possessed superior flavors. The concentrates stored at 10° F. for three years were decidedly off flavor. The flavor of samples stored at 5° F. for three years was slightly impaired but was considered commercially acceptable. After three years' storage the concentrates stored at —4° F. were judged to approximate closely the flavor of the particular concentrate when it was produced.

Summary

Commercial frozen orange concentrate representing a cross section of the Florida products were studied to determine the effects of time and temperature of storage. At 35° F. storage temperature a marked difference in cloud stability was observed between the samples tested. Cloud stability dropped sharply at storage temperatures above 15° F. Below this temperature greater stability was observed with no marked change noted in any of the samples stored at —4° F. for three years. Gelation was observed to occur much more rapidly at 15° F. or above than at lower storage temperatures. No gels were observed after three years at —4° F. Neither flavor nor vitamin C content was appreciably affected in any concentrate after three years at the latter temperature. Increased rates of flavor deterioration were observed at the higher storage temperatures.

Literature Cited


Characteristics of Six-Fold Frozen Concentrated Orange Juice

Roger Patrick and R. L. Huggart
Lake Alfred

Various investigators have studied the characteristics of frozen citrus concentrates containing total soluble solids greater than that found in 4-fold (3 to 1) commercial frozen concentrate. The stability of 6-fold (5 to 1) products is good - - and container, storage
and shipping costs are less because of the higher concentration. The Florida Citrus Code (13) permits the shipping and sale of 5 to 1 (58°-60° Brix) frozen orange concentrate for experimental purposes, provided it is packed only in large containers and used exclusively for institutional or commercial purposes.

Cotton et al. (3) were the first to point out the differences in rates of clarification in frozen orange concentrates containing different amounts of soluble solids. Similar results were reported by Wenzel et al. (14). The effect of concentration on clarification in concentrated citrus juices was investigated by Huggart (6), using Duncan grapefruit concentrates ranging from 10° to 75° Brix and Valencia orange concentrates of 13° to 78° Brix. Storage temperatures of 40°, 60° and 80°F. were used. It was also noted that the addition of fresh juice or citrus peel oil was necessary for improvement of flavor in products concentrated above 42° Brix. Rice et al. (10) made similar studies concerning cloud stability at 20° and 40°F. in 4, 5, 6 and 7-fold orange or grapefruit concentrates, containing added citrus peel oil for fortification of flavor. They found greater stability of flavor in a 6-fold orange concentrate than that in a 4-fold product. DuBois and Murdock (4) reported and compared data on flavor and cloud retention, vitamin C retention, viscosity and freezing characteristics of 58.5° and 42° Brix frozen orange concentrates. Recently Bissett et al (2) reported on the cloud stability and flavor of 58.5° and 42° Brix Valencia orange concentrates that were made from unheated and heated juices.

The survival and growth of microorganisms in citrus concentrates have also been investigated. Rushing, Patrick and Veldhuis (11) found that no cans of concentrated orange juice of 50° Brix or higher swelled in 35°F. storage, but at 50° and 60°F. swells were observed in all concentrations below 70° Brix. They found that yeasts were the main spoilage agents. There was a decrease in numbers with the increase of concentration and storage time. Slime and gum-forming bacteria decreased more rapidly at 50° and 60°F. than at 35°F. The survival of strains of Leuconostoc, Lactobacillus and yeast in 42°, 58.5° and 70° Brix orange concentrates stored at 0°, 15° and 40°F. were studied by Murdock and DuBois (8). Increased concentration or temperature of storage resulted in increased death rates of the organisms in all instances except in a 42° Brix product in which the yeasts died at 0°F., died more rapidly at 15°F., but grew at 40°F. Yeasts grew in concentrations through 58.5° Brix and bacterial growth occurred in all concentrations through 50° Brix.

The effect of the concentration of citrus juices on the growth rates of microorganisms has also been investigated by Barreto (1) and by Rushing et al. (12). Results of investigations have also been reported concerning the survival and growth of microorganisms in 42° Brix orange concentrates. Strains of yeast in two out of 13 samples of commercial packs were found by Patrick (9) to survive 198 days at 0°F., and were observed to grow and produce spoilage in two samples out of ten when stored at 42°F. Wolford (15) observed a rapid drop in total numbers during the first three to eight weeks of storage at —10°F. Moore et al (7) found at 40°F. storage a sharp drop in total count that leveled off in about two months. At —8°F., the reduction in total count was much slower with a gradual decrease over a six months period. Faville, Hill and Parish (5) found that the total number of organisms was 10% higher in commercial packs than in experimental pilot plant packs and that 50% died during the first month of storage as compared with about 10% in the experimental packs for the same period.

The purpose of this paper is to present some information obtained from the examination of packs of 6-fold (5 to 1) Valencia orange concentrates that were stored at —8°, 20°, 40° and 60°F. These products contained different amounts of cut-back juice; citrus peel oil was added to them for improvement of flavor.

**Experimental Procedure**

Four packs of concentrated Valencia orange juices were prepared in June, 1953, from fruit obtained from the Indian River citrus area. The fruit was washed with a detergent, rinsed with chlorine water and inspected; all damaged and decayed fruits were discarded. After thoroughly mixing all of the fruit, it was placed in washed field boxes and stored at 32°F. The number of boxes of fruit necessary to make one pack of concentrate was re-
moved from storage as needed and the oranges re-washed before the juice was extracted. On each of four successive days, one pack of concentrate was prepared in the Station pilot plant. None of these products were stabilized by heat treatment. Three 6-fold (58°-60° Brix) concentrates were prepared from concentrates of 81.5°, 71.5° and 61° Brix by the addition of various amounts of cut-back juice. The cut-back juice was from the same batch as that which was concentrated and was finished using a 0.020 inch screen. A 42° Brix concentrate was made by blending 55° Brix concentrate and cut-back juice. Peel oil was added to all of the products to a calculated level of 0.015% by volume. The characteristics of the raw juices and the four concentrates are given in Table 1. The concentrates in 6 oz. cans were stored at —8°, 20°, 40° and 60°F.

The samples of all of the concentrates were reconstituted and plated initially and at periodic intervals as shown in Table 2. The 4-fold concentrate was reconstituted by the addition of three volumes of water and the 6-fold concentrates by mixing with five volumes of water. Dextrose tryptone agar, pH 7.0, and orange serum agar, pH 5.6, were used for plating of 1:10, 1:100 and 1:1000 dilutions of the reconstituted juices. Plates were incubated at 30-32°C for 48 hr.

The 4-fold and 6-fold concentrates stored at the various temperatures were also examined initially and at periodic intervals to determine changes in the cloud and flavor of the reconstituted juices.

Experimental Results and Discussions

Results of the microbiological examinations of the 4-fold and 6-fold Valencia orange concentrates, initially and after storage at —8°, 20°, 40° and 60°F, are shown in Table 2.

After storage of the 6-fold concentrates for 12 months at —8°F, the decrease in the number of organisms ranged from 74 to 88%; a decrease of 79% was found in the 4-fold product.

In the 6-fold concentrates stored for 9 months at 20° and 40°F, the decrease in counts ranged from 86 to 99%; whereas, in the 4-fold product stored at 20° and 40°F, the decrease was 99% and 90%, respectively.

All of the concentrates stored at 60°F deteriorated rapidly. The 4-fold product fermented in one week. The number of organisms in the 6-fold concentrates decreased to a minimum in two weeks, then gradually increased and caused spoilage in two of the packs after two months; the third pack had not fermented after three months, but was discarded because of excessive gelation and loss of cloud.

There was a rapid decline during the first month in the number of organisms in the three packs of 6-fold concentrates stored at —8°, 20° and 40°F. The rate of decline was slower at —8°F than at the higher temperatures. The amount of cut-back juice used had no effect upon the number of organisms that survived. The counts in most of the 4-fold and 6-fold samples decreased to the lowest numbers after three months, with the samples stored at 40°F, showing the greatest declines.

The number of cans of each pack stored at 40° and 60°F were only sufficient for examinations during a period of nine and three months, respectively, since it was believed that spoilage would occur during these periods of time.

Apparent increases in the number of organisms were found in many of the samples during the one-year period of examination, because of the gradual breaking up of clumps or groups of bacteria or yeasts. The greatest apparent increase occurred after six months storage of the concentrates at —8°F, with the largest apparent increase appearing in Pack No. 3. In general, these apparent increases in counts were smaller as the storage temperature increased.

Initial evaluation of the flavor of these concentrates indicated a slight preference for the samples that contained the larger amounts of
TABLE 2

Effect of Storage Time and Temperature on Microbiological Counts in Six-Fold Valencia Orange Concentrates.*

<table>
<thead>
<tr>
<th>Pack No.</th>
<th>Concentration, °Brix</th>
<th>Storage period</th>
<th>Initial</th>
<th>1 wk.</th>
<th>1 mo.</th>
<th>3 mo.</th>
<th>6 mo.</th>
<th>9 mo.</th>
<th>12 mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>167</td>
<td>59.3</td>
<td>59.3</td>
<td>60.4</td>
<td>59.8</td>
<td>59.3</td>
<td>60.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pH 7.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dextrose tryptone agar,</td>
<td></td>
<td></td>
<td>15,500</td>
<td>17,000</td>
<td>15,500</td>
<td>17,000</td>
<td>18,500</td>
<td>18,500</td>
<td>35,500</td>
</tr>
<tr>
<td>pH 7.0</td>
<td></td>
<td></td>
<td>26,500</td>
<td>12,000</td>
<td>14,000</td>
<td>11,000</td>
<td>10,000</td>
<td>16,000</td>
<td>13,000</td>
</tr>
<tr>
<td>Orange serum agar,</td>
<td></td>
<td></td>
<td>31,500</td>
<td>33,500</td>
<td>31,500</td>
<td>33,500</td>
<td>33,500</td>
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</tr>
<tr>
<td>pH 5.6</td>
<td></td>
<td></td>
<td>17,000</td>
<td>18,500</td>
<td>18,500</td>
<td>35,500</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>26,500</td>
<td>11,000</td>
<td>10,600</td>
<td>9,700</td>
<td>7,100</td>
<td>12,500</td>
<td>8,500</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>31,500</td>
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</tr>
</tbody>
</table>

** Average plate counts as number per ml. in 12°Brix reconstituted juice.

Insignificant count.

Cut-back juice. Considering all of the products, the 4-fold concentrate or the 6-fold concentrate cut-back from 81.5°Brix were preferred, but these could not be differentiated one from the other. Least preference was expressed for the concentrate that contained added peel oil and only a very small amount of cut-back juice. After storage of the concentrates at —8°F., preference of the tasters, if any, shifted to the concentrates containing...
the smaller amounts of cut-back juice. Thus, apparently, during storage some of the flavor that is obtained by the use of cut-back juice gradually decreases in intensity, but the flavor from added peel oil is more permanent.

The determination of clarification in the concentrates stored at the different temperatures resulted in data that confirmed results obtained previously by various investigators (3) (4) (6) (10), which show that 6-fold or 5 to 1 orange concentrates are more stable to enzymic changes than 4-fold products and that the rate of clarification increases with the temperature of storage. After three weeks storage at 20°F., the 4-fold concentrate showed cloud deterioration and gelation. It was commercially unacceptable after one week at higher storage temperatures. All of the 6-fold concentrates were stable for one week at 60°F. and for four weeks at 40°F. When stored at 20°F., they were found to be good after nine months and showed only slight degradation after storage for one year. Cloud retention was excellent in all of the concentrates stored for one year at —8°F.

**Summary**

To determine their relative stability at storage temperatures of —8°, 20°, 40° and 60°F., 6-fold (5 to 1) and 4-fold (3 to 1) Valencia orange concentrates were prepared from one lot of fruit. The 6-fold products of 58° to 60°Brix were prepared from 81.5, 71.5 and 61°Brix concentrates to study the effect of using various amounts of cut-back juice. Peel oil was added to a calculated level of 0.015% by volume.

A rapid decline in the number of organisms occurred during the first month when 4-fold or 6-fold concentrates were stored at —8°, 20° and 40°F. The rate of decline was slower at —8°F. than at higher temperatures. The decrease in counts in all of the samples examined ranged from 74% in one pack stored at —8° to 99% in products stored at higher temperatures. Storage of the concentrates at 60°F. was not satisfactory because of the occurrence of fermentation, clarification and gelation.

Initially, both the 4-fold and the 6-fold orange concentrates containing the larger amounts of cut-back juice were preferred because of a slightly better flavor; however, this preference disappeared after storage of the products at —8°F.

Cloud stability data obtained confirmed the results of previous investigations which indicate that 6-fold concentrates are more stable than 4-fold products. A list of references to previous investigations concerning the characteristics of 6-fold (58°-60°Brix) orange concentrates is included.

**LITERATURE CITED**


