

A CHEMICAL MARKER (M-2) BASED COMPUTER VISION METHOD TO
LOCATE THE COLD SPOT IN MICROWAVE STERILIZATION PROCESS

ABSTRACT

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The single-mode 915 MHz microwave sterilization system developed at Washington State University, Pullman has the capability to produce high quality shelf stable foods. In order for this technology to receive FDA approval there is a need for a rapid and reliable method to determine the location of cold spots in food products of different chemical composition, and size. My dissertation overcomes the limitations of the single point temperature sensor with a special focus on the development of a novel approach for determining heating patterns using chemical marker M-2 based computer vision method.

Kinetic of chemical marker M-2 formation in mashed potato has been studied to develop a method to locate the cold spots in microwave sterilization processes. Formation of chemical marker M-2 with 1.5% D-ribose was found to be suitable over the time-temperature range of the microwave sterilization process. Factors for chemical marker formation and kinetic parameters, including the order of reaction, reaction rate constant and energy of activation, were determined in this study. The results demonstrated that formation of chemical marker M-2 in mashed potato is a first order reaction.

A computer vision method based on the yield of chemical marker M-2 was developed to determine the heating patterns in a model food, mashed potato. Through interactive programming an IMAQ Vision Builder script was designed to locate the cold spot in foods during thermal processing. Sensitivities to the heating patterns were tested at different levels of salt and for different tray sizes. Results indicated that salt significantly influenced the dielectric loss but microwave heating patterns were repeatable for model foods. The location of the cold spot predicted by the model was validated using fiber optic temperature probes and microbial inoculation studies.

The developed method here was further improved to facilitate the comparison of the heating patterns for multiple trays. To do this, a new visual scale which adjusted the brightness of the scale for samples was developed. A new image system independent of the lighting position was designed as part of this study. Relationships among computer vision parameters, color value, thermal lethality (F_0), and M-2 yield for mashed potatoes were established for two different paths of heating. Validation tests confirmed that the method based on chemical marker M-2 yield can accurately determine the cold spot location in pre-package model food processed by microwave.

To evaluate this method in a food product, salmon in Alfredo was used to determine the efficacy of this computer vision method. For these studies, a different model food based upon whey protein gels were used to simulate the heating patterns in salmon with Alfredo sauce. The dielectric properties of the whey protein gel were matched as closely as possible to the target food with addition of 0.3% salt. To predict the heating patterns in salmon with Alfredo sauce, relationship among color value in terms of grayscale value, thermal lethality to *C. botulinum* (F_0), and M-2 yield were studied with

wey protein gels. Matching the time-temperature profile between wey protein gel and salmon during microwave sterilization process confirmed that wey protein gel can be used to emulate the heating patterns in real foods. The microbiological study was conducted in 10 oz polymeric trays to validate the cold spot location in auto processed salmon with Alfredo sauce. Results showed that wey protein gels in combination with a computer vision method can predict the cold spot in real food system.

The developed computer vision method in this study is effective in locating the cold spots in model and real food systems. Because microwave sterilization process is a promising alternative to conventional retorting methods for producing high quality shelf stable foods, methods are needed to ensure that these foods can be made safely and that processes can be reliably validated. The developed method and protocol can be used to prepare documentation for FDA approval.