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.

Bins used with this mechanical harvester are specially vented for fast cooling of prunes for cold storage.

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 commencing 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 efforts to cold-store fresh French prunes resulted in excessive losses from fruit softening, 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 cooling 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 occurred 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.

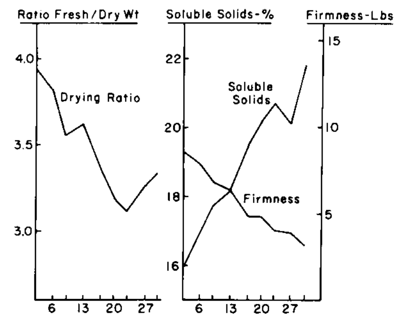

Fig. 1. Relationship of harvest date to maturity measures and drying ratio of fresh French prunes, Tulare County, 1979. Average of 15 25-fruit samples per date.

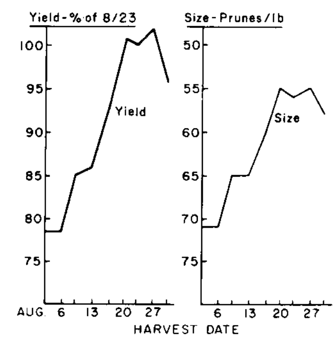

Fig. 2. Harvest timing effect on size and yield, French prunes, Tulare County, 1979. Average of 15 100-fruit samples per date.

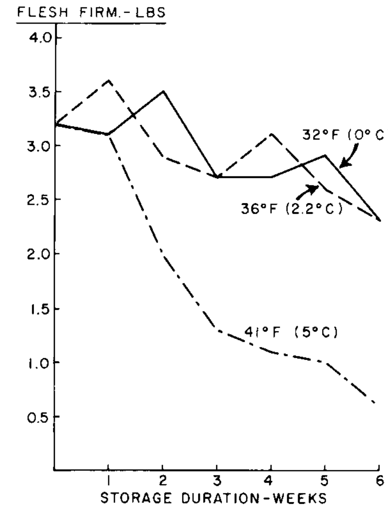

Fig. 3. Influence of storage temperature and duration on flesh softening of fresh French prunes, Tulare County, 1979.

TABLE 1. Influence of Harvest Date on Projected Yield and Value per Acre of French Prunes, Tulare County, 1979

Harvest date (August)	Drying ratio	Yield (dry fruit)*	Value/ acre†
		tons/acre	*$*
2	3.9	3.1	2,480
6	3.8	3.2	2,560
9	3.6	3.3	2,640
13	3.6	3.3	2,640
17	3.4	3.5	2,800
20	3.2	3.8	3,040
23‡	3.1	3.9	3,120
27	3.3	3.6	2,880
30	3.3	3.6	2,880

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

	Injury score* at:		
Storage time	32°F	36°F	41°F
weeks			
1	0.3	0.2	0.2
2	0.1	0.5	0.5
3	0.5	0.1	0.3
4	0.1	0.2	0.2
5	0.8	0	0.3
6	3.6	4.8	0.3

*Scored on 0 to 5 scale: 0 = no damage; 5 = severe injury. Each fruit was scored individually and a mean value calculated for each lot.

TABLE 3. Influence of Cooling Method and Storage Duration on Storage Mold Incidence in Fresh French Prunes, Tulare County, 1979

Storage duration	Mold (percent of fruits)* under: Room cool	Forced-air	Hydro-cool
weeks	%	%	%
1	22 bc	3 f	3 f
2	42 a	6 ef	6 ef
3	—	11 def	14 cde
4	—	—	18 bcd
5	—	17 cd	26 b

*Values followed by a common letter are not significantly different at the 0.05 level as determined by Duncan's Multiple Range Test.

TABLE 4. Influence of Cooling Method and Storage Duration on Level of Marketable Standard Grade in Fresh French Prunes, Tulare County, 1979

Storage duration	Marketable standard fruit* under: No cooling†	Room cool	Forced-air	Hydro-cool
weeks	%	%	%	%
0	100 d	—	—	—
1	—	89 bc	97 cd	100 d
2	—	54 a	97 cd	97 cd
3	—	—	94 bcd	94 bcd
4	—	—	92 bcd	88 bc
5	—	—	87 bc	86 b

*Values followed by a common letter are not significantly different at the 0.05 level as determined by Duncan's Multiple Range Test.
†Fruits were dried immediately after harvest.

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 day of harvest. Similar sampling of fruit from 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 5½ 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 after two and three weeks of storage.

When results of the two cooling and storage tests were combined, fresh French prunes stored for three weeks after either forced-air or hydrocooling scored 94 to 98 percent marketable standard prunes compared with 96 to 100 percent when fruit was immediately dehydrated without delays or cold storage. When the storage period was extended to five weeks, marketable standard prunes dropped to 87 percent.

Discussion and conclusions

French prunes appear capable of storage 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, venting 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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