Nationwide Federal Plant Raw Ground Beef Microbiological Survey

August 1993 - March 1994

NATIONWIDE FEDERAL PLANT RAW GROUND BEEF

MICROBIOLOGICAL SURVEY

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EXECUTIVE SUMMARY

From August 1993 through March 1994, raw ground beef samples were collected from meat plants operating under Federal inspection. Five hundred sixty-three samples were analyzed to estimate the national prevalence and levels of bacteria of public health concern in raw ground beef as currently produced. The samples were analyzed for the presence of those bacteria most often associated with human illness as determined by foodborne illness reports; other pathogens of interest, because of the severity of human illness they produce; and certain bacteria, or groups of bacteria, thought to be of value as indicators of general hygiene or process control.

The national prevalence of the Aerobic Plate Count was estimated to be 100%; total coliforms, 92.0%; *E. coli* (Biotype I), 78.6%; *Clostridium perfringens*, 53.3%; *Staphylococcus aureus*, 30%; *Listeria monocytogenes*, 11.7%; *Campylobacter jejuni/coli*, 0.002%; *and Salmonella*, 7.5%. *Escherichia coli* O157:H7 was not recovered from any of the 563 samples analyzed. These prevalences provide an estimate of the percentage of 25 gram samples of ground beef that would be positive if the total volume of all the federally inspected ground beef produced was analyzed.

INTRODUCTION

It has been estimated that nearly 50% of the beef consumed in the United States is in the form of ground beef.[1] Those who consume the product without cooking (as in steak tartar) or undercooked have an increased risk of contracting salmonellosis, campylobacteriosis, and *E. coli* O157:H7 gastroenteritis[2][3]. *E. coli* O157:H7 in improperly cooked hamburgers has been responsible for outbreaks of hemorrhagic colitis and hemolytic uremic syndrome[4], and has resulted in several deaths[5], especially in children and the elderly. Improperly cooked ground beef as an ingredient in a variety of foods can also be associated with foodborne illness[6]. Adequate cooking of the meat and proper handling of the cooked meat should minimize or eliminate the risk of contracting foodborne illness from eating hamburgers and other foods containing ground beef.

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OBJECTIVE

The objective of the Nationwide Federal Plant Raw Ground Beef Microbiological Survey was to provide estimates of the national prevalence and levels of selected bacteria of public health concern in raw ground beef produced in plants operating under Federal inspection. The survey was limited to approximately 600 samples, collected over a seven month period.

SURVEY DESIGN

Plants Included in the Sampling Frame:

The target population for this survey was raw ground beef produced in plants operating under Federal inspection. Currently, FSIS does not collect direct information on which federally inspected plants produce raw ground beef nor how much is produced. Therefore, the sampling frame was compiled using information from two different FSIS databases, selecting those plants having both grinding equipment and laboratory results from chemical, microbiological, or residue testing of ground beef. There were 1916 plants identified for the sampling frame, from which the plants were randomly selected.

Sample Design:

The sampling plan was designed to estimate the prevalence and levels of bacteria in raw ground beef produced in all federally inspected plants. Since production and, therefore, production practices possibly affecting bacterial levels may vary greatly from plant to plant, a random sampling plan which guaranteed the selection of large, medium and small plants was used.

Based on available resources, it was decided that 600 ground beef samples would be analyzed. To help insure that 600 samples were available for analysis (some of the plants selected may no longer produce raw ground beef), the frame was over-sampled by approximately 25%. A total of 789 plants was randomly selected for sampling; one randomly selected pound of ground beef was requested from each of the 789 plants. Due to the constraints imposed by the service for overnight delivery of samples to the laboratory, the random collection of beef samples was restricted to first shift, Monday through Thursday.

Sample Collection and Description:

Samples were collected by FSIS Inspectors-in-Charge following the procedures in FSIS

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Directive 10230.2 (8/6/92), instructions provided on computer-generated sample collection request forms, and specific instructions applicable to this program. Samples consisted of one pound of raw ground beef (finished product) aseptically collected from the processing line just prior to final packaging. The samples were bagged, placed in an insulated shipper with gel packs capable of maintaining refrigeration temperatures and shipped to the laboratory via an overnight delivery service. Only those samples received at the laboratory the day after sample collection, with a sample receipt temperature of 0°C to 10°C (inclusive), were analyzed. Those samples received outside of these constraints were not analyzed. In addition, the inspectors were asked to provide information regarding the plant's production volume for that day and the previous week.

Selection of Organisms:

For the purposes of this survey, the organisms selected were those most often associated with human illness as determined by foodborne illness reports[2][7] or certain pathogens of concern because of the severity of the illness they produce in humans:

- *Salmonella*
- *Staphylococcus aureus* (coagulase positive staphylococci)
- *Clostridium perfringens*
- *Escherichia coli* O157:H7
- *Campylobacter jejuni/coli*
- *Listeria monocytogenes*

Data on certain bacteria, or groups of bacteria, thought to be of value as indicators of general hygiene or process control were also collected:

- Total coliforms
- *Escherichia coli* (Biotype I)
- Aerobic Plate Count (APC) at 35°C (total viable aerobic microorganisms)

Laboratory Methods:

The laboratory methods used were identical to those used in the Nationwide Beef Microbiological Baseline Data Collection Programs[8][9], with the exception of using a sample size of 25 grams of ground beef versus 60 square centimeters of carcass tissue.

The Aerobic Plate Count (APC) at 35°C, total coliforms, *E. coli* (Biotype I), *C. perfringens* and *S. aureus* are reported as colony forming units (cfu) per gram. *L. monocytogenes*, *C. jejuni/coli*, *E. coli* O157:H7 and *Salmonella*, because they require enrichment, are reported as the Most Probable Number estimate of bacterial population

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density (MPN) per gram. For these pathogenic bacteria, 25 gram samples were first analyzed by a qualitative enrichment method with a minimum detection level of 0.04 organisms per gram. If positive, the analysis was repeated on a separate 25 gram portion of the original sample using the MPN method for enumeration which has a minimum detection level of 0.03 MPN per gram. In some cases, insufficient sample reserve was available to perform all required enumeration analyses. Differences in the number of samples enumerated are noted in the tables.

Statistical Methods:

National prevalences provide an estimate of the percentage of 25 gram portions of raw ground beef that would be positive for a particular microorganism if the total volume of all the federally inspected raw ground beef produced was analyzed.

Plants with higher production volumes will have a greater impact on the overall bacterial profile of federally inspected ground beef.

- For example, if plant #1 has a prevalence of 10% positive for *Salmonella* and produced 100 pounds and plant #2 has a 20% positive rate for the same organism but produces 200 pounds, the overall product prevalence for the 300 pounds of product would be about 17%.

- On the other hand, if plant #1 had a 20% positive rate for *Salmonella* and produced 100 pounds and plant #2 had 10% positive for *Salmonella* and produced 200 pounds, the overall product prevalence for the 300 pounds of product would be about 13%.

Prevalence data are based on the microbiological analyses performed on a 25 gram sample of raw ground beef. Standard errors of estimates were derived and calculated using standard statistical methods.

Data Limitations:

The survey was designed to provide estimates of national prevalences and levels of selected microorganisms in raw ground beef. The data obtained provides a first-hand indication of which microorganisms might be present in federally inspected raw ground beef. These results are useful for comparison purposes, for example, for comparing these results with future survey results obtained using the same methodology. The information also could be useful for determining relationships between different organisms.

The survey was not designed to provide microbiological information for individual plants. In order to obtain such information, one would need to collect a large number of

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samples from each plant over a period of time.

Sampling of establishments occurred over a relatively short period of time (August 1993 - March 1994) and not over a yearly period. As a result, the estimates may not reflect possible seasonal differences.

The data generated through this survey and the data presented in the Nationwide Beef Baseline Data Collection Program: Steers and Heifers are not directly comparable. These results cannot be extrapolated to the steer and heifer results because ground beef may be comprised of only a portion of meat from steer and heifer carcasses. Further, these data cannot be extrapolated to retail surveys of ground beef since factors in the product distribution channels such as further grinding, storage and handling can effect the microbiological status of the product.

RESULTS

At the time of the survey, 661 out of the 789 selected plants were operating and producing raw ground beef. From the 661 plants, 563 sets of analytical results were obtained and used for the final statistical summaries. From this data, it is estimated that at the time of the survey, approximately 1590 of the 1916 plants in the sampling frame were producing raw ground beef under Federal inspection. These plants are estimated to produce approximately 94 million pounds of raw ground beef per week.

The prevalences shown in Table 1 represent the percent of 25 gram samples estimated to be positive for that analysis if the total volume of all federally inspected ground beef produced was analyzed. Aerobic Plate Counts (APC @ 35°C) were found in 100% of samples analyzed. Coliforms were found to have a national prevalence of 92% and *E. coli* Biotype I, 78.6%. Of the pathogens, *C. perfringens* was found to have a national prevalence of 53.3%; *S. aureus*, 30.0%; *L. monocytogenes*, 11.7%; *C. jejuni/coli*, 0.002%; and *Salmonella, 7.5%. E. coli* O157:H7 was not recovered from any of the 563 samples analyzed.

National levels of bacteria per gram of product are presented in Table 2. The mean levels are expressed as both the log mean and the geometric mean; the geometric mean is the antilog of the log mean. For example, in Table 2, the geometric mean level for estimated prevalence of viable aerobic bacteria recovered in the Aerobic Plate Count @ 35°C was approximately 7,920 cfu per gram (cfu/gram); the corresponding log mean was 3.90. The geometric means of total coliforms and *E. coli* (Biotype I), when detected, were 96 cfu/gram and 54 cfu/gram, respectively. When positive for a specific pathogen, the geometric mean of *S. aureus* was 31 cfu/gram; *C. perfringens*, 67 cfu/gram; *Salmonella*, 0.05 MPN/gram; and *L. monocytogenes*, 2.9 MPN/gram.

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Table 1. Estimated National Prevalences of Selected Bacteria in Raw Ground Beef Produced under Federal Inspection

Microorganism	Samples Analyzed	Prevalence[1]	SE[2]
Direct Enumeration (cfu/g)			
Aerobic Plate Count @ 35°C	563	100.0	NA[3]
Total Coliforms	563	92.0	3.9
Escherichia coli (Biotype I)	563	78.6	5.9
Clostridium perfringens	563	53.3	8.7
Staphylococcus aureus	563	30.0	8.7
MPN Enumeration (MPN/g)			
Listeria monocytogenes	563	11.7	4.1
Campylobacter jejuni/coli	562[4]	0.002	0.003
Escherichia coli O157:H7	563	0.0	NA
Salmonella spp.	563	7.5	3.1

[1] Estimates are weighted by weekly production estimates and take into account the probability with which the plants were selected, with an adjustment for non-response and non-producers.
[2] Standard Error of prevalence.
[3] NA = not applicable.
[4] Insufficient tissue available to perform all analyses on one sample.

Source: Nationwide Federal Plant Raw Ground Beef Microbiological Survey (August 1993 - March 1994)

Table 2.   Estimated National Mean Levels of Selected Bacteria in Raw Ground Beef Produced under Federal Inspection

Microorganism	Number of Samples Quantified	Number of Quantified Samples Positive[1]	Level of Positives[2]			
			Log$_{10}$ Mean[3]	SE[4]	Geometric Mean[3]	95% CI[5]
Direct Enumeration (cfu/g)						
Aerobic Plate Count @ 35°C	563	563	3.90	0.12	7,920	4,700, 13,300
Total Coliforms	563	497	1.98	0.10	96	60, 154
Escherichia coli (Biotype I)	563	348	1.73	0.13	54	31, 95
Clostridium perfringens	563	115	1.83	0.10	67	42, 107
Staphylococcus aureus	563	173	1.49	0.06	31	23, 41
MPN Enumeration (MPN/g)						
Listeria monocytogenes	99[6]	52	0.46	0.43	2.9	0.42, 19.7
Campylobacter jejuni/coli	1[6]	0	NA[7]	NA	NA	NA
Escherichia coli O157:H7	0[6]	0	NA	NA	NA	NA
Salmonella spp.	29[6]	8	-1.29	0.89	0.05	0.001, 2.84

1   Positive by quantitative method.
2   Levels only of those samples found positive by quantitative method.
3   Estimates are weighted by weekly production estimates and take into account the probability with which the plants were selected, with an adjustment for non-responders and non-producers.
4   Standard Error of the log$_{10}$ mean of positives. The Standard Error can be used to construct confidence intervals for the log$_{10}$ mean of positives.
5   Confidence Interval for the geometric mean of positives.
6   Only those samples found positive by qualitative method were quantified.
7   NA = not applicable.

Source: Nationwide Federal Plant Raw Ground Beef Microbiological Survey (August 1993 - March 1994)

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