

# Fungus causes deterioration of dried prunes

Peter L. Sholberg □ Joseph M. Ogawa

**D**eterioration of dried French prunes is characterized by macerated, wet, sticky areas on the fruit surface and by skin that tends to slip with the slightest pressure. This condition is most often the result of fresh-fruit decay caused by the fungus *Rhizopus stolonifer*. The mold is also known as "bread mold fungus" or the "whiskers disease" on fresh market stone fruits, strawberries, and almond hulls. Prune growers have called this type of deterioration of dried prunes "box rot" and have suspected it to be responsible for serious losses.

In 1978 we began to accumulate evidence that *R. stolonifer* is the cause. Discussions with prune growers, packers, and farm advisors established that the condition of fresh fruit just before drying was possibly related to development of deterioration (box rot). Initial experiments, which proved negative for deterioration, included testing fruit of different sizes and soluble solid content, sunburned fruit, and fruit injured by rough handling.

Fungi were implicated by pilot tests, which consisted of holding fruits for 0, 24, 48, and 72 hours before drying to different moisture contents. Significant deterioration occurred if the fruit remained at ambient temperature (85°F) for 48 hours or more before drying. The moisture content of the dried product or length of time stored under controlled environments did not influence the deterioration; only the length of time fresh fruits were allowed to decay before drying had an effect.

We tested several fungal pathogens of prunes for their ability to cause deterioration, including the brown rot fungus (*Monilinia fructicola*), the rhizopus rot fungus (*Rhizopus stolonifer*), and blue mold (*Penicillium expansum*). We also tested *Aspergillus* spp. commonly found on dried prunes. Freshly harvested prunes were surface-sterilized with a 10:1 dilution in water of household bleach (5.5 percent sodium hypochlorite), air-dried, wounded with a needle and inoculated with a heavy spore suspension of a candidate fungus. Samples were incubated for 24, 48, and 68 hours

at 82°F and then dried commercially. Coded samples of dried prunes were rated for box rot by industry inspectors.

Results of these inoculations proved that *Rhizopus* could cause significant fresh-fruit decay in 24 hours and excessive decay after 68 hours of incubation. After drying, these fruits were confirmed to be "box rotted" by industry inspectors (see table). (Since the prunes are deteriorated and not the box, we prefer to use the term "deterioration" rather than "box rot" for this condition on dried prune fruits.)

As further evidence, 25 prunes inoculated with *Rhizopus* spores were placed below the upper surface layer of fruit in bins of commercially harvested prunes purchased from growers in Tulare, Sonoma, and Yuba counties. At ambient field temperatures, the *Rhizopus* fungus quickly spread to adjacent healthy fruits within the bin in 24, 48, and 72 hours of incubation and after drying induced symptoms of deterioration on the dried prunes.

Critical observation of decay development on fresh prunes showed that mature and over-mature mechanically injured fruits were most susceptible to initial infections. Once the *Rhizopus* fungus was established in the fruit, it quickly spread to nearby fruits by means of aerial fungal strands (stolons) growing from fruit to fruit. Later the white mycelial mat developed gray-black round fruiting bodies (spore-bearing structures), which when disturbed, released masses of spores that contaminated fruits in the same bin as well as in other bins. At this stage juice from rotting prunes containing enzymes able to macerate prune tissue, as well as spores, dripped down onto healthy fruits, providing another mechanism for injury and infection.

The optimum temperature for *Rhizopus* development is around 28°C (82°F), and the fungus grows rapidly when the relative humidity is near 100 percent. The environment in a bin of freshly harvested prunes is very close to these optimum values, especially in the afternoon harvest. Other decay-causing or-

Percent "box rot" of dried prunes inoculated with various fungi

Fungus	Rot after following hours of incubation before drying		
	24	48	68
	%	%	%
<i>Rhizopus arrhizus</i>	14	35	94
<i>R. stolonifer</i>	2	25	74
<i>Aspergillus japonicus</i>	0	8	40
<i>Penicillium expansum</i>	0	4	10
<i>Monilinia fructicola</i>	0	12*	6
<i>Aspergillus chevalieri</i>	0	0	4
Control (surface-sterilized)	0	0	2
Control (non-sterilized)†	10	12	58

\*Visual examination indicated that this sample was contaminated by other fungi in addition to the test fungus.  
†Control (nonsterilized) prunes were naturally infected with *Rhizopus*.

ganisms do not develop as rapidly in bins and are usually not a problem if the fruit is dried in 24 hours.

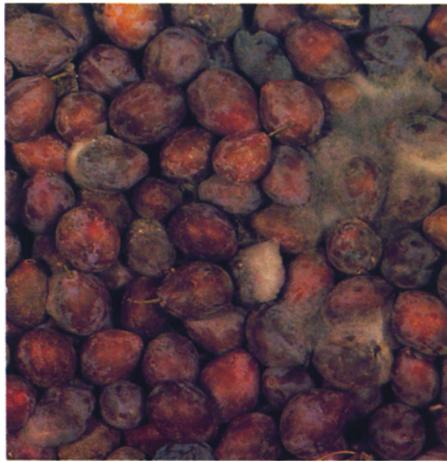
We also found that fruit dropped from trees and harvested from the orchard floor developed more decay than those harvested onto catching frames. Since the soil is a common source of living *Rhizopus* spores, fruits shaken to the ground may be injured and inoculated at the same time. Fruit without mechanical injury is resistant to infection, even though its surface may be contaminated with *Rhizopus* spores.

The following evidence shows that *Rhizopus* can cause deterioration of dried prunes: (1) *Rhizopus* could rot freshly harvested surface-sterilized fruits within a 24-hour period of incubation at ambient field temperatures; (2) dried *Rhizopus*-rotted fruit were classified by inspectors as "box rotted"; (3) both naturally and artificially induced deteriorated dried fruit contained a peptolytic enzyme naturally produced by *Rhizopus* during decay of fresh prunes; and (4) prune dehydration personnel indicated that fresh prunes harvested and dried within 24 hours seldom had deterioration problems.

To reduce deterioration ("box rot") of dried prunes we suggest the following:

□ Dry the prunes within 24 hours of harvest.

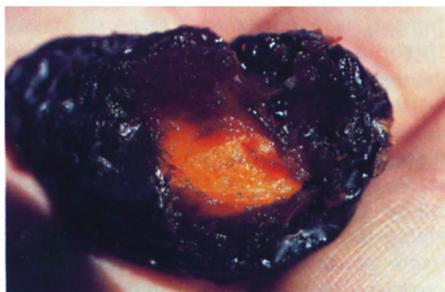
□ If fresh prunes cannot be dried within 24 hours, keep the fruit in cold



**Rhizopus fungus infection spreads rapidly in fresh prunes stored in standard harvest bin.**



**Sulfur treatment to create golden color of prunes (right) kills *Rhizopus* fungus spores.**



**"Box rot" fungus infection of French prunes is characterized by macerated, wet, sticky areas on the fruit surface and a skin that slips with the slightest pressure.**

storage at temperatures below 41°F to prevent rhizopus rot.

□ If cold storage is not available, fruits harvested in the morning should be held for drying after those harvested in the afternoon. Fruits harvested in the morning remain cooler longer and thus are less favorable for *Rhizopus* growth.

□ Protective chemical treatment of fresh prunes with compounds such as potassium sorbate has reduced decay rates under experimental conditions (not registered at this time).

□ In sun drying, if the golden color of prunes is desired fresh fruits may be exposed to burning sulfur or sulfur dioxide gas to kill fungal spores and make the prunes resistant to *Rhizopus* infections.

*Peter L. Sholberg is graduate student, and Joseph M. Ogawa is Professor, Department of Plant Pathology, University of California, Davis. This research was supported in part by the California Prune Advisory Board. The authors thank employees of Sun Diamond for their technical help in assessing deterioration and Mr. Clarence Paine for drying experimental fruit at the Fairfield dehydrator. The technical advice from Dr. T. Kosuge and technical assistance of Bill Manji, Elaine Bose, Steve Sibbett, Steve Koike, and Bob Hanowell are appreciated.*

## **Conserving water can have both beneficial and adverse effects**

**S**ince agriculture accounts for 85 percent of the state's applied water demands, much emphasis has been placed on agricultural water conservation. Farmers have practiced various forms of water conservation for years, particularly in areas where supplies are deficient and sometimes barely adequate to irrigate their planted acreage, but there is little incentive to conserve when water is plentiful and inexpensive. The complexities of the total water system suggest that reductions of water consumption by one user may have indirect or incidental effects on other uses and users. These effects may be costly or beneficial and, to the extent that they occur off the farm, growers have no direct incentive to account for them. The incidental effects of farm water conservation actions were the subject of a study suggested by the California Department of Water Resources (DWR).

### **Agricultural water conservation**

In the November-December 1981 issue of *California Agriculture*, we briefly described concepts and techniques for conserving agricultural water and emphasized the distinction between the saving of water that is ultimately recoverable and the saving of water that is ultimately lost for use and is thus irrecoverable. Incidental effects of reducing recoverable losses (leakage, seepage, spillage, deep percolation, runoff) fall into a variety of categories, some of which occur on-farm and some off-farm. When irrecoverable evapotranspiration losses are reduced, on-farm crop yield may be curtailed; when irrecoverable flows to saline sinks are reduced, there can be off-farm incidental effects on in-stream values and on the saline water bodies that receive agricultural return flows.

### **Incidental effects**

In a report to the DWR, we identified over 400 potential incidental effects of agricultural water conservation actions and divided them into 23 categories. Examples of these effects are given in