Food Safety and Inspection Service

*Salmonella* Update from USDA’s Food Safety and Inspection Service

Kis Robertson Hale, DVM, MPH, DACVPM
Captain, US Public Health Service
Deputy Assistant Administrator, Office of Public Health Science
USDA/FSIS

USAHA, Salmonella Subcommittee
October 16, 2017
Food Safety and Inspection Service

Topics

- Background
- Adoption of Neutralizing Buffered Peptone Water (nBPW)
- Update on Whole Genome Sequencing
- Latest on National Antimicrobial Resistance Monitoring System (NARMS)
Food Safety and Inspection Service: Mission in Action

The public health agency in the USDA responsible for ensuring that meat, poultry, and processed egg products are safe, wholesome, and accurately labeled.

Our Authority

Through a series of Acts, Congress empowers FSIS to inspect all meat, poultry, and processed egg products in interstate commerce.

- Federal Meat Inspection Act (FMIA)
- Agricultural Marketing Act (AMA)
- Poultry Products Inspection Act (PPIA)
- Humane Methods of Slaughter Act (HMSA)
- Egg Products Inspection Act (EPIA)
Food Safety and Inspection Service: 

*Salmonella* Developments in Recent Years

- FSIS released *Salmonella* Action Plan in 2014
- Key accomplishments included:
  - New poultry performance standards to include poultry carcasses, chicken parts and comminuted
  - Revised compliance guidelines for poultry slaughter and processing
  - Increased consumer education on *Salmonella*
  - Modernized poultry slaughter inspection
  - Continuous sampling ("moving windows") for verifying process control
Paving the way for more progress in *Salmonella* reduction
Food Safety and Inspection Service:

nBPW
Starting in 2013, ARS investigated whether antimicrobial carry-over negatively impacted pathogen recovery in sampled carcasses using the conventional sampling and transport medium (Buffered Peptone Water).

Study objectives:
- I. Determine the potential volume of intervention chemical solution carry-over to carcass rinsates
- II. Determine if antimicrobial intervention carry-over has the potential to impact *Salmonella* monitoring
Phase III:
After results showed a significant carry-over effect, researchers assessed *Salmonella* recovery after reformulation of BPW with neutralizing agents (nBPW)

Conclusions:
• Recovery of *Salmonella* superior to BPW
• Carcasses showed no carry-over effect when sampled using nBPW, based on performance relative to controls
In July 2016, FSIS began use of nBPW for carcass rinse and sponge samples.

Aggregate data in the first year indicates *Salmonella* recovery is relatively unchanged in chicken parts, but higher in carcasses.

To allow time for industry to update food safety systems after nBPW implementation, FSIS announced in Nov. 2016 temporarily replacement of individual establishment category postings on FSIS website with aggregate.
Food Safety and Inspection Service:

Whole Genome Sequencing (WGS)
Objective 1.2.2: Enhance Response to Foodborne Illness Outbreaks and Adulteration Events

- Increase use of new technologies, such as whole genome sequencing, to supplement information obtained during an investigation and to improve the effectiveness of responses to outbreaks.

Objective 2.1.1: Modernize Scientific Techniques and Inspection Procedures

- FSIS has started building WGS capacity and intends to have WGS fully implemented into its sampling programs—to generate real-time analysis to inform FSIS’ food safety and public health regulatory decisions.
Food Safety and Inspection Service:

Why WGS?

• Improved resolution for foodborne illness investigations
• Supports FSIS mission goals
• Alignment of pathogen surveillance with public health and regulatory partners
Food Safety and Inspection Service

Discriminatory Power of WGS vs. PFGE

Large range of SNPs between pattern JEGX01.004 isolates, isolates with different PFGE patterns clustering with pattern JEGX01.004 isolates.
Food Safety and Inspection Service:

FSIS Collaborations for WGS Efforts

• FSIS is actively engaged in partnerships/collaborations with:
  – Gen-FS: An interagency collaboration on genomics and food safety
  – IFSH: An FDA/Industry/IIT collaboration
  – GMI: Global Microbial Identifier - Global initiative for furthering whole genome sequencing as a tool for diagnostics and epidemiological surveillance
  – WHO: Joint effort with WHO/PAHO/FDA to develop guidance for implementation of WGS for developing countries
  – IRAC: Interagency group discussing how WGS can be used for QMRA
  – APHIS and ARS
Food Safety and Inspection Service:  

**WGS at FSIS: Current Status**

- FSIS has built capacity for conducting WGS on all pathogens obtained from FSIS sampling programs
  - Currently 12 sequencers in FSIS Field Service Laboratories, and expect all to be operational in early FY18
  - In FY17, FSIS sequenced 7282 isolates

- In collaboration with our public health and regulatory partners, FSIS currently considers available WGS analyses in addition to PFGE, epidemiological and traceback information to further understand the relationship between clinical and food isolates

- FSIS works with National Antimicrobial Resistance Monitoring System (NARMS) partners (FDA, CDC) to understand the occurrence or introduction of antimicrobial resistance genes in pathogens of interest
Food Safety and Inspection Service
WGS Milestones and Uploads into the National Center for Biotechnology Information (NCBI) Genomic Database

**Isolates Sequenced**

**Milestone Dates**

- July 2014: *Salmonella* and *Listeria monocytogenes*
- December 2014: STECs
- February 2015: *Campylobacter*
- May 2015: Capability to directly upload WGS files to NCBI

As of 10/01/2017: 10,935 FSIS isolates have been sequenced and uploaded to NCBI

<table>
<thead>
<tr>
<th></th>
<th>Listeria monocytogenes</th>
<th>STEC</th>
<th>Salmonella</th>
<th>Campylobacter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine/Special Projects</td>
<td>435</td>
<td>482</td>
<td>3825</td>
<td>1007</td>
<td>5749</td>
</tr>
<tr>
<td>NARMS Cecal Sampling</td>
<td></td>
<td></td>
<td>2396</td>
<td>2790</td>
<td>5186</td>
</tr>
<tr>
<td>Total</td>
<td>435</td>
<td>482</td>
<td>6221</td>
<td>3797</td>
<td>10935</td>
</tr>
<tr>
<td>Total for FY 2017</td>
<td>7219</td>
<td></td>
<td>6221</td>
<td>3797</td>
<td>10935</td>
</tr>
</tbody>
</table>

(Note: In FY 2016 we completed 3313 WGS and in 2015 it was 524. About 121 WGS from NARMS ‘E. coli + Enterococcus’ are not included in the 10935 total)
FSIS is beginning to explore using genotypic data to predict phenotypic characteristics
  – Previous examples of antimicrobial resistance markers
  – Resistance to other environmental factors (i.e. heat, acid, certain chemicals, etc)

Example: Locus of Heat Resistance (LHR)
  – Present in a diverse group of Enterobacteriaceae, including Cronobacter sakazakii, Klebsiella pneumoniae, Enterobacter cloacae, E. coli, and Salmonella
  – A BLAST database including genes contained in the LHR was built based on the published sequence of E. coli AW1.7
  – Salmonella isolates from FSIS-regulated products were sequenced, assembled and queried against the LHR BLAST database
  – Additional phenotypic testing required to determine if isolates exhibit resistance to heat

Heat resistance can be linked to different biological pathways/genes
  – Advantage of WGS: As new pathways/genes are identified, data can be queried again
FSIS’ new strategic plan is focused on the use of new technology to prevent foodborne illnesses and protect public health.

FSIS has built sufficient capacity for conducting WGS on all FSIS pathogen isolates.

FSIS is exploring how we can use WGS data beyond outbreak investigations, including understanding the link between genotypes and phenotypes of interest.

FSIS continues to engage with national and international partners.

FSIS continues to use WGS analyses in conjunction with other metadata, including epidemiological and traceback information, to further understand the relationship between clinical, food and environmental isolates.
Food Safety and Inspection Service:

NARMS
Samples are collected from federally inspected slaughter and processing plants throughout U.S. Target all four major food animal species and antimicrobial susceptibility data on all four bacteria.
Food Safety and Inspection Service:  

**FSIS NARMS Milestones**

- **ARS**
  - 1996: FSIS PR/HACCP verification sampling begins
  - 1997: Cecal sampling begins - culture, subtyping, and AST conducted by ARS

- **FSIS**
  - 2012: NARMS antimicrobial susceptibility testing (AST) on PR/HACCP isolates conducted by ARS
  - 2013: FSIS conducts and AST for PR/HACCP and cecal isolates
  - 2014: FSIS begins WGS on selected cecal Salmonella and Campylobacter
  - 2015: FDA - Whole Genome Sequencing (WGS) for Salmonella isolates from cecal samples
  - 2016: FSIS - WGS for all Salmonella and Campylobacter from cecal samples
  - 2017: FSIS - WGS for all Salmonella and Campylobacter from cecal samples
### NARMS Salmonella

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Samples</td>
<td>No. Isolates</td>
<td>Percent Positive</td>
</tr>
<tr>
<td>HACCP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chickens</td>
<td>10,446</td>
<td>936</td>
<td>9.0%</td>
</tr>
<tr>
<td>Turkey</td>
<td>3,374</td>
<td>299</td>
<td>8.9%</td>
</tr>
<tr>
<td>Cattle</td>
<td>16,720</td>
<td>344</td>
<td>2.1%</td>
</tr>
<tr>
<td>Total</td>
<td>30,540</td>
<td>1579</td>
<td></td>
</tr>
<tr>
<td>Total HACCP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chickens</td>
<td>575</td>
<td>103</td>
<td>17.9%</td>
</tr>
<tr>
<td>Turkey</td>
<td>264</td>
<td>45</td>
<td>17.0%</td>
</tr>
<tr>
<td>Beef</td>
<td>1,798</td>
<td>104</td>
<td>5.8%</td>
</tr>
<tr>
<td>Dairy</td>
<td>1,069</td>
<td>217</td>
<td>20.3%</td>
</tr>
<tr>
<td>Swine</td>
<td>1,295</td>
<td>606</td>
<td>46.8%</td>
</tr>
<tr>
<td>Total</td>
<td>5,001</td>
<td>1,075</td>
<td>21.5%</td>
</tr>
</tbody>
</table>

<sup>1</sup>Preliminary 2016 Data
Food Safety and Inspection Service:

MDR *Salmonella*: Cattle-Associated Isolates

**Percent of *Salmonella* isolates MDR - resistant to > 3 antimicrobial classes**

- **Cecal MDR**:
  - > 90% R to Str, Sul, Tet
  - >70% R to Amp
  - 57% R to Ceftriaxone (C)

- **HACCP MDR**:
  - > 90% R to Str, Sul, Tet
  - >70% R to Amp, Chl
  - 60% R to Ceftriaxone (C)

**Years and Numbers**

- Beef cow (cecal):
  - 2014 n=15
  - 2015 n=31
  - 2016 n=29

- Dairy (cecal):
  - 2014 n=217
  - 2015 n=233
  - 2016 n=218

- Heifer (cecal):
  - 2014 n=42
  - 2015 n=45
  - 2016 n=47

- Steer (cecal):
  - 2014 n=47
  - 2015 n=50
  - 2016 n=74

- HACCP:
  - 2014 n=344
  - 2015 n=291
  - 2016 n=285

---

1 Preliminary 2016 Data
Food Safety and Inspection Service: MDR *Salmonella* in Chicken

Percent of *Salmonella* isolates MDR - resistant to > 3 antimicrobial classes

<table>
<thead>
<tr>
<th>Year</th>
<th>Cecal</th>
<th>HACCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td>2015</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>2016</td>
<td>18%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Cecal Chicken – MDR Serotypes

- Typhimurium: 54%
- Kentucky: 18%
- Infantis: 5%
- Heidelberg: 4%
- Schwarzengrund: 4%
- Others: 4%

HACCP Chicken – MDR Serotypes

- Kentucky: 37%
- Typhimurium: 28%
- Infantis: 15%
- Heidelberg: 9%
- Schwarzengrund: 3%
- Enteritidis: 2%
- Others: 5%

1Preliminary 2016 Data
Food Safety and Inspection Service:

MDR *Salmonella* in Turkey

**Percent of *Salmonella* isolates MDR - resistant to ≥ 3 antimicrobial classes**

<table>
<thead>
<tr>
<th></th>
<th>2014 n=299</th>
<th>2015 n=185</th>
<th>2016 n=136</th>
</tr>
</thead>
<tbody>
<tr>
<td>HACCP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cecal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cecal Turkey – MDR Serotypes**

- I 4,[5],12:i-: 16%
- Reading: 30%
- Saintpaul: 16%
- Hadar: 14%
- Heidelberg: 14%
- Senftenberg: 10%
- Others: 8%

**HACCP Turkey – MDR Serotypes**

- Reading: 26%
- I 4,[5],12:i-: 11%
- Saintpaul: 11%
- Hadar: 10%
- Heidelberg: 9%
- Senftenberg: 9%
- Muenchen: 6%
- Agona: 5%
- Others: 4%

1Preliminary 2016 Data
Food Safety and Inspection Service:
MDR *Salmonella* in Swine

Percent of *Salmonella* isolates MDR - resistant to > 3 antimicrobial classes

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Swine (Cecal)</td>
<td>280</td>
<td>216</td>
<td>307</td>
</tr>
<tr>
<td>Sow (Cecal)</td>
<td>328</td>
<td>278</td>
<td>312</td>
</tr>
</tbody>
</table>

*Cecal Market Swine – MDR Serotypes*

<table>
<thead>
<tr>
<th>Serotype</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derby</td>
<td>33%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td><em>I 4,[5],12:i:-</em></td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>4%</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>Agona</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johannesburg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brandenburg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infantis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Cecal Sow – MDR Serotypes*

<table>
<thead>
<tr>
<th>Serotype</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derby</td>
<td>32%</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td><em>I 4,[5],12:i:-</em></td>
<td>17%</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agona</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johannesburg</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brandenburg</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infantis</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Preliminary 2016 Data
Food Safety and Inspection Service:

Future Directions

• Continuation of WGS and timely sequence uploads into NCBI

• Work with NARMS to monitor resistomes and mobilomes

• Develop a mechanism to inform regulated industry of new findings of concern

• FSIS NARMS webpage and publications
Food Safety and Inspection Service:

Upcoming Public Meetings

• NARMS Public Meeting hosted by FDA - Oct 24th and 25th
  – This two day NARMS meeting will cover topics related to partner agency and stakeholder perspectives, genomics, recommendations from the science board and data needs to make the necessary AMR linkages

• WGS Public Meeting hosted by FSIS - Oct 26th and 27th
  – This two day meeting will cover topics related to WGS – the big picture, Federal and State WGS collaborations, international and stakeholder perspectives and a roundtable to broadly discuss significant WGS issues in a regulatory context
Questions?

Kis.Robertson@fsis.usda.gov