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Pathogen Testing of Ready-to-Eat Meat and Poultry Products Collected at Federally Inspected Establishments in the United States, 1990 to 1999†

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ABSTRACT

The Food Safety and Inspection Service (FSIS) conducted microbiological testing programs for ready-to-eat (RTE) meat and poultry products produced at approximately 1,800 federally inspected establishments. All samples were collected at production facilities and not at retail. We report results here for the years 1990 through 1999. Prevalence data for *Salmonella, Listeria monocytogenes, Escherichia coli* O157:H7, or staphylococcal enterotoxins in nine different categories of RTE meat and poultry products are presented and discussed. The prevalence data have certain limitations that restrict statistical inferences, because these RTE product-testing programs are strictly regulatory in nature and not statistically designed. The cumulative 10-year *Salmonella* prevalences were as follows: jerky, 0.31%; cooked, uncured poultry products, 0.10%; large-diameter cooked sausages, 0.07%; small-diameter cooked sausages, 0.20%; cooked beef, roast beef, and cooked corned beef, 0.22%; salads, spreads, and pâtés, 0.05%; and sliced ham and luncheon meat, 0.22%. The cumulative 3-year *Salmonella* prevalence for dry and semidry fermented sausages was 1.43%. The cumulative 10-year *L. monocytogenes* prevalences were as follows: jerky, 0.52%; cooked, uncured poultry products, 2.12%; large-diameter cooked sausages, 1.31%; small-diameter cooked sausages, 3.56%; cooked beef, roast beef, and cooked corned beef, 3.09%; salads, spreads, and pâtés, 3.03%; and sliced ham and luncheon meat, 5.16%. The cumulative 3-year *L. monocytogenes* prevalence for dry and semidry fermented sausages was 3.25%. None of the RTE products tested for *E. coli* O157:H7 or staphylococcal enterotoxins was positive. Although FSIS and the industry have made progress in reducing pathogens in these products, additional efforts are ongoing to continually improve the safety of all RTE meat and poultry products manufactured in federally inspected establishments in the United States.

The Food Safety and Inspection Service (FSIS) is the agency within the U.S. Department of Agriculture (USDA) responsible for ensuring the safety, wholesomeness, and accurate labeling of meat, poultry, and egg products. The Federal Meat Inspection Act and the Poultry Products Inspection Act prohibit the sale or transportation of adulterated or misbranded meat and poultry products. The presence of a microbial hazard, such as pathogenic bacteria or a microbial toxin, in ready-to-eat (RTE) meat or poultry products is one basis on which these products may be found adulterated. The FSIS is especially concerned with the presence of *Listeria monocytogenes, Salmonella, Escherichia coli* O157:H7, and staphylococcal enterotoxins in RTE meat and poultry products because of the potential for moderate to severe illness or death, especially among high-risk individuals.

During the 1980s and 1990s, the FSIS established nine microbiological testing programs for RTE meat and poultry products produced and collected at federally inspected establishments. These testing programs did not include sample collection at retail outlets. These ongoing sampling programs are strictly regulatory in nature and, as such, are not statistically designed. Establishments to be sampled are randomly selected each month from the database of all establishments known to be producing the particular class of product. Sampling probability is not proportional to plant size or production volume. Inspection personnel notify establishment management at the time of sampling, offering management the option of voluntarily holding the sampled product pending FSIS laboratory test results. If samples test positive for a microbial hazard, regulatory action will be taken on the product represented by the samples. Such products are subject to retention, seizure, or voluntary recall. If the establishment management can treat the product in a manner such that it is no longer adulterated, inspection personnel will allow product release; alternatively, the product will be condemned. In addition to action taken against an adulterated product, where appropriate, the Agency will consider undertaking administrative measures concerning plant operations or criminal prosecution of individuals.

One of the primary purposes of the FSIS microbiological testing programs for RTE meat and poultry products is to encourage the industry to continually monitor its production procedures. Emphasis is placed on RTE products because consumers are not likely to reheat these products sufficiently to kill microorganisms of human public health concern. These testing programs provide data on the prev-

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† The mention of specific products does not constitute an endorsement by the U.S. Department of Agriculture, Food Safety and Inspection Service.

‡ Retired.

TABLE 1. *USDA–FSIS microbiological testing programs for RTE meat and poultry products produced in USDA-inspected establishments*

Program title	Products sampled	Analytes
Cooked beef, roast beef, cooked corned beef	Sliced, half, or whole cooked beef or roast beef or cooked corned beef	*L. monocytogenes* and *Salmonella*
Sliced ham and luncheon meat—pork only	Sliced ham, sliced luncheon loaves	*L. monocytogenes* and *Salmonella*
Small-diameter cooked comminuted products—meat or poultry	Franks, wieners, hot dogs, knockwurst, kielbasa, bratwurst, or other small-diameter (up to 1½ in.) cooked comminuted sausage products	*L. monocytogenes* and *Salmonella*
Large-diameter cooked comminuted products—meat or poultry	Cooked salami, bologna, liver sausage, or other large-diameter (greater than 1½ in.) cooked comminuted sausage products	*L. monocytogenes* and *Salmonella*
Jerky—meat or poultry	Shelf-stable jerky—all species	*L. monocytogenes* and *Salmonella*
Cooked poultry products—uncured	Whole birds, fried parts, nuggets, fritters, sliced rolls, roasted breasts, sliced breasts, diced poultry, heat-and-serve poultry entrees, burritos, or other uncured poultry products	*L. monocytogenes* and *Salmonella*
Meat or poultry salads, spreads, and pâtés	Liver spreads, meat spreads, pâté, chicken salad, ham salad, turkey salad, cooked teawurst, cooked mettwurst, or other cooked meat or poultry salads and spreads	*L. monocytogenes* and *Salmonella*
Fully cooked meat patties	Fully cooked meat patties (meat only)	*E. coli* O157:H7
Dry and semidry fermented sausages	RTE-comminuted stuffed meat products generally processed at temperatures above 70°F; pepperoni, cervelot, Italian salami, Genoa salami, Lebanon bologna, summer sausage, hard salami, sopresatte, etc.	Staphylococcal enterotoxins, *E. coli* O157:H7, *L. monocytogenes* and *Salmonella*[a]

[a] *E. coli* O157:H7 analyses were added to this testing program in March 1995. *L. monocytogenes* and *Salmonella* analyses were added in July 1997.

alence of specific microbial hazards in RTE products and permit the Agency to focus its regulatory activities on problems of most concern to public health. They also provide evidence of poor sanitation or other problems in those establishments found producing products containing a microbial hazard. If an FSIS sample of an establishment's RTE product tests positive for a pathogen or microbial toxin, additional sampling, known as surveillance sampling, is conducted to verify the effectiveness of the establishment's corrective and preventive actions.

This paper reports the results of FSIS microbiological testing programs for RTE meat and poultry products produced, and collected by inspection personnel, at approximately 1,800 federally inspected establishments from 1990 through 1999. Prevalence data for *L. monocytogenes, Salmonella, E. coli* O157:H7, or staphylococcal enterotoxins in nine different categories of RTE meat and poultry products are presented and discussed. The data from the surveillance sampling conducted when an establishment's RTE product tests positive have been purposely omitted from this report so as not to bias the results of the routine random microbiological sampling–testing programs.

MATERIALS AND METHODS

Table 1 lists the program titles, products sampled, and microbiological analyses performed for each of the nine FSIS microbiological testing programs for RTE meat and poultry products produced in USDA-inspected establishments. Half of the samples collected under the first seven testing programs are analyzed only for *L. monocytogenes,* and the other half, only for *Salmonella.* Fully cooked meat patties are analyzed only for the presence of *E. coli* O157:H7. When the dry and semidry fermented sausages testing program was initiated in 1994, samples were analyzed only for the presence of staphylococcal enterotoxins. As a result of foodborne illness outbreaks associated with these products, *E. coli* O157:H7 analysis was added in March 1995, and *L. monocytogenes* and *Salmonella* analyses were added in July 1997.

Sample collection and shipment. FSIS inspection personnel randomly collected samples representing a single production lot of a commercial product and shipped them to one of the following FSIS field service laboratories for microbiological analyses: Eastern Laboratory, Athens, Ga.; Midwestern Laboratory, St. Louis, Mo.; or Western Laboratory, Alameda, Calif. All products except jerky were shipped refrigerated or frozen. Samples were shipped as soon as possible by overnight carrier so that they arrived in the laboratory on a weekday. Sufficient frozen coolant was placed in the shipping containers to keep samples cold during transit. Jerky samples were shipped either at room temperature, refrigerated, or frozen. Sample collection procedures for specific RTE product categories are described below and summarized in Table 2.

Sample collection and shipment: all products except fully cooked meat patties and dry–semidry fermented sausages. For packages weighing 1 lb or less, six intact individual packages were randomly collected after final packaging. For final packages weighing more than 1 lb, but up to and including 3 lb, two intact

TABLE 2. *USDA–FSIS sample collection procedures for RTE meat and poultry products produced in USDA-inspected establishments*

Program title	Sample collection
Cooked beef, roast beef, cooked corned beef	Pkg.[a] ≤ 1 lb: collect six intact pkg. Pkg. > 1 lb but ≤3 lb: collect two intact pkg. Pkg. > 3 lb: aseptically collect a 1-in. center slice Starting in June 1999 for pkg. > 3 lb: collect one intact pkg.
Fully cooked meat patties	Collect only intact pkg. Pkg. ≤ 1 lb: collect six pkg. for a total of at least 1 lb of product Pkg. > 1 lb but ≤3 lb: collect two pkg. Pkg. > 3 lb: collect one short-weighted or slack-filled pkg. containing at least 1 lb of product
Dry and semidry fermented sausages	Sausages ≤ 6 in.: collect two pieces of finished product Sausages > 6 in.: collect two pieces approximately 6 in. from each of two sausages Starting in summer 1997: collect only intact whole sausages Collect at least 2 lb of product
All products except cooked beef, roast beef, cooked corned beef, fully cooked meat patties, and dry/semidry fermented sausages	Pkg. ≤ 1 lb: collect six intact pkg. Pkg. > 1 lb but ≤3 lb: collect two intact pkg. Pkg. > 3 lb: aseptically collect a 0.5- to 1-lb sample unit of product Starting in June 1999 for pkg. > 3 lb: collect one short-weighted or slack-filled pkg. containing at least 1 lb of product

[a] Package, a finished product unit for shipping.

units were collected. For final packages weighing more than 3 lb, FSIS inspection personnel aseptically collected a single 0.5- to 1-lb sample unit of product (or a 1-in. center slice if the product was cooked beef, roast beef, or cooked corned beef). Beginning in June 1999, inspectors were instructed to collect only intact samples of product for final packages weighing more than 3 lb. Instead of the 1-in. center slice, they began collecting one intact package of cooked beef, roast beef, or cooked corned beef weighing more than 3 lb. For other products, they collected one intact package containing at least 1 lb of finished product that had been short-weighted or slack-filled by establishment personnel. An intact short-weighted or slack-filled package contains less product but has been processed and packaged in the same manner as the larger final consumer-ready package.

Sample collection and shipment: fully cooked meat patties. Only intact samples of fully cooked meat patties were collected. For packages of 1 lb or less, six intact individual packages were randomly collected after final packaging, for a total of at least 1 lb of product. For final packages weighing more than 1 lb, but up to and including 3 lb, two intact individual packages were collected. For final packages weighing more than 3 lb, inspection personnel collected one intact package that had been short-weighted or slack-filled with finished product by establishment personnel, so that at least 1 lb of product was submitted to the laboratory.

Sample collection and shipment: dry and semidry fermented sausages. When this testing program began in 1994, inspection personnel collected two pieces of finished product if the sausages were 6 in. long or less. If the finished sausages exceeded 6 in. in length, the inspector used a sanitized knife to cut two pieces approximately 6 in. long from two sausages. In the summer of 1997, additional microbiological analyses (*Salmonella* and *L. monocytogenes*) were added to this testing program, at which time inspectors were instructed to collect only intact whole sausages so that at least 2 lb of product were submitted to the laboratory.

Sample preparation and analyses. The analytical unit for *Salmonella* analysis of RTE meat and poultry products was 325 g. A single 325-g composite sample or multiple composite sample pools containing combinations of one, two, or three 65-g units were aseptically prepared by removing approximately equal amounts of product from each package–unit representing a single production lot. The samples were analyzed by the official FSIS method for isolation and identification of *Salmonella.* Initially, samples were analyzed according to procedures described in sections 4.0 to 4.9 of the second edition of the USDA–FSIS *Microbiology Laboratory Guidebook (MLG; 9)* and Laboratory Communication 68 *(2, 14).* Subsequent modifications to the method included replacement of lactose broth with buffered peptone water as the nonselective enrichment broth in 1993 and replacement of selenite cystine broth with Rappaport–Vassiliadis broth for selective enrichment in 1996 *(12, 13).* Two commercially available AOAC-approved ELISA test kits (987.11, 993.08, 989.14, 998.09) were optional tests used *(1),* in conjunction with the FSIS cultural method, on an as-needed basis to reduce turnaround time or the cost of labor and supplies.

For *L. monocytogenes* analysis, a 25-g composite sample was aseptically prepared by representatively sampling each package–unit submitted so that the composite contained approximately equal amounts of each. The composite sample was analyzed by the official FSIS method for isolation and identification of *L. monocytogenes* at the time: Laboratory Communication 57 *(8)* or subsequent modifications as described in Chapter 8 of the USDA–FSIS *MLG (3, 5, 6).*

Only fully cooked meat patties and dry and semidry fermented sausages were analyzed for the presence of *E. coli* O157:H7. For each production lot of fully cooked meat patties, thirteen 25-g subsamples were aseptically removed at random from the intact package(s) of each lot. The 25-g subsamples were individually analyzed by the official FSIS method for the detection, isolation, and identification of *E. coli* O157:H7. When the testing program began in 1994, the official method was detailed in Revision 3 of Laboratory Communication 38 *(10, 11).* Beginning in February 1995, the subsamples were analyzed according to procedures subsequently described in Chapter 5 of the USDA–FSIS *MLG (15)* and, beginning in September 1999, according to procedures subsequently described in Chapter 5, Revision 1, of the USDA–FSIS *MLG (4).*

E. coli O157:H7 analyses were added to the microbiological testing program for dry and semidry fermented sausages in March 1995. The fermented sausages from each production lot were

aseptically cut into small cubes consisting of both shell and core. Initially, the cubes were divided into two 162.5-g subsamples for individual analysis by the official FSIS method. In October 1997, the number of subsamples for *E. coli* O157:H7 analysis of dry and semidry fermented sausages was changed from two 162.5-g subsamples to five 65-g subsamples. The subsamples were individually analyzed according to procedures described in the USDA–FSIS *MLG (4, 15).*

Only dry and semidry fermented sausage products were analyzed for the presence of staphylococcal enterotoxins. A 20-g composite sample was aseptically prepared by cutting 3- to 5-mm-deep pieces from the outer layer (shell) of the fermented sausages. The composite sample was analyzed according to procedures described in Chapter 15 of the USDA–FSIS *MLG (7).* A staphylococcal enterotoxin reverse passive latex agglutination test (SET-RPLA, Catalog TD0900A; Oxoid, Inc., Ogdensburg, N.Y.) was used as a presumptive screen test. Samples positive by screening were confirmed by a biotin–streptavidin ELISA for staphylococcal enterotoxins *(7).*

Statistical analysis. Contingency table analysis was used to determine if percentages of *L. monocytogenes*- and *Salmonella*-positive lots differed significantly by year for various RTE products. The contingency table analysis is based on the chi-square distribution and tests the hypothesis that percentages of positive lots do not differ significantly from year to year. These positive lot percentages are weighted by the numbers of samples analyzed. A computed chi-square statistic is compared to a critical (table) chi-square value to determine if differences in percentages are statistically significant. The 5% level of significance was used for all tests. A major limitation of this test is, if the percentages are found to differ significantly, it does not identify which particular year's percentages are different from the others. The analysis was first done comparing cumulative positive lot percentages for all 10 years to positive lot percentages for each individual year (3 years in the case of dry and semidry fermented sausages). The analysis was also performed comparing combined positive lot percentages for 1990 and 1991 to combined percentages for 1998 and 1999 (except dry and semidry fermented sausages, where there are no data for 1990 and 1991).

RESULTS AND DISCUSSION

The prevalence data reported here for *Salmonella, L. monocytogenes, E. coli* O157:H7, and staphylococcal enterotoxins in RTE meat and poultry products have certain limitations that restrict statistical inferences. These microbiological testing programs are strictly regulatory in nature, with the primary goal of encouraging the industry to continually monitor and improve its production procedures. As such, these programs are not statistically designed, in that the numbers of samples planned and collected are not statistically derived, and the same establishments may not be sampled every year. The number of samples collected each year within a product category varies, depending on a variety of factors such as current food safety concerns, previous prevalence data for the product categories, the number of non-RTE samples generated by other microbiological testing programs, and FSIS laboratory analytical capacity. Establishments to be sampled are randomly selected on a monthly basis from the database of all known establishments, regardless of size, producing a particular class of RTE products. The sampling is not proportional to the production volume of the establishments. As previously stated, these testing programs do not include sample collection at retail outlets. Therefore, these data are indicative of prevalence trends but may not indicate the exposure of humans to these foodborne pathogens–microbial toxins through the consumption of RTE meat and poultry products. The data have been subjected to nonparametric contingency table analysis.

Testing for *E. coli* O157:H7 in fully cooked meat patties began in March 1994, as a result of a foodborne illness outbreak associated with this product. From March 1994 through December 1999, a total of 452 samples of fully cooked meat patties were analyzed, with no samples testing positive for the presence of *E. coli* O157:H7. These results are not surprising, given the incidence of *E. coli* O157:H7 in raw ground beef and the sensitivity of current sampling and analytical methods. The *E. coli* O157:H7 incidence in U.S. raw ground beef in calendar year 2000 was 0.86% (FSIS microbiological testing program data, 1 January through 31 December 2000; unpublished data). FSIS laboratories use the same sample size (325 g) and test method for *E. coli* O157:H7 analysis of both cooked meat patties and raw ground beef.

The microbiological testing program for dry and semidry fermented sausages began in September 1994, with analysis for staphylococcal enterotoxins. From September 1994 through December 1999, of 1,668 dry and semidry fermented sausage samples analyzed, no samples were found positive for staphylococcal enterotoxins. In March 1995, the *E. coli* O157:H7 analysis was added to the microbiological testing program. From March 1995 through December 1999, of 3,445 samples of dry and semidry fermented sausages analyzed, no samples were positive for *E. coli* O157:H7.

In July 1997, *Salmonella* and *L. monocytogenes* analyses were added to the dry and semidry fermented sausages testing program. The cumulative 3-year *Salmonella* and *L. monocytogenes* prevalences were 1.43 and 3.25%, respectively (Tables 3 and 4). The *Salmonella* prevalences in dry and semidry fermented sausages were 4.05, 2.20, and 0.68% for the years 1997, 1998, and 1999, respectively (Table 3). The *L. monocytogenes* prevalences in dry and semidry fermented sausages were 9.26, 2.87, and 2.09% for the years 1997, 1998, and 1999, respectively (Table 4). When the contingency table analysis was done comparing cumulative prevalences for all 3 years to prevalences for each individual year, the differences in prevalences for both *Salmonella* and *L. monocytogenes* were significant, indicating a downward trend in the prevalences of both of these pathogenic bacteria in dry and semidry fermented sausages.

Table 3 lists the *Salmonella* prevalences for RTE meat and poultry products (1990 through 1999). The low *Salmonella* prevalences in these RTE products indicate that the heat lethality processes used in manufacturing these products were generally effective in eliminating this pathogen and that post-process contamination was not a significant problem. When the contingency table analysis was done comparing cumulative *Salmonella* prevalences for all 10 years to prevalences for each individual year, there were no significant differences. When the contingency table analysis was done comparing combined *Salmonella* prevalences for 1990 and 1991 to com-

TABLE 3. *Prevalence (%) of* Salmonella *in RTE meat and poultry products, 1990 through 1999*

Year	Cooked, roast, corned beef	Sliced ham and luncheon meats	Small cooked sausages	Large cooked sausages	Jerky	Cooked poultry products	Salads/ Spreads/Pâtés	Fermented sausages
1990	0.21 (1/478)[a]	0.00 (0/29)	0.00 (0/455)	0.00 (0/112)	0.00 (0/57)	0.00 (0/647)	0.18 (1/564)	N/A[b]
1991	0.61 (3/490)	0.00 (0/54)	0.00 (0/391)	0.35 (1/286)	0.00 (0/36)	0.30 (2/668)	0.00 (0/494)	N/A
1992	0.39 (2/510)	0.00 (0/117)	0.00 (0/366)	0.00 (0/269)	0.00 (0/24)	0.00 (0/381)	0.00 (0/257)	N/A
1993	0.24 (1/409)	0.00 (0/150)	0.00 (0/478)	0.00 (0/320)	0.00 (0/34)	0.00 (0/295)	0.00 (0/279)	N/A
1994	0.00 (0/470)	0.00 (0/234)	0.00 (0/596)	0.00 (0/436)	0.00 (0/52)	0.00 (0/597)	0.00 (0/620)	N/A
1995	0.18 (1/567)	0.90 (1/111)	0.16 (1/613)	0.00 (0/449)	0.00 (0/51)	0.00 (0/877)	0.00 (0/607)	N/A
1996	0.00 (0/554)	0.00 (0/94)	0.18 (1/564)	0.00 (0/417)	0.00 (0/40)	0.11 (1/877)	0.19 (1/516)	N/A
1997	0.38 (2/530)	0.37 (1/268)	0.49 (3/611)	0.26 (1/386)	0.00 (0/43)	0.11 (1/883)	0.00 (0/248)	4.05 (3/74)
1998	0.00 (0/510)	0.00 (0/287)	0.27 (2/745)	0.20 (1/497)	0.00 (0/140)	0.11 (1/882)	0.00 (0/223)	2.20 (4/182)
1999	0.22 (2/926)	0.32 (3/949)	0.32 (7/2,177)	0.00 (0/1,156)	1.17 (2/171)	0.22 (2/913)	0.00 (0/396)	0.68 (3/442)
Cumulative	0.22 (12/5,444)	0.22 (5/2,293)	0.20 (14/6,996)	0.07 (3/4,328)	0.31 (2/648)	0.10 (7/7,020)	0.05 (2/4,204)	1.43 (10/698)

[a] No. of positive samples/No. of samples analyzed.
[b] N/A, not applicable.

TABLE 4. *Prevalence (%) of* L. monocytogenes *in RTE meat and poultry products, 1990 through 1999*

Year	Cooked, roast, corned beef	Sliced ham and luncheon meats	Small cooked sausages	Large cooked sausages	Jerky	Cooked poultry products	Salads/ Spreads/Pâtés	Fermented sausages
1990	6.38 (22/345)[a]	7.69 (1/13)	4.21 (13/309)	5.32 (5/94)	0.00 (0/25)	2.79 (12/430)	5.48 (19/347)	N/A[b]
1991	4.02 (20/498)	5.48 (4/73)	7.24 (28/387)	4.60 (12/261)	0.00 (0/39)	2.62 (17/649)	3.17 (15/473)	N/A
1992	3.86 (19/492)	7.89 (9/114)	6.03 (21/348)	0.42 (1/239)	0.00 (0/19)	2.01 (7/349)	3.32 (8/241)	N/A
1993	3.04 (13/428)	8.05 (12/149)	5.30 (25/472)	2.13 (7/328)	0.00 (0/39)	1.91 (6/314)	2.19 (6/274)	N/A
1994	2.09 (10/479)	5.46 (13/238)	4.81 (29/603)	1.14 (5/438)	2.22 (1/45)	2.37 (13/549)	2.41 (14/580)	N/A
1995	2.68 (15/560)	5.00 (5/100)	4.09 (25/611)	1.14 (5/438)	0.00 (0/50)	2.25 (20/889)	4.69 (28/597)	N/A
1996	3.35 (17/507)	7.69 (7/91)	3.74 (21/561)	0.95 (4/420)	0.00 (0/43)	3.17 (28/883)	2.17 (12/554)	N/A
1997	2.08 (11/530)	4.20 (12/286)	2.74 (17/621)	1.62 (6/371)	0.00 (0/40)	0.95 (9/946)	2.43 (5/206)	9.26 (10/108)
1998	2.15 (11/511)	4.18 (11/263)	3.49 (26/746)	1.19 (6/506)	1.56 (3/192)	2.22 (19/857)	3.11 (7/225)	2.87 (7/244)
1999	2.71 (25/922)	4.58 (44/960)	1.76 (38/2,162)	0.43 (5/1,167)	0.00 (0/278)	1.44 (14/970)	1.15 (5/435)	2.09 (10/478)
Cumulative	3.09 (163/5,272)	5.16 (118/2,287)	3.56 (243/6,820)	1.31 (56/4,262)	0.52 (4/770)	2.12 (145/6,836)	3.03 (119/3,932)	3.25 (27/830)

[a] No. of positive samples/No. of samples analyzed.
[b] N/A, not applicable.

bined *Salmonella* prevalences for 1998 and 1999, no significant differences were found in any product category for these time periods.

Table 4 lists the *L. monocytogenes* prevalences for RTE meat and poultry products (1990 through 1999). The RTE products with the highest prevalences of *L. monocytogenes* were those that required a significant amount of postheat treatment handling (e.g., peeling, slicing, repackaging, etc.) or addition of other ingredients. When the contingency table analysis was done comparing cumulative *L. monocytogenes* prevalences for all 10 years to prevalences for each individual year, significant differences were found in the following products: large-diameter cooked sausages; small-diameter cooked sausages; cooked beef, roast beef, and cooked corned beef; and salads, spreads, and pâtés. When the contingency table analysis was done comparing combined *L. monocytogenes* prevalences for 1990 and 1991 to combined *L. monocytogenes* prevalences for 1998 and 1999, significant differences were found in the same four products listed above as in the individual-year analysis. The downward trend in the prevalences of *L. monocytogenes* in RTE meat and poultry products during the last decade suggests that industry has made significant improvements in plant sanitation and control of postprocess contamination.

The managements of most establishments voluntarily hold sampled lots of RTE products pending notification of FSIS laboratory test results. Only products that test negative for pathogens–microbial toxins are released; therefore, very few adulterated RTE products that are tested actually enter commerce. From 1994 through 1999, there were only nine voluntary product recalls as a result of 55 *Salmonella*-positive samples from the Agency's routine microbiological testing program. There were only 54 voluntary recalls as a result of 573 *L. monocytogenes*-positive samples. Products representing over 90% of the RTE samples that tested positive for *L. monocytogenes* and over 83% of the RTE samples that tested positive for *Salmonella* never left the producing establishments. As a result, the public was exposed to very few of the adulterated RTE meat and poultry products detected by the Agency's microbiological testing program, and an improved measure of public health protection was achieved. Recalls of a product not held offer an important added safeguard.

Although the Agency and the industry have made tremendous progress in reducing pathogens in RTE meat and poultry products, there is obviously room for improvement. The mandatory implementation of hazard analysis and critical control point systems in all RTE processing establishments and the Agency's revised RTE product microbial testing program based on hazard analysis and critical control point verification (effective December 2000) should further improve the safety of all RTE meat and poultry products manufactured in the United States.

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REFERENCES

1. Andrews, W. H. (ed.). 1999. Microbiological methods, chapter 17. *In* Official methods of analysis of AOAC International, 16th ed., 5th rev., vol. 1. AOAC International, Gaithersburg, Md.
2. Bailey, J. S., J. Y. Chiu, N. A. Cox, and R. W. Johnston. 1988. Improved selective procedure for detection of salmonellae from poultry and sausage products. J. Food Prot. 51:391–396.
3. Cook, L. V. 1999. Isolation and identification of *Listeria monocytogenes* from red meat, poultry, egg and environmental samples, chapter 8, rev. 2; 8 November 1999. USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. http://www.fsis.usda.gov/OPHS/microlab/mlgchpt8.htm.
4. Cray, W. C., Jr., D. O. Abbott, F. J. Beacorn, and S. T. Benson. 1999. Detection, isolation and identification of *Escherichia coli* O157:H7 and O157:NM (nonmotile) from meat products, chapter 5, rev. 1; 6 September 1999. USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. http://www.fsis.usda.gov/OPHS/microlab/mlgchpt5.htm.
5. Johnson, J. L. 1998. Isolation and identification of *Listeria monocytogenes* from meat, poultry and egg products, p. 8-1. *In* B. P. Dey and C. P. Lattuada (ed.), USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C.
6. Johnson, J. L. 1999. Isolation and identification of *Listeria monocytogenes* from meat, poultry and egg products, chapter 8, rev. 1; 12 January 1999. USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. USDA, FSIS, Microbiology Division, Washington, D.C.
7. Mageau, R. P. 1998. Immunoassays for the detection and quantitation of staphylococcal enterotoxins from meat and poultry products and/or broth culture fluids, p. 15-1. *In* B. P. Dey and C. P. Lattuada (ed.), USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C.
8. McClain, D., and W. H. Lee. 1989. FSIS method for the isolation and identification of *Listeria monocytogenes* from processed meat and poultry products. Lab. Comm. 57 (revised 24 May 1989). USDA, FSIS, Microbiology Division, Washington, D.C.
9. Moran, A. B. 1974. Isolation and identification of *Salmonella* from foods, sections 4.0–4.9. *In* Microbiology laboratory guidebook, 2nd ed. USDA, FSIS, Washington, D.C.
10. Okrend, A., and B. E. Rose. 1989. Isolation and identification of *Escherichia coli* O157:H7 from meat. Rev. 3, Lab. Comm. 38. USDA, FSIS, Microbiology Division, Washington, D.C.
11. Okrend, A. J. G., B. E. Rose, and R. Matner. 1990. An improved screening method for the detection and isolation of *Escherichia coli* O157:H7 from meat, incorporating the 3M Petrifilm™ test kit-HEC-for hemorrhagic *Escherichia coli* O157:H7. J. Food Prot. 53:936–940.
12. Rose, B. E. 1996. Isolation and identification of *Salmonella* from meat, poultry, and egg products. Rev. 2, Lab. Comm. 75. USDA, FSIS, Microbiology Division, Washington, D.C.
13. Rose, B. E. 1998. Isolation and identification of *Salmonella* from meat, poultry, and egg products, p. 4-1. *In* B. P. Dey and C. P. Lattuada (ed.), USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C.
14. Rose, B. E., and R. W. Johnston. 1991. Double modified lysine iron agar (DMLIA) for isolation of *Salmonella*. Lab. Comm. 68. USDA, FSIS, Microbiology Division, Washington, D.C.
15. Sharar, A. K., and B. E. Rose. 1998. Detection, isolation and identification of *Escherichia coli* O157:H7 and O157:NM (nonmotile) from meat and poultry products, p. 5-1. *In* B. P. Dey and C. P. Lattuada (ed.), USDA–FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C.