is stored and sold under refrigeration in order to preserve quality. This product is packed in 6-oz cans. The 4½-to-1 concentrate is also produced in both a sterile and frozen form. The sterile form is packed in #10 cans. It may be held for short periods of time without refrigeration, but it is important to store at 40 F or less if it is to be held for any appreciable length of time. The frozen 6i F concentrate is packaged in polyethylene bags and held in 7-gal fiber containers. This product is stored under refrigeration.

One of the principal uses for bulk pineapple concentrate is as an ingredient for mixing with citrus concentrate in the production of frozen juice blends. Pineapple concentrate is also used as an ingredient in the production of many types of canned fruit drinks. A popular combination has been a pineapple-grapefruit drink which has reached a volume of production exceeding that of single strength canned pineapple juice.

There is considerable range in the composition of pineapple juice. Brix will vary between 12 and 18, with an average of about 13.5 to 14. Acidity will range between 0.6 to 1.1, with an average of about 0.8. Brix-acid ratio will range from 12 to over 20 and will usually average between 16 and 17. Since pineapple concentrate is produced at a standard Brix, variation in composition will show up only in the acidity and Brix-acid ratio.

APPLE JUICE

Considerable attention has been given to the commercial possibilities of frozen apple juice concentrate. Laboratory studies have been made on problems related to its preparation and storage and the concentrate has been prepared in substantial amounts in pilot plants and commercial-scale installations. In addition, the literature contains reports of market studies and estimates of cost of production of frozen apple juice concentrate. Results of these investigations are most encouraging with regard to technical feasibility of manufacturing a high quality concentrate at reasonable clost.

Both evaporative and freeze-concentration have been investigated as procedures for manufacture of frozen apple juice concentrate. As development of practical equipment for freeze-concentration has limited use of such a process, much attention has been given to the use of conventional vacuum-concentration in manufacture of the concentrate. Nevertheless, some of the samples of frozen apple juice concentrate submitted for market test were manufactured by freeze-concentration procedures similar to that described by Gore.

Evaporative procedures, now in favor, include some method of essense (ester) recovery for purpose of incorporating the volatile components of apple flavor in the final concentrate. These procedures are designed so as to take advantage of the fact that in distillation of apple juice most of the volatile flavors are found in the first 10 percent of the distillate. In manufacture of apple juice concentrate by these procedures, this portion of the distillate is passed through a fractionating column to obtain the volatile flavors in concentrated form, usually about 100-fold as compared to the fresh juice. The remaining 90 percent of the original juice, now stripped of its volatile flavors, is then concentrated under vacuum to somewhat more than the concentration desired for the final product. For example, by such procedures 100 gal of apple juice, prepared in conventional manner, may be treated so as to yield 1 gal of 100-fold essence and 24 gal of concentrated stripped-juice. Upon combination of these two fractions full flavored (4-fold) concentrate is obtained. If a higher fold concentrate is desired, concentration of the stripped-juice is carried out to a greater extent. (In such instances, however, it is necessary to de-pectinize the juice in order to avoid excessive viscosity and gelation of the highly concentrated juice.) In accordance with the procedure outlined, it is possible to prepare 4-fold apple juice concentrate which may be reconstituted with three volumes of water to yield a juice that is not perceptibily different in organoleptic quality from the original juice.

Success in retention of natural flavor in manufacture of frozen apple juice concentrate depends on proper attention to time and temperature conditions used in processing. (It is assumed that microbial contamination will be avoided through the use of sound sanitary practice.) The volatile flavors may be stripped from the fresh juice and fractionated at atmospheric pressure without change when the residence time of juice components at high temperature is short. For this purpose, practical equipment has been designed so that the volatile flavors and other juice constituents are heated only a few seconds. It has been shown that concentration of the stripped apple juice may be effected in conventional vacuum pans at temperatures as high as 130 F (54 C) without significant alteration of flavor.

Freezing of the concentrated juice may be done commercially according to known practice. Some investigators propose *case freezing* while others suggest use of slush freezers and freezing tunnels for freezing the product prior to casing.

The keeping quality of frozen apple juice concentrate has not been fully investigated. One report shows that 4-fold apple juice (de-pectinized) concentrate was essentially unchanged after one year of storage at 0 F (−18 C). Similar information is not available on concentrate, prepared without depectinization of the apple juice.

Thus far frozen apple juice concentrate has not found a strong market as a beverage, despite reports of its high acceptability. One non-beverage outlet that has been investigated is frozen desserts, where a concentrate offers the possibility of incorporating readily detectable amounts of natural flavor. Apple ice cream, flavored with frozen apple juice concentrate, has been prepared on a small scale and marketed successfully. Apple sherbet has been prepared and marketed under commercial conditions. Jelly has been prepared in a continuous process from apple juice concentrate and 100-fold volatile flavor concentrate (essence).

GRAPE JUICE

Most of the concentrated grape juice marketed today is prepared from Concord grapes (Vitis Labrusca) grown in the cooler regions of North America; New York, Michigan, Washington, Pennsylvania, Ohio, Arkansas and Ontario. The grapes are harvested when the soluble solids have reached a concentration of 15 to 16 percent which varies with maturity and is influenced by cultural and climatic factors.

After washing, the grapes are conveyed to the stemmer consisting of a perforated, slowly revolving (20 rpm) horizontal drum inside of which several beaters revolving at a much faster speed (200 rpm) knock the berries off the cluster and partially crush them before they are discharged through the drum perforations; the cluster stems are expelled from the open end of the drum. The crushed fruit is then pumped through a tubular heat exchanger where it is heated to 140–145 F for good extraction of the pigments and juice. The hot pulp may then go to hydraulic presses where a series of *cheeses* each 2-in. thick are formed on a cart with the aid of loosely woven cloths. Heavy weights are placed on the pile of cheeses and the *free-run* juice is obtained. Complete expression of the juice is subsequently obtained by rolling the cart onto the platen of a hydraulic press where the cheeses are subjected to pressure of 100–150 psi. The juice expressed by hydraulic presses will have a suspended solids of 1 percent or less. More recently hydraulic presses have been replaced by continuous screw presses. In the latter operation the hot pulp is pumped into large holding tanks equipped with slowly moving agitators which facilitate the mixing of 0.2 lb of pectic enzyme preparation and 10 to 20 lb of purified wood fiber per ton of grapes. A 30 min holding period allows the enzymes to break down the pectin, thereby reducing the slipperiness of the pulp and also dispersing the wood fiber which acts as a bulking agent and permits the screw to exert a pressing action.

The digested pulp is partially drained (approximately 30 percent) of the free-run juice in either revolving screens having a 40 mesh or finer screen, or on sloping vibrating decks equipped with trapezoidal shaped rods. This free-run juice may have 4 to 10 percent suspended solids as determined by centrifuge tests. The remainder of the pulp is then pumped to a continuous screw press. The expressed juice from the screw press may have 4–6 percent suspended solids and the cake a moisture content of 45 to 50 percent.

The free-run and expressed juice are combined and the suspended solids removed by pressure leaf filtration, rotary vacuum filtration or by centrifugation. In pressure filtration ample space (4 to 7 in.) between the leaves is provided for cake formation since 1 to 2 percent diatomaceous filter-aid is used and pressures of 70–80 psi are applied by the filter pumps. Continuous desludging centrifuges may also be used to remove the suspended solids followed by plate and frame filters using diatomaceous filter-aids. Under normal operating conditions, 190 to 195 gal of juice are obtained from a ton of grapes. In some instances the cake from the screw press may be extracted with water in a countercurrent system so that the final extract contains approximately 14 percent soluble solids, which may represent a 5 percent increase in juice yield.

The clarified juice is then pasteurized in tubular or plate type heat exchangers to a temperature of 180–190 F and cooled immediately to 30 F before storage in tanks in refrigerated rooms maintained at 28 F. The cooling of the juice is usually accomplished in two or more steps. In some heat exchange systems, a regeneration cycle is used in the first step whereby the hot juice leaving the pasteurizer preheats entering juice. On occasion the cooling water discharged from the heat exchangers is piped to the washers to heat the water applied to the incoming grapes.

The method of handling the cooled juice depends on the intended use of the concentrate. Where it is to be used in later manufacture of a jelly, the juice is stored at 28 F for 1 to 6 months to permit settling of the argols which consist of potassium acid tartarate, tannins and some colored materials that would give a gritty texture to the jelly or detract from its clarity. In this case the clear juice is syphoned off the precipitate in the storage tanks and may be refiltered. Where the concentrate is to be sold as a blend formed by mixing sugar and ascorbic acid before canning and freezing, the cold storage tank merely serves as a surge tank since the juice is pumped out within a few hours to the concentrator. Here a polishing filter is used before the concentrator to minimize fouling of the evaporator tubes. The concentrate for either jelly manufacture or blended juice may be stored in tanks at 27 F prior to subsequent processing. Whenever single strength juice is bulk stored at 27 F prior to concentration, danger exists from spoilage by fermentation. To minimize yeast growth during storage, all pipe lines and equipment from the pasteurizer to the cold room should be of a sanitary design that permits their ready and frequent cleaning. Further, the interior surfaces of the storage tanks must be relatively smooth or free from crevices and the tank should be thoroughly cleaned before use.

Concentration is carried out in two steps. In the first step, the volatile flavoring materials are stripped from the juice and the stripped juice is then concentrated to the desired density. The volatile components are removed by heating the single strength juice to 220–230 F for a fraction of a minute in a heat exchanger, flashing a percentage of the liquid into vapor in a jacketed tube bundle, and then discharging the liquid and vapor through an orifice tangentially into a separator. The separator should be of sufficient size that the vapor velocity is reduced to 10 fps or less for minimal entrainment. From 20 to 30 percent by weight of the original juice flashes off as a vapor that is led into the base of a fractionating column filled with ceramic saddles or rings. A reflex condenser on the vapor line from the column and a reboiler section at the base of the column are used to provide the necessary reflux ratio. The vent gases from the reflux condenser are then chilled in a heat exchanger and the condensate containing the essence is collected at a rate equivalent to 1/150 of the volume of entering flavoring material.

An important flavor component of Concord grape juice is methyl anthranilate that has a boiling point of 512 F and is only slightly soluble in water. This high boiling point and low solubility in water has resulted in losses of methyl anthranilate when the efficiency of the stripping column is low. It has been suggested that these losses may be reduced by increasing the vaporizing temperature.

The unflashed juice from the separator may be concentrated in a forced circulation, falling film or a single pass evaporator having a relatively short retention time. Forced circulation evaporation may be carried out in one or several stages using temperatures ranging from 135 to 160 F and with a retention time in the evaporator of possibly an hour's duration. This retention time and heat exposure have been reduced by use of falling film evaporators to approximately 15 to 20 min at 100 to 150 F while under vacua of 27 to 29 in. More recently in a single-pass evaporator of special design, the exposure time has been further reduced to approximately 2 to 3 min for complete concentration to 48 Brix in a multiple stage unit using temperatures of 150 to 160 F in the first effect, and 115 F in the second effect. The same type of evaporator may be used to achieve concentrations of 72 Brix if the juice has been depectinized.

The concentrate is cooled to around 70 F and all of the essence is added back along with 10 percent by weight of single strength juice to give a final concentration of 45 to 47 Brix. Sugar is added and an edible fruit acid may also be added to adjust the sugar-acid ratio to optimal flavor. Ascorbic acid (vitamin C) may also be added. In some instances a certain percentage of concentrate prepared from European type grapes may also be added.

Further chilling to 30 F is carried out in a heat exchanger and in refrigerated tanks with agitation to 20–30 F before filling into 6-oz cans. The cans are then placed in cardboard cases which are palletized in such a manner that freezing occurs during holding in an air blast at 10–20 F.

Frozen grape juice concentrate is often purchased according to its grade. The various types of concentrates and methods of scoring along with objective tests of quality are listed in the USDA Standards for Grades of Frozen Concentrated Grape Juice. Similar information is available regarding the quality of concentrate purchased under government contract. No standards of identity for frozen grape juice concentrate have been established under the Federal Food, Drug and Cosmetic Act. However the general provisions of this Act regarding labelling and preparation under sanitary conditions from clean sound raw materials apply to this product.

STRAWBERRY AND OTHER BERRY JUICES

Production of frozen strawberry juice concentrate was undertaken on a commercial scale in 1953. The product, a seven-fold concentrate with separately packed concentrated