Inverse Problems Symposium 2025

Name: Olumide Fashakin
Organization: Biosystems and Agricultural Engineering, MSU

Abstract Title: Modeling and Parameter Estimation for Predicting Bacillus coagulans Spore Inactivation in Tomato Pulp

Authors: Olumide Fashakin; Boyang Deng; Vikas Rai

Abstract

Title: Modeling and Parameter Estimation for Predicting *Bacillus coagulans* Spore Inactivation in Tomato Pulp

Authors: Olumide Fashakin; Boyang Deng; Vikas Rai

Introduction

Canned fruits and vegetables are prone to spoilage by spore-forming microorganisms, leading to economic losses. Bacillus coagulans, a type of microorganism that can cause this type of spoilage, is a thermotolerant, spore-forming bacterium that causes spoilage and can survive typical heat treatments used in the canning process in acidified canned foods like tomato products. Understanding B. coagulans inactivation under varying temperature conditions is critical for designing and optimizing safe and effective thermal processes in the food industry.

Objective

This study aimed to develop a model to predict *B. coagulans* spores' inactivation in tomato pulp under dynamic temperature conditions. Specifically, we aim to validate the model's predictions for parameter estimation of *B. coagulans* spore inactivation in tomato pulp under nonisothermal conditions (95-105°C) using a Gompertz-inspired model.

Methods

We employed scaled sensitivity analysis, ordinary least squares (OLS) parameter estimation, sequential inverse problem solving, and bootstrapping techniques. The Gompertz-inspired model incorporated temperature-dependent parameters for maximum inactivation rate (k_max) and shoulder length (L). Seven dynamic temperature profiles were used for validation.

Results

Analysis identified the minimum inactivation temperature (T_min1) as the most accurately estimated parameter, while residual microbial density (Y_res) showed negligible significance. The model effectively predicted inactivation for profiles above 99°C but overpredicted lower starting temperatures (95°C). Statistical validation revealed non-constant variance in residuals, indicating model limitations.

Significance

This work provides a validated framework for predicting *B. coagulans* inactivation under industrial processing conditions. The methodology can help optimize thermal processes to ensure food safety while minimizing energy use and quality degradation.

References

1. Zimmermann M, Longhi DA, Schaffner DW, Aragão GM. (2014). Predicting Bacillus coagulans spores' inactivation in tomato pulp under nonisothermal heat treatments. J Food Sci. 2014 May;79(5): M935-40. https://doi/10.1111/1750-3841.12430.

2. Peleg M, Penchina CM. (2000). Modeling microbial survival during exposure to a lethal agent with varying intensity. Crit Rev Food Sci Nutr 40:159–72.

3. Beck, J. V., & Arnold, K. J. (1977). Parameter estimation in engineering and science. James Beck.