Modelling the extraction kinetics of ?-Carotene and Betalains for solid-liquid extractor design

KUMAR R. (1), ORUNA CONCHA M. (1), METHVEN L. (1), NIRANJAN K. (1)
1 University of Reading, Reading, United Kingdom

Betalains and Beta-carotene are two bioactives which are widely present in human diet. Betalains are potent antioxidants and Beta-carotene is a precursor of vitamin A. Betalains are extracted from beet root, either from raw beetroot or its processing waste, using polar solvents such as aqueous ethanol. Beta-carotene, on the other hand, is extracted from carrots or its processing wastes into non-polar solvents such as hexane and edible oils. Betalains and Beta-carotene are known to be thermolabile, and extraction conditions must be carefully chosen to minimise degradation. A semi-empirical model is developed to characterise the extraction kinetics of: 1) Betalains in aqueous ethanolic solution (10, 20, and 30%) at temperature ranges 55-85 °C, and 2) Beta-carotene in sunflower oil at the temperature range 90-150 °C, which can be employed for designing and optimising solid-liquid extractors for separating these bioactives. The model considers the net rate of change of bioactive concentration in the extract to be a balance between: i) the rate at which the bioactive is released from the solid phase and ii) the rate at which the bioactive decomposes in the extract phase.The main parameters of the models are: C_{si} – representing the mass of extractable bioactive in the solid phase, k_m representing the dynamics of solid phase exhaustion/extraction with respect to Beta-carotene or Betalains, and k representing the first order rate constant for the degradation of bioactives. The model is experimentally validated, and the model parameters are used to design and compare the performance of different types of extraction systems. This study shows that careful selection of the operating variables such as extraction time and temperature can eliminate the need for using process intensification methods which involve the use of expensive devices such as microwave and ultrasound. Experimental data are also presented for the thermal degradation kinetics of both bioactives to help develop robust extraction systems. In general, Betalains were found to be more thermally labile than Beta-carotene. The experimental data and model shows a good fit with lower values of sum squared error (SSE) and root mean square error (RMSE) and higher values of R^2 and Adj. R^2.