Literature Review: Efficacy on Interventions on Pathogens in Processed Meats

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Wendy Bedale, PhD
University of Wisconsin-Madison
Project Background

• Validation questions:
  - FSA’s suggesting validation did not properly take place or at all...
  - Are supporting documents used for validation being used appropriately and as intended?
  - Are the right things being monitored and verified?
Element 1: Scientific or Technical Support (Design)

- Identify supporting documentation that closely matches the actual process (e.g., published processing guidelines, journal articles, challenge studies, etc.);
- Identify supporting documentation that demonstrates the expected level of bacterial pathogen reduction; and
- Identify the critical operational parameters from the supporting documentation relevant to the establishment's commercial process.

Element 2: Initial In-plant Demonstration (Execution)

- Implement the same critical operational parameters from the supporting documentation in the actual production process;
- Identify at least one product from each HACCP category to gather in-plant validation data; and
- Gather data demonstrating the effectiveness of the implementation of the critical operational parameters in-plant for such products.
Elements of the HACCP System Validation

• **Element 1 - Supporting Documentation**
  - Closely matches the actual process
  - Published processing guidelines
  - Peer-reviewed journal articles
  - Challenge study
  - Pathogen modeling programs
  - Internal data collected by the establishment
  - Regulatory performance standards

• Provides adequate support for the hazard identified

• Identification of **critical operational parameters**
Elements of the HACCP System Validation

• **Element 2 – In-plant Demonstration (i.e. data collection)**
  - In-plant observations
  - Measurements
  - Microbiological test results
  - Other information demonstrating that control measures can be executed to achieve intended results
Project Background

- A need to “bridge the gap” was identified
  - “Critical operating parameters” vs. extraneous research data.

<table>
<thead>
<tr>
<th>Product category</th>
<th>Processor</th>
<th>MPR</th>
<th>a_w</th>
<th>%WPS</th>
<th>pH</th>
<th>Growth</th>
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<td>5.4 ± 0.2 2.0 ± 0 (3) 0.9 ± 0 (3)</td>
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<td>6.3 ± 0.1 2.7 ± 0.1 0.9 ± 0 (3)</td>
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Goal of Project

• Create a comprehensive, searchable, user-friendly **tabular listing** which summarizes interventions (i.e. safe harbors, antimicrobial interventions, other validation support) used for **processed** meats.

• Develop a resource that meat processing establishments can use to:
  - Identify potential interventions
  - Find scientific and technical documentation to support validation activities
  - Identify **critical operational parameters** for an intervention
What Inspired Us?

Supporting Documentation Materials for HACCP Decisions

By Mary Kay Folk
and Lynn Knipe, Ph. D.

Department of Animal Sciences
and Food Science and Technology
The Ohio State University
2029 Fyffe Road
Columbus, Ohio 43210

https://meatsci.osu.edu/programs/food-safety/resources/haccp/documentation-materials
# The Periodic Table of Meat

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Taking the Lead...

- Wendy Bedale, Ph.D.
  - Scientific writer with the University of Wisconsin-Madison
  - Food Research Institute
Kathy Glass, PhD  
Associate Director of FRI

Jeff Sindelar, PhD  
Associate Professor  
Extension Meat Specialist

Dennis Seman, PhD  
Honorary Fellow  
25 years in meat industry

Adam Borger, MS  
FRI Outreach Program Manager  
14 years in meat/food industry

Andy Milkowski, PhD  
Adjunct Professor  
29 years in meat industry
Databases: Web of Science, all databases

Search Terms: TOPIC: (processed OR cured OR fermented OR ham OR sausage) AND TOPIC: (meat or poultry) AND TOPIC: (antimicrobial or intervention)

Exclusions: meeting abstracts, patents, editorials, dissertations, studies not published in English, and studies published prior to 1950

3999 unique documents identified

STEP 1: LITERATURE SEARCH
WE ARE MISSING DOCUMENTS
More Searching

- Additional literature searches by name, product, etc.
- USDA FSIS website and associated documents
- University and extension websites, industry organizations
- References cited within 2007 version of “Supporting Documentation Materials for HACCP Decisions” (Folk and Knipe, 2007)
- References within guidance documents, review articles, or other documents already retrieved
There are a lot of potentially relevant documents out there
First Cut: Assess Studies by Objective Criteria

• To be included, studies must:
  • Discuss an intervention tested in a processed meat or poultry product
  • Include quantitative microbiological data on a specific pathogen

• Studies were excluded if:
  • They tested for microbes already present in the meat and did not inoculate the meat with known levels of a pathogen
  • The intervention tested was not commercially available
Results of First Cut

From >6000 documents to ~900
Expert Subjective Review for Inclusion

• 900 references retrieved and assigned to an expert reviewer

• Reviewers assessed documents for scientific quality while considering:
  - Can the results be transferred into a practical application?
  - How useful would the intervention be?
  - Would USDA FSIS or other regulatory body accept the intervention?

• Reviewers judged 376 papers worthy of inclusion
Next Step: Organizing Study Data into Table Format

<table>
<thead>
<tr>
<th>Reference</th>
<th>Product Category</th>
<th>Product Type of Meat</th>
<th>Micro-organism Tested</th>
<th>Process/Intervention</th>
<th>Pathogen Effect</th>
<th>Operational Parameters</th>
<th>Critical Operational Parameters</th>
<th>Comments</th>
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</tbody>
</table>
TP/CS = thermally processed, commercially sterile

NHT/SS = not heat treated, shelf-stable

HT/SS = heat treated, shelf-stable

FC/NSS = fully cooked, not shelf-stable

NFC/NSS = heat treated but not fully cooked, not shelf stable

PRODUCT CATEGORIES
Process/Interventions

• Temperature control
  – Heat treatment
  – Post-lethality heat treatment
  – Stabilization
  – Refrigeration
  – Freezing
• Antimicrobials
  – In formulation
  – On product surface
• Water activity control
  – Drying
  – Formulation

• pH control
  – Fermentation
  – Acidification
• High-pressure processing
• Packaging
  – Vacuum packaging
  – Modified atmosphere packaging
  – Active packaging
• Pulsed light
• Irradiation
• Others
Pathogen Effects

- Pathogen reduction (lethality)
- Inhibition of pathogen growth during storage
- Prevention of pathogen growth during cooling (stabilization)
- Prevention of toxin production
- Inhibition of spore germination and outgrowth
Operational Parameters

- Time (heating, drying, storage, etc.)
- Temperature (during cooking, drying, storage, etc.)
- Concentration (of antimicrobials and key formulation ingredients)
- Humidity (during cooking, drying, storage, etc.)
- Water activity
- pH
- Spatial configuration
- Pressure
- Equipment settings
- Other (packaging type, product characteristics such as % fat, etc.)
Critical Operational Parameters

• How to identify and list COPs? For example:
  - A study tested **how long** an antimicrobial added to frankfurters would prevent *L. monocytogenes* growth at an abusive storage **temperature**
  - The study did not vary the **salt** concentration or **fat** content in the formulation
  - Other studies show these parameters affect how well the antimicrobial will work

• **If a critical parameter was not specifically discussed in a particular reference, that parameter may not be listed as a critical operational parameter in the column for that reference**
<table>
<thead>
<tr>
<th>Reference</th>
<th>Product Category</th>
<th>Product</th>
<th>Type of Meat</th>
<th>Microorganism Tested</th>
<th>Process/Intervention</th>
<th>Pathogen Effect</th>
<th>Operational Parameters</th>
<th>Critical Operational Parameters</th>
<th>Comments</th>
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<tr>
<td>Aymerich T, Jofre A, Garriga M, Hugas M (2005)</td>
<td>FC/NSS</td>
<td>Sliced cooked ham made from minced pork shoulder</td>
<td>Pork</td>
<td><em>Listeria monocytogenes</em>&lt;br&gt;<em>Salmonella</em> spp.</td>
<td>Antimicrobials (Nisin A, potassium lactate)</td>
<td>High-pressure processing</td>
<td>Inhibition of pathogen growth during storage</td>
<td><strong>Concentration:</strong> Potassium lactate at 1.8%&lt;br&gt;<strong>Pressure:</strong> 400 MPa, 17°C for 10 minutes</td>
<td>A synergistic inhibitory effect of potassium lactate, HPP, and low storage temperature on <em>Listeria monocytogenes</em> growth was observed. HPP also inhibited <em>Salmonella</em> growth during storage. No growth occurred with HPP and potassium lactate at 1°C, although growth did occur at 6°C. Nisin allowed growth.</td>
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</table>

<table>
<thead>
<tr>
<th>Reference</th>
<th>Product Category</th>
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<tr>
<td>The American Meat Institute Foundation (1997) Good manufacturing practices for fermented dry &amp; semi-dry sausage products. Accessed 6 April 2016.</td>
<td>NHT/SS</td>
<td>Fermented dry and semi-dry sausage products</td>
<td>Pork</td>
<td>Staphylococcus aureus</td>
<td>Time: Number of hours to reach pH 5.3</td>
<td>Pathogen reduction</td>
<td>Time: 18 to 80 hours, see below</td>
<td>Temperature: 75 to 110°F, see below</td>
<td>The document states that fermentation to pH ≤4.6 at 90°F or 110°F requires further holding and potentially a heat process in order to destroy <em>E. coli</em> O157:H7. During fermentation it is necessary to limit the time during which the sausage meat is exposed to temperatures exceeding 60°F.</td>
</tr>
<tr>
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<td>HT/SS</td>
<td></td>
<td>Beef</td>
<td><em>E. coli</em> O157:H7</td>
<td>Temperature control</td>
<td>Inhibition of pathogen growth during storage</td>
<td>pH: Reduction in pH, which can be achieved by fermentation or by acidulation of sausage batter</td>
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http://meatha ccp.wisc.edu/Model_Haccp_Plans/assets/GMP%20Dry%20Sausage.pdf
<table>
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<td>Juneja VK, Thippareddi H, Bari L, Inatsu Y, Kawamoto S, Friedman M (2006) Chitosan protects cooked ground beef and turkey against Clostridium perfringens spores during chilling, Journal of Food Science 71 (6):M236-M240.</td>
<td>FC/NSS</td>
<td>Cooked ground beef and turkey</td>
<td>Beef</td>
<td>Clostridium perfringens (Chitosan)</td>
<td>Antimicrobials</td>
<td>Prevention of pathogen growth during cooling</td>
<td>Time: Cooling time of 12, 15, 18, or 21 hours</td>
<td>Time: 3% chitosan was effective during 12, 15, or 18 hours (but not 21 hours) of cooling</td>
<td>Both beef and turkey exhibited similar trends, but actual log increases varied among treatments.</td>
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<td>(Juneja et al., 2006)</td>
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<td>Turkey</td>
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<td>Temperature: Cooling from 54.4 to 7.2°C</td>
<td>Concentration: 0.5, 1, 2, or 3% chitosan</td>
<td>• Control (0%) allowed ~4-5 log increase at 12 h for both meat matrices</td>
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<td>Concentration: 3% chitosan was most effective</td>
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<td>• 0.5% and 1.0% chitosan allowed 1-2 log increase at 12 h</td>
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<td>Product Coverage: Chitosan was mixed with raw ground meat</td>
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<td>• 2.0% chitosan inhibited growth (&lt;1 log increase) for 15 h in ground turkey, but allowed a 2 log increase in ground beef</td>
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<td>Spatial Configuration: 5 g of meat</td>
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<td>• 3.0% chitosan inhibited growth (&lt;0.5 log increase) for 18 h in both meat matrices</td>
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<td>Other: % fat in beef (25%) and in turkey (7%); 5g samples of meat were vacuum packaged during cooking at 60°C for 1 hour</td>
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Challenges

• When to stop searching?
• How to “judge” references as worthy for inclusion?
• How to best format information in the table?
• How to consistently harvest information?
• How to incorporate information from guidance documents, predictive modeling studies, etc.?
Future Plans

• Version 1 of the table (with ~200 references/interventions) is in review now; should be publically available in both Word and Excel formats in October from NAMI

• We plan to update this table with more studies

• We welcome your input to:
  - Suggest ways to make it more useful
  - Correct errors

• An accompanying review article on antimicrobial interventions in processed meats is also in preparation
Contact Information

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jsindelar@wisc.edu

kglass@wisc.edu
ACKNOWLEDGEMENTS

• Foundation for Meat and Poultry Research and Education (formerly the North American Meat Institute Foundation) and the North American Meat Institute, a contractor to the Beef Checkoff
• University of Wisconsin Team: Jeff Sindelar, Kathy Glass, Andy Milkowski, Dennis Seman, Adam Borger
• Kerri Gehring, PhD and Ashley Arnold, PhD of Texas A&M
• Consortium of Food Process Validation Experts
• Food Research Institute at the University of Wisconsin-Madison
• Susan Backus