Simulation of Microwave Induced Heat, Mass, and Momentum Transfer in Food Product in Domestic Microwave Oven Using COMSOL Multiphysics

Jeyamkondan Subbiah[1], Jiajia Chen[1], Krishnamoorthy Pitchai[1], Sohan Birla[1], David Jones[1]

[1]University of Nebraska, Lincoln, NE, USA

Abstract

Microwave interaction with food material generates heat, which in turn initiates mass and momentum transfer in food. To fully understand the microwave interactions in food system, a multiphysics simulation is highly desirable. For solving Maxwell's electromagnetic field equations, heat transfer in porous media equation, Darcy's equation, and species transport in porous media, a comprehensive microwave model needs to be developed. A 3-D model was developed using RF, heat transfer and chemical species transport modules in COMSOL 4.3 to solve all these equations. Partially coupled iterative segregated method was used to solve the equations in frequency-transient solver. The model was validated by comparing microwave heating profile of cylindrical mashed potatoes in a 1100 W microwave oven. Dielectric and thermal properties of mashed potato was measured as a function of temperature and moisture content. An infrared camera was used to acquire temperature profile of top, bottom and middle layers upon microwave heating of the mashed potatoes. Fiber optic sensors were used to determine point temperatures. Preliminary simulation and experiment results showed that the model reasonably predicted temperature and moisture content.

Reference

1. Alexander Warning,et al., Porous media based model for deep-fat vacuum frying potato chips, Jornal of Food Engineering, 110, 428-440 (2012)
2. Vineet Rakesh, Ashim K. Datta, Microwave puffing: Determination of optimal conditions using a coupled multiphase porous media - Large deformation model, Journal of Food Engineering, 107, 152-163 (2011)

Figures used in the abstract

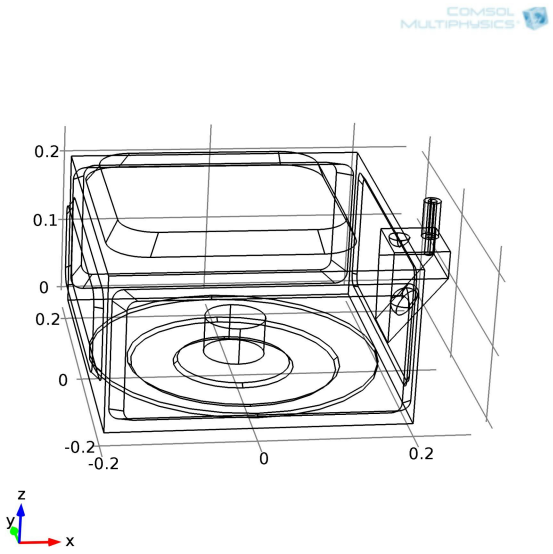

Figure 1: Geometric model of 1100 W microwave oven.

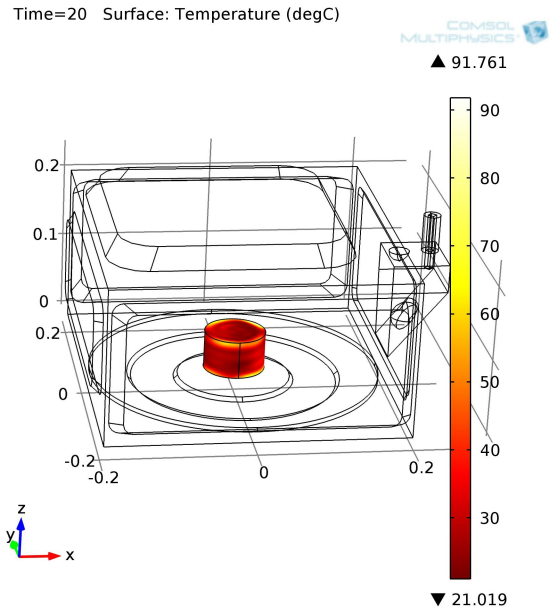

Figure 2: Temperature profile of food at 20 s.

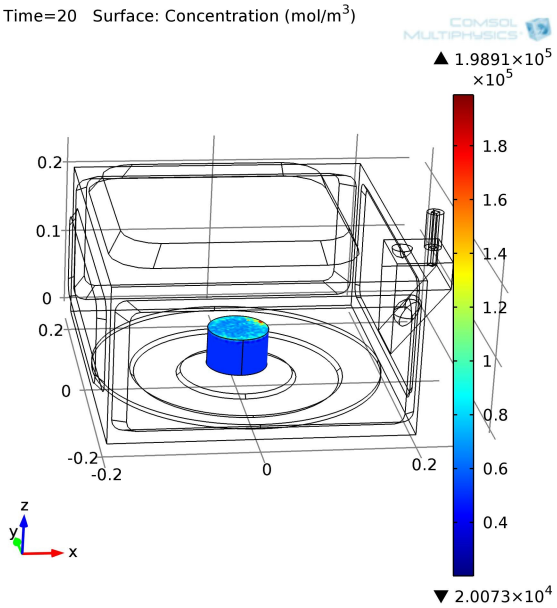

Figure 3: Concentration of water of food at 20 s.