Computational multiphysics comparison: conventional vs ohmic heating assisted thermal sterilization validated at a semi-industrial scale

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Ohmic Heating (OH) is an emerging technology which is characterized by the volumetric heating of food products. OH preserves food delicately by maintaining the product quality and reducing the formation of neo contaminants caused by the thermal overload during processing. In former studies, OH characterization has been carried out on a lab-scale with precise operating conditions to avoid typical inhomogeneities that occur during large scale processing. However, process benefits also need to be shown at larger processing scales. Therefore, this study proposes the evaluation and comparison of a semi-industrial OH treatment to a conventional UHT thermal sterilization. For this purpose, carrot-based food matrices (juice representing low and puree high viscosity products) were inoculated with spores of Bacillus Subtilis and Geobacillus stearothermophilus and thermally treated at different temperature profiles with both a conventional UHT-unit and a colinear OH-chamber. To evaluate the sterilization efficiency and thermal load of the treatments, the F-Value was calculated for each temperature profile based on in-house determined inactivation kinetics of above-mentioned microorganisms for each food matrix. To determine and describe the treatment inhomogeneities a multiphysics computational fluid dynamics (CFD) model was developed for both conventional and OH thermal sterilization and validated through the comparison of temperature profiles and predicted inactivation rates. The implementation of CFD was a successful approach in obtaining accurate F-Values, which take into consideration the flow behavior and thermal inhomogeneities inside the equipment. The presence and influence of hotspots, which would have been impossible to characterize without the help of this computational approach, give a mechanistic explanation to the additional microbial inactivation observed after OH treatments. Moreover, this holistic approach allows the quantification of heat loss occurring through the usage of both processing technologies, which provides valuable information for the determination of energy efficiency. This study lays the groundwork for the optimization and design improvement of OH based thermal sterilization technologies, which require the implementation of multiphysics CFD models as the one developed for this study.