Clarification and concentration of fruit juices using membrane techniques

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The application of membrane technologies to tropical fruit juices is addressed by CIRAD-FLHOR using two main approaches:

- juice clarification by combining enzymatic treatment and tangential micro/ultrafiltration;
- concentration by osmotic evaporation.

Clarification

Results have been obtained not only at the laboratory scale but also at the industrial pilot scale directly at production locations. We currently have both public and private partners in Latin America, especially in Colombia, Ecuador and Costa Rica. Partner enterprises include Passicol in Colombia, where we have worked on passion fruit, Andes berry and other tropical fruits, and Florida Product in Costa Rica where we are developing applications for banana. Our equipment partner is TIA (Techniques Industrielles Avancées) in Bollène in the South of France.

Our first line of research is the clarification of fruit juices by combining enzymatic treatment and tangential microfiltration. The objectives of clarification can be classified in two main categories:

- the obtaining of clarified juices with no pulp (no solids in suspension). These juices can be used in different products such as clarified juices or cocktails of clarified juices, liqueurs, fizzy beverages, flavoured mineral waters, etc., and to facilitate procedures further downstream such as concentration, deacidification by electrodialysis, micronutrient extraction, etc.;
- the production of microbiologically stabilised juices without the need for subsequent pasteurisation of the permeate. We thus profit from the fact that tangential microfiltration allows filtration on membranes capable of retaining microorganisms, the case when average pore diameter is less than 0.2 µm. The retentate consists of pulp, fibres and microorganisms. The clarified juice can be used as it is or mixed with the pulp retentate after pasteurisation of the latter. In some cases, this gives a high quality stabilised juice whose aroma is very similar to that of fresh juice.

In theory, clarification by tangential microfiltration can be used for all fruit juices but filtration performance depends mainly on the viscosity, pulp content and characteristics of the fruit juices. Application to high-pulp juices generally requires prior enzymatic treatment to lower the viscosity by hydrolysing the pectin chains and solubilising part of the cell wall debris forming the pulp and that is released into the juice during extraction. The enzymatic treatment consists of incubating the juice after extraction mainly with pectinase and cellulase and possibly with other enzymes according to the pulp characteristics.

Enzymed juices are easily microfiltered. However, there is always a limit to extraction yield in clarified juice beyond which the filtration flow falls to a low level of little economic interest. The yield is fairly low for high-pulp juices and tangential microfiltration at these values could not be applied to high-pulp juices even after enzymatic treatment. This led us to seeking another strategy, consisting of drawing off just enough juice serum (permeate) for the retentate to conserve the same characteristics as the juice before enzymation. Under these conditions, the retentate can be recycled and then mixed with the high-pulp juice without deterioration of its characteristics. For example, removal of approximately 30% of clarified mango juice leaves the retentate with the same characteristics as the initial high-pulp juice. This is the case in pineapple juice when a 70% yield is attained. This strategy is not used to seek maximum yield but rather a yield that allows the continuous recycling of retentate.

With regard to process flows in a conventional factory, tangential microfiltration can be positioned as a line parallel to the classic production line, from which high pulp juice is drawn off and subjected to enzymatic treatment and then tangential microfiltration. The retentate is recycled continuously when the desired yield is attained. This strategy makes it possible to use high-pulp juices to produce microfiltered juices at a very competitive price because there are no wastes and no products of lesser value.

Concentration

Juice can be concentrated. We are seeking new low temperature concentration processes to conserve the nutritional and aromatic potential of juices and are currently focusing our research on osmotic evaporation.

The osmotic evaporation principle consists of placing a porous, hydrophobic membrane between two solutions of different concentrations—juice and saturated brine. The membrane and the pore diameter are chosen to prevent liquid from entering the pores, which

remain filled with air. The difference in concentration between the two liquids causes a difference in the activity of water, creating a difference in partial pressure at the liquid-air interfaces on either side of the membrane. This results in water transfer in the form of vapour from the solution to be concentrated to the brine compartment. The evaporation flow is proportional to the difference in partial pressure at the interfaces and the aim is therefore to maintain the brine at saturation point by eliminating the water as it evaporates from the juice. The application is simple to operate as it consists simply of setting up two circuits in parallel with a module containing a membrane as an interface and with continuous re-circulation of the juice to be concentrated and of the brine, which is constantly regenerated so that the inflow is effectively saturated.

Practically constant evaporation fluxes can be obtained in industrial pilot trials, with the achieving of very high concentrations of over 60° Brix. The average evaporated flows at the pilot scale are still fairly low (0.6 kg/h. m^2), but these results are being improved since flows of the order of 10 kg/h.m^2 are easily achieved in small units in the laboratory. Excellent results are obtained with regard to organoleptic and nutritional quality. The fresh notes of the aroma and vitamin C are fully conserved.

This research has made it possible to develop new products and diversify the range of agroindustries producing tropical fruit juices in developing countries ■

Application of flash-release, a new extraction procedure (juice, pulp, essential oil)

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The procedure

The first part consists of a description of the process as a whole.

Stage 1*: *sterilisation of the plant material at 85-90°C. Heating is by means of a vapour injection inlet. This type of blanching is necessary for implementing the procedure and also inhibits endogenous enzymatic activity (e.g. polyphenoloxidase and pectinmethylesterase) and destroys bacterial flora.

***Stage 2*: *release stage*,** with the sudden intake under vacuum (approximately 30 mbar) of previously sterilised material (fruits, vegetables, plants, etc.). Under these vacuum conditions, the boiling point of water is between 27 and 30°C. This instantaneous vacuum treatment causes the sudden evaporation of part of the water contained in the sterilised plant material (approximately 10% of the initial moisture content) and a sudden fall in temperature of the material. This instantaneous moisture loss causes fine crushing by the creation of intercellular micro-channels. Disturbance and cell bursting give the products special physicochemical, rheological and organoleptic properties. The evaporation water is recovered separately by evaporation; it is particular rich in volatile aromatic compounds and referred to as **aromatic waters**. It can be re-incorporated in products after 'flash release'.

Products

'Flash release' is a produce with many uses and many effects. The products obtained are treated in two categories; juices and purées and then the recovery of essential oils.

Juices and purées

The process is thus upstream of the refining stage essential for obtaining homogeneous purées and downstream of the paring stages (leaves and stems removed) and fruit washing. Two purée type applications are presented.

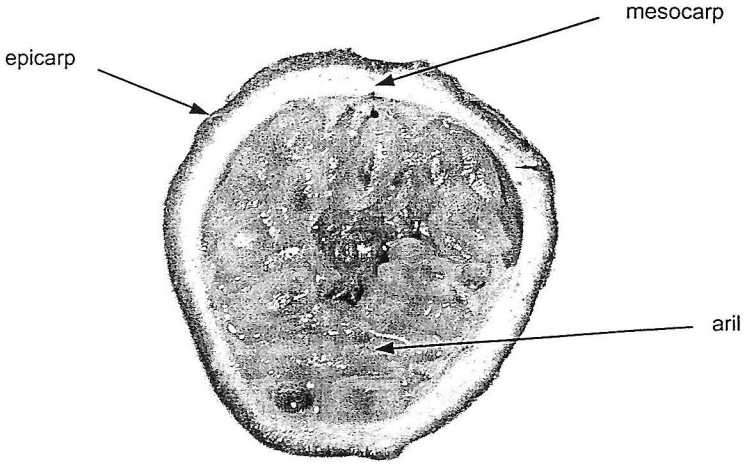

Photo 1 : Longitudinal section of a purple passion fruit (*Passiflora edulis* Sims)