Market Diseases of Citrus and Other Subtropical Fruits

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Preface

This handbook is a revision of Miscellaneous Publication No. 498, "Market Diseases of Fruits and Vegetables: Citrus and Other Subtropical Fruits," by Dean H. Rose, Charles Brooks, C. O. Bratley, and J. R. Winston, issued June 1943 and reissued April 1955 with no change in text. This is one of a group pertaining to market diseases of fruits and vegetables. The publications are designed to aid in the recognition and identification of pathological and physiological defects of economic importance affecting fruits and vegetables in the channels of marketing, to facilitate the market inspection of these food products, and to prevent losses from such defects. Other publications in this group are—

MISCELLANEOUS PUBLICATIONS

98. Market Diseases of Fruits and Vegetables: Potatoes. Revised January 1949. [Out of print.]
228. Market Diseases of Fruits and Vegetables: Peaches, Plums, Cherries, and Other Stone Fruits. Revised February 1950. [Out of print.]

AGRICULTURE HANDBOOKS

28. Market Diseases of Tomatoes, Peppers, and Eggplants. Revised February 1968.
155. Market Diseases of Beets, Chicory, Endive, Escarole, Globe Artichokes, Lettuce, Rhubarb, Spinach, and Sweetpotatoes. April 1959. Reprinted May 1967.
184. Market Diseases of Cabbage, Turnips, Cucumbers, Melons, and Related Crops. September 1961.
189. Market Diseases of Grapes and Other Small Fruits. November 1960.
303. Market Diseases of Asparagus, Onions, Beans, Peas, Carrots, Celery, and Related Vegetables. September 1966.
371. Market Diseases of Apples, Pears, and Quinces. 1971.

Market Diseases of Citrus and Other Subtropical Fruits

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INTRODUCTION

Market diseases of fruits and vegetables are those that develop during the process of marketing. Marketing includes the harvesting, grading, and packing of the crop, its transportation to market, its storage at shipping point or at the market, and the various handling operations required to move it from the wholesale dealer to the retail store and the ultimate consumer. During any of these operations the product may be subjected to conditions that impair its appearance and food value and render it liable to attack by decay-producing organisms or physiological breakdown.

The fruits discussed in this publication, like all other fruits and vegetables, are susceptible to invasion by bacteria and fungi at bruises and skin breaks. Hence, it is of prime importance that they be handled as carefully as possible at all times. Clipper cuts, fingernail scratches, injuries caused by packinghouse machinery, packing bruises, and damage caused by rough handling in transit and on the market are all sources of danger. This is especially true if the places where the fruit is packed, stored, or offered for sale are not kept free of rotting fruit and other infectious material. These injuries, as well as those caused by insects, must all be considered when judging the storage or shipping quality of the fruit or its likelihood of maintaining its quality until it is consumed.

Temperature and humidity directly affect the development of decay in fruit. They should have the critical attention of those who ship or store fruit and of those who attempt to determine why a given lot, at any stage in marketing, shows decay or other deterioration. Too low temperature may freeze the fruit, or it may cause only chilling injury; subtropical fruits are particularly susceptible to such injury. Too high temperature favors decay and may cause undesirable color changes. High humidity favors the growth of fungi. Low humidity causes loss in weight and possibly shriveling, especially if temperatures are high. For all of these reasons, the management of storage rooms for citrus and other subtropical fruits and the choice of conditions under which to ship them to market, whether under refrigeration or under ventilation, are not likely to give the best results unless based on an intelligent use of all available information concerning the market diseases of those fruits.

CITRUS FRUITS

Aging (Stem-End Rind Breakdown)

Occurrence, symptoms, and effects

The term "aging" or stem-end rind breakdown refers to a condition sometimes found after harvest on most citrus fruits, but chiefly on oranges, grapefruit, and tangerines. In this disorder, the rind around the stem button or elsewhere on the upper part of the fruit wilts and shrivels, usually accompanied by a collapse of outer rind tissues. This is a physiological condition, apparently caused by the loss of water from the fruit. The affected areas may turn brown, and the oil glands may collapse (pl. 6, *A* and *B*). Under severe conditions with overripe fruit, aging may be apparent before harvest. In examining fruit after a storage or holding period, it is sometimes difficult to be certain whether brown sunken areas are pits or aged spots. Generally, these spots are called aging if they occur around or near the stem button, and pitting if they occur around the equator or lower part of the fruit. Spots in the latter locations are usually smaller and more sunken, but they may coalesce to form large discolored areas.

Fruit that shows extreme symptoms of aging, accompanied by browning, usually has an off-flavor. Similarly affected fruit may be invaded by stem-end rot or other fungi which cause the fruit to decay.

Another condition, similar to aging, is found late in the season on tangerines and oranges. Minute cracks develop in a roughly concentric pattern in the rind around the button. These cracks may develop on normal-colored rind, but later the affected area may develop a tan-to-brown corky appearance. This condition is commonly observed on fruit on the tree, but symptoms intensify after harvest.

Causal factors

The actual cause of aging is not known. The incidence varies considerably from season to season and from crop to crop. It is more prevalent on fully mature or overripe fruit. Several factors tend to increase or aggravate symptoms in fruit prone to age. These include delay between harvesting and packing-house handling, excessive brushing, and low humidity during holding before packing or in storage. Heated solutions used in washing or in the "color add" process may also increase aging. Control is best obtained by avoiding as many of the above factors as possible. Varieties and crops known to be weak should be handled as carefully and promptly as possible.

(See *56, 61, 87, 114, 116, 201, 208, 209.*) [1]

Alga Spot

Cephaleuros virescens Kunze

Alga spot and blight is a disease of citrus and many other subtropical fruits grown in areas of warm temperatures and high humidity and rainfall. In the United States it is most common in the southern part of Florida. It is most common on lemons and limes and to a less extent on oranges and grapefruit, but the problem is seldom serious. It does not originate on fruit after harvest.

Damage results not by parasitism but by growth and expansion of the algal tissues on the host tree, causing bark on the twigs and smaller branches to crack and scale. Citrus fruits and leaves may also be spotted by the superficial growth of algal colonies. The spots on the fruit are slightly raised, nearly circular, and up to a quarter inch in diameter. Under a hand lens, they are moss-like in appearance.

Cause and control

The causal organism for algal disease is *Cephaleuros virescens* Kunze, a filamentous green alga which sometimes associates with

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[1] Italic numbers refer to Literature Cited, pages 82 to 101.

fungi to form a lichen. The disease can be readily controlled by maintaining good tree vigor, by good air drainage, by pruning out of diseased branches, and by spraying with a copper fungicide. (See *4, 76, 136, 147, 201, 208, 283.*)

Alternaria Rot of Lemons and Black Rot of Oranges

Alternaria citri Ell. & Pierce

Occurrence, symptoms, and effects

Alternaria rot of lemons and black rot of oranges, grapefruit, and tangerines are caused by the same fungus (*Alternaria citri*). Alternaria rot, found in lemons from all producing areas, is sometimes an important storage and market disease. Before present control measures were developed, Alternaria rot was second in importance only to the green and blue penicillium rots on lemons.

Black rot of oranges and other species is a widely distributed, usually minor, rot found in fruit from all citrus-growing areas. Only occasionally is it prevalent enough to cause significant losses in fresh fruit. The rot is important in fruit destined for processing, since infection of 2 to 3 percent of the fruit is sufficient to produce off-flavored juice.

Spores of the alternaria fungus may be found on or under the buttons of almost all lemons, even very young fruit in the orchard. Infection usually occurs through the button tissues, but not until after the lemons are harvested and in storage. The rot affects the central core and stem end or may occur as a stem-end rot. First, usually, the buttons turn brown, then a slowly developing pinkish to light-brown discoloration proceeds along the vascular tissues of the central core, and to some extent in the inner tissues of the rind, without at first visibly affecting the exterior surface. Later the fungus breaks down the fruit interior to a slimy, lead-brown mass, and grows outward to the surface. There a dark-colored area becomes apparent, increases in size rapidly, and develops a lead-brown color. Eventually the entire rind breaks down (pl. 1, *E*).

Oranges, grapefruit, and tangerines may be infected by the alternaria fungus (black rot) in the orchard or during storage. In the orchard young, green, physiologically weakened fruit is susceptible. Entry points for infection are the button or stem end (pl. 1, *A*), the stylar end, and peel wounds (pl. 1, *B*). Navel oranges are usually invaded through the stylar end. Infected fruit may color prematurely and drop from the tree, or it may appear sound and remain on the tree. In the latter case, the cut fruit shows an internal, rather solid, black rot at either the stem or stylar end (pl. 1, *C*). Later, during storage and transit, the rot reaches the rind surface, causing a tan discolored spot or spots that enlarge and usually turn dark brown or black (pl. 1, *D*). The spots eventually become covered with gray-to-black fungus mycelial growth. The absence of early external symptoms of alternaria decay makes detection at the packinghouse extremely difficult.

Causal factors

Lemons of low vitality are most susceptible to alternaria rot. Such fruit includes that which is overripe, is held in storage too long, or is weakened by such orchard conditions as cold weather, drought, sunburning, dry winds, and internal decline.

Black rot of oranges, grapefruit, and tangerines infects physiologically weakened fruit. This classification includes young green fruit weakened by improper fertilization or unfavorable weather conditions and mature fruit weakened by long storage.

Control measures

Freshly picked immature lemons are resistant to growth of the alternaria fungus in peel wounds, while ripe lemons are not. Infection usually occurs through the button, but it is not until the button tissues weaken and die that the fungus is able to gain entry into the lemon. The length of time lemons can be held in storage before button strength declines depends upon the stage of maturity when stored, the time of picking, the year, and the conditions in storage.

Alternaria rot is controlled or delayed by applying 2,4–dichlorophenoxyacetic acid (2,4–D) to lemons in the packinghouse as part of the washing before storage. Buttons of 2,4–D-treated fruit stay green longer during storage than buttons on nontreated fruit. By prolonging button life, infection of the lemon by the fungus is delayed.

Direct chemical control of the alternaria fungus on citrus fruits has not been successful. Fungicidal treatments effective against penicillium and stem-end rots provide less than adequate control. Fortunately, black rot of oranges and grapefruit is not usually important on the market unless the fruits have been held in prolonged storage. Disease development is greatly reduced under refrigeration. The fungus develops rather slowly at temperatures below 50° F., but some growth occurs even at 32° in oranges and grapefruit after 8 to 10 weeks.

(See *17, 48, 57, 59, 76, 90, 100, 110, 129, 131, 136, 147, 201, 208, 209, 255, 256, 257, 258.*)

Anthracnose

Colletotrichum gloeosporioides (Penz.) Sacc.[2]

Occurrence, symptoms, and effects

Anthracnose attacks all citrus fruits on the tree, in the packinghouse, and on the market as well as in storage. It is a serious disease of tangerines, tangerine hybrids, and certain other mandarin fruits in Florida that are harvested early in the fall when long periods of ethylene degreening are required. The decay on these degreened fruits may start at the stem end or on the side of the fruit. It develops rapidly and may involve the whole fruit. The decay is silvery-gray at first, changing to a leathery brown (pl. 1, *G*). On round oranges, grapefruit, and lemons, it is usually of minor importance. It occurs in fruit from weak, unhealthy trees, in overripe or slightly damaged fruit, and in fruit that has been stored for long periods of time.

Affected fruits may have one or more brown-to-black spots ranging up to a half-inch or more in diameter (pl. 1, *F*). These spots start as bruised or otherwise injured areas, which are invaded by the causal fungus. The spores at first are a pink mass that can be observed with the naked eye or hand lens. After exposure to the air they discolor and appear as brown-to-black spots. The affected area originally involves only the rind. It is sunken, with a definite line of demarcation between healthy and diseased tissues. Anthracnose, in the advanced stages, penetrates deeply into the flesh and develops into an actual rot. If it occurs at the stem end of the fruit, the affected area is firmer and drier than stem-end rot, and the core region is gray-to-black, fading through pink to the normal color. Blackening of the segment wall is less pronounced than with alternaria black rot.

Anthracnose is attributed to infection by the fungus *Colletotrichum gloeosporioides*. Other species of *Colletotrichum* associated with field diseases of citrus trees may be involved under certain

[2] Perfect stage, *Glomerella cingulata* (Ston.) Spauld.. et Schrenk.

conditions. The fungus is a secondary invader. Injury to twigs and young growth by drought, freeze damage, poor soil conditions, and other factors weaken the trees. In the resulting dead growth the fungus lives, grows, and carries over from one year to the next. From this source the spores are spread to the fruit by winds, rain, and insects. The fungus gains entrance to the fruit at pits, mechanical injuries, or dead buttons. Except in mandarin-type fruits that have been subjected to long periods of ethylene degreening, the disease rarely develops until the fruit is quite ripe.

Control measures

Control of anthracnose depends on harvesting the fruit at prime maturity. This avoids the necessity for prolonged degreening of immature fruit and eliminates the overripe fruit which is more subject to decay than fruit of prime maturity. Control depends also on careful handling, the shipping of strong, first-quality fruit, and the avoidance of unduly long storage. Temperatures below 50° F. would prevent development of the rot during the usual transit period. Pruning and the use of good cultural practices maintain the trees in good healthy condition and reduce the excessive accumulation of dead twigs that may harbor the fungus. Presently approved fungicides are not effective in eliminating anthracnose in fruit that has been mishandled and made susceptible to decay.

(See *76, 136, 147, 201, 206, 208, 209, 246, 251, 279.*)

Armored Scale Injury

Several scale insects are pests to citrus trees. They infest the leaves, twigs, trunks, and fruit. They may cause serious damage to the trees and degrade the fruit for fresh market. The insect injures the fruit directly by feeding. On nearly ripe fruit, scale injury has a tendency to delay degreening (pl. 5, *B*) or to prevent uniform distribution of carotenoid pigments in peel of highly colored fruits (pl. 5, *C*). The scales are so firmly attached to the fruit that they are removed only with great difficulty by the washer brushes in the packinghouse. As a result, scales are very often seen on fruit at the market.

The armored scales are characterized by a waxy shell, which is secreted by the insect but is not actually a part of it. This shell, which is enlarged as the insect grows, is what is seen on casual inspection.

The scales most frequently observed on the fruit include California red scale, *Aonidiella aurantii* (Maskell); chaff scale, *Parlatoria pergandii* (Comstock); Florida red scale, *Chrysomphalus anonidum* (L.); Glover scale, *Lepidosaphes gloverii* (Packard); purple scale, *Lepidosaphes beckii* (Newman); yellow scale, *Aonidiella citrina* (Coquillett); and others. These scale insects can be controlled by an approved spray schedule in the orchard.

(See *4, 31, 62, 88, 147, 201, 208.*)

Aspergillus Rot

Aspergillus niger v. Tiegh., *Aspergillus* spp.

Aspergillus rot is of minor importance. It is not often seen except on fruit held at high temperatures. This decay is caused by several species of the fungus *Aspergillus*, the most common being *A. niger*. It has been reported on fruit from most citrus-producing areas.

The rot is at first light-colored, watersoaked, very soft, and easily punctured by light pressure with a finger. The rotted area becomes sunken and darker. Later it is profusely covered with masses of black spores (pl. 1, *H*).

The decay appears to spread between fruit by contact at medium to fairly high temperatures. On citrus fruit held at high temperatures and infected with a mixture of decay organisms, *A. niger* usually overgrows the other organisms on oranges, and *Geotrichum candidum* (sour-rot fungus) predominates on lemons (p. 37).

Aspergillus rot is prevented by holding fruit at recommended temperatures and by many of the same methods used for control of blue and green molds. (See control of blue and green molds, p. 11.)

(See *13, 136, 194, 208, 231.*)

Black Pit

Pseudomonas syringae van Hall

Black pit of citrus fruit has been found in nearly all citrus-growing regions except Florida, Brazil, and tropical areas with high temperatures. In the United States, it is more common in central and northern California than in other areas, but even there, it is a serious problem only 2 or 3 years in a decade. Black pit is rarely found in the market, because diseased fruit are easily recognized and removed in the packinghouse.

Pseudomonas syringae, the bacterium causing black pit, is distributed widely. It also causes citrus blast, a disease of citrus leaves and twigs, as well as diseases of many other plants. Lemon fruit is particularly susceptible to damage by this bacterium, but orange and grapefruit trees are more often attacked on twigs and leaves (citrus blast).

Black pit appears as brown to black-colored, sunken rind spots or lesions ¼ to ½ inch in diameter, which penetrate the oil-bearing and inner white layers of the peel. The spots may consist of many small pits or specks. Black pit lesions may enlarge in storage (pl. 3, *H*).

Since cool and moist weather favors development of the bacterium, most damage occurs in winter or early spring after heavy rains. The organism enters fruit at thorn pricks or other injuries caused by wind or hail. This disease is of minor importance. Preventive measures are not ordinarily considered necessary.

(See *27, 75, 76, 77, 136, 146, 166, 203, 204, 208, 209, 240, 241, 242, 261.*)

Blue-Mold and Green-Mold Rots

Penicillium italicum Wehmer and *P. digitatum* Sacc.

Occurrence, symptoms, and effects

Blue-mold rot, caused by *Penicillium italicum,* and green-mold rot, caused by *P. digitatum,* are also known as penicillium rots. They are probably the most common of all the postharvest diseases affecting citrus fruit. They occur in all parts of the world where citrus is grown. They may attack the fruit on the tree, in the packinghouse, in transit, in storage, and on the market. Green-mold rot is more prevalent and important than blue-mold rot. It sometimes accounts for up to 90 percent of decay in transit, in storage, and on the market. Blue-mold rot on fruit is more common in storage than in transit.

In an early stage both diseases appear as soft, watery, slightly discolored spots about ¼ to ½ inch in diameter. This stage is called "pinhole rot." If the temperature is favorable, the spots enlarge to 1½ to 2 inches in diameter within 24 to 36 hours. They are then sometimes known as "blister rot." Soon after this stage is reached, a white mold begins to grow on the rind surface, starting from the center of the blistered area. When this mold colony has grown to an area of ½ to 1 inch, it starts producing spores. At room temperature blue mold grows more slowly than green mold and produces fewer spores.

In green-mold rot the sporulating part of the fungus growth has an olive-green color, usually surrounded by a broad zone of white mycelium, ahead of which is an indefinite watery band of softened rind (pl. 2, *A*). In blue-mold rot the sporulating area is blue, surrounded by only a small band of white mycelium at the outer edge (pl. 2, *B*), and there is a definite band of water-soaked rind just ahead of the mycelium. Blue mold sporulates on the surface and also in the flesh, sometimes reaching the center of the fruit. Green mold sporulates predominantly on the surface. If fruit wrappers are used, they adhere closely to fruits rotted by green mold but not to those rotted by blue mold. Under dry conditions, the molded fruit may shrink and become mummified. Under moist conditions, other organisms such as secondary fungi and yeasts enter the fruit and reduce it to a wet, soft mass.

Further losses are caused when healthy fruit is soiled by mold spores from the rotting fruit and must be repacked.

The green-mold fungus produces ethylene, a gas which increases fruit respiration, hastens rind coloring, and accelerates button (stem-end) loss of healthy fruit. This ethylene production reduces the storage life of healthy fruit in the same container or even the same room with fruit infected with green mold, since only small amounts of ethylene are necessary to stimulate these processes.

Causal factors

Most of the damage from these rots shows up after the fruit leaves the producing region, but it seems to be correlated with weather at time of harvesting and packing. Fruit picked and handled during wet, humid weather is more prone to decay than fruit harvested under more favorable conditions.

The chief factor that favors the development of these rots is mechanical injury to the rind, since both causal fungi enter readily at such injuries. Skin breaks may result from careless harvesting and packing methods, from rough handling in transit, or from shifting and breakage caused by improper stowage of the load. Blue mold is also able to grow from rotting fruit through the uninjured skin of healthy fruit and for this reason is often called blue-contact mold.

An important factor influencing the development of these rots is temperature. Both molds grow best around 75° F. and are slowed by lower temperatures. Storage at 59° delays development of the decay about 5 or 6 days. Storage at 50° adds a further 5 or 6 days to the salable life of the fruit. At 40° to 45° the development of both molds is practically negligible during the ordinary handling period for citrus fruit. In overseas shipments or in extended storage, both molds will eventually rot fruit held at this temperature range. Blue mold develops slowly at low temperatures that more completely inhibit green mold. Low temperatures of 32° to 34° usually hold these rots in check during short storage periods, but these temperatures may cause rind pitting or internal physiological injury to fruit and should not be used unless specifically recommended.

Control measures

The control of blue-mold and green-mold rots depends most of all upon careful handling throughout the harvesting, packing, and marketing processes. The fruit should be kept as free as possible from skin breaks and bruises through which infection can take place.

It is important to reduce the source of contamination. There is a definite correlation between the number of rotting fruit and the number of spores present on the fruit, in the air, and on equipment. Sanitation of field boxes and packinghouses is very important. Where possible, fruit arriving in a packinghouse should be unloaded and cleaned in a separate area to reduce contamination in the processing, packing, and storage areas. Field and storage boxes are often treated with formaldehyde, other disinfecting solutions, or live steam. Packinghouses are fumigated with chlorine gas, or all surfaces are thoroughly covered with atomized pine-oil emulsions, formaldehyde, or other disinfectants.

Preharvest sprays of fruit in the orchard have not been effective in reducing postharvest decay, probably because the vast majority of rind injuries occur during harvesting or packinghouse handling.

Fruit, especially lemons, should be cleaned and then treated in a hot (110° to 120° F.) antiseptic solution as soon as practical after arrival at the packinghouse. Heat or fungicides kill spores on the fruit and eradicate many of the infections that are just getting started in rind injuries received during picking. The rind injuries may absorb or take up enough fungicide to inhibit infection by fungus spores picked up during later processing and packing. To avoid liberating oil from the rind and causing green-spotting and decay, it is often necessary to hold fruit at the packinghouse for 24 to 72 hours before washing or to reduce the temperature of the wash solution. Holding fruit too long allows the fungi in wounds to grow more deeply into the rind, where fungicides or heat will not eradicate them. Too early treatment of turgid or sensitive fruit may release oil or damage the rind, creating sites for future infections.

Fungicidal wash treatments now used commercially include soap solutions, borax, or mixtures of borax and boric acid or borax and pentabor, soda ash, thiabendazole (TBZ), and sodium *o*-phenylphenate (SOPP). Sodium *o*-phenylphenate has also been used with detergents as a foam or lather brushed onto the fruit. Fungicide wash treatments are more effective when used hot. Temperatures of 90° to 120° F. are used, depending on the susceptibility to injury of different lots or varieties of fruit.

Detection of early infections, in the pinhole or blister rot stages, is greatly aided by using black (ultraviolet) lamps, under which the lesions are easily visible.

During storage and transport, other supplementary aids or precautions help reduce fruit decay. Volatile, in-package fungistats such as biphenyl, or ammonia-emitting chemicals, or nitrogen trichloride-forming chemicals impregnated in paper sheets, will retard fungus growth and help prevent spread of decay. Nitrogen trichloride gas has been used to fumigate fruit in storage or in closed refrigerator cars after loading. Biphenyl-impregnated kraft paper sheets inserted in the citrus cartons during packing are commonly used and, in combination with proper refrigeration, effectively retard development and spore production of green-mold and blue-mold rots.

Refrigeration of fruit at 40° to 45° F. almost completely retards growth of most decay fungi. Penicillium green and blue molds, however, will grow very slowly below 40°. Holding fruit under proper refrigerated conditions is very necessary in delaying mold development. When fruit are returned to warm conditions, molds resume growth, and infected fruit will decay.

(See *20, 21, 22, 23, 36, 48, 76, 78, 95, 97, 98, 99, 108, 113, 115, 120, 132, 136, 147, 150, 151, 156, 161, 174, 201, 202, 206, 207, 208, 209, 228, 229, 230, 246, 247, 248, 250, 263, 282, 284*.)

Botrytis, or Gray-Mold, Rot

Botrytis cinerea Pers. ex Fr.

Occurrence, symptoms, and effects

Botrytis rot caused by the fungus *Botrytis cinerea* has been reported from most of the citrus regions of the world. It is primarily a storage, transit, and market disease, but it may occur to some extent in orchards. It is most common on lemons, then oranges, but it may decay other kinds of citrus fruit.

The early stage of the decay may closely resemble sclerotinia or cottony rot, but distinguishing characteristics soon become evident. In the early stages of botrytis rot the decaying tissues are firm, but later they become leathery and pliable. The affected surface of a lemon becomes drab or cinnamon brown and later may turn buff or dark brown, darker than cottony rot. The color of the affected surface of an orange is medium to dark yellowish-brown. The mycelium that develops in moist air is white but includes a mass of gray spores (pl. 2, *C*). The gray, granular-appearing spore tufts are characteristic. The rind, core, and membranes are invaded by the fungus faster than the pulp is.

Causal factors

The fungus causing botrytis rot lives on decaying leaves, twigs, fruit, and organic matter in the soil. Spores are spread by rain, wind, and insects. Decay generally starts at the button, on the cut stem, or at injuries. Also, the fungus can grow from bits of organic matter and penetrate through uninjured rind. Citrus fruits stored at 60° to 70° F. may become entirely rotted in 2 weeks or less. *B. cinerea* can grow at very low temperatures, and even at 32° F., decay develops slowly.

Control

Control measures are similar to those for brown rot. Briefly, they are (1) avoid leaving picking boxes for very long on the ground in moist weather, (2) prevent injuries to fruit, (3) keep fruit from contact with organic matter and trash, (4) wash the fruit at 115° to 120° F., (5) avoid excessive humidity in storage rooms, (6) inspect fruit in long storage frequently to remove decayed fruit, and (7) refrigerate fruit to prevent rapid decay.

(See *26, 76, 136, 137, 208, 209, 231.*)

Brown Rot

Phytophthora citrophthora (R. E. Sm. et E. H. Sm.) Leonian, *P. parasitica* Dast., *P. syringae* (Kleb.) Kleb., *P. hibernalis* Carne, and other *Phytophthora* species

Occurrence, symptoms, and effects

Brown rot occurs on citrus fruit in orchards, packinghouses, storage, and transit. The disease, caused by any of several phytophthora species, is found in all principal citrus-growing areas of the world. The rot attacks all citrus varieties but is most important on lemons. Mature fruit is attacked more frequently than green fruit.

Decay produced by brown rot is remarkably firm and leathery. Affected areas do not soften rapidly, despite their soft appearance. The first symptom of the disease is a slight olive-drab or brownish-tan rind discoloration. Later this rind discoloration may appear dark greenish-brown (pl. 2, *D* and *E*). The affected areas remain flush with the level of the surrounding unaffected rind. The juice of lemon is too acid for this fungus, so in lemons the mold usually grows only in the rind, core, and tissues between the segments. Usually there is no evidence of mold on the fruit surface, but under very humid conditions a delicate, white fungus growth will appear. Brown rot can infect other fruit by contact, and thus spread in stored or packed fruit. The disease can be identified by a rather penetrating, aromatic, rancid, or fermented odor. Some other forms of decay leave the fruit somewhat firm, but only the phytophthora brown rots have this distinctive odor. In later stages, after secondary decay organisms have invaded fruit affected with brown rot, decomposition is rapid and the tissues are soft.

Causal factors

The phytophthora fungi causing brown rot are common in soil. Most infections occur within 3 to 4 feet of the ground, as a result of the splashing of the motile swimming spores onto the lower leaves and fruit during rains. Winds during or immediately after rains or moist periods can carry spores high into the trees and cause infections 20 or 30 feet from the ground. For the fungus to cause infection, the fruit must be wet for a relatively long and uninterrupted period. Evaporation of moisture from fruit before the fungus spores germinate and penetrate the rind will stop the infection process. Rain is not the only cause for moisture on fruit, and any moisture which remains for long periods provides conditions ideal for infection.

In the orchard, the infected fruit rots and eventually drops from the tree. If fruit is harvested during the 3- to 10-day period between infection and appearance of rot symptoms, infected fruit are carried into the packinghouse and processed. During storage or transit the disease develops and can be spread from infected fruit to adjacent healthy fruit.

Control measures

Control of brown rot should be carried out in the orchard, as well as in the packinghouse. Ideally this disease ought to be prevented in the orchard. This can be partly achieved by applying fungicidal sprays before or just after rainy or moist periods. Pruning and cultural practices should be used to reduce chances that spores from the soil will splash onto fruit. Picked fruit should not be placed on the soil, nor should boxes of fruit be left on the soil during rainy or foggy periods.

In California, the immersion of fruit for 2 to 4 minutes in wash solutions at 115° to 120° F. has been effective in eradicating infections, provided the period from infection to treatment is short and the fungus is still confined to the external layers of the fruit rind where heat will penetrate rapidly. The rate of growth of the fungus into the fruit depends chiefly on fruit temperature, but also on fruit maturity. Picked fruit should be delivered to the packinghouse promptly and given the hot-water treatment as soon as possible. However, turgid fruit picked in cool or humid weather can be severely injured if immersed immediately in hot wash solutions. Heat-injured fruit is susceptible to decay by other rot organisms. A strong soap added to the wash solution helps emulsify rind oil and reduce injury. Lemons are usually more sensitive to heat injury than are oranges. If possible, lemons should be held from 1 to 4 days at the packinghouse until wilted sufficiently to tolerate the heat treatment. If holding is not practical, then a lower temperature should be used for the wash solution. However, the longer the infected fruit is held before treatment, the deeper the fungus penetrates into the fruit. Cooler wash solutions are not as effective in killing the fungus as are the 115° to 120° treatments. Hot water alone is as effective for brown-rot control as are hot fungicidal solutions, since only heat can penetrate the rind and reach the fungus. Cold fungicidal solutions cannot eradicate established infections, but they will kill fungus spores accumulating in the wash solution and thereby prevent them from infecting healthy fruit. Soda ash and sodium *o*-phenylphenate (SOPP) are fungicides often used in the hot wash solutions to control blue and green molds and other decay fungi.

Volatile chemicals often used during transit have not proved effective against the brown-rot fungi. Fruit should be stored and shipped refrigerated (below 50° F.), since most brown-rot phytophthora species grow slowly or not at all at cool temperatures.

(See *58, 74, 76, 132, 133, 134, 135, 136, 139, 140, 141, 142, 144, 145, 147, 182, 183, 201, 208, 209, 267.*)

Chewing-Insect Injury

When citrus fruits are young, they are sometimes attacked by grasshoppers, katydids, and other voracious chewing insects, which eat away the rind over areas of varying size on any part of the fruit. Some of the injuries are probably so severe that they cause the fruit to drop. Others heal over, producing a roughly circular or oblong scar, which on mature fruit may be an inch or so in diameter. The edges are sharply sunken below the level of the rest of the rind (pl. 5, *A*). These scars are smooth and have the same color as the rest of the fruit, but they are devoid of the oil glands characteristic of the rind. All citrus fruits may be affected, but the injury is more common on oranges and grapefruit than on other fruits. Scars on the mature fruits do not act as avenues for decay fungi.

This type of injury is best prevented by cultural practices and spraying in the orchard to control the insects that cause the damage.

(See *62, 201, 208.*)

Chilling Injury

Chilling may injure citrus fruits stored at low temperatures but above the actual freezing point of the fruit. Lemons, limes, and grapefruit are most susceptible to injury caused by chilling. Oranges are least apt to be damaged. Tangerines, tangelos, and other mandarin-type fruits are intermediate.

Symptoms of chilling injury are quite varied. They may be external in the form of pitting, brown staining, oil-gland darkening, diffuse rind breakdown (scald), or albedo browning. Watery breakdown involves the whole fruit, while membranous stain of lemons affects only the segment walls and core. The susceptibility to chilling injury is very unpredictable. Considerable variation in type and severity of injury occurs from year to year with fruit from the same orchard. Occasionally more than one type of chilling injury may develop on the same fruit. These symptoms may develop after 2 weeks or longer at unfavorable temperatures.

Albedo Browning

Albedo browning, which affects only lemons, is a discoloration of the white, spongy inner tissues of the rind. The disease may show externally as a slight, pebbly, brown-to-gray darkening of the rind where the discolored albedo shows through the surface layer. It tends to develop on fruit in storage at low temperatures (32° F.) and with poor ventilation, especially fruit that was harvested at an immature or dark-green stage (pl. 7, *H*).

Brown Staining

Brown staining may affect most citrus fruits, although grapefruit and mandarins are most susceptible. It is a diffuse, irregular, tan-to-brown superficial discoloration of the peel (pl. 8, *B*). It may involve a small area or the whole surface of the fruit. It is usually observed on fruit stored at 32° to 34° F. When the fruit is removed to room temperature, the discoloration usually fades or disappears completely after several days. In severe cases, pitting or collapse of surface tissues may accompany the discoloration (pl. 7, *F*).

Membranous Stain

Membranous stain, or membranosis of lemons, is characterized by a browning or darkening of the membranes or carpellary walls between the segments. The core tissues and the inner tissues of the rind also may be affected. The disorder can be detected only when the lemons are cut. It can be seen best when the segments are pulled apart for a longitudinal view (pl. 8, *C*).

This disorder is more prevalent in fruit picked in cool, damp weather. It is extremely responsive to storage temperature. Lemons held at 40° F. become seriously affected, whereas those held at either 32° or 60° seldom develop sufficient stain to be seriously damaged.

Oil-Gland Darkening

Darkening of the oil glands has been observed in grapefruit and tangelos subjected to chilling temperatures (pl. 8, *A*). This prominent discoloration of the oil glands gives a polka-dot appearance to all or part of the surface of the fruit. In severe cases or with fruit left for longer periods in storage, the space between the oil glands also becomes discolored and may collapse, giving a scalded or heat-damaged appearance to the rind. Internally, severely affected fruit may become soft and disorganized as with watery breakdown.

Pitting

(See Storage Pitting, page 32.)

Watery Breakdown

Citrus fruits affected with watery breakdown are soft and spongy and have a soaked appearance resembling that of fruit that has been frozen. The flesh as well as the rind may be softened. Within the affected fruit, the carpels are loosely attached to the inner part of the rind. When a section of the rind is pressed, a watery substance oozes freely from the albedo.

Watery breakdown is a low-temperature disease found most often in fruit stored at temperatures below 40° F. However, even at 32° it does not develop until after several weeks of storage. Affected fruits have a disagreeable odor of fermentation that is particularly noticeable when they warm up after removal from storage. Watery breakdown may occur without other symptoms of chilling, or it may follow such symptoms as brown staining and oil-gland browning. The water-logged tissues usually do not contain decay organisms in the initial stages, but they may later become infected with *Penicillium*, *Geotrichum*, and other fungi.

Control of Chilling Injuries

Chilling injuries obviously can be prevented largely by using temperatures at which injury does not occur. However, in actual practice it is not this simple, since decay increases at higher storage temperatures. A compromise must be made, with all factors considered, in determining the best storage temperature. The same variety of citrus grown under different climatic conditions may well have different storage temperature requirements. Generally, California and Arizona fruit are more susceptible to low-temperature disorders than those of the same variety grown in Florida and Texas.

There appears to be no shortcut for successful long storage of citrus. Fruit must be harvested at proper maturity, handled carefully, given proper fungicidal and wax treatments, and stored promptly at recommended temperatures (table 1) and 87 to 92 percent relative humidity to prevent drying out.

(See *33, 76, 136, 157, 208, 273.*)

TABLE 1.—*Recommendations for storage of citrus fruits*

[Relative humidity 87 to 92 percent]

Variety	Production area	Storage temperature	Length of storage period
		° *F.*	*Weeks*
Dancy tangerines	Florida	38–40	2–4
Tangelos	Florida	38–40	4
Temple oranges	Florida	38–40	4
Murcott Honey oranges	Florida	32–34	6–8
Valencia oranges	Florida	32–34	8–12
Do	Texas	32–34	8–12
Do	California	40–44	4–6
Navel oranges	California	40–44	4–6
Grapefruit	Florida	50	4–6
Do	Texas	50	4–6
Do	California	58–60	4–6
Do	Arizona	58–60	4–6
Limes	Florida	48–50	6–8
Lemons	California	58–60	12–24

Citrus Rust Mite Russeting

Phyllocoptruta oleivora (Ashmead)

Occurrence, symptoms, and effects

The citrus rust mite and the russeting it causes occur in the Gulf States, the West Indies, and to a much lesser extent in California and Arizona. Although the mite may attack all commercial varieties of citrus, most of the damage is done on grapefruit and oranges.

Rust mites injure both leaves and fruit; but the injury to the fruit is most important. The injuries differ with the variety of fruit and the time and intensity of the mite infestation. Early-season injury to grapefruit, lemons, and limes appears as silvering of the peel and, if severe, is known as "sharkskin." Early-season injury to oranges causes a brown scarring and cracking of all or part of the fruit surface (pl. 5, *D*). Severe early injury of citrus fruits may result in small-sized fruits. Early-infested fruits will not take a sheen when waxed and polished.

Injury during late summer and fall is a smooth brown staining of the fruit, which permits a high polish (pl. 5, *E*). On grapefruit it is called "bronzing." In some markets bronzed fruits bring premium prices because they are thought to be sweeter than uninjured fruit. Injured oranges may show a smooth purplish staining, otherwise similar to grapefruit injury. Summer injury may be somewhat intermediate between the early and late injury described above. Some fruits develop a streaking or a tearstain effect down the sides. Tearstain caused by rust mite is smooth and diffuse in contrast to melanose tearstain; the latter is a series of raised spots that are darker in color and have a sandpapery feel.

Russeted fruit is less attractive in appearance than bright fruit. The injury to the skin, whether early or late, does not render the fruit more liable to decay than unblemished fruit, but does cause it to lose water and shrivel rather rapidly under ordinary storage conditions. For this reason, russeted fruit should not be stored longer than is required for orderly marketing.

Causal factors

The citrus rust mite (*P. oleivora* (Ashmead)) is a light-yellow, wedge-shaped arachnid about 1/200-inch long. It injures fruit by sucking the juice from the skin. Mites are not likely to be found on fruit that has gone through washing and polishing in the packinghouse, but the evidence of their prior presence, of course, remains. Fungi have been reported to be associated with rust mites in causing the russet symptoms by secondary invasion; however, this has not been fully substantiated. Other mites have been reported to cause injury to fruit, but they are not generally associated with the russeting described above.

Control measures

The most effective means of preventing russeting is to control the rust mite population by dusting or spraying with recommended miticides.

(See *4, 31, 62, 76, 80, 88, 136, 147, 201, 208, 279.*)

Cottony Rot

Sclerotinia sclerotiorum (Lib.) dBy.

Cottony rot, caused by the fungus *Sclerotinia sclerotiorum,* is widely distributed in many of the citrus-growing regions of the world. It is found chiefly in lemons, but it may affect other citrus fruits.

Affected fruit softens slowly, but the skin is at first leathery and pliable. In a dry atmosphere, the color of decayed areas on mature fruit becomes yellowish-brown or greenish-brown. In a moist atmosphere, the fruit is rapidly covered with a white, cottony growth of mycelium that is the outstanding distinguishing characteristic of this decay (pl. 2, *F* and *G*). Black, irregularly shaped sclerotial bodies 1/16 to 1/2 inch long later develop in the fungus mat.

Cottony rot is a rapidly spreading contact decay that may attack either green or mature fruit. Although it is not common, it may cause heavy losses in the packinghouse or in storage. Moderate temperatures, high humidity, and stagnant air favor its development. However, the causal fungus is able to grow to some extent even at temperatures close to freezing and hence may cause damage in transit and storage at the temperatures ordinarily provided. Careful handling, packinghouse and field sanitation, and washing the fruit in hot water as for brown rot, are recommended preventives.

(See *75, 76, 136, 208.*)

Creasing

Creasing is a condition found in mature and overripe oranges and mandarin-type citrus fruits. It is characterized by narrow sunken furrows or irregular grooves in the rind, usually less than 1/4 inch wide and from 1/2 to 2 inches long (pl. 4, *G*). The sunken creases are due to weakness or uneven thickness of the albedo, the underlying white spongy part of the rind. If a thin paring is made, or if the peel is completely removed, it can be seen that the albedo is thin or there is a void in the albedo beneath the creased area (pl. 4, *H*). These creases may extend both longitudinally and crosswise and in severe cases may run together to produce large areas of uneven rind. In small narrow creases, the color of the sunken skin is normal, but in larger ones it may be yellowish green to gray. When fruit is subjected to hot solutions, such as used in the "color-add" treatment, creases become more apparent, the sunken rind often becoming water-soaked or split.

Mild creasing of California oranges is not considered a serious defect because the rind is pliable, and few of the fruits split open from pressure during packing and shipping. Florida fruit, however, has a thinner and more brittle rind, so that creased areas split more easily. The cause of creasing is not known, but it may be associated with potash and phosphorus nutrition of the trees.

Creasing does not increase after harvest, but creases in fruit that has been subjected to hot solutions or pressure due to tight packing and high stacking of containers may split during transit and subsequent handling and open the way for blue-mold and green-mold rots.

(See *136, 201, 208.*)

Endoxerosis (Internal Decline)

Occurrence, symptoms, and effects

The term "endoxerosis," meaning "internal drying," is used to describe a physiological abnormality of lemons. Several names, especially "internal decline," but also "tip deterioration," "yellow tip," "pink tip," "dry tip," and "blossom-end decline," have been used by growers, packers, and shippers for this condition.

Endoxerosis has been recognized by lemon growers in California for at least 70 or 80 years. It is more prevalent in the drier, warmer interior valleys than in the more humid, cooler districts near the coast. All varieties are susceptible. In California it usually appears first about May or June, develops to its maximum in the dry summer, and extends into early autumn. It has been reported from Sicily, Australia, and Israel also, but the symptoms described differ somewhat from those in California, probably due to differences in varieties and environment.

The disorder is characterized by the destruction of internal tissues, especially at the stylar end of the lemon. Cells collapse and may disappear entirely, leaving cavities in the peel at the stylar end. Affected tissues become pinkish or brownish in color. As the disease progresses, an exudate or gummy substance, at first colorless but later pinkish or straw-brown in color, is deposited in or next to the peel near the cavities. The gum formation starts in the stylar end, but as the disorder becomes more severe it advances through the core into the basal end and even into the buttons. Such advanced cases are not often seen on the market, since severely affected fruit has a tendency to float in water, with the stylar end up. This, along with external symptoms, allows most seriously endoxerotic fruit to be culled out at the packinghouse.

External symptoms of this disease are vague and difficult to detect. On green fruit the disease may be indicated by a loss of luster or the development of a yellow color at the stylar end while the rest of the surface is still a normal green. On either silver or yellow fruit, it is difficult to detect endoxerosis by external symptoms, especially in mild cases. Sometimes there is a more intense color of the rind at the stylar end, and a collapse of the tissues at the base of the nipple may cause it to bend over.

Causal factors

The principal cause of this disorder is believed to be related to water conditions within the tree and the fruit, which in turn are influenced by the moisture supply, temperature of air and soil, and growth conditions for the tree. Decay organisms are not responsible for endoxerosis, but endoxerosis is frequently confused with alternaria rot, which sometimes accompanies or follows it. Endoxerosis develops only while lemons are on the tree. It will neither start nor progress in fruit once it is harvested.

Control measures

In the orchard endoxerosis can be partly prevented by keeping water conditions as favorable as possible for tree health. It also helps if lemons are picked while green and are not allowed to become too old or tree ripe. In the packinghouse, affected fruits are usually recognized in the wash tank or on the inspection line and removed.

(See *18, 33, 76, 136, 208.*)

Exanthema (Ammoniation)

Occurrence, symptoms, and effects

Exanthema is a nonparasitic, nutritional disease of the fruit, leaves, and twigs of all commercial citrus. It occurs in practically all the citrus-growing regions of the world. In the United States it is more common in Florida, especially on oranges and grapefruit. It is less prevalent now than in past years, due to routine application of minor elements, including copper. It is seldom seen in commercially packed fruit.

The distinguishing characteristics of the disease are dark-brown, glossy spots on the rind of the fruit (pl. 4, *F*), which may be of various sizes and shapes. Gum pockets may sometimes be found in the albedo of thickskinned fruit when no symptoms appear on the surface. The surface spots or scars may be pimple-like and reddish-brown, coalescing to form large roughened areas on the fruit, or they may be smooth and flat, or concave and rough. In many instances the rind is hard and stiff. This causes cracks as the fruit grows or when the affected areas dry out more rapidly after harvest than the sound areas. These cracked and split fruit are likely to decay after secondary invasion by *Penicillium digitatum* or stem-end rot fungi. Gum may also form in the angles of the segments of the fruit along the central axis or core. The pimple stage of exanthema on the fruit is sometimes mistaken for melanose. The two can be distinguished by the fact that exanthema originates in tissues beneath the epidermis and thus seems to come up through the epidermis, while melanose is on the surface of the rind.

Causal factors

Exanthema is caused by a deficiency of copper. The disease is most common on trees with poor drainage, where the soil is underlain by hardpan, or where the moisture supply is irregular. The trouble may be aggravated or become more pronounced just after high nitrogen and phosphorus fertilization. These factors, however, are not directly responsible for exanthema and are important only when copper is deficient.

Control measures

Exanthema is effectively controlled by orchard application of copper sprays for the control of scab or melanose, by soil application of copper sulfate, or by supplemental nutritional minor-element sprays. Since copper may also cause toxicity to citrus trees, it should be applied in only trace amounts.

(See *4, 28, 76, 130, 136, 145, 147, 201, 206, 208, 244.*)

Freeze Damage

Citrus fruits will freeze and subsequently show freeze damage at temperatures ranging from 25° to 30° F. and averaging about 27.5° F. In general, tangerines, lemons, and limes freeze at the higher limits of this range, oranges are at the lower end, and grapefruit and hybrid fruits are intermediate. However, considerable variation occurs between varieties and sources within varieties, so that all citrus fruits are likely to show freezing injury when subjected to temperatures below 30° for sufficient time. The flesh of the fruit freezes at a slightly higher temperature than the rind of the same fruit.

Postharvest Freezing

Freezing injury in transit is more likely to occur in the fruit next to the side walls and along the floor of the car or van, or near the air delivery, than in fruit in the body of the load. Freezing damage in oranges is best identified by cutting off both ends of the fruit, then cutting through the rind of the central part remaining, and pulling the segments apart. If the fruit has been frozen, the membrane between the segments will look soaked and usually will contain a number of white specks, which are hesperidin crystals (naringin in grapefruit) resulting from the freezing (pl. 7, *A*). In tangerines, the hesperidin crystals occur in the pulp as well as on the segment walls and are, therefore, evident in cross section. If the freezing has been severe, the rind may show effects ranging from a typical brown stain to gray discolored areas of varying size. The affected rind tissues may or may not be sunken. When severely frozen they usually become soft and mushy and are underlain by mushy pulp. Lemons and grapefruit show damage in cross section much more plainly than oranges, although it is desirable at times to pull grapefruit sections apart for viewing as recommended for oranges. If lemons have been seriously damaged, the pulp becomes mushy immediately after thawing.

Grapefruit shows, in addition to the symptoms described above, a milky appearance of the pulp, which is in marked contrast to the very light amber color and almost transparent look of the unfrozen pulp. The contrast is especially noticeable in fruits that have been frozen on only one side.

A positive diagnosis of fruit frozen in transit or storage must depend on a consideration of the history of the fruit and the conditions under which the injury is found.

Freezing on the Tree

Citrus fruit frozen on the tree shows a number of the symptoms described under postharvest freezing, if examined soon after the freezing occurs. After a few days, however, additional symptoms appear. First and most characteristic among these is a buckling of the partition walls at the stem end of the fruit, with or without drying of the pulp (pl. 7, *B* and *C*). Small pits or pitted areas may also develop in the rind on any part of the fruit. In fruit on the market, picked several days after it had been frozen on the tree, the injury is shown by woodiness of the pulp or by open spaces between the segments after the collapse and drying out of some of the juice sacs. Cavities usually appear in the orange pulp before open spaces develop between the segment walls. Later, when the pulp has dried out considerably, small open spaces appear between these segment walls. Sometimes only one or two segments will be dried out, and all or only a part of the segment may be affected. Where only one or two segments are affected, considerable time is required for them to dry an inch or more.

There are, of course, all degrees of dryness, from very slight to total. In the practical handling of citrus fruit, three degrees are recognized: (1) Slightly open, in which the cut surface shows a slight open space between the segment walls and the juice sacs, but the surface of the pulp appears juicy; (2) distinctly open, in which the cut surface shows large open spaces, but the pulp still appears juicy; and (3) dry, in which the cut surface shows no large open spaces, but the fruit seems to have dried out evenly all through, and the color of the pulp shows it to be almost devoid of juice, or when the fruit has dried out and some of the segments have more or less collapsed.

Drying in oranges usually progresses from the stem end. In grapefruit it may proceed from either or both ends, or it may begin around the outside of the pulp. The center of the fruit is not dried except in extreme cases. If an orange that has been frozen is examined a few days after it thaws, it will usually show the hesperidin crystals already mentioned on the membrane or rag that separates the segments of the pulp. Sometimes the crystals can be seen within a few hours after the freezing. Several weeks after freezing, the crystals may not be so numerous or conspicuous, probably because the more severely frozen fruit falls soon after the freeze. Fruit that has remained on the tree for several weeks after freezing has a rind that is thicker than normal, especially over the damaged part of the fruit.

Dryness from freezing differs from dryness of granulation because the juice sacs are collapsed after they have been emptied by disappearance of the juice. In granulation the juice sacs do not collapse but become filled with gelatinous or solid matter.

Fruit frozen on the tree dries out as described above and is consequently lighter in weight. Flotation devices at the packinghouse can be used to separate severely or moderately dried fruit from fruit that is normal or only slightly dried. The internal quality of an orange is still considered U.S. No. 1 if drying does not exceed a depth of 1/4 inch into the flesh from the stem end.

(See *157, 208, 277.*)

Fusarium Brown Rot

Fusarium spp.

Fusarium brown rot is a minor decay of both oranges and lemons. It has been reported from most citrus-producing regions of the world. Since this decay develops slowly, it is more important on fruit that is held in storage for long periods than on fruit held for short periods.

Fusarium rot is similar, in most cases, to the rot produced by either *Colletotrichum* or *Alternaria.* The decay varies from a semipliable form somewhat resembling the later stages of anthracnose rot to almost a soft rot. It may become nearly as soft as the alternaria rot of lemons. Infection usually starts at the stem end, occasionally at the stylar end, and very rarely elsewhere on the mature fruit surface, unless there are wounds. A soft brown spot is formed, and under humid conditions a white surface mycelium appears. The lesions vary somewhat but are generally dark brown in color, leathery, and sunken (pl. 2, *H*). Occasionally the center of the lesion becomes watersoaked and softer than the surrounding area. The fungus grows through the center of the fruit, causing considerable internal breakdown and a generalized, reddish-brown discoloration of the center, which is almost the typical symptom. This fungus is often mixed with other fungi.

Fusarium rot can be caused by several species of *Fusarium.* Low vitality of fruit and any tendency to slight separation of tissue at the navel end of oranges contribute to its development. This decay as a rule is not important enough commercially to require control measures. Storage and shipping at 40° F. suppresses development.

(See *13, 48, 60, 76, 83, 121, 136, 209.*)

Granulation

Occurrence, symptoms, and effects

Granulation is a physiological disorder. It consists of dryness of juice sacs or vesicles of citrus fruits that have not been exposed to freezing temperatures. Other names include "dry end," "crystallization," "Koa Sarn," and "corkiness." A technical name, "sclerocystosis," has been proposed.

Granulation has been reported from all citrus areas in the United States. In California, granulation is primarily a problem of late-season (July to October) Valencia oranges, but early- or midseason fruit also may show it. It is more common in fruit from coastal areas and on frequently watered trees than in fruit from the interior. In Florida, navel and Valencia oranges and mandarin hybrids are most likely to show granulation late in their shipping season.

Affected juice sacs, particularly at the stem end, become comparatively hard and firm by thickening and stiffening of their walls, assume a clear-white or grayish color, and become somewhat enlarged. The condition is not generally evident until the fruit is mature. The name granulation is appropriate because the juice sacs are hard and are easily separated from each other, and because the affected pulp assumes a texture of grains or granules. Finally, a dry, woody, solid condition results. Granulation usually starts in the stem end of the fruit, but in some varieties and in certain areas the condition can appear throughout the pulp. Even in fruits affected only at the stem end, the granulation as seen in cross section affects all of the segments and not merely small spots in two or three segments, as so often happens in freezing injury (pl. 6, *H*).

In tree-frozen fruit the juice sacs collapse, wither, and separate from each other and from the segment walls. The fruit is soft and light in weight. In granulated fruit the juice sacs do not separate from each other or from the segment walls; they remain turgid, the juice being replaced by solid matter that is yellow-to-grayish white. Such fruit feels firm but is light in weight.

Granulation is almost impossible to detect by any external markings. The only reliable diagnosis is made after cutting the fruit. Granulation develops while fruit is on the tree and does not progress materially after harvesting.

Cause and control

Granulation is a growth phenomenon. Rapidly growing and larger fruits that have received nitrogen applications have a greater tendency to granulate than do slower growing, smaller fruits. Some rootstocks, especially rough lemon, tend to induce it more than others. Early picking when possible may avoid some losses from granulation. Preharvest use of 2,4–D delays or reduces severity but does not prevent the disorder.

(See *76, 110, 136, 154, 208.*)

Melanose

Phomopsis citri Fawc.[3]

Melanose occurs in all citrus-growing regions of the United States and elsewhere. It is most prevalent in areas of high humidity and summer rainfall, such as Florida and other Gulf States. It is exclusively a field disease. It lowers the grade of the fruit on the market because it greatly affects the appearance. Leaves, young twigs, and fruits of all *Citrus* plants are affected. Of the commercial citrus fruits, grapefruit is the most susceptible. On the fruit, the disease can be recognized as small, brown, raised spots or pustules, produced when the causal fungus attacks and kills a few epidermal cells of the rind during the early development of the fruit. In these spots the fungus usually dies long before the fruit matures. The individual spots are usually about the size of a pinhead (pl. 4, *A*), although they may coalesce to form rather large scablike patches known as "mudcake" melanose (pl. 4, *B*). It may appear as a tearstain where water from rain or dew previously has run down the side of the fruit carrying spores with it (pl. 4, *C*). Melanose may be distinguished from rust-mite injury by its sandpapery feel and definite pustules rather than the smooth diffuse appearance of the rust-mite injury. Melanose does not spread in storage or transit.

Control measures

In an average season in Florida, the disease is readily controlled by a single copper spray applied 1 to 3 weeks after petal

[3] The perfect stage, *Diaporthe citri* Wolf. *P. citri* also causes a stem-end rot.

fall, since only the very young fruit are susceptible. The removal of dead wood and twigs, the source of the infective spores, is also beneficial.

(See *4, 10, 76, 136, 147, 201, 205, 208, 226, 279, 285, 286, 288.*)

Modified Atmosphere Injury

Controlled levels of oxygen and carbon dioxide in storage (CA storage) may be used to supplement refrigeration to maintain the quality of fruits and vegetables for extended periods. Nitrogen also may be used during transit in rail cars and piggyback containers for the same reason. However, improper modification of the atmosphere often leads to injury and off-flavors in citrus fruits (pl. 6, *F*). Poor air ventilation during long domestic shipments with delayed unloadings or in export shipments may also cause similar injuries.

Oranges seem to be particularly susceptible to injury from low oxygen or a combination of low oxygen and high carbon dioxide. A type of scald may be produced on Florida Valencia oranges stored in 5 percent oxygen. This injury appears as large, dark-brown, abruptly sunken areas, frequently covering more than half the fruit and producing an acorn-like appearance (pl. 6, *E*). If the fruit is held for extended periods in oxygen levels below 5 percent and carbon dioxide levels of 5 percent or higher, the rind will develop a light-brown pebbly appearance around the stem end. An internal watery breakdown may develop, accompanied by a high level of ethyl alcohol and a fermented odor and flavor. Normal-appearing fruit from the same lot will be off-flavored.

Control measures

Only atmospheres recommended for a specific variety, from a specific growing area, should be used, and for the recommended length of time. Avoid mixing varieties or kinds of citrus fruit in the same CA storage or using an atmosphere recommended for other fruits or vegetables. The atmosphere should be carefully monitored during the storage or transit.

In air storage or long transit of citrus fruits, adequate ventilation must be maintained to prevent depletion of oxygen or buildup of carbon dioxide. Vents should be periodically opened and the water drains kept clear to allow for air exchange.

(See *46, 47, 246.*)

Oil Spotting (Oleocellosis)

Rind oil spotting is found on citrus fruit from all producing regions. It is worse and probably most commonly seen on lemons and limes. It is also found on other citrus fruits, especially Marrs Early and navel oranges harvested early in the fall before they have lost their green color (pl. 9, *A*). The most common symptom is irregularly shaped yellow, green, or brown spots in which the oil glands of the skin stand out prominently because of slight sinking of the tissues between them. The yellow spots develop on fully colored mature fruit, and the green spots develop on fruit that was green in color when picked. Brown spots are either a later or older stage of spots that were originally green or of spots that were more severely injured. Spots seen on fruit on the market are usually not more than one-half inch across, but some in orchards and packinghouses are so large that they cover the greater part of the fruit surface. In either the green or the brown stage they become more evident after the fruit has been degreened.

Oil spotting is a form of bruising injury. It is particularly likely to occur on immature citrus fruit if it is handled while wet or turgid. The immediate cause is liberation of oil from ruptured oil glands by mechanical injury. Pressure incident to the picking and handling of green-colored fruit is particularly likely to cause the green spots, and bruises incident to packing degreened fruit cause yellow or brown spots. The severity of the injury depends on the quantity of oil released. Field freezing or insect punctures may also liberate oil and cause spotting (pl. 9, *B*). Fruits with raised, prominent oil vesicles are more likely to show oil spotting than those with less prominent ones.

Control

Oleocellosis is controlled by avoiding the conditions that contribute to the escape of oil from rind. Avoid picking fruit when it is wet with rain or dew or during periods of high humidity (morning hours, or cloudy days). Avoid rough handling that might liberate the oil, especially during the early part of the season. A pressure tester to determine the rind oil rupture pressure (RORP) can be used to determine when the fruit has lost sufficient turgidity to be handled without injury.

(See *40, 72, 76, 127, 136, 143, 186, 201, 208, 264.*)

Pitting

Pitting occurs on all types of citrus fruits but is more prevalent on grapefruit and oranges. It consists of abruptly sunken spots in the rind. It is a physiological breakdown of the rind on the shoulder or cheek of the fruit, in contrast to "aging," a breakdown of the rind at the stem end. The spots are not discolored at first, but later they may become slightly pink-to-tan on grapefruit and eventually brown on both grapefruit and oranges. Pits on oranges are usually less than ¼ inch in diameter, although they may coalesce into larger areas. In Florida, early and midseason oranges are more susceptible to pitting than are the late-ripening varieties of the Valencia type. The Pineapple variety is the most susceptible. Smooth-skinned fruit is more likely to develop pitting than is coarse-skinned fruit. Small-sized fruits are more susceptible than large ones.

Pitting of Freshly Harvested Fruit

Pitting as seen in the field and packinghouse differs markedly from pitting that develops in storage. In the field the pits seen on both oranges and grapefruit are small and rarely coalesce, and the affected areas remain firm. Pits that develop soon after harvest are usually not discolored (pl. 6, *D*), but they may coalesce to form a large area of collapsed rind tissue. Pits on fruit in the field or freshly harvested rarely lead to invasion by decay fungi.

Storage Pitting

Pits on fruit in storage or on the market after storage are usually a symptom of chilling injury, which may occur at temperatures well above the actual freezing point of the fruit. These depressed spots may not be discolored at first, but later they turn tan-to-brown (pl. 7, *E* and *G*). Where they occur singly, they are usually ¼- to ½-inch in diameter. In severe pitting, a large part of the surface may be affected. Softening beneath the pits may lead to invasion by blue-mold, anthracnose, or stem-end rot fungi (pl. 7, *D*). Severely pitted fruit may have an off-flavor even when decay organisms are not involved. Pitting is not usually observed before the fruit has been stored or in transit 2 to 4 weeks. Grapefruit harvested from September to January is more susceptible to pitting than fruit harvested later. Brown staining and other forms of chilling injury may be associated with pitting caused by low storage temperature.

A type of pitting of lemons known as peteca may develop in storage. It is characterized by depressions with rounded edges. The collapse begins in the albedo, and the outer layer of the rind sinks with little or no discoloration at first. The oil glands may darken. In extreme cases the surface layer may collapse and become discolored. Its occurrence seems to be largely determined by previous orchard and climatic conditions. It is most common on fruit picked in cold, wet seasons (pl. 6, *C*).

Control measures

Pitting and other forms of rind breakdown of freshly harvested fruit are best controlled by harvesting at prime maturity, careful and prompt handling, avoiding over-brushing, and a good application of fruit wax.

Pitting in storage can be avoided or reduced by storing only prime waxed fruit at recommended temperatures (table 1, p. 19) and 87 to 92 percent relative humidity. Grapefruit may well benefit from curing the fruit at 70° to 75° F. for several days before putting it into colder storage.

(See *56, 61, 76, 87, 114, 116, 201, 208.*)

Puffiness

Puffiness in citrus fruits is a condition in which the rind becomes thickened, somewhat soft, loose, and separated from the segments beneath. Affected fruits lose their natural shape after packing and shipping. The loose rind sometimes cracks, thus affording easy entrance for the organisms causing blue-mold and green-mold decay.

Puffiness is usually found in overripe fruit. In California oranges, it is often associated with creasing, though fruit may be puffy without being creased. Puffiness is exceedingly rare in most varieties of Florida oranges but is common in tangerines, Temple oranges, and other mandarin-type fruits (pl. 9, *G*). Fruits may become puffy while on the tree, or this condition may develop in storage after packing. The cause is apparently a loss of water from the segments, which shrink and separate from the peel.

Overripe fruit that tends to be puffy at the time of packing should be handled carefully and marketed promptly.

(See *76, 136, 208.*)

Scab

Elsinoe fawcettii Bitanc. & Jenkins

Occurrence, symptoms, and effects

Scab is an important field disease in Florida, the Gulf States, and other areas having moist summers, but is absent in California, Arizona, and countries having a semiarid climate. Scab in the United States is the type known as sour orange scab, or lemon scab. It was introduced in 1876 on the first Satsuma trees brought to this country from Japan, where it had existed since ancient times.

Considerable range in susceptibility to sour orange scab occurs among the different kinds and varieties of citrus. Among commercial varieties in Florida, sour orange, Temple orange, lemon, and some tangelos are very susceptible. Grapefruit, tangerine, King orange, and Satsuma are generally less susceptible. Considerable resistance is shown by sweet oranges and Persian limes, while Key limes, citrons, Cleopatra, mandarin, and round kumquats are immune.

Scab occurs on leaves, twigs, and fruits, but attacks only young host tissues. Symptoms start as small translucent spots which, as they grow older with the maturation of the host tissues, become irregular scabby areas or warty protuberances ranging in color from buff to dark olive-gray. These protuberances may be single, or they may coalesce to form large raised patches of gray or tan-colored scab (pl. 4, *E*). Fruits severely infected while young may become misshapen because of excessive development of the warty outgrowths. On grapefruit, the infected areas tend to be flatter and with maturity are merely scaly patches. These patches may flake off and leave scar tissue similar to windscar or other mechanical injuries. On mature grapefruit, the skin around the scabby areas tends to remain green, a condition that may also occur after melanose or scale-insect injury.

The disease affects only the skin of the fruit but makes it unsightly and, therefore, less valuable for fresh market. Since infection takes place only when the fruit is small, there is no danger of new infection after harvest. Areas affected by scab are not invaded by other fruit-rotting organisms.

Causal factors

Sour orange scab is caused by *Elsinoe fawcettii* Bitanc. & Jenkins (*Sphaceloma fawcettii* Jenkins). The causal fungus overwinters on scabbed leaves and twigs and multiplies on the new flushes of growth in the spring.

Two other types of scab affect citrus but are not known to occur in North America. These are (1) sweet orange scab (*Elsinoe australis* Bitanc. & Jenkins), which is serious in South America, and (2) Tryon's scab [*Sphaceloma fawcettii* var. Scabiosa (McAlp. & Tryon) Jenkins] on lemons in Australia and Argentina.

Control measures

Since infection occurs only in the orchard, treatments after harvest are of no value. Scab can be controlled by field application of protective sprays.

(See *4, 25, 71, 73, 76, 122, 136, 147 ,201, 206, 208, 280.*)

Sclerotium Rot

Sclerotium rolfsii Sacc.

A minor decay due to the soil fungus *Sclerotium rolfsii* has been reported in the market on citrus fruits from Florida and other Gulf States, Caribbean Islands, Israel, Italy, Brazil, China, Japan, and some parts of Australia. Sclerotium rot is not found on fruit from California or Arizona.

The decay on grapefruit and lemons is yellowish-green, slightly darker than normal. On oranges it is dark brown with slightly lighter margins. The fungus rots oranges and lemons at about the same rate. At 65° to 75° F., the decay spreads within 2 to 3 weeks through most of a fruit. If the air is moist, an extensive white, fluffy mycelium forms on the surface. Small, spherical sclerotia, yellow at first but deep brown or black later, $\frac{1}{16}$ inch or less in diameter, are formed in great quantities on the surface and sometimes in the albedo and core. The decay is fairly soft and watery. Breaking down of the flesh extends into the core and the juice sacs.

Because *Sclerotium rolfsii* is a soil inhabitant, fruits touching the ground are usually the only ones affected. They should be avoided, if possible, during picking. Use refrigeration to prevent spread of the decay from diseased to sound fruit during transit. (See *79, 153, 208, 209*.)

Septoria Spot

Septoria sp.

Occurrence, symptoms, and effects

Spots or pits caused by a species of *Septoria*, probably *S. citri*, sometimes occur on lemons, grapefruit, and Valencia oranges in California and other citrus areas, notably New South Wales, Australia. Septoria spot is rarely seen on fruit on the market in the United States and usually is of only minor importance in the orchard.

The pits seen on fruit on the tree are usually round, dark brown, and sunken. They vary in size from 1/12 inch up to 1/2 inch in diameter (pl. 4, *D*.). The pattern ranges from few and scattered spots to numerous ones that coalesce, sometimes in streaks similar to tear-staining or as scald-like areas, probably associated with frost burns. The spots are surrounded at first by a narrow green halo, which eventually turns reddish brown. Eventually the pits extend deeply into the rind, which is discolored. Badly infected fruit develops off-flavor and usually falls from the tree.

The fungus grows and sporulates freely on twigs and fruit stems and on dead wood on or under the tree. The latter is the primary source of infection to the fruit and leaves.

Causal factors

For years there was a general belief that septoria spot and frost injury were associated and that frost injury was necessary before the fungus could infect the fruit. Investigations in New South Wales revealed that the septoria fungus must be established in the rind before the frost and that it does not infect fruit after frosting. Septoria spot develops quickly on fruit weakened by frost but from prefrost infections.

Control measures

A zinc-copper-lime spray applied in early fall to citrus orchards in interior areas in California protects against septoria spotting and brown rot of fruit, as well as copper and zinc deficiency of foliage.

(See *1, 136, 138, 145, 208.*)

Sour Rot

Geotrichum candidum Lk. ex Pers.

Occurrence, symptoms, and effects

Sour rot at its worst is one of the messiest and most unpleasant deteriorations of citrus fruit. The disease has been reported from most areas of the world where citrus is grown. It is primarily a disease of citrus fruit in storage or transit, although fruit on trees may be affected. Sour rot is usually not a disease of major industry-wide importance, as compared with blue-mold and green-mold decays or the stem-end rots. However, the importance of sour rot may generally be underestimated because initial infections are easily overgrown by other molds.

Sour rot is found most often on lemons and limes, since they are often stored longer, but occurs as well on oranges, grapefruit, and other citrus. Ripe or overmature fruit is more susceptible to this decay than green or immature fruit. The disease is more of a problem during and after prolonged wet seasons. Generally, lemons from coastal districts are particularly affected by this disease. Heavy losses have occurred after long wet periods.

Causal factors

Sour rot is caused by the fungus *Geotrichum candidum,* formerly called *Oöspora citri-aurantii* or *Oidium citri-aurantii.* This fungus is widely distributed in soils and causes postharvest decay in several crops. Primary source of sour rot infection is found in the orchard. The surface of citrus fruit may become contaminated with geotrichum spores by soil contact, dust from cultivation, or splash from soil during irrigation or rain. Low-hanging fruit has more geotrichum spores on rind surfaces than does fruit higher in the tree.

Symptoms of the initial stages of sour rot are very similar to those of green and blue molds, and the rots are often confused. Infected fruit first shows a water-soaked spot, which enlarges and eventually involves the whole fruit (pl. 3, *A*). The water-soaked areas are very easily punctured, are slightly raised above the healthy adjacent surface, and are dark buff-yellow colored.

The sour-rot fungus at first grows mainly inside the fruit. Later a thin, water-soaked layer of compact cream-colored growth develops on the surface. The whole inside becomes a sour-smelling, decomposed, often putrid, watery mass, which is very attractive to fruit flies. Fruit with sour rot may decay completely in as little as 5 days at 75 to 85° F. and high humidity. Not only does the original infected fruit collapse, but neighboring fruit in the package is infected by contact.

Control measures

Sour rot is not found frequently. Its development can be prevented by transport and storage at 40° F. However, lemons and grapefruit held long at less than 50° may develop physiologic injuries. Although large numbers of fruit are contaminated with geotrichum spores, infection cannot occur except through a wound and during high humidity. Therefore, it is especially important to avoid rind injuries during picking and packinghouse treatments. SOPP or soda ash in the wash water may aid in reducing sour rot. Storage boxes that have contained sour-rot decayed fruit should be sanitized with steam, formaldehyde, or similar agents. Less sour rot develops in fruit shipped in vented than in nonvented cartons. *Geotrichum candidum* is resistant to biphenyl and thiobendazole, and these chemicals cannot be expected to give any protection.

(See *39, 48, 51, 63, 67, 76, 96, 117, 136, 208, 209, 231, 238, 239, 246.*)

Stem-End Rot

Phomopsis citri Fawc.[4] and *Diplodia natalensis* P. Evans [5]

Occurrence, symptoms, and effects

Stem-end rot caused by *Phomopsis citri* and *Diplodia natalensis* is a destructive and widely distributed disease of all citrus fruits in the Gulf States, the West Indies, and other citrus-growing regions of the world that have high rainfall during the growing season. Stem-end rot is rarely seen in California and other semiarid regions.

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[4] The perfect stage, *Diaporthe citri* Wolf.

[5] The perfect stage, *Physalospora rhodina* (Berk. et Curt) Cke.

Both forms are characterized by a softening of the rind and underlying pulp. It usually begins at the stem end, although it sometimes begins at injuries on the side or stylar end. Neither form shows much discoloration in the early stages. Later the affected rind turns tan to brown, and sometimes even black. At room temperature, fruit infected with *Diplodia* will decay completely in 3 to 4 days after the first symptoms appear. The decayed tissues do not shrink. The infection progresses rapidly down the spongy central axis, usually reaching the stylar end much sooner by this route than through the surface rind. There is frequently a more rapid decay development in the rind along the lines that mark the divisions between the segments of the pulp, giving an appearance of "fingers" connecting the rotted ends of the fruit (pl. 3, *B* and *C*). There is usually a sour, fermented odor. *Phomopsis* decay is slower, and there is some shriveling of the decayed tissue, which causes a shoulder or line of demarcation between decayed and sound tissue (pl. 3, *D* and *E*). It likewise progresses more rapidly down the core, but doesn't reach the stylar end until the rind is two-thirds decayed. Fingers or streaks on the outside of the fruit are seldom seen, due to the slower rate of decay. The taste is flat and somewhat bitter, and the odor is unpleasantly rancid. The invaded pulp becomes mushy but is not discolored. Affected fruits do not lose their shape unless subjected to pressure. Surface growth is occasionally seen on fruit infected with *Phomopsis,* but seldom on that with *Diplodia* before the fruit mummifies. Immature citrus fruit is very resistant to stem-end rot, whereas deadripe fruit is very susceptible.

Causal factors

The stem-end rot fungi flourish and form spores in or on dead citrus bark. During rainy weather the spore crops are produced and disseminated to the fruit. The fruit is first infected on the stem button at some time during the growing season. Soon after the fruit is clipped from the tree, the fungus begins growth from the button into the rind and flesh.

Phomopsis and diplodia rots may occur in the same lots of fruit, or both fungi may be isolated from the same fruit. *Phomopsis* occurs throughout the harvest season, whereas *Diplodia* is more common during the autumn ethylene-degreening season and in late spring after the return of warmer weather and frequent rains. When both rots occur, an important factor in determining which will predominate is temperature. The optimum temperature for growth of *Diplodia* is about 86° F., and that for *Phomopsis* about 73°. When grown on agar medium at room temperature, *Phomopsis* grows relatively slowly and produces a fine-textured white mycelium, and *Diplodia* produces a coarse, rapid-growing, grayish-black mycelium.

Under certain conditions, stem-end rot may attack fruit on the tree, causing it to drop. Usually, however, it shows up only after harvest and becomes severe by the time the fruit reaches the retailer or consumer. It is impossible to detect and cull out fruit that may later develop stem-end rot, since at room temperature the rot does not develop until 10 to 20 days after harvest.

Control measures

Practical prevention of excessive loss from stem-end rot depends on several factors: prompt marketing of the fruit and proper refrigeration during storage and transportation. Temperatures of 40° to 45° F. are as necessary for control of stem-end rots in transit as for green-mold and blue-mold rots. In storage, 33° to 34° F. is desirable for control of all of these rots of oranges. Due to peel injury and other effects of chilling, higher temperatures must be used for tangerines, grapefruit, lemons, limes, and certain hybrids.

Stem-end rot after the fruit is harvested has been markedly reduced with various chemicals. Orthophenylphenol or its sodium salt, thiabendazole, and biphenyl are recommended as postharvest treatments.

Hot-water treatment (127° F. for 5 min.), applied just before packing, may also help reduce decay.

Debuttoning of fruit at harvest is beneficial, because it removes the source from which the initial infection may spread into otherwise sound fruit. Pulling of fruit of most varieties instead of removing it with clippers is recommended for the same reason and is extensively practiced in Florida. Some varieties at certain maturities must be clipped because of the danger that the rind around the button will be plugged (torn).

Pruning out dead limbs and twigs to diminish the sources of infection is very helpful and is beneficial for melanose control also, but usually it is not economically practical.

(See *11, 32, 36, 37, 38, 76, 113, 115, 136, 147,161, 165, 177, 178, 184, 200, 201, 202, 206, 208, 246, 247, 249, 250, 251, 281, 284, 286, 288.*)

Stylar-End Breakdown

Occurrence, symptoms, and effects

Tahiti (Persian) limes, as they approach maturity either on the tree or after being picked, are susceptible to a collapse of the rind. This most frequently occurs at the stylar or blossom end of the fruit, but it may occur at other locations. This breakdown, which has been observed on lemons and other limes also, is the most serious postharvest disorder or market defect of commercial limes.

Symptoms first appear at the base of the nipple or tip as a grayish-tan, water-soaked spot. The affected area enlarges rapidly, involving up to one third to one half of the fruit (pl. 6, *G*). The affected area remains firm but becomes darker with age and usually sinks below the healthy surface. There is often a partial collapse of the flesh beneath the breakdown and a water soaking of the core tissue. Gum pockets and gum-filled vascular bundles may be observed in the albedo and central axis. The area may be quickly invaded by organisms such as *Geotrichum, Aspergillus, Gloeosporium,* and *Penicillium,* producing a stylar-end rot.

Causal factors

No organism has been associated with the early stages of this disease. Its inception is considered to be physiological.

Control measures

Control of stylar-end breakdown of limes has been reported after the use of ferbam and other organic fungicides used for tar spot and scab control. Since no organism is involved, these chemicals may provide nutrition (possibly iron) or be otherwise beneficial to the physiology of the tree. Also, the disease may be reduced by avoiding overmature fruit, by harvesting only in the afternoon and under dry conditions, and by handling the fruit carefully after harvest.

(See *81, 104, 136, 147, 193, 201, 206, 208.*)

Sunburn

On fruit of most citrus varieties, large areas of the rind may be pitted all over, hard, flat, and much yellower or paler than the rest of the surface. The pits, which are very small, have resulted from collapse of the oil glands. In severe cases, the fruit will be one-sided, with up to one-half of the fruit being involved. The yellow surface may have a brown or gray center where the surface cells have been killed. The flesh under the affected area is dried out and contains little or no juice (pl. 9, *F*). Such fruit may become infected with various decay organisms. It would normally be graded out before being packed.

Fruit on smaller trees is more frequently affected than fruit on large trees, because of the unevenness of the foliage canopy. Certain varieties, such as the Murcott Honey orange, are more susceptible than others because their stiff branches and fruit pedicels hold more of the fruit on the perimeter of the tree and allow longer exposure to the direct rays of the sun.

Similar symptoms may result from spray injury, without any contributory action by sunshine. Such affected areas may have brown necrotic centers or brown necrotic pitted areas. The fruit is not misshapen unless the injury occurs at an early stage of development.

(See *136, 201, 208.*)

Thrip Injury

Scirtothrips citri (Moult.) = Citrus thrips in California; *Frankliniella bispinosa* (Morg.) and *Chaetanaphothrips orchidii* (Moult.) in Florida

The damage done by thrips to citrus fruit is caused by the feeding of both adults and larvae upon the fruit surface. They may feed on either young or nearly mature fruit and foliage. Thrip injury is most important on oranges but may occur on other fruits. The most characteristic form is a roughened band or corky ring around the stem or stylar end (pl. 5, *F*), caused by feeding injury when the fruit was small. This type of injury is more prevalent in California than elsewhere. It is caused by *S. citri in California,* but may be produced by *F. bispinosa* in Florida. Injury produced by orchid thrips (*C. orchidii*) is similar in appearance to rust-mite russeting. It occurs as rings or roughened areas where two fruits are in direct contact or a leaf and fruit touch, since these insects avoid direct sunlight and feed in shaded areas.

Thrips generally do not cause sufficient damage to need specific control. They are normally held in check by the sprays that control rust mite and scale.

(See *4, 88, 201, 208.*)

Trichoderma Rot

Trichoderma viride Pers. ex Fr.[6]

Occurrence, symptoms, and effects

In some areas trichoderma rot probably rates second in importance after penicillium green mold. In other areas, including Florida and Texas, this decay is found only occasionally. Lemons are attacked more often, and decay develops faster in them than in grapefruit or oranges. Fruit maturity is not an important factor in susceptibility to this decay, although fruit are more susceptible after they have been off the tree for more than a week.

Trichoderma viride enters fruit through injuries, usually at the stem end. The deeper the injuries, the greater the chance for infection. The fungus, under some conditions, can also spread by contact with infected fruit. *T. viride* is an important soil-inhabiting decomposer of cellulose. It is able to grow from infected fruit into wooden storage boxes, and later to grow out from the box into healthy fruit.

Citrus fruit rotted by *T. viride* turns brown to cocoa-brown (pl. 3, *F*) and has a firm somewhat pliable texture as compared to the soft, "colorless" rot caused by the green mold, *Penicillium digitatum*, which secretes pectolytic enzymes. A coconut-like odor is typical in trichoderma-decayed tissues. The decay develops slowly and is very often overgrown by *Penicillium*. If *P. digitatum* does not take over, the whole fruit will become dark brown, but will not soften or shrink. If the rotted fruit is kept moist and in the dark, a white mycelium will soon appear. When trichoderma-infected fruit is exposed to light, yellow-green to dark-green spores are produced, which somewhat resemble *Penicillium* spores (pl. 3, *G*).

Control measures

The same control measures are recommended for *Trichoderma* as for *Penicillium*. Injuries should be avoided and sanitation practiced. The fungus should be completely removed from wooden storage boxes, using steam, formaldehyde, or other disinfectants. Also, the storage boxes can be protected from fungus invasion by coatings of wax, resins, or plastics, or by lining the boxes with

[6] The perfect stage, *Hypocrea rufa* Fr.

plastic-coated paper. *T. viride* is partly resistant to biphenyl, the use of which only partly reduces spread of contact infections. Shipping fruit in vented rather than nonvented cartons reduces contact spread of trichoderma rot. The main protection, however, is achieved by refrigeration.

(See *24, 48, 76, 79, 82, 91, 92, 93, 96, 136, 208.*)

Water Spot

Water spot is a disease that develops especially on mature Washington navel oranges on the tree, after exposure to prolonged rainy or foggy weather. The earliest stage is a minute cracking of the cuticle, usually near the navel, caused by a swelling of the underlying tissue when it absorbs water. It also develops on the shoulder of the fruit, where drops of water may easily collect, and at or near wounds. If the wet weather continues, these affected areas enlarge, assume a water-soaked appearance, and are eventually invaded by decay organisms, chiefly green mold or blue mold. Under extreme conditions, half or more of the fruit on a tree may be ruined by this rind breakdown and the rot that follows. Water spots that develop elsewhere than at the navel usually start at bruises or skin breaks.

If the weather turns dry after the first stage of the spots has developed, the water-soaked areas become brown, dry, and slightly sunken (pl. 9, *H*). However, some of the blemished fruit may escape notice during the harvesting and packing and so get into the packed boxes. It may also happen that the spots are invaded by fungi but are kept from decaying by the coming of dry weather. When such fruit reaches the packinghouse, much of the external fungus growth is removed by the brushes, and again the damaged fruit may be packed along with sound fruit. In either of these cases, the spots become a potential source of trouble during transit and on the market, because of the danger of renewed growth of the fungi through the weakened rind whenever conditions become favorable.

Water spot is most common in groves sprayed with oil.

Delayed harvesting of the crop should be avoided, along with careful orchard protection to eliminate fruit injury by insects and freezing. Orchard applications of hormone sprays are reported to reduce the incidence and severity of this disorder.

(See *76, 136, 208.*)

Wind Scarring

The surface of fruit may be injured when the fruit is rubbed against twigs, leaves, or thorns by the wind. The resulting scars reduce the grade of the fruit. If small green fruits are injured, the damaged area develops a thin tan-to-silvery scar over a relatively large area as the fruit matures (pl. 5, *G*). Injury that occurs later may be in the form of scratches, pits, or thorn punctures (pl. 5, *H*), which usually heal over with corky scar tissues.

Scars resulting from injuries when the fruit was small do not act as avenues for decay organisms. However, fruit injured when almost mature may decay because of invasion of the injured tissues by *Penicillium, Phomopsis,* or other rot fungi.

(See *201, 208.*)

Miscellaneous Spotting and Discoloration

Oranges and other citrus fruit arriving on the market show at times various kinds of spots and larger discolored areas of the rind that are hard to relate to a definite cause. Most of these imperfections are various shades of brown. Some are superficial, while others are more or less sunken. Descriptions and illustrations have been published at various times attributing them to such causes as improper coloring-room conditions, fumigation injury, cold temperatures, mechanical bruising, brush injury scarring, heat damage, chemical injury due to orchard sprays or postharvest treatments, unusual weather conditions, or combinations of these, which cause a surface necrosis or a physiological breakdown of the rind tissues (pls. 8 and 9).

The difficulty, from the market point of view, is that in many instances the history of the fruit is not known and cannot be obtained accurately. Consequently, definite diagnosis of the cause cannot be made. These maladies, however, are observed more frequently at the beginning of the shipping season when the fruit is somewhat immature and the rind is more tender and subject to injury. These affected fruit may become infected with various decay fungi or may remain unchanged during the storage and marketing period.

(See *136, 208, 284.*)

AVOCADOS

Anthracnose (Black Spot)

Colletotrichum gloeosporioides (Penz.) Sacc.

Occurrence, symptoms, and effects

Anthracnose, or black spot, is the most frequently observed rot of softening avocados on the market. This decay may be found on fruit from all commercial growing areas and of all commercial varieties.

Small, light brown, mostly circular, discolorations of the skin first appear scattered over the surface of the fruit. As they enlarge rapidly to ¼- or ½-inch diameter, the color changes through light brown at the edge, to dark brown, and black or greenish black in the center of the spot. Centers of the spots may be slightly sunken. Surfaces of the larger spots, 1 to 2 inches across, frequently appear zonated, cracked, or fissured. A single lesion may enlarge to cover the entire side of a fruit, or scattered smaller lesions may coalesce to cover large surface areas. Large decayed areas are found only on overripe fruit. If the fruit is in a moist atmosphere, the fungus forms pink waxy spore masses on the surface of the spots (pl. 10, *A*). These spore masses may merge as spots coalesce, and they turn black with age.

The decay penetrates rapidly and deeply into the flesh beneath the spots. It forms a greenish-black, fairly firm, globular decayed mass that can be easily and cleanly separated from the healthy meat, leaving a fairly clean cavity. Eventually the decay extends to the seed. Anthracnose decay lacks the characteristic rancid odor of dothiorella rot, and it is not as moist. The black color of the spots and the decay immediately beneath are distinctive features of anthracnose.

Causal factors

The causal fungus, *Colletotrichum gloeosporioides* (Penz.) Sacc. causes anthracnose decays of mangos, papayas, and citrus fruits. In avocados the fungus commonly grows on dead twigs and in dead spots on leaves and fruit. This fungus is a weak parasite. It is unable to penetrate and grow actively in healthy, uninjured, growing fruits, but it may establish itself as a latent infection on the fruit, especially at the lenticels. Later, as the fruit becomes mature and softens, it is able to develop. As avocado fruits approach maturity, the fungus establishes itself actively through dead areas or cracks in the rind caused by other fungi, mechanical injuries, or insects. In Florida, anthracnose commonly infects fruit through cercospora spot or sphaceloma scab lesions.

Control measures

Anthracnose decay is controlled by preventing skin breaks or injuries to fruit. A good field spray program to control insects, cercospora spot, and sphaceloma scab is helpful. Injury to fruit during picking and handling should also be avoided. If avocados are to be held in storage for several weeks, anthracnose decay often becomes important as the fruits mature and soften. Anthracnose is not usually troublesome if fruit is held at 45° F. However, many avocado varieties are subject to chilling injury, and they should be stored at 55°.

(See *118, 125, 185, 187, 211, 212, 215, 217, 222, 225, 254, 287, 291, 292.*)

Avocado Scab

Sphaceloma perseae Jenkins

Occurrence, symptoms, and effects

Avocado scab is one of the most important diseases of avocado fruit and foliage in Florida and in several important commercial growing areas of Latin America and South Africa. It has not been found in California or the Hawaiian Islands. Avocado varieties vary in susceptibility to scab. Lula is the most susceptible commercial variety; Hall, Fuerte, Booth 8, Booth 7, and Taylor are moderately susceptible; while Fuchs, Pollock, Booth 1, and Waldin are quite resistant.

The disease occurs on fruit as raised, circular-to-oval, dark-brown to purplish-brown corky spots. These spots are scattered, or may coalesce to give the fruit a russeted appearance, or may form irregular extended areas sometimes involving practically the entire surface of the fruit (pl. 10, *B*). Scabby, deforming lesions are also formed on leaves, leaf petioles, and twigs. On mature fruit the injury is confined to the outer surface, and eating quality is not impaired by this disease. However, fruit appearance can be very unattractive, and in severe cases the fruit may be so undersized or misshapen as to rate as culls. Other fungi may gain entrance through cracks in scab blemishes and cause decay. Avocado scab itself does not develop or spread in transit or storage.

Causal factors

The fungus causing this disease, *Sphaceloma perseae,* is capable of entering young succulent tissue of avocado foliage and fruit, forming definite spots from which it grows and produces spores. From these centers the disease is spread in rain drops or dew drip, by insect carriers, or wind. It is carried over from one season to another on leaf and stem lesions. The critical period for fruit infection is from the time the petals fall until fruit has attained a third or half of its normal development.

Avocado scab is very similar to citrus scab in general appearance and in the reaction of its host. The fungi causing these two diseases were once considered identical, but they are now recognized as distinct morphologically and culturally.

Control measures

Avocado scab is controlled with field sprays of copper-containing fungicides.

(See *123, 124, 155, 208, 212, 213, 214, 218, 221, 223, 225, 254, 287, 292.*)

Cercospora Spot (Blotch)

Cercospora purpurea Cke.

Occurrence, symptoms, and effects

Cercospora spot or blotch is an important disease of avocado in Florida; it occurs in several areas in Latin America also. In Florida it is widely distributed throughout the avocado-producing areas. No commercial varieties have been found immune to cercospora spot once the fungus has become firmly established in the trees, but the disease is less severe and more easily controlled on Fuchs and Pollock than on other commercial varieties. This disease occurs on leaves and young stems as well as fruit, but it is of economic importance chiefly as a fruit disease.

Spots on the fruit appear as small scattered greenish-white dots, which later develop into slightly sunken, brown-to-dark-brown spots of definite outline but irregular shape (pl. 10, *C*). Characteristic short, gray, spore-bearing tufts of fungus may develop on the surface of these spots. These spots may increase in size to ⅛- or ¼-inch in diameter and finally develop into circular areas of hard brown dead tissues with a cracked or fissured surface. Spots frequently occur in groups on the surface of the fruit, or coalesce to form irregular areas of dead rind tissue deeply fissured by surface cracks. By itself this disease spoils only the appearance of fruit, as the fungus is limited to rind tissue and does not penetrate the flesh. However, tissues killed by the fungus and the cracks made in the rind allow other fungi, especially the anthracnose fungus, to enter and decay the ripening fruit.

Causal factors

The fungus *Cercospora purpurea* does not require a break in the skin to enter. It can attack avocado fruit at any stage of its development on the tree. The fungus is carried over from one season to the next on old leaf infections. If control measures are not taken, the disease tends to become progressively more serious in an orchard.

Control measures

Cercospora spot can be controlled by timely applications of various copper sprays to developing fruit on the tree. Methods that control cercospora spot usually control anthracnose also.

(See *208, 215, 216, 217, 218, 219, 220, 223, 224, 225, 254, 287, 292.*)

Flesh Darkening

Avocado fruits of different varieties vary in the normal color of their flesh. In certain varieties the flesh is sometimes rather gray, and during certain seasons, possibly because of abnormal conditions of growth, the flesh of commercial varieties may be unusually dark. The flesh may also darken in overripe or very soft fruit or when the seed begins to grow. On the market, hard dark areas are sometimes found in fruit from Florida and the West Indies believed to have grown on seedling trees. Flesh discoloration is also commonly caused by chilling, freezing, or heating the fruit.

Chilling Injury

In general, chilling injury occurs when the fruit is stored below a critical temperature. This critical temperature varies with variety, fruit maturity, season, and length of time the fruit is held in storage. Some varieties can withstand temperatures as low as 36° F. for several weeks without injury. Other varieties are severely injured if held below 55°. Avocados of the West Indian race are more susceptible to chilling injury than those of the Guatemalan and Mexican races or hybrid varieties. Generally, most avocados from California can be stored for a month or longer at 40°, except the Fuerte, which should be stored at 45°. Florida avocados vary in cold susceptibility. Cold-tolerant varieties such as Booth 1, Booth 8, Lula, and Taylor may be stored for more than a month at 40°. Cold-intolerant varieties, such as Fuchs, Pollock, and Waldin may eventually show chilling injury even at 55°. Booth 7 is intermediate in cold tolerance and may be held at 55° without injury or at 40° to 45° for 2 weeks before chilling injury develops. Fruits just beginning to soften are more susceptible to chilling injury than green, unripe fruit. It is desirable to store avocados as cool as possible to retard ripening (softening) and restrict development of anthracnose and other storage decays.

Chilling injury in avocados is characterized by several symptoms that may occur in combination or singly in different varieties. The most common symptom is a grayish-brown discoloration of the flesh, especially in the vascular tissues (pl. 10, *E*). In slightly injured fruit, the discoloration may occur in inconspicuous trace areas in the seed cavity or in vascular tissues only. In more severe cases, all the flesh is discolored. In very severe cases, abnormal ripening, development of undesirable flavors and odors, pitting, and a scald-like browning or darkening of the skin commonly occur. Sometimes fruit appears normal while held at the storage temperature but shows chilling injury when allowed to soften at higher temperatures.

The freezing points of a number of varieties of avocado fruit have been reported to range between 29.1° and 31.5° F. Immature and partly mature fruits may freeze at a slightly higher temperature. If the fruit freezes on the tree or in storage before it softens, the flesh remains tough and rubbery and becomes penetrated by many small cracks.

Heat Injury

Heat may damage picked avocados at temperatures as low as 77° F. if the fruit is held at this temperature very long. Relatively short exposures to temperatures above 86° after picking will prevent fruit from softening normally and cause it to turn black. The best ripening temperature for all varieties of avocados has been reported to be 60°, although temperatures of 65° and 70° are also very good. Avocados ripened at 80° are usually acceptable but generally poorer in appearance and flavor than those softened at lower temperatures. At 80°, rapid and occasionally uneven softening may occur, decay and discoloration may appear, and some fruit may be unpalatable because of off-flavors. Small brown spots appear on the skin, and the flesh darkens. At 90°, a scald-like discoloration of the skin may occur, and the flesh becomes rubbery. Sometimes avocados held at 85° and 90° require longer to soften than fruit held at 80° or lower.

(See *2, 45, 70, 105, 118, 157, 159, 180, 181,188, 189, 208, 269, 270, 277.*)

Rhizopus Rot

Rhizopus stolonifer (Ehr. ex Fr.) Lind

Rhizopus rot is the most rapidly developing decay of ripe avocados at room temperature. It is not found on the fruit until it begins to soften. It is fairly common on roughly handled fruit ripened at high temperatures. The decayed area is extensive, dark brown, and, if the atmosphere is moist, covered with a coarse white-to-gray mycelium bearing the typical spherical black sporangia. If the atmosphere is dry, little surface mold growth will occur, and the sporangia will be borne on short tufts in depressions or breaks in the skin. Decayed tissues are collapsed and watery but are held together by the tough mycelial threads of the fungus. These can be detected with the tongue when the tissue is tasted. Affected fruits usually become cracked and exude an ambercolored liquid. Flesh pulls easily from the seed and has a peculiar and unpleasant odor.

Rhizopus soft rots also occur in peaches, strawberries, and a number of other fruits and vegetables. In avocado fruit, it enters at skin breaks or at the stem scar if the fruit has been pulled from the tree. The fungus develops most rapidly at temperatures between 70° and 85° F. At 50° there is little danger of new infections being initiated, and at about 45° development ceases altogether. Control measures consist of carefully picking and handling of the fruit to avoid injuries to the skin, cooling of the ripe fruit to 50° or lower, and preventing fruit from getting wet.

(See *118*, *208*.)

Stem-End Rots

Species of *Diplodia*, *Phomopsis*, *Dothiorella*

These rots of avocado fruit start at the stem end and develop as the fruit softens. Considerable losses occur in shipments from Florida and the West Indies. In typical stem-end rots the decay begins at the stem end and proceeds rather uniformly toward the blossom end, finally involving the whole fruit. The rot begins as a small ring of affected tissue, dark brown in color and of firm texture. Except for discoloration, there is very little external change, and the surface remains firm and smooth. Progress of the rot may be more rapid near the rind, but the flesh is rapidly invaded down to the seed, becoming dark to black, at first soft and spongy, and later more or less firm. Later a surface growth of short, felt-like fungus mass appears on the fruit, varying in color and amount with the fungus causing the rot (pl. 10, *D*).

Three fungi can cause stem-end rots. The three kinds of rots are very similar in general appearance in the early stages, and one description will apply to all. The fungus most commonly associated with stem-end rots is *Diplodia*, usually *D. natalensis* P. Evans, although a species of *Phomopsis* and a species of *Dothiorella* are frequently found.

No special control measures appear to be necessary, if fruit free of decay and blemishes is selected for storage and kept refrigerated within safe limits.

(See *89*, *105*, *118*, *119*, *208*, *225*, *254*, *268*, *289*, *290*, *291*, *292*, *293*.)

BANANAS

Anthracnose

Gloeosporium musarum Cke. & Mass.

Occurrence, symptoms, and effects

Anthracnose or gloeosporium fruit rot is probably the most common market disease of bananas. Primary infection occurs either on the plantation when the fruit is very young or during the harvest, local transport, and loading of the mature green fruit. A secondary infection may occur during transport or after the fruit is in the ripening room. Manifestations of the disease include a finger-stalk rot, the characteristic spotting and later general blackening of the peel, and tip rot. The disease also has a role in main-stalk disorders and crown rot of boxed bananas. The first two types may become evident during transport, but the greatest development of all types of anthracnose occurs in the ripening room or afterward. Most commercial varieties are subject to infection, with the Gros Michel less susceptible than the Lacatan, Cavendish, and Robusta.

Disease symptoms may result from wound-induced infections after harvest or from latent infections of the immature fruit. Wound-induced infections, which occur during the handling of fruit from plantation to ship's hold, cause finger-stalk rot and spotting of green and turning fruit.

Finger-stalk rot.—Twisting, bruising, scarring, or pressure injury to the individual finger-stalk is usually followed by infection of the tissues with anthracnose or other wound fungi. The affected area first becomes brown in color, then slowly enlarges to involve the entire finger and turns black. The rot may progress during long refrigerated transport to the extent that fingers drop off when the stems are discharged at destination. This condition is further accelerated by the higher temperatures in the ripening room. Detached fruit may be sound, but usually the rot has spread to the edible pulp.

Anthracnose spotting—Infection enters through scars or other small peel injuries common to harvested green bananas. On green fruit, very small, often lenticular, slightly sunken brown spots with orange-yellow borders occur generally over the surface of the fruit, after 8 to 10 days in refrigerated storage (pl. 11, *A*). In the ripening room they rapidly increase in size to an inch or more in diameter, may coalesce, and turn black. The discoloration is largely confined to the peel, with little involvement of the underlying pulp.

The latent type of anthracnose infection occurs when the fingers are first exposed on the plant. The infection remains symptomless in fruit from most producing areas until final maturity is reached in the ripening room or in marketing channels, a period of about 90 days. Latent anthracnose is usually associated with overripe fruit. It can be minimized by prompt marketing of the fruit soon after its color changes from green to yellow. It is of much less economic importance than infections after postharvest injuries.

Ripe-fruit rot.—The symptoms are similar to those described for the late stages of anthracnose spotting. Superficial brown spots or patches turn black, enlarge, and coalesce, so that the entire peel surface may be involved along with some of the underlying pulp.

Tip rot.—This type of anthracnose also appears when the fruit is turning yellow. A latent infection in the diseased flower remnants on the tip-end is activated by advancing maturity and spreads slowly to the adjacent peel and pulp. The affected tip, up to one inch, darkens in color and is separated from the sound yellow peel by a narrow, water-soaked, greenish-brown transition ring. Eventually the underlying pulp decays completely.

One characteristic common to all types of anthracnose in their late stage is the black color of the affected areas, along with the visible production of pink-to-red masses of spores that later change to gray or black (pl. 11, *A*). Spore masses are usually accompanied by a scant, white growth of aerial mycelium.

Causal factors

The various types of anthracnose, known under several common names, are caused by *Gloeosporium musarum,* a fungus reported from every banana-producing area in the world. On the plantation the fungus exists saprophytically on the sheaths of dead and dying banana leaves and trash, where spore masses are produced in abundance. The spores are dispersed by rain, dew, and wind so they are always present for either latent infection of very young fruit or wound infection of harvested fruit.

Control measures

Control or reduction of anthracnose depends on following a number of steps in a more or less standard procedure for handling bananas from the plantation to the retail store. (1) The newly cut bunches are immediately bagged in perforated polyethylene film to minimize bruising and infection. (2) The cut ends of main stalks are treated with a fungicide and may be retrimmed and retreated immediately before loading aboard ship. (3) Exposure of harvested bunches to tropical temperatures is limited to 30 hours or less. (4) Cooling of fruit to desired temperatures in the ship's hold is done promptly, and the temperature is carefully maintained during ocean and land transport. (5) At destination the fruit is ripened expeditiously under exact limits of temperature and relative humidity before delivery to the retail store. (6) The ripening room is sprayed regularly with a freshly mixed 5 percent solution of sodium hypochlorite before each shipment of fruit is received.

(See *167, 168, 208, 272.*)

Botryodiplodia Fruit Rot

Botryodiplodia theobromae Pat.

Occurrence, symptoms, and effects

Botryodiplodia fruit rot is one of the most serious market diseases of bananas. The causal fungus is widely established in the tropics as a wound parasite of most commercial varieties of bananas and other hosts. On bananas it is capable of causing a main-stalk rot, crown rot, fingerstalk rot, and tip rot. The banana fruit can be infected either in the field or after harvest, the decay becomes evident either in transport or in the ripening room.

Main-stalk rot.—An ideal entry point for infection by *Botryodiplodia* is the cut end of the main stalk, where the fungus grows rapidly. The first symptom is a water-soaked appearance of the affected area, followed by blackening, softening, and splitting of the infected stem. A grayish-green mycelial mat develops over the affected area if the relative humidity is high, and later fruiting bodies (pycnidia) cover the mat.

Crown rot.—Symptoms are similar to those described under main-stalk rot. The same tissues are involved, but an even greater area of wounded tissue has been exposed by dehanding.

Finger-stalk rot.—*Botryodiplodia* infection of the main-stalk and crown tissues penetrates through the cushion and infects the finger stalks. The infection causes watersoaking and blackening of the finger stalks, after which the fingers ripen prematurely and drop off.

Tip rot.—This phase of the disease shows up in the ripening room. The infection originates in or just below the flower remnants on the tip end of the fruit, and progresses uniformly from the tip. It is accompanied by a brownish-black discoloration and softening of the involved pulp. Whole fingers may be rotted, with the pulp changing to a semiliquid with a sweetish odor. The peel acquires a black, wrinkled appearance and becomes covered with pycnidia. Secondary infection of injured fingers and bruised areas may occur in the ripening room (pl. 11, *B*).

Causal factors

The fungus, *Botryodiplodia theobromae,* formerly known as *Diplodia musae,* is the cause of this fruit rot. The source of infection is always present on fallen immature bunches and plant debris common to the banana plantation. The banana can be infected over a long period, ranging from small immature fingers to harvested bunches at commercial maturity. The fungus grows rapidly at tropical temperatures. During hot weather with abundant moisture in the producing area, the harvested fruit can be expected to develop botryodiplodia rot during its transport and ripening.

Control measures

Rapid cooling of the harvested fruit to 53° to 56° F. affords protection from *Botryodiplodia* infections. Resumption of growth of the fungus in the higher temperatures of the ripening room makes prompt ripening and marketing mandatory when this fruit rot is involved. (See control measures under Anthracnose.)

(See *86, 272.*)

Chilling Injury

Occurrence, symptoms, and effects

The banana fruit is probably, of all fruits and vegetables, most susceptible to chilling or low-temperature injury. This condition results whenever bananas, either unharvested or harvested, are exposed to low but not freezing temperatures for relatively short periods. Carrying temperatures during ocean and destination transport are especially critical in that they must be low enough to delay the start of ripening and retard the growth of incipient infections but avoid chilling injury. Slightly chilled bananas may be ripened and marketed with little difficulty, but those which are more severely chilled are either discounted or dumped.

Chilling is evidenced by internal and external symptoms but is mainly a peel injury. Both green and ripe bananas are affected, but the symptoms become most conspicuous when the fruit is in the ripening room. In chilled green fruit, some of the surface cells in the peel are killed, become discolored by oxidation, and later darken to a characteristic "smoky" or dull appearance. Before darkening occurs, dark-green, water-soaked areas, sometimes involving the entire peel surface, are visible on the peel of severely chilled green bananas. External symptoms are masked on less severely chilled green and ripening fruit. An examination of the subepidermal tissues reveals dark-brown streaks (pl. 11, *E*). Also, a lateral cut through the fruit shows browning of the vascular bundles arranged in a concentric ring under the peel (pl. 11, *F*). Slight chilling of green fruit is difficult to recognize. In such fruit, latex exudation from a broken finger or cut wound in the peel is greatly reduced and tends to be clear instead of milky or cloudy. The pulp is not affected and will ripen normally.

Chilled fruit is more sensitive to mechanical injury during handling than normal fruit, in that finger marks and other bruises later become discolored.

Ripening in chilled fruit is greatly delayed and is evidenced by a dull, smoky, yellow peel color. In severely chilled fruit the peel becomes entirely brown and eventually turns black. Other symptoms of chilling in ripening fruit, varying somewhat with variety, include loss of banana flavor and hardening of the central core (placenta) in the edible pulp.

Ripe bananas can be chilled by prolonged exposure to temperatures below 50° F. (refrigerated display case or home refrigerator). Such fruit quickly develops the characteristic dull appearance of chilled bananas, and the peel later becomes dark brown. Likewise, continuous exposure to sunlight will darken the peel of ripe fruit.

Causal factors

Factors involved in chilling include the maturity and condition of the fruit, the minimum temperature, and the duration of the exposure. The less mature and thin fruits are more susceptible to low temperatures than the more mature and full fruits of the same variety. In general, a 12-hour exposure at any temperature below 45° F. in still air causes chilling injury in most varieties, regardless of the stage of maturity.

Control measures

Precise temperature, relative humidity, and ethylene gas schedules have been developed and are used by the industry for the transportation and ripening of the different varieties of bananas. Minimum transportation temperatures for periods up to 12 and 18 days range from 53° F. for Gros Michel and Dwarf Cavendish to 56° for Lacatan and Giant Cavendish. Most banana ripening rooms are operated in a temperature range of 55° to 68°, depending on the maturity at arrival and the demand for ripe fruit.

(See *157*, *272*.)

Crown Rot

Occurrence, symptoms, and effects

The banana trade uses the name "crown rot" to designate the decay that develops on the crown surfaces of boxed bananas. The rot is an important problem with boxed bananas from Central and South America. Most commercial varieties are susceptible to the disorder.

The rot is limited mainly to the crescentic cushion or crown, but in severe cases the finger stalks and fingers are involved. The decay in the crown tissues causes the affected area to darken in color and become covered with mold growth. Its presence in a severe form in the crown tissues may cause some finger dropping and make the fruit hard to handle. Also, the presence of surface mold growth, even without any decay, detracts from the eye appeal of the fruit.

Causal factors

Crown rot can be caused by several fungi acting separately or in some instances by a mixture of two or more fungi. These include *Botryodiplodia theobromae, Thielaviopsis paradoxa, Gloeosporium musarum, Deightoniella torulosa, Fusarium roseum,* and *Verticillium theobromae.*

Control measures

The fungi responsible for crown rot, all of which may be found on the fruit in the field, have been known for many years as wound parasites on bananas. The increased wound area resulting from dehanding the bananas increases the importance of these fungi. Protection of the exposed wound areas by means of a chemical or possibly a hot-water treatment is a possibility for control. (See control measures under Anthracnose.)

(See *86, 266, 272.*)

Pitting

Piricularia grisea (Cke.) Sacc.

Occurrence, symptoms, and effects

Pitting is an important disease of bananas on the plantation and after arrival at destination. The severity of the disease can increase during the transport and ripening of the fruit. At peak severity, pitting can cause apparently clean fruit to become unsalable during its short stay in the ripening room. The disorder was first called "Johnston fruit-spot," but later it was recognized as a fungus disease. Pitting occurs usually on the Dwarf and Giant Cavendish varieties but has been reported on other varieties including the Gros Michel. Reporting countries are numerous and worldwide, ranging from Costa Rica to Queensland, Australia.

Pitting occurs mainly on the fruit but may involve the finger stalk and cushion. Usually symptoms do not appear until the fruit is more than 70 days old, it may not become evident until after harvest or later. Symptoms in the field and on the market are similar.

During ripening, the individual pit first appears as a faint, reddish-brown, depressed ring, about 1/8 inch in diameter, with a small dark spot in the middle of a central area that is not yet sunken. Within 24 to 36 hours this central area becomes sunken and acquires the characteristic dark-brown-to-black color. The diameter of the pit is the same as that of the original depressed ring and may measure up to nearly 1/4 inch (pl. 11, *C*). Individual pits may coalesce. Pitting on the fruit may extend deeply into the peel but does not involve the pulp.

Finger-stalk infections cause some fingers to drop and provide entry points for invasion by other fungi, i.e., *Gloeosporium musarum, Botryodiplodia theobromae, Fusarium* spp., and others.

Causal factors

The causal fungus *Piricularia grisea* sporulates on decaying transition leaves and flower bracts. The young fruit are infected several weeks after shooting, but symptoms of the disease are not evident until full maturity.

The causal organism grows best at temperatures of 75° to 89° F. It is little retarded at 55°, at which temperature additional pits may develop on stored fruit.

Control measures

Pitting is a disease of plantation origin, but the symptoms are not evident until time of harvest. The number of pits continue to increase during transportation and storage. Effective plantation control methods have not been devised. Rejection of affected fruit at time of harvest is a practical method of reducing losses during later handling of the fruit.

(See *19, 171, 208.*)

Speckle

Deightoniella torulosa (Syd.) M. B. Ell.

Occurrence, symptoms, and effects

Speckle fruit-spot, recently described as a fungus disease on Jamaican bananas, and speckling, long thought in Central America to be a physiological disease, are probably the same disorder.

If so, it is a widespread disease that has been found on many commercial varieties of bananas including the Gros Michel and Lacatan. Severely speckled fruit is graded out on the plantation, but fruit less severely affected is often shipped if market conditions are favorable. Thus, speckle is important both on the plantation and market.

Speckle lesions occur on young, green fruit in the field and become more numerous with maturity. The spot is nearly round, with a reddish-brown or black center and a darker green, water-soaked halo. The spots range up to 1/16 inch in diameter, and different sizes may be found on the same finger. They are most numerous on the inside of the fingers and toward the tips, where they may coalesce. Symptoms are fully developed within 7 days after infection. They vary slightly, depending on the source and age of fruit.

The disease attacks only the peel, which impairs the attractiveness of the fruit. It causes no decay, nor does it affect the ripening or eating qualities.

Causal factors

Speckle is caused by *Deightoniella torulosa,* a fungus reported from many banana-growing countries. It occurs usually as a common saprophyte on dead or dying banana leaves. It previously had been described as the cause of two plantation diseases, black-spot on the banana leaf and black-tip disease on fruit. The main source of infection is reported to be from dead leaves hanging from the pseudostem of the banana plant. Spores are produced in abundance during heavy and continuous rains. The peel of the fruit is susceptible to infection from shortly after shooting to nearly full field maturity.

Control measures

Speckle fruit-spot is a disease of plantation origin, and symptoms are fully developed before the bananas arrive at destination. Rejection of severely affected fruit on the plantation and at ports of cargo loading and discharge should eliminate the undesirable grades. Control measures on the plantation may include (1) fungicidal sprays applied directly to the bunches; (2) covering the individual stem with a plastic bag from shortly after shooting to harvest; and (3) removing and destroying the dead banana leaves and trash two or three times a year.

The latter method effectively reduces the disease and is probably the cheapest and most practical control measure.

(See *169, 170, 172, 272.*)

Thielaviopsis Stalk Rot

Ceratocystis paradoxa (Dade) C. Moreau
Thielaviopsis paradoxa (De Seyn.) Hoehn.

Occurrence, symptoms, and effects

Thielaviopsis stalk rot is nearly as destructive as botryodiplodia fruit rot in the marketing of bananas from some areas. The causal fungus is a wound parasite. It attacks bananas and other tropical hosts and is the cause of black rot of pineapples. On the Gros Michel and other varieties of bananas it is active as a main-stalk rot and finger-stalk rot. The infection occurs on the plantation and after harvest, but the symptoms develop when the fruit is in transport and in the ripening room. Thielaviopsis fruit rot is responsible for most of the "neck rot" losses in ripening rooms in the United States.

Main-stalk rot.—The mode of infection of the cut end is similar to that described for *Botryodiplodia.* The affected area blackens and becomes soft and watersoaked in appearance. Under humid conditions, a cobweb-like mass of dark mycelium develops over the epidermis. The fungus grows extremely fast in the main-stalk tissues, which are rapidly destroyed.

Finger-stalk rot.—The invading fungus continues from the main stalk through the cushion to infect the finger-stalks and fingers (pl. 11, *D*). The stalks blacken in color and may show outgrowing webs of mycelium. The peel acquires an uneven black color, and the pulp becomes dark brown and soft. The infection of the finger tips results in finger dropping and premature ripening, characteristic of both *Thielaviopsis* and *Botryodiplodia.*

Causal factors

The decay in question is caused by the fungus *Thielaviopsis paradoxa.* The finger-stalk decay phase of *Thielaviopsis, Botryodiplodia,* and other fungi is called by the trade "neck rot." Possibly the term "black neck rot" would limit the group to the two fungi listed.

T. paradoxa and *B. theobromae* are similar in many respects. The information under Causal Factors for Botryodiplodia Fruit

Rot applies to *Thielaviopsis*. Both fungi are rapid growers and can produce active decay before the bananas are cooled in the holds of the ship. Neither is retarded greatly by moderate refrigerated temperatures, especially *T. paradoxa,* which continues growth at 58° F. (See control measures under Anthracnose and Botryodiplodia Fruit Rot.)

(See *86, 94, 272.*)

FIGS

Alternaria Rot

Alternaria tenuis Auct.

One of the chief causes of loss in fresh figs is a surface spotting and rot caused by *Alternaria tenuis.* (Also see Cladosporium Spot.) It is found on all the important varieties and on fruit from the Atlantic, Gulf, and Pacific coast states.

Alternaria causes small, circular, brown-to-black spots scattered over the fruit surface (pl. 12, *A, B,* and *C*). Decay is shallow on immature fruit, but it penetrates deeper with maturity. The fungus is first evident as a surface growth of small, grayish-white tufts of mycelium. At this stage it is often called "mildew." The mycelium soon darkens to an olivaceous color or even darker, and the spots may enlarge to a diameter of 1/4 or 1/2 inch. At first the fungus appears to have but a slight attachment to the skin and sometimes can be rubbed off with little evidence of injury, but as the spots enlarge and the tissue beneath becomes slightly sunken, any attempt to remove the fungus removes the skin also.

Alternaria spotting occurs on fruit on the tree as well as on fruit in transit, held at the cannery, or at the market. The disease is confined largely to fully ripe fruit. The fungus is favored by cracks in the skin and by the sugary solution often found on the surface of figs. Infection can occur in the field or during harvesting and shipping. Other fungi, especially *Cladosporium* and *Botrytis,* are often associated with *Alternaria* in these surface spots.

High humidity tends to increase spotting, but storage at low humidity may cause an undesirable shriveling of the fruit. A rain before or during harvest will greatly increase the incidence of this disease in the orchard, with resultant carryover into market fruit. Low-temperature storage offers the best means of controlling alternaria spot and rot. Figs that are promptly precooled after harvest and kept at a temperature below 45° to 50° F. in transit are not likely to become seriously affected during the usual marketing period. Sanitation of picking boxes by dipping in fungicidal solutions, or lining the boxes with clean paper, helps reduce postharvest infections. Preharvest infections may be reduced by control of thrips and other orchard insects and by fungicidal sprays. One or two preharvest applications of fungicides in combination with a postharvest spray or dip gives better results than either one alone. Frequent pickings to prevent fruit from becoming overmature reduce severity of surface spotting.

(See *34, 52, 54, 68, 69, 101, 102, 175, 199, 245, 275.*)

Aspergillus Black-Mold Rot

Aspergillus niger v. Tiegh.

Occurrence, symptoms, and effects

Black-mold rot of figs, often erroneously called "smut," can be found in figs on the tree, in the drying yard, and in dried, packed figs as well. It has been reported on figs from Georgia and California and on imported figs. It is more common on the white varieties Calimyrna and Adriatic than on the black Mission or white Kadota. It is one of the three chief causes of spoilage in fresh figs.

The disease on fresh figs is characterized by a dirty-white to slightly pink color of the skin and pulp of affected fruits and a firm to finally a cheesy consistency of the pulp. A mass of white mycelium develops within the fig. Eventually cavities are formed, which become lined with the black spore masses of the fungus. Spores may also be produced on the surface (pl. 12, *D*). Infection varies greatly in severity. A severe infection gives fruit a dark translucent appearance by which it is easily identified. A light infection may produce merely dark or yellowish spots in the pulp, with no spores. Fruit in this condition shows no signs of the disease on the outside, is difficult to eliminate during the packing process, and consequently may sometimes reach the market. Badly "smutted" figs, when squeezed, give off from the eye a black cloud of fungus spores.

Causal factors

Black-mold rot is caused by the fungus *Aspergillus niger*. The same species causes a fruit rot of citrus, the black-mold rot of onions, an internal rot of pomegranates, and a decay of the fruit and fruit stems of grapes. The fungus is widely distributed in nature and is common on the soil surface and on vegetable debris. It also can live over from one season to the next on the small twigs of fig trees. Spores are carried through the eye of the fruit to the interior by fruit flies and other insects. In fully mature or shriveled figs, the sugar content of the pulp is so high the fungus cannot grow.

Control measures

Most of the infection takes place while figs are still on the tree. More takes place if fruit falls to the ground. Careful handling to reduce injuries and prevent contamination, as well as fungicidal dips to kill spores on fruit surfaces, reduce postharvest infections. Refrigeration at 31° to 32° F. holds decay somewhat in check, but figs can not generally be held for more than 10 to 14 days.

(See *52, 53, 54, 148, 175, 196, 199, 274, 276, 278.*)

Blue-Mold Rot

Penicillium sp.

Blue-mold rot, caused by *Penicillium* sp., is sometimes found on fresh figs on the market. Its development is relatively slow, and the affected tissues are only slightly softened. The disease is readily recognized by the blue-green color of the fungus growth.

(See *52, 54, 175.*)

Cladosporium Spot

Cladosporium herbarum Lk. ex Fr.

Cladosporium herbarum causes occasional spotting of figs. The spots appear first as dark olive-green specks that are particularly noticeable on lightskinned varieties. As they enlarge, they become slightly depressed and finally turn to a yellowish-olive color.

Cladosporium spot starts from a surface mold or "smudge" on either immature or mature fruit. As fruit approaches maturity, a spot rot develops, largely caused by the *Alternaria* fungus. (See Alternaria Spot.) While both *Cladosporium* and *Alternaria* are present in the surface mold, the *Alternaria* predominates. *Cladosporium* does not appear to be involved in the active decay of the fruit. However, cladosporium smudge can develop into spots, chiefly on overripe figs, and cause minor losses of fresh figs.

Methods of control are the same as those recommended for alternaria spot (p. 63).

(See *34, 52, 68, 69, 101, 102, 175, 199.*)

Endosepsis (Soft Rot)

Fusarium moniliforme Sheldon

Occurrence, symptoms, and effects

This internal rot of fig is important in several fig-producing areas of the world, but in the United States endosepsis is largely restricted to California. In this State endosepsis is one of the three major causes of mold spoilage.

Symptoms of endosepsis in edible figs are not always visible externally, for the decay progresses from the cavity of the fig outward. Sometimes the disease affects only the pulp, which often becomes slightly watery and separates easily from the meat. When the skin is affected, it takes on a watersoaked appearance in indefinite areas around the eye. These areas gradually assume a pink or purplish coloration. The flesh and pulp inside are yellowish brown, disintegrated, soft and watery, and may or may not have an offensive odor. In many cases the affected figs have a putrid, somewhat bitter taste, and an odor suggestive of spoiled tomatoes. Frequently the outside of a diseased fig appears sound.

Causal factors

Endosepsis is caused by the fungus *Fusarium moniliforme*. The spores are carried from infected caprifigs by the fig wasp, *Blastophaga psenes*, during pollination. There are two general kinds of figs, those varieties that require pollination (caprification) by the fig wasp, and varieties that are self-fertilizing. Although the fig wasp requires the caprifigs for survival, it will visit the self-fertilizing varieties as well and spread the fungus.

The fungus grows in both the caprifigs and the self-fertilizing varieties, but causes most decay in the latter.

Control measures

Nothing can be done after harvest to control development of this disease in infected figs. Control has to take place in the field. In the caprifig-growing regions of the United States, laws regulate the growing of caprifigs.

(See *12, 41, 52, 175.*)

Gray-Mold Rot

Botrytis cinerea **Pers. ex Fr.**

Botrytis cinerea sometimes causes considerable loss of figs on the market. The fig tissues soften, some juice leaks, and a growth of gray fluffy or velvety mycelium spreads over the surface (pl. 12, *E*). The disease occurs chiefly on overripe fruit.

Prompt refrigeration at 40° to 45° F. after harvest greatly retards, although it does not entirely prevent, growth of the fungus.

(See *34, 52.*)

Soft Rot or Watery Soft Rot

Rhizopus nigricans **Ehr.;** ***Mucor*** **sp.**

Rots caused by *Rhizopus nigricans* and *Mucor* sp. have been found occasionally on fresh figs on the market, although these rots usually attack figs while they are still on the tree. The trouble is favored by damp, rainy weather in the orchard and by high temperature and high humidity in transit or in the market. Fruit in very early stages of infection appears healthy and is often picked along with the healthy fruit. During transit or in the market this infected fruit becomes soft and leaky. The skin and flesh of the fig turn brown, the affected area becomes covered with a coarse, grayish mycelium, and black fruiting bodies develop. Soft, overripe fruit is particularly susceptible to these diseases. Figs that are picked at proper maturity, carefully handled, promptly cooled to 50° F. or lower, and kept cool will not be seriously affected with *Rhizopus* or *Mucor* watery or soft rots.

(See *52, 54, 64, 175, 199, 245.*)

Souring

Various yeasts and bacteria

Occurrence, symptoms, and effects

Souring is a disease or condition of figs that has been reported from most fig-growing areas. In the United States it is especially troublesome in large commercial fig orchards in California. It is a destructive fermentation of the fruit which, if not controlled, can cause the loss of nearly the entire crop. While mainly a disease of fruit on the tree, it can escape detection in lightly infected fruit, and the disease can spread during marketing.

In souring the pulp changes color from pink to colorless and subsequently becomes watery. A pink liquid exudes from the eye, dropping on leaves or jelling at the eye. The skin may become watersoaked and soft, with gas bubbles inside the pulp. The pulp disintegrates and smells strongly of alcohol. In many instances the pulp is covered by a white scum. Figs then shrivel and dry up. Fig souring is primarily an alcoholic fermentation, but subsequent changes by action of microorganisms on the alcohol produce acetic acid, which is readily discerned by its pungent, strong odor.

Causal factors

Souring can be caused by several yeasts and acetic acid bacteria carried into figs by insects, especially vinegar flies (*Drosophila*). Two of the yeasts disseminated by drosophila have been identified as *Hanseniaspora* and *Torulopsis.*

Control measures

Control of souring requires control of drosophila. In harvested figs, spread of souring is restricted by discarding all sour and endoseptic figs.

(See *42, 52, 54, 148, 175, 197, 198, 245, 276.*)

Splitting

Splitting or cracking at the eye end of the fig sometimes causes heavy losses in the orchard and is occasionally found on the market. The cracks may be mere crevices at the side of the eye or may be so deep that the affected fig is practically split in half.

Split figs attract vinegar flies (*Drosophila*), dried-fruit beetles, and other insects which spread the fungi, yeasts, and bacteria causing souring and other rots and decays.

Spherical or oblate figs apparently have a greater tendency to split than elongated or pyriform figs. Also, figs from some districts split worse than the same varieties from other districts. Splitting in the orchard appears to be associated with damp or cool weather and a turgid condition of the fruit. It is probable that package pressure and careless handling may increase splitting in transit and on the market.

(See *52, 245.*)

Sunburn

Sunburn consists of dead, hard, tan-to-dark-brown bands about ¼ of an inch wide, encircling the eye, or of similar blotches or spots ½ to ¾ of an inch across, on the side of the fruit. Sunburn is not important on the market except as a blemish, although occasionally some molds become established on these dead tissues. Control of sunburn is a field problem. Adequate irrigation seems to reduce sunburn. Figs from vigorous trees have less sunburn than figs from trees with low vitality.

(See *245.*)

LYCHEES

Browning

Occurrence, symptoms, and effects

Browning is a physiological condition affecting the shell or pericarp of the lychee fruit after harvest. It is associated with the desiccation of fruit on exposure to dry air. On rough-fruited varieties, such as Brewster (the major commercial variety in Florida), browning starts at the tips of the tubercles, the horny outgrowths of the shell, within several days after harvest under favorable conditions. The discoloration progresses until brown spots are easily discernible on the bright-red shell. Under severe conditions or prolonged exposure, the spots enlarge and coalesce until the surface is completely brown (pl. 13, *A*).

Browning results from desiccation at room temperature. The flavor of browned fruit may or may not be adversely affected. Off-flavors are most often associated with decay and fermentation by various yeasts that produce no typical external symptoms, but browning may well be accompanied by off-flavors due to yeast growth in the flesh. However, fruit browned at lower temperatures is not off-flavored until after an extended holding period.

Control measures

Browning, desiccation, and yeast decay of lychees may be best prevented or delayed by packaging the the fruit in polyethylene bags or other closed containers and storing at 35° F. for up to 5 weeks. For storage periods of less than 2 weeks, a temperature of 45° plus polyethylene packaging is satisfactory. No chemical control has been devised for extending the storage life of lychees.

(See *5, 43, 49, 107, 157, 210.*)

MANGOS

Anthracnose

Colletotrichum gloeosporioides Penz.

Occurrence, symptoms, and effects

Anthracnose, also known as "black spot" or "ripe rot," is the most important disease of mangos in regions where the fruit is grown commercially. In the field it develops on all tender parts of the tree and is especially severe on the flowers, young fruit, and leaves. It causes flowers and young fruit to drop.

The fruit is susceptible to infection from blossoming time until about half grown. Most of the decay on mature fruit develops from latent infection when the fruit was small. These incipient infections, which may be pinpoint in size on the growing fruit, develop into large coalescing black spots as the fruits soften at maturity (pl. 10, *F*). These spots frequently appear near the stem as very small brown areas that enlarge rapidly and become black. Often the entire surface of the fruit is covered by the coalescing of the spots. The affected areas usually crack and sink slightly. The decay is confined to the skin of the fruit, except in the later stages when it may penetrate deeply and rot the fruit either on the tree or after it has been harvested. Surface tearstaining or russeting may result from spores being washed down upon the fruit from an infected twig or flower stalk. These areas usually develop into rots as the fruit ripens.

Except in severe cases or during the late stages of decay, the fruit is not greatly damaged and can be used after removing the surface decay. However, the lesions detract markedly from the appearance of the fruit. Ripe mangos, free from obvious anthracnose symptoms, are often difficult to find on the market.

Causal factors

The fungus (*Colletotrichum gloeosporioides*) causing anthracnose is the same one that causes anthracnose of avocado, citrus, and papaya. On the mango tree it sporulates on the dead twigs and leaves, from which the spores of the fungus wash onto the susceptible parts of the tree. Rainy weather is an important factor in spreading this fungus during bloom and early fruit development.

Control measures

Fairly good control can be obtained in the grove with a rigid spray schedule using copper, captan, and other organic fungicides. Control of the postharvest rot of the fruit can best be attained by hot-water treatment (130° F. for 5 min.) at harvest time before the fruit begins to soften. Since the fungus establishes itself in the skin early, fungicidal washes applied to the fruit at picking time are of no value.

(See *103, 106, 158, 195, 208, 211, 212, 222, 227, 247, 252.*)

Chilling Injury

Mangos are harvested, packed, and shipped when the fruit is mature but still green in color and firm. They are consumed after they have ripened, which involves a loss of green color, softening of the flesh, and development of a desirable flavor. Before ripening they are susceptible to chilling injuries when held at temperatures below 50° F. Chilling injury is manifested primarily as a graying scald-like discoloration of the skin, often accompanied by pitting, uneven softening, and poor development of color and flavor (pl. 10, *H*). These symptoms usually appear while the fruit is stored at unfavorably low temperatures. Under marginal conditions, the symptoms do not develop until the fruit is allowed to ripen at higher temperatures. Fully ripened fruit is not as susceptible to the chilling injury as immature fruit.

Control measures

Chilling injuries of mangos can be avoided by using fully mature fruit and storing at recommended temperatures. Most varieties of fully mature unripened mangos can be stored successfully at temperatures of 50° to 55° F. for 3 weeks. For ripening, temperatures of 70° to 75° develop the most desirable color and flavor. When fully ripened, the fruit can be held for several weeks at temperatures of 35° to 40° without adverse effects.

(See *7, 15, 44, 106, 157, 277.*)

Stem-End Rot

Diplodia natalensis P. Evans

Occurrence, symptoms, and effects

Stem-end rot of mango fruit frequently causes losses during transit and storage. *Diplodia natalensis,* which causes stem-end rot of citrus and other subtropical fruits, is usually associated with this decay in Florida, but *Phomopsis citri* and other fungi have been known to cause a stem-end rot. Factors that contribute to the development of stem-end decay include the harvesting of immature fruit and storage in poorly ventilated rooms at temperatures much above the 55° F. optimum storage temperature. The decay usually starts at the stem end, although it may begin after injuries at other locations on the fruit. The rot develops rapidly at room temperature and involves the whole fruit within several days after the initial stages of decay. The skin turns light brown to almost black, forming a soft watery rot that has a sour fermented odor (pl. 10, *G*).

Control measures

Direct methods for control of stem-end rot of mango have not been developed. However, the spray program and postharvest heat treatment used for anthracnose control is beneficial in reducing stem-end rot. (See control of anthracnose, p. 71.)

(See *106, 158, 222, 227.*)

PAPAYAS

Anthracnose

Colletotrichum gloeosporioides (Penz.) Sacc.

Anthracnose is the most important and widespread decay of papayas on the market. It also affects the leaf petioles, flowers, and young fruit in the field. Lesions on the mature papaya usually appear first near the stem. They occur as saucerlike depressions, ¼ inch or larger in diameter, in which the skin at first is normal appearing or slightly deeper in color. The spots develop rapidly and may coalesce to cover the entire fruit before it is fully ripe (pl. 13, *B*). As they enlarge, the lesions become brown-to-black in the centers and are often covered with a scaly wax composed of dried latex. The decayed area is shallow, fairly firm, and may be readily lifted from the surrounding healthy flesh. Under moist conditions, pink spore masses are produced in the older or center part of the lesion.

Cause and control

The causal fungus, *Colletotrichum gloeosporioides,* also causes anthracnose of citrus fruits, avocado, and mango. Papaya fruits may be infected at any stage in their development, but are particularly susceptible as they approach maturity. However, most of the lesions do not become visible until the fruit begins to soften.

The disease may be controlled in the field by fungicidal sprays. Control of the postharvest decay of the fruit can best be attained by hot-water treatment or moist hot-air pasteurization at harvest time before the fruit begins to soften. Application of currently approved fungicides after harvest is of little or no value.

(See *6, 9, 14, 187, 208, 253.*)

Stem-End Rot

Diplodia natalensis P. Evans, and other fungi

Stem-end rot of papayas frequently causes losses during transit and storage. The rot usually starts at the stem end, although it may follow injuries incurred shortly before harvest at other locations on the fruit. The infection develops rapidly at room temperature and will rot the entire fruit within a week after the first stages appear. The skin of the affected area may remain yellow like the remainder of the sound ripened fruit, or turn a light brown forming a soft watery rot that has a sour fermented odor (pl. 13, *C*).

Cause and control

Diplodia natalensis, which causes stem-end rot of citrus, mangos, and other subtropical fruits, is usually associated with this decay in Florida, but *Phomopsis citri* and *Dothiorella gregarea* have been known to cause a decay with similar symptoms. Direct methods of control have not been developed. However, storage at temperatures of 45° to 50° F. will retard decay development, and the postharvest heat treatment used for anthracnose control reduces stem-end rot.

(See *253*).

PINEAPPLES

Black Rot

Ceratocystis paradoxa (Dade) C. Moreau

Occurrence, symptoms, and effects

Black rot (sometimes called "water blister," "soft rot," or "water rot") of pineapples is found in all commercial pineapple-growing regions of the world. The fungus causing this rot attacks all parts of the growing plant, but it is rarely seen on pineapple fruit in the field unless the fruit is allowed to ripen fully. On ripening fruit shipped long distances to market, it frequently assumes major importance. All commercial varieties are susceptible, but the Red Spanish variety is considered more resistant than the Cayenne variety.

Black rot may originate at the base of the fruit, through the cut stem, or at the side of the fruit through injuries received during packing and handling. In side infections, rotting progresses much more slowly than in basal infections. The decay in the fruit is characterized by a slightly brown watersoaked appearance of the affected tissues. It soon becomes very soft and almost liquid, with the skin of the fruit forming a brittle shell. The fungus grows rapidly through the water-conducting strands in the core of the fruit, producing no external evidence of decay except for slight softening at the site of infection. In later stages the fruit becomes so completely disintegrated that it yields to the slightest pressure. On broken or otherwise exposed surfaces, decayed tissues become covered with a black crust composed of macrospores of the fungus. These also form in the decayed tissues near the core of the fruit, turning it black (pl. 13, *D*). Under warm conditions the vascular strands in the fruit are not disintegrated as rapidly as the remaining tissue, thus giving a decided stringiness to the decayed portion. A sweetish odor of fermentation accompanies the decay.

Causal factors

Black rot is caused by the fungus *Ceratocystis paradoxa,* better known by the name of its imperfect stage, *Thielaviopsis paradoxa* (De Seyn.) Hoehn. This fungus is widely distributed in tropical and subtropical countries, where it causes important diseases of pineapple, sugarcane, bananas, and other plants. The organism lives and sporulates freely on dead plant parts in the pineapple fields. Thus abundant infective material is present at harvest-time. When the fruit is removed from the stalk, the cut allows easy entry for the fungus. It also may enter the fruit through insect punctures or through injuries received during harvesting, packing, and marketing. Much of the rot on the side follows packing bruises that could have been prevented by proper handling and sizing of fruit. Although it is probable that the fungus cannot penetrate the uninjured surface of the fruit, very small, invisible cracks between the eyes may allow infection if they come in contact with decayed tissue from a neighboring fruit. More than 48 hours elapse between the time of infection and the appearance of symptoms.

Moisture conditions in the field at harvest are very important in decay development. High percentages of decay in a shipment usually mean that the fruit was harvested either during or immediately after a prolonged rainy period. The relation between moisture and the decay is so marked that in some sections it is called "water rot."

The fungus develops in the fruit very rapidly at temperatures between 70° and 90° F., but becomes almost quiescent below 50°. It develops more rapidly in ripe than in green fruit. At room temperature, a ripe fruit may become entirely decayed in 3 or 4 days.

Control measures

Fruit for the fresh market should be cut and not snapped from the plant. Care should be taken in handling and packing to avoid bruising the fruit. Proper sizing insures a tight pack without side-bruising the fruit, thus avoiding resultant side decay. Sunburned, damaged fruit, or fruit with an excessive number of growth cracks should be excluded from fresh fruit shipments. The packing of wet fruit should be avoided, and the packed cases or cartons should be kept dry.

Protecting the fruit against fungus invasion will almost completely control black rot starting at the stem end. Fungicides and treatments that have been used include: Immersing the whole fruit and crown in a 10-percent *o*-phenylphenate solution; dipping the lower half of fruit in a 1-percent sodium salicylanilide solution; spraying or painting the cut end of the fruit with 2½ percent salicylic or benzoic acid in 30-percent alcohol solution or a 10-percent benzoic acid-kaolin mixture (1:4); or dusting 25-percent benzoic acid dust on the cut surface. Dipping or spraying treatments are usually more effective than dusting and are easier to perform. For maximum protection, fruit should be treated within 2 hours after cutting.

Black rot will not develop in fruit refrigerated at 45° F. For fruit in the ripe and half-ripe stages of maturity, this temperature is satisfactory during transit. Green fruit at this temperature may fail to develop good flavor and may retain part of the green color in the skin, so that shipping and storage is generally at 45° to 55°, usually with ventilation.

(See *3, 8, 29, 30, 50, 128, 160, 162, 163, 191, 208, 233.*)

Brown Rot

Erwinia ananas Serrano, *Fusarium moniliforme* Sheldon, *Penicillium funiculosum* Thom, and *Pseudomonas ananas* Serrano

Occurrence, symptoms, and effects

Pineapples on the market sometimes show brown rotten spots, from which *Penicillium* sp., *Fusarium* sp., or bacteria can be isolated. This is commonly called brown rot in United States markets, but in pineapple-producing areas it is variously referred to as "fruitlet core rot," "fruitlet brown rot," "fruitlet black rot," "ripe fruit rot," "marbled fruit," "bacterial fruitlet rot," "exogenous brown discoloration," "black rot," and "black spot." Disease symptoms vary somewhat, depending upon whether fungi, bacteria, or both, cause the disorder. It is often hard to differentiate between the rots by appearance only.

Brown rot can rarely be detected from the outside of the fruit, though underdeveloped fruitlets and uneven coloring or ripening may be an indication. Some badly affected eyes may become brown and sunken as the fruit ripens. Internal symptoms consist of small light-to-dark brown, moist, firm, decayed, mottled areas at the center of the fruitlet or eye. Sometimes only the style or central part of the fruitlet is affected, although frequently the entire fruitlet is involved. In later stages the decay may progress to the core of the fruit and involve all of the tissues immediately surrounding the floral cavity (pl. 13, *E*). It rarely spreads from one fruitlet to another. The decay may develop in fruit during transit and marketing as well as in ripe or mature fruit in the field.

The decay also occurs as a thin, tan, dry layer lining deep cracks between fruitlets. These cracks, which are usually accompanied by a gummy exudate, are apparently caused by growing conditions in the field. Before the fruit is picked, the cracks are contaminated with the organisms, which then initiate the shallow decay and produce the typically colored sporulation, pink or white with *Fusarium,* and blue-green with *Penicillium.* Where bacteria cause the rot, the affected fruitlets are filled with masses of bacteria. Diseased tissue cultured on potato-dextrose agar yields yellow (*Erwinia ananas*) or white (*Pseudomonas ananas*) bacteria.

Causal factors

This disease seems to develop very rapidly, but only during ripening. The fungi and bacteria most frequently associated with the decay are common saprophytes on rotting vegetation in the field. They grow on the decaying floral remnants of pineapple in the cavities under the eyes but can enter the flesh of the fruit only through injuries or breaks in the hard lining of the cavity. Such breaks or injuries may be caused by growth cracks or the feeding of certain insects, such as mealybugs and mites. Apparently the organisms can gain entrance into the eye and work down the floral parts into the center of the fruitlet at any stage of fruit development, but flesh decay is fastest in ripe or nearly ripe fruit. The disease is especially severe when a dry season is followed by wet weather. Growth cracks and mealybugs are then especially common.

Control measures

Although the disease is fairly prevalent, especially in pineapples from the warmer, humid areas, and most of the organisms causing it are known, no effective means of controlling this kind of fruit-rot damage have been developed.

Fruits of low acidity are more susceptible to bacterial infections. Cultural practices that result in high acidity may be effective in reducing bacterial decay.

(See *16, 50, 65, 66, 109, 126, 128, 149, 152, 190, 191, 192, 208, 234, 235, 236, 237, 243, 262, 265.*)

Physiological Breakdown

Occurrence, symptoms, and effects

Physiological or internal breakdown of pineapple fruits, often called "waterlogging" or "juicy pineapples," is characterized by a firm light-brown watersoaking of the flesh of the fruitlets, beginning near their attachment to the core in a region an inch or two above the base of the fruit. The watersoaking progresses upward, and may eventually involve all of the fruitlet except the ovary and a layer about ¼ inch deep below the skin. Only in advanced stages do the surface of the fruit and the core become discolored (pl. 13, *F*). These fruit may change from a normal yellow to a dull hue. Sometimes the leaves are rather loose in their sockets and some can be plucked out easily, or even the entire crown may be lifted from the fruit. Surface molds may increase rapidly on severely affected fruit. Most fruits, however, have no external symptoms of the disorder. Severe cases of physiological breakdown are frequently discovered in pineapples that appear normal and attractive from the exterior. The disorder is not a form of overripeness.

Causal factors

Microorganisms do not cause physiological injury in pineapples. The most common or usual cause of physiological breakdown is exposure of the fruits to relatively low temperatures. Storing or shipping pineapples at 32° to 40° F. is especially harmful (pl. 13, *G*). The critical temperatures below which injury occurs are between 41° and 45°, depending on the particular lot of fruit. Pineapples unloaded and held in cold weather in northern ports have been observed to develop physiological injury. This disorder is relatively common in pineapples ripening in cool winter months but rare in summer fruit unless they are subjected to cool temperatures after harvest. After the fruit is removed from storage, physiological damage becomes more severe with time.

Conditions other than low temperature may start the physiological breakdown. The disorder has been observed in imported fruits that have not been subjected to low temperatures during transit. A somewhat similar if not identical disorder may be induced by heavily waxing mature fruits or by holding them in airtight containers.

(See *55, 84, 85, 157, 173, 208, 271, 273.*)

POMEGRANATES

Pomegranates are remarkable for their keeping quality and are exceptionally free from diseases, as compared with other fruit. They may be picked before fully ripe to ripen during storage. The fruit are easily kept 4 to 7 months in excellent condition at 32° to 38° F. and 80 to 85 percent humidity. The rind may dry and harden during storage in dry air, but the interior remains good and even improves.

Gray-Mold Rot

Botrytis cinerea Pers. ex Fr.

Pomegranates on the market are occasionally affected with a light-brown, firm decay starting at the calyx. The decayed skin is tough and leathery, but the inner part of the fruit is dark and disintegrated. Under moist conditions, a sparse mycelium of a dirty-gray color appears on the decayed area. At various points in the mycelium, the typical tan-gray spore-bearing tufts develop.

Control measures for the disease have not been reported. It is probable, however, that the development of the rot in transit and storage can be greatly retarded if the temperature is kept below 45° F. However, the *Botrytis* fungus can develop at low temperatures and grow slowly even at 32°.

(See *179, 208.*)

Heart Rot

Aspergillus niger v. Tiegh., *Aspergillus* spp., and *Alternaria* sp.

Heart rot, sometimes called "fruit rot," is found only occasionally in pomegranates on the market, but in some years it is so prevalent in the orchard that heavy culling in the packing-house is necessary. The decay has been found in fruit from the various producing districts of southwestern United States. It rarely appears on the surface of the fruit, but the skin color of affected fruits is slightly abnormal, so that experienced graders can eliminate most of it from the pack. Diseased fruits when opened are found to contain a mass of blackened arils (pl. 12, *F*) (the pulp-bearing seeds) and usually a threadlike black line of decay extending from the calyx into the interior of the fruit.

Typical symptoms of the decay are produced by species of *Aspergillus* and a species of *Alternaria*. The only control measure that can be suggested is the gathering and destroying of all affected fruits found in the orchard.

(See *111, 112, 164, 176, 208, 259, 260.*)

Internal Breakdown

In some seasons, pomegranates from certain areas may occasionally be affected with a peculiar condition of the arils (the pulp-bearing seeds). The arils have a lighter color than is normal, are rather flat and unsatisfactory in taste, and exhibit a streaked appearance. Many delicate white lines can be seen radiating in all directions from the seed to the outer wall of the aril. There are no external symptoms of this deterioration, and no organism has been identified that causes it. It is a physiological disorder.

(See *111, 112, 179.*)

Penicillium or Blue-Mold Rot

***Penicillium expansum* Lk. ex Thom and other *Penicillium* species**

Penicillium rot is found occasionally on pomegranates. It starts at splits, cracks, or insect wounds and forms pockets of blue- or green-spored fungus colonies (pl. 12, *G*). *Aspergillus, Alternaria,* or *Botrytis* often occur in the same wounds with the *Penicillium,* in which case one or another of these fungi often overgrow the *Penicillium* and predominate.

(See *179, 259, 260.*)

Splitting and Cracking

During ripening, the pomegranate is very susceptible to splitting and cracking (pl. 12, *H*). This is a common malady of pomegranate fruit, and is a natural characteristic, similar to splitting in figs and oranges. The exact cause of pomegranate splitting is not known, but a common idea is that it is due to sudden fluctuations in the moisture content of soil and air, due to irrigations, dry winds, etc. Splitting is always worse in fruit that is allowed to become overmature on the trees. To avoid splitting, fruit should be picked just before becoming mature. The pomegranates then ripen very well during storage. Split or cracked fruit quickly develops *Botrytis, Penicillium, Aspergillus,* or *Alternaria* rots, especially when stored in warm moist areas.

(See *35, 111, 112, 232.*)

Sunscald or Sunburn

Pomegranates at almost any stage after blossoming hang with the blossom end down and thus are exposed at the stem end to injury by the sun. This appears as brown, slightly russeted, very tough, leathery areas of the rind. Sometimes they are on only one side of the fruit but may extend entirely around it. The injury does not lead to decay and is of importance only as a blemish.

(See *111, 112, 208.*)

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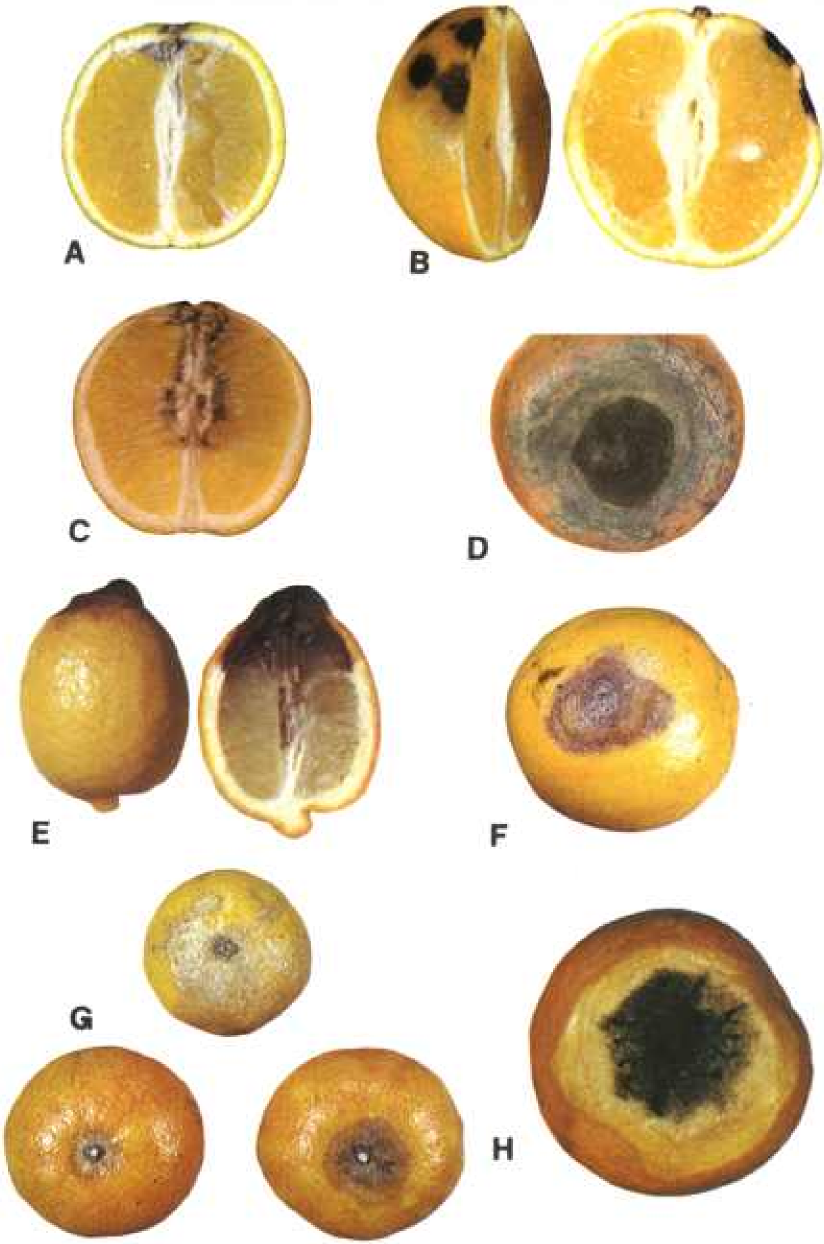
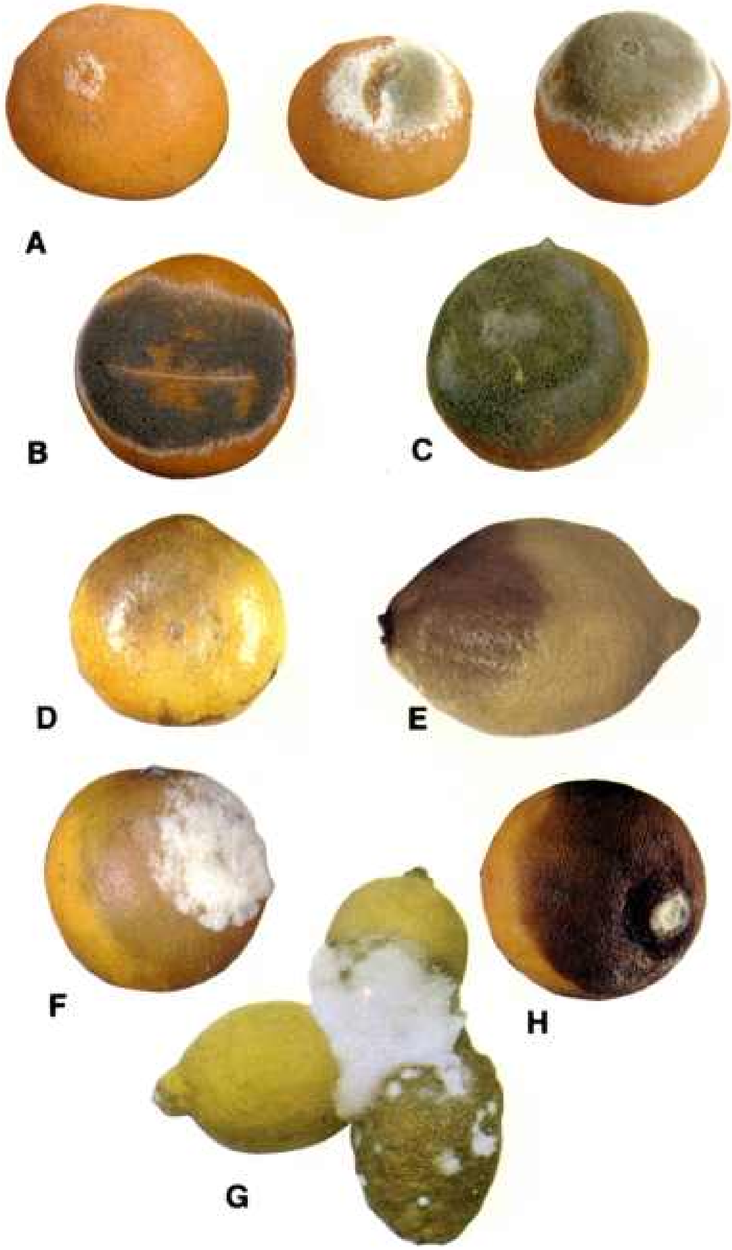


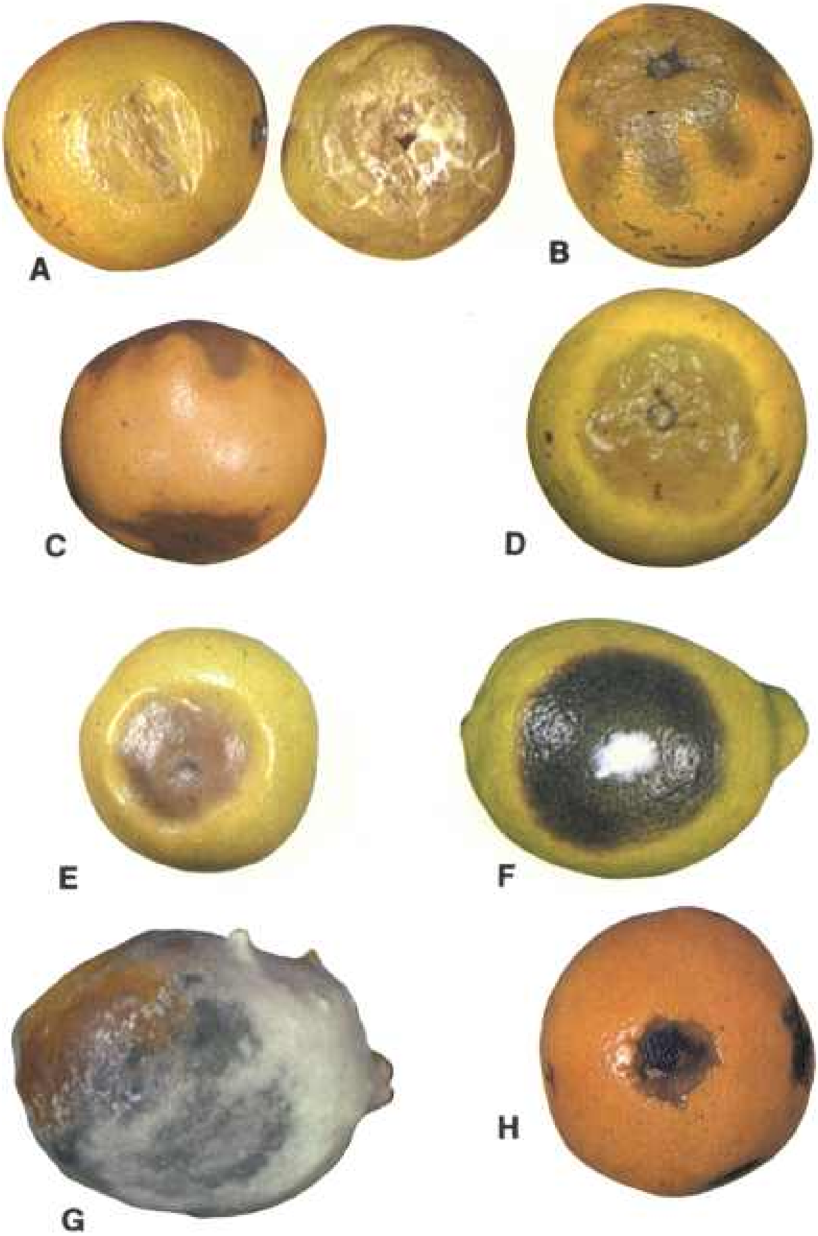
DECAYS AND ROTS OF CITRUS FRUITS

A, Alternaria black rot at stem end of orange; B, alternaria side rot of orange; C, alternaria black rot of navel orange; D, advanced stage of alternaria rot; E, alternaria rot of lemon; F, anthracnose of grapefruit; G, anthracnose of tangerine following degreening; H, aspergillus rot of tangerine.



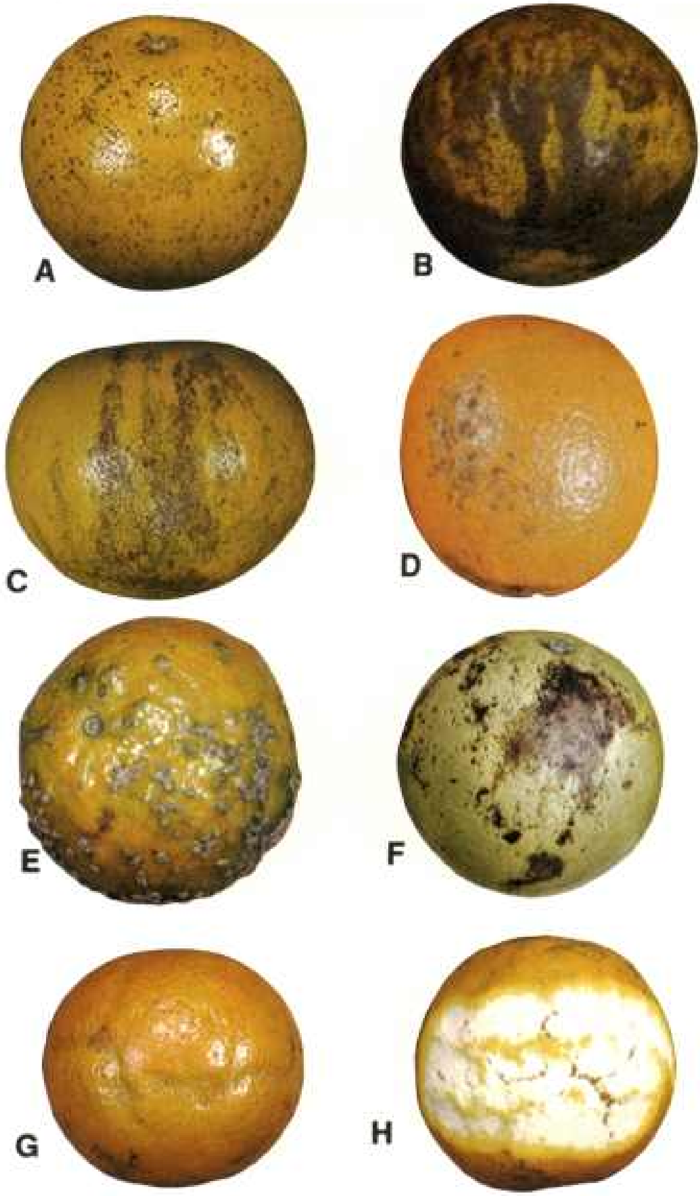
DECAY AND ROTS OF CITRUS FRUITS

A, Green-mold rot showing stages of development; B, blue-mold rot of orange; C, botrytis rot of orange; D, brown rot of tangerine; E, brown rot of lemon; F, cottony rot of orange; G, contact cottony rot of lemons; H, fusarium rot of orange.



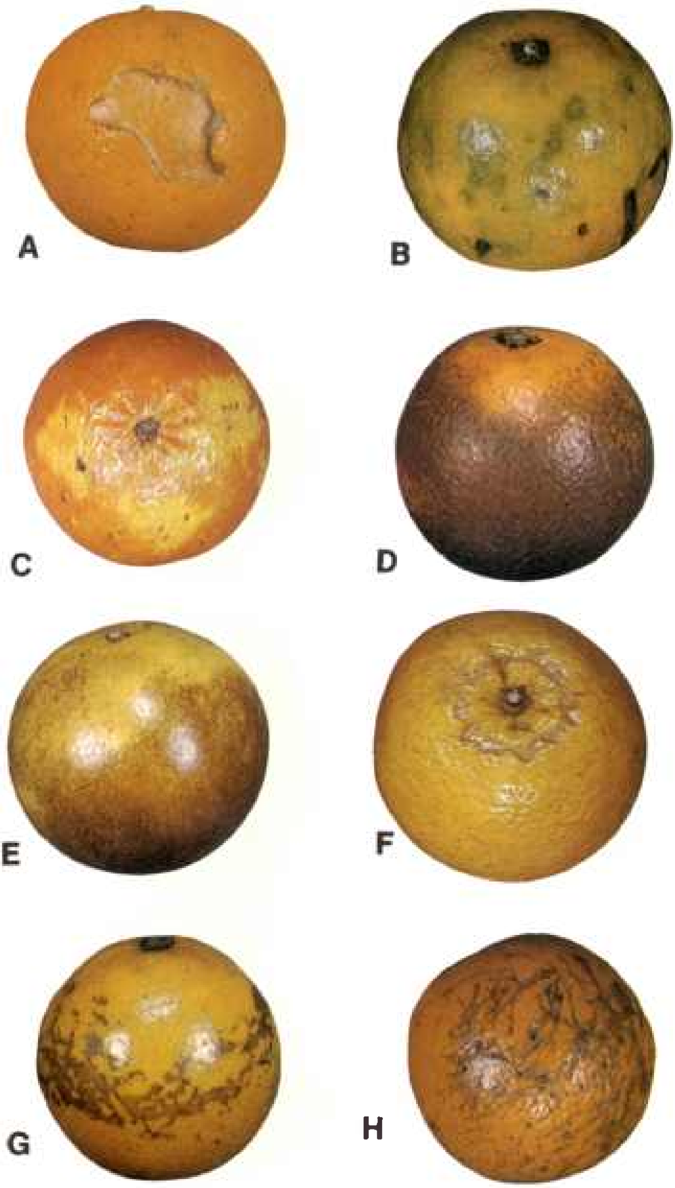
DECAYS AND ROTS OF CITRUS FRUITS

A, Sour rot of orange (early and late stage); B, diplodia stem-end rot of orange; C, diplodia stem-end rot of grapefruit; D, phomopsis stem-end rot of orange; E, phomopsis stem-end rot of grapefruit; F, trichoderma rot of lemon (early); G, trichoderma rot of lemon (later); H, black pit of orange.



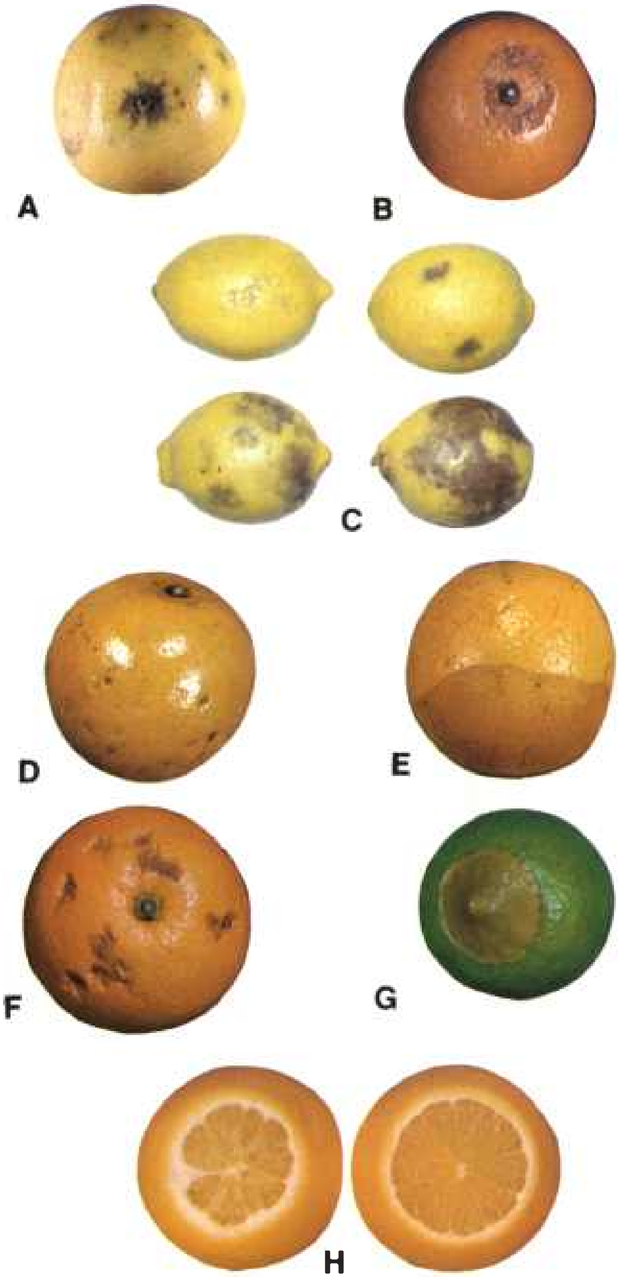
ORCHARD DISORDERS AFFECTING MARKET QUALITY

A, Melanose (common); B, melanose (mudcake); C, melanose (tear stain); D, septoria spot of orange; E, scab of Temple orange; F, exanthema of orange; G, creasing of orange; H, creasing (peeled to show voids in albedo).



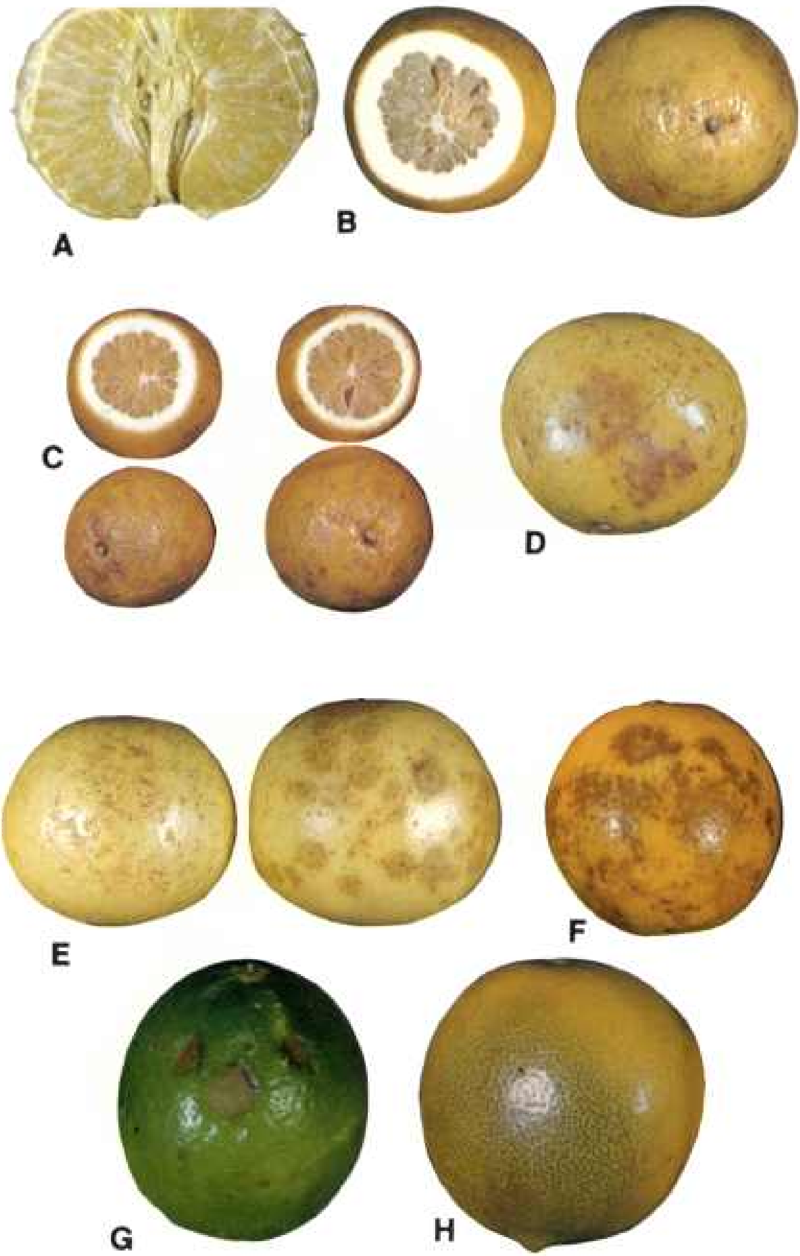
ORCHARD DISORDERS AFFECTING MARKET QUALITY

A, Grasshopper or katydid damage to orange; B, scale injury preventing normal degreening of orange; C, scale injury preventing normal color development of Temple orange; D, early season rust-mite injury of orange; E, late season rust-mite injury of grapefruit; F, thrip injury of orange; G, leaf scarring of orange; H, thorn injury of orange.



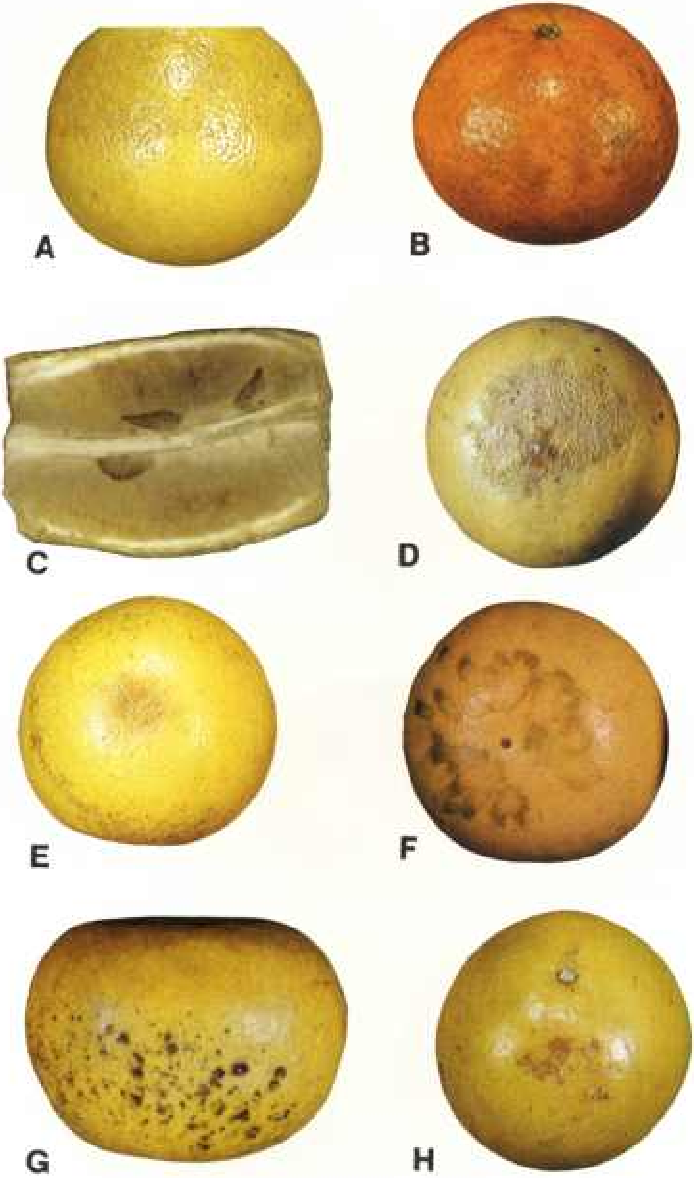
PHYSIOLOGICAL DISEASES OF CITRUS FRUITS

A, Aging of grapefruit; B, aging of oranges; C, peteca of California lemons; D, pitting of freshly harvested Pineapple orange; E, low O_2 injury of orange; F, pitting of orange following storage in N_2; G, stylar-end breakdown of lime; H, granulation of navel orange compared with normal.



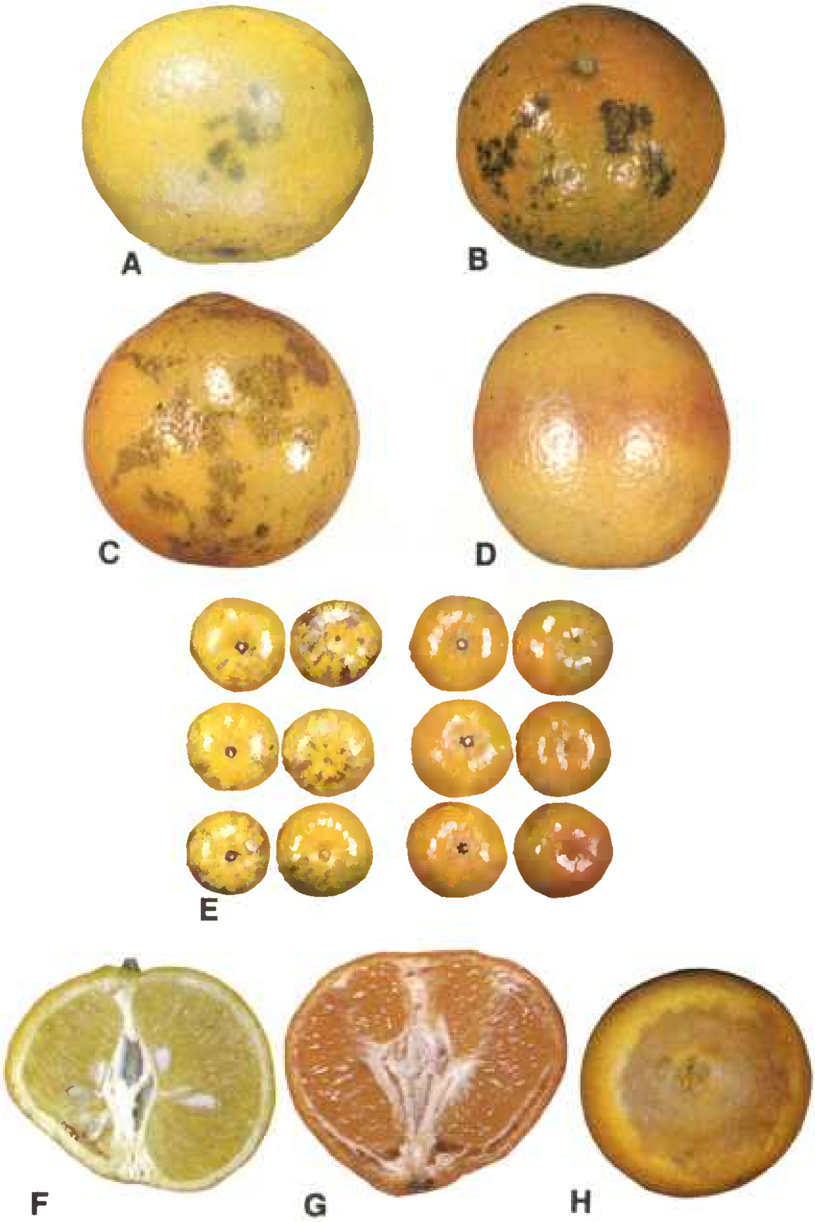
FREEZING AND CHILLING INJURIES OF CITRUS FRUITS

A, Hesperidin crystals on segment walls, resulting from freezing injury of tangelo; B, freeze damage of grapefruit (internal drying, external pitting); C, freeze damage of orange (internal buckling and drying, external pitting); D, phomopsis side rot of grapefruit following storage pitting; E, storage pitting of grapefruit; F, storage pitting and brown staining of oranges following chilling; G, pitting of limes following chilling injury; H, albedo browning of lemons.



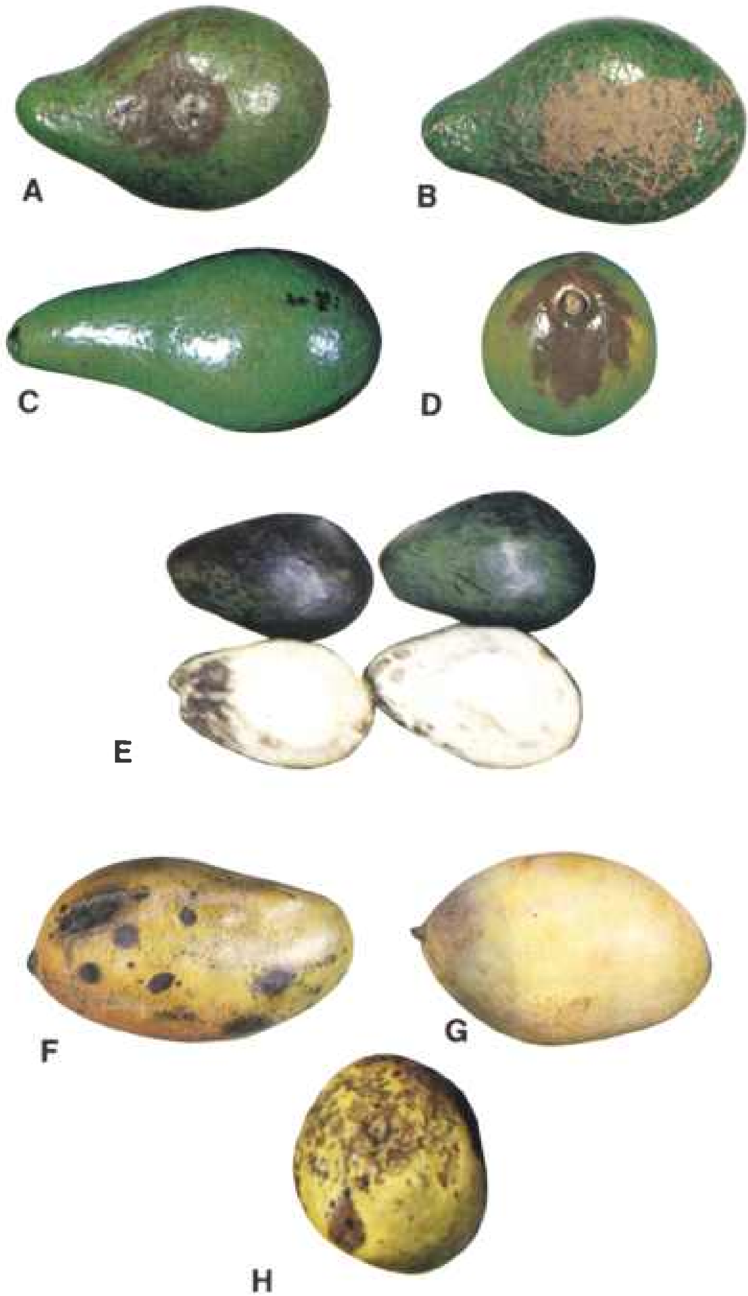
DISORDERS FOLLOWING CHILLING AND OTHER INJURIES

A, Oil-gland darkening of grapefruit; B, brown staining of Temple orange; C, membranous stain of lemon; D, hot-water damage to grapefruit; E, SOPP injury to grapefruit; F, chemical injury due to spray residue on grapefruit; G, chemical injury (dry fertilizer) to grapefruit prior to harvest; H, sand bruising of grapefruit due to sand on bottom of field boxes.



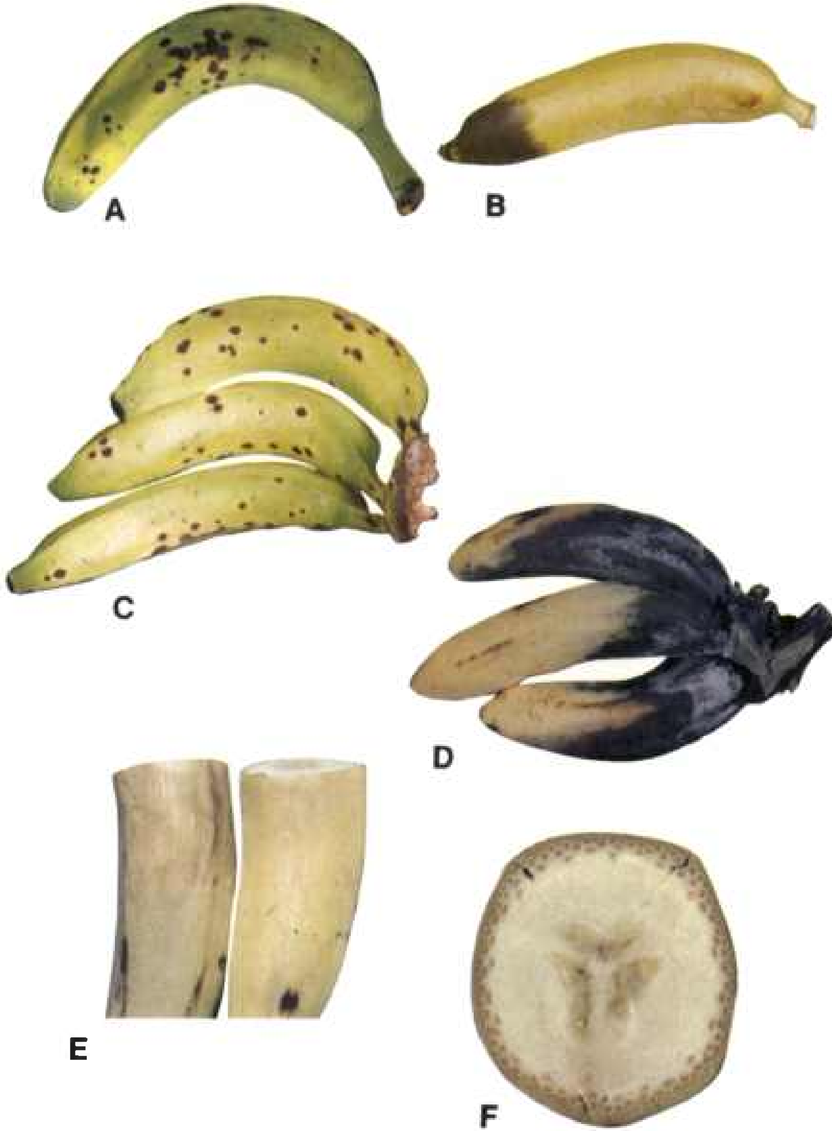
MISCELLANEOUS DISORDERS OF CITRUS FRUITS

A, Rind-oil spotting of Marrs Early orange; B, rind-oil spotting following insect injury of orange; C, bruising of navel orange followed by color-add treatment; D, brush burn of orange; E, zebra skin of tangerines due to handling immature fruit following rainy periods (note poor color of affected fruit); F, sunburn injury of tangelo; G, puffiness of tangerine; H, water spot of navel orange.



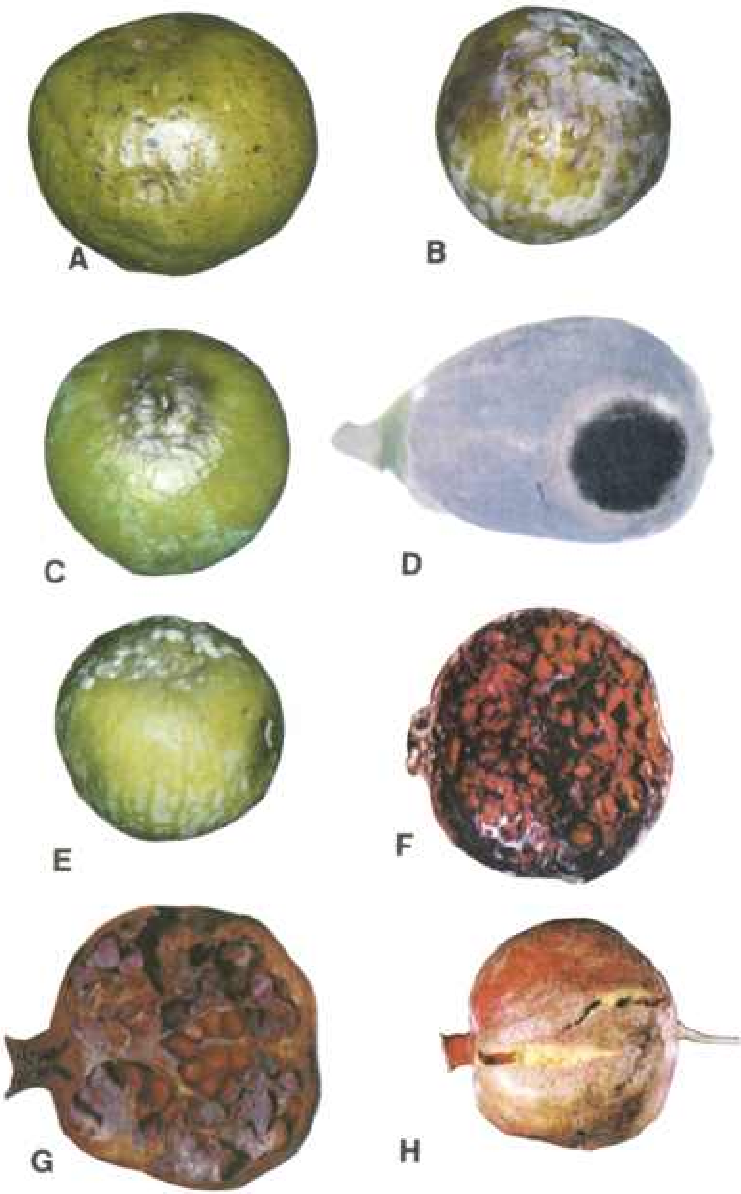
DISEASES AND DISORDERS OF AVOCADO AND MANGO

A, Anthracnose of avocado; B, scab of avocado; C, cercospora spot of avocado; D, diplodia stem-end rot of avocado; E, chilling injury of avocado; F, anthracnose of mango; G, diplodia stem-end rot of mango; H, chilling injury of mango.



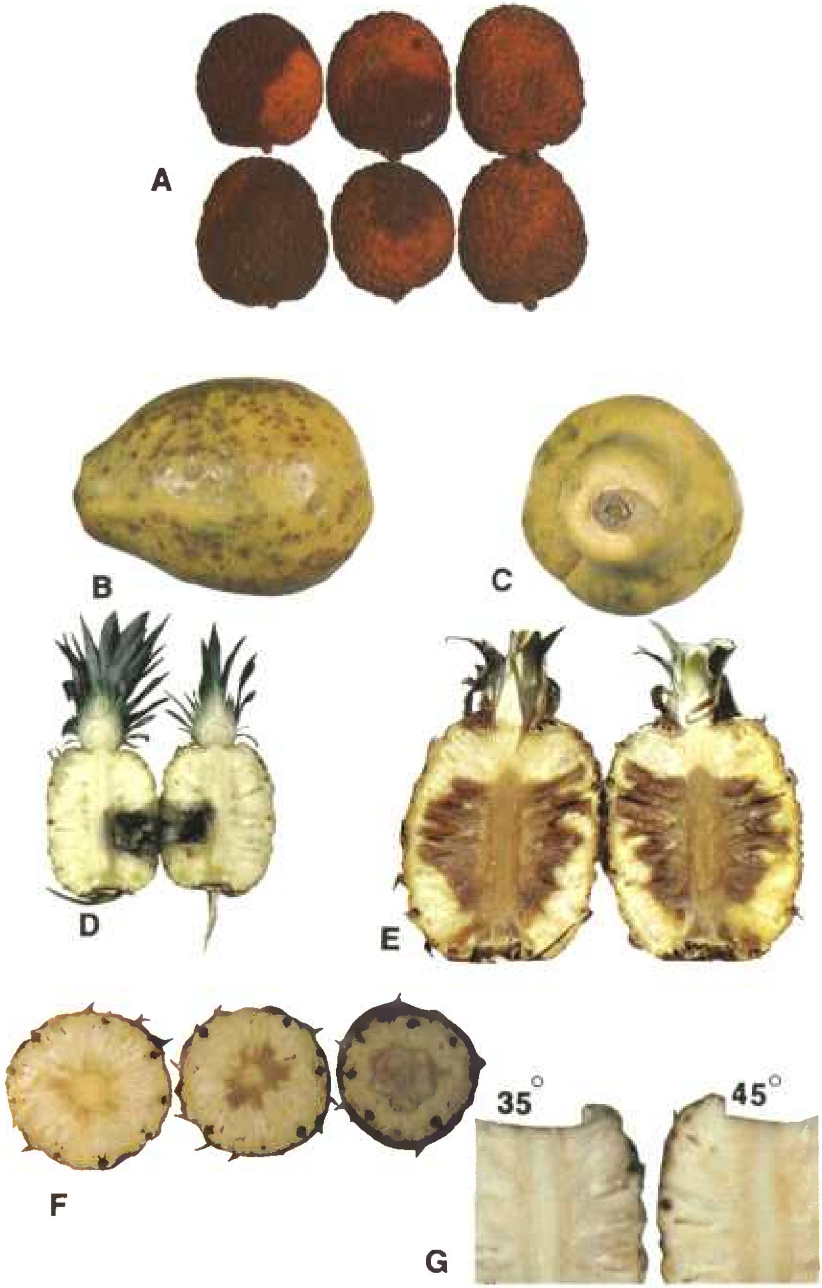
DISEASES AND DISORDERS OF BANANA

A, Anthracnose of banana; B, botryodiplodia fruit rot of banana; C, pitting of bananas; D, thielaviopsis rots of bananas; E, chilling injury of banana peel; F, internal chilling injury of banana.



DISEASES AND DISORDERS OF FIG AND POMEGRANATE

A, Alternaria rot of fig (early infection); B, alternaria rot of fig (severe infection); C, alternaria rot of fig (around eye); D, aspergillus black rot of fig; E, botrytis gray-mold rot of fig; F, heart rot of pomegranate; G, blue-mold rot of pomegranate; H, splitting of ripe pomegranate.



DISEASES AND DISORDERS OF LYCHEE, PAPAYA, AND PINEAPPLE

A, Physiological browning of lychees; B, anthracnose of papaya; C, stem-end rot of papaya; D, black rot of pineapple; E, brown rot of pineapple; F, physiological breakdown of pineapple (successive slices from base of fruit); G, chilling injury of pineapple at 35° F.

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PRECAUTIONS

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations.

PROTECT

Use Pesticides Safely
FOLLOW THE LABEL
U.S. DEPARTMENT OF AGRICULTURE

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