Multicomponent Diffusion Applied to Osmotic Dehydration

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Abstract

Introduction
Osmotic dehydration involves subjecting the solid food, either whole or in pieces, to aqueous solutions that have high osmotic pressures to promote the removal of water present in the food (Schwartzberg and Chao, 1982). The study of processes involved in osmotic dehydration, as well as mass transfer simulation and modeling, is a useful predictive tool for the food industry, for assisting in the process time optimization among other variables involved (Borsato, et al. 2009). Several studies on the diffusion in foods uses Fick's laws for binary and ternary systems and have been developed for investigating the osmotic dehydration . The complexity and the diversity of coefficients involved in osmotic dehydration makes modeling a laborious process, and the finite element method (FEM) is a set of efficient techniques to obtain numerical solutions of differential equations (Teles, et al, 2006). The purpose of this study was to determine the diffusion coefficients, the mass transfer coefficient and the Biot number by simulating the process using the finite element method coupled with the simplex optimisation procedure.

Application of COMSOL Muitiphysics® software.
COMSOL was used iteratively and in association with simplex optimization. It was used Chemical Engineering Module/ Mass Transport/ Diffusion/ Lagrange - Cubic. The Boundary conditions were 42% commercial sucrose and 18% FOS, the corresponding values of moisture, sucrose ande FOS of pieces of melon before starting the osmotic dehydration process werw 87,44, 10,66 ande 1,9% respectively. The simulation was performed using an automatically generated tetrahedra, which was composed of 5440 elements with 24,948 degrees of freedom (Figure 1).

In this method a set of parameters based on Fick's law, it was suggested by simplex and tested in COMSOL, and the components concentrations were compared to experimental responses. The methodology was conducted in order to achieve the lowest error value.

Results and disussion
The optmized main coefficients, in m2s-1, were 21.07x10-11 for sucrose, 15.60x10-11 for water and 8.96x10-11 for FOS; and the obtained Biot number were 14.87.

Figure 2 presents the sucrose, FOS and water diffusion profiles as a function of time with the concentration values obtained experimentally and by applying COMSOL Multiphysics using the

primary and crossed diffusion coefficients and Biot number optimised in the dehydration process in this study.

Conclusion
The values of concentration obtained by the simulation proved to be convergent and consistent with the experimental results, which validates the application of FEM to model the osmotic dehydration process.

Reference

U.M.Teles,et al., Optimization of osmotic dehydration of melons followed by air-drying. International Journal Food Science Technoology, V.41, 674 - 680, (2006).

D. Borsato, et al., Modelagem e simulação da desidratação osmótica em pedaços de abacaxi utilizando o método de elementos finitos, Química Nova, V.32, 2109 - 2113, (2009).

H. G. Schwartzberg, R. Y. Chao, Solute diffusivities in leaching process. Food Technology, V.36, 73-86, (1982).

Figures used in the abstract

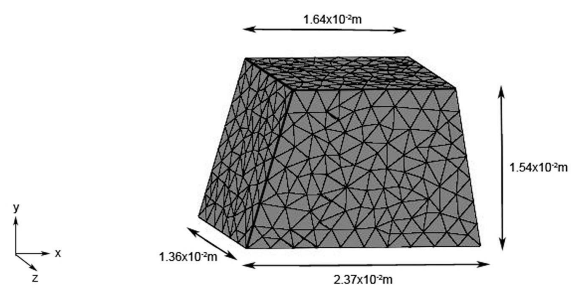

Figure 1: Tetrahedral mesh with average dimensions and spatial orientation.

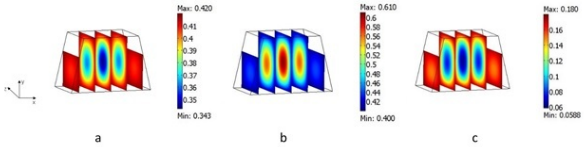

Figure 2: Concentration profile of a) sucrose, b) water and c) fructooligosaccheride (FOS) in melo after 28 hours of immersion.