Freeze Concentration for Juice Preparation

The modern beverage industry offers a wide range of healthy fruit and vegetable juices. The heat sensitivity of these ingredients requires a gentle concentration method that removes water without damaging the thermally fragile components from fruits of our earth.

1 Healthy and tasty fruit juices thanks to juice crystallization.

There are several ways to preserve fruits after they have been picked. Have you ever smelled the wonderful aroma of fruits when marmalade is cooking? That wonderful scent was the delicate fruit flavors being evaporated and lost to the atmosphere. When these volatile components can be retained, the resulting fruit product has a much better taste.

Ice cold to preserve vitamins

One method of removing water from fruit juices without heating it or changing the juice flavor is freeze concentration. Freeze concentration is based on the fractional crystallization of water to ice and the subsequent separation of the ice crystals from the concentrated liquid. This process preserves the quality of the fresh juice.

Operating at subzero temperatures retains the flavors, which tend to evaporate in a heating process. An additional advantage is that freeze concentration does not thermally damage fragile components such as color, vitamins, and nutrients. Freeze-concentrated liquid foods and juices often taste much better than evaporative concentrates.

Technologies for thickening beverages

Transport costs and storage costs are influenced by volume and weight. For economic reasons, fruit juices are routinely concentrated. Different methods are used to remove the water from the juice.

Classical thermal concentration techniques, such as evaporation, are the most common for liquid food concentration. However, they lead to significant losses of the initial aromatic compounds, and the resulting concentrates tend to be judged as low quality. Furthermore, the energy consumed during thermal concentration is high. Crystallization requires much less energy than evaporation. For example, for water, the enthalpy of crystallization is 334 kJ/kg compared with the enthalpy of vaporization, which is 2260 kJ/kg at atmospheric pressure.

Functioning principle of conventional freeze concentration

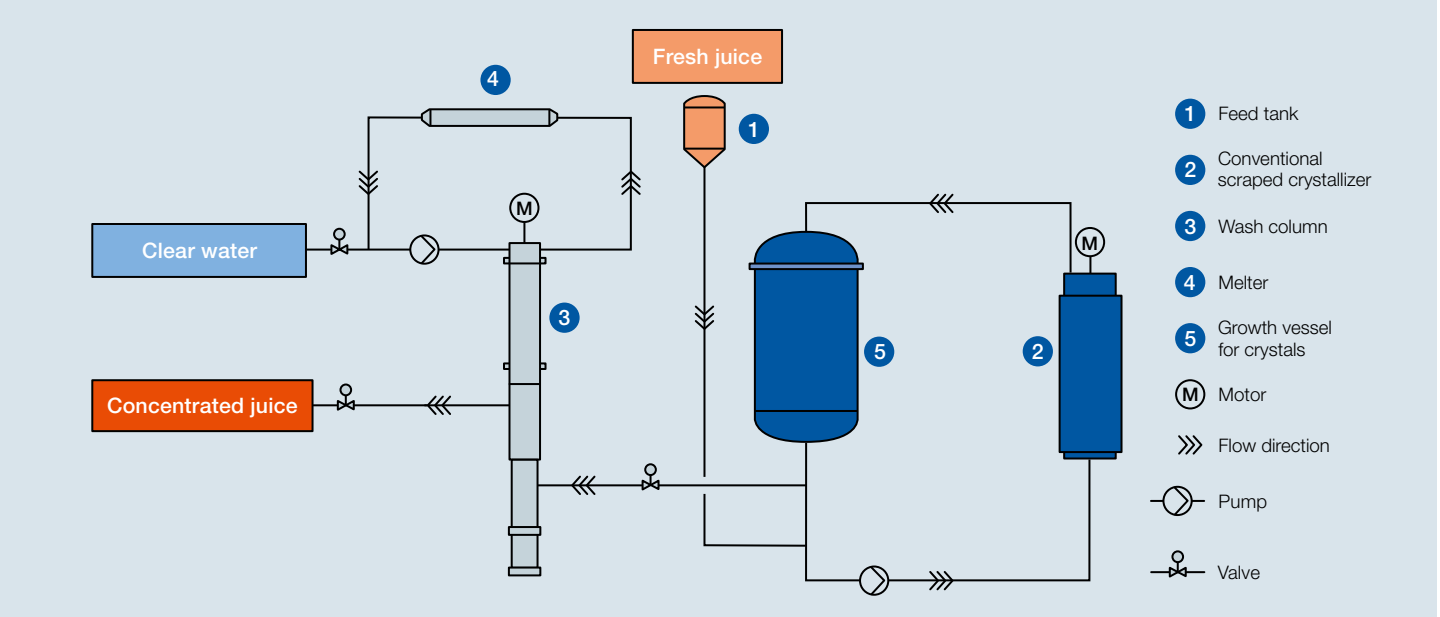
The fractional crystallization of water to ice and the subsequent separation of the ice crystals from the concentrated liquid form the basic process of conventional freeze concentration.

Figure 2 shows the six main steps of the freeze-crystallization process:

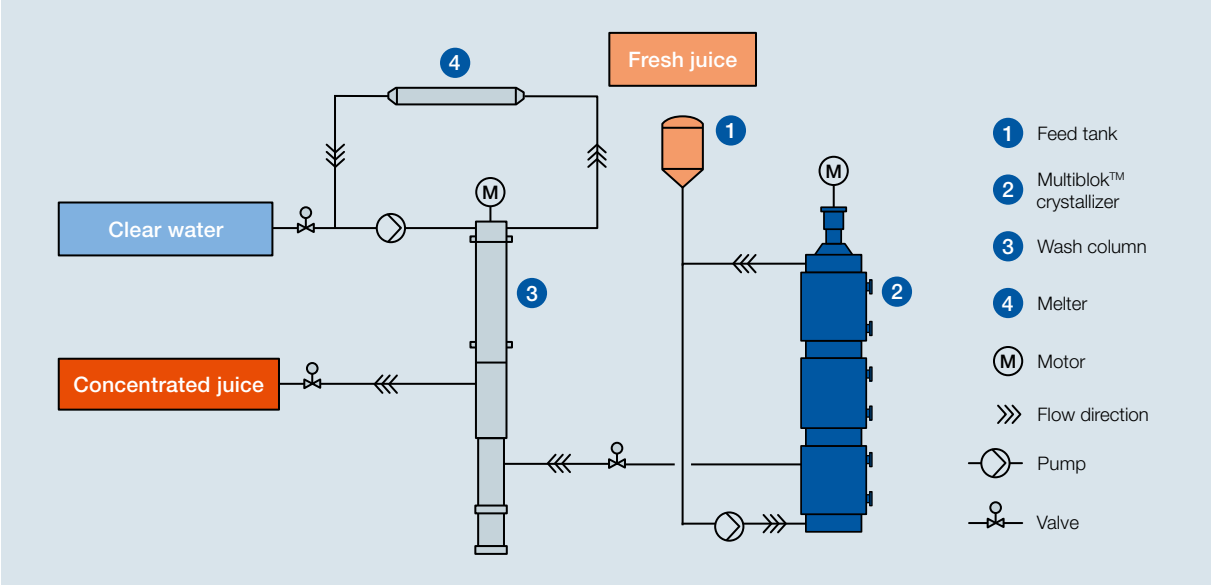
- Filling the liquid, which needs to be concentrated, into a feed tank
- Fractional crystallization of water to ice with the help of the scraped crystallizer
- Growing ice crystals in the growth vessel
- Continuous circulation of the liquid between the crystallizer and the growth vessel with pump
- Removing the large ice crystals (frozen water) from the liquid in the wash column
- Using the concentrated liquid for the next production step.

Application of freeze concentration

Freeze concentration has been practiced in the food industry for more than 30 years. The technology is used for



2 Process flow diagram of a conventional freeze concentration plant.



3 Shortened process in a freeze concentration plant with Multiblok™ crystallizer.

vegetable and fruit juices. Freeze concentration is used in producing coffee and tea extracts, creating milk powder, or thickening vinegar. Beer and wine are concentrated to ease storage and transport (Fig. 4).

The ice crystals are produced on the cold wall of the crystallizer and scraped away from this wall. For a good scraping effect, an extremely smooth surface at the contact area of the scraper and the jacketed steel cylinder is necessary. This avoids the accumulation of crystals at the cooled wall, which would lead over time to an icy plate. Ice plates are insulating — an effect known from the freezer at home. This leads to a reduced temperature transfer at the position of the ice plates and over time to increased energy and process costs.

Current limitations of the conventional freeze concentration in large-scale applications process include:

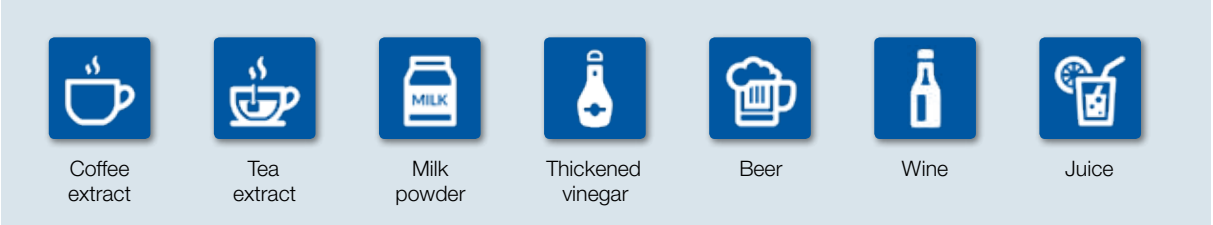
- Inadequate scraping of scrapers at the cooled wall
- Insufficient mixing and mass transfer at the cooled wall with the bulk of the circulating juice
- Mechanically complex designs with high maintenance and operation costs.

Innovative and modular concept

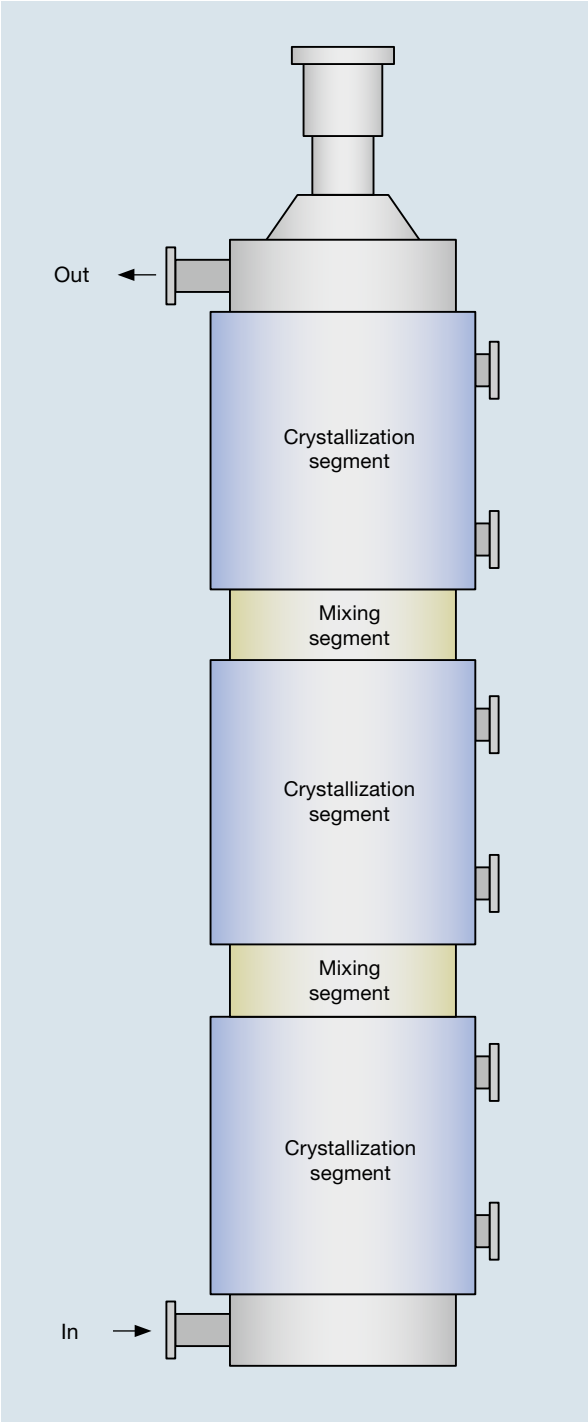
Recent technological developments at Sulzer have aimed to minimize these drawbacks through an innovative concept: the modular Multiblok™ crystallizer. With the increased volume of the Multiblok crystallizer, the process is simplified and two process steps can be combined (Fig. 3). The growth vessel can be eliminated and the continuous circulation between crystallizer and growth vessel is no longer necessary. The wash column follows directly after the crystallizer. This new crystallizer consists of two end caps, a central shaft with a scraper construction, and a variable number of crystallization segments separated from one another by a mixing segment (see Fig. 5 on page 12).

Benefits of the new Multiblok™ crystallizer

The Sulzer crystallization segments are of a size where precise machining of the scraped wall is still feasible without the use of special, expensive lathes. The mixing segment located between two crystallization segments has dividers, called baffles, which enable effective radial and axial mixing. This leads to an increased average crystal size and prevents crystal agglomeration.



4 Application areas for freeze concentration.



5 Multiblok™ crystallizer — a modular construction system with crystallization and mixing segments.

6 Sulzer's test center for crystallization in Switzerland.

The concept of the new Multiblok crystallizer is a modular construction system. It places several segments of the same defined diameter on top of each other. To increase the processing capacity according to the demand of the customer, Sulzer adds more segments to the customer-specific assembly. This standardization feature improves flexibility in plant capacity and optimizes engineering and fabrication costs. The footprint of the installation does not increase with higher crystallization volume. Thanks to the elimination of the growth vessel, the footprint is even reduced. Sulzer can conduct crystallization tests for customers in its test center in Allschwil, Switzerland (see Fig. 6).

Gentle food preservation

Methods of food preservation are influenced by the increasing awareness of people for more tasty or healthy food. More and more people prefer food or juices that taste as they did in "the good old days." With the Multiblok crystallizer, Sulzer supports the cost-effective production of food and beverages with more taste, vitamins, and nutrients.

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