Cold storage of French prunes may expand dehydrator capacity

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Improved fast-cooling methods make it practical to harvest French prunes at optimum maturity and cold-store them for up to three weeks before dehydration.

French prunes are considered mature and ready for harvest when the average fruit flesh firmness has decreased to 3 to 4 pounds on the pressure gauge. At this time the fruits have nearly attained their maximum sugar content and will yield the highest tonnage of best quality dried prunes. French prunes remain in this optimum condition for harvest approximately 7 to 10 days.

Although prune growers strive to harvest when the crop is at optimal maturity, the harvesting capability of many growers and total tonnage of fruit to be dried exceed dehydrator processing capacity. Consequently, dehydrator operators limit (prorate) daily fruit deliveries. Growers compensate by spreading harvest over a three- to four-week period, beginning when fruits reach 5 to 6 pounds flesh firmness, continuing through optimal maturity to the time when fruits are overly mature and natural fruit drop is occurring.

Under present practices, early harvest may adversely affect fruit size and yield, and late harvest results in losses from natural drop of over mature fruit. Prune acreage is increasing, and procedures are needed to extend the drying season to handle this larger crop. Otherwise, substantial investment would be needed in additional drying facilities.

Three tests were conducted to explore the possible use of cold storage in an alternative prune harvest program. The first test evaluated the effect of current harvest practices on size, yield, and quality. The others investigated the feasibility of cold-storing prunes of optimum maturity before dehydration to allow growers a more timely harvest and dehydrators an extended processing season.

Effect on yield and quality

To evaluate effects of harvest timing on French prune yield and quality, 15 uniformly cropped mature trees were selected. A 100-fruit drying sample and a 25-fruit maturity sample were hand-picked from each tree twice a week between August 2 and August 30, 1979, covering the entire commercial harvest period within the Tulare County prune district. Each 100-fruit drying sample was placed in a net bag, identified, weighed fresh, dried, then reweighed to obtain drying ratio, and dry fruit size and quality were determined. Each 25-fruit maturity sample was evaluated for flesh firmness and soluble solids content.

Fresh fruit softening continued throughout the harvest period: average flesh firmness declined from 8.5 pounds on August 2 to 3.1 pounds on August 30. Correspondingly, the average soluble solids content increased from 15.9 to 21.8 percent during this period (fig. 1).

Based on these data, the optimal harvest date for this orchard was approximately August 23, 1979.

The increasing soluble solids content during the harvest period reduced the ratio of fresh to dry weight. Decreases in drying ratio directly affected dried fruit yield and size (fig. 2).

These results show that early harvest can decrease fruit size and yield in French prunes. Whether the increased drying ratio in late
season is fully explained by natural drop of
the most mature fruit is not known.
The effect of harvest date on gross revenue
(table 1) was projected assuming a yield of 12
fresh tons per acre and a price for dry prunes
of 40 cents per pound. It is clear that growers
can sustain a serious economic loss by com-
mencing harvest before full fruit maturity.

Cold storage effects

Many stone fruits suffer a low-temperature
physiological breakdown of the flesh, which
can severely limit their storage life. Past ef-
forts to cold-store fresh French prunes
resulted in excessive losses from fruit soften-
ing, flesh breakdown, and rot. However,
these studies were conducted before modern
rapid cooling facilities were available.

Two studies were therefore undertaken.
One evaluated storage life potential for
French prunes when held at temperatures
between 32° and 41° F (0° and 5° C). The
other compared quality of fruit cooled by the
slow "room cooling" method and by either
forced-air or hydrocooling (both rapid cool-
ing methods).

In the storage-life study, fresh French
prunes were harvested at optimal maturity,
forced-air-cooled and stored at 32°, 36°, and
41° F (0°, 2.2°, and 5° C). Samples were
removed from storage at weekly intervals for
a period of six weeks and monitored for flesh
firmness and internal breakdown injury.

Fruit promptly cooled and stored at 41° F
did not show internal breakdown symptoms
at the end of six weeks. Fruit stored at 32° or
36° F did not show internal breakdown by
five weeks but showed severe symptoms at six
weeks (table 2).

Considerably more flesh softening oc-
curred at 41° F (averaging 13 percent per
week) than at 32° or 36° F (about 6 percent
per week). At 41° F fruit flesh softened to
two pounds within two weeks (fig. 3). Based
on work with other stone fruits, this ripening
could have accounted for the lack of internal
breakdown symptoms following 41° F
storage. These results indicate that fresh
French prunes can be held with no internal
breakdown problems during the desired two-
to-three-week cold storage period.

### TABLE 1. Influence of Harvest Date
Value per Acre of French Prunes, Tulare County, 1979

<table>
<thead>
<tr>
<th>Harvest date (August)</th>
<th>Drying ratio</th>
<th>Yield (dry fruit)*</th>
<th>Value/acre†</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>3.9</td>
<td>3.1</td>
<td>2,480</td>
</tr>
<tr>
<td>6</td>
<td>3.8</td>
<td>3.2</td>
<td>2,560</td>
</tr>
<tr>
<td>9</td>
<td>3.6</td>
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</tr>
<tr>
<td>20</td>
<td>3.2</td>
<td>3.8</td>
<td>3,040</td>
</tr>
<tr>
<td>23†</td>
<td>3.1</td>
<td>3.9</td>
<td>3,120</td>
</tr>
<tr>
<td>27</td>
<td>3.3</td>
<td>3.6</td>
<td>2,880</td>
</tr>
<tr>
<td>30</td>
<td>3.3</td>
<td>3.6</td>
<td>2,880</td>
</tr>
</tbody>
</table>

NOTE: Projections of dry fruit size and yield are based on drying ratio data obtained in Tulare County during the 1979 season (fig. 1).
*Assume 12 fresh (green) tons per acre.
†Assume value at 40 cents per dry pound.
‡Optimal harvest date.

### TABLE 2. Influence of Storage Temperature and Duration on Internal Breakdown Development in French Prunes, Tulare County, 1979

<table>
<thead>
<tr>
<th>Storage time</th>
<th>Injury score* at:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>32°F</td>
</tr>
<tr>
<td>weeks</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

*Scored on a 0 to 5 scale: 0 = no damage; 5 = severe injury. Each fruit was scored individually and a mean value calculated for each lot.
In the cooling-method study, French prunes were commercially harvested at optimal maturity, and again when overripe on the last day of harvest. Samples of 100 fruits (in mesh bags) were placed in the center of test bins and covered with fruit. Bins for each harvest were subjected to: (1) room cooling—fruit placed in 32°F cold storage; (2) forced-air cooling—air in the 32°F cold storage passed through the bins until fruit temperature approached 32°F; and (3) hydrocooling—fruit drenched with 32°F water for 30 minutes before storage.

Following the first harvest, duplicate samples were drawn from test bins at weekly intervals for five weeks. One sample was evaluated fresh for mold; the other was dried and submitted to the Dried Fruit Association for quality analyses. Dried fruit quality was compared with that of samples dried on the second harvest was terminated after three weeks.

Room cooled fruit approached storage temperature within 72 to 96 hours of harvest. This fruit softened about 16 percent per week, and after two weeks of storage showed 42 percent mold incidence when fresh and only 54 percent marketable standard prunes when dried (Tables 3 and 4). Because of this rapid deterioration, this treatment was terminated after two weeks.

Forced-air cooling was delayed about 10 hours following the first harvest (due to equipment difficulties), and the fruit cooled to near storage temperature about 18 hours after harvest. Hydrocooling was delayed only about 5 hours, and the fruit cooled to near storage temperature within about 32 hours after harvest.

Forced-air-cooled fruit showed no significant increase in mold during three weeks of storage; hydrocooled fruit showed a significant increase in mold by the third week of storage. When compared with fruit dried immediately after harvest, forced-air-cooled fruit stored for four weeks, and hydrocooled fruit stored for three weeks showed no significant reduction in marketable standard prunes.

With late season fruit (second harvest), the initial delay in both the forced-air and hydrocooling treatments was standardized at four hours. After two weeks in storage, mold increased on both forced-air and hydrocooled fresh fruit. However, no significant reduction in marketable standard prunes was found in either treatment when fruit was dried for up to three weeks before dehydration, provided the fruit is rapidly cooled and stored at 32° to 36°F. Forced-air cooling consistently gave slightly better results than hydrocooling.

The most reasonable rapid air-cooling method for fresh prune storage appears to be "serpentine" forced-air cooling, which is described in detail elsewhere. Essentially, this cooling method allows tight stacking of bins within a cooling room and with proper baffling, utilizes the bin fork-lift openings as air supply and air return plenums. The cold air thus moves vertically through the depth of one bin.

If properly designed, this serpentine air flow system might be utilized for both cooling and storage, thus allowing bins to be placed for cooling and not moved until after storage. The constant air flow through the fruit that would occur during storage would help to maintain uniform fruit temperatures. Because of subsequent fruit drying, water loss during storage would not be a problem.

Many bins now used for fresh prune handling have no side or bottom ventilation. To achieve rapid cooling, ventilating would be required, at least on bin bottoms. Ideally, this should be in several small slots distributed across the bottom surface and totaling 4 to 6 percent of the bottom area.

The potential for using cold storage to extend the French prune dehydration season will depend on the economics of each storage. Availability of cold storage facilities near the dehydration facility would be an important consideration. Costs of cold storage will include not only the cooling and storage facility and its operation, but also extra bins needed for storage as well as any extra labor and transport costs. These costs must be weighed against the increased value of optimal harvest, and the cost of construction and operation of additional dehydration facilities.

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