HOT WATER DECONTAMINATION OF E. COLI ON BEEF SURFACES: INACTIVATION MODELING AND MEAT SURFACE CHANGES

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I. INTRODUCTION

Hide removal and evisceration are the main sources of bacterial contamination of beef carcasses in abattoirs, during which pathogens, present on the skin or in the gastro-intestinal tract can contaminate the surface [1]. Amongst interventions applied to beef carcasses, hot water treatments (70 to 95, °C) exert decontamination through physical removal and thermal inactivation of viable bacteria present on the meat surface [2]. Although bacterial reductions of two orders of magnitude are generally reported with combinations of temperature and treatment time [2], few attempts have been made to model hot water decontamination and thermal inactivation [3]. The modeling of inactivation with first-order reaction kinetics that takes into account deviations such as tails [4] should be considered. Hot water decontamination can also modify the microstructure of the meat surface, and bacteria may be physically entrapped by meat tissue as reported on poultry [5].

II. MATERIALS AND METHODS

Hot water inactivation modeling used experimental data generated in laboratory-scale studies following a previously published experimental design [6] i.e. pouring hot water perpendicularly onto the surface of beef meat cuts inoculated with viable *Escherichia coli* (ATCC 25922). Four sets of controlled hot water temperature were tested: 60, 65, 70 and 75, °C, with exposure times ranging from 5 to 55, s. Different models were evaluated by linear regression analysis (Microsoft Excel 13.0), and accuracy assessed by adjusted R^2 values. Scanning electron microscopy (SEM) was conducted on samples of approximately 10 x 5, mm of “lean” and “fat” tissue (with 2 to 5, mm of subcutaneous fat) removed from meat artificially contaminated with *E. coli*, before and after hot water treatment at 75 °C for 30 s. SEM samples were prepared according to the experimental procedure designed for poultry tissues [6], coated with approximately 25 nm of gold by direct sputtering, and examined in a SEM unit (Phillips XL-20 SEM) operated with an accelerated voltage of 10kV.

III. RESULTS AND DISCUSSION

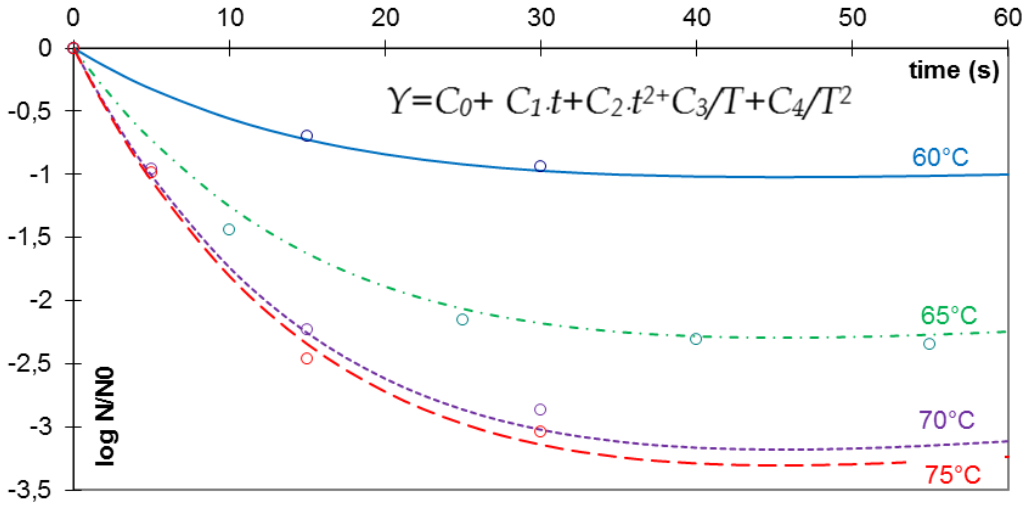

Figure 1. Experimental hot water inactivation data (dots) and model predicted kinetics (lines)

Results were similar to an earlier bench-scale study [6] and confirmed the effectiveness of hot water treatment. Maximal bacterial $\log_{10}$ reductions were achieved after 25 to 30, s of hot water treatment (Figure 1), and because the decontamination rate remained constant after 30 s a tail was again observed. The kinetics can be accurately modeled with a first-order reaction as a quadratic function of both temperature (T, K) and exposure time (t, s) with an adjusted $R^2 = 0.98$, calculated on a limited set of values. This model derives from the generalized additive linear-Arrhenius model proposed for the combined influence of n environmental factors on inactivation rate [7].

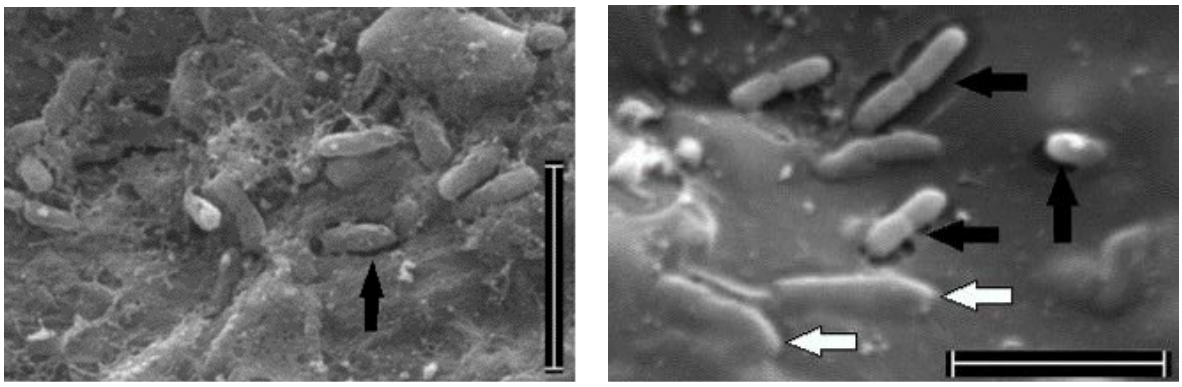

Figure 2. Lean (Left) and fat (Right) tissue after hot water treatment (75 °C for 30 s). Bar = 5 µm. Note the cleared zones or pits around the bacteria (black arrow) and the buried bacteria under the film (white arrow)

SEM of the beef surface after hot water treatment confirmed differences in texture and structure of lean tissue and subcutaneous fat. Subcutaneous fat had a smoother surface than that of the lean tissue that presented collagen fibers which can entrap bacteria. Bacteria can also be retained in crevices in fat tissue (data not shown). Hot water induced changes in the microstructure of the meat surface with the formation of a film, very probably composed of water and meat surface components such as proteins and lipids. This film was able to completely cover any bacteria left on the meat surface (Figure 2), and may retain viable bacteria and/or facilitate growth.

IV. CONCLUSIONS

The inactivation kinetics of hot water thermal decontamination of beef carcass can be accurately modeled using a generalized additive linear-Arrhenius form ($R^2 = 0.98$) on laboratory-scale data. However data from naturally contaminated carcasses should be used to improve predicted reductions that might be achieved in abattoirs and to optimize the efficacy of the hot water decontamination. SEM could be a useful tool to investigate quantitatively the impact of decontamination on the microstructure of the meat as evidence reveals an altered the surface of both lean and fat tissue following hot water decontamination.

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