines should be kept free of sand, dirt, and other foreign particles. Stems should be removed from all fruit before packaging. Tomatoes, especially those harvested when free moisture (dew, rain) causes dirt to adhere to fruit, should be washed early in the packing operation. Sanitation throughout market channels helps control decay.
- Green tomatoes should be harvested at as mature a stage as possible. Immature fruit is more susceptible to scuffs, abrasions, shrinkage, and resulting decay. Prevention of surface injuries of mature greens is extremely important, because longer holding periods increase the probability of decay.
- Good temperature management is the best way to maintain quality and promote uniform ripening, regardless of damage levels. Prompt cooling to 55° to 60° F and maintaining these temperatures discourage decay organisms, minimize symptom development of surface injuries, and slow deterioration. Prompt ripening of mature tomatoes reduces excessive quality loss and shrinkage due to physical damage.

Physical damage will always be present on fresh tomatoes at the retail market. However, through increased efforts to minimize the causes, damage can be reduced and overall quality improved.

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