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AVOCADO FRUIT DECAYS

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A few years ago I raised the question with my friends at the Citrus Experiment Station, what are the principal agents which cause spoilage and loss of avocado fruits? It appeared that an extremely meagre scientific literature existed on the subject and that nobody was giving very much study to it. Accordingly I have given as much attention as I could with other duties, to this interesting question.

We know that oranges spoil mainly from blue and green molds, with brown rot (Pythiacystis rot), sour rot, cottony rot and others. We know that, with minor exceptions, these rots do not affect apples. More or less each fruit has its own particular enemies. Spoilage in fruits comes mainly from attacks by partially parasitic organisms, but unfortunate changes may come about from processes within the fruit itself. Conditions of the fruit may give opportunity for the entrance of the molds, bacteria, etc., which cause rapid spoilage. See also the very important contribution by C. O. Smith on avocado blast in this Report, which should explain some at least of the trouble from scabbing and cracking of unripe fruit on the trees. These scabs may furnish places where some decay organisms can enter.

Overripening

Ripening before fruit reaches the consumer may occasion serious loss and especially since our people do not always know just how far they may go in the use of soft avocados. I have had dealers give me perfectly good fruit for study because they feared it was too soft for use.

The ripening processes are changes in the living flesh of the fruit and these changes doubtless would, if uninterrupted, go on until the fruit would not be desirable for food. This does not occur because the ripe fruit becomes a prey to so many molds, bacteria and other organisms that we do not have a chance to find out what the ultimate results of natural ripening would be.

The greatest importance attaches to first, keeping the fruit on the tree to a suitable stage of maturity, and then of getting it to the consumer in the earliest acceptable stages of ripeness.

It is the ripe fruit which decays and the writer has found certain organisms mentioned below causing active decay of the ripe fruit.

Black Mold Rot or Rhizopus Rot

Black mold or bread mold (Rhizopus sps.) is the most rapid working and altogether the most menacing fungus which we have found in connection with avocado spoilage. This is the fungus which causes rapid breakdown of ripe berries, peaches and pears, of sweet potatoes and of many fruits and other food stuffs. It is known to fruit stand men as "whiskers" because of the long, copious, hairlike growth, at first white and then more or less black. It is not a parasite of healthy growing plant tissues but can attack the flesh of ripe fruits where sugars and other available nutrients are abundant.

Rhizopus is primarily a wound fungus on the avocado but when the fruit becomes ripe it can penetrate the unbroken skin. A fruit rotted with Rhizopus in moist air is covered with coarse, copious fungous mycelium, sometimes an inch tall but collapsing and turning from white to nearly black with numerous black specks. The specks are the spore-bearing structures (sporangia) and each contains a very large number of microscopic spores which are liberated when the sporangia are broken.

The coarse threads of the fungus penetrate throughout the flesh of the fruit which becomes moist, less firm/buttery and more wet fibrous. Where the decayed flesh is pulled off from the seed the surface of flesh and seed is wet and rough from the presence of the coarse fungus threads. The seed is not penetrated nor injured for planting. The flesh becomes rank smelling and disgusting.

As Rhizopus rot advances through a fruit it is not possible to recognize clearly the limits to the decay. This has been particularly true of firm fleshed fruit like the Fuerte. The mycelium grows forward through the fruit as more or less isolated coarse threads following the lines of least resistance, sometimes through the fibres in the flesh, between the seed and flesh or along areas of softer tissues. If the atmosphere is moist the mycelium grows over the surface more rapidly than through the flesh and from the surface penetrates inward. Progress of the mycelium has varied somewhat but in moist air and at room temperature it generally advanced about an inch in two or three days. Firm fleshed fruits may be covered by the fungus and largely penetrated so that any piece as large as a pea would contain the fungus and be completely spoiled as shown by the odor and at first not much is detected, though the coarse fibre of the fungus may be felt on the tongue. At a fairly early stage the taste becomes unquestionably bad but the flavor is not easily described.

It has been reported that food material in which Rhizopus has been growing may cause pronounced nervous disturbances. No person in possession of his senses would be likely to eat avocado with advanced Rhizopus rot but it became desirable to have some idea as to the possible danger from such food. Through the kindness of Dr. C. M. Haring, Professor of Veterinary Science in the University, Mr. B. S. Henry, an advanced student in Plant Pathology and an expert in the handling of experimental animals, fed five grams of typically Rhizopus rotted avocado flesh to each of two guinea pigs and ten grams to a rabbit. The animals showed no signs of harm from this food.

Rhizopus is of almost universal distribution so that by sanitation we may not hope to do more than reduce its abundance. However, a number of facts are fortunate. It does not attack sound and unripe fruit, a certain amount of moisture and warmth are necessary for its growth and sometimes it fails to grow for unknown reasons. In making

inoculations in numerous cases it has failed to start growth promptly where conditions were thought to be favorable. Few fungi have been more studied and many of its features, as its relation to temperature, are well known. Growth is prevented or stopped below about 40-deg. F. and is slow below 50-deg. F. It is most active at room temperature or higher. By skill in management, cold storage, and prompt using, loss from Rhizopus should be practically eliminated, but it remains a possible source of calamitous loss.

A peculiar feature of the avocado should be noted here. As the fruit ripens the stem or calyx button dries and shrinks. At the same time the flesh also shrinks somewhat, bringing about a separation between flesh and calyx button. This is an open wound into the flesh and a. very good place for any sort of decay organism to enter and grow. Dipping the stem end when freshly cut, into denatured alcohol and when dry into melted paraffin has prevented this splitting in a few laboratory experiments. This feature should be watched.

Pythiacystis Rot

Pythiacystis rot, caused by the fungus of lemon brown rot and of lemon gum disease (*Pythiacystis citrophthora* S & S) has not been observed in naturally infected avocado fruit by me. We have produced this rot by inoculating sound ripe fruit with a pure culture furnished by Dr. H. S. Fawcett. Infection may be by a wound or by contact with the unbroken surface. A spot 2/3 inches in diameter is produced from a single infection in ten days. In moist air the surface becomes covered with tiny whitish tufts in which the spores of the fungus are produced freely. Color and texture of the surface are otherwise not strikingly changed. The flesh is penetrated to the seed and becomes firmer and tougher and more elastic than normal and less buttery. As compared with Rhizopus rot texture of the invaded flesh is firmer, more finely fibrous and less watery, and progress is much slower.

This rot has not been extensively studied, having been merely produced by artificial infection, but no doubt it will sometimes appear naturally in rainy seasons and on low fruit. Fortunately methods of control have been developed for citrus fruits. Dr. Fawcett has already shown that a very violent form of canker disease on large avocado trunks is due to this or a very similar fungus and I have observed a disease of avocado tree bark in Cuba which I suspect may be due to this sort of fungi.

The Florida Rots

From the study of a limited number of fruits found in the market and said to be from Florida I have come to the belief that the Florida fruit can be distinguished from the California fruit by the fungi which develop on it.

Diplodia rot, caused by the fungus tentatively identified as *Diplodia natalensis* I. B. Pole-Evans, is a dark colored rot, dryer than Rhizopus rot with a pronounced blackening of both flesh and surface. The rot acts more slowly than Rhizopus rot and is more definitely cut off from the unspoiled portion. Tiny black pimples appear on the affected part and if moisture is abundant a fine cottony fungous mycelium covers the surface

with a white growth which turns irregularly to black. Seed, as well as flesh, is slowly invaded with a dry, corky decay and is destroyed. Definite cankers on small trees were produced by inoculation in our greenhouse. Fungi of this or related species are serious enemies of citrus fruits in Florida, the West Indies and on avocados and citrus fruits in South Africa. A fungus on Taft avocados, given to the writer by Professor Overholser from his storage studies, appears to be similar to the Florida fungus but has not yet been carefully studied. Professor Fawcett has pointed out to me that there seems to be a difference between the Diplodias found in California and *Diplodia natalensis* of Florida. No wound is necessary for the initiating of Diplodia rot, less moisture is necessary than with Rhizopus rot and decay is steady and sure. Our inoculations of fruit have been practically 100% successful.

Anthracnose, or wither tip rot is caused by the wither tip fungus *Colletotrichum gloeosporioides* Penz. Ripe fruit becomes darkened in patches and moist salmon colored points appear on the dark patches and turn to a pink on dying. The salmon to pink points are masses of microscopic spores. This is not a rapid acting rot but by the great number of spores attack may be made at many points on the surface. Penetration is without wounding and the fungus enters flesh as well as rind, but our studies have not yet established all the features of this rot. I believe there is much misapprehension as to the seriousness of the withertip disease both on orange and avocado trees. There is much non-critical writing on the subject in the literature and I believe that serious injury on orange or avocado trees is comparatively rare, though old or injured tissues are freely attacked. Withertip as a fruit rot on citrus and avocado is apparently a matter of importance. I have never observed on tender young foliage, flowers and fruit of avocado any such destruction as occurs very commonly on lime and mango in Florida and Cuba.

Pestolotzia rot, caused by Pestalotzia sp. has been observed in Florida avocados as patches on over ripe fruit, resembling the withertip patches but instead of salmon to pink, intense black points appear. Our studies thus far indicate that this rot has features similar to the withertip rot but it is less aggressive and abundant.

The California Dry Rots

In addition to the moist Rhizopus rot, California avocados spoil from a number of molds which invade the tissues slowly at wounds *Alternaria* sps. are greenish or smoky-gray molds of the type which cause internal black rot of naval oranges and dry rot of pomegranates. *Fusarium* sps. have been found as light colored molds, forming definite dense patches and gradually sinking spots. Apple blue mold, the most common cause of apple wet rot, causes a rather slow, dry rot of avocados with bright bluegreen powdery, sunken spots on the surface. *Cladosporium* sp. forms a fine powdery to nearly velvety greenish covering in wounds and on scabs. Various other fungi have been found less constantly. These molds work slowly and affected fruit may be trimmed and sound portions used. It is interesting to note that the blue and green molds of citrus fruits have failed to attack avocados in our experiments; cottony rot mold grows rather slowly in avocado, turning black fruit to wine color, Botrytis or gray mold so common in berries acts much as cottony rot mold; the brown rot of apricots inoculated into ripe avocados has grown very little in our experiments. A very large number of common molds grow

well on avocado and doubtless most of them cause some form of decay.

Bacteria

Avocados in advanced stages of spoilage are found to have abundant infection with bacteria; especially if the fruit is cut the surfaces become covered with a white and then dirty slime which is a mass of bacteria. One set of fruit developed red bacteria giving the cut fruit a blood-like stain on standing over night. Very little work has been done on these bacteria but some inoculations have been made from which it appears that they are not aggressive invaders of avocado flesh but develop on exposed surfaces or may follow rot fungi. The very offensive smelling purification in some avocado fruits is doubtless due to certain kinds of bacteria.

How Serious Are Fruit Rots to California Avocados

In Cuba and doubtless in other countries which produce their avocados during the rainy midsummer and where refrigeration and careful handling are not developed, the avocado is decidedly a perishable fruit. In California with a large part of the crop maturing during the cool season, with a dry Summer to restrain Diplodia, anthracnose and other fungi on the fruit, with refrigeration and careful handling and skillful management to prevent Rhizopus rot, the outlook for marketing avocados to distant places is most promising. My observations in the San Francisco Bay region suggest that there is less loss than with oranges. Even the cities of tropical countries may become our best markets for eight or nine months of the year.

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