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Heat transfer modeling of canned Vegetarian Khoreshteh Bademjan (VKB) using computational fluid dynamics

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Statement of the Problem: Thermal food processing is an important preservation technique to manufacture shelf stable foods. The objective of this study was to optimize the thermal processing of Vegetarian Khoreshteh Bademjan (VKB) in order to maintain nutritional quality and saving the processing energy requirements. Up to now no studies have been published on the canning of (VKB) as an Iranian food. A computational fluid dynamics (CFD) model was used to predict the temperature distribution and flow behavior of the product during the process. The effectiveness of the thermal processing was estimated by the F values at the slowest heating zone (SHZ) in the can. The CFD model predicts the position of SHZ in the process at various time stages (Bacillus coagulans was considered as the target microorganism).

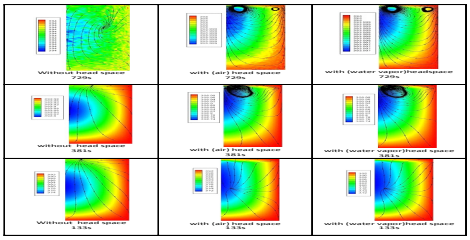

Figure-1: Temperature contours and flow profiles in the cans during thermal processing in three different modeling (without head space, with air head space and water vapor head space) at three different times: t=133, 381 and 729 seconds.

Methodology & Theoretical Orientation: Steam (394 k) was used to heat the canned VKB. ANSYS FLUENT 16.0, which is a commercial computational dynamic fluid solver, was used to solve the NAVIER-STOKES equations. First step was designing the geometry of the cylindrical container (with and without head space). The geometry was symmetric, hence only a segment of the can needed to be modeled. Meshing the geometry was done and the finer rectangular mesh was applied in the boundary layers. The thermophysical properties of the product were measured as functions of temperature (density, thermal conductivity, specific heat and viscosity). Boundary conditions were based on uniform heating on all sides of the container. Simulation was done using the pressure-based solver and PISO algorithm. To validate the numerical results, an experimental result was also conducted at the same condition. Finally T student test was used.

Findings: The SHZ was found at the geometric center of the can in the without head space model and at an area between the center and top of the container in the model with considering head space (real model). The validation results (of time-temperature contribution and F value) showed a good similarity between the predicted and experimentally determined values in the real model. Then to optimize the process, the time-temperature was adjusted to a lower F value by using Simpson's rule.

Conclusion & Significance: CFD simulation, by analyzing the temperature profiles inside the can during the process showed that using the optimization led to reducing the quality losses and energy consumption while keeping the product safe.

Recent Publications

1. Cordioli M, Massimiliano R, Gabriele C, Paolo C and Davide B (2014) Computational Fluid Dynamics (CFD) Modeling and Experimental Validation of Thermal Processing of Canned Fruit Salad in Glass Jar. *Journal of Food Engineering*; 150: 62-69.

2. Dhayal P, Chhanwal N and Anandharamakrishnan C (2013) Heat Transfer Analysis of Sterilization of Canned Milk Using Computational Fluid Dynamics Simulations. *Journal of Food Science and Engineering*; 3: 571-83.

Biography

Vahideh Jalali is an undergraduate student in Food Science and Technology in Isfahan Azad University, Khorasgan, Iran. She has worked in different food companies for about 12 years.

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