ABSTRACT

The knowledge of heat and mass transfer parameters during drying of food product is essential for effective temperature and moisture analysis. With an objective to model the transport processes and study the influence of product geometry and shrinkage on transport parameters, a series of drying experiments with potato cylinders of varying diameters (8, 10 and 13 mm) with a fixed length of 50 mm was carried out in an in-house designed natural convection mixed-mode solar dryer. The convective heat transfer coefficient (h_c), moisture diffusion coefficient (D_{eff}) and convective mass transfer coefficient (h_m) were determined without and with considering shrinkage effect during the drying period. The results predicted that consideration of product shrinkage in the mathematical model provided 55.72-61.86% higher values of $\bar{h}_c$ than without shrinkage; whereas, $\overline{D}_{eff}$ and $\bar{h}_m$ values were 85.07-90.41% and 39.08-44.70% lower than without shrinkage for the product diameter range considered. Heat transfer correlations in terms of dimensionless numbers were developed for each sample diameter by an equation of the form $Nu=C(Ra)^n$. The uncertainty in the average values of h_c was found to lie within the range of 1-3%. A finite element (FE) based COMSOL Multiphysics software was used to develop a numerical model to simulate the drying behavior of potato cylinders. The FE model satisfactorily simulated the experimental data of transient temperature and moisture ratio of potato cylinders. Moreover, a modest attempt was made to appraise the suitability of artificial neural network (ANN) model for describing the drying performance of potato cylinders in the mixed-mode solar dryer. Results of the comparison between FE and ANN model revealed that the FE model better simulated the experiments compared to ANN model, which was further verified with the statistical measures of error. To expand the scope of acceptability among consumers, the influence of pre-drying treatment on dried product quality was characterized in terms of rehydration, color, texture, nano-indentation, microstructure, surface roughness and X-ray diffraction analyses. It was observed that the pretreated and thinner diameter samples exhibited better quality attributes as compared to untreated ones.

Keywords: Mixed-mode solar dryer; potato cylinders; heat and mass transfer parameters; shrinkage effect; COMSOL Multiphysics; quality attributes