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Research Note

Prevalence and Genetic Characterization of *Listeria monocytogenes* in Retail Broiler Meat in Estonia

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ABSTRACT

The prevalence and genetic diversity of *Listeria monocytogenes* in raw broiler legs at the retail level in Estonia were studied. A total of 240 raw broiler legs (120 from Estonia and 120 of foreign origin, which had been imported to Estonia from Denmark, Finland, Hungary, Sweden, and the United States) from 12 retail stores in the two largest cities in Estonia (Tallinn and Tartu) were investigated from January to December 2002. Of these, 70% were positive for *L. monocytogenes*. The prevalence of *L. monocytogenes* in broiler legs of Estonian origin (88%) was significantly higher than in broiler legs of foreign origin (53%) ($P < 0.001$). Altogether, 169 (106 Estonian and 63 imported) *L. monocytogenes* isolates were characterized by pulsed-field gel electrophoresis (PFGE) typing after treatment with the restriction enzyme *Asc*I. The isolates showed a wide genetic diversity, with 35 different PFGE types obtained. Of these, 11 PFGE types came only from isolates of broiler legs of Estonian origin, 4 of Danish origin, 2 of Finnish origin, and 4 of Hungarian origin. Fourteen PFGE types came from isolates of broiler legs that originated from various countries. The strains that shared the same PFGE types from isolates of Estonian origin were recovered from broiler legs that came from different stores over the course of several months. Seventy-one *L. monocytogenes* isolates, including all PFGE types, were serotyped, and three serotypes (1/2a, 1/2b, and 4b) were obtained. Serotype 1/2a accounted for 96% of the isolates.

The consumption of foods contaminated with *Listeria monocytogenes* can result in listeriosis, an uncommon but potentially fatal disease. Listeriosis can be life threatening to elderly persons, persons with weakened immune systems, and women who are pregnant. Poultry products have been associated with listeriosis *(7–10, 14, 15, 22)*.

Healthy birds may shed *L. monocytogenes* in fecal material asymptomatically *(23)*. However, poultry meat becomes contaminated during slaughter and processing *(17, 18, 20)*. Contamination rates for *L. monocytogenes* in raw poultry products have ranged from 10 to 62% *(3, 6, 12, 17, 19, 21, 24–26)*. The prevention of poultry product contamination with *L. monocytogenes* is therefore of major importance.

Within the past few years, consumption of poultry meat has increased in Estonia and presently stands at about 22 kg per capita *(2)*. To our knowledge, no data exist about the prevalence of *L. monocytogenes* in poultry products. The goal of this study was thus to determine the prevalence of *L. monocytogenes* in raw broiler legs of Estonian and foreign origin sold on the Estonian retail market. To obtain information on the diversity of *L. monocytogenes* isolates, genotyping with pulsed-field gel electrophoresis (PFGE) was performed.

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MATERIALS AND METHODS

Samples. A total of 240 raw broiler legs (120 from Estonia and 120 of foreign origin) from 12 retail stores (supermarkets) in the two largest cities (Tallinn and Tartu) of Estonia were studied from January to December 2002. All samples of Estonian origin were from one of the country's main producers of poultry products, where broiler chickens were reared for meat and slaughtered after 6 or 7 weeks. Of these, 104 were obtained from stores that sold only products of the main producer, and 16 were obtained from stores that also sold poultry products from other countries. Of the samples of foreign origin, 60, 18, 21, 12, and 9 were imported from Denmark, Finland, Hungary, Sweden, and the United States, respectively. Products of Estonian origin were fresh, and those of foreign origin were frozen. All broiler legs had been stored unpackaged on the store counter (1 to 5°C). Each sampled broiler leg was placed in a separate sterile plastic bag. During transportation to the laboratory, the samples were kept cool in portable insulated boxes by ice packs and were stored at 4°C until analysis.

Isolation of *L. monocytogenes*. Microbiological analyses for *L. monocytogenes* were started within 24 h of sample collection. One hundred milliliters of peptone (0.1%)–saline (0.85%) solution was added to the whole broiler leg in the plastic bag, and the broiler leg was massaged by hand for 1 min. Twenty-five milliliters of this peptone–saline solution was used for the enrichment procedure. The isolation of *L. monocytogenes* was carried out by a two-step enrichment method according to the recommendations of the International Organization for Standardization, with the use of half-Fraser and Fraser broth (Oxoid, Basingstoke, Hampshire, UK) *(1)*. Both enrichment broths were plated on PALCAM agar

TABLE 1. *Prevalence of* Listeria monocytogenes *in raw broiler legs in retail stores (A–L) in Estonia*

City or store	No. of positive samples/total no. of samples (%) originating from different countries[a]						
	DK	EE	FI	HU	SE	US	Total
Tallinn							
A	NS[b]	30/38 (79)	NS	NS	NS	NS	30/38 (79)
B	NS	10/12 (83)	NS	NS	NS	NS	10/12 (83)
C	NS	2/2 (100)	NS	NS	NS	NS	2/2 (100)
D	NS	17/19 (90)	NS	NS	NS	NS	17/19 (90)
E	22/49 (45)	10/10 (100)	NS	NS	10/12 (83)	2/9 (22)	44/80 (55)
F	NS	1/3 (33)	10/18 (56)	NS	NS	NS	11/21 (52)
G	NS	NS	NS	16/21 (76)	NS	NS	16/21 (76)
Subtotal	22/49 (45)	70/84 (83)	10/18 (56)	16/21 (76)	10/12 (83)	2/9 (22)	130/193 (67)
Tartu							
H	NS	4/4 (100)	NS	NS	NS	NS	4/4 (100)
I	3/11 (27)	3/3 (100)	NS	NS	NS	NS	6/14 (43)
J	NS	6/6 (100)	NS	NS	NS	NS	6/6 (100)
K	NS	19/19 (100)	NS	NS	NS	NS	19/19 (100)
L	NS	4/4 (100)	NS	NS	NS	NS	4/4 (100)
Subtotal	3/11 (27)	36/36 (100)	NS	NS	NS	NS	39/47 (83)
Total	25/60 (42)	106/120 (88)	10/18 (56)	16/21 (76)	10/12 (83)	2/9 (22)	169/240 (70)

[a] Country: DK, Denmark; EE, Estonia; FI, Finland; HU, Hungary; SE, Sweden; US, United States.
[b] NS, no samples available.

(Oxoid) and *L. monocytogenes* blood agar (Lab M, Bury, Lancashire, UK), as suggested by Johansson *(13)*. Five typical colonies from each selective plate were streaked on blood agar, and five beta-hemolytic colonies were confirmed by catalase reaction, Gram staining, and biochemical identification with the API *Listeria* test (bioMérieux, Marcy-l'Etoile, France).

In situ DNA isolation and PFGE. Altogether, 169 *L. monocytogenes* isolates were obtained for PFGE typing and represented one isolate from each positive sample. Cultures for DNA isolation were grown overnight in Trypticase soy broth (Difco, Becton Dickinson, Sparks, Md.) at 37°C. In situ DNA was isolated and digested with the restriction enzyme *Asc*I (New England Biolabs, Beverly, Mass.) in agarose plugs and was then characterized by PFGE as described by Autio et al. *(4)* with the use of pronase (Roche Diagnostics GmbH, Mannheim, Germany) instead of proteinase K.

PFGE pattern analysis. Numerical analysis of *Asc*I macrorestriction patterns was performed by the computer software program BioNumerics 3.5 (Applied Maths, Sint-Martens-Latem, Belgium). Similarity analysis was carried out by use of the Dice coefficient (position tolerance, 1.0%). The clustering and construction of the dendrogram were performed by the unweighted pair-group method with arithmetic averages.

Serotyping. Serotyping was performed with commercial *Listeria* antisera according to the instructions given by the manufacturer (Denka Seiken, Tokyo, Japan), with some modifications. For detection of the O-antigen, the cells were cultured on Trypticase soy agar (TSA; Difco, Becton Dickinson) plates. Detection of the flagellar H-antigens (A, B, C, and D) was performed at 25°C in TSA tubes.

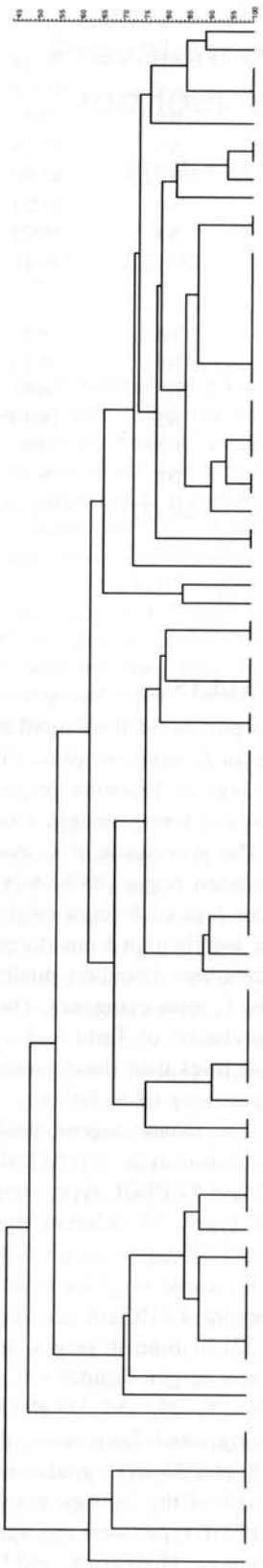
Statistical analysis. The prevalence data were analyzed statistically by the chi-square test.

RESULTS

Of the raw broiler legs purchased from retail stores in Estonia, 70% were positive for *L. monocytogenes* (Table 1). The prevalence in broiler legs of Estonian origin varied from 33 to 100% and, in legs of foreign origin, from 22 to 83% from various stores. The prevalence of *L. monocytogenes* in broiler legs of Estonian origin (88%) was significantly higher than in broiler legs of foreign origin (53%) ($P < 0.001$). Of the broiler legs bought from stores selling only products of the predominant Estonian poultry meat plant, 89% were positive for *L. monocytogenes*. The broiler legs of Estonian origin purchased in Tartu had a significantly higher contamination level than those purchased in Tallinn, 100 and 83%, respectively ($P < 0.05$).

The characterization of *L. monocytogenes* isolates recovered from broiler legs of Estonian ($n = 106$) and foreign ($n = 63$) origin yielded 22 and 24 PFGE types, respectively. Combining these PFGE types, 35 different types were obtained (Fig. 1). Of these PFGE types, 11 (2, 5, 6, 7, 14, 22, 25, 27, 28, 30, and 34) came only from isolates of broiler legs of Estonian origin, 4 (16, 20, 23, and 31) of Danish origin, 2 (15 and 32) of Finnish origin, and 4 (9, 10, 13, and 35) of Hungarian origin. Fourteen (1, 3, 4, 8, 11, 12, 17, 18, 19, 21, 24, 26, 29, and 33) PFGE types came from isolates that originated from more than one country. PFGE types 4, 21, and 33 were predominant, accounting for 13, 15, and 10% of the isolates, respectively. The isolates of these three PFGE types were recovered from broiler legs of Danish, Estonian, Hungarian, and U.S. origin.

In some cases, the same PFGE types were recovered from broiler legs that had originated from different countries but that had been obtained from the same stores (Table



PFGE type	Country	No. of strains	Store	Month	City
5	EE	2	K	Jul, Aug	Trt
6	EE	1	J	Aug	Trt
12	EE	1	D	Nov	Tln
12	SE	6	E	Nov, Dec	Tln
12	EE	4	E	Sep	Tln
13	HU	2	G	Apr, Jul	Tln
8	DK	1	E	May	Tln
8	EE	1	A	Mar	Tln
9	HU	1	G	May	Tln
10	HU	6	G	May, Jun	Tln
11	DK	1	E	Nov	Tln
11	SE	2	E	Nov, Dec	Tln
4	EE	1	D	Dec	Tln
4	US	2	E	Sep, Oct	Tln
4	HU	2	G	Sep	Tln
4	EE	1	K	Aug	Trt
4	EE	3	H	May	Trt
4	EE	8	A	Jan-Mar, Jun, Jul, Nov	Tln
4	EE	3	B	Apr, Nov	Tln
4	EE	2	C	Apr	Tln
3	DK	1	E	Apr	Tln
3	EE	3	A	Feb-Apr	Tln
3	EE	1	L	Jul	Trt
3	EE	1	K	May	Trt
1	FI	2	F	Dec	Tln
1	EE	2	A	Feb	Tln
2	EE	1	A	Jun	Tln
7	EE	1	A	Jul	Tln
7	EE	1	K	Jul	Trt
14	EE	2	A	Apr	Tln
15	FI	1	F	Nov	Tln
16	DK	1	E	Apr	Tln
17	HU	1	G	Jul	Tln
17	DK	1	E	May	Tln
19	FI	1	F	Sep	Tln
19	EE	1	D	Jul	Tln
19	DK	2	E	Mar, Apr	Tln
18	DK	1	E	Nov	Tln
18	FI	2	F	Nov, Dec	Tln
21	HU	2	G	Jul	Tln
21	DK	1	E	Mar	Tln
21	EE	1	L	Jul	Trt
21	EE	5	J	Aug	Trt
21	EE	3	I	Aug	Trt
21	DK	1	I	Aug	Trt
21	EE	1	B	Jun	Tln
21	EE	1	H	May	Trt
21	EE	7	K	May, Jul, Aug	Trt
21	EE	2	D	May, Jul	Tln
21	EE	1	A	Jan	Tln
20	DK	2	I	Aug	Trt
22	EE	1	K	May	Trt
24	FI	1	F	Nov	Tln
24	EE	1	E	Oct	Tln
24	EE	1	F	Oct	Tln
24	EE	1	B	Nov	Tln
24	EE	3	D	Jul, Dec	Tln
24	EE	1	K	Aug	Trt
23	DK	2	E	May	Tln
25	EE	1	L	Jul	Trt
25	EE	1	B	Jun	Tln
26	SE	1	E	Oct	Tln
26	EE	3	K	Jul, Aug	Trt
26	EE	4	A	Jan, Apr, Jul	Tln
26	DK	1	E	Jan	Tln
27	EE	1	L	Jul	Trt
28	EE	1	A	Nov	Tln
28	EE	1	D	Nov	Tln
29	EE	2	E	Oct	Tln
29	SE	1	E	Dec	Tln
29	EE	1	A	Jun	Tln
29	EE	2	K	May, Jul	Trt
29	EE	1	D	May	Tln
31	DK	1	E	Jan	Tln
30	EE	1	B	Jun	Tln
32	FI	3	F	Oct, Nov	Tln
33	DK	9	E	Apr, Jun, Nov	Tln
33	EE	2	D	Apr, Nov	Tln
33	EE	1	B	Nov	Tln
33	EE	5	A	Jan, Feb	Tln
34	EE	3	E	Oct, Dec	Tln
34	EE	2	B	Nov	Tln
34	EE	5	D	Nov, Dec	Tln
35	HU	2	G	May	Tln

FIGURE 1. *Dendrogram of defined PFGE patterns of* Listeria monocytogenes *strains isolated from raw broiler legs in retail stores in Estonia. Similarity analysis was performed by use of the Dice coefficient, and clustering was performed by the unweighted pair-group method with arithmetic averages (position tolerance, 1.0%). Country: DK, Denmark; EE, Estonia; FI, Finland; HU, Hungary; SE, Sweden; US, United States. City: Tln, Tallinn; Trt, Tartu.*

TABLE 2. *Distributions of* Listeria monocytogenes *PFGE types and serotypes in raw broiler legs in retail stores (A–L)*

Store	No. of PFGE types	PFGE types originating from different countries[a]						No. of serotyped isolates		
		DK	EE	FI	HU	SE	US	1/2a	1/2b	4b
A	12		1, 2, 3, 4, 7, 8, 14, 21, 26, 28, 29, 33					14		
B	7		4, 21, 24, 25, 30, 33, 34					5		
C	1		4					1		
D	9		4, 12, 19, 21, 24, 28, 29, 33, 34					6		
E	17	3, 8, 11, 16, 17, 18, 19, 21, 23, 26, 31, 33	12, 24, 29, 34			11, 12, 26, 29	4	20	2	
F	6		24	1, 15, 18, 19, 24, 32				5	2	
G	7				4, 9, 10, 13, 17, 21, 35			5	1	1
H	2		4, 21							
I	2	20, 21	21					1		
J	2		6, 21					1		
K	9		3, 4, 5, 7, 21, 22, 24, 26, 29					6		
L	4		3, 21, 25, 27					1		
Total	35							65	5	1

[a] Country: DK, Denmark; EE, Estonia; FI, Finland, HU, Hungary; SE, Sweden; US, United States.

2). In store E, strains of PFGE types 12 and 29 were found in broiler legs of Estonian and Swedish origin, and strains of PFGE types 11 and 26 were found in legs of Danish and Swedish origin. Isolates of PFGE type 24 were detected in broiler legs of both Estonian and Finnish origin that were obtained from store F. Strains of PFGE type 21 were detected in store I in broiler legs of both Estonian and Danish origin.

In several cases, the same PFGE types were detected in samples of Estonian origin that came from different stores over the course of several months (Fig. 1). The strains of PFGE type 4 were obtained from broiler legs that came from various stores during 10 different months and from store A during six different months. Isolates of PFGE types 3, 21, and 24 were detected in broiler legs from various stores during five different months.

One to eight representative isolates from each PFGE type were selected for serotyping, which resulted in a total of 71 isolates. Three different serotypes were obtained: 1/2a, 1/2b, and 4b (Table 2). All broiler legs of Estonian origin and most broiler legs of foreign origin had serotype 1/2a. Isolates of serotype 1/2b were of Danish, Finnish, and Hungarian origin, and isolates of serotype 4b were of Hungarian origin.

DISCUSSION

Raw broiler legs showed a high level of contamination with *L. monocytogenes* (70%). The prevalence of *L. monocytogenes* in broiler legs of Estonian origin in general and in broiler legs obtained from stores selling only products of the predominant Estonian poultry meat plant (stores A, B, C, D, H, J, K, and L) was higher (88 and 89%, respectively) than that reported by Genigeorgis et al. *(11)* (16%) or Miettinen et al. *(17)* (68%) in broiler legs. Furthermore, the broiler legs of Estonian origin bought in Tartu were all (100%) contaminated by *L. monocytogenes*. To our knowledge, this is the first time that such a high prevalence of *L. monocytogenes* in raw broiler legs has been reported. The high prevalence in broiler legs at the Estonian retail level could be because of contamination that may have occurred during processing at the plant. However, cross-contamination of retail poultry products cannot be excluded, because products were sold unpackaged.

Thirty-five PFGE types were presented by 169 *L. monocytogenes* strains. These data suggest that the *L. monocytogenes* strains recovered from the broiler legs showed wide genetic diversity. The PFGE types recovered from the broiler legs of Estonian (2, 5, 6, 7, 14, 22, 25, 27, 28, 30, and 34) and Hungarian origin (9, 10, 13, and 35) were obtained from stores that sold only products from these countries and were possibly associated with the producing country. Strains that shared the same PFGE types (14 PFGE types) were identified among isolates of broiler legs that originated from different countries. For example, the strains of PFGE types 1, 3, 4, 8, 12, 19, 21, 24, 26, 29, and 33 were common in broiler legs of both Estonian and foreign

origin. Three predominant PFGE types (4, 21, and 33), possessed by 38% of all strains, were recovered from broiler legs of Danish, Estonian, Hungarian, and U.S. origin. The strains of PFGE types 11, 17, and 18 were of Danish, Finnish, Hungarian, and Swedish origin.

Because the broiler legs had been sold unpackaged and from the same counter, one of the reasons for the same PFGE types could be cross-contamination in the stores that sold products that had originated from various countries. In stores E, F, and I, the same PFGE types (12, 21, 24, and 29) were detected in broiler legs of both Estonian and foreign origin (Table 2). In store E, the strains from broiler legs of Danish and Swedish origin shared the same PFGE types (11 and 26).

Recovery of strains that shared the same PFGE types (3, 4, 21, and 24) from different stores obtained during the course of several months suggests a wide temporal distribution of many of the *L. monocytogenes* strains isolated in broiler legs. Because the broiler legs of Estonian origin came from one processing plant, the PFGE types are likely associated with contamination during processing *(17, 18, 20)*. The occurrence of the same PFGE types (3, 4, 21, and 24) in broiler legs of Estonian origin during the course of several months indicates that these strains are persistent *(16)*. Furthermore, *L. monocytogenes* from broiler legs can contaminate retail counters and cause cross-contamination of other raw foods if hygienic procedures are inadequate. This emphasizes the need for strict hygienic conditions during processing and at the retail level to prevent cross-contamination.

Serotype 1/2a was predominant in Estonian poultry products. The same serotype was also predominant in raw chicken from Portugal *(12)*. In the United States and Spain, serotype 1/2b *(5, 26)* and, in Finland, serotype 1/2c *(17)* have been the most common serotypes found in poultry meat.

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REFERENCES

1. Anonymous. 1996. Microbiology of food and animals feeding stuffs—horizontal method for the detection and enumeration of *Listeria monocytogenes*—part 1: detection method. International Standard ISO 11290-1. International Organization for Standardization, Geneva.
2. Anonymous. 2004. Overviews and reports. Agriculture and rural development. Overview 2003/2004. Ministry of Agriculture, Republic of Estonia.
3. Antunes, P., C. Réu, J. C. Sousa, N. Pestana, and L. Peixe. 2002. Incidence and susceptibility to antimicrobial agents of *Listeria* spp. and *Listeria monocytogenes* isolated from poultry carcasses in Porto, Portugal. *J. Food Prot.* 65:1888–1893.
4. Autio, T., J. Lundén, M. Fredriksson-Ahomaa, J. Björkroth, A.-M. Sjöberg, and H. Korkeala. 2002. Similar *Listeria monocytogenes* pulsotypes detected in several foods originating from different sources. *Int. J. Food Microbiol.* 77:83–90.
5. Bailey, J. S., D. L. Fletcher, and N. A. Cox. 1989. Recovery and serotype distribution of *Listeria monocytogenes* from broiler chickens in the southeastern United States. *J. Food Prot.* 52:148–150.
6. Capita, R., C. Alonso-Calleja, B. Moreno, and M. C. Garcia Fernández. 2001. Occurrence of *Listeria* species in retail poultry meat and comparison of a cultural/immunoassay for their detection. *Int. J. Food Microbiol.* 65:75–82.
7. Centers for Disease Control. 1989. Listeriosis associated with consumption of turkey franks. *Morb. Mortal. Wkly. Rep.* 38:267–268.
8. Centers for Disease Control and Prevention. 2000. Multistate outbreak of listeriosis—United States, 2000. *Morb. Mortal. Wkly. Rep.* 49:1129–1130.
9. Centers for Disease Control and Prevention. 2002. Outbreak of listeriosis—northeastern United States, 2002. *Morb. Mortal. Wkly. Rep.* 51:950–951.
10. Frye, D. M., R. Zweig, J. Sturgeon, M. Tormey, M. LeCavalier, I. Lee, L. Lawani, and L. Mascola. 2002. An outbreak of febrile gastroenteritis associated with delicatessen meat contaminated with *Listeria monocytogenes*. *Clin. Infect. Dis.* 35:943–949.
11. Genigeorgis, C. A., D. Dutulescu, and J. F. Garayzabal. 1989. Prevalence of *Listeria* spp. in poultry meat at the supermarket and slaughterhouse level. *J. Food Prot.* 52:618–624.
12. Guerra, M. M., J. McLauchlin, and F. A. Bernardo. 2001. *Listeria* in ready-to-eat and unprocessed foods produced in Portugal. *Food Microbiol.* 18:423–429.
13. Johansson, T. 1998. Enhanced detection and enumeration of *Listeria monocytogenes* from foodstuffs and food-processing environments. *Int. J. Food Microbiol.* 40:77–85.
14. Kaczmarski, E. B., and D. M. Jones. 1989. Listeriosis and ready-cooked chicken. *Lancet* i:549.
15. Kerr, K. G., S. F. Dealler, and R. W. Lacey. 1988. Materno-fetal listeriosis from cook-chill and refrigerated food. *Lancet* ii:1133.
16. Lundén, J. M., T. J. Autio, A.-M. Sjöberg, and H. J. Korkeala. 2003. Persistent and nonpersistent *Listeria monocytogenes* contamination in meat and poultry processing plants. *J. Food Prot.* 66:2062–2069.
17. Miettinen, M. K., L. Palmu, K. J. Björkroth, and H. Korkeala. 2001. Prevalence of *Listeria monocytogenes* in broilers at the abattoir, processing plant, and retail level. *J. Food Prot.* 64:994–999.
18. Ojeniyi, B., H. C. Wegener, N. E. Jensen, and M. Bisgaard. 1996. *Listeria monocytogenes* in poultry and poultry products: epidemiological investigations in seven Danish abattoirs. *J. Appl. Bacteriol.* 80:395–401.
19. Pini, P. N., and R. J. Gilbert. 1988. The occurrence in the U.K. of *Listeria* species in raw chickens and soft cheeses. *Int. J. Food Microbiol.* 6:317–326.
20. Rørvik, L. M., B. Aase, T. Alvestad, and D. A. Caugant. 2003. Molecular epidemiological survey of *Listeria monocytogenes* in broilers and poultry products. *J. Appl. Microbiol.* 94:633–640.
21. Rørvik, L. M., and M. Yndestad. 1991. *Listeria monocytogenes* in foods in Norway. *Int. J. Food Microbiol.* 13:97–104.
22. Schwartz, B., C. A. Ciesielski, C. V. Broome, S. Gaventa, G. R. Brown, B. G. Gellin, A. W. Hightower, and L. Mascola. 1988. Association of sporadic listeriosis with consumption of uncooked hot dogs and undercooked chicken. *Lancet* ii:779–782.
23. Skovgaard, N., and C. A. Morgen. 1988. Detection of *Listeria* spp. in faeces from animals, in feeds, and in raw foods of animal origin. *Int. J. Food Microbiol.* 6:229–242.
24. Soultos, N., P. Koidis, and R. H. Madden. 2003. Presence of *Listeria* and *Salmonella* spp. in retail chicken in Northern Ireland. *Lett. Appl. Microbiol.* 37:421–423.
25. Uyttendaele, M. R., K. D. Neyts, R. M. Lips, and J. M. Debevere. 1997. Incidence of *Listeria monocytogenes* in poultry and poultry products obtained from Belgian and French abbatoirs. *Food Microbiol.* 14:339–345.
26. Vitas, A. I., V. Aguado, and I. Garcia-Jalon. 2004. Occurrence of *Listeria monocytogenes* in fresh and processed foods in Navarra (Spain). *Int. J. Food Microbiol.* 90:349–356.