



Food Safety and Inspection Service Nationwide Raw Pork Product Sampling Study

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Background

- Undercooked pork is a known source of foodborne illness but data is lacking on the prevalence of *Salmonella* and STEC in raw pork products.

Purpose of the Raw Pork Exploratory Baseline Study

- Determine the National Prevalence of *Salmonella* in raw pork products.
- To ascertain the presence of STEC in raw pork products and develop a risk profile.

Methods

Phase I (May 2015 to November 2015) – Pilot Study to Set the Parameters for the Baseline Study

- A total of 1,200 samples, from slaughter and processing-only establishments, of comminuted, non-intact, and intact cuts of raw pork products were tested for *Salmonella*.
- 200 of the 1,200 samples collected from slaughter and processing-only establishments were analyzed for STEC.

Phase II (June 2017 through May 2018) – Baseline Study to address Prevalence and Risk

- Total 4,014 raw pork samples (comminuted, non-intact, and intact cuts) from slaughter and processing-only establishments were tested for *Salmonella*.
- Only samples from slaughter establishments were tested for top 7 STEC (1,395 samples).
- Sample design was a stratified approach based on establishment production volume for each group of raw pork products, specifically comminuted, non-intact, and intact cuts.

Sample and Bacterial Isolate Testing

- FSIS-Microbiology Laboratory Guidebook methods for raw pork sample analysis.
- Antibiotic susceptibility according to National Antimicrobial Resistance Monitoring System (NARMS).
- Illumina MiSeq Sequencer using Pulse Net standard procedures with Nextera XT library for the Illumina.
- Antibiotic resistance genetic markers determined via U.S. National Library of Medicine, National Center for Biotechnology Information Database Pathogen Browser with the Antibiotic Resistance Isolate Bank hosted by CDC and the FDA.
- Statistical software WesVar v 5.1 was used to calculate the national prevalence (weighted average) of *Salmonella* within the U.S. raw pork industry.

Raw Pork Product Categories

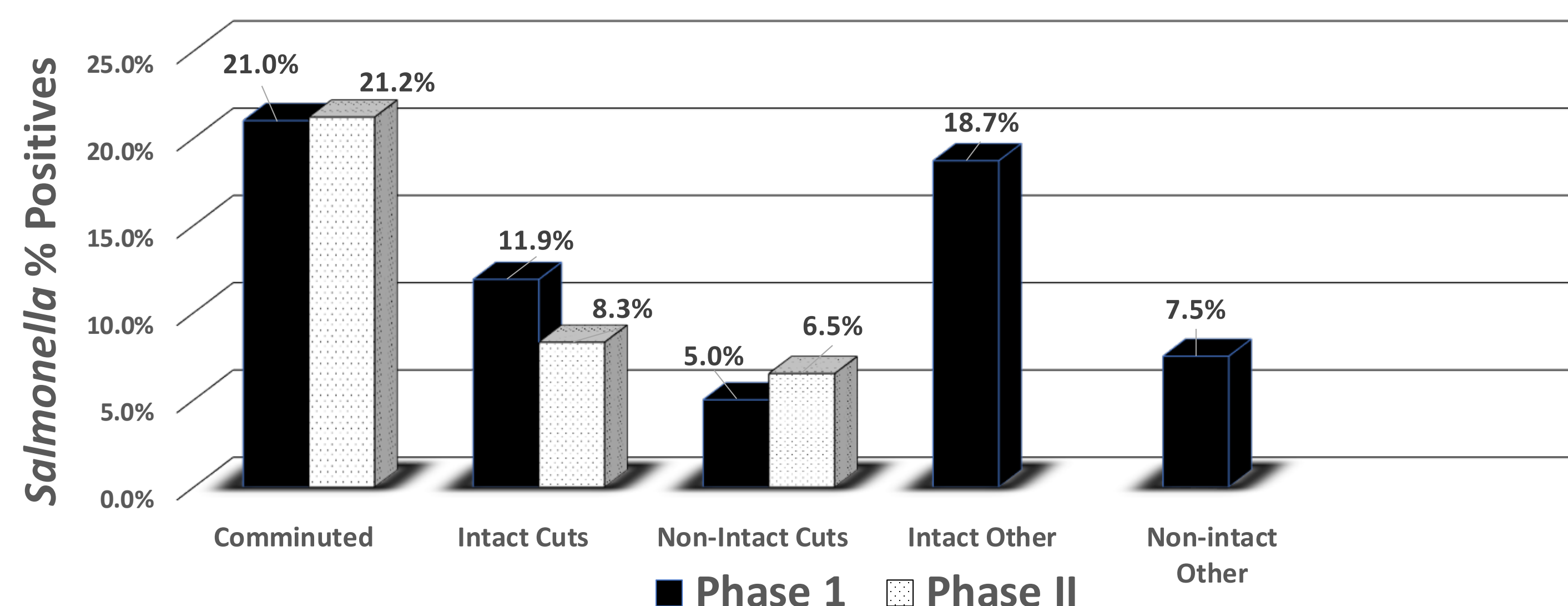
- Comminuted (Ground, Other Comminuted, Advanced Meat Recovery, Mechanically Separated, Sausage, Patties, and Other Formed Products).
- Intact Cuts (bone-in and boneless).
- Non-intact Cuts (bone-in and boneless tenderized or injected).
- Intact and Non-Intact Other [*Phase I only*] (Feet, Neck Bones, and Cutlets not tenderized or injected).

| Proposed Sample Allocation for Raw Pork Product Groups Phase II | | | | | | |
|---|-------------------------|------------|--------------|--------------------|------|---------------------------------------|
| Pork Product Strata | Eligible Establishments | | | Sampling Frequency | | Proposed # of Samples to Be Collected |
| | Total | # Sampled | % Included | Month | Year | |
| Comminuted | | | | | | |
| ≥1,000,000 lbs. | 25 | 25 | 100.0% | 2 | 24 | 600 |
| >90,000 up to 1,000,000 lbs. | 99 | 50 | 50.5% | 1 | 12 | 600 |
| >10,000 up to 90,000 lbs. | 129 | 80 | 62.0% | 0.5 | 6 | 480 |
| Total | 253 | 155 | 61.2% | | | 1,680 |
| Intact | | | | | | |
| ≥1,000,000 lbs. | 20 | 20 | 100.0% | 2 | 24 | 480 |
| >90,000 up to 1,000,000 lbs. | 45 | 20 | 44.4% | 1 | 12 | 240 |
| >10,000 up to 90,000 lbs. | 113 | 90 | 79.6% | 0.5 | 6 | 540 |
| Total | 178 | 130 | 73.0% | | | 1,260 |
| Non-Intact | | | | | | |
| ≥1,000,000 lbs. | 9 | 9 | 100.0% | 4 | 48 | 432 |
| >10,000 and <1,000,000 lbs. | 36 | 34 | 94.4% | 2 | 24 | 816 |
| Total | 45 | 43 | 95.5% | | | 1,248 |
| Total Samples Projected for Phase II (Baseline study) | | | | | | 4,188 |

Salmonella Results

| The Top Five Serotypes of <i>Salmonella</i> Identified | | | | |
|--|-----------------------------|------------------------------|-----------------------------|------------------------------|
| Rank | Phase I | | Phase II | |
| | <i>Salmonella</i> Serotypes | Number of Isolates Recovered | <i>Salmonella</i> Serotypes | Number of Isolates Recovered |
| 1 | Derby | 25 | Anatum | 75 |
| 2 | Anatum | 23 | Infantis | 71 |
| 3 | Infantis | 17 | Johannesburg | 49 |
| 4 | Johannesburg | 12 | Derby | 47 |
| 5 | I 4, [5], 12:i:- | 11 | I 4, [5], 12:i:- | 33 |
| 5 | Typhimurium | 11 | --- | |

| Percent Antibiotic Resistance of <i>Salmonella</i> Isolates Recovered | | | |
|---|---------------------------------------|--------------------------------------|---------------------------------------|
| Phase I | | Phase II | |
| <i>Salmonella</i> isolates recovered | Percent antibiotic resistance markers | <i>Salmonella</i> isolates recovered | Percent antibiotic resistance markers |
| 200 | 48% (96/200 isolates) | 545 | 32% (174/545 isolates) |



| Phase II <i>Salmonella</i> Results | | | | |
|------------------------------------|------------------|--------------------|---------------------|---------------------|
| Product | Samples Analyzed | Percent Positive | National Prevalence | Confidence Interval |
| Comminuted | 1,796 | 21.2% (380) | 28.9% | 24.1% - 33.8% |
| Intact | 1,170 | 8.3% (97) | 5.3% | 4.3% - 6.4% |
| Non-intact | 1,048 | 6.5% (68) | 3.9% | 0.6% - 7.2% |
| Total | 4,014 | 13.6% (545) | | |

References

- United States Department of Agriculture, Food Safety and Inspection Service. Microbiology Laboratory Guidebook. Available at: <https://www.fsis.usda.gov/wps/wcm/connect/fsis-content/internet/main/topics/science/laboratories-and-procedures/guidebooks-and-methods/microbiology-laboratory-guidebook/microbiology-laboratory-guidebook>
- National Antimicrobial Resistance Monitoring System. Manual of Laboratory Methods. Available at: <https://www.fda.gov/downloads/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/UCM528831.pdf>
- Whole genome sequencing using laboratory standard operating procedure for PulseNet NexteraXT library preparation and setup for Illumina MiSeq. Available at: <https://www.cdc.gov/pulsenet/pdf/PNL32-MiSeq-Nextera-XT.pdf>
- National Institutes of Health, United States Library of Medicine, National Center for Biotechnology Information, pathogen browser to identify genetic markers. Available at: <https://www.ncbi.nlm.nih.gov/pathogens/isolates/>
- Center Antibiotic Resistance Isolate Bank hosted by CDC and the Food and Drug Administration. Available at: <https://www.cdc.gov/AVIsolateBank/GeneGlossary>

STEC Results

| Phase I | | | | | | | | |
|---------------------------|--------------------------|----------------------------|----------|----------|----------|----------|----------|-----------|
| Pork Product | Samples Percent Positive | Serogroup of STEC Isolates | | | | | | Total |
| | | O26 | O45 | O103 | O111 | O121 | O145 | |
| Comminuted | 5.4% (6/112) | 1 | 5 | 1 | 1 | 1 | 3 | 12 |
| Intact | 4.9% (4/53) | 2 | 3 | 3 | 1 | 3 | 3 | 15 |
| Non-intact | 0.0% (0/1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Intact & Non-intact Other | 0.0% (0/34) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 5.0% (10/200) | 3 | 8 | 4 | 2 | 4 | 6 | 27 |

| Phase II | | | |
|--------------|---------------|--------------------|----------------------------|
| Pork Product | STEC Isolated | Confirmed Positive | Number of Samples Analyzed |
| Comminuted | O157:H7 | 1 | 667 |
| | O103 | 2 | |
| Intact | None | 0 | 406 |
| Non-intact | None | 0 | 322 |
| Total | | 3 | 1,395 |

Summary of Results

Phase I [*Pilot study*]

- Of the 1200 samples collected, 200 tested positive for *Salmonella* (16.7%).
- Of the 200 samples tested for STEC, 10 samples confirmed positive resulting in 27 independent STEC isolates recovered.
- Seventeen of these isolates were recovered from processing establishments and 10 from slaughter establishments.

Phase II [*Baseline study*]

- National Prevalence of *Salmonella* was 29% for comminuted, 5% for intact cuts, and 4% for non-intact cuts.
- Three STEC isolates were recovered.
- Comminuted pork products had the highest prevalence of *Salmonella*.
- Data suggest fabrication and processing augmented the levels of pathogens.

Significance of the Work

- Salmonella* associated with raw pork products is a public health concern.
- Data from this study will be used to develop standards or policies to reduce the levels of *Salmonella* in raw pork products.
- Further investigation is warranted to determine if STEC is an emerging public health concern in raw pork products.

Next Steps

- Review current policies as they apply to efforts to mitigate levels of *Salmonella* in raw pork products.
- Continue to monitor levels of *Salmonella* in these products.
- Use data collected to conduct multivariate analysis of *Salmonella* data to help identify factors that contribute to high levels of *Salmonella* in raw pork products.
- Use data generated as support for a risk profile that explains possible public health risk of STEC in raw pork products.

Acknowledgements: The authors recognize the many FSIS individuals responsible for making a baseline study like the Raw Pork Product Sampling Program successful. A special recognition goes to the Office of Field Operations/Inspection Program Personnel and those at Headquarters (HQ); Office of Public Health Science/Field Service Laboratories and HQ staff; Office of Policy and Program Development; as well as the Office of Planning, Analysis, and Risk Management and others.