



United States Department of Agriculture

Food Safety and Inspection Service

The FSIS Beef and Veal Carcass Baseline Survey (BVCBS)

Dr. Evelyne Mbandi

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International Association for Food Protection
(IAFP)

Salt Lake City, Utah

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Introduction

- Baselines are statistically designed microbiological surveys to assess and test food commodities for foodborne pathogens and bacteria that indicate process control.
- The data generated by baseline surveys are used to determine levels of pathogen and indicator bacteria in a particular commodity, establish microbiological industry criteria/standards, provide data for risk assessments, assess microbiological production parameters, and assess seasonal and regional variability.

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Purpose of Beef-Veal Carcass Baseline Survey (BVCBS)

- To estimate the prevalence and quantitative level of pathogenic organisms *E. coli* O157:H7, non-O157 STEC, and *Salmonella*.
- To estimate the presence and quantitative levels of indicator organisms Generic *E. coli*, Total Aerobic Bacteria, *Enterobacteriaceae*, and coliforms.
- To gain information on the effectiveness of sanitary dressing and slaughter interventions in beef/veal slaughter establishments.
- To provide process control criteria for beef/veal slaughter establishments.

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Survey Details

- Sample collection began August 2014 and ended in December 2015
 - The survey was extended from the originally scheduled 12 months in order to collect the planned number of samples
- Swabbed 8,000 cm² beef carcass using the non-templated MARC method (4,000 cm² for veal)
- Two collection points:
 - Post-hide removal
 - Pre-chill (after interventions)

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ARS-MARC Sampling Method



Collect ~4,000cm² from the inside and outside round, and 4,000 cm² from the navel-plate-brisket-fore-shank areas as shown, each with a separate sponge. Sponges were later combined in the laboratory for processing, giving an 8,000 cm² sample.

<https://www.youtube.com/watch?v=SP0t9raTLCw&feature=youtu.be>

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Survey Details

- Microbiological targets:
 - Pathogens
 - *E. coli* O157:H7
 - Non-O157 Shiga toxin-producing *E. coli* (Non-O157 STEC)
 - *Salmonella*
 - Indicator organisms:
 - Total Aerobic Bacteria
 - *Enterobacteriaceae*
 - Coliforms
 - Generic *E. coli*
- Samples were analyzed using standard FSIS MLG methods (<https://www.fsis.usda.gov/wps/portal/fsis/topics/science/laboratories-and-procedures/guidebooks-and-methods/microbiology-laboratory-guidebook/microbiology-laboratory-guidebook>)

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Survey Design

- Three strata design for beef plants. Plants were allocated to strata according to production volume.
 - All (100%) beef plants in strata 1 and 2 were sampled and 57% of plants in stratum 3 participated in the survey.
- Veal plants, due to their scarcity, were put in a single group without further stratification and all of them were sampled.
- More information on the survey design is found at:
<https://www.fsis.usda.gov/wps/wcm/connect/5057f4ef-f924-422c-bafe-771b1ead78e4/Beef-Veal-Carcass-Baseline-Study-Design.pdf?MOD=AJPERES>

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BVCBS Results

- Total of 149 FSIS-inspected establishments participated.
- Beef
 - 2,736 carcass samples
 - 1,368 Post-hide removal
 - 1,368 Pre-chill
- Veal
 - 548 carcass samples
 - 274 Post-hide removal
 - 274 Pre-chill

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BVCBS Results – Beef Carcasses

Percent Positive

- At post-hide-removal:
 - *Salmonella* - 27.12%
 - *E. coli* O157:H7 - 1.83%
 - non-O157 STEC - 6.14%
- At pre-chill:
 - *Salmonella* - 3.36%
 - *E. coli* O157:H7 - 0.66%
 - non-O157 STEC - 0.73%

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BVCBS Results – Beef Carcasses

- National Prevalence Estimates (Pre-chill)
 - *Salmonella* - 0.71% (95% Confidence Interval)
 - *E. coli* O157:H7 - 0.06% (95% Confidence Interval)
 - non-O157 STEC - 0.21% (95.00% Confidence Interval)

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Pathogen Positives by Strata at Pre-chill – Beef Carcasses

Strata	Samples	<i>Salmonella</i> Positive Samples	<i>E. coli</i> O157:H7 Positive Samples	Non-O157 STEC Positive Samples
1	322	2	0	1
2	446	3	0	0
3	600	41	9	9
Total	1,368	46	9	10



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BVCBS Results – Beef Carcasses (Post-Hide Removal)

Table 1. Summary for Quantified Beef Samples at Post-hide Removal by Microorganism in the 2014-2015 Beef Veal Carcass Baseline Survey

Microorganisms	Sample Collected at	Number of Samples Tested	Number of Samples Quantifiable ⁽²⁾	Percent Positive	Quantitative Levels ⁽³⁾				
					Mean (Data units)	Mean Std Error	Geometric Mean	Geo Mean 95% CI	Log 10 of the Geo Mean
Aerobic Count	Post-hide Removal	1,348	1,341	99.48%	340,973	66,960	8,946.0	(7,873 – 10,163)	3.95
Enterobacteriaceae	Post-hide Removal	1,366	1,020	74.67%	17,724	16,929	30.0	(26.8 – 33.6)	1.47
Total Coliforms	Post-hide Removal	1,366	922	67.50%	2,627	2,154	19.7	(17.7 – 21.9)	1.29
Generic Escherichia coli	Post-hide Removal	1,365	1,034	75.75%	6,472	2,531	40.8	(35.9 – 46.5)	1.61
Pathogenic Organism ^{(4) (5)}									
<i>Salmonella</i>	Post-hide Removal	1,368	371	27.12%	1.53	1.11	0.20	(0.18 – 0.22)	-0.71
<i>E. coli O157:H7</i>	Post-hide Removal	1,368	25	1.83%	0.20	0.05	0.16	(0.13 – 0.20)	-0.79
<i>non-O157 STEC ⁽⁶⁾</i>	Post-hide Removal	1,368	84	6.14%	4.52	4.10	0.30	(0.24 - 0.37)	-0.52

(1) Units are MPN/100 cm² and limit of Detection (LOD) < 6.25 MPN/100 cm²

(2) This is results above Limit of Detection (LOD); LOD < 6.25 MPN/100cm²

(3) Calculations include estimations for results under LOD < 6.25 at LOD/2 = 3.12 MPN/ 100cm²

(4) Calculations include results under LOD < 0.2815 and estimated at LOD/2 = 0.14

(5) Pathogens results are in MPN/100 cm² with LOD < 0.2815 MPN/100cm²

(6) Non-O157 STEC are: O26, O45, O103, O111, O121, and O145. Table shows aggregate results.



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BVCBS Results – Beef Carcasses (Pre-Chill)

Table 2. Summary for Quantified Beef Samples at Pre-Chill by Microorganism in the 2014-2015 Beef Veal Carcass Baseline Survey

Microorganisms	Sample Collected at	Number of Samples Tested	Number of Samples Quantifiable ⁽²⁾	Percent Positive	Quantitative Levels ⁽³⁾				
					Mean (Data units)	Mean Std Error	Geometric Mean	Geo Mean 95% CI	Log 10 of the Geo Mean
Aerobic Count	Pre-Chill	1,359	1,094	80.50%	89,591	30,485	106.8	(90 – 127)	2.02
Enterobacteriaceae	Pre-Chill	1,366	306	22.40%	380	223	5.4	(5.0 – 5.8)	0.73
Total Coliforms	Pre-Chill	1,366	229	16.76%	25,528	22,528	4.8	(4.4 – 5.2)	0.68
Generic Escherichia coli	Pre-Chill	1,368	189	13.82%	452	244	4.4	(4.1 – 4.7)	0.64
Pathogenic Organism ^{(4) (5)}									
<i>Salmonella</i>	Pre-Chill	1,368	46	3.36%	0.19	0.03	0.16	(0.14 – 0.19)	-0.78
<i>E. coli O157:H7</i>	Pre-Chill	1,368	9	0.66%	0.14	0.00	0.14	(0.14 – 0.14)	-0.85
<i>non-O157 STEC ⁽⁶⁾</i>	Pre-Chill	1,368	10	0.73%	0.21	0.05	0.18	(0.12 - 0.26)	-0.74

(1) Units are MPN/100 cm² and limit of Detection (LOD) < 6.25 MPN/100 cm²

(2) This is results above Limit of Detection (LOD); LOD < 6.25 MPN/100cm²

(3) Calculations include estimations for results under LOD < 6.25 at LOD/2 = 3.12 MPN/ 100cm²

(4) Calculations include results under LOD < 0.2815 and estimated at LOD/2 = 0.14

(5) Pathogens results are in MPN/100 cm² with LOD < 0.2815 MPN/100cm²

(6) Non-O157 STEC are: O26, O45, O103, O111, O121, and O145. Table shows aggregate results.

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BVCBS Results – Veal Carcasses

Percent Positive

- At post-hide-removal:
 - *Salmonella* - 12.04%
 - *E. coli* O157:H7 - 0.73%
 - non-O157 STEC - 23.72%
- At pre-chill:
 - *Salmonella* - 1.82%
 - *E. coli* O157:H7 - 0.73%
 - non-O157 STEC - 9.85%

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BVCBS Results – Veal Carcasses

- National Prevalence Estimates (Pre-chill)
 - *Salmonella* - 3.32% (95% Confidence Interval)
 - *E. coli* O157:H7 - 0.50% (95% Confidence)
 - non-O157 STEC - 8.54% (95% Confidence Interval)
 - As expected, all sample percent positives are within the 95% Confidence Interval of the Prevalence



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BVCBS Results – Veal Carcasses (Post-Hide Removal)

Table 3. Summary for Quantified Veal Samples at Post-hide Removal by Microorganism in the 2014-2015 Beef Veal Carcass Baseline Survey

Microorganisms	Sample Collected at	Number of Samples Tested	Number of Samples Quantifiable ⁽²⁾	Percent Positive	Quantitative Levels ⁽³⁾				
					Mean (Data units)	Mean Std Error	Geometric Mean	Geo Mean 95% CI	Log 10 of the Geo Mean
Aerobic Count	Post-hide Removal	272	271	99.63%	575,654	286,655	14,057.0	(10,405 – 18,990)	4.14
Enterobacteriaceae	Post-hide Removal	274	202	73.72%	5,705	1,988	95.0	(68.9 – 131.1)	1.98
Total Coliforms	Post-hide Removal	271	180	66.42%	22,939	19,854	61.3	(45.2 – 83.2)	1.79
Generic Escherichia coli	Post-hide Removal	274	193	70.44%	5,592	2,021	79.6	(58.1 – 109.0)	1.90
Pathogenic Organism ⁽⁴⁾⁽⁵⁾									
<i>Salmonella</i>	Post-hide Removal	274	33	12.04%	0.37	0.05	0.32	(0.27 – 0.37)	-0.49
<i>E. coli O157:H7</i>	Post-hide Removal	274	2	0.73%	0.28	0.00	0.28	(0.28 – 0.28)	-0.55
<i>Non-O157 STEC ⁽⁶⁾</i>	Post-hide Removal	274	65	23.72%	0.50	0.19	0.44	(0.35 - 0.56)	-0.35

(1) Units are MPN/100 cm² and limit of Detection (LOD) < 12.5 MPN/100 cm²

(2) This is results above Limit of Detection (LOD); LOD < 12.5 MPN/100cm²

(3) Calculations include estimations for results under LOD at LOD/2 = 6.25 MPN/ 100cm²

(4) Calculations include results under LOD <0.5625 and estimated at LOD/2 = 0.28125 MPN/ 100cm²

(5) Pathogens results are in MPN/100 cm² with LOD < 0.5625 MPN/100cm²

(6) Non-O157 STEC are: O26, O45, O103, O111, O121, and O145. Table shows aggregate results.



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BVCBS Results – Veal Carcasses (Pre-Chill)

Table 4. Summary for Quantified Veal Samples at Pre-Chill by Microorganism in the 2014-2015 Beef Veal Carcass Baseline Survey

Microorganisms	Sample Collected at	Number of Samples Tested	Number of Samples Quantifiable ⁽²⁾	Percent Positive	Quantitative Levels ⁽³⁾				
					Mean (Data units)	Mean Std Error	Geometric Mean	Geo Mean 95% CI	Log 10 of the Geo Mean
Aerobic Count	Pre-Chill	272	204	75.00%	21,548	7,327	292.0	(198 – 429)	2.46
Enterobacteriaceae	Pre-Chill	273	90	32.97%	700	321	15.6	(12.6 – 19.3)	1.19
Total Coliforms	Pre-Chill	274	85	31.02%	19,976	19,616	14.0	(11.3 – 17.2)	1.15
Generic Escherichia coli	Pre-Chill	274	89	32.48%	323	123	13.9	(11.5 – 16.8)	1.14
Pathogenic Organism ^{(4) (5)}									
<i>Salmonella</i>	Pre-Chill	274	5	1.82%	0.28	0.00	0.28	(0.28 – 0.28)	-0.55
<i>E. coli O157:H7</i>	Pre-Chill	274	2	0.73%	0.28	0.00	0.28	(0.28 – 0.28)	-0.55
<i>Non-O157 STEC ⁽⁶⁾</i>	Pre-Chill	274	27	9.85%	1.16	0.64	0.42	(0.29 - 0.63)	-0.37

(1) Units are MPN/100 cm² and limit of Detection (LOD) < 12.5 MPN/100 cm²

(2) This is results above Limit of Detection (LOD); LOD < 12.5 MPN/100cm²

(3) Calculations include estimations for results under LOD at LOD/2 = 6.25 MPN/ 100cm²

(4) Calculations include results under LOD <0.5625 and estimated at LOD/2 = 0.28125 MPN/ 100cm²

(5) Pathogens results are in MPN/100 cm² with LOD < 0.5625 MPN/100cm²

(6) Non-O157 STEC are: O26, O45, O103, O111, O121, and O145. Table shows aggregate results.

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BVCBS Results – Comparison of Beef and Veal

At Post-Hide Removal					
Pathogens	Animal	Samples	Number of Positives	% Positive	Significant Difference? (*)
<i>Salmonella</i>	Beef	1,368	371	27.12%	Yes p-value < 0.0001
	Veal	274	33	12.04%	
<i>E. coli</i> O157:H7	Beef	1,368	25	1.83%	No p-value = 0.19
	Veal	274	2	0.73%	
Non-O157 STEC	Beef	1,368	84	6.14%	Yes p-value < 0.0001
	Veal	274	65	23.72%	

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BVCBS Results – Comparison of Beef and Veal

At Pre-Chill					
Pathogens	Animal	Samples	Number of Positives	% Positive	Significant Difference? (*)
<i>Salmonella</i>	Beef	1,368	46	3.36%	No p-value = 0.18
	Veal	274	5	1.82%	
<i>E. coli</i> O157:H7	Beef	1,368	9	0.65%	No p-value = 0.89
	Veal	274	2	0.73%	
Non-O157 STEC	Beef	1,368	10	0.73%	Yes p-value < 0.0001
	Veal	274	27	9.85%	

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BVCBS Results – Comparison of Beef and Veal

- Post-hide (based on Geometric Mean values)

Indicator	Beef	Veal	Comparison (*)
Aerobic Count (AC)	8,946	14,057	Different p-value = 0.0012
<i>Enterobacteriaceae</i>	30	95	Different p-value < 0.0001
Total Coliforms	19.7	61.3	Different p-value < 0.0001
Generic <i>E. coli</i>	40.8	79.6	Different p-value < 0.0001

- Pre-chill (based on Geometric Mean values)

Indicator	Beef	Veal	Comparison (*)
Aerobic Count (AC)	106.8	292.0	Different p-value < 0.0001
<i>Enterobacteriaceae</i>	5.4	15.6	Different p-value < 0.0001
Total Coliforms	4.8	14.0	Different p-value < 0.0001
Generic <i>E. coli</i>	4.4	13.9	Different p-value < 0.0001

(*) Non-parametric Wilcoxon / Kruskal-Wallis test

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BVCBS – Summary

- *Salmonella* was the pathogen most frequently recovered from all beef and veal samples, with post-hide at 27.12% (beef) and 12.04% (veal) and pre-chill at 3.36% (beef) and 1.82% (veal).
- Non-O157 STEC was recovered more frequently than *E. coli* O157 in beef and veal samples at post-hide (6.14% vs 1.83% in beef and 23.72% vs. 9.85% in veal), however, recovery was similar at pre-chill for beef (0.73% vs. 0.66%, respectively) and more frequent for veal (9.85% vs. 0.73%).
- Aerobic Count was most prevalent organism for both beef and veal at both post-hide removal and pre-chill.
- *Salmonella* serotypes differed in distribution between beef and veal samples. In beef, Montevideo was the most common serotype at both post-hide and pre-chill (21.56% and 17.29%, respectively). In veal, Cerro was the most common at post-hide (21.21%) while Newport and Typhimurium were both the most common at pre-chill (40% each).

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BVCBS - Summary and Next Steps

- **Objective 1- Accomplished**
 - Estimate percent positive, prevalence, and bacterial load (quantitative level) of pathogenic organisms, including *Salmonella*, *Escherichia coli* O157:H7 and non-O157 Shiga-toxin producing *E. coli* (non-O157 STEC) on beef and veal carcasses.
 - Detect the presence and estimate the quantitative levels of indicator organisms, including generic *E. coli*, Aerobic Count (AC), *Enterobacteriaceae* and total coliforms.
 - In addition, obtain serotyping data for *Salmonella* isolates.

- **Objective 2 - Next steps**
 - Obtain data for use in microbiological risk assessments to guide the development of Agency programs and guidance for industry related to process control.
 - Sequence isolates of all pathogens and compare with product isolates from regulatory sampling programs (and outbreak strains) to determine any possible relationships to further inform policy and industry guidance.

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Questions?

