Semi-industrial scaling up of a membrane process to obtain a nutrient-dense citrus concentrate

DORNIER M. (1), SOW A. (1), SERVENT A. (1,2), DHUIQUE-MAYER C. (1,2)
1 QualiSud, Univ Montpellier, Avignon Univ, CIRAD, Institut Agro, IRD, Univ La Rnion, Montpellier, France
2 CIRAD, UMR QualiSud, Montpellier, France

Citrus fruits and their juices are important sources of bioactive compounds such as provitamin A carotenoids (?-cryptoxanthin, ?-carotene), and flavonoids (hesperidin, narirutin) that contribute along with vitamins, minerals and fibers to their beneficial health effects. Crossflow microfiltration (CMF) is a non-thermal and low energy consuming process increasingly used for insoluble solid concentration in liquid foods. As previously demonstrated at laboratory scale (membrane area 0.02 m²), an optimized CMF process allowed to obtain nutrient-dense foods, up to 8-10 times enriched in carotenoids and flavonoids, from citrus juices without increasing total soluble solids.

The aim of this study was to evaluate and validate at semi-industrial scale an integrated process including enzymatic liquefaction (pectinolytic enzymes), CMF with continuous retentate extraction (0.2 m², average pore diameter 0.2 µm, transmembrane pressure 2.25 bar, crossflow velocity 5 m?s^{-1}), and a final step of stabilization by pasteurization (84°C). The interest of the combination of these 3 successive unit operations was appreciated through the nutritional quality of the citrus concentrate, in particular carotenoid and flavonoid contents.

For carotenoids and hesperidin, concentration factors between 6 and 7 were reached. These values were slightly lower than the chosen volume reduction ratio (VRR = 8) due to 20% losses probably by oxidation. The retention of narirutin was found to be partial (below 50%). This result was linked to its lower hydrophobicity and so its lower association with the insoluble fraction retained by the membrane. Even with a 10-fold increase in membrane area (compared to the lab scale) and fully continuous operation, the permeate flux was still above 70 kg?h^{-1}?m^{-2}. It was repeatable for different production batches and stable up to VRR = 8 that was promising for higher VRR applications. Using a pasteurization value of 120 min (Tref = 70°C), the thermal stabilization step had no significant effect on the concentrate quality.

The whole process was therefore proved to be transposable and applicable at a semi-industrial scale, with good performance and robustness. It enabled the production of citrus concentrates with a much higher nutritional potential than the raw citrus juices and with a shelf life of several months at room temperature.