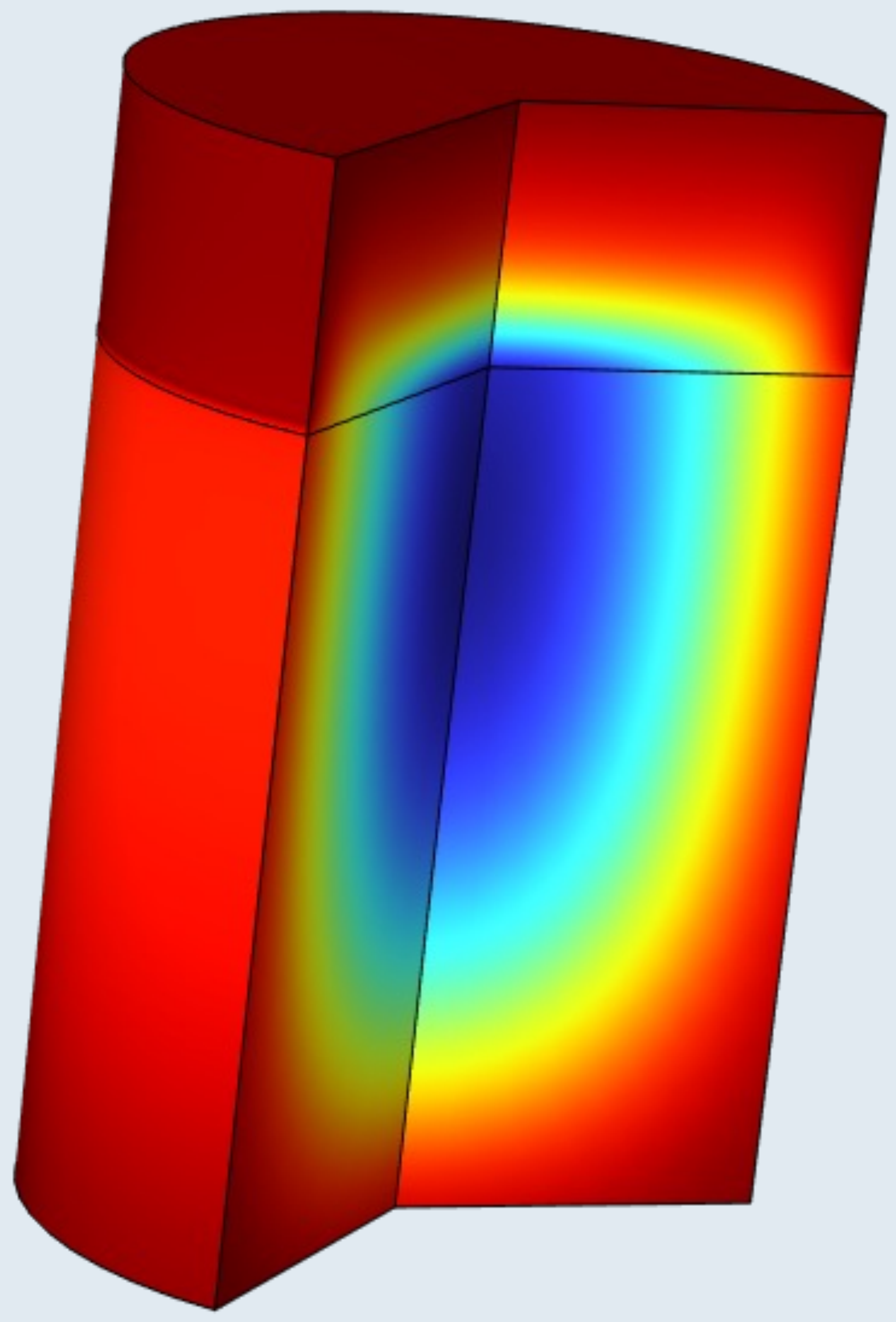

CFD-based Approach for Prediction of Headspace Pressure in Can During Thermal Sterilization of Foods

Numerical and experimental study to investigate headspace pressure dynamics inside canned foods during thermal sterilization, highlighting the key role of water vapor.

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Abstract

Thermal sterilization is crucial for food safety and shelf life, but understanding internal pressure during this process is essential for maintaining packaging integrity [1]. This computational-experimental approach aims to study the headspace pressure in canned foods during sterilization. A 2D-axisymmetric model was developed in COMSOL Multiphysics® to simulate temperature and pressure distribution within a can containing mashed potato as a model food. Simulations showed a maximum dry air absolute pressure of 1.35 bar, while experimental data revealed a total headspace pressure of 3.45 bar. This results showed that water vapor pressure has a big effect on headspace pressure during thermal sterilization. Estimation with simulation and experimental data showed that a mass of 0.12 g water vapor was generated during the thermal sterilization process. This study highlights the importance of including water vapor in pressure predictions to improve food packaging design for both conventional and non-conventional sterilization methods.

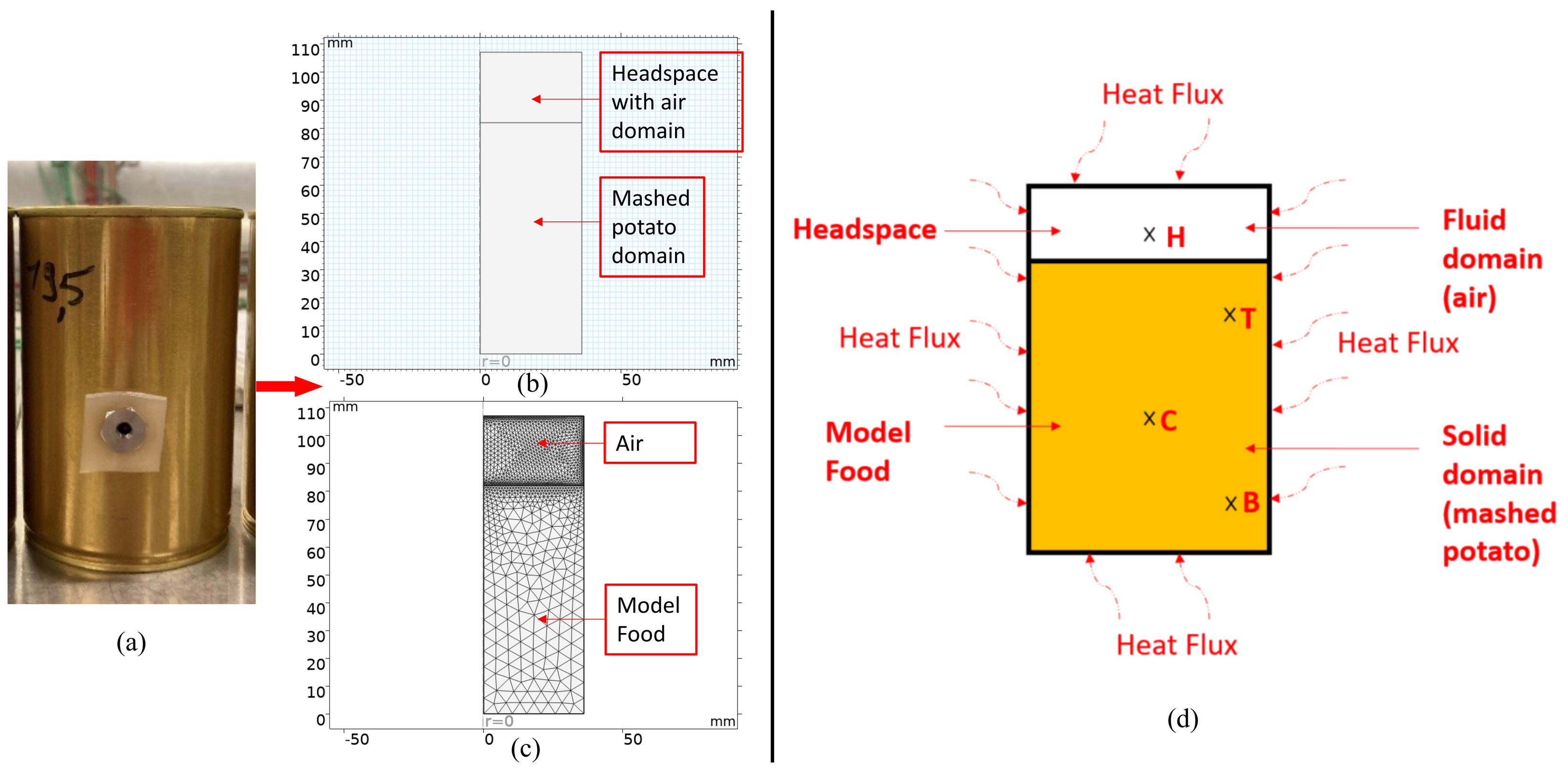

FIGURE 1: (a) Metal can with mashed potato (b) Geometry in COMSOL (c) Meshing of solid and fluid domain (d) Temperature measurement locations at top (T), center (C), bottom (B), and headspace (H) and pressure measurement location at headspace (H)

Methodology

Thermal sterilization experiments were carried out using mashed potato samples in metal cans (107 mm × 72 mm) with a 25 mm headspace (Fig. 1(a)). External heat was provided by pressurized steam in a retort for 8340 s. A numerical model was developed in COMSOL Multiphysics® to simulate heat transfer and pressure changes inside the can (Fig. 1(b),1(c)). The model was used to study headspace pressure during thermal sterilization to understand how pressure builds up particularly from water vapor and dry air. Temperature probes measured heat distribution at four locations: top, center, bottom, and headspace, while absolute pressure inside the cans was recorded using pressure sensors (Figure 1(d)).

Results

- The simulation results demonstrated the model's ability to predict dry air pressure (Fig. 2(a)) and temperature distribution (Fig. 2(e),(f),(g)) during thermal sterilization
- Experimental data at 4821 s recorded a maximum total headspace pressure of 3.45 bar while the simulation calculated dry air pressure at 1.35 bar (Fig. 2(a)).
- Thus, water vapour contributed 2.1 bar to the total headspace pressure (Fig. 2(b)).
- 0.12 g of water vapour was generated during the process (Fig. 2(c)) which is the same order of magnitude determined experimentally (less than 0.5 g).

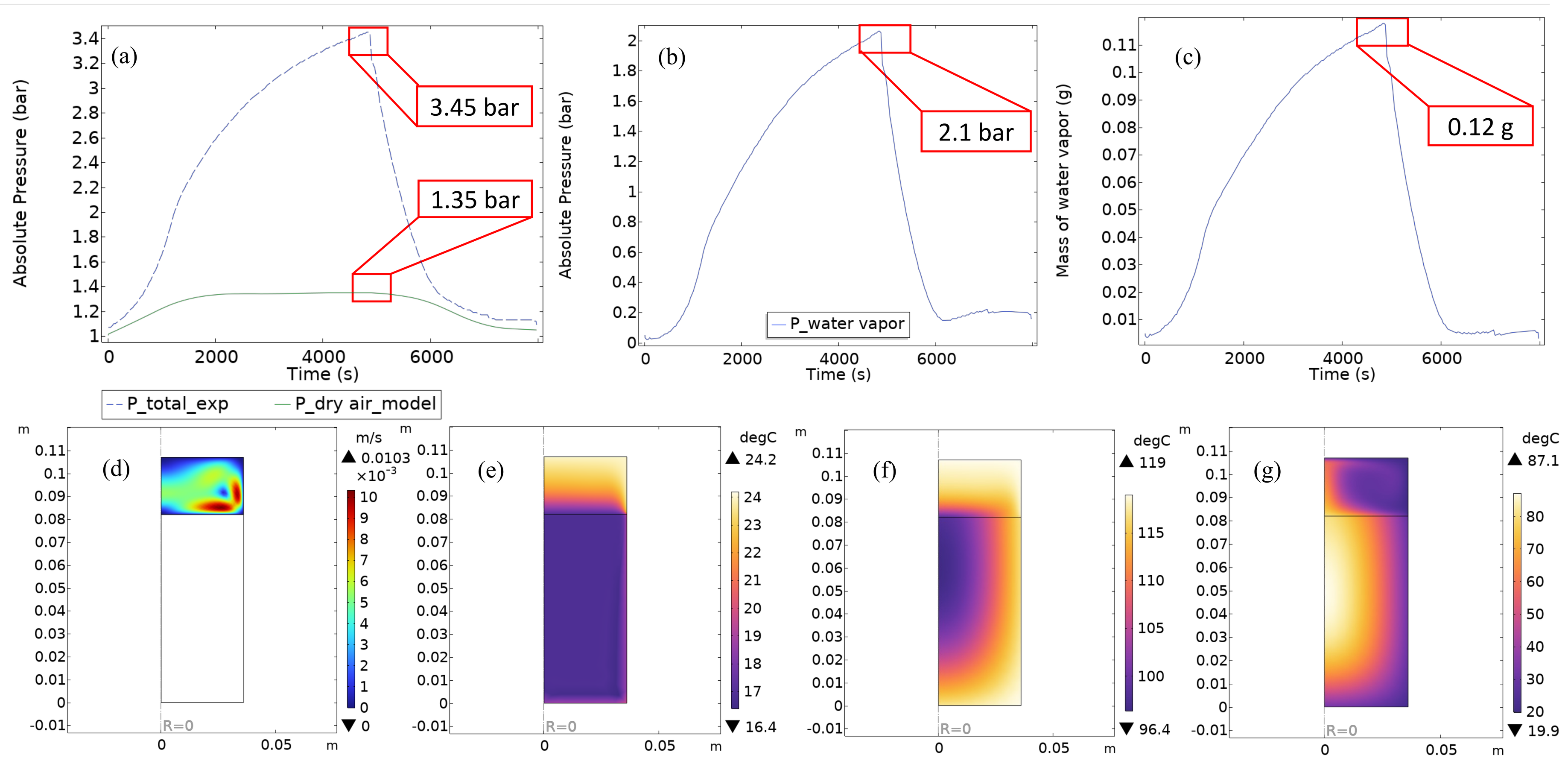

FIGURE 2: (a)Experimental total pressure and simulated dry air pressure profile (b) Estimated water vapor pressure profile (c) Mass of water vapor generated (d) Air velocity at 4821 s (e)Temperature distribution at 10 s (f) Temperature distribution at 4821 s (g) e)Temperature distribution at 7968 s

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