The Diseases Bacteria Cause

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Diseases caused by bacteria are responsible for a large share of the spoilage of fresh fruits and vegetables in storage or during marketing.

Losses from infection by the soft rot group of bacteria are especially important. They attack nearly all vegetables and on each may cause a serious decay within a few hours. They do not cause decay of tree fruits.

Of lesser importance are bacteria that cause leaf, stem, and fruit spotting and internal discoloration and decay. Both tree fruits and vegetables are affected by bacterial diseases of this type. Though the infected areas are usually limited in size and depth and may be trimmed out without serious waste, the spots make the produce unattractive, form places for invasion by other organisms, and cause serious inconvenience and added expense in preparing the produce for use.

The bacteria that cause postharvest diseases of vegetables and fruits belong to five of the six genera of bacteria that cause plant diseases. In the soft rot group are species of the genera Pseudomonas, Erwinia, and Bacillus. Members of the genera Pseudomonas, Xanthomonas, Erwinia, and Corynebacterium are responsible for the necrotic lesions on leaves, stems, and fruits, and internal discolorations and decay.

As the two groups differ widely in the symptoms they produce and the plants they attack, we discuss them separately.

Bacteria that produce soft rot are most common on vegetables that have either a succulent, tender type of growth or fleshy storage tissues. Among the first are such leafy vegetables as lettuce, endive, and spinach; stem or stalk types, like asparagus and celery; and the leafy tops of root crops like carrots and radishes. In the second group are potatoes, carrots, radishes, parsnips, beets, and turnips.

The soft rots are well known because of the losses in white potatoes during transit and marketing. Often 1 to 2 percent of the sacks in a car or truck contain potatoes that are affected with bacterial soft rot. Losses of 5 to 10 percent are not uncommon. The appearance of one "wet sack" in a load indicates soft rot infection to the inspector or purchasing agent, and a reduction in the price of the entire load often follows. A 7-year study of railroad car inspection reports for New York City disclosed that losses due to decay of vegetables was 3.8 percent. Bacterial soft rot alone was responsible for 38 percent of the decay and was found on all of the 31 vegetables inspected, except corn and sweetpotatoes.

The first complete account of any bacterial soft rot and its causal organism was one concerning carrots by L. R. Jones in 1901. He named the causal organism Bacterium carotovorum. Later the name was changed to Erwinia carotovora. Since then soft rots of many of the vegetables have been attributed wrongly to E. carotovora, although other species of bacteria were to blame. At least two other species of the genus Erwinia—E. atroseptica and E. aroideae—cause soft rot of vegetables.

A number of species of the genus Pseudomonas have been described as the cause of soft rot. Among them are P. solanacearum on potatoes, P. marginalis, and P. viridiflavidum on lettuce and endive, and P. alliiocola and P. cepacia on onions. Three species of the genus Bacillus—B. polymyxia, B. subtilis, and B. megatherium—cause extensive soft rot of potatoes. Each of the species has been reported to infect
many different vegetables, and soft rot of vegetables after harvest may be caused by bacteria other than *Erwinia carotovora*. Sometimes it may be caused by a combination of several species.

Soft rot starts on leaves, stems, and seed pods as small, water-soaked, translucent spots, which later may become muddy green or greasy. Rapid softening and disintegration of the diseased tissue follows. Within 20 to 48 hours the entire structure may become a wet, slimy mass.

The first symptom of soft rot on root crops is a water-soaked appearance of the affected tissue. The diseased parts later disintegrate into a mushy mass of disorganized cells, which slough off, while the rest of the root remains firm. The bacteria may invade the plant at the crown and the decay may extend deep into the root through the innermost cells while the outer tissues remain apparently healthy.

The first symptoms on tubers often are a dark or black discoloration of the surface and a somewhat blistered appearance of the skin. The affected tissues are usually cream-colored, soft, and not watery. They are separated by a distinct boundary from the sound tissues so that, if pressed, the mushy tissue squirts from the tuber. Often the outer surface of the tubers appears healthy while the inner part is a mass of rotting cells. Upon exposure to air, the infected tissues may turn tan, gray, or dark brown. Infection may occur first at the lenticels, which at first are water-soaked and swollen. The tissue underneath is generally firm. Unless the potatoes are exposed to high temperatures, the infected area often dries up. Infected tubers have little smell until the infected tissues collapse. Then a foul odor may develop because of bacteria that live on the decomposing tissue.

The complex nature of soft rot is indicated by the following summary of the symptoms of soft rot caused by different bacteria on several kinds of vegetables.

**Potato**

*Erwinia carotovora*: Rot at lenticels or at injuries. Internal rot usually cream or light-tan color.

*Erwinia atroseptica*: Rot usually starting at stem end but sometimes at injuries, black and sunken, sometimes dry. May progress through heart of tuber. Internal rot brown to black-brown color.

*Bacillus polymyxa, B. subtilis, and B. megatherium*: Usually starts at injuries and extends to heart of tuber. Internal rot dark brown to black, or grayish cast.

*Pseudomonas solanacearum*: Causes depression at point of stem attachment. Gray-brown discoloration at the surface and moist brown discoloration of water-conducting system. Entire inner tissue of potato may become soft and brown.

**Lettuce, Chicory, Escarole, Endive**

*Erwinia carotovora*: Inner leaves of head at first have a greasy water-soaked appearance. Later infected areas turn dark brown and become slimy.

*Pseudomonas viridilividium*: Outer leaves spotted or darkened. Center of head at first firm but later soft rot develops.

*Pseudomonas marginalis*: Starts as greasy water-soaked spot that later turns greenish to reddish brown. The infected tissues are soft and slimy and rapidly disintegrate into a foul odorous mass.

**Onions**

*Erwinia carotovora*: Affected tissue glossy or water-soaked, later mushy. Generally starts at neck, often confined to central scales. Foul odor.


*Pseudomonas cepacia*: Outer scales yellow and slimy. Inner scales not affected. Upper portion of bulb shrinks and skin slips off.
Tomato

*Erwinia aroideae*: Skin water-soaked, light-colored, greasy translucent, blistered with mass of gas and decomposing cells. Decay progresses rapidly.

*Erwinia carotovora*: Rot on ripe fruit brownish, often limited to slowly spreading circular lesion.

*Erwinia atroseptica*: Lesions on ripe fruit dark and water-soaked, and spreading medium rapidly. Medium gas formation and only slight blistering. May be firm.

Celery

*Erwinia carotovora*: Affected lesions water-soaked and softened. Infected areas turn brown and mushy, but epidermis remains intact. Decay may affect crown, leaf stalks, and leaflets.

Melons

*Erwinia aroideae*: Decay usually on under side of fruit. Skin shrunken but usually nearly intact. Bacterial ooze through skin. Internal infection forms irregular funnel-shaped decayed section extending into the cavity. Entire inner portion becomes soft and outer tissues may collapse.

The soft rot bacteria grow and cause infection over a wide temperature range. *Erwinia carotovora* and *E. atroseptica* grow at temperatures from about 35° to about 89° F. *E. aroideae* grows at temperatures up to 105°. The optimum temperatures for growth and infection by the three organisms are 77°, 78°, and 95°, respectively. The soft rot bacteria of the genus *Pseudomonas* grow at temperatures from about 41° to about 102°, with an optimum around 86°. Growth of soft rot bacteria in the genus *Bacillus* is scant or absent below 55° and greatest at slightly above 89°. One species within this group, *B. subtilis*, will grow at 122° and *B. polymyxa* and *B. megatherium* at temperatures above 105°. At the lower temperatures, therefore, infection by bacterial species in the genera *Erwinia* and *Pseudomonas* is most probable. At higher temperatures soft rot would more likely be caused by species of *Bacillus*. Although soft rot may occur over a wide temperature range the highest percentage is apt to develop within the range of 69° to 89°, where most of the bacterial species that cause soft rot grow well.

Organisms that cause soft rot live for long periods in the soil and may infect plants before they are removed from the field. Contaminated water in large washing vats resulting from washing infected produce is also a source of infection. Infection of many vegetables may occur in trimming, as cutting knives transmit the bacteria from diseased to healthy plants.

Standing water in the field when the plants are approaching maturity, injury from exposure to sun and wind on hot, dry days, and mechanical injuries during harvesting, grading, and packing may form places for bacterial invasion and favor development of soft rot.

Soft rot often is not evident at the time of storage or when the produce is shipped to market, but in order to delay the possible development of the disease it is customary to use low temperatures during storage or transit. During short storage periods or in transit, temperatures below 50° will delay the appearance of soft rot symptoms. For longer storage periods, temperatures approaching 32° are recommended for leafy vegetables and root crops and 40° for potatoes. It is highly important to keep moisture from condensing on the produce. Standing moisture facilitates invasion by soft rot bacteria. If the temperatures fluctuate above 32°, infection and decay follow rapidly. Low temperatures do not prevent bacterial infection, but they delay development of decay and are the common (and possibly the best) way to preserve fresh produce. Soft rot often develops rapidly, however, after the produce has been removed from refrigerated
storage. Such produce should be consumed or processed as soon as possible after removal from cold storage.

Good control of bacterial soft rots may be obtained by care in sorting and packaging the produce. Spreading of infection is retarded by use of sterilized trimming knives, eliminating and disposing of diseased produce before it comes in contact with healthy material, sorting out injured or bruised produce, and careful handling to avoid causing mechanical injuries. Curing potatoes at moderate temperatures and high humidity before storing or shipping allows the injured surfaces of the tubers to "cork over"; the "cork layer" prevents the entrance of most bacterial pathogens.

The bacterial diseases that cause spotting and wilting are most important during the growing period, but sometimes they continue to develop after harvest and cause damage in storage or at the market. The wilt diseases cause discoloration of the internal tissues and are often not discovered until the vegetable is cut when it is prepared for food. The symptoms of the more important of these diseases are:

**Tomato**

Bacterial spot (caused by *Xanthomonas vesicatoria*): Spots on mature green fruit are brownish-black, elevated, scabby areas, one-eighth to one-fourth inch in diameter, with feathered or irregular margins. Old spots are sunken, gray, or bleached and the affected skin is dry, paperlike, and ragged. Spots are superficial and do not develop into soft rot.

Bacterial speck (*Pseudomonas tomato*): Causes dark brown, slightly raised specks, one thirty-second to one-sixteenth inch in diameter, with definite margins. Spots are superficial and decay does not follow.

Bacterial canker (*Corynebacterium michiganense*): Spots on mature green fruit are light brown to brown, slightly raised circular areas, about one-sixteenth to one-eighth inch in diameter. They are surrounded by a characteristic white halo. Spots are superficial and do not develop into soft rot.

**Beans**

Common blight (*Xanthomonas phaseoli*) and halo blight (*Pseudomonas phaseolicola*): Cause circular to irregular-shaped, wet or greasy-appearing spots on the pods. The margin of the common blight spots becomes almost brick red as the spots become older. A yellowish crust of bacterial ooze is sometimes evident on the common blight spots and a grayish-white crust on the halo blight spots.

**Peas**

Bacterial blight (*Pseudomonas pisi*): Pod spots in the early stages are small and water-soaked. In more advanced stages they are larger, slightly sunken, greasy, or water-soaked, irregular-shaped, and have gray or grayish-brown centers.

**Cucumbers**

Bacterial spot (*Pseudomonas lachrymans*): Spots on cucumbers start as minute, circular, water-soaked areas. Later the affected tissues dry and crack and the centers of the spots become sunken and chalky white in color. A gummy exudate is sometimes present on the spots. A breakdown and soft rot frequently follow.

**Cauliflower and Cabbage**

Leaf spot (*Pseudomonas maculicola*): Leaf spots are water-soaked at first and then become brownish or purplish gray. They coalesce and become elongated as they enlarge and give the leaf a ragged appearance. Spots on the cauliflower head are small, gray to brown, and affect both the epidermis and deeper tissues. Later develops into soft rot.
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Black rot (Xanthomonas campestris): Causes yellowing of the leaves and blackening of the veins. Leaves shed from stalk. Often followed by soft rot.

Celery

Bacterial blight (Pseudomonas api): Causes numerous small irregular-shaped spots on the leaflets. Spots are yellow at first, but later are rusty brown with a yellow border or halo.

Stone fruits

Bacterial spot (Xanthomonas pruni): Fruit spots at first are small, circular, and light brown. Later they enlarge, darken, dry out, and crack. A viscid, yellowish, gummy exudate is sometimes present on the lesions.

Lemon

Black pit (Xanthomonas citri): Fruit spots are sunken, roughly circular, one-fourth to one-half inch in diameter, brown at first and later black. The white part of the peel beneath the pits collapses and turns light brown to reddish brown.

Potato

Ring rot (Corynebacterium sepedonicum): Causes odorless decay that is confined at first to vicinity of vascular ring of the potato. Affected tissues are cream-colored to pale lemon yellow and have a soft cheesy texture. Starts at stolon attachment and progresses through vascular system to the eyes. Causes characteristic cracking that extends into the vascular ring. Soft rot frequently follows.

Brown rot (Pseudomonas solanacearum): May cause a slight depression at the stolon attachment. Sometimes shows as a grayish discolored patch on surface of potato. Causes moist brown discoloration and slight softening of the vascular ring. A gray sticky bacterial ooze often exudes from the vascular tissue. Later the interior becomes soft brown and only the shell of the potato holds it together.

Fruits and vegetables affected with bacterial spot and wilt diseases at harvest should be carefully graded and sorted to eliminate all that show symptoms of disease and then should be refrigerated promptly to retard development on the apparently sound produce. They should be used as promptly as possible after they are removed from the refrigerated storage.

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