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Research article

DEVELOPMENT OF A MATHEMATICAL MODEL TO DETERMINE THE MOISTURE DIFFUSIVITY OF AN INFINITE FLAT SLAB DRYING MATERIAL: APPLICATION TO FREEZE-DRYING OF YOGURT

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ABSTRACT

In the study of freeze-drying engineering and technology, one of the key factors is the development and solution of a mathematical modeling problem to describe the drying kinetics, thereby determining the optimal technological parameters. The ultimate goal is to ensure that the dried product meets high quality standards, achieves the desired moisture content, and minimizes energy consumption. However, this modeling and optimization process cannot be effectively carried out without first determining the characteristic moisture diffusion coefficient of the material. In particular, the characteristic moisture diffusivity coefficient of the material depends on the temperature and pressure of the freeze-drying environment, which, until now, has not been addressed in any research work. Therefore, this study presents a mathematical model for determining the effective moisture diffusivity of yogurt during the freeze-drying process: $D = (0.284 + 0.05\times X_1 + 0.123\times X_2 + 0.144\times X_1\times X_2)\times 10^{-11}$, m^2/s, with the maximum error of 1.11% for the mathematical model and the correlation coefficient $R^2 = 0.9979$. Based on this model, when the freeze-drying temperature $X_1 = T = (30\div 40)^0C$ and the pressure $X_2 = P = (0.01\div 0.1)$mmHg the effective moisture diffusivity of yogurt during freeze-drying was determined to range from 1.822×10^{-11} to 2.864×10^{-11} m^2/s.