

# Microbiological Testing Results of Boneless and Ground Beef Purchased for the National School Lunch Program, 2011 to 2014

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## ABSTRACT

The Agricultural Marketing Service (AMS) purchases boneless and ground beef for distribution to recipients through federal nutrition assistance programs, including the National School Lunch Program, which represents 93% of the overall volume. Approximately every 2,000 lb (ca. 907 kg) of boneless beef and 10,000 lb (ca. 4,535 kg) of ground beef are designated a “lot” and tested for *Escherichia coli* O157:H7, *Salmonella*, standard plate count organisms (SPCs), *E. coli*, and coliforms. Any lot of beef positive for *E. coli* O157:H7 or for *Salmonella*, or any beef with concentrations of organisms exceeding critical limits for SPCs (100,000 CFU g<sup>-1</sup>), *E. coli* (500 CFU g<sup>-1</sup>), or coliforms (1,000 CFU g<sup>-1</sup>) is rejected for purchase by AMS and must be diverted from federal nutrition assistance programs. From July 2011 through June 2014, 537,478,212 lb (ca. 243,795,996 kg) of boneless beef and 428,130,984 lb (ca. 194,196,932 kg) of ground beef were produced for federal nutrition assistance programs. Of the 230,359 boneless beef samples collected over this period, 82 (0.04%) were positive for *E. coli* O157:H7, 924 (0.40%) were positive for *Salmonella*, 222 (0.10%) exceeded the critical limit for SPCs, 69 (0.03%) exceeded the critical limit for *E. coli*, and 123 (0.05%) exceeded the critical limit for coliforms. Of the 46,527 ground beef samples collected over this period, 30 (0.06%) were positive for *E. coli* O157:H7, 360 (0.77%) were positive for *Salmonella*, 20 (0.04%) exceeded the critical limit for SPCs, 22 (0.05%) exceeded the critical limit for *E. coli*, and 17 (0.04%) exceeded the critical limit for coliforms. Cumulatively, these data suggest beef produced for the AMS National School Lunch Program is done so under an adequate food safety system, as indicated by the low percentage of lots that were pathogen positive or exceeded critical limits for indicator organisms.

The U.S. Department of Agriculture (USDA) purchases food for various federal nutrition assistance programs, including the National School Lunch Program (NSLP). Purchases for the NSLP are done under authority of the Richard B. Russell National School Lunch Act. The food is provided by USDA to states for use in preparing school lunches. The amount of food provided to states is based on the number of lunches served to children at participating schools at reimbursement rates that vary by family economic need. In the aggregate, each day, food purchased through the NSLP is served to approximately 31 million schoolchildren in over 101,000 participating institutions (26).

Beef—including fresh and frozen boneless and ground—is a staple of the NSLP. For example, during fiscal year 2014, of the approximately 87 million lb (ca. 39 million kg) of fresh and frozen boneless and ground beef purchased by the USDA Agricultural Marketing Service (AMS), approximately 82 million lb (ca. 37 million kg) were designated for the NSLP (4) (to convert pounds to kilograms, multiply by 0.45359237). Beef purchased by AMS is delivered to recipient states one of two ways. It is delivered raw, in which case it is cooked by kitchens in

individual school districts, or it is delivered cooked, having been cooked under federal inspection at a further processing facility.

The AMS purchase specifications for beef include domestic origin and harvest (slaughter), quality control and food safety, and animal handling and welfare requirements (3). For beef scheduled for delivery to states raw, AMS requires individual lots of beef (approximately 2,000 lb for boneless and approximately 10,000 lb for ground) be tested for the pathogens *Escherichia coli* O157:H7 and *Salmonella*, and for standard plate count organisms (SPCs), total coliforms, and *E. coli* as indicator organisms. AMS rejects for purchase any lot found positive for pathogens or exceeding the critical limits for SPCs (100,000 CFU g<sup>-1</sup>), total coliforms (1,000 CFU g<sup>-1</sup>), or *E. coli* (500 CFU g<sup>-1</sup>). In addition, indicator organism results from one out of every five lots, selected at random, are used to calculate process capability values as a measure of an establishment’s overall process control, the results of which determine whether the establishment may continue producing beef for AMS (3). The same specifications apply for beef scheduled for cooking at federally inspected further processing establishments during 2011 to 2013, with the exception of 2014, where boneless beef destined for this avenue of processing were no longer required to undergo pathogen testing. This

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change in requirement was a result of recommendations made by the National Academies National Research Council (NRC) (20) and the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) (19).

Results from AMS purchase specification microbiological testing are summarized and posted quarterly to the AMS Web site (1). AMS posts the results so that stakeholders and other interested parties may monitor the overall microbiological quality of beef produced for the NSLP. Given the number of children fed through the NSLP with public funds, it is important to make the data available to ensure program transparency.

The purpose of this analysis is twofold. First, to describe in detail the microbiological results generated through AMS beef purchase specifications for the most recent 4-year period. Second, to discuss the evolution of current purchase specifications, including improvements made based on independent reviews by the NRC and NACMCF, and potential future revisions that may further strengthen the AMS beef purchase program.

## MATERIALS AND METHODS

**Sample collection.** All samples were collected by trained employees of AMS vendor establishments (2). Fresh (not frozen) samples were collected as described in the Food Safety and Inspection Service (FSIS) Directive 10,010.1 Revision 3 (28). For boneless beef, an individual sample representing the beef carcass exterior (3 in. long by 1 in. wide by 1/8 in. thick) was removed aseptically by knife from each of 70 individual pieces of beef trim, randomly chosen from each approximately 2,000-lb lot by the AMS vendor establishment employee. Sixty individual samples were aseptically transferred into a single Whirl-Pak bag (Nasco, Fort Atkinson, WI) and designated for testing for the presence of *E. coli* O157:H7; five individual samples were aseptically transferred into a separate single Whirl-Pak bag and designated for testing for the presence of *Salmonella*, and five individual samples were aseptically transferred into a separate single Whirl-Pak bag and designated for testing for the concentration of indicator organisms (SPCs, total coliforms, and *E. coli*). The bags were sealed and placed on prefrozen gel ice packs in insulated shipping containers.

For ground beef, three samples were collected randomly by the AMS vendor establishment employee from each approximately 10,000-lb lot: 325 g  $\pm$  10% (293 to 358 g) was collected for *E. coli* O157:H7 testing; 25 g  $\pm$  10% (23 to 28 g) was collected for *Salmonella* testing; and 25 g  $\pm$  10% (23 to 28 g) was collected for indicator organism testing. (In 2014, FSIS increased the sample size of ground beef for *Salmonella* testing from 25 to 325 g. However, AMS did not require vendors to collect 325 g for *Salmonella* testing until 2015. Thus, all of the samples used to test for *Salmonella* in this study were 25 g.) Each sample was aseptically transferred to a separate prelabeled sterile Whirl-Pak bag and processed for shipping, as described previously for boneless beef trim.

All samples collected by AMS vendor establishment employees were sent to an AMS-designated laboratory (ADL), as assigned by AMS. Establishment employees completed sample submission forms (which included tracking numbers, weight of product samples, lot numbers, and similar information) supplied by the ADL to the AMS vendor establishment. The sample submission forms were then placed with the samples inside the insulated shipping containers and sent overnight to the ADL.

**Sample receipt and processing.** Upon receipt by the ADL, sample shipping containers and Whirl-Pak bags were examined to ensure they were intact. In addition, sample submission forms were examined to ensure they were fully and properly completed. If the integrity of the packaging was not confirmed, if there were signs of temperature abuse, or if the submission form was deemed incomplete or incorrect, the sample was discarded and a backup sample was requested from the AMS vendor. If packaging integrity and proper temperature were confirmed and the submission form deemed complete and correct, samples were then processed.

AMS requires samples be processed according to methods described in the *Microbiological Laboratory Guidebook* (MLG) of the FSIS (27). For detecting *E. coli* O157:H7 in boneless beef and in ground beef, a sample (325  $\pm$  32.5 g) was placed into modified tryptic soy broth (mTSB) at a ratio of 1:4 and incubated at 42  $\pm$  1°C for 15 to 24 h. Following incubation, a 20- $\mu$ l sample aliquot was used as template in the BAX System Real-Time PCR Assay (DuPont, Wilmington, DE) for *E. coli* O157:H7. Samples that tested BAX negative were reported as negative. For samples that tested BAX positive, culture confirmation was attempted by using the protocol described in Section 5.09 of the FSIS MLG (27). Culture-confirmed samples were reported as positive, and non-confirmed samples were reported as negative.

For detecting *Salmonella* in boneless beef, a sample (25  $\pm$  2.5 g) was placed into mTSB at a ratio of 1:4 and incubated at 42  $\pm$  1°C for 15 to 24 h. Following incubation, a 5- $\mu$ l sample aliquot was used as template in the BAX System Real-Time PCR Assay for *Salmonella*. Samples that tested BAX negative were reported as negative. For samples that tested BAX positive, culture confirmation was attempted by using the protocol described in Section 4.08 of the FSIS MLG (27). Culture-confirmed samples were reported as positive, and nonconfirmed samples were reported as negative.

For detecting *Salmonella* in ground beef, a sample (25  $\pm$  0.5 g) was placed into a Whirl-Pak or stomacher bag, 225  $\pm$  22.5 ml of buffered peptone water was added, the mixture was blended by vigorous shaking for 2 min, and incubated at 35  $\pm$  2°C for 20 to 24 h. Following incubation, 5  $\mu$ l of sample was used as template in the BAX System Real-Time PCR Assay for *Salmonella*. Samples that tested BAX negative were reported as negative. For samples that tested BAX positive, culture confirmation was attempted by using the protocol described in Section 4.08 of the FSIS MLG (27).

All *Salmonella* isolates recovered through the AMS testing program were sent by AMS ADLs to the FSIS Southeastern Laboratory in Athens, GA, where they were serotyped using the methods described by McQuiston et al. (18) and by Fitzgerald et al. (12). Serotyping and reporting of *Salmonella* isolates recovered began in January 2013 and has continued since.

For detecting and quantifying SPCs, total coliforms, and *E. coli* in boneless beef, protocols described in Section 3.02 of the FSIS MLG (27) were used. Twenty-five grams of sample was placed into a sterile blender jar or bag, 450 ml of sterile Butterfield's phosphate diluent or buffered peptone water was added, and the sample was blended or shaken vigorously for 2 min. The resultant homogenate was serially diluted. SPCs were quantified by using the petrifilm method described in Subsection 3.6.2 of the FSIS MLG (27). Total coliforms and *E. coli* were quantified by using the method described in Subsection 3.7.2 of the FSIS MLG (27).

**Result reporting.** Microbiological results were provided by the ADL to AMS through two routes. First, the ADL placed the results in a comma-separated value file and transmitted the file to AMS by uploading it to a Microsoft SQL database. Second, the ADL placed the results in a Microsoft Excel spreadsheet (Micro-

TABLE 1. Incidence of *E. coli* O157:H7 and *Salmonella* in boneless beef produced for AMS during school years 2011 to 2014<sup>a</sup>

School year	Tonnage		Lot count		<i>E. coli</i> O157:H7 positive <sup>b</sup>		<i>Salmonella</i> positive <sup>c</sup>	
	lb	%	No.	%	No.	%	No.	%
2011	172,185,015	32.04	49,217	21.37	6	0.01	96	0.20
2012	127,071,414	23.64	62,830	27.27	12	0.02	258	0.41
2013	122,071,614	22.71	60,802	26.39	41	0.07	300	0.49
2014	116,150,169	21.61	57,510	24.97	23	0.04	270	0.47
Total	537,478,212	100.00	230,359	100.00	82	0.04	924	0.40

<sup>a</sup> School year: July to June. All *E. coli* O157:H7–positive boneless beef and all *Salmonella*-positive boneless beef was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs. To convert pounds to kilograms, multiply by 0.45359237.

<sup>b</sup> *E. coli* O157:H7 critical limit: positive (+) result 325 g<sup>-1</sup>.

<sup>c</sup> *Salmonella* critical limit: positive (+) result 25 g<sup>-1</sup>.

soft Corporation, Redmond, WA) and transmitted the spreadsheet to AMS via electronic mail. Upon receipt of both data files, AMS sought to reconcile the data in the files. In the event of discrepancies, AMS worked with the ADL to identify the cause and resolve the discrepancy. The reason for this dual approach for transmitting data was to ensure data were delivered to AMS in a timely and accurate way so that AMS could make daily determinations about vendor eligibility (3). Serotype information was provided by electronic mail from FSIS to AMS quarterly.

**Data analysis.** Microbiological test results were organized and summarized by using Microsoft Excel pivot table functions. Further analyses were done with Spotfire 6.5.0 (TIBCO Software Inc., Palo Alto, CA) to examine trends and anomalies in the data, including correlations between pathogen-positive samples and those in which indicator microorganisms exceeded critical limits.

## RESULTS

For the period July 2011 through June 2014, AMS purchased 537,478,212 lb of boneless beef. A total of 230,359 lots of boneless beef (an average of 2,333 lb per lot) were tested for the presence of *E. coli* O157:H7 and *Salmonella*. Eighty-two (0.04%) of the lots were positive for *E. coli* O157:H7 and 924 (0.40%) of the lots were positive for *Salmonella* (Table 1). The lots of boneless beef were also tested for the presence and concentration of SPC organisms,

total coliforms, and *E. coli*. Two hundred twenty-two (0.10%) of the lots contained SPC concentrations greater than the AMS purchase specification critical limit of 100,000 CFU g<sup>-1</sup>, 123 (0.05%) of the lots contained total coliform concentrations greater than the AMS purchase specification critical limit of 1,000 CFU g<sup>-1</sup>, and 69 (<0.03) contained *E. coli* concentrations greater than the AMS purchase specification critical limit of 500 CFU g<sup>-1</sup> (Table 2).

Also for the period July 2011 through June 2014, AMS purchased 428,130,984 lb of ground beef, all of which was derived from the boneless beef purchased by AMS during the same period. A total of 46,527 lots of ground beef (an average of 9,202 lb per lot) were tested for the presence of *E. coli* O157:H7 and *Salmonella*. Thirty (0.06%) of the lots were positive for *E. coli* O157:H7, and 360 (0.77%) of the lots were positive for *Salmonella* (Table 3). Twenty (<0.04%) of the lots contained SPC concentrations greater than the AMS purchase specification critical limit of 100,000 CFU g<sup>-1</sup>, 17 (<0.04%) of the lots contained total coliform concentrations greater than the AMS purchase specification critical limit of 1,000 CFU g<sup>-1</sup>, and 22 (0.05%) contained *E. coli* concentrations greater than the AMS purchase specification critical limit of 500 CFU g<sup>-1</sup> (Table 4).

TABLE 2. Incidence of indicator organism concentrations exceeding critical limits in boneless beef produced for AMS during school years 2011 to 2014<sup>a</sup>

School year	Tonnage		Lot count		SPC critical limit exceeded <sup>b</sup>		Coliform critical limit exceeded <sup>c</sup>		<i>E. coli</i> critical limit exceeded <sup>d</sup>	
	lb	%	No.	%	No.	%	No.	%	No.	%
2011	172,185,015	32.04	49,217	21.37	57	0.12	19	0.04	8	0.02
2012	127,071,414	23.64	62,830	27.27	108	0.17	29	0.05	16	0.03
2013	122,071,614	22.71	60,802	26.39	43	0.07	53	0.09	26	0.04
2014	116,150,169	21.61	57,510	24.97	14	0.02	22	0.04	19	0.03
Total	537,478,212	100.00	230,359	100.00	222	0.10	123	0.05	69	0.03

<sup>a</sup> School year: July to June. All boneless beef with indicator organism critical limit exceeds was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs. To convert pounds to kilograms, multiply by 0.45359237.

<sup>b</sup> Standard plate count critical limit: 100,000 CFU g<sup>-1</sup>.

<sup>c</sup> Total coliforms critical limit: 1,000 CFU g<sup>-1</sup>.

<sup>d</sup> *E. coli* critical limit: 500 CFU g<sup>-1</sup>.

TABLE 3. Incidence of *E. coli* O157:H7 and *Salmonella* in ground beef produced for AMS during school years 2011 to 2014<sup>a</sup>

School year	Tonnage		Lot count		<i>E. coli</i> O157:H7 positive <sup>b</sup>		<i>Salmonella</i> positive <sup>c</sup>	
	lb	%	No.	%	No.	%	No.	%
2011	134,099,784	31.32	10,107	21.72	1	0.01	82	0.81
2012	106,085,081	24.78	15,734	33.82	11	0.07	149	0.95
2013	95,640,940	22.34	10,503	22.57	12	0.11	88	0.84
2014	92,305,179	21.56	10,183	21.89	6	0.06	41	0.40
Total	428,130,984	100.00	46,527	100.00	30	0.06	360	0.77

<sup>a</sup> School year: July to June. All *E. coli* O157:H7–positive ground beef and all *Salmonella*-positive ground beef was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs. To convert pounds to kilograms, multiply by 0.45359237.

<sup>b</sup> *E. coli* O157:H7 critical limit: positive (+) result 325 g<sup>-1</sup>.

<sup>c</sup> *Salmonella* critical limit: positive (+) result 25 g<sup>-1</sup>.

For boneless beef, of the 222 samples with concentrations of SPCs exceeding the AMS purchase specification critical limit, 1 sample (0.50%) was positive for *E. coli* O157:H7, and 2 samples (0.90%) were positive for *Salmonella*. Of the 123 samples with concentrations of total coliforms exceeding the AMS purchase specification critical limit, no sample was positive for *E. coli* O157:H7, and 5 samples (4.10%) were positive for *Salmonella*. Of the 69 samples with concentrations of *E. coli* exceeding the AMS purchase specification critical limit, no sample was positive for *E. coli* O157:H7, and 3 samples (4.30%) were positive for *Salmonella* (Table 5).

For ground beef, of the 20 samples with concentrations of SPCs exceeding the AMS purchase specification critical limit, no sample was positive for *E. coli* O157:H7, and 3 samples (15.00%) were positive for *Salmonella*. Of the 17 samples with concentrations of total coliforms exceeding the AMS purchase specification critical limit, no sample was positive for *E. coli* O157:H7, and 2 samples (11.80%) were positive for *Salmonella*. Of the 22 samples with concentrations of *E. coli* exceeding the AMS purchase specification critical limit, no sample was positive for *E. coli* O157:H7, and 1 sample (4.50%) was positive for *Salmonella* (Table 6). The *r* values computed as part of this study did not indicate

demonstrable positive or negative correlations between indicator microorganisms and pathogens (Tables 5 and 6).

Of the 233 boneless beef isolates of *Salmonella* that were serotyped, Dublin was the most commonly observed serotype (114 isolates; 48.93% of total) of the 23 serotypes identified (Fig. 1). For the 40 *Salmonella* isolates recovered from ground beef, Dublin was also the most commonly observed serotype (15 isolates; 37.50% of total) of the 15 serotypes identified (Fig. 2). One of the isolates from ground beef could not be definitively serotyped and was classified as *Salmonella* Montevideo:Anatum. The following *Salmonella* serotypes were recovered from boneless beef but not from ground beef: 3,10:e,h: , Amager, Brandenburg, Give, i4,[5],12:i: , Infantis, Muenster, Reading, Senftenberg, Sundsvall, Uganda, and Virchow. Conversely, the following *Salmonella* serotypes were recovered from ground beef but not from boneless beef: Bovismorbificans, Enteritidis, and Gaminara.

## DISCUSSION

The AMS microbiological purchase specifications for boneless and ground beef are based on dispositional testing for pathogens and on monitoring process control through indicator microorganisms. The observation that less than 1%

TABLE 4. Incidence of indicator organism concentrations exceeding critical limits in ground beef produced for AMS during school years 2011 to 2014<sup>a</sup>

School year	Tonnage		Lot count		SPC critical limit exceeded <sup>b</sup>		Coliform critical limit exceeded <sup>c</sup>		<i>E. coli</i> critical limit exceeded <sup>d</sup>	
	lb	%	No.	%	No.	%	No.	%	No.	%
2011	134,099,784	31.32	10,107	21.72	0	0.00	0	0.00	5	0.05
2012	106,085,081	24.78	15,734	33.82	10	0.06	11	0.07	10	0.06
2013	95,640,940	22.34	10,503	22.57	7	0.07	4	0.04	5	0.05
2014	92,305,179	21.56	10,183	21.89	3	0.03	2	0.02	2	0.02
Total	428,130,984	100.00	46,527	100.00	20	0.04	17	0.04	22	0.05

<sup>a</sup> School year: July to June. All ground beef with indicator organism critical limit exceeds was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs. To convert pounds to kilograms, multiply by 0.45359237.

<sup>b</sup> Standard plate count critical limit: 100,000 CFU g<sup>-1</sup>.

<sup>c</sup> Total coliforms critical limit: 1,000 CFU g<sup>-1</sup>.

<sup>d</sup> *E. coli* critical limit: 500 CFU g<sup>-1</sup>.



TABLE 5. Relationship between indicator organism concentrations exceeding critical limits and pathogen positives in boneless beef produced for AMS during school years 2011 to 2014<sup>a</sup>

Indicator organism	Result count of critical limit exceeded	<i>Salmonella</i>		<i>E. coli</i> O157:H7	
		Positive	<i>r</i>	Positive	<i>r</i>
SPC <sup>b</sup>	222	2	0.002	1	0.007 <sup>c</sup>
Coliform <sup>d</sup>	123	5	0.013 <sup>e</sup>	0	0
<i>E. coli</i> <sup>f</sup>	69	3	0.011 <sup>e</sup>	0	0

<sup>a</sup> Lot count: 230,359.

<sup>b</sup> Standard plate count critical limit: 100,000 CFU g<sup>-1</sup>.

<sup>c</sup> *P* < 0.01.

<sup>d</sup> Total coliforms critical limit: 1,000 CFU g<sup>-1</sup>.

<sup>e</sup> *P* < 0.0001.

<sup>f</sup> *E. coli* critical limit: 500 CFU g<sup>-1</sup>.

of the boneless and ground beef lots described in this study were positive for *E. coli* O157:H7 or for *Salmonella* suggests the beef intended for distribution to the NSLP is unlikely to contain pathogens. Moreover, all of the pathogen-positive lots of beef described in this study were rejected for purchase by AMS and thus not distributed to the NSLP. Lots rejected for purchase were sent to commercial cooking operations and sold commercially. AMS purchase specifications require AMS vendors to use a minimum of two pathogen intervention steps. Such steps, including carcass washes (6, 17, 22, 29–31) and rapid chilling of beef (5), are effective for reducing pathogens on beef and likely contributed to the low pathogen positive rate observed here.

In addition to a minimum of two pathogen interventions, AMS purchase specifications also require removal of major lymph glands, including the prescapular, popliteal,

TABLE 6. Relationship between indicator organism concentrations exceeding critical limits and pathogen positives in ground beef produced for AMS during school years 2011 to 2014<sup>a</sup>

Indicator organism	Result count of critical limit exceeded	<i>Salmonella</i>		<i>E. coli</i> O157:H7	
		Positive	<i>r</i>	Positive	<i>r</i>
SPC <sup>b</sup>	20	3	0.034 <sup>c</sup>	0	0.001
Coliform <sup>d</sup>	17	2	0.024 <sup>c</sup>	0	0
<i>E. coli</i> <sup>e</sup>	22	1	0.009 <sup>f</sup>	0	0.001

<sup>a</sup> Lot count: 46,527.

<sup>b</sup> Standard plate count critical limit: 100,000 CFU g<sup>-1</sup>.

<sup>c</sup> *P* < 0.0001.

<sup>d</sup> Total coliforms critical limit: 1,000 CFU g<sup>-1</sup>.

<sup>e</sup> *E. coli* critical limit: 500 CFU g<sup>-1</sup>.

<sup>f</sup> *P* < 0.05.

and prefemoral lymph nodes (3). This requirement began approximately 40 years ago. Given that cattle lymph nodes have been shown to harbor *Salmonella* (7, 10, 14–16, 25), it is reasonable to hypothesize that removal of the major lymph glands contributed to the low level of *Salmonella* observed in beef produced for AMS. However, data from this study cannot, by themselves, be used to test the hypothesis. Continued refinement of AMS purchase specifications will thus benefit from additional research to further discern the overall importance of lymph nodes to *Salmonella* contamination in ground beef, including a cost-benefit analysis of lymph node removal, vaccination for reducing *Salmonella* in lymph nodes, or both (11), in ground beef production.

The serotypes observed among the *Salmonella* isolates described in this study are similar to those previously

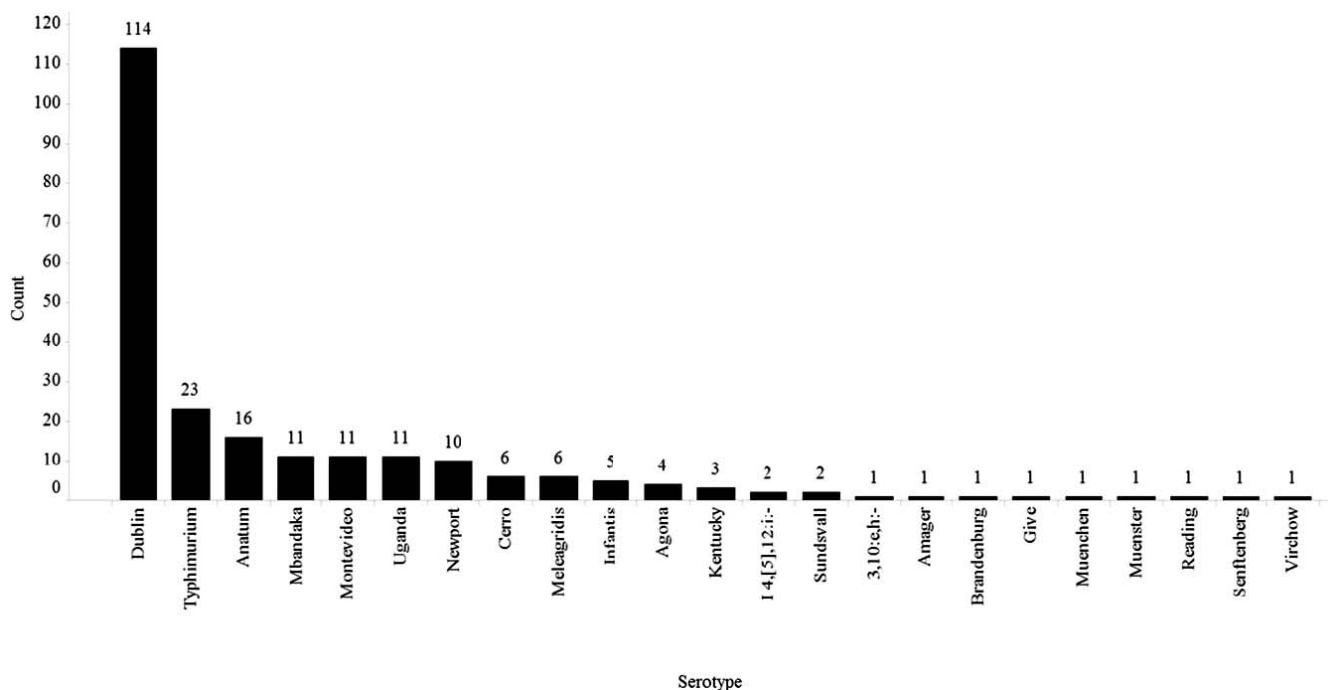


FIGURE 1. *Salmonella* serotypes recovered from boneless beef produced for AMS during school years 2011 to 2014. All *Salmonella*-positive beef was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs.

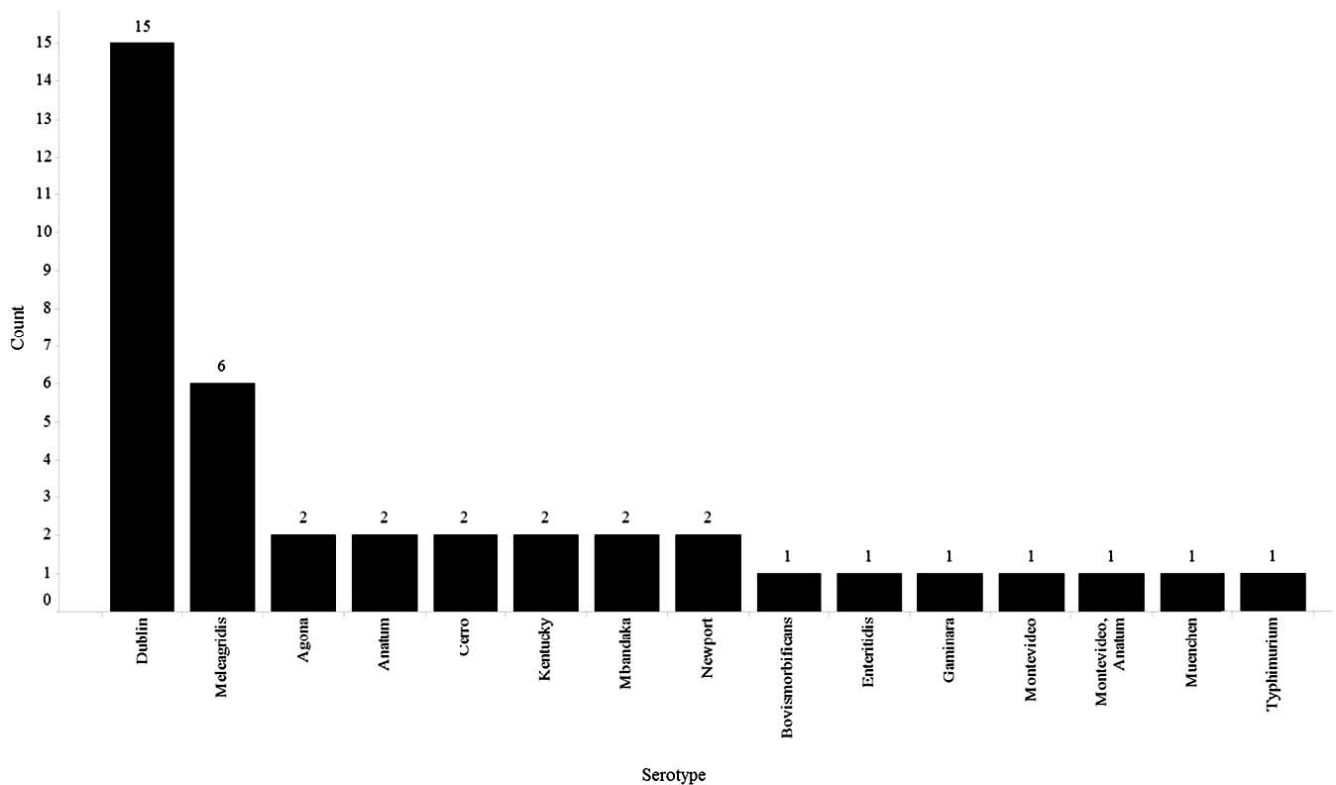


FIGURE 2. *Salmonella* serotypes recovered from ground beef produced for AMS during school years 2011 to 2014. All *Salmonella*-positive beef was rejected for purchase by AMS and thus not distributed to the National School Lunch Program or other federal nutrition assistance programs.

reported for *Salmonella* recovered from beef at processing establishments and at retail (9) in the United States. They are also similar to those recovered from cattle in U.S. feedlots (8) and from cattle upon arrival at processing establishments (13–15). The one notable exception, however, is that no *Salmonella* Kentucky serotypes were observed among the AMS isolates described in this study.

Aside from pathogen testing, measuring concentrations of indicator microorganisms is a useful tool for examining an establishment's overall process control capability (23, 24). Less than 1% of all lots of boneless and ground beef were found to exceed critical limits for *E. coli*, total coliforms, or SPCs. AMS monitors indicator organisms not as a predictor of or surrogate for pathogen-positive samples but rather to assess an establishment's ability to produce beef in a sanitary manner. An establishment that loses process control must conduct a cause-and-effect analysis and implement corrective actions before resuming production for AMS (3). Taken together, the results for pathogen testing and indicator microorganism testing described in this study offer reassurance that monitoring process control is a useful purchase specification.

Findings from a recent study by Ollinger et al. (21), in which AMS purchase specification data were compared with those from FSIS baseline and regulatory sampling programs, suggest that establishments actively supplying beef to the NSLP are less likely to have samples test positive for *Salmonella* compared with establishments that do not supply beef to the NSLP. The reasons for the observed differences in *Salmonella* incidence among the sampling sets, however,

are not clear. Indeed, caution should be exercised in comparing AMS results with those of FSIS. Notwithstanding the requirement that AMS samples be processed according to FSIS MLG protocols (27), there are stark differences between the AMS purchase specification testing protocol and the FSIS baseline and regulatory testing protocol, including sample collection personnel, collection frequency, and purpose of sampling. In addition, all beef procured by AMS must be produced and processed under FSIS inspection (3). As such, AMS purchase specifications are used in addition to, not in lieu of, FSIS testing and related inspection requirements.

The NRC reviewed the AMS ground beef purchase program and published its findings in 2010 (20). Building upon the NRC review, the NACMCF reviewed the program and published its findings in 2013 (19). AMS has implemented most of the recommendations of the NRC and the NACMCF, including discontinuing testing for *E. coli* O157:H7 and *Salmonella* in raw beef destined for cooking by using a validated time and temperature protocol at an FSIS-inspected establishment. In addition, AMS, in 2014, began testing 1 of every 10 lots, drawn at random, of beef destined for delivery to recipient agencies raw for the presence of the six additional serotypes of Shiga toxin-producing *E. coli*—declared adulterants by FSIS in 2012 (i.e., O26, O45, O103, O111, O126, and O145).

AMS purchase specifications are a balance of scientific principles, food (security) needs, and stakeholder input. Funds used for AMS purchase specification microbiological testing come from those appropriated by Congress to the

USDA to administer various nutritious assistance programs. Thus, every dollar spent on microbiological testing is a dollar that could otherwise be used to purchase additional food for recipients in need. As a government agency, AMS is responsible for considering the views of all stakeholders, including program recipients. Most of these views represent value judgments and are thus not quantifiable. The intent of sharing the AMS microbiological testing data described in this article is to help facilitate a transparent and ongoing discussion among AMS and its stakeholders about the continual refinement of NSLP beef purchase specifications to ensure the ongoing procurement of safe, wholesome, and nutritious food.

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