Application of membrane technology at pilot plant scale to manufacture concentrated colored polyphenolic water extracts from tropical vegetal biodiversity

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Various plants from the tropical biodiversity are traditionally used to produce ingredients locally used in medicinal, pharmaceutical, cosmetic and beverage preparations. At home scale, tree leaves and flower petals are generally soaked in water to prepare colored natural extracts, containing polyphenols.
Coupled Membrane Separation Technology (CMST), including Cross Flow Microfiltration (CFM) and Reverse Osmosis (RO), was used to scale up such traditional extraction processes. At pilot plant scale, fresh or dry vegetal substrates were processed to produce liquid concentrates of natural water-soluble biomolecules including anthocyanins, flavones and acid-phenols. Membranes used were of industrial types: a multi-channel ceramic membrane for CFM and a folded polymeric membrane for RO.
Large volume of tap water was used (250L) to extract, at one time, dried or fresh substrates in a ratio of 1/100 (w/w). Each substrate was firstly macerated overnight in water. The macerate was microfiltrated at constant transmembrane pressure (TMP=0.6b) and room temperature (25-30°C), using a single P19-60 membrane (0.2µm pore size, 0.304m^2 filtration surface). Filtration fluxes were regularly recorded until the end of the CFM step (5-11h). A dead CFM volume (10L) was generally left unfiltered in the pilot plant. The CFM extract was concentrated by RO (TMP=40b, T=25-30°C) using a SW30 membrane (2m^2). The Volume Reduction Factor (VRF) achieved by RO was generally up to 100, resulting of the fixed volume ratio between the RO concentrate final volume (2L) and the CFM initial volume processed once (200L).
Petals from various *Hibiscus sabdariffa* flower cultivars, harvested in Thailand or in Africa (Egypte, Senegal), were extracted with water, and *Carapa Procera* tree leaves and *Delonix regia* tree flowers, from Ivory Coast, were soaked in acidified water with sulfuric or citric acid 0.05N. CFM fluxes started at 600 and stabilized for 2.5h microfiltration time at 200$L.h^{-1}.m^{-2}.b^{-1}$, 2.5h after CFM start for *Hibiscus* extracts, and both stabilized around 100$L.h^{-1}.m^{-2}.b^{-1}$, for *Carapa* and *Delonix* extracts. RO concentration showed water elimination fluxes of 20, 16 and 17$L.h^{-1}.m^{-2}$ respectively, leading to concentrates of only 15, 11.7 and 9.6% dry matter, compared to the average of 0.3% dry matter for the 3 CFM extracted substrates. RO concentrates showed low microbial loads. Recovered pure water (>200L) can be recycled in the process and the extracted substrates returned to the fields.
CMST showed new eco-friendly applications for manufacturing added-value extracts from plants of the tropical biodiversity. Small-scale pilot plants can operate in low technical environments in developing countries with good levels of process performances to produce marketable traditional extracts.

References:
[1] L. Meng, Y. Lozano, E. Gaydou, B. Li, Antioxidant Activities of Polyphenols Extracted from Perilla frutescens Varieties, Molecules, **2009**, 14, 133-140.
[2] F. Adje, Y. Lozano, E. Meudec, P. Lozano, A. Adima, G. Agbo N'zi, E. Gaydou, Anthocyanin Characterization of Pilot Plant Water Extracts of Delonix regia Flowers, Molecules, **2008**, 13, 1238-1245.
[3] L. Meng, Y. Lozano, I. Bombarda, E. Gaydou, B. Li, Anthocyanin and Flavonoid Production from Perilla frutescens: Pilot Plant Scale Processing Including Cross-Flow Microfiltration and Reverse Osmosis, J. Agric. Food Chem. 2006, 54, 4297-4303.