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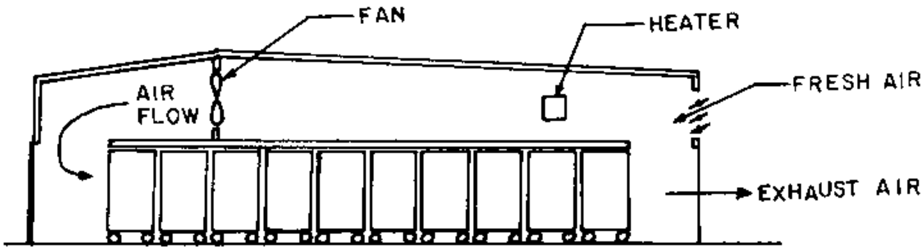


Ten-car dehydration tunnel.

PARALLEL-FLOW PRUNE DEHYDRATION

About 20% of California's dried prune crop will be processed through parallel-flow dehydrators this year—a technique developed by University researchers that allows a 50% increase in seasonal capacity of conventional dehydrators, with no important differences in quality of the dried prunes. The new system involves moving the cars of prune dehydration trays through conventional drying tunnels with the hot air flow rather than against it. This operation exposes the moist prunes to the hottest air at the start of the drying process when higher temperatures are desired, rather than when nearly dry as they leave the tunnel. The new technique has also made feasible complete time-clock automation of dehydration tunnels.

PRUNE DRYING in tunnel dehydrators involves the following methods of handling: prunes are spread in a layer one fruit deep on trays; loaded trays are placed one above another on a wheeled low dolly or car to form a stack approximately 6½ ft high (trays are constructed with end and center cleats so that a clear air passage of about 2½ inches is left between successive trays); and loaded cars are then moved one at a time into one end of the tunnel dehydrator. The drying section of the tunnel is a straight passage just large enough in cross section to accommodate the loaded cars.

The ten-car twin tunnel (see sketch) is the type of dehydrator most commonly used for drying prunes. It is normally operated in a counter-flow manner, i.e., drying air is introduced into one end of the tunnel and moves in a direction opposite to that of car progression. This type of tunnel operation offers most rapid drying conditions at the end of the tunnel where the prunes are already nearly dry. The maximum safe temperature that will not cause severe heat damage to the nearly-dry prunes is considered to be 165° F.

Investigations were recently undertaken to evaluate prune dehydrating practices, particularly with respect to improving dehydrator performance and the possibility of increasing the capacity of the prune dehydrator by converting from counter-flow to parallel-flow operation. In parallel-flow dehydration, fruit and air pass through the dehydrator in the same direction. Parallel-flow operation is characterized by very fast drying conditions in the portion of the tunnel where the fruit to be dried is still very wet.

For these tests, French variety prunes from the northern coastal (Sonoma County) and the interior valley (Sutter County) areas of California were harvested at early, mid- and late season. All prunes were dehydrated in tunnels at Healdsburg.

Fruit handling

Except for the smaller test lots, fresh fruit delivered in bulk bins was handled under commercial conditions. Fruits were dumped into water and mechanically spread one layer deep on trays that were automatically stacked onto cars. Smaller sub-samples for test purposes were separated by a vibrating sizer into three size classifications, spread on trays, and washed with water. Trays of the sized lots, together with a selected field-run "control" sample from the same bin or bins, were stacked at selected locations on cars containing fruit of the commercial run.

One ten-car tunnel was modified to permit prunes to pass through in the same direction as the air or parallel-flow. Therefore, prunes with highest moisture content were exposed to the warmest air, where the evaporation of moisture from fruit caused it to remain considerably cooler than the air. The temperature of the warmest air in the tunnel was increased to 195° F, without raising fruit temperatures to levels considered to be damaging to quality. Wet bulb temperatures were 115° ± 3° F.

Car pulls were provided for moving the cars through the tunnel in the direction of the air movement. Car stops, to prevent the cars from being pushed by the moving air, were provided for the ninth and tenth car positions at the exhaust end of the tunnel.

Cars were placed into the parallel-flow tunnel at timed intervals of approximately

1½ hours. If a car of prunes was not dry (20% moisture) when it was scheduled to be removed from the ninth position, it was held in the tenth position until dry. If it was necessary to hold a car in the tenth position, the time interval was adjusted so that prunes would normally be dry when they were due to be removed from the ninth position.

Counter-flow

Fresh prunes were placed in a tunnel at the exhaust end and the dried prunes were removed from the warmest end. The cars were mechanically advanced from the exhaust end toward the warmest end of the tunnel. When a dry car was removed, a car of fresh fruit was added. The maximum temperature in the counter-flow tunnel was approximately 165° F. The wet bulb temperature was 105° ± 3° F.

Fuel consumption, air velocity, air temperatures, fruit temperatures, fruit flesh firmness, per cent soluble solids, flesh color, and moisture content of fruit were determined for both parallel- and counter-flow conditions. All samples were graded for commercial acceptability on the basis of external skin color and appearance as well as flesh color and condition.

The size of fresh prunes was determined by the weight of 100-fruit random samples. The number of fruits per pound dried was determined by actual count of three random 1-lb sub-samples, and results were recorded as an average of the three values obtained.

Drying rate

Drying times of the sized prunes are shown in table 1. The values represent the averages obtained for large, medium, and small fresh fruit, irrespective of growing area and date of harvest.

The drying time reduction, expressed in percentage of time to dry by counter-flow, is apparently constant and independent of size. An average of all lots shows a reduction of 5.39 hours, which would represent an increase of dehydrator capacity of 37%. This increase is based on the assumption that dried prunes are removed from the dehydrator at a specific moisture content, but this is seldom accomplished in commercial counter-flow prune dehydration operations.

During the 1964 season an estimated 6,000 tons of dried prunes were commercially dehydrated by the parallel-flow method, with accompanying increases in dehydrator capacity of approximately 50%.

Air and prune temperatures for the counter-flow operated tunnel are shown in graph 1. The air temperature adjacent to the prune rises slowly. The prune temperature initially trails the surrounding air temperature by approximately 8° F and gradually approaches the temperature of the air as dehydration progresses. Temperature changes in parallel-flow operation are quite different as shown by the air and prune temperatures presented in graph 2. In parallel-flow operation, the prune temperatures rise quite rapidly and then remain relatively constant.

On a weight basis, fruit dried in the parallel-flow tunnel used 12% more fuel than the counter-flow tunnel. This increase in fuel consumption was again based on the assumption that counter-flow dried prunes are removed from the tunnel at a specific moisture content. In commercial application there may be little if any increase in fuel consumption per unit of dried fruit, but the fuel will have to be available for consumption at a faster rate.

Average air velocity in the tunnels was 800 fpm. The thermostat and burner in a tunnel dehydrator control the temperature at the hot end of the tunnel. The temperature in the remainder of the tunnel is controlled by the air velocity and distribution. In parallel-flow operation it is essential to have an air velocity of at least 800 fpm and uniform distribution of the air.

Table 2 shows the average fresh and dried fruit characteristics of prunes dried by the counter- and parallel-flow methods

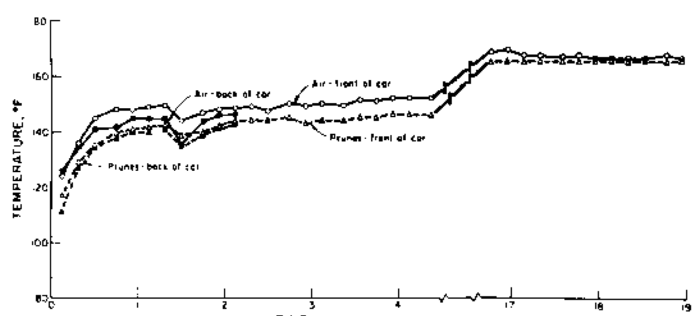
TABLE 1. MOISTURE CONTENT AND DRYING TIME OF SIZED PRUNES DRIED IN PARALLEL- AND COUNTER-FLOW TUNNELS

Size	Fruit		Parallel-flow		Counter-flow	
	Fresh	Dry	Drying time	Moisture	Drying time	Moisture
	Count/lb		Hours	%	Hours	%
Large	14.6–16.9	37–47	16.25	20.6	23.25	20.1
Medium	19.3–21.4	47–60	14.83	19.9	20.67	19.75
Small	25.9–31.7	61–74	11.71	19.1	15.04	20.1
Average			14.26	19.9	19.65	20.0

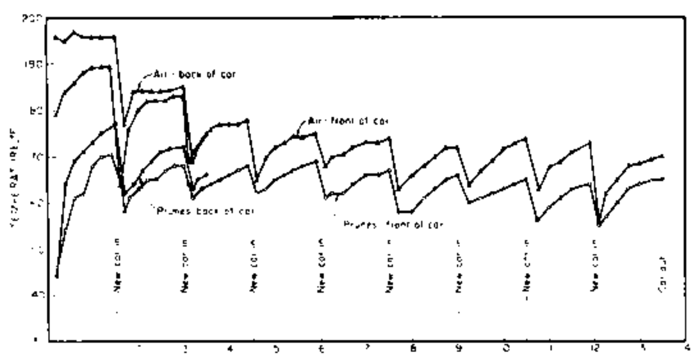
TABLE 2. FRUIT CHARACTERISTICS OF PRUNES DRIED IN PARALLEL- AND COUNTER-FLOW TUNNELS

Size	Dehydration procedure	Fresh fruit: Ave. flesh firmness	Fresh fruit: Ave. soluble solids, 68° F	Dry fruit			Color differences* Fresh to dry	
		Pounds	%	Av. count/lb		Drying ratio	Hue	Value
Large	Parallel	2.7	28.2	15.2	40.8	2.52:1	−8.3	1.4
	Counter	2.6	28.0	15.1	39.9	2.52:1	−7.9	1.6
Medium	Parallel	1.9	28.4	20.4	53.4	2.43:1	−7.3	1.6
	Counter	2.1	29.0	20.3	51.5	2.40:1	−7.3	1.4
Small	Parallel	0.8	31.5	28.5	68.2	2.21:1	−6.2	1.6
	Counter	0.6	32.1	28.7	67.8	2.10:1	−6.1	1.7

* The color differences are based on the Munsell system of color showing hue and value (reflectance).



Graph 1. Prune and adjacent air temperature during drying in a counter flow tunnel.



Graph 2. Prune and adjacent air temperatures during drying in a parallel flow tunnel.

irrespective of area and date of harvest. These data show the fruit within a size category to be similar regardless of the method of drying.

The difference in drying ratio (pound of fresh fruit per pound of dried fruit at 20% moisture) primarily reflects differences in maturity of the fresh fruit as measured by flesh firmness. The softer fruits are partially field-dehydrated, and, therefore, have an apparent higher soluble solids content than firmer fruits.

There appear to be no significant differences between parallel- and counter-flow fruit in color changes during dehydration. Similarly, no significant pattern change associated with drying method is found in values (reflectance), but firmer fresh fruits have a higher value that also remains higher after harvest. External (skin) color was not measured, although initially, visual observations indicated that fruit dried by the parallel-flow procedure had a more reddish cast than fruit dried by counter-flow dehydration. This difference was not apparent after a few months of storage.

Parallel-flow dehydration has reduced prune dehydration to a time-clock operation, and complete automation of prune dehydration tunnels now appears feasible.

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PUMP IRRIGATION

Cost Increases in Salinas Valley

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Salinas Valley pumping costs vary widely depending upon their location, with great differences in pumping costs often occurring over relatively short distances. Yield of ground water aquifers, proximity to the river, and ground elevation are the basic factors determining the pumping lift at any particular location in the Valley. A sample of 1,562 well tests made by the Pacific Gas and Electric Company showed that pump lifts in the Salinas Valley range from less than 25 ft near the Salinas River to over 350 ft on the bench lands near the eastern foothills.

For the study reported here, the Salinas Valley was divided into five areas, which roughly parallel the five hydrographic areas outlined in earlier geological investigations of the area. A township grid of 640-acre sections was superimposed over the area, and each of the 431 sections on the Valley floor was numbered for subsequent computer analysis. Final definition of the five areas used in this study was based on the delineation of areas of homogeneous pumping lift. Several possible groupings of sections were analyzed. The grouping finally selected was that which minimized the variance about the mean (arithmetic average) pumping lift in each area.

Area 1 extends along the west side of the Valley from Gonzales to the edge of Monterey Bay. Pumping lifts are quite uniform in this area with a mean value of 72 ft. Most of the wells obtain water from the confined "180-ft aquifer." The discharge of wells tested averaged 1,071 gpm (gallons per minute) with a specific capacity of 91 gpm per foot of drawdown.

Area 2 lies to the east of area 1 and extends further south, almost to Soledad. Pumping lifts in this area are less homogeneous than in area 1 because of the relatively steep-sloping alluvial fans extending from the foothills to the middle of the Valley. The mean pumping lift in area 2 is 184 ft with an average discharge of only 786 gpm. The specific capacity of these wells is a relatively low 33 gpm per foot of drawdown.

TABLE 1. NUMBER OF WELLS BY DEPTH OF PUMPING LIFT, SALINAS VALLEY, 1962–64

Pump lift (feet)	Area 1	Area 2	Area 3	Area 4	Area 5
			Number of wells		
0– 24.9	3	0	6	0	12
25– 49.9	73	2	83	4	69
50– 74.9	233	11	117	5	63
75– 99.9	140	19	54	7	19
100–124.9	28	33	19	13	21
125–149.9	14	47	4	9	18
150–174.9	3	42	4	18	11
175–199.9	2	48	2	14	4
200–224.9	2	62	2	4	0
Over 225	0	94	5	16	0
Total	498	358	296	90	217
Item	Mean pumping plant characteristics				
Gallons per minute	1,071	786	1,669	1,329	1,523
Horsepower	34.9	62.0	51.5	93.7	58.6
Plant efficiency (%)	53.6	55.5	55.0	58.9	56.3
Total head (ft)	87.0	209.1	86.4	203.3	114.8

TABLE 2. IRRIGATION PUMPING COSTS, BY HYDROGRAPHIC AREA, SALINAS VALLEY, 1962–64

Area	*Well cost	Pump cost	†Total annual depr.	Standby charges	Int. & taxes	Rpr. & maint.	Energy cost	‡Ac. ft pumped	Total annual cost	Av. cost/ac. ft	Av. cost/ac. ft/ft. of lift
				dollars				ac. ft.		dollars	
1	6,054	3,017	453.10	235.55	451.48	58.02	646.54	355	1,844.69	5.20	0.081
2	7,981	5,875	667.30	389.35	690.78	112.98	1,115.95	244	2,976.36	12.20	0.064
3	5,290	4,206	453.30	299.50	465.83	80.88	943.98	551	2,243.49	4.07	0.053
4	5,821	7,846	645.95	526.00	688.71	150.90	1,682.85	427	3,694.41	8.65	0.053
5	4,828	4,414	436.63	395.40	465.84	84.88	1,124.36	536	2,507.11	4.68	0.074

* Includes development costs.
† Based on expected life of 20 years for both pump and well with salvage value of 40% of motor.
‡ Based on annual use of 1,675 hours.