Numerical studies on the electromagnetic and thermal performances of radio frequency disinfestation treatments for dried apricots

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Abstract

In recent years, radio frequency (RF) dielectric heating has been increasingly studied as a promising novel disinfestation method for agricultural commodities, especially dried fruit. Three-dimensional multiphysics-based models have been established with a commercial finite element (FE) simulation package (COMSOL Multiphysics) to analyze the RF disinfestation process of dried apricots by defining six sub-domains: the flesh, a thin air layer, pit, air layer, kernel, and Indian meal moth larva located on the apricot surface. Thermo-physical and dielectric properties of the apricot flesh, pit and kernel were measured, respectively, by considering the heterogeneous structures of each individual dried fruit. The models were then experimentally validated by RF heating (27.12 MHz, 6 kW) 0.2 kg dried apricots filled in a rectangular container. The simulated point temperatures matched well with the experimental results both for the dried apricots and larvae, with a smallest average relative percentage error (RPE) of 1.45 %. Spatial distributions of simulated temperatures also indicated good agreement with the available experimental data, indicating that the maximum temperature of insect larvae was 11.3 °C higher than that of the flesh. Model prediction results demonstrated that compared with other physical locations (insect in perfect/partial contact with the flesh), the focusing effect of electric fields caused relatively fast heating rate (10.2 °C min^{-1}) and high average temperature (68 °C) when the insects were located on the fruit surface (in point contact with flesh). Thus, the focusing effect of electric fields within insect body plays an important role in efficacy of RF disinfestation treatment for dried fruit.