Parallel-Flow Drying of Italian Prunes

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The Counterflow System

Italian prunes have been dehydrated in Oregon for a number of years. In general, a counterflow technique is employed wherein the fresh prunes enter the cooler end of the dehydration tunnel and emerge dehydrated at the hot end of the tunnel. Temperatures for drying prunes are usually around 165 to 175°F. with approximately 25 to 50% recirculation of the air. The time of drying varies between 25 and 28 hours, and during this time the moisture in the prune is reduced from approximately 75% to 19% on the wet weight basis.

A typical counterflow dehydration curve is shown in Figure 1.

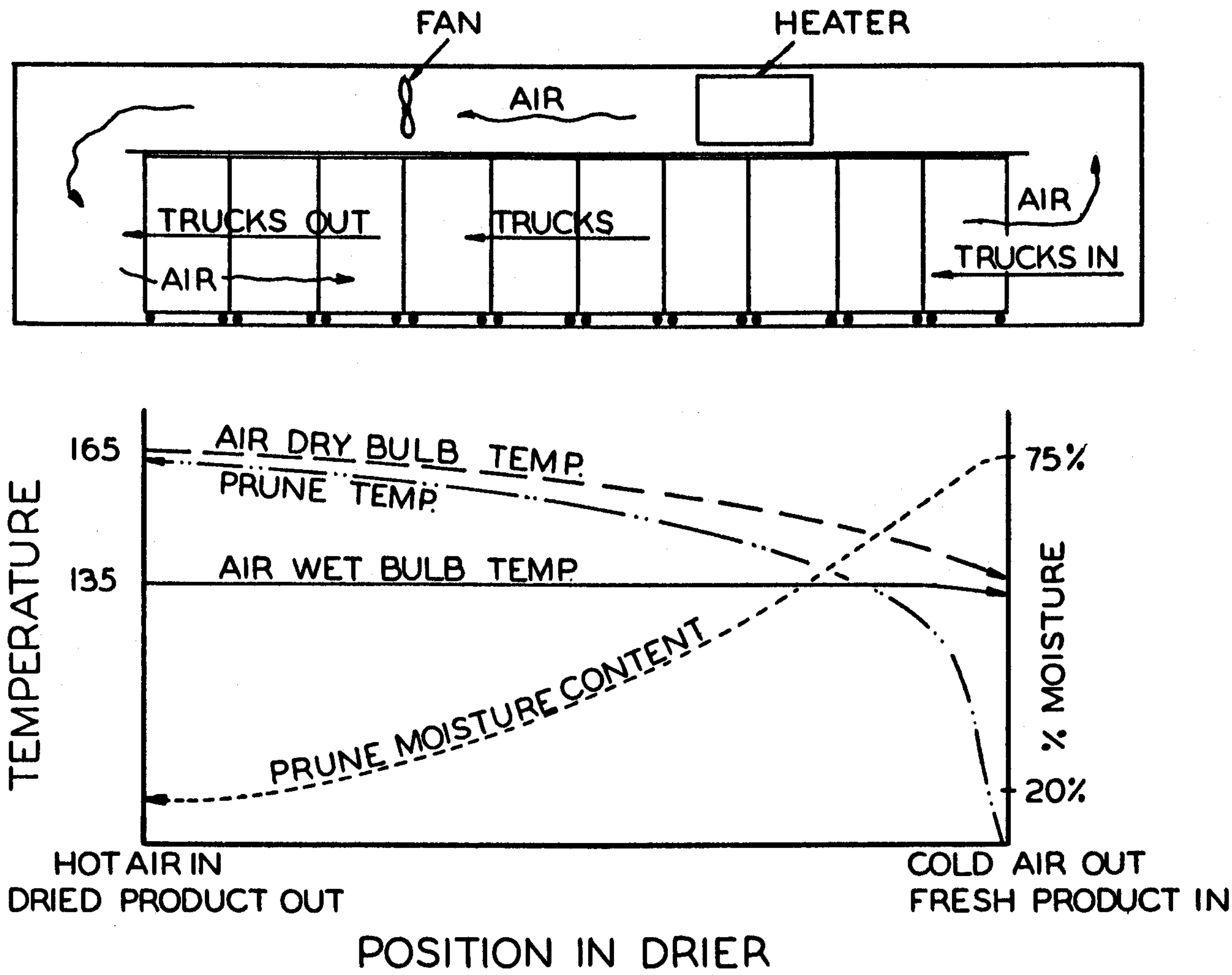

Figure 1. Typical Curves in a Counterflow Dehydration Tunnel for Prunes

Note that the prune temperature is approximately 10°F. less than the air temperature soon after the prunes enter the cool end of the tunnel. The differential between air and prune temperatures narrows as the prunes progress toward the hot end of the tunnel. The prune temperature should not exceed 165°F. Prune temperatures higher than 165°F. may cause caramelization of the sugars, particularly in the latter stages of drying.

The Parallel-Flow System

In a parallel-flow drier, the prunes enter the hot end of the tunnel where the temperature is maintained at a higher level than for counterflow drying. The prunes still remain below the critical 165°F. point because of the rapid evaporative cooling. As the prunes progress through the tunnel in the same direction as the air flow, there is a gradual reduction in air temperature. The critical difference between the two methods of drying is that in the initial period of drying, when the evaporation is most rapid, the prunes are exposed to much higher temperatures in the parallel-flow system and thus give up their moisture more rapidly.

Early Oregon Studies

Early in 1960, Mr. Kim Roberts (2)*, then Polk County Extension Agent, dehydrated Italian prunes in the experimental dehydrator located in the Food Science and Technology Department. He was interested in the application of parallel-flow and the resultant effect on dried prune quality. At the time Mr. Roberts did his work, he used 1959-season Italian prunes which had been frozen and held at 0°F. The results of his experiments indicated that prunes could be easily dehydrated in a parallel-flow tunnel with certain modifications to the ingoing air temperatures and flow of air across the prunes. In these experiments, he raised the initial air temperature to 200°F., the air velocity to 1,100 feet per minute, and was able to dry the prunes in from 12 to 16 hours. The quality of the parallel-flow dried prunes was equal to or superior to conventionally dried prunes. The main effect was a reduction in the drying time of approximately 50%.

California Studies (1)

In 1964, parallel-flow driers were tested in California on French prunes. This prune variety is smaller and has a higher soluble solids content than the Italian prune. French prunes required from 15 to 23 hours drying time in a counterflow drier using 165°F. initial air temperature and 11 to 16 hours drying time in a parallel-flow dryer using 195°F. air temperature at the hot end. This resulted in an overall increase in drying capacity of 37% for a given size tunnel. The drying ratio varied from 2.1 to 2.5 to 1.

The California work noted that an air velocity of at least 800 feet per minute was required. A range of 800 to 1,000 feet per minute was suggested as optimum.

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*Numbers in parentheses indicate reference cited, page 5.

1965 Oregon Pilot Study

Mr. Roberts used frozen prunes as the basis for his experimental work. It is known that freezing prior to dehydration provides a more porous structure and therefore increases the rate of drying. A question was raised by interested members of industry whether this system would give comparable results with fresh prunes. A simple pilot study was set up and cooperation was obtained from a commercial dehydrator who provided fresh Italian prunes and conventionally dried fruit.

Data obtained from California provided certain parameters with respect to time of exposure and wet-bulb temperatures. Utilizing these data and that obtained by Mr. Roberts in 1960, specific temperatures (wet and dry bulb) and time of exposure were programmed to simulate drying conditions in a 10-car parallel-flow drying tunnel. The programmed parameters are shown in Figure 2.

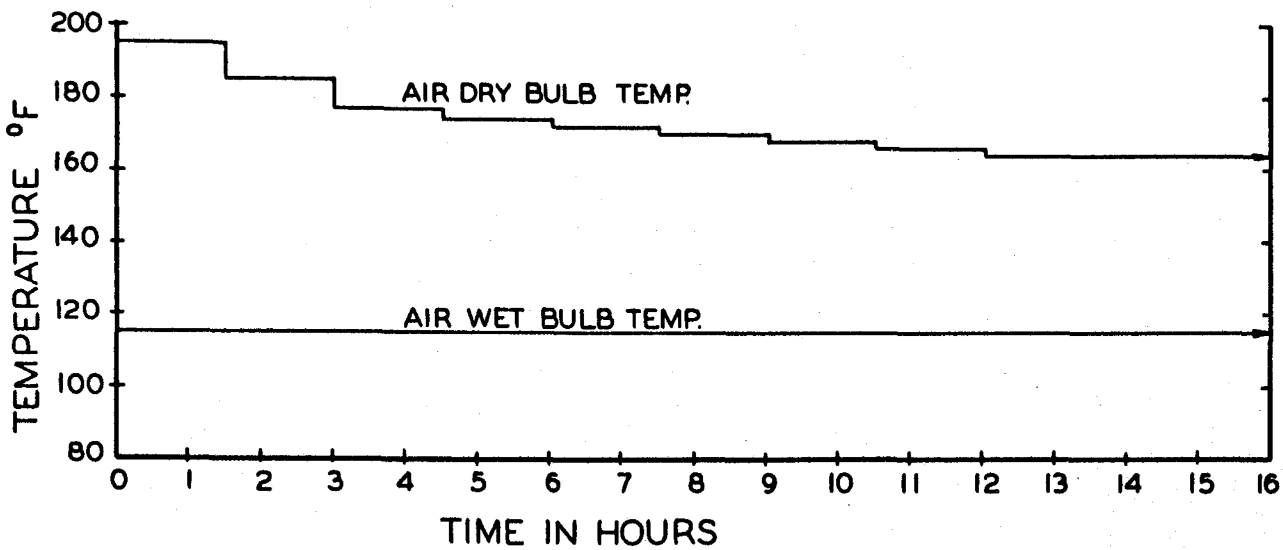

Figure 2. Schedule of Dry Bulb and Wet Bulb Temperatures Used in a Simulated Parallel-Flow Tunnel

Prunes at 76% moisture were weighed onto trays and inserted into the dehydrator. Initial air conditions were 195°F. dry bulb and 115°F. wet bulb. An air flow rate of 1,100 feet per minute was provided. At the end of one and and one-half hours the dry bulb temperature was lowered to 185°F. All other conditions remained the same. This periodic reduction of temperature simulated another load of prunes being inserted into the hot end of the drier; thus the first truck load of prunes was now in the second position exposed to somewhat cooler conditions. This programmed reduction of temperature was continued throughout the drying cycle and may be observed in Figure 3.

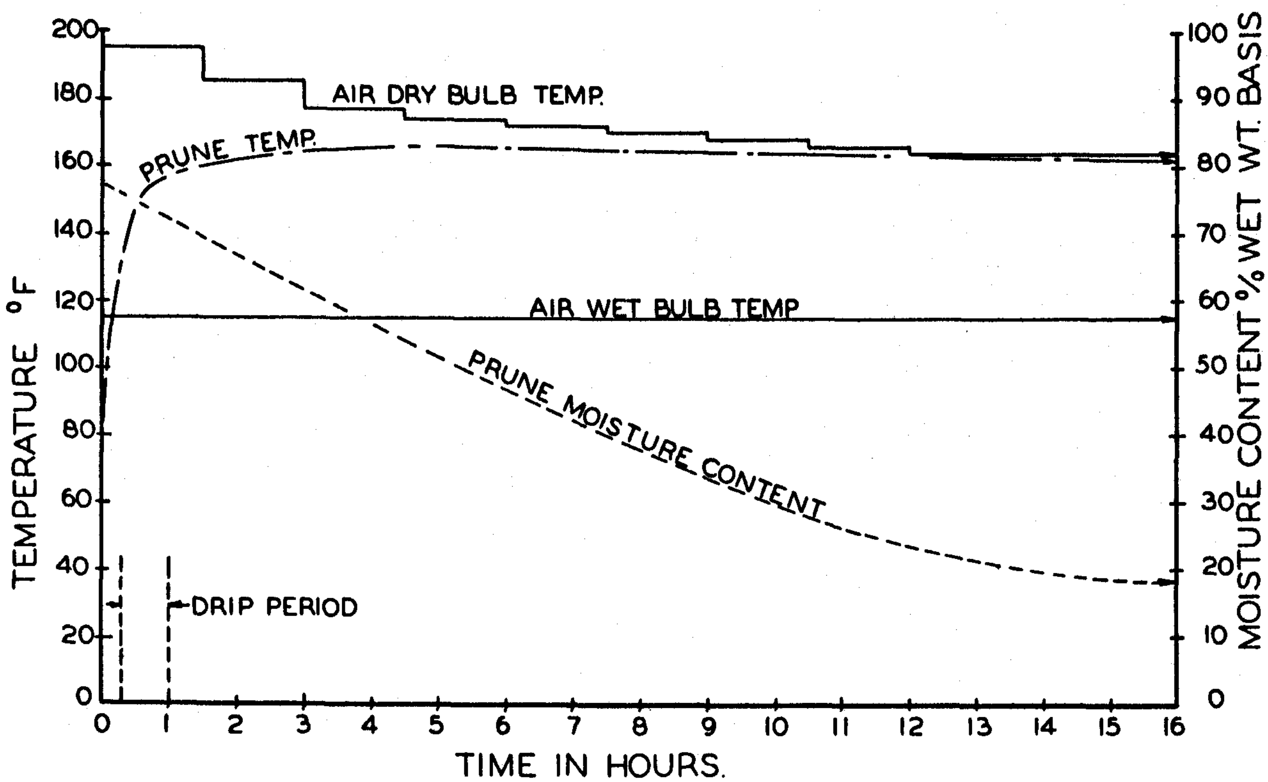

Figure 3. Prune Temperature and Prune Moisture Curves Observed in a Simulated Parallel-Flow Tunnel

In the initial stages, the fresh prunes began to lose their bloom, swell, and exude juice. This occurred about 15 minutes after the prunes were placed in the dehydrator and continued for about 45 minutes. This juice, which represents a loss, was measured and it accounted for one half of one per cent of the final dried weight.

The moisture content was reduced from 76% to 17% in 14 to 16 hours.

The prune temperature, as measured by thermocouples, rapidly increased during the first 30 minutes and gradually reached a level of 165°F. after 4 hours when the moisture content was about 56%. Throughout the balance of the drying period, the prune temperature remained at approximately 165°F.

The drying ratio of the Italian prunes was 3.27/1 for the counterflow method and 3.37/1 for parallel-flow drying when calculated at the same final moisture content of 19%. The final moisture content of the commercial counterflow dried prunes was actually 16.9% and of the parallel-flow, 19.2%.

Evaluation of Dried Fruit

The dried prunes were conditioned by exposing them to live steam to raise them to 26% moisture. A panel of 25 members of the prune industry examined both the dried and reconditioned prunes which were unidentified as to variety and method of drying. The general consensus of opinion was that there was no difference between the dried or conditioned prunes with respect to flesh color, but that the skin texture of the parallel-flow dried prunes was more tender and desirable than in prunes dried by the conventional counterflow method.

In summary, the panel could not tell the difference between the two methods of drying except in skin texture. It appears that Italian prunes can be dried in a parallel-flow tunnel in from 14 to 16 hours, thus effecting a sizable reduction in drying time without affecting quality.

If possible conversion of an existing counterflow tunnel is contemplated, however, several items should be considered carefully.

(a) Reduction in drying time can be obtained only by increasing the heating capacity of the dryer firing system.

(b) Besides requiring a greater BTU output, the parallel drying system calls for a higher initial air temperature. This may require an entirely new heating system capable of operating safely at the higher temperatures.

(c) California studies indicated a need for 800 to 1,000 feet per minute air velocity across the trays. This may mean an increase in fan capacity in many existing counterflow tunnels.

(d) Since the air will be discharged from the parallel-flow tunnel at a less saturated condition, fuel efficiencies can be expected to be lower.

It is recommended that qualified engineering assistance be obtained before attempting to convert an existing counterflow tunnel to parallel-flow or before constructing a new parallel-flow installation.

References Cited

1. Gentry, J. P., L. L. Claypool, and M. W. Miller. Parallel-Flow Prune Dehydration. California Agriculture, August 1965.

2. Roberts, Kim. 1960. Unpublished report.