Modeling and kinetic characterization of the cross-contamination of *Salmonella* in poultry chilling process

Wenqian Wang[1], Xingning Xiao[4], Ronghui Wang[3], Lisa M. Cooney-Kelso[2], Wen Wang[5], Michael T. Kidd[1,2], Yanbin Li[1,2,3]

[1]Department of Poultry Science [2]Center of Excellence for Poultry Science

[3]Department of Biological & Agricultural Engineering, University of Arkansas, Fayetteville, AR 72701

[4]College of Biosystem Engineering and Food Science, Zhejiang University, Hangzhou, Zhejiang, China 310058

[5]Zhejiang Academy of Agricultural Sciences, Hangzhou, Zhejiang, China 310021

Abstract

Salmonella cross-contamination in the chilling process of poultry carcasses is a food safety issue. The objective of this study was to characterize the survival and inactivation of *Salmonella* in poultry chilling process and develop a predictive model for cross-contamination of *Salmonella* in chiller water and poultry carcasses.

To study the kinetic model, twenty-four chicken breast meat samples were prepared in each of the duplicate trials under each condition, and twelve of them were inoculated with *Salmonella* Typhimurium to achieve an initial population of 10^5 cfu/g. Twelve inoculated samples and twelve uninoculated samples were put into different sides of a filtered stomacher bag filled with chlorinated water, and incubated in a chiller water bath. Treated chicken breast meat samples and water samples were pulled out at each time point, and plated on xylose lysine tergitol-4 agar to determine the number of *Salmonella* cells. One-way ANOVA and regression analysis were performed to determine critical parameters that may affect *Salmonella* survival and cross-contamination in the poultry chilling process.

Salmonella survival and cross-contamination kinetics under each condition (4°C of chiller temperature, 0, 20, and 50 ppm of total chlorine concentration, 0, 10, 20, 30, 40, and 50 min of incubation time) was studied. The preliminary result indicated limited efficacy of sodium hypochlorite against cross-contamination of *Salmonella*, due to the protective effect of chicken tissue, and dynamic reduction of free chlorine. A predictive model is being developed and validated with chicken carcasses for further study.

Introduction

- Food-borne illness due to *Salmonella* is a major public health problem, and severe outbreaks have been observed in poultry products internationally.
- Chlorine in low concentrations have been commonly used as a sanitizing agent for chicken carcasses in the chilling process, especially in China. However, cross-contamination of *Salmonella* has been a critical concern during the process.
- A laboratory characterization of survival and cross-contamination kinetics of *Salmonella* in the poultry chilling process is needed to estimate risk reduction. Predictive modeling based on lab-scale experiments would help evaluate the risk in industrial process.

Objectives

The objective of this study was to investigate the effect of chlorine as an antimicrobial agent in poultry chilling process, characterize the survival and inactivation kinetics of *Salmonella*, and develop a predictive model for cross-contamination in chiller water and poultry carcasses.

Materials & Methods

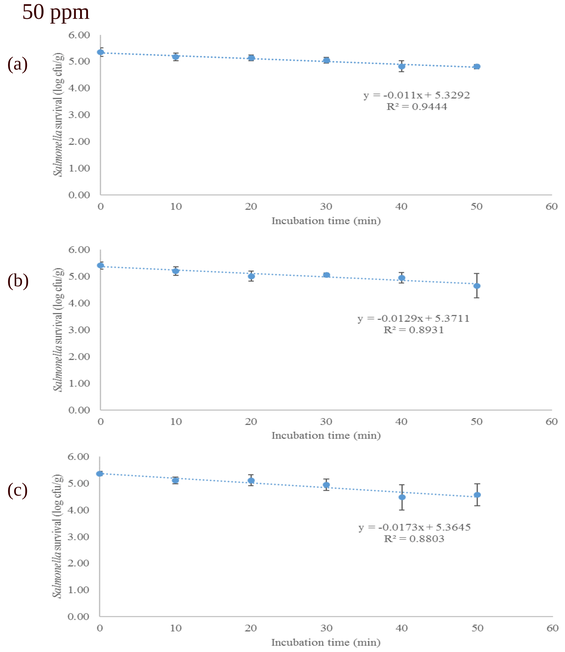
- Microorganism:
  - *Salmonella* Typhimurium (ATCC 14028)
- Poultry sample:
  - Chicken breast meat purchased from a market
- Tools and equipment:
  - VWR sterile filtered sampling bag
  - 2095 bath & circulator (FormaScientific, Marietta, OH, USA)

  - ChloroSense chlorine meter (Palintest, Gateshead, UK)

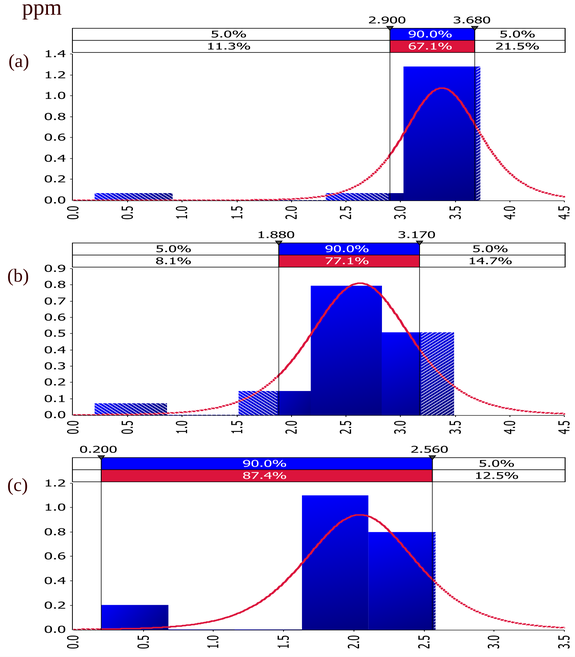
- Inoculum preparation:
  - Thaw frozen stock culture from -80°C freezer
  - Resuscitate in 10 ml TSB
  - Incubate at 37°C for 18 h
  - Dilute with 1 L autoclaved DI water
- Poultry sample inoculation:
  - Cut chicken breast meat into 25 ± 5 g samples
  - Add processed poultry samples into diluted inoculum
  - Mix at room temperature for 30 min
  - Transfer inoculated samples onto sterile tray
  - Hold at room temperature for 30 min
- Enumeration:
  - Dilute samples with phosphate buffered solution
  - Plate on xylose lysine tergitol-4 agar
  - Incubate at 37°C for 18 h
- Test conditions:
  - Chiller water temperature: 4°C
  - Chlorine concentration: 0, 20, 50 ppm
  - Incubation time: 0, 10, 20, 30, 40, 50 min
- Statistical analysis:
  - One-way ANOVA and linear regression analysis
  - Time-based distribution analysis

Results

- Time-based linear regression analysis of *Salmonella* survival on inoculated chicken breast meat samples vs. incubation time with chlorine concentrations of (a) 0 ppm (b) 20 ppm (c) 50 ppm



- Time-based distribution analysis of *Salmonella* cross-contamination on uninoculated chicken breast meat samples with chlorine concentrations of (a) 0 ppm (b) 20 ppm (c) 50 ppm



- *Salmonella* survival/cross-contamination impacted by chlorine concentration (One-way ANOVA analysis

Pull out time(min)	0	10	20	30	40	50
Salmonella survival on the inoculated samples:						
p value	0.8373	0.7514	0.6475	0.5947	0.2171	0.7297
Salmonella cross-contamination on uninoculated samples:						
p value	N/A	0.0016	0.0010	0.0002	<.0001	<.0001
Salmonella cross-contamination in chiller water samples:						
p value	<.0001	0.0022	0.0031	0.0122	0.0070	0.0040

Conclusions

- Despite of chlorine concentration, longer incubation time in chiller water led to greater *Salmonella* inactivation on inoculated chicken breast meat samples, and linear inactivation curve was observed.
- Cross-contamination onto uninoculated chicken breast meat samples was not significantly affected by incubation time, and decreased as chlorine concentration increased.
- One-way ANOVA analysis indicated cross-contamination was impacted by chlorine concentration, while *Salmonella* inactivation on inoculated chicken breast meat samples was not.
- Limited efficacy of sodium hypochlorite against cross-contamination of *Salmonella* was observed, due to the protective effect of chicken tissue, and dynamic reduction of free chlorine.
- Impact parameters, including initial inoculation level on chicken breast meat sample, free chlorine level and pH value in chiller water need to be further studied to develop a predictive model.

Acknowledgements

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References

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