ABSTRACT

The current work has been undertaken to study the effect of different solar drying processes on the drying characteristics, heat and mass transfer parameters and quality of carrot slices. The thermal performance of direct, indirect and mixed mode solar dryers were evaluated in terms of efficiency of dryer and convective heat transfer coefficient from absorber plate to air, $h_{c, p-a}$ under no load condition. The average instantaneous efficiency and $h_{c, p-a}$ were found to be 31.40%, 27.55% and 41.43% and 16.31, 14.92 and 23.81 W/m^2 °C for direct, indirect and mixed mode solar dryers, respectively. A three dimensional finite element model was developed using COMSOL Multiphysics® (Version 5.2a) software to predict the temperature distribution inside the dryers. Further, carrot slices of 5, 7 and 10 mm thickness and 30 mm diameter were dried in natural convection direct, indirect and mixed mode solar dryers. Dryer performance indicators like drying efficiency, pick-up efficiency and specific energy consumption indicated the mixed mode solar dryer to be the most efficient one, followed by direct and indirect solar dryer. The convective heat transfer coefficient, h_c, moisture diffusivity, D_{eff} and convective mass transfer coefficient, h_m were determined during solar drying of carrot slices. It was observed that samples dried in mixed-mode solar dryer achieved higher values of $\overline{h_c}$ (24.95 W/m^{2o}C) followed by indirect (15.80 W/m^{2o}C) and direct solar dryer (13.52 W/m^{2o}C). The h_c values were correlated with the standard dimensionless numbers in the form $Nu=C(Ra)^n$. The D_{eff} and h_m of carrot slices ranged from 2.59×10^{-8}-6.36×10^{-8} m^2/s and 3.15×10^{-7}-4.28×10^{-7} m/s, respectively. A Multiphysics approach was chosen to model the process of heat and mass transfer during drying of carrot slices. The numerical results were compared against experimental data and the outcome suggested that the sample temperatures and moisture ratios are in close agreement with the model predictions. The effect of solar drying in terms of quality of dried product indicated that indirect solar drying preserves most of the nutrients with minimum damage to the cell due to attainment of lower drying temperature as compared to direct and mixed mode solar drying.

Keywords

Solar dryer, carrot, convective heat transfer coefficient, moisture diffusivity, convective mass transfer coefficient, finite element model, COMSOL Multiphysics, quality