

jejuni/coli MPN/cm²; 0.2 *L. monocytogenes* MPN/cm²; and 0.6 *E. coli* O157:H7 MPN/cm².

Of the samples tested for indicator organisms (Tables 3-5, Figures 3-5), 93.1% had aerobic plate counts (APC @35°C) of 10,000 or less colony forming units (cfu) per cm², 96.4% contained 100 or fewer coliforms per cm², and 95.9% contained 10 or fewer *E. coli* (Biotype I) per cm². Biotype I *E. coli* are generally considered to be non-pathogenic.

The highest level detected (Tables 6-11, Figures 6-11) for each of the various pathogens was: less than 100,000 cfu/cm² for *S. aureus*; less than 1.0 MPN/cm² for *Salmonella*; less than 100,000 cfu/cm² for *C. perfringens*; less than 1.0 MPN/cm² for *C. jejuni/coli*; and less than 1.0 MPN/cm² for *E. coli* O157:H7. Four of the 82 positive samples enumerated for *L. monocytogenes* reached the upper detection limit for the method of > 11 *L. monocytogenes* MPN/cm². No further enumeration was done on these samples; the most probable next number, 24, was used in calculations.

Pathogens were not recovered from 1,785 (85.4%) of the 2,089 carcasses tested (Table 12, Figure 12). 278 carcasses contained only one pathogenic bacterial species, whereas 23 carcasses contained two species and three carcasses contained a total of three species. No carcasses tested contained more than 3 pathogenic species.

DISCUSSION

Current procedures in use in federally inspected establishments are generally unable to completely remove viable bacteria from steer or heifer carcasses during slaughter and dressing operations. APC levels recovered in this study (Figure 3), however, agree with historical data reported in 1985 by the National Academy of Sciences for freshly dressed beef carcasses in the United States⁽¹⁾ in which APCs were found to range normally around 100 to 10,000 cfu/cm². The study showed that pathogenic bacteria cited as causing foodborne illness by the CDC can be isolated from the surfaces of carcasses after slaughter and dressing operations. However, the highest levels of pathogenic bacteria enumerated were at levels where recommended cooking temperatures would render product produced from these carcasses safe, as long as the carcasses, and the products produced from them, are maintained at refrigeration temperatures throughout subsequent distribution, storage, processing, marketing and preparation for consumption.

The presence of pathogenic bacteria on the surfaces of carcasses, even though infrequent, emphasizes the need for proper refrigeration, handling and cooking of

beef products throughout the food chain. In addition, special care must also be taken to avoid cross contamination of ready-to-eat foods with raw beef products and in the cleaning and disinfection of food preparation work surfaces after handling raw beef products.

This manuscript presents the primary goal of this program: a microbial profile of steer and heifer carcasses which includes the number and types of bacteria recovered. As stated, certain of the bacterial analyses performed have been considered to be of value as indicators of general hygiene or process control. These tests have been recommended as being faster, easier or cheaper to perform than tests for specific pathogens. Additional analyses examining potential relationships between the presence of these indicator organisms with the presence of pathogenic bacteria are planned.

TABLES

TABLE 1. PREVALENCE OF SELECTED MICROORGANISMS ON RAW BEEF CARCASS SURFACE SAMPLES

Microorganism	Samples Analyzed	Samples Positive		SE ¹
		Number Positive	Percent Positive	
INDICATOR ORGANISMS				
Aerobic Plate Count @ 35°C	2,089	2,064	98.8	0.24
Total Coliforms	2,089	340	16.3	0.81
<i>Escherichia coli</i> (Biotype I)	2,089	172	8.2	0.60
PATHOGENIC ORGANISMS				
<i>Clostridium perfringens</i>	2,079 ²	54	2.6	0.35
<i>Staphylococcus aureus</i>	2,089	87	4.2	0.44
<i>Listeria monocytogenes</i>	2,089	86	4.1	0.43
<i>Campylobacter jejuni/coli</i>	2,064 ²	82	4.0	0.43
<i>Escherichia coli</i> O157:H7	2,081 ²	4	0.2	0.10
<i>Salmonella</i>	2,089	20	1.0	0.21

¹ Standard Error using the binomial distribution.

² Insufficient tissue available to perform all analyses.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 2. MEAN LEVEL OF SELECTED MICROORGANISMS PER SQUARE CENTIMETER ON RAW BEEF CARCASS SURFACE SAMPLES

Microorganism	Number of Samples Quantified	Number of Samples Positive ¹	Level of Positives			
			Log ₁₀ Mean		Geometric Mean	
			Mean ²	SE ³	Mean ²	95% CI ⁴
INDICATOR ORGANISMS						
Aerobic Plate Count @ 35°C	2,089	2,064	2.68	0.02	474.7	(434.7, 518.2)
Total Coliforms	2,089	340	1.55	0.05	35.3	(28.7, 43.5)
<i>Escherichia coli</i> (Biotype I)	2,089	172	1.55	0.07	35.3	(25.9, 48.1)
PATHOGENIC ORGANISMS						
<i>Clostridium perfringens</i>	2,079	54	1.65	0.13	45.1	(25.0, 81.4)
<i>Staphylococcus aureus</i>	2,089	87	1.39	0.07	24.3	(18.0, 32.7)
<i>Listeria monocytogenes</i>	82 ⁵	29	- 0.62	0.18	0.2	(0.1, 0.5)
<i>Campylobacter jejuni/coli</i>	75 ⁵	4	- 1.17	0.19	0.1	(-) ⁶
<i>Escherichia coli</i> O157:H7	4	2	- 0.20	0.17	0.6	(-) ⁶
<i>Salmonella</i>	19 ⁵	4	- 0.93	0.18	0.1	(-) ⁶

1 Positive by quantitative method.
2 Level only of those samples found positive by quantitative method.
3 Standard error of the mean of positive samples.
4 Confidence Interval.
5 Insufficient tissue available to perform all analyses.
6 (-) Insufficient number of positive results to calculate valid CI.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 3. AEROBIC PLATE COUNT @35°C DISTRIBUTION ON RAW BEEF CARCASS SURFACE SAMPLES

Range, cfu/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
< 1 ¹	25	1.2	25	1.2
1 - 10	41	2.0	66	3.2
11 - 100	415	19.9	481	23.0
101 - 1,000	990	47.4	1,471	70.4
1,001 - 10,000	474	22.7	1,945	93.1
10,001 - 100,000	103	4.9	2,048	98.0
100,001 - 1,000,000	32	1.5	2,080	99.6
1,000,001 - 10,000,000	9	0.4	2,089	100.0
TOTAL	2,089	100.0	-	-

¹ Negative by method.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 4. TOTAL COLIFORM DISTRIBUTION ON RAW BEEF CARCASS SURFACE SAMPLES

Range, cfu/cm²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
< 1 ¹	1,749	83.7	1,749	83.7
1 - 10	157	7.5	1,906	91.2
11 - 100	108	5.2	2,014	96.4
101 - 1,000	54	2.6	2,068	99.0
1,001 - 10,000	12	0.6	2,080	99.6
10,001 - 100,000	8	0.4	2,088	100.0
100,001 - 1,000,000	1	0.0	2,089	100.0
TOTAL	2,089	100.0	-	-

¹ Negative by method.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 5. *ESCHERICHIA COLI* (BIOTYPE I) DISTRIBUTION ON RAW BEEF CARCASS SURFACE SAMPLES

Range, cfu/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
< 1 ¹	1,917	91.8	1,917	91.8
1 - 10	86	4.1	2,003	95.9
11 - 100	50	2.4	2,053	98.3
101 - 1,000	21	1.0	2,074	99.3
1,001 - 10,000	10	0.5	2,084	99.8
10,001 - 100,000	4	0.2	2,088	100.0
100,001 - 1,000,000	1	0.0	2,089	100.0
TOTAL	2,089	100.0	-	-

¹ Negative by method.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 6. *CLOSTRIDIUM PERFRINGENS* DISTRIBUTION ON RAW BEEF CARCASS SURFACE SAMPLES

Range, cfu/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
< 1 ¹	2,025	97.4	2,025	97.4
1 - 10	29	1.4	2,054	98.8
11 - 100	10	0.5	2,064	99.3
101 - 1,000	6	0.3	2,070	99.6
1,001 - 10,000	7	0.3	2,077	99.9
10,001 - 100,000	2	0.1	2,079	100.0
TOTAL	2,079	100.0	-	-

¹ Negative by method.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 7. STAPHYLOCOCCUS AUREUS DISTRIBUTION ON RAW BEEF CARCASS SURFACE SAMPLES

Range, cfu/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
< 1 ¹	2,002	95.8	2,002	95.8
1 - 10	45	2.2	2,047	98.0
11 - 100	32	1.5	2,079	99.5
101 - 1,000	7	0.3	2,086	99.9
1,001 - 10,000	2	0.1	2,088	100.0
10,001 - 100,000	1	0.0	2,089	100.0
TOTAL	2,089	100.0	-	-

¹ Negative by method.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

**TABLE 8. *LISTERIA MONOCYTOGENES* DISTRIBUTION ON
ENUMERATED POSITIVE RAW BEEF CARCASS
SURFACE SAMPLES**

Range, MPN/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
<.03 ¹	53	64.6	53	64.6
0.030 - 0.300	20	24.4	73	89.0
0.301 - 3.000	4	4.9	77	93.9
3.001 - 30.000 ²	5	6.1	82	100.0
TOTAL	82	100.0	-	-

¹ Negative by quantitative MPN method.

² Four of the 82 samples enumerated reached the upper detection limit for the method of > 11 MPN/cm². No further enumeration was done.

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

**TABLE 9. *CAMPYLOBACTER JEJUNI/COLI* DISTRIBUTION ON
ENUMERATED POSITIVE RAW BEEF CARCASS
SURFACE SAMPLES**

Range, MPN/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
<.03 ¹	71	94.7	71	94.7
0.030 - 0.300 ²	4	5.3	75	100.0
0.301 - 3.000	0	0.0	75	100.0
TOTAL	75	100.0	-	-

¹ Negative by quantitative MPN method.

² Maximum level detected = 0.23 MPN/cm²

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

**TABLE 10. *ESCHERICHIA COLI* O157:H7 DISTRIBUTION ON
ENUMERATED POSITIVE RAW BEEF CARCASS
SURFACE SAMPLES**

Range, MPN/cm ²	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
<.03 ¹	2	50.0	2	50.0
0.030 - 0.300	0	0.0	2	50.0
0.301 - 3.000 ²	2	50.0	4	100.0
TOTAL	4	100.0	-	-

¹ Negative by quantitative MPN method.

² Maximum level detected = 0.93 MPN/cm²

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).

TABLE 11. SALMONELLA DISTRIBUTION ON ENUMERATED POSITIVE RAW BEEF CARCASS SURFACE SAMPLES

Range (MPN/cm ²)	Number of Samples	Percent of Total	Cumulative Number	Cumulative Percent
<.03 ¹	15	78.9	15	78.9
0.030 - 0.300 ²	4	21.1	19	100.0
0.301 - 3.000	0	0.0	19	100.0
TOTAL	19	100.0	-	-

¹ Negative by quantitative MPN method.

² Maximum level detected = 0.23 MPN/cm²

Source: Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers (October 1992 - September 1993).