face. Glossy at first, they turn brown and usually are slightly sunken. The spots often merge into larger, irregular, brown ones. Sinking and discoloration of the affected areas increases with time and can be expected to become more conspicuous in transit. Fruits showing the disease are unattractive. The most seriously affected ones may be a total loss.

The virus disease known as spotted wilt has caused serious losses in some sections of California and Oregon because of the presence there of a damaging strain of the virus. The disease also occurs in Texas and in some of the east North Central and Atlantic States, but generally it does not cause serious losses there. Affected fruits in the market usually show several or many ring patterns, often with a mottled condition, which is due to the lack of normal ripening in the surrounding tissues. The ring appearance is due to a slight sinking and shriveling of the tissues around the margin of the affected area which causes the center of the ring to appear raised. The affected areas may be practically normal in color or may appear bronzed or reddish brown.

STONY PIT, a virus disease of pears, may occur anywhere pears are grown. Commercially important losses, however, appear to be confined to the Pacific coast area. The Bosc variety is most subject to stony pit, but the disease also affects Anjou, Winter Nelis, Hardy, and Forelle.

In affected fruit, masses of stone cells occur in the flesh of pears at the bottoms of dimplelike depressions. The lumps of stone cells are so hard that it is almost impossible to cut them. When the pitting is severe and the pits are numerous, fruits may be greatly distorted. Seriously affected fruits are worthless. Fruits that are only slightly pitted, however, are often marketed.

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Injuries From Chilling and Freezing

Lacy P. McColloch

Fresh fruits and vegetables are kept cool on their way to market so as to slow down the processes that cause their overripeness and decay. Refrigeration is the foundation of the big industry that makes it possible for us to have fresh produce the year around.

But some commodities that are subjected too long to low temperatures are so injured or weakened that their physiological processes are impaired or slowed to the point of inability to function, and decay becomes far more extensive than normal.

The fruits and vegetables that require high temperatures for growth generally are the ones most subject to injury by chilling or low temperature. Among them are bananas, citrus fruits, cucurbits, eggplant, peppers, potatoes, sweetpotatoes, and tomatoes. In handling them one has to remember that each has its own requirements or limitation as to the temperatures at which it can be held safely.

Chilling injury, which differs from freezing injury, results from holding a commodity at low (32° to 50° F.) but not freezing temperatures for enough time to impair its life processes. The effect is not well understood, but it appears that the tissues, unable to carry on normal metabolism, gradually become weakened. Chilling injury therefore is relatively slow.

Freezing injury results when ice crystals form in the tissues of fruits or vegetables. It usually occurs if they

are subjected to temperatures corresponding to their freezing points or lower. Freezing injury may take place in a few hours and in spots or throughout the commodity. Tissues injured by freezing generally look as if they were soaked in water.

Chilling injury often is not apparent at the time fruits and vegetables are removed from low temperatures but becomes evident several days later. The symptoms are more noticeable in some commodities than in others. It is hard to diagnose chilling injury definitely because clear-cut symptoms are absent.

BANANAS are highly sensitive to unfavorably low temperatures. Injury so severe as to make them unsalable may occur if they are held at 45° F. or below in still air for 12 hours. The upper limits of temperatures that may cause chilling injury are not sharply defined, but the lowest temperature at which bananas should be held is 56°.

Ripe fruits are slightly more susceptible than green fruits. Chilling injury is confined mainly to the peel, in which some of the surface cells are killed. Severely chilled green fruits may have dark-green, water-soaked specks or nearly the entire surface may be dark. The latex exudes little or not at all in chilled green bananas when they are broken. It is clear, rather than milky or cloudy. That condition, however, is not a definite indication of chilling—it also is characteristic of bananas that are beginning to ripen. If chilled to a lesser degree, green fruits develop a dull, smoky appearance on ripening, rather than a bright-yellow color.

Chilling injury does not become apparent on ripe fruits unless they are held at low temperatures a long time. The characteristic dull appearance soon develops, however, when chilled ripe fruits are removed to higher temperatures.

One has to know a good deal about bananas to recognize chilling injury, especially in green fruits, because factors other than chilling may cause a similar appearance.

CITRUS FRUITS are not chilled to the point of injury during the normal transportation period, but may be injured in storage if unfavorably low temperatures prevail. Storage may be necessary for citrus fruits in order to spread the marketing period. Because the demand for lemons is greatest in warm weather, a large part of that crop is stored for a while.

The storage behavior of citrus fruits is influenced by their degree of maturity and their inherent differences. The storage temperatures recommended, however, are those found most desirable for most of them. Low-temperature injury results in the development of various disorders, some of which are common to all citrus while others are specific for certain kinds.

Grapefruit stored at 32° to 40° F. for 2 or 3 months might suffer pitting, watery breakdown, scald, and browning of the oil glands. The pits in the rind are a type of low-temperature injury that may occur in all citrus fruits. Pitting is especially serious if grapefruits are stored for 2 months or more at 32° to 40°. The pits may occur anywhere on the surface and often are numerous. Occasionally the collapsed tissues appear bleached, but usually they are darker than the healthy rind. Pits developed on fruits stored at 32° are smaller than those on fruits stored at 36° and 40°.

Watery breakdown may develop in any citrus fruit stored at low temperatures for 2 or 3 months. Grapefruit picked late in the season are more susceptible than fruits picked earlier. Affected fruits are soft, spongy, and water-soaked in both peel and flesh and look as if they had been frozen. Affected fruits develop a fermented odor when they are held at room temperature.

Scald involves a superficial and fairly uniform browning of large areas of the rind. Affected areas at first are firm, but in severe cases the surface

becomes spongy and soft and resembles an early stage of watery breakdown.

Another type of browning is confined entirely to the oil glands. It usually occurs at 32° and 36° F. Affected glands close together give the appearance of mass discoloration. Actually the discoloration is confined to the oil glands and the surrounding tissues are only slightly discolored.

Lemons also are subject to pitting, watery breakdown, and scald. The handling and storage problems of lemons are quite different, however, from those of grapefruit or oranges. Because lemons can be picked at a more immature stage than grapefruit and oranges, they can be held at a higher storage temperature for the 3 months needed to carry the winter and spring crop to summer.

Lemons stored at 58° F. until ready to ship will escape the disorders I mentioned. Even at that temperature, however, lemons are somewhat subject to a browning of the membranes—a disorder known as membranous stain, which cannot be detected until the fruits are cut. It is greatly increased by storing lemons at 40°. If lemons are stored after reaching the market at temperatures of 32° to 40° for 60 to 90 days, low-temperature disorders may be expected to develop. For short-term storage (2 to 4 weeks) in the market, 32° is perhaps the most desirable temperature for lemons because membranous stain does not occur then and other injuries do not become serious in that period if the fruits have not previously been stored at a low temperature.

Pitting, brown stain, and watery breakdown usually develop if oranges are stored at low temperatures for a long time. Such disorders can be avoided if the storage period is shortened and fruits with longer storage-life expectancy are selected.

Pitting is worse on early and midseason varieties of Florida oranges than on late-maturing varieties. The variety Pineapple is one of the most susceptible. The variety Valencia is quite resistant to pitting and other low-temperature disorders. Valencia oranges can be stored at 32° to 34°, but the storage period should not exceed 12 weeks.

Brown stain is characterized by a superficial and fairly uniform browning of a large area of the rind. Like watery breakdown of grapefruit, it usually develops in certain varieties of oranges stored at 32° for 2 months or longer. None of the low-temperature disorders has been serious in Florida-grown Valencias stored at 32° for 8 to 12 weeks.

SWEETPOTATOES are much more subject to chilling injury than is generally thought. Noncured sweetpotatoes are more susceptible than cured ones. Subjecting noncured roots to temperatures of 50° or below for only a few days may seriously affect their storage life. Although no variety should be held at low temperatures, the varieties differ in their sensitivity to low temperatures. The Jersey group—Big Stem Jersey, Little Stem Jersey, Orange Little Stem, Maryland Golden—is most seriously affected by cold. Second to this group is Nancy Hall. Porto Rico is the most resistant.

Chilling injury of sweetpotatoes does not become evident immediately after exposure to low temperatures. Noncured roots subjected to 40° or below during transit or on the market may develop surface pits in 2 or 3 weeks. Roots stored at 50° show evidence of cold injury after 5 months in storage. Increased decay is the best indication of such injury. The most typical symptom in the Jersey group is a type of spongy breakdown and brown discoloration of the inner tissues. After the same period of storage at 50°, the Nancy Hall variety develops a dull cast, and discoloration develops usually at the stem end. Because fungi attack the weakened tissues, the condition soon appears as typical end rot. Chilled sweetpotatoes are poor keepers in

storage, and losses continue during wholesale and retail handling. The consumer may make selections that are free from decay, but be unaware of the internal condition until after the roots are cooked. Hard areas, pithy breakdown, or a darkened condition of the cooked flesh indicate that sweetpotatoes were stored at temperatures that were too low.

Freshly dug sweetpotatoes that are to be marketed promptly without curing should not be subjected to temperatures below 50°. Roots that are to be stored should be promptly cured at 85° and the subsequent storage temperatures should be maintained between 55° and 60°.

TOMATOES may suffer chilling injury in the field while they are on the vine, while they are in transit, or after they reach the market. The conditions during the normal transit period from shipping point to market generally do not lead to chilling injury, but some cars arrive at the markets each year in which the fruits have been chilled. Unless the fruits are injured to the point of physiological breakdown, the symptoms of chilling injury on tomatoes are not clearly evident. As a result much confusion exists and litigation over losses occurs each year.

Tomatoes may be considered as having been chilled when their physiological processes have been so impaired that ripening does not take place when the fruits are placed at temperatures that are normally favorable for ripening. Chilling injury ordinarily cannot be detected at the time tomatoes are removed from cars with low temperatures. The injury usually does not become apparent until the fruits have been in the ripening room 2 or 3 days. At that time tomatoes that have been seriously chilled have a dull, lifeless, picklelike appearance and feel rubbery to the touch. The internal symptoms are a watery (but not mushy) appearance of the tissues and a slightly fermented odor.

Alternaria rot around the stem scar and as numerous small lesions over the surface of a high percentage of the tomatoes in the ripening room usually accompanies chilling injury and is an indication that the fruits have been chilled. Fruits that are less chilled show little sign of physiological injury while in the ripening room.

Tomatoes may be held at temperatures of 32° to 40° for 3 to 5 days and still ripen satisfactorily with little or no increase in decay. Tomatoes held for 6 to 8 days will ripen satisfactorily as to color, but may show an increase in decay in proportion to the length of exposure. Tomatoes are definitely weakened by holding at those low temperatures for 9 to 12 days. Ripening is unsatisfactory and decay is extensive. Tomatoes are so weakened by holding at 32° to 40° for 17 to 21 days that the entire lot usually becomes lifeless and rots without ripening. Chilling injury develops more slowly at 45° than at 32° or 40°, but tomatoes should not be held at 45° for more than 3 to 5 days.

Ordinarily the field heat in the tomatoes when loaded is such that several days are required to cool the load to desirable temperatures, even by refrigeration. Fruits near the bottom bunker of the car, however, cool rapidly and may arrive on the market with a pulp temperature of 36° to 40° if the car was moved under bunker icing. Under normal conditions, if the transit period does not exceed 6 days, the tomatoes would be at such low temperatures for only 2 to 4 days, and those conditions are not sufficient to cause chilling injury.

If, however, the transit period exceeds 10 days and the load is refrigerated, there is danger of chilling injury to the tomatoes near the bottom of the bunker. If the tomatoes have been exposed to temperatures of 40° or below in the field for a week or more before harvesting, or stored at 40° to 45° for a week before shipping, and are refrigerated in transit, or if the car is iced and left on track at the market, the fruits may be at low temperatures

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for a long enough time to become chilled.

Refrigerated cars that are diverted from one prospective market to another are likely to become chilled because of the longer time in transit. Chilling injury is particularly likely in shipments made when the outdoor temperatures are low. Heavy icing at that time is undesirable. Tomatoes shipped to northern markets in winter may even need heater service to protect them against chilling injury as well as freezing.

Although tomatoes can withstand low, but not freezing, temperatures for 3 to 5 days without suffering injury, it is not advisable for the fruit temperature to be lower than 50° during transit. This recommendation is made because of the uncertainty of the previous treatment of the tomatoes and also the uncertainty of how the load may be handled before the tomatoes are ripened.

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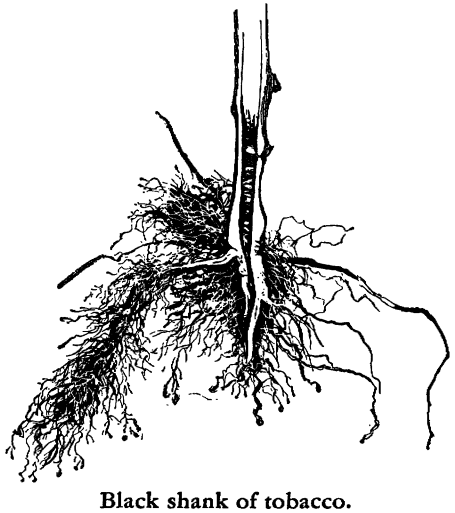

Black shank of tobacco.

Physiological Disorders

T. R. Wright

Diseases of fruits and vegetables caused by adverse environmental conditions during growth in fields or orchards or during harvest, storage, and marketing are called physiological diseases.

One important cause of a number of physiological disorders is suboxidation, or anaerobic respiration. The first part of this chapter is devoted to symptoms of suboxidation on a number of commodities; the latter section is devoted to the description of miscellaneous disorders.

Fruits and vegetables are living organisms. If their supply of oxygen is greatly reduced or withheld during postharvest handling they are likely to smother with progressive death of various parts of their tissues. Off-odors and off-flavors accompany the smothering of tissues, and the tissues become susceptible to decay because of weakening and death of cells.

Potato black heart may occur in the field during excessively hot weather in waterlogged soils because the tubers cannot get enough oxygen to supply the respiratory demands at high temperatures under those conditions. It may occur in potatoes in transit when the car temperatures are allowed to go over 90° F., or in storage houses where bins are so large that the middle of piles receive insufficient ventilation. Flues through the piles and the false floors and walls with which newer storage houses are being equipped