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Abstract Title: Parameter Estimation for Effective Moisture Diffusivity During Convective Drying of Apple Slices

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Introduction

Drying is a critical unit process for preserving fruits like apples, impacting quality and shelf life. Impingement ovens are commonly used for this purpose. Understanding and modeling moisture removal while drying relies heavily on accurate material properties, particularly effective moisture diffusivity (D_{eff}). This parameter quantifies internal moisture transport but is challenging to determine directly due to its dependence on both temperature and moisture content.

Objective

This study aimed to utilize an inverse method to estimate the specific parameters (reference moisture diffusivity; D_{ref} and scaling factor, z) of the D_{eff} equation within a coupled heat and mass transfer model applied to the convective drying of apple slices.

Methods

Thin apple slices were dried in an air impingement oven at air temperatures of 65ºC and 70ºC, yielding temperature (T) and moisture content (M) profiles at the apple surface and center over time. A coupled heat and mass transfer model was then built using Crank-Nicholson Finite Difference Approximation. The model predicted internal T and M distribution based on slice dimensions, initial conditions and oven parameters (temperature, air velocity, RH), using established literature correlations. Scaled sensitivity coefficients for D_{ref} and z were plotted to confirm adequate sensitivity for parameter estimation from the experimental data. An inverse problem was then formulated, employing nonlinear regression to minimize the least squares difference between model-predicted and experimental moisture content by simultaneously adjusting D_{ref} and z.

Results

The model estimated D_{ref} as 10^{-8} m/s and z as 22 ºC, with T_{ref} as 65ºC. The coupled model, utilizing these parameters, demonstrated strong alignment with the experimental moisture content and temperature profiles.

Significance

This inverse method of determining D_{eff} provides a robust way for understanding and optimizing convective apple drying processes, enhancing energy efficiency and product quality.

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