DEHYDRATION OF FRUITS BY SUGAR OSMOSIS

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We have worked a number of years on sulfur dioxide in dried fruits. This preservative performs a number of important functions not the least of which is prevention of browning. We have reported in the past on time and temperature effects on sulfur dioxide loss, on the manner by which it breaks down, on the effect of factors such as light, trace metals, packaging materials, reducing sugar content, and chelating agents on sulfur dioxide requirements in dried fruits, and even on an in-package oxygen scavenger containing sulfite as an active ingredient.

In this paper we describe a process which controls browning but requires little or no sulfur dioxide.

The process which I will describe, however, started with two other objectives in mind, to overcome the poor rates of heat transfer to the fruit piece and to overcome the slow rate of water removal from the pieces in dehydration. I remember as a boy watching vendors on the streets in China roasting chestnuts and sweet potatoes in beds of hot sand. A stirred bed of sand provides an excellent system for heat transfer. If the sand is also a drying agent, and we fluidize the bed with hot dry air, we have a system that should provide improvements in both respects. Sugar was one drying agent considered for this purpose.

Very quickly, though, we found out that sugar in contact with the freshly cut surface of fruit removed water too fast. The sugar had to be mixed with starch or other edible powders to make it manageable. The sugar system itself, nevertheless, had such interesting advantages that we postponed our original plan and made a thorough study of stationary beds of sugar and then of baths of concentrated syrups.

The system that developed, that now appears to be optimum in our opinion, is a two-step process. Fruit is immersed in sugar in a stationary bed or in syrup until about 50% weight loss has occurred by osmosis. At this point the rate of water removal has leveled off. Granular sugar has been converted to syrup, if it was used to begin with. In either case, the syrup is then drained off and the pieces are further dried to the desired moisture with air in a tunnel drier (180° F. for 7 hours reduces moisture to 6 to 20%) or in a vacuum shelf drier (0.1 to 1 mm. Hg pressure, shelf temperature 200° F., 1-1/2 to 2 hours reduces moisture to 1 to 3%). The vacuum finish drying is more desirable because the product has an open honeycomb-like structure. We have produced fruit pieces with about 10 to 20% moisture and others with less than 2% moisture. The latter are particularly interesting because they are suitabl e for use in dry cereals.

We are interested in this process because it produces a very high quality product with virtually no residual sulfur dioxide. The pieces below 2% moisture require no sulfur dioxide, the pieces at 10 to 20% moisture contain a residual level of below or about 100 ppm of sulfur dioxide (see Table 1).

An additional bonus in this process is a remarkable retention of natural flavor. The sugar in the final drying process may act as a selectively permeable membrane which allows water to pass through but bars the volatile flavoring components that are less polar (esters and aldehydes). Some recent collaborative studies with Dr. Salunkhe at Utah State even suggest that volatiles are generated during the initial osmotic drying step. In addition, some of the acids in the fruit pass into the syrup so that the product is not as sharply acidic as freeze-dried fruit. If acidity is wanted in the product, a reasonable level of acid would have to be maintained in the syrup during the osmotic step.

The effect of temperature on the rate of water removal with different sugar formulations is shown in Figure 1. Surprisingly, there is little difference between sucrose and invert sugar syrups. The effect of temperature on osmotic drying with granular sugar is shown in Figure 2. Above 120° F. some undesirable off-flavor develops. Rehydration is faster for vacuum finish-dried product than air finish-dried but not as fast as for conventionally tunnel dried fruit.

The process, admittedly, is more expensive than tunnel drying but is not as expensive as freeze drying and the product has a superior flavor. In specialty mixes, dry cereals, candies or for eating out-of-hand, the products look particularly promising. We have had most interest expressed by dry cereals manufacturers and confectioners. The slower rehydration rate and lower acidity appear to be particularly desirable in cereals.

The economics of the system can be improved by recycling the syrup. For this a lighter syrup, 65° Brix can be used. Ligher syrup would permit more rapid draining because of the lower viscosity. In a diversified processing operation, spent syrup could be used in canned fruit pieces, sauce, and puree manufacture as it contains much fruit flavor.

It is clear that besides having a new product of considerable interest, we have learned two important facts which may eventually be applied to other types of dried fruit. One is that sugar interferes with the browning process and the other is that sugar films retain volatile flavors remarkably.

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Table 1

Moisture and Sulfur Dioxide Content of Various Fruits after Sugar-Air Dehydration.

Air-Drying at 180° F. for 7 hr.

Fruit	Fractional size of piece	Moisture content, percent	SO_2 content, ppm
Apples	1/12	5-6	80-137
Peaches	1/6	18-25	37-92
Peaches	1/8	10-12	--
Apricots	1/2	13-16	15-93
Pears	1/6	10-12	0-41

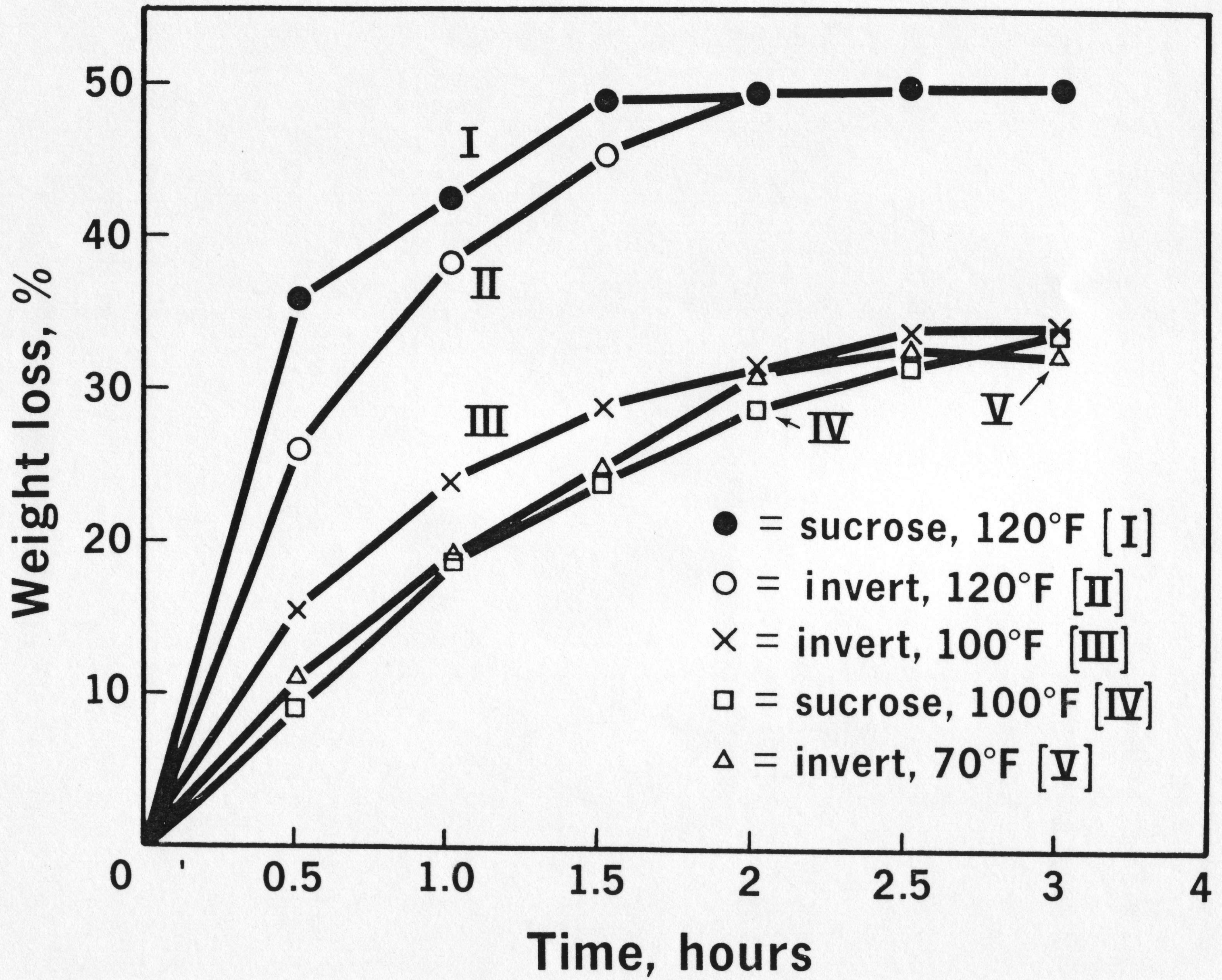

Figure 1. Effect of temperature on rate of dehydration of apple chips in sucrose and invert syrups.

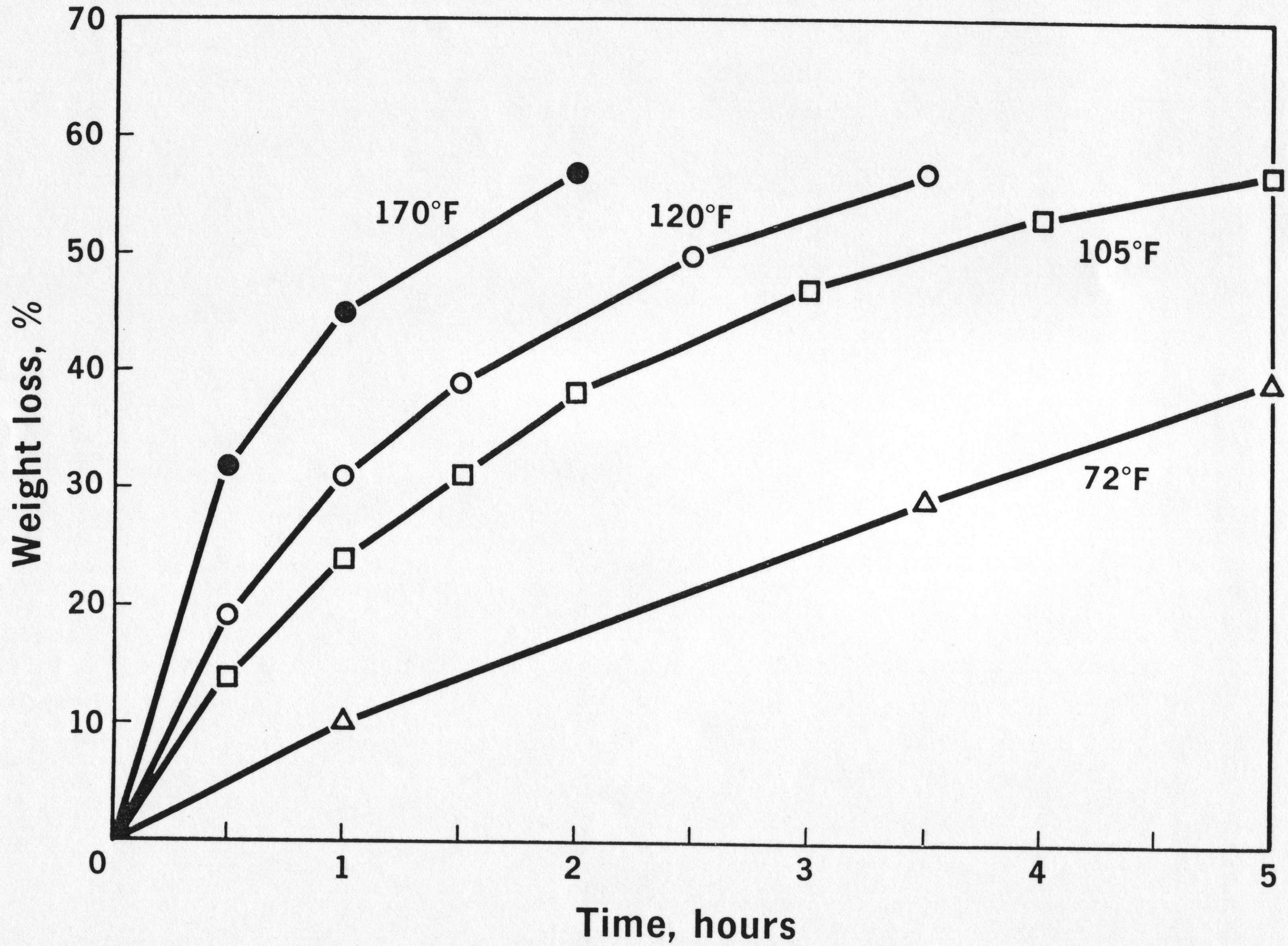

Figure 2. Effect of temperature on rate of dehydration of apple slices in tumbled dry sucrose.