Controlling *Salmonella* in Feed

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American Proteins Food Safety Assurance Programs
Thank you

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Performance Poultry Consulting
U. of Arkansas Professor Emeritus
PET FOOD?
Can I get the other two to go in a doggy bag.
Perspective
Perspective
Perspective

RECALL

PORK RECALLED

Salmonella Found in Chicken Feed
Perspective

- 334
  - *Salmonella* infections from baby chicks
- 248
  - *Salmonella* infections from turtles
- 49
  - *Salmonella* infections from pet food

Source: http://www.cdc.gov/salmonella/general/index.html
Perspective

- 2300 known serotypes
- 30 to 40 of clinical pertinence

Source: http://www.cdc.gov/salmonella/general/index.html
Guidance for FDA Staff

Compliance Policy Guide
Sec. 690.800 Salmonella in Animal Feed

Draft Guidance

This guidance document is being distributed for comment purposes only.
FDA Compliance Policy Guide
*Salmonella* in Animal Feed

- A new compliance policy guide for *Salmonella* in feed, including pet food
- Removes the premise that all *Salmonellae* are bad
FDA Compliance Policy Guide

- CPG categorizes by species and animal

If the serotypes are found in feed, the feed is adulterated!

But, ingredients with any *Salmonella* no longer considered adulterated
FDA Compliance Policy Guide

- Poultry feed with *Salmonella Pullorum*, *Salmonella Gallinarum*, or *Salmonella Enteritidis*;
- Swine feed with *Salmonella Choleraesuis*;
- Sheep feed with *Salmonella Abortusovis*;
- Horse feed with *Salmonella Abortusequi*;
- Dairy and beef feed(s) with *Salmonella Newport* or *Salmonella Dublin*. 
Says all *salmonellae* in milk replacers and pet food are adulterants

- Young animals, human contact
- Further heat treatment of ingredients

CPG is functioning as regulation now.
Salmonella Basics

- European feed experts state that Salmonella is:
  - “...the major hazard for microbial contamination of animal feed.”
- Salmonella highly adaptable to environmental conditions.
- Salmonella native habitat is the intestinal tract, but widely distributed in nature (ubiquitous).
- One researcher observed: “Given its ubiquity, it is unlikely that Salmonella will be eradicated from the food chain.” (Humphrey, 2004).
Salmonella Basics

- *Salmonella* survives stress (particularly dehydration) better than most of its family (*Enterobactiaceae*).
- Dust is thought to be a sensitive indicator for the presence of *Salmonella* in feed and poultry houses.
- *Salmonella* is capable of surviving for extended periods in a variety of environments on numerous materials.
### Estimated *Salmonella* Survival Times

<table>
<thead>
<tr>
<th>Contaminated Material</th>
<th>Est. Survival (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloth</td>
<td>228</td>
</tr>
<tr>
<td>Dried cattle feces</td>
<td>1000+</td>
</tr>
<tr>
<td>Dried rosemary</td>
<td>203</td>
</tr>
<tr>
<td>Dried whole egg</td>
<td>4+</td>
</tr>
<tr>
<td>Earth and pasture</td>
<td>200</td>
</tr>
<tr>
<td>Edible nuts</td>
<td>&gt;365</td>
</tr>
<tr>
<td>Egg shells</td>
<td>350</td>
</tr>
<tr>
<td>Fresh Parsley</td>
<td>161</td>
</tr>
<tr>
<td>Frozen Shrimp</td>
<td>150</td>
</tr>
<tr>
<td>Lettuce</td>
<td>63</td>
</tr>
<tr>
<td><strong>Poultry Feed</strong></td>
<td><strong>98+</strong></td>
</tr>
<tr>
<td>Roach pellets</td>
<td>199</td>
</tr>
<tr>
<td>Rodent feces</td>
<td>148</td>
</tr>
<tr>
<td>Spray Dried Milk</td>
<td>&gt;120</td>
</tr>
<tr>
<td>Sweeper dust</td>
<td>300</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>49</td>
</tr>
<tr>
<td><strong>Wash and wear fabric</strong></td>
<td><strong>70+</strong></td>
</tr>
</tbody>
</table>
### Number of *Salmonella* in Naturally Contaminated Feeds¹

<table>
<thead>
<tr>
<th>Feed or Ingredient</th>
<th>Salmonella / 100g</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Meat &amp; Bone Meals</td>
<td>1.65</td>
<td>0.5-7.0</td>
</tr>
<tr>
<td>Poultry Meals</td>
<td>1.22</td>
<td>1.0-2.0</td>
</tr>
<tr>
<td>Swine Feeds</td>
<td>1.5</td>
<td>0.5-3.5</td>
</tr>
<tr>
<td>Poultry Feeds</td>
<td>9.61</td>
<td>&gt;1-50</td>
</tr>
<tr>
<td>Fish Meals</td>
<td>9.1</td>
<td>&lt;3-21</td>
</tr>
<tr>
<td>Hog Supplements</td>
<td>&lt;3</td>
<td>&lt;3-23</td>
</tr>
<tr>
<td>Meat &amp; Bone Meals</td>
<td>3.6</td>
<td>&lt;3-460</td>
</tr>
<tr>
<td>Meat Meals</td>
<td>9.1</td>
<td>&lt;3-1,100</td>
</tr>
<tr>
<td>Animal Feeds</td>
<td>9.1</td>
<td>&lt;3-1,100</td>
</tr>
<tr>
<td>Cottonseed Meals</td>
<td>207</td>
<td>100-400</td>
</tr>
<tr>
<td>Animal Protein Meals</td>
<td>16.3</td>
<td>0.03-1,100</td>
</tr>
</tbody>
</table>

¹May be underestimated.
## Sampling for *Salmonella* in Feed Mill Facilities

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Mill Personnel Collected</th>
<th>Researcher Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Run</td>
<td>No. Pos</td>
</tr>
<tr>
<td>Feed</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Meat Meal</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Fish Meal</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Corn</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Liquid Fat</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td><strong>All Samples</strong></td>
<td><strong>80</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

1^Adapted from Jones, 2008
Sampling Feed and Ingredients for *Salmonella*

- 1 MT w/ 100 *Salm*. If evenly distributed – ONE 25g sample - odds of 1/400
- Uneven distribution = uncertainty
- Variety of products & dynamic process
- *Salmonella* could be nearly anywhere
- Positives are a BIG deal
- Are positives from samples?
- Aseptic Sampling
  - A – “without” or “not”
  - Septic - “infection” or “putrefaction”
Where do *Salmonella* come from?

- **External Sources**
  - **Raw Materials** - Raw Ingredient = contaminated
  - **Personnel** - infected feces $10^5$ - $10^9$ – shed ~ 5 wks
  - **Leaks or openings**
  - **Equipment / Transport Vehicles**
  - **Vermin**
    - Mice Inf. by 15 cfu; Conc. contam. 3-4X; droppings ~ $10^5$
    - Wild birds – carry contam. – Congregation points
    - Insects – spread contam.

- **Prevent Contamination**
Preventing *Salmonella* Contamination

- **Raw Materials Purchasing Practices**
  - **Formal Supplier Approval Process** should address:
    - Raw Materials Procurement
    - Manufacturing Procedures
    - Documentation of Process Control
    - Transportation Expectations
    - Facilities Inspections
    - Criteria for Rejecting Loads
    - Procedures for Dealing with Positive Results
    - Criteria for Termination of the Relationship
Preventing *Salmonella* Contamination

- Arrival Inspections
  - Verification of Ingredient Identity
  - Inspection of Documentation
  - Transportation Vehicle Inspection
  - Visual Product Inspection
  - Reject Deficient Loads
  - Sample Accepted Loads
- Sample Aseptically
Preventing *Salmonella* Contamination

- **Ingredient Receiving** – Usually the most contaminated area of the plant
- **Ingredient Unloading** – LOTS of contaminated dust
- **WHERE DOES THE DUST GO?**
Relationship of Dust Accumulation to *Salmonella* Contamination

Abstracted from Nape, 1968

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1Abstracted from Nape, 1968
Where do *Salmonella* come from?

- **Internal Sources**
  - “Segregation of raw material areas... is important...but microbial growth niches in the finished product environment are responsible for the bulk of high incidence rates.” Gabis (1991)
  - *Salmonella* may find niches in the processing area and survive for long periods
    - Cracks or crevices
    - Under equipment
    - In equipment
    - Hollow places
    - Defective packaging
Where do *Salmonella* come from?

- **Internal Sources Compounding Factors**
  - Moisture accumulation
    - Condensation in coolers / driers
    - Inadequate dry time after wet cleaning
    - Storage bins
    - Particle size reduction
    - Temperature changes
  - Fat
    - Protects
    - Adhesive
  - Biofilms
Where do *Salmonella* come from?

- “If the *salmonellae* are not provided with a suitable environment in which to grow, the risk of finished product contamination is greatly reduced because the original populations do not proliferate.” Gabis (1991)
- **Reduce Multiplication**
- **How?**
Residues In Mill Consistently Contaminate Feed

Address Obvious Sources of Potential Contamination

How long can contamination persist?
An Example from Dry Cereal Manufacturing

1998, \textit{S. agona}
209 Cases
47 Hospitalized

- Same Company
- Same Plant
- Isolates with same genetic fingerprint

How long does Salmonella persist? – At least 10 years!

2008, \textit{S. agona}
28 Cases
- Establish important parameters at EACH step
  - Temperature
  - Time
  - pH
  - Moisture
  - Indicator organisms
    - *E. coli*, *Enterobacteriaceae*
  - Contamination level
  - Contamination potential
- Establishes a baseline and an evaluation tool
- Evaluate temperature differences to find trouble spots
Cleaning Versus Sanitation

- Cleaning is physically removing food or soil (and associated microbes) from a surface or area often by muscle power and with the aid of tools.

- Sanitizing is destroying microbes by chemical or physical means.

- **BOTH** cleaning and sanitation are indispensable.
Salmonella Control

• Kill

• Reduce multiplication

• Prevent contamination
Processes that Kill *Salmonella*

- Irradiation
- Thermal Processing
- Chemicals
What Temperature kills *Salmonella*?

- Depends on (among other things):
  1. Application time
  2. *Salmonella* serotype or strain
  3. Number of *Salmonella* present
  4. State of *Salmonella* prior to treatment
  5. Product available moisture (Aw); Aw↓ Heat Res↑
  6. Formulation (particularly fat content)
  7. Product pH
  8. Presence of antimicrobial compounds
  9. Moisture during treatment
  10. System pressure
  11. Holding conditions following treatment
Moisture and *Salmonella* Reduction in Conditioning or Preconditioning

% Reduction in Salm.

![Bar chart showing % Reduction in Salm.](image)

Added Moisture

- 7: 50.29
- 10: 79.41

Target ≥15%

1 Adapted from Israelsen et al. 1994
# Chemical Treatment for Contamination

- Safe use for years in other products
- Effectiveness
  - Number of Salmonella present
  - Type of product
  - Concentration used
  - Contact Time
  - Dispersion
- May be primary or secondary treatment
- Effective treatments offer residual activity
- Basic Types –
  - Organic Acids (Acetic, Formic, Lactic, Propionic)
  - Formaldehyde
Organic Acids

**Advantages**
- History of safe use
- Most on GRAS list
- Widely used in human foods

**Disadvantages**
- High conc. to kill
- Feed palatability?
- Pure acids corrosive
- Incr. nutrient density?
- Increased virulence?
Level and time required for organic acids to reduce *Enterobacteriaceae* in feed

<table>
<thead>
<tr>
<th>ORGANIC ACID REDUCTION</th>
<th>DAYS REQUIRED FOR 90% (KG/TON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMIC</td>
<td>5     8     10     12</td>
</tr>
<tr>
<td>ACETIC</td>
<td>12    4      1.5   0.8</td>
</tr>
<tr>
<td>PROPIONIC</td>
<td>&gt;35   &gt;35   16     12</td>
</tr>
<tr>
<td>LACTIC</td>
<td>&gt;35   &gt;35   14     8</td>
</tr>
</tbody>
</table>

1VANDERWAL, 1979
Level and time required for commercial products to eliminate *salmonella* from fish meal

<table>
<thead>
<tr>
<th>Product / Concentration</th>
<th>Time Required (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffered Propionic Acid – 6 kg/ton</td>
<td>5-7</td>
</tr>
<tr>
<td>Propionic Acid Mixture – 10 kg/ton</td>
<td>5-7</td>
</tr>
<tr>
<td>Propionic-Formic Acid Mixture – 10 kg/ton</td>
<td>1-2</td>
</tr>
<tr>
<td>Formaldehyde-Propionic Acid Mixture – 2 kg/ton</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Zaldivar 1990; Kaiser 1992
Summary

- *Salmonella* is a survivor in/on many materials
- Sampling for *Salmonella*
  - Uncertainty
  - septic procedures necessary
- Control requires
  - Preventing Contamination
  - Reducing Multiplication
  - Establish a baseline of conditions as a guide
- Killing *Salmonella*
  - Pelleting is effective but recontamination issues
  - Chemicals reduce recontamination but present other issues
Sources

- [http://www.cdc.gov/salmonella/](http://www.cdc.gov/salmonella/)

- **Essential Rendering**
  - ISBN 0-9654660-3-5

- **The Original Recyclers**
  - ISBN 0-9654660-0-0

- **Sanitation and Hygiene in the Production of Rendered animal Products**
  - ISBN 0-9654660-1-9

- **HACCP A Systematic Approach to Food Safety**
Thank You

Questions

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