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G1600 Freeze Concentration of Fruit Juices

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Freeze Concentration of Fruit Juices

Food Processing for Entrepreneurs Series

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This publication describes research conducted to examine the feasibility of freeze concentration with small-scale, simple equipment; and research results on juice extraction and concentration from fruit held in frozen storage.

When Grandmother made jelly the wonderful aroma of cooking fruit filled the house. That wonderful aroma was the delicate fruit flavors being evaporated and lost from the jelly. When volatile flavors are retained food has a much better flavor.

Freeze concentration of fruit juices is a method of removing water from juices without heating and changing juice flavor. Freeze concentration is effective because a solute in solution has a lower melting point than pure ice, and can be separated from the water component (ice) as the temperature approaches the melting point of pure ice. To easily confirm this, remove a plastic jug of cider from the freezer, invert the jug in a suitable container, place the jug and container in a refrigerator and allow it to approach thawing temperature. Concentrated apple juice will collect in the container, leaving ice in the jug.

Freeze concentration has many practical applications in food processing. It is effective in adding fruit solids to wine musts; in reducing the amount of cooking necessary to produce jellies, jams and preserves; and in improving flavor and characteristics in many food products. Freeze concentration has been practiced in the food industry for over 30 years, but the equipment is too expensive for most small enterprises.

Extraction methods

Different methods are used to extract juice from different fruits. Apples and grapes usually are extracted with a rack-and-cloth hydraulic press, or the pneumatic press that is similar in principle to the rack-and-cloth press. Squeeze box presses are used in many cider and apple juice applications. Continuous screw presses often are used in larger-scale operations. Commercial pressing equipment often is beyond the means of small orchardists or food processing entrepreneurs. The food processing research laboratory uses a small, homemade stainless steel rack and cloth press. This press has a capacity of approximately 200 pounds of fruit and can be built for a modest price.

Freeze-press extraction

An optimally ripe fruit at harvest can be partially processed i.e. crushed or shredded, then frozen. This allows pressing and processing into finished product at a more convenient time, and often results in higher quality finished products. Freeze pressing results in substantial concentration of the juice during extraction and has other advantages. By this method, harvested fruit is cleaned, crushed, packaged and stored at approximately 0°F. Later it is partially defrosted in storage containers, emptied, mashed into an icy slurry at approximately 28°F and then pressed in a rack-and-cloth, hydraulic press using approximately 80 pounds per square inch gauge (psig) on the press cloths. Concentration of the juice and recovery of fruit solids varies with pressing temperatures *(Figures 1* and *2)*. A more concentrated juice is obtained at lower temperatures, but optimal recovery of fruit solids is achieved at a temperature of 29°F. When 'Flame Tokay' grapes were crushed, frozen and pressed, the original soluble solids content of the fruit (17.8 percent) was concentrated to 24.6 percent in the pressed juice. This eliminates in excess of 20 percent of the water that would normally need to be evaporated in making jelly. Experimentally the grapes were washed, hand sorted, crushed and packaged in 32-pound containers before storage at 0°F until pressing. One-half of the grapes were enzyme treated with Pectinase PX (Enzieco) at a rate of 1 ml blended in each 32-pound container and were held for 40 hours at 40°F before storage at 0°F. The juice was pressed by partially defrosting the frozen, crushed grapes and pressing in a rack-and-cloth press for 20 minutes at 80 psig on the cloths. Duplicate 186-pound batches were pressed for each treatment. Enzyme treatment resulted in a higher recovery of fruit soluble solids (78.69 percent) than non-treated grapes (73.45 percent). Additional fruit solids were recovered if the press cake from the first pressing was broken up and 1 pound of boiling water was added for each 2 pounds of press cake before freezing the mixture and pressing as described above.

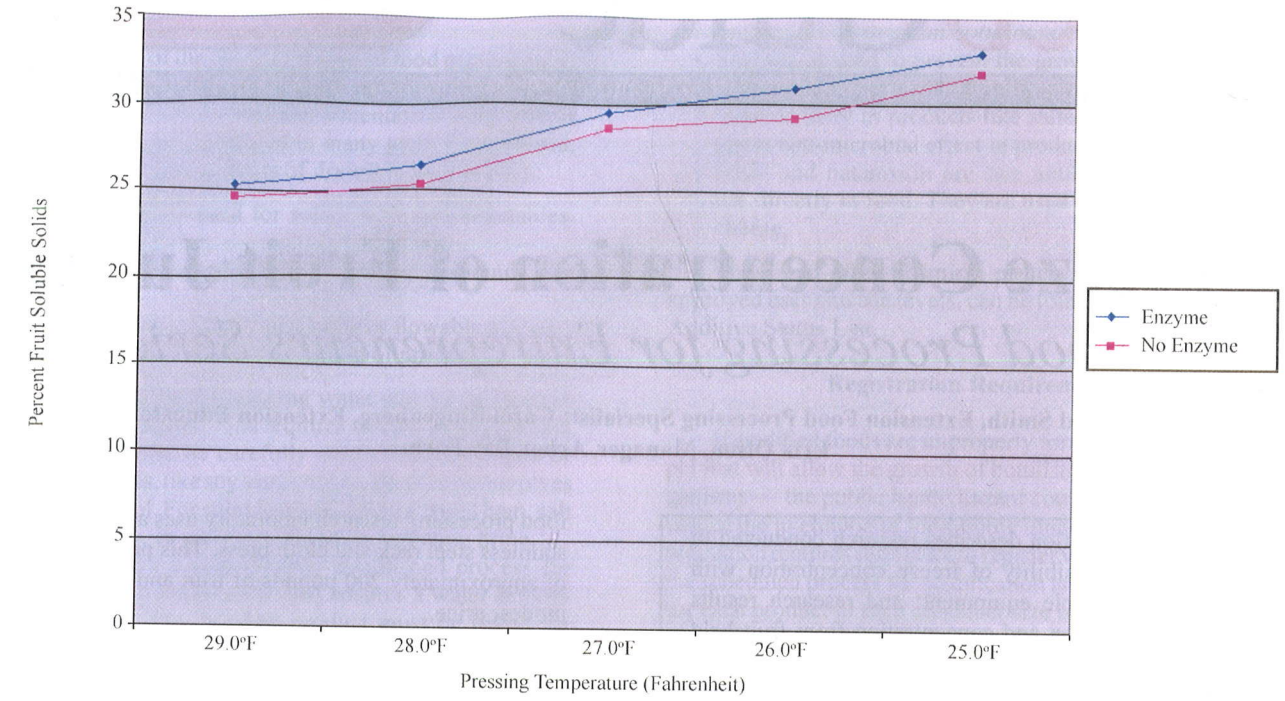

Figure 1. Effect of extraction temperature on concentration of grape juice.

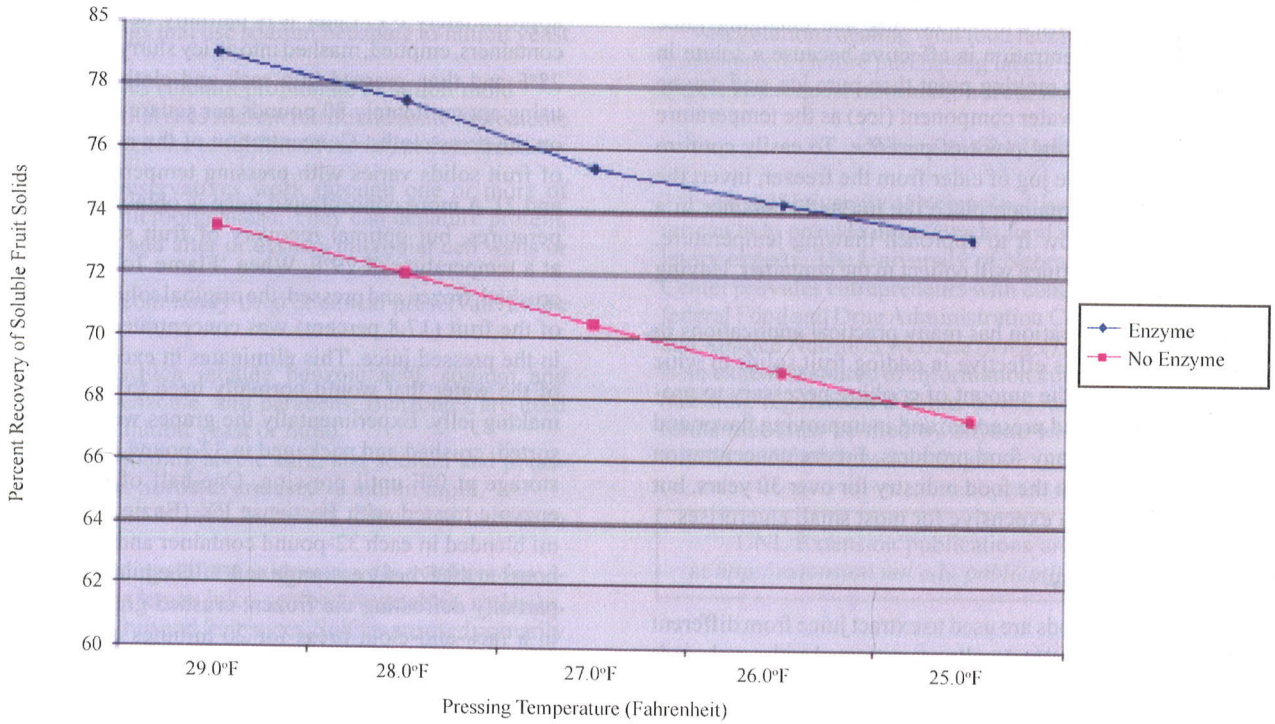

Figure 2. Effect of extraction temperature on recovery of grape fruit solids.

This resulted in a cumulative fruit soluble solids recovery of 89.65 percent for the enzyme treated juice and 87.87 percent for the juice without enzyme treatment.

It is feasible to freeze-press a juice with a soluble solids content of 18 percent from apples with an original soluble solids content of 13 percent. This eliminates approximately 39 percent of the water to be removed in making a final concentrate with 39 percent soluble solids. Shredding apples before freezing can cause browning and be problematic with some cultivars (varieties). Where browning is a problem, sprinkling a small amount of a 40 ppm ascorbic acid (vitamin C) solution on the shredded apples helps reduce browning. When working with some apple cultivars it is better to press the juice, freeze and then press the frozen juice to produce a concentrated juice without substantial browning. If the juice is later heated for the manufacture of a finished food such as jelly, the color brightens unless the product is over cooked.

Refreezing the first-run pressed juice and freeze pressing a second time yields a juice concentrate that is adequately concentrated to manufacture jelly without boiling the juice.

Additional advantages resulting from the ice in the product during pressing as compared with conventional pressing are:

1. No filter aid is needed during pressing. The ice serves as a filter aid and provides excellent clarification of juice.
2. Extrusion of pulpy material through cloth is greatly reduced when ice crystals are present. This greatly reduces stress on press cloths, the labor requirements for removing the press cake from cloths and for cleaning cloths between batches.
3. The load in the press is stabilized against crawling or shifting of individual "cheeses" during pressing. Cheeses are the fruit-loaded press cloths.
4. Double the quantity of material put in each press cloth and a higher stack of "cheese" can be pressed in a given batch. Two-step extraction by freeze-pressing results in very high recovery of soluble solids from the original fruit. A two-step extraction involves pressing the frozen fruit, refreezing the expressed juice and then pressing the frozen juice to extract a fruit juice concentrate from the ice. This concentrated juice from the two-step freeze extraction is usually sufficiently concentrated for jelly making without boiling to evaporate water from the juice.
5. The operation is more sanitary at the relatively low pressing temperatures used in the freeze-press method.

Juice Concentration

Advantages of freeze concentration

Freeze concentration results in higher retention of volatile flavor constituents in the concentrate than any other concentration process, including freeze drying. Basic physical principles account for this unique feature. During freeze concentration, latent heat is removed from the product and water in the crystalline form is separated from the dissolved solids. By other concentration processes except reverse osmosis, latent heat is added to the product and water vapor is removed. Even if the volatile flavors driven off by evaporative processes are recovered and returned to the product, the heat required to evaporate the water can easily cause change in flavor and result in some loss of vitamin content. Furthermore, there is an additional cost in recovering the volatile materials and in blending them back into the finished concentrate.

Centrifuge test on frozen apple juice

Research was done to determine the minimum fruit solids loss in the discarded ice that could be achieved during freeze concentration of frozen apple juice by centrifugation. The outcome of this test indicates good possibilities for freeze concentration of frozen juice, and for reducing the fruit solids loss in the ice to a low level. *Table I* shows experimental results obtained for juice that was pressed from shredded and frozen Winesap apples. The juice had previously been concentrated to 17.6° Brix by pressing the frozen shredded apples.

The flavor advantage attainable by freeze concentration of fruit juices can be approximated in the test kitchen by making apple jelly from frozen apple juice concentrate (below). Use of a fruit concentrate allows production of the fruit product without boiling the juice to concentrate the fruit solids to the level required to produce a standard jelly. Loss of volatile flavors and thermal degradation of the product is thus minimized.

Caution: Handle boiling sugar solutions (jellies) carefully – severe burns can result from spills.

Apple Jelly

1 twelve-ounce package of frozen apple juice concentrate
1 six-ounce package (2 bags) of liquid pectin
7 ½ cups of sugar
2 ½ cups of water
2 ½ level teaspoons citric acid

1. Assemble equipment, jars, ingredients. The frozen juice concentrate should be previously defrosted by holding at room temperature or in a hot water bath.
2. Clean jars and covers. Place covers in a hot water bath and jars in a convenient location for filling.
3. Mix the fruit juice concentrate, liquid pectin (such as Certo™) and the citric acid as specified, and place in a hot water bath.
4. Mix the sugar and water specified in the formulation in the jelly vessel (4 to 6-quart capacity) and heat at a high level while stirring gently until the mixture approaches a full boil. Reduce the heat and continue to boil one minute. This effectively removes entrained air which causes foaming. Immediately turn off heat, but leave vessel resting on the burner. Rapidly add premixed fruit juice component containing the concentrate, pectin and citric acid. Stir gently from the bottom of the vessel upward for 30 seconds
5. Pour the jelly into jars and place the covers on the jars. After one to two minutes tighten the covers firmly.
6. Hold at room temperature for the jelly to cool and set.

Table I. Concentration of Winesap apple juice by freezing in storage containers and separating by centrifuging[1]

Material	*Treatment[1]* *Test No.*	*Temp. °F*	*Centrifugation* *Stage Sec.*	*Time min.-Lb.*	*Data on Fractions* *Weight*	*Brix Lb.*	*Soluble Solids* *Weight Pct.*	*Recovery*
Apple Juice 17.5% Soluble solids	1	15	Start		8.00			
			concentrate	5:00	2.70	46.6	1.258	89.2
			Intermediate	3:00	0.41	26.0	0.107	7.6
			1st wash[2]	3:00	0.33	7.6	0.025	1.8
			2nd wash[3]	3:00	0.42	2.5	0.01	0.8
			Ice		4.10	0.2	0.008	0.6[4]
			Total	14:00	7.96		1.409	100.0
Removed From 0°F storage, crushed without thawing, centrifuged.	2	9	Start		8.00			
			concentrate	10:00	2.77	47.5	1.316	96.0
			Intermediate	2:00	0.30	9.0	0.027	2.0
			1st wash	3:00	0.33	4.0	0.013	1.0
			2nd	2:00	0.40	1.4	0.006	0.3
			Ice		4.32	0.2	0.009	0.7[4]
			Total	17:00	8.12[3]		1.371	100.0
Ice fractions from 1 and 2 were held 24 hours at 32°F, crushed, centrifuged	3	34	Start		8.42	0.2	0.017	0.6
			Effluent	5:00	1.94	0.6	0.012	0.4
			Final ice		6.25	<0.1	0.005	0.2[4]

[1]International laboratory centrifuge with 11 1/8"diameter basket 4" deep, 1/8" diameter perforations on ½" centers. Operated at 68°F, speed 3,500 rpm.
[2]Wash was from melting ice in the product. No water was added.
[3]A small amount of steam was admitted to the centrifuge as the 2nd wash treatment. This accounts for weights higher than the beginning weight.
[4]Lost in the ice fraction.

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