Predictive Microbiology: 
an overview and a practical application

Møller, Cleide Oliveira de Almeida

Publication date:
2013

Document Version
Early version, also known as pre-print

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Predictive Microbiology: an overview and a practical application

Cleide Oliveira de Almeida Møller

National Food Institute, Technical University of Denmark, Søborg, Denmark.

Correspondence
Cleide Møller. E-mail: clemo@food.dtu.dk

DTU Food
National Food Institute
Outline:

- Definition
- Challenges
- Applications
- Example (Eg)
  - Introduction
  - Objectives of the study
  - Summarizing the performed work
  - Process to build up the developed models
  - Results
  - Remarks and future perspectives
Definition:

Predictive Microbiology

- New area
- Development due to emergence of powerful computational resources and statistics
- Responses of microorganisms in foods to environmental factors
- Assurance of: food safety and food quality

Challenges:

• Many different researchers have developed models for the behaviour of particular microorganisms in laboratory media and different food matrices, and made them available in the public domain through peer reviewed publications (Ross and Dalgaard, 2004).

• From an industry perspective, the utility of these public-domain models is often somewhat limited:
  ✓ In many cases, models have been developed under laboratory conditions,
  ✓ are based on specific combinations of parameters that might not be appropriate for the particular food products of an industry,
  ✓ and have not always been validated or even used in real food systems.

• Despite that, such models can be useful as long as their limitations are recognised and considered in their application (Membré and Lambert, 2008).
Applications:

Current applications of predictive microbiology in an industrial context are wide and according to Membré and Lambert (2008) can be summarised into three groups of activities:

1. **Product innovation**, where new products and process are developed, existing products are reformulated, storage conditions and shelf-life are determined, by assessment of speed of microbial proliferation, growth limits, or inactivation rate associated with particular food formulations and/or process conditions;

2. **Operational support**, where predictive models are used as support decision tools to implement or run a food manufacturing operation, such as designing in-factory heating regimes, setting Critical Control Points (CCPs) in Hazard Analysis and Critical Control Points (HACCP), assessing impact of process deviations on microbiological safety and quality of food products;

3. **Incident support**, where the impact on consumer safety or product quality are estimated in case of problems with products on the market.
Modelling transfer of *Salmonella Typhimurium DT104* during grinding of pork

C.O.A. Møller¹, M.J. Nauta¹, B.B. Christensen², P. Dalgaard³, T.B. Hansen¹

1 National Food Institute, Technical University of Denmark, Søborg, DK.

2 Department of Food Science, Faculty of Life Sciences, University of Copenhagen, Copenhagen, DK.

3 National Food Institute, Technical University of Denmark, Kgs. Lyngby, DK.

Correspondence
Cleide Møller. E-mail: clemo@food.dtu.dk

DTU Food
National Food Institute
Introduction

• Salmonella is a critical pathogen (CDC, 2011; EFSA, 2010).

• Pork still is an important source of salmonellosis (EFSA, 2010; van Hoek et al., 2012; Wegener et al., 2003).

• Ground meat is frequently associated with outbreaks of salmonellosis (Stock and Stolle, 2001).

• Up to 70% of foodborne illnesses are estimated to be linked to catered food (Filion and Powell, 2011; Hensen et al., 2006; Jones et al., 2004; Lee and Middleton, 2003).

• In Denmark, 61 of 86 reported outbreaks in 2011 were associated with outside-the-home settings (anonymous, 2012).

• To model the distribution of pathogens during the processing operation are of major relevance to risk analysts (Flores, 2006).
The aim of this study was to develop a model able to predict cross contamination of *Salmonella* in pork grinding.
Experimental work

Transfer study

S. Typhimurium DT104

37°C, overnight + 5°C, 1-3 days
Ca.10⁹ Salmonella/g

Matrix
Salmonella

Distribution of Salmonella
- Analysis performed
- Build up the model
- Validation

Transfer Modelling

Up to 100 slices

37°C, 24h
22°C, 3d
Describing the transfer rates of *Salmonella* during pork grinding

![Graph showing the transfer rates of *Salmonella*](image-url)
Modelling cross-contamination during pork grinding

**Nauta et al. (2005) Model**

- **Salmonella** input

  - **Grinder surfaces**
    - **a:** transfer of *Salmonella* from meat to grinder
    - **b:** transfer of *Salmonella* from grinder to meat
    - **c1:** *Salmonella* inactivated on grinder during the process
    - **c2:** *Salmonella* inactivated on the ground meat

- **Salmonella** output
Describing the transfer rates of *Salmonella* during pork grinding

Transfer rates of *Salmonella* DT104 based on cell count data fitted to the suggested model
Modelling cross-contamination during pork grinding

Suggested Model

- **Salmonella** input
- Environment 1 (E1)
- Environment 2 (E2)
- Grinder surfaces
- Meat
- **Salmonella** output
- a₁ - transfer from meat slice to E1
- a₂ - transfer from meat slice to E2
- b₁ - transfer from E1 to ground meat
- b₂ - transfer from E2 to ground meat
- c₁ - inactivation in E1
- c₂ - inactivation in E2
- c₃ - inactivation in meat

- - grinder surfaces
- - grinding process
Describing the transfer rates of *Salmonella* during pork grinding

Transfer rates of *Salmonella* DT104 based on cell count data fitted to the suggested model
Challenges in cross-contamination during pork grinding

**Graph:**
- Salmonella counts (log CFU/portion)
- Portion number
- Data from challenge test
- Suggested model

**Legend:**
- Black dots: data from challenge test
- Red line: Suggested model

**Note:**
- Example: Transfer study
Remarks and future perspectives

Modelling transfer of *Salmonella* Typhimurium DT104 during simulation of grinding of pork

C.O.A. Møller¹, M.J. Nauta¹, B.B. Christensen², P. Dalgaard³ and T.B. Hansen¹

- Tail phenomenon
  - Food processors
    - Control measures
    - Cleaning and sanitization
- Observed transfer successfully modelled
- Model can describe different processes
- Tool to support risk assessors

- To be investigated:
  - Food matrices
  - Pathogens
  - Inoculum levels
  - Processings
Available pathogen modeling programs

http://ucfoodsafety.ucdavis.edu/Food_Safety_Links/Pathogen_Modeling_Programs/#

<table>
<thead>
<tr>
<th>Model name</th>
<th>URL</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lethality Determination Spreadsheet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) ComBase Predictor</td>
<td><a href="http://www.combase.cc/index.php/en/predictive-models/134-combase-predictor">http://www.combase.cc/index.php/en/predictive-models/134-combase-predictor</a></td>
<td>based on observations made in culture media, and comprise a set of 20 growth models, seven thermal death models and two non thermal survival models. Temperature, pH and $a_w$ (usually as a function of NaCl) are the core factors.</td>
</tr>
</tbody>
</table>
Available pathogen modeling programs

Model name | URL | Applicability
--- | --- | ---

4) Isothermal-Based Prediction Tool, IBPT | [http://www.meathaccp.wisc.edu/pathogen_modeling/therm.html](http://www.meathaccp.wisc.edu/pathogen_modeling/therm.html) | can predict whether *Salmonella*, *E. coli* O157:H7, or *S. aureus* will grow to a “level of concern” in raw beef and pork products.
### Available pathogen modeling programs

#### Model name

<table>
<thead>
<tr>
<th>Model name</th>
<th>URL</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>5) OptiForm <em>Listeria</em> Control Model 2007</td>
<td><a href="http://www.purac.com/EN/Food/Brands/OptiForm.aspx">http://www.purac.com/EN/Food/Brands/OptiForm.aspx</a></td>
<td>help to calculate the level of lactate and diacetate needed to control <em>Listeria</em> in cured and uncured cooked meat and poultry products for their required shelf life.</td>
</tr>
<tr>
<td>6) Risk Management Tool for the Control of <em>Campylobacter</em> and <em>Salmonella</em> in Chicken Meat (Version 1.0)</td>
<td><a href="http://www.mramodels.org/poultryRMTool/">http://www.mramodels.org/poultryRMTool/</a></td>
<td>To be used in conjunction with the Codex Guidelines for the Control of <em>Campylobacter</em> and <em>Salmonella</em> in chicken meat.</td>
</tr>
</tbody>
</table>
### Available pathogen modeling programs

**Model name** | **URL** | **Applicability**
--- | --- | ---
7) Seafood Safety and Spoilage Predictor, SSSP v 3.0 | [http://sssp.dtuaqua.dk/](http://sssp.dtuaqua.dk/) | To predict the simultaneous growth of *Listeria monocytogenes* and lactic acid bacteria in lightly preserved seafood.

8) USDA Pathogen Modeling Program | [http://ars.usda.gov/Services/docs.htm?docid=11550](http://ars.usda.gov/Services/docs.htm?docid=11550) | Estimates the effects of multiple variables on the growth, inactivation or survival of foodborne pathogens. Most of the models are based on experimental data of microbial behavior in liquid microbiological media.
Acknowledgements

✓ This research project was financed by the Technical University of Denmark through the FoodDTU programme.

✓ Constructive advice and critical comments were given by:

Tina Beck Hansen
Maarten Nauta
Paw Dalgaard
Bjarke Bak Christensen

✓ Skillful technical assistance was provided by colleagues from the Division of Food Microbiology at the National Food Institute.
Acknowledgements

Latin American Symposium of Food Science
Food Science Impact on Nutrition and Health

NOVEMBER 03-06, 2013 - SP BRAZIL

Thank You!