Current Trends in Salmonella: Epidemiology, infection and control
Dr. Keith Warriner, University of Guelph
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Outline

- Description of Salmonella -- classification, sources, physiology, and mode of drug resistance
- Recent outbreaks and recalls linked to Salmonella
- Routes of introducing and the dissemination of Salmonella in the food chain
- Overview of the Salmonella Action Plan and implications to the industry
- On farm interventions
- Processing interventions
- Trends in Salmonella diagnostics
- Conclusions and research needs
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Salmonella

- Gram negative
- Facultative anaerobe
- Acid tolerant
- Member of Enterobacteriaceae family
- One Species: S. enterica
- >2500 serotypes

- 1.2 million cases
- Number 1 cause of bacterial foodborne illness

Species and subspecies were originally defined by DNA-DNA hybridisation, confirmed by MLEE and MLST and are currently differentiated by biochemistry and serology.

The split in typhoidal and non-typhoidal is based on the disease syndrome. Typhoid and paratyphoid fever is prolonged, whilst extra-intestinal infection is usually acute and metastatic. Gastroenteritis is characterised by diarrhoea.

Differentiation of serovars is by agglutination with specific antisera against LPS (O), two phases of flagella (H1 and H2). There are 46 O, 85 H and 1 capsule (Vi) antigen which have been described in about 1,500 combinations within subspecies I.

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<table>
<thead>
<tr>
<th>Rank</th>
<th>Serovar</th>
<th>Number of Cases</th>
<th>Incidence per 100,000</th>
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<tbody>
<tr>
<td>1</td>
<td>Enterititis</td>
<td>1062</td>
<td>2.33</td>
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<tr>
<td>2</td>
<td>Typhimurium</td>
<td>1006</td>
<td>2.17</td>
</tr>
<tr>
<td>3</td>
<td>Newport</td>
<td>656</td>
<td>1.44</td>
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<tr>
<td>4</td>
<td>I, 4,[5], 12, i</td>
<td>383</td>
<td>0.79</td>
</tr>
<tr>
<td>5</td>
<td>Javiana</td>
<td>347</td>
<td>0.76</td>
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<tr>
<td>6</td>
<td>Heidleberg</td>
<td>243</td>
<td>0.53</td>
</tr>
<tr>
<td>7</td>
<td>Montevideo</td>
<td>211</td>
<td>0.46</td>
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<td>8</td>
<td>Muenchen</td>
<td>194</td>
<td>0.43</td>
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<td>9</td>
<td>Tennessee</td>
<td>140</td>
<td>0.31</td>
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<tr>
<td>10</td>
<td>Saint Paul</td>
<td>117</td>
<td>0.26</td>
</tr>
</tbody>
</table>

**Salmonella in EU**

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Where does *Salmonella* come from?

Inhabitant of intestinal tract of
- animals
- birds
- reptiles
- insects

Asymptomatic Carriage

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Pasture and soil ---- 200 days
Garden soil ---- 251 days
Liquid manure --- 27 days (S. Dublin), --- 286 days (S. Anatum)
Slurry - 84 to 250 days
Infected feces stored in cans - 159 days
(S. Dublin)
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Growth Parameters
Temp: 7 – 49°C Opt 37°C Some serovars grow <7°C

pH 3.8 – 9.5 Opt 7.0 – 7.5 (less acid resistant compared to E. coli)
Facultative anaerobe: Can grow in presence of 20-80% carbon dioxide.

Water Activity: 0.94-0.99

Controls
Survives freezing
Thermal resistance is serovar specific
Growth inhibited by 0.1% acetic acid
Irradiation: D 0.5-0.8
Low water activity: enhances Salmonella survival and increased thermal resistance

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Foods Commonly Implicated

Pets and Pet Food

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Vehicles for Salmonella

Outbreaks

Cases

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Illness

Salmonella infection

Almost any kind of food or beverage can carry the bacteria that causes salmonella infection, although meat and eggs are common sources.

Contaminated food or drink

How salmonella progresses

Bacteria travel to small intestine, adhere to lining, begin life cycle

In severe cases, bacteria break through intestinal wall to bloodstream; can be deadly if not properly treated

Symptoms

Within 12-72 hours
Nausea, vomiting, fever, diarrhea, abdominal cramps

4-7 days illness ranges from mild to severe; most people recover without treatment

Severe cases
More likely with infants, elderly, people with impaired immune systems

Treatment

Oral or injected antibiotics, usually for 2 weeks

Treatment

None: Let infection run its course; fluid replenishment

Antibiotics: Ciprofloxacin for 10-14 days

Antibiotics for immuno-compromised, infants and elderly
Long Term (secondary) Symptoms

- Somatization
- Anxiety
- Depression
- Arthritis
- Encephalopathy
  - $8m damages

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## Selected Outbreaks

<table>
<thead>
<tr>
<th>Year</th>
<th>Serovar</th>
<th>Number of Cases</th>
<th>Product</th>
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<tbody>
<tr>
<td>2012</td>
<td>Typhimurium</td>
<td>19</td>
<td>Ground Beef</td>
</tr>
<tr>
<td>2011</td>
<td>Heidelberg</td>
<td>190</td>
<td>Chicken Livers</td>
</tr>
<tr>
<td>2011</td>
<td>Heidelberg</td>
<td>111</td>
<td>Turkey meat</td>
</tr>
<tr>
<td>2010</td>
<td>Newport</td>
<td>24</td>
<td>Alfalfa sprouts</td>
</tr>
<tr>
<td>2010</td>
<td>Enteritidis</td>
<td>1700</td>
<td>Eggs</td>
</tr>
<tr>
<td>2010</td>
<td>Typhimurium</td>
<td>23</td>
<td>Bagged lettuce</td>
</tr>
<tr>
<td>2010</td>
<td>Montevideo</td>
<td>204</td>
<td>Pepper</td>
</tr>
<tr>
<td>2009</td>
<td>Typhimurium</td>
<td>714</td>
<td>Peanut butter</td>
</tr>
<tr>
<td>2009</td>
<td>Saint Paul</td>
<td>235</td>
<td>Alfalfa sprouts</td>
</tr>
<tr>
<td>2008</td>
<td>Saint Paul</td>
<td>1400</td>
<td>Tomato/Peppers</td>
</tr>
<tr>
<td>2007</td>
<td>Montevideo</td>
<td>37</td>
<td>Chocolate</td>
</tr>
<tr>
<td>2007</td>
<td>Typhimurium</td>
<td>167</td>
<td>Pot Pies</td>
</tr>
<tr>
<td>2006-08</td>
<td>Schwarzengrund</td>
<td>32</td>
<td>Dry Pet Food</td>
</tr>
<tr>
<td>2002</td>
<td>Poona</td>
<td>46</td>
<td>Melon</td>
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## Outbreaks 2014

<table>
<thead>
<tr>
<th>Serotype</th>
<th>Source</th>
<th>Cases</th>
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<tbody>
<tr>
<td>Stanley</td>
<td>Raw Cashew Cheese</td>
<td>17</td>
</tr>
<tr>
<td>Heidelberg</td>
<td>Tyson Chicken</td>
<td>9</td>
</tr>
<tr>
<td>Cothan and Kisarawe</td>
<td>Bearded Dragons</td>
<td>150</td>
</tr>
<tr>
<td>Infantis and Newport</td>
<td>Live Poultry</td>
<td>251</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>Feeder Rodents</td>
<td>41</td>
</tr>
<tr>
<td>Newport, Hartford, Oranienburg</td>
<td>Sprouted Chia Powder</td>
<td>21</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>Lab Exposure</td>
<td>41</td>
</tr>
<tr>
<td>Stanley</td>
<td>Turkey meat</td>
<td>700 (2011-Present)</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>Seaweed</td>
<td>19</td>
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<tr>
<td>Enteritidis</td>
<td>Raw Egg</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Heidelberg</td>
<td>Foster Farms Raw Poultry</td>
<td>574 (2013-2014)</td>
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</tbody>
</table>
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Outbreaks 2015

<table>
<thead>
<tr>
<th>Serotype</th>
<th>Source</th>
<th>Cases</th>
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<tbody>
<tr>
<td>Typhimurium</td>
<td>Restaurant</td>
<td>280</td>
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<tr>
<td>Enteritidis</td>
<td>Breaded poultry</td>
<td>44</td>
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<tr>
<td>Enteritidis</td>
<td>Poultry Entrees US)</td>
<td>24</td>
</tr>
<tr>
<td>I, 4, 5, 12:i</td>
<td>Pork (Pig Roast)</td>
<td>90</td>
</tr>
<tr>
<td>Enteritidis</td>
<td>Chicks</td>
<td>6</td>
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<tr>
<td>Typhimurium</td>
<td>Pet frogs</td>
<td>200</td>
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<tr>
<td>Paratyphoid</td>
<td>Frozen tuna</td>
<td>62</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>Portland Conference</td>
<td>51</td>
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<tr>
<td>Enteritidis</td>
<td>School</td>
<td>175</td>
</tr>
<tr>
<td>Newport</td>
<td>Cucumber</td>
<td>780</td>
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<tr>
<td>Enteritidis</td>
<td>Bean Sprouts</td>
<td>115</td>
</tr>
<tr>
<td>Infantis</td>
<td>Unknown</td>
<td>34</td>
</tr>
</tbody>
</table>

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Effects of climate change on Salmonella infections.
Aabi L1, Ahmed HA, Reddy RS.

Abstract
BACKGROUND: Climate change and global warming have been reported to increase spread of foodborne pathogens. To understand these effects on Salmonella infections, modeling approaches such as regression analysis and neural network (NN) were used.

METHODS: Monthly data for Salmonella outbreaks in Mississippi (MS), Tennessee (TN), and Alabama (AL) were analyzed from 2002 to 2011 using analysis of variance and time series analysis. Meteorological data were collected and the correlation with salmonellosis was examined using regression analysis and NN.

Food Safety Inspection Service Salmonella Action Plan

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Salmonella Action Plan
Dec 13

FSIS Strategic Performance Working Group (SPWG)
Proposed Poultry Slaughter Rule
Baseline data
New Plant Strategies
Sanitary Dressing of Hogs
Processing Plant Scores
Revise Performance Standards
Salmonella associated with lymph nodes and interventions
Outreach and Education
Final Rule approved – Aug 2014

Poultry Products Inspection Act (1968)

HACCP
Sanitation Standard Operating Procedure
Generic Escherichia coli testing: Trend analysis
Salmonella performance standards
Inspection (Postmortem)
- Head
- Viscera
- Carcass

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Verification Testing in Poultry Processing

One carcass per day for 51 consecutive processing days
Carcass rinse
>13 positive indicates failure
Provide 30 days to correct
Failure for second sampling: Write a corrective action plan
Third failure: Withdraw inspection – plant closure

Salmonella Performance Standards

• FSIS 2011
• Carcass rinse or sponge samples
• 5 positive/51 carcasses Chicken
• 4 positive/56 for turkey

• Cat 3: Failure to meet standard >7.5% Positives
• Cat 2: Meet Standard 7.5% Positives
• Cat 1: Exceed Standard <7.5% Positives
### Poultry Slaughter Rule

| Processing plant personnel to inspect carcasses: Verified by FSIS |
| Reduce FSIS inspectors (one per line) |
| Inspectors to verify off-line activities (documentation, sanitation) |
| Permit faster line speeds |
| Abolish Finished Product Standards: Ready to Cook Poultry Standards |
| More efficient FSIS inspection |

#### Finished Product Standards
- Stop Generic E. coli testing
- Poor indicator for presence of Salmonella

#### Ready to Cook Poultry Standards
- Sample at points at CCP’s
- Processor must establish sample frequency and target
- Standards to be established

### Sampling Activities

FSIS Annual Sampling Plan Microbiological and Residual Sampling Program 2014

- Establish baseline for comminuted poultry and parts
- Testing ground beef for *Salmonella*, in addition to STEC
- Develop *Salmonella* sampling plan for raw pork and raw pork products: Currently not performed
Develop New in Plant Strategies

Identify developing in-plant conditions (i.e. increasing trend of non-compliance, inability to control Salmonella)

Categorize plants based on Salmonella control performance (C1, C2 and C3): Positing operators names in C2 and C3 classes

Food Safety Assessment of comminuted poultry operations

Extend Hazard Analysis Verification in poultry operations

Pre-Harvest Related Activities and Outreach

Identify practices that leads to increased Salmonella prevalence

Evidence based interventions

Transparency and closer links with industry

Provide Salmonella specific food safety advice to consumers
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Will the Action Plan Work?

Essentially deregulation of poultry industry: Self policing throw back to 1990’s
Increased line speeds: Increase efficiency or increased risk?
Failure to address multi-drug resistant *Salmonella*
More focus on testing that introduction of novel decontaminating technologies
Implications for beef and pork processors
Focus on data gathering rather than interventions

What does it mean to industry?

In theory carriage of *Salmonella* decrease by 4.5%; Save FSIS $90m per year
Greater responsibility of the processor to reduce Salmonella carriage
Cost saving (abolish *E coli* testing)
Increased costs
Extended Salmonella testing (pre- and post chill points)
Interventions
Personnel for inspection

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<table>
<thead>
<tr>
<th>Species</th>
<th>Salmonella Prevalence 2011</th>
<th>Salmonella Prevalence 2012</th>
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<tbody>
<tr>
<td>Steers</td>
<td>0.5%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Market bulls and cows</td>
<td>0.8%</td>
<td>0</td>
</tr>
<tr>
<td>Poultry</td>
<td>6.5%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Ground poultry</td>
<td>30.9%</td>
<td>28%</td>
</tr>
<tr>
<td>Pork</td>
<td>3.3%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

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Opening the door for Zero Tolerance for *Salmonella*

- *Salmonella* is not considered an adulterant in meat
- Petition to class top 4 serovars as adulterants
  - Heidelberg
  - Newport
  - Hadar
  - Typhimurium

- Technically achievable?

Is Zero Tolerance Achievable?

EU Danish and Swedish models: <1% Salmonella

North America
Centralized and intensive production
Reliance on antimicrobials
Lack of interventions or willingness to adopt
Definition of zero: Depends on diagnostics

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Foster Farms
Est 1939 in California by Max and Verda Foster (Poultry and Dairy)
Fully integrated poultry production – processing
Revenue: $2bn
Employ 10, 500
Reputation for quality and innovation

Foster Farms
On-Farm
- *Salmonella* screening of breeder hens
- Probiotic supplements
- Vaccination
- Biosecurity
- Sanitation

- Processing Plant
  - Increase sanitation
  - In-line conveyor disinfection
  - Steam pasteurization
  - Anti-microbial washes

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Incidence

1997: Strike due to labor practices  
Salmonella Hiedelberg  
High virulence

1998: Dumped 11 million gallons manure polluted water into a lake  
Rapid mutation rate

2013  
Salmonella Heidelberg  
Antibiotic resistant

- 278 cases

Refused to recall  
Strains

Eventual recall due to insect infestation  
B182

>700 cases

Salmonella Heidelberg SL476

- 111 Confirmed Clinical Cases

- 31 States

- Link to ground turkey meat and products

- Recall of 36 million pounds of meat (Production from Feb 2011)

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Multi-Drug Resistant 
*Salmonella*

• Resistant to two or more antimicrobial agents  
  • Plasmid  
  • Chromosome  
• 3rd generation cephalosporin  
• Quinolone  
• Fluroquinolone  
• Ciprofloxacin  
• Nalidixic acid

Sources of Antibiotic Resistant *Salmonella*

• Widespread use of antibiotics  
• Imported foods  
• Travel  
• Zoonotic
Antibiotic Usage

• Agriculture: 12 million kg per year
• 5.1 million kg: Pig production
• 5.2 million kg: Poultry production
• 1.6 million kg: Cattle

• Prevent infection
• Compensate for high density of animals and poor sanitation
• Promote growth

Reasons for Emergence of Antibiotic Resistance in Developing Countries

- Little or no regulation on antibiotic usage
- Poor quality antimicrobial products (low activity)
- Poor infection prevention and control
- Lack of surveillance
- Antibiotics in environment
Preservation of Antibiotics for Medical Treatment Act

• FDA banned enrofloxacin (fluroquinone) 2005 in poultry production
• Removal of antibiotics from feed: 30 years in the pipeline
• Phase out medicated feed
• Sparing use of antibiotics for treating animals
• No restriction of antibiotics for non-food animals-pets.

FDA

22\textsuperscript{nd} Dec 2011: FDA withdrew partition
Industry must self-regulate antibiotic use
Ban “non-label use” cephalosporins
\begin{itemize}
  \item \(<1\%\) of antibiotics used in agriculture
  \item Pressure from lobby groups (Dark Money)
\end{itemize}

Weight of evidence connecting antibiotic use with drug-resistant pathogens
Consumer groups taking legal action against FDA
Guidance 209: Antibiotics should not be used for growth promotion

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Antibiotic-resistant superbugs drive chicken producers to change

Health Canada

Ban antibiotics as growth promoters July 2014
No change on disease prevention
No significant reduction in antibiotic use
Industry being pro-active at finding alternatives

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How to Reduce Antibiotic Resistance

- Develop/isolate new antibiotics
- Removal of antibiotics
- Seek alternative antimicrobial agents
- Regulations

New Antibiotics

![Bar chart showing the number of new antibiotics approved for use from 1983 to 2007.](image)

Figure 5. Number of New Antimicrobials Approved by the U.S. FDA between 1983 and 2007

No new class of antibiotics have been discovered in the last 30 years.
Decreasing Antibiotic Resistance

Remove antibiotics from animal production

Denmark
Removal of avoparcin: 80% reduction in vancomycin resistance

Ban of antibiotics as growth promotors

Medicated Feed (Antibiotics)

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Denmark Experiment

• Withdrew mass use of antibiotics in animal production 12 years ago

• Decrease in prevalence of drug resistant Salmonella

• Decreased efficacy in animal production

• Net benefit through increased exports and reduction in health care costs.

EU Ban

• 2006: Ban on growth promoting antibiotics

• Decrease in avoparcin resistance with no significant effect on animal health

• Long term effects yet to be determined

• Proposal to take all antibiotics (medicated and therapy) out of animal production

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Antibiotic Alternatives

Vaccination
Competitive exclusion
Antimicrobial peptides
Bacteriocins
Natural antimicrobials
Management practice and surveillance
Consumer education

Vaccination

• Prime immune system to detect multiple drug resistant strains of *Salmonella*

• Oral administration of antibodies

• Cost effective production of antibodies using transgenic plants. ($0.1/g)

• Potential allergic reactions

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Competitive Exclusion

Probiotics

Engineered *E. coli* to detect signaling molecules from pathogens then release of anti-microbial agents

Antimicrobial Peptides

D-amino acid containing peptides: Disrupt cell membranes

Absorb onto pathogen surfaces to block binding

Bind intracellular molecules

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**Salmonella Control**

Focus on high risk foods
Prevention is key
- Fresh produce (e.g. sprouts and tomatoes)
- Poultry and eggs
- Low moisture foods

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**Poultry & Eggs**
Eggs

UK: 136 cases from Spanish imported eggs

US: >1000 cases 0.5bn eggs recalled

Salmonella in Poultry - Industry

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Poultry Production

- Feed from HACCP certified mills
- Pest-control program
- Biosecurity (animals, facility equipment, GAP)
- Manure management
- Vaccination
- Competitive exclusion
- Medicated Feed
- Surveillance

Manure Management

- Compost for at least 120 days
- 3-12 month period from manure application to planting.
- Biosolids < 4 cfu/g Salmonella (US); Not detected (Canada).
- 50 meter separation from open water
- Minimize run off
- Liquid manure decreases persistence of Salmonella.
Vaccination

Live (attenuated) *Salmonella* spray or dead cells incorporated into feed.

Pork farms: No evidence of benefit

Poultry: Permitted but not applied universally in North America.

UK: Extensive vaccination: SE prevalence <1% of flocks.

---

Competitive Exclusion

Pre- and Probiotics

Produce antimicrobials

Biological buffer

Prevent colonization by *Salmonella*

*Saccharomyces boulardii* produce mannose that inhibits attachment of *Salmonella*
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Surveillance
Sampling buildings: Drag swabs
Boot swabs
Fecal samples
Boxes and other contact surfaces
Incoming chicks: 1 week old

If positive for SE the flock destruction eggs diverted to processing.

Transovarian Transmission of SE
Salmonella Enteritidis

Contaminates yolk before laying

Sufficient cooking essential
(no sunny side up eggs)
Egg Handling

Rapid cooling can cause shell fracture

Minimize temperature fluctuations

EU: Maintain eggs <15°C cannot vary more than 4°C throughout handling and distribution

FDA: Maintain <7.2°C

Condensation: Surface growth, increased penetration

Egg Washing

**ADVANTAGES**
- Improve egg appearance
- Reduction in surface bacterial counts

**DISADVANTAGES**
- Remove cutical layer
- Potential ingress of water into the shell (use warm water)
- No conclusive evidence of efficacy to decrease incidence of *Salmonella*
Alternative Techniques

Gamma irradiation: 1.5 kGy  Impact on sensory quality
Microwave 0.75-2 W/g: Problems with scale-up
Hot air: 600°C for 8s. Effective no changes to egg quality 1 log reduction *Salmonella*
Gas plasma: 1-5 log reduction Lab based
UV light: Limited efficacy

Liquid Egg Pasteurization

56 – 60°C (3-4 weeks shelf life)

Dielectric and gamma irradiation
  - Reduction in *Salmonella* although changes in functionality

High Hydrostatic Pressure: Cold pasteurization
  - protein denaturation (minimize by addition salt or adjusting pH to >7.7)
Pulsed Electric Fields: SE tolerant to PEF treatment
Egg Rule 2010

Clean and disinfect poultry houses that have tested positive for *Salmonella* Enteritidis –

- Refrigerate eggs at 7.2°C during storage and transportation no later than 36 hours after the eggs are laid
- Egg producers must maintain a written *Salmonella* Enteritidis prevention plan and records documenting their compliance.
- Egg producers must also register with the FDA.
- Mandatory: July 2012.

FDA Guidelines

- Biosecurity
- Reduce cross-contamination
- Distances of farms from houses
- Time period between depopulation and repopulation
- Sanitation

http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodSafety/ucm222469.htm

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Poultry Processing

Scald tank
- Counter current water flow
- Temp >50°C
- Sanitizers (limited selection)

- Chill tanks
- 50 ppm chlorine pH 7 (Only in US)
- Counter-flow
- Fresh water recharging
- Air chilling using ozone

Carcass Decontamination Methods

Hot water wash: 75-80°C 1-3 log reduction *Salmonella*

Steam pasteurization: 90°C for 12s 3 log reduction in *Salmonella*

Organic acid wash: 2% lactate 5 log reduction

Ozonated water: negligible efficacy

Irradiation: *Salmonella* more sensitive than *E. coli* D 0.62-0.80.
Bacteriophages

• Viruses that infect bacteria
• Specific to Broad host range
• Extensively used in Eastern Europe

• High doses required (MOI)
• Natural equilibrium establishes between host and phage
• Replication in the environment limited
• Resistance
• Possible route to control *Salmonella* in lymph nodes

### Hide/Skin Treatment

<table>
<thead>
<tr>
<th>Surface</th>
<th>Target</th>
<th>MOI</th>
<th>Log Reduction</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle Hide</td>
<td><em>E. coli</em> O157</td>
<td>10,000</td>
<td>1.5</td>
<td>Coffey et al., 2003</td>
</tr>
<tr>
<td>Poultry</td>
<td><em>Campylobacter</em></td>
<td>100,000</td>
<td>2.0</td>
<td>Goode et al 2003</td>
</tr>
<tr>
<td>Poultry</td>
<td><em>Pseudomonas</em></td>
<td>1000</td>
<td>2.0</td>
<td>Greer, 1982</td>
</tr>
<tr>
<td>Pig skin</td>
<td><em>Salmonella</em></td>
<td>10</td>
<td>4.0</td>
<td>Hotton et al., 2011</td>
</tr>
</tbody>
</table>
Salmonella bacteriophages on Poultry Skin

Hungaro et al., 2013

Chemical Sprays

Fig. 2  Carcass during spray treatment

Purnell et al., 2014

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Chilling

Immersion in hypochlorite (50 ppm) baths: 0.3 – 0.4 log cfu reduction of Enterobacteriaceae

Air chilling: minimal log reduction
Potential cross contamination
Ozone gas

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Ozone Gas (2000ppm) Chilling of Poultry Carcasses

![Graph showing the reduction of Salmonella Log cfu/10cm² over time.]

Commercial HPP systems

Wave 6000 /55 L – 420 L
Maximum pressure : 600 MPa
Pressure Hold Time: 3 min
Toll facilities

- Lab and industrial
  0.1L – 2 L
  100 L – 687 L
- Toll facilities

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Sampling and Detection

Egg sampling (composite)

Carcass sampling (Carcass rinse)
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Enumeration and Enrichment

Buffered Peptone Water

- 37°C 24h

Semi-solid RV Medium

- 42°C for 16h

XLD agar

- 37°C 24h

Confirmation (genetic, Immuno, Physiological test)

Overview of Rapid Methods for Sensitivity vs. Time

From Christina Harzman Biotecon diagnostics

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Chromagenic Agar

Diagram of TaqMan® Salmonella Enteriditis Egg Testing Workflow

- Prepare the pre-enrichment of pooled shelled eggs in growth media and allow SE to multiply to detectable levels (24 Hrs)
- Automated DNA extraction with the MagMax™ Express 96 Instrument with PrepSEQ® NA reagents (1 Hr)
- Real-time PCR detection with the TaqMan® Salmonella Enteriditis Detection Kit on the 7500 Fast Instrument (2 Hrs)

Result in approximately 27 Hours

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SureTect *Salmonella*

- RT-PCR identification
- AOAC approved
- Single enrichment
- Inclusivity and exclusivity
- 20 mins analysis time

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Isothermal Amplification
Simplified equipment: No need for thermal cycling
Adaptable to miniaturization

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**DNA Typing**

Track origins of *Salmonella*

Identify endemic populations

Link between contamination sources

Surveillance

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Pin pointing the specific source of *Salmonella*

Hatchery hygiene

*Infantis*

*Infantis*

Senftenberg

Feed

*Infantis*

Pinpointing the source of the contamination
Each single step of the Chain can be secured
Proven practice
Serotyping is essential in an effective Reduction program
Result: Healthier broilers and improved product quality

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PathoGenetix's Genome Sequence Scanning

10 million bases per second

5 h assay (40 samples per 24 h)

No specific target pathogen

Current being evaluated by CDC ($40m project)

DNA sequencing costs have gone down

Moore's Law: A long-term trend in the computer hardware industry that involves the doubling of ‘computer power’ every two years.

SOURCE: NATIONAL INSTITUTES OF HEALTH

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Almost $10 million for salmonella research
News
Genomic research to identify Salmonella strains that cause human disease
PUBLISHED: 21 JUL 2015

Poultry used to be the usual suspect in cases of Salmonella poisoning. Today, however, most outbreaks of the illness come from fruit and vegetables that have become infected when the soil in which they grow is polluted by animal waste or non-potable water. There currently is no method of reducing the growth of Salmonella on such produce.

Poultry used to be the usual suspect in cases of Salmonella poisoning. Today, however, most outbreaks of the illness come from fruit and vegetables that have become infected when the soil in which they grow is

Consumer Education
Sanitation
Food storage
Minimize cross-contamination events
Thermometers to verify adequate cooking

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Food Standards Agency UK

Don’t wash chicken
Coordinated media campaign
- Public health units
- TV
- News outlets
- Twitter
- Facebook
- National and International

>20 million goggle hits
Simple message but reinforced

Conclusions

Salmonella remains a key foodborne pathogen
Adaptable and high virulence
Broad range of food types affected
Multi-drug resistance needs to be addressed
Interventions and diagnostics available
Is FSIS Strategic Plan going to work?
Can Salmonella be eliminated?

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November 17  (FREE Teleclass … Denver Russell Memorial Teleclass Lecture)
THE ROLE OF WATER AS A VECTOR IN THE TRANSMISSION OF
INFECTIONS IN HOSPITALS
Dr. Jimmy Walker, Public Health England, Biosafety Unit

November 19  CLOSTRIDIUM DIFFICILE INFECTION IN RURAL HOSPITALS
Dr. Nasir Saldar, University of Wisconsin

December 3  (FREE Teleclass)
HIV TREATMENT AS PREVENTION: THE KEY TO AN AIDS-FREE
GENERATION
Prof. Julio S. G. Montaner, BC Centre for Excellence in HIV/AIDS

December 10  RISING TO THE CHALLENGE OF MULTIDRUG-RESISTANT GRAM-
NEGATIVE RODS (CRE & FRIENDS)
Dr. Jonathan Otter, King’s College, London

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JUST OVER THE HORIZON . . .

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