ation must be left for individual comparison where the investigator can more completely evaluate all factors.

Several million pounds of pimientos were dehydrofrozen in 1960 by three companies in California, for use in dairy products. Dehydrofrozen apples and carrots are being produced and marketed commercially. Dehydrofrozen peas are now being produced commercially in this country for domestic and export markets. Rapid expansion of the production of dehydrofrozen products is indicated over the next few years.

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CHAPTER 39

FROZEN FRUIT JUICE CONCENTRATES

Processing and Quality Control: Selection, Grading, and Storage, Washing, Juice Extraction, Heat Treatment, Concentration, Packing, Storing, and Distribution, Quality Control; Concentration Methods: Freezing and Mechanical Separation, Vacuum Drying to Powder, Vacuum Evaporation, Direct Refrigerant Contact, Indirect Refrigerant Contact, Vapor Recompression and Thermo-Compression, Plate Evaporator; Orange Juice; Grapefruit Juice; Blended Grapefruit and Orange Juice; Tangerine Juice; Pineapple Juice; Apple Juice; Grape Juice; Strawberry and Other Berry Juices

WITH the introduction of frozen orange juice concentrate in 1945, it was possible for the consumer to get tree ripened quality where previously he was limited to fruit which had been ripened in transport and storage. Transportation costs were reduced, since the water and pulp of the fruit had been discarded at point of growing. From that time, purchases in the United States of frozen orange juice concentrate have risen to become the largest single item in the frozen food market. Orange is the most important of these concentrates and essentially all process development in this field was based upon this material. Today the techniques are extended with proper modifications to increasing number of products including other citrus juices, apple juice, grape juice, pineapple juice, berries, and many new blends (such as grapefruit-pineapple, strawberry-lemon).

While it is true that fresh juice and frozen fresh juice can be (and are to a limited extent) marketed, the large bulk of associated water which is necessarily frozen, stored, and distributed, makes this economically less desirable. The economy of distributing frozen concentrate as compared with that for fresh juice is dependent upon the degree of concentration of the distributed product. The industry has established what appears to be a practical optimum for the retail market, which is known as a *three-to-one* concentrate. This means that to one volume of concentrate, three volumes of water are added to effect reconstitution—or in other words, about ¾ of the weight of the fresh juice is removed (as water), and only ¼ of the weight of the fresh juice need be frozen, stored, distributed and carried home. The economies in this are obvious and lead to the requirement for a fruit juice concentration process in which the water be removed at low cost and without deterioration of any of the desirable properties of the juice. Compared to frozen fresh juice, the lowered volume of the juice to be distributed means that smaller cans can be used, requiring less freezer space, both in stores and homes. Recent studies have indicated the desirability of retail marketing of a more concentrated product, such as the 58.5 Brix (a measure of sugar content) six-to-one orange concentrate now being made for the government. These concentrates deteriorate less from abnormal temperatures during storage and distribution because of greater cloud stability and less tendency to gel.

The delicate flavors and aromas of fruits are deteriorated by the high temperatures associated with the usual canning operations. While these methods of canning alter the flavor of all plant produce, it is keenly noticed in the flavors of fruits which are available fresh and ripe to the consumer, such as oranges, grapefruit, apples and so forth. This is in contrast to fruits such as pineapple, in which the flavor of the canned product is preferred, probably due to familiarity. The low temperature concentration processes provide products having a flavor equivalent to tree-ripened fruit and containing 90 percent or more of the vitamin content of fresh juice.

PROCESSING AND QUALITY CONTROL

Selection, Grading, and Storage

The composition of the juice varies with size and degree of fruit maturity (this data is available in various publications). By means of periodic analysis fruit is selected as suitable for picking and concentration. The necessary criteria are established by Federal and State standards, as well as those which influence processing yields, such as percent of juice in the fruit and percent of solids in the juice. Upon delivery, the fruit is manually inspected. Damaged, cut or bruised fruit and that showing any indication of spoilage is rejected (often used in animal feed). Deliveries are scheduled so that storage for more than a day or so is not required. Each load of fruit is tested for juice yield (reported in gallons per box), Brix value, total acid, and Brix-to-acid ratio. Individual storage of each load in separate wooden bins permits these data to be used as a basis for subsequent blending operations or as a basis for rejecting a sub-standard load.

Washing

Prior to juice extraction, the fruit is washed by immersion in a solution of a cleaning and wetting agent. During or following this, it is scrubbed and then rinsed. The fruit is next treated with a bactericidal spray and then thoroughly rinsed.

Juice Extraction

The details of extraction, which vary with the nature of the individual fruit, are discussed in detail in the later sections of this chapter dealing with the various juices.

Heat Treatment

As an example, frozen concentrated orange juice prepared without heat treatment is stable for several years at 0 F, and for nearly a year at 5 F. From the condition of the product reaching the consumer, it has become obvious that these low temperatures frequently are not maintained during storage, shipment, and distribution of the product. Deterioration is first noted by a tendency for the cloud to settle and a clear layer to form at the top of the reconstituted juice. Further deterioration is characterized by the development of off flavors and the formation of a gel in the concentrate which makes the product unsightly and difficult to reconstitute. The increased yields of juice from fruit and processing also contribute to the rate at which the product deteriorates at elevated temperatures. Another factor to be considered, is that many consumers do not have the facilities for maintaining zero temperatures in the home. In order to increase the stability of the product, most processors now use a heat treatment to inactivate enzyme and improve cloud stability. Usually, the evaporator feed juice is treated briefly to 150 to 180 F, but in some plants the heating is between stages of the evaporator after the juice