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Prevalence of *Listeria* spp. in Turkey Meat at the Supermarket and Slaughterhouse Level

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ABSTRACT

The prevalence of *Listeria* spp. in the skins of turkey wings, legs (drumsticks), and tails was studied first. During three trips to local supermarkets we purchased and analyzed 180 packages representing two national brands. Overall, total *Listeria* spp., *L. monocytogenes, L. welshimeri,* and *L. innocua* were present in 32.2, 15.0, 15.6, and 1.7% of the packages. *Listeria* spp. were present in 23.3 and 41.1% of the products of Company A and B, respectively. The corresponding figures for *L. monocytogenes* were 12.2 and 17.8% and for *L. welshimeri*, 11.1 and 20.0%. The overall prevalence of *Listeria* spp. on wings, legs, and tails was 45.0, 28.5, and 23.3%, respectively. The corresponding numbers for *L. monocytogenes* were 20.0, 13.3, 11.7%. Next, we determined the presence of *Listeria* spp. in 10 locations and products collected from a slaughterhouse of Company A during three visits. A total of 225 samples were analyzed. No *Listeria* spp. were isolated from 30 feather samples (5g composite samples from 10 birds), 15 scalding tank water overflow samples (25 ml), 30 samples of neck skin (149 to 183 cm^2), 30 whole liver and 30 heart samples after chilling, and 30 samples of cecum and large intestine content (1g). *Listeria* spp. were present in 13.4, 6.7, 33.3, and 26.7% of 15 feather picker drip water (25 ml), 15 chiller water overflow (25 ml), 15 recycling water for cleaning gutters (25 ml), and in 15 of mechanically deboned meat (25 g) samples, respectively. The prevalence of *Listeria* spp. in wings, legs, and tails increased through processing and distribution. The prevalence immediately after chilling, after packaging and at the retail level was 4.4, 13.3, and 23.3%. No *Listeria* spp. was isolated from 30 livers after chilling and 30 liver packages ready to go to the market. The prevalence of *Listeria* spp. on the hands and gloves of the persons hanging birds after chilling, cutting carcasses, and packaging parts was 16.7, 33.3, and 40.0%, respectively. Overall, the study demonstrated the high prevalence of *Listeria* spp. and specifically *L. monocytogenes* in turkey products. Improvements and innovations at the slaughterhouse level may effectively reduce final product contamination with *Listeria*.

The presence of *Listeria monocytogenes* on poultry, red meat, and meat products, with frequencies of 10 to 80%, has been reported and reviewed (*4,6,9,13,16,18,20, 23,25,26,29*). These frequencies have been considered as presenting a potential risk which could lead to food-borne listeriosis if such products were eaten raw or undercooked. Therefore the absence of any documented cases of human listeriosis attributed to meat and poultry was considered an anomaly, and many scientists thought that it was only a matter of time before such products would be incriminated.

A case-control study involving 82 sporadic cases of listeriosis and 233 controls, was conducted recently by the Centers of Disease Control to identify risk factors for the disease, and reported in 1988 (*30*). One third of the cases were perinatal and the remaining occurred in elderly and immunosupressed individuals. Cases were significantly more likely than controls to have eaten undercooked chicken or uncooked hot dogs with 20% of the overall risk of the disease attributable to consumption of these foods. While epidemiologic associations do not establish causality, they are nevertheless of great value in the better understanding of a health problem, especially when the associations have biological explanations. With *L. monocytogenes* growing at refrigeration temperatures in meat even under vacuum (*15*), its high prevalence in raw meats and the high probability of cross-contamination of hot dogs post processing (*36*), it is only a matter of extended storage to allow growth to infective levels. This scenario occurred recently in frankfurters resulting in the death of a woman suffering from cancer. She acquired listeriosis after consuming one turkey frank daily, after heating it in a microwave oven (*2*). *Listeria monocytogenes* was isolated from an opened frankfurter package found in the woman's refrigerator and unopened packages collected from supermarkets which were available for consumption long after the sell-by date (*1*). Whether the problem originated from under-processing or post-processing cross contamination is still unknown. Studies indicated that *Listeria* may survive marginal thermal processing of such products (*7,36*). In 1988, a pregnant woman in the UK acquired listeriosis from a pre-cooked refrigerated chicken purchased at a supermarket (*17*).

While the prevalence of *Listeria* spp. in chicken meat has been studied extensively, practically nothing is known about its presence in turkeys. Considering this, as well as the continuous increase in consumption of such meat, especially as processed, the present study was undertaken. At first we determined the prevalence of *Listeria* spp. in fresh turkey meat and organs at the supermarket level. Products

originating from two suppliers, collected from three local supermarkets, were evaluated. The study then evaluated the potential contribution of slaughterhouse practices to the prevalence of *Listeria* spp. in the finished products.

MATERIALS AND METHODS

Sample collection from supermarket

Fresh packaged turkey wings, legs (drumsticks), and tails were collected from three supermarkets in Davis, CA. The samples representing two national brands (A and B) were brought to the laboratory on ice and analyzed immediately.

Sample collection in slaughterhouse

A federally inspected California turkey processing plant cooperated in this study. Conventional slaughtering and processing techniques are used in this plant, which is part of a vertically integrated operation processing birds from its own turkey flocks. Hens were approximately 100 d and toms were 130 d old at kill. The birds were scalded at 137-138 F (58.3-58.9°C). Hens were scalded for 2.5 min and toms were scalded for 3.5 min. Potable water was used in the scalding tank and feather pickers. Final rinse water and chiller water contained 20-25 ppm chlorine. Equipment and environment were washed every 2 h including a final clean-up using detergent at the end of the day.

Slaughterhouse sampling sites and tissue samples included: feathers from live, hanging turkeys, scalding tank water overflow (SWO); feather picker drip water (FPDW); chiller water overflow (CWO); recycled water for cleaning gutters (RWCG) in the receiving room; ceca and the last part of the large intestine (CC & LI) from the evisceration line; neck skins (NK), wings, legs (drumsticks), and tails cut aseptically from whole turkeys after they came out of the chilling tank; hearts (HT), and livers (LV) taken immediately after coming out of the giblet chiller; and mechanically deboned meat (MDM) taken directly from the machine's outlet.

Ten consecutive feather samples were taken from every fifth turkey and placed in a sterile "Whirl-Pak" bag to form a composite feather sample. Feathers were plucked from the breast region. Individual heart, liver, neck skin, wing, leg, and MDM samples were collected aseptically and placed in "Whirl-Pak" bags. Several crystals of sodium thiosulfate were added to each water sample to neutralize any residual chlorine. A total of 15-30 samples per site were taken during three sampling trips. In addition to individual turkey samples taken immediately after chilling, packaged products were obtained from the packaging station at the end of the processing line.

Swabbing workers hands and gloves

Workers hands and gloves were sampled by wetting sterile cotton swabs in Food and Drug Administration *Listeria* enrichment broth (EB) (*21,22*), swabbing an area of 2x2 cm and placing the swabs into tubes containing 9 ml of EB. All slaughterhouse samples and final product packages were placed in an ice chest, brought to the laboratory, and analyzed within 5 h after collection.

Sample processing

Water samples (25 ml) were placed in 100 ml screw cap bottles containing 25 ml of double strength EB. One gram of ceca & large intestine contents was placed in sterile "Whirl-Pak" bags containing 9 ml of EB and homogenized by hand for 1 min. Each composite feather sample (approximately 5 g) and each whole liver or heart were placed in 100 ml of EB and massaged by hand. Neck skins of approximately 54 to 84 cm^2 were placed in "Whirl-Pak" bags and mixed with EB at ratio of 1 ml broth to 1.6 cm^2 skin surface and then massaged by hand for 1 min. Legs (drumsticks), wings, and tails originating from supermarkets and those brought to the laboratory from the slaughterhouse were handled as follows: the whole skin from each drumstick of approximately 284 to 360 cm^2 surface was removed aseptically and placed in a "Whirl-Pak" bag. Enrichment broth was added to each bag at a ratio of 1 ml to 1.6 cm^2 skin. The tip of each wing, representing metacarpi-falangean bones, was cut and placed in a bag. An additional 41 to 51 cm^2 skin was removed from the rest of the wing and placed in the same bag. The total skin placed in each bag was 149 to 183 cm^2. Enrichment broth was added to each bag at a ratio of 1 ml broth to 1.6 cm^2 skin and massaged for 1 min. Each tail, market size, was placed in a bag containing 100 ml EB and massaged for 1 min. Twenty five grams of MDM were placed in a bag containing 225 ml EB homogenized.

All tubes, bottles, and bags containing the samples (primary enrichment) were incubated aerobically at 30°C for 24 h. Next, the contents were mixed very well and 0.1 ml was transferred to 9 ml EB containing tubes (secondary enrichment). The tubes were incubated at 30°C for 24 h and then 0.01 ml of the subculture was streaked onto Lithium chloride-phenylethanol-moxalactam (LPM) plating agar (*19,22*) and Modified McBride *Listeria* agar (MMA) (*22*). All secondary EB after the 24 h incubation at 30°C were placed at 4°C for 28 d and streaked again on LPM and MMA agar. Both agars were incubated at 37°C for 48 h. The plates were checked after 24 and 48 h with a dissecting microscope under Henry's 45° transillumination (*19,22*) for typical *Listeria* colonies. Three to four suspect colonies (Gram+, catalase+, rods) were subcultured for purity on brain heart infusion (BHI) agar (Difco), and then transferred to BHI agar slants for further biochemical characterization. This was done within a week, using selected criteria proposed by Seeliger and Jones (*31*) and Lovett (*21*). They included tests for: Gram stain, production of beta-hemolysis on sheep blood agar, catalase, and Camp tests, motility and utilization of esculin, glucose, rhamnose, mannitol, xylose, and alpha-methyl-D-mannopyranoside. Camp test was performed as described by Lovett (*21*) using both *S. aureus* and *Rhodococcus equi* cultures. Positive and negative controls were used as reference. The other tests were performed as we described previously (*13*).

RESULTS

Market product prevalence

Three times during the period of October 1988 through May 1989 we visited three local supermarkets and bought a total of 180 packages of fresh turkey wings, drumsticks, and tails in order to determine the prevalence of *Listeria* spp.

Table 1 summarizes the findings with respect to producer, type of product, and type of *Listeria* spp. Of the 60 samples each of wings, drumsticks, and tails, 27 (45%), 17 (28.3%) and 14 (23.3%) harbored *Listeria* spp., respectively. Irrespective of company, the prevalence differed significantly among these three products. This was true also for products of company B ($p<0.05$) but not for company A ($p>0.20$).

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TABLE 1. *Prevalence of* Listeria *spp. on raw turkey products representing three companies and purchased from local supermarkets in Davis, California during the period of October 1988 through May 1989.*

Product	Species	Trip	Companies A.	Companies B.	A,B Total	%
			Percentages			
Wings	*L. monocytogenes*	1	20	10	3[a]	15
		2	20	20	4[a]	20
		3	10	40	5[a]	25
	L. welshimeri	1	0	10	1[a]	5
		2	20	40	6[a]	30
		3	20	30	5[a]	25
	L. innocua	1	0	20	2[a]	10
		2	0	10	1[a]	5
		3	0	0	0[a]	0
Total *Listeria* spp.		1,2,3	30	60	27/60	45
Drumstick	*L. monocytogenes*	1	10	20	3[a]	15
		2	10	10	2[a]	10
		3	20	10	3[a]	15
	L. welshimeri	1	20	40	6[a]	30
		2	0	0	0[a]	0
		3	0	30	3[a]	15
	L. innocua	1,2,3	0	0	0/60	0
Total *Listeria* spp.		1,2,3	20	36.7	17/60	28.3
Tails	*L. monocytogenes*	1	10	20	3[a]	15
		2	10	10	2[a]	10
		3	0	20	2[a]	10
	L. welshimeri	1	30	10	4[a]	25
		2	10	10	0[a]	0
		3	0	10	3[a]	15
	L. innocua	1,2,3	0	0	0[b]	0
Total *Listeria* spp.		1,2,3	20	26.6	14/60[b]	23.3

[a] = Number of positive samples out of 20.
[b] = Number of positive samples/Total.

L. monocytogenes was detected in 20% of the wings, 13.3% of the drumsticks, and 11.7% of the tails. *L. innocua* was detected in 5% of wings, and in none of the drumsticks and tails. *L. welshimeri* was detected in 20% of wings, 15% of drumsticks, and 11.7% of tails. Company A had a *Listeria* spp. prevalence of 30.0% and company B had 43.3% for all three types of meats during the first trip. The corresponding figures for the 2nd trip were 23.3 and 33.3% and for the 3rd trip 16.7 and 46.7%, respectively. The prevalence of *Listeria* spp. in the fresh parts did not differ significantly among trips for company A ($p>0.20$), or company B ($p>0.20$).

Table 2 presents the observed variations in the overall prevalence of *L. monocytogenes*, *L. innocua*, and *L. welshimeri* in the products of each company. *L. welshimeri* was the most prevalent species (15.6%) followed by *L. monocytogenes* (15.0%) and *L. innocua* which was present only in 1.7% of the samples. Twenty-three and three-tenths percent of products from Company A harbored *Listeria* spp., including 12.2% *L. monocytogenes*, 0.0% *L. innocua*, and 11.1% *L. welshimeri*. Forty-one and one-tenths percent of products from Company B harbored *Listeria* spp., including 17.8% *L. monocytogenes*, 3.3% *L. innocua*, and 20.0% *L. welshimeri*. The prevalence of *Listeria* spp. differed significantly ($p<0.01$) between the two companies although the frequency of isolation of *L. monocytogenes* ($p>0.30$) and *L. welshimeri* ($p>0.10$) was not significantly different. None of the positive samples harbored more than one *Listeria* spp. All *Listeria* spp. recoveries mentioned above were based on the isolation of the agent on selective agars inoculated with 24 h secondary EB cultures, or inoculated with the same EB after an additional storage at 4°C for 28 d. This plating recovered 19% more positive *Listeria* spp. than if we plated only the 24 h secondary EB.

TABLE 2. *Grand total numbers and percentages of fresh turkey parts representing two companies and harboring various* Listeria *spp.*

Microorganisms	Companies A Total	A %	Companies B Total	B %	A,B Total %
L. monocytogenes	11[a]	12.2	16[a]	17.8	15.0
L. welshimeri	10[a]	11.1	18[a]	20.0	15.6
L. innocua	0[a]	0.0	3[a]	3.3	1.7
Listeria spp.	21[a]	23.3	37[a]	41.1	32.2

[a] = Number of positive samples out of 90.

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Slaughterhouse sampling

During three trips to company A slaughterhouse, a total of 225 samples were obtained representing 10 stations and products. The prevalence of *Listeria* spp. by trip, sampling sites, and summary data are presented in Table 3. No *Listeria* spp. were isolated from feathers, scalding water overflow (SWO), neck skin (NK), liver (LV), heart (HT), or ceca and large intestine (CC+LI) samples. *Listeria* spp. were isolated from 13.4% of feather picker drip water (FPDW), 6.7% of chiller water overflow (CWO), 33.3% of recycled water for cleaning gutters (RWCG), and 26.7% of mechanically deboned meat (MDM). *L. monocytogenes* was present only in FPDW (6.7%), RWCG (13.3%), and MDM (13.3%). Overall, from 225 samples, 12 (5.3%) were positive for *Listeria* spp., 5 (2.2%) for *L. monocytogenes*, 7 (3.3%) for *L. welshimeri*, and none for *L. innocua*.

The overall prevalence of *Listeria* spp. in wing, drumstick, and tail packages of company A was 23.3% at the supermarket level and 0% in the individual NK skin, LV, and HT samples, at the slaughterhouse level. The big difference in the frequency of *Listeria* present in retail products and slaughterhouse samples, required further sampling at the slaughterhouse level to identify the contributing factors. During three trips to the slaughterhouse, *L. monocytogenes* was isolated from only 1/30 wings, while *L. welshimeri* was isolated from 1/30 drumsticks, 1/30 wings, and 1/30 tails taken from birds immediately after coming out of the chilling tank, and 0/30 livers collected after coming out of the giblet chiller (Table 4). During the same trips we also collected packaged livers, wings, legs, and tails from the packing station. In parts from packages analyzed the day of production we found *Listeria* spp. in 0.0% (0/30) of livers, 13.3% (4/30) of wings, 10% (3/30) of legs, and 16.7% (5/30) of tails. The corresponding percentages for *L. monocytogenes* were 0.0% 13.3%, 6.7%, and 0.0% (Table 4).

We assumed that the added handling involving hanging the carcasses after the chilling process, cutting carcasses into drumsticks, wings and tails, and handling during packaging was responsible for the significant increase in prevalence at the end of the processing line. Table 4 compares the prevalence of *Listeria* in individual and packaged turkey parts of Company A at the end of processing and at supermarket levels. A significantly higher prevalence for wings, legs, and tails was found in the retail market samples than the corresponding product packages at the end of the processing line.

The potential contribution of turkey meat handlers to an increasing *Listeria* prevalence through cross-contamination was evaluated next. The presence of *Listeria* in the hands and gloves of handlers in three stations was determined during three trips (Table 5). Of the persons handling turkey carcasses immediately after chilling, 10% (3/30) harbored *L. monocytogenes*, 6.7% harbored *L. welshimeri* and 16.7% (5/30) harbored *Listeria* spp. The prevalence of *L. monocytogenes* and *Listeria* spp. on the hands of persons cutting the carcasses into legs and wings was 10% (3/30), and 33.3% (10/30), respectively. Finally, 16.7% (5/30), and 40% (12/30) of the hands and gloves of persons packaging turkey cuts were positive for *L. monocytogenes* and *Listeria* spp., respectively. Overall, 30.0% (27/90) of the handlers in the three stations studied harbored *Listeria* spp. on their hands and gloves, 12.2% (11/90) harbored *L. monocytogenes*, and 17.7% (16/90) harbored *L. welshimeri*.

The above data demonstrated beyond doubt the potential contribution of handlers to cross-contamination of products by *Listeria* spp. Serological and phage typing of the isolated *Listeria* strains was not done.

DISCUSSION

In the last five years, a number of outbreaks of listeriosis attributed to food consumption have been reported and epidemiologic aspects have been reviewed (*3,5,11,23*). Meat, poultry, or their processed products were not incriminated

TABLE 3. *Prevalence of* Listeria monocytogenes *and* Listeria welshimeri *in product and environmental samples collected from different sites during three trips to a slaughterhouse.*

		Sampling sites or turkey products										
Trip.	Micr.	Ftr.	SWO.	FPDW.	CWO.	RWCG.	NK.	LV.	HT.	CC&LI.	MDM.	Total +
1	*L. mon.*	0[a]	0[b]	1[b]	0[b]	0[b]	0[a]	0[a]	0[a]	0[a]	1[b]	2/75
	L. welsh.	0[a]	0[b]	0[b]	1[b]	1[b]	0[a]	0[a]	0[a]	0[a]	0[b]	2/75
2	*L. mon.*	0[a]	0[b]	0[b]	0[b]	2[b]	0[a]	0[a]	0[a]	0[a]	0[b]	2/75
	L. welsh.	0[a]	0[b]	1[b]	0[b]	1[b]	0[a]	0[a]	0[a]	0[a]	2[b]	4/75
3	*L. mon.*	0[a]	0[b]	0[b]	0[b]	0[b]	0[a]	0[a]	0[a]	0[a]	1[b]	1/75
	L. welsh.	0[a]	0[b]	0[b]	0[b]	1[b]	0[a]	0[a]	0[a]	0[a]	0[b]	1/75
Total		0/30[a]	0/15	2/15	1/15	5/15	0/30	0/30	0/30	0/30	4/15	12/225
TOTAL	*L. mon.*	0.0	0.0	6.7	0.0	13.3	0.0	0.0	0.0	0.0	13.3	2.2
pos.	*L. welsh.*	0.0	0.0	6.7	6.7	20.0	0.0	0.0	0.0	0.0	13.3	3.1
(%)	*L.* spp.	0.0	0.0	13.4	6.7	33.3	0.0	0.0	0.0	0.0	26.7	5.3

Ftr = feathers, *SWO* = scalding water overflow, *FPDW* = feather-picker drip water, *CWO* = chiller water overflow, *RWCG* = recycled water for cleaning water for cleaning gutters in the receiving room, *NK* = neck skin, *LV* = livers, *HT* = hearts, *CC+LI* = ceca & last part of the intesting from the evisceration line, *MDM* = mechanically deboned meat.

a = Number of positive samples out of 10.

b = Number of positive samples out of 5.

c = Number of positive/Total.

L. mon. = *L. monocytogenes*, L. welsh = *L. welshimeri*, L. spp. = *Listeria* spp.

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TABLE 4. *Prevalence of* Listeria *spp. in individual and packaged turkey parts of Company A at the end of processing, and at supermarket levels.*

Trip	Micr.	Individual product				Packaged final product				Market samples		
		Wing	Leg	Tail	Liver	Wing	Leg	Tail	Liver	Wing	Leg	Tail
1	*L. mon.*	0[a]	0[a]	0[a]	0[a]	1[a]	0[a]	0[a]	0[a]	2[a]	1[a]	1[a]
	L. wel.	1[a]	1[a]	0[a]	0[a]	0[a]	0[a]	2[a]	0[a]	0[a]	2[a]	3[a]
2	*L. mon.*	1[a]	0[a]	0[a]	0[a]	3[a]	1[a]	0[a]	0[a]	2[a]	1[a]	1[a]
	L. wel.	0[a]	0[a]	0[a]	0[a]	0[a]	1[a]	1[a]	0[a]	2[a]	0[a]	1[a]
3	*L. mon.*	0[a]	0[a]	0[a]	0[a]	0[a]	1[a]	0[a]	0[a]	1[a]	2[a]	0[a]
	L. wel.	0[a]	0[a]	1[a]	0[a]	0[a]	0[a]	2[a]	0[a]	2[a]	0[a]	0[a]
TOTAL		2/30[b]	1/30[b]	1/30[b]	0/30[b]	4/30[b]	3/30[b]	5/30[b]	0/30[b]	9/30[b]	6/30[b]	6/30[b]
Total positive %												
L. mon.		3.3	0.0	0.0	0.0	13.3	6.7	0.0	0.0	16.7	13.3	6.7
L. wel.		3.3	3.3	3.3	0.0	0.0	3.3	16.7	0.0	13.3	6.7	13.3
L. spp.		6.7	3.3	3.3	0.0	13.3	10.0	16.7	0.0	30.0	20.0	20.0

[a] = Number of positive samples out of 10.
[b] = Number of positive/Total samples, *L. mon.* = *L. monocytogenes*, *L. wel.* = *L. welshimeri*, *L.* spp. = *Listeria* spp.

TABLE 5. *Prevalence of* Listeria *spp. in the hands and gloves of turkey meat handlers in three stations (post chiller, leg/wing cutters, and packaging) of the slaughterhouse.*

Trip	Station	*L. monocytogenes* Positive/total	Total %	*L. welshimeri* Positive/total	Total %	*Listeria* spp. Total	(%)
1	A	1[a]		1[a]		2[a]	
2	A	2[a]		1[a]		3[a]	
3	A	0[a]		0[a]		0[a]	
Total	A	3/30[b]	10.0	2/30[b]	6.7	5/30[b]	16.7
1	B	2[a]		1[a]		3[a]	
2	B	0[a]		4[a]		4[a]	
3	B	1[a]		2[a]		3[a]	
Total	B	3/30[b]	10.0	7/30[b]	23.3	10/30[b]	33.3
1	C	1[a]		4[a]		5[a]	
2	C	3[a]		1[a]		4[a]	
3	C	1[a]		2[a]		3[a]	
Total	C	5/30[b]	16.7	7/30[b]	23.3	12.30[b]	40.0
Grand Total		11/90[b]	12.2	16/90[b]	17.7	27/90[b]	30.0

Station A = post chilling handlers, Station B = leg and wing cutters.
Station C = handlers packaging legs and wings.
[a] = Number of positive samples out of 10.
[b] = Number of positive/Total.

in any of these outbreaks and reported cases of sporadic listeriosis. Two recent cases of listeriosis attributed to consumption of precooked refrigerated chicken purchased at a supermarket in UK (*17*), and the other to consumption of turkey franks by a cancer patient (*2*) have changed our thinking about the role of cooked meats and poultry in human listeriosis. The implicated open package of franks found in the cancer patient's refrigerator contained 1100 *L. monocytogenes* cfu/g. At the time of sampling, 40 d already had passed since expiration of sell-by date (*1*). Both of the above cases support evidence of a recent case-control study (*30*) which attributed 20% of the risk of sporadic listeriosis to the consumption of undercooked chicken or reheated hot dog. The high prevalence of *L. monocytogenes* in retailed poultry and turkey meat as shown in this and other studies (*4,6,9,10,13,18,23,26,28*), may indicated an increased health risk, if not for the general "healthy" public, but for pregnant women, the elderly, and immunocompromised individuals exposed to undercooked poultry meat. In the case of consumption of uncooked or insufficiently reheated hot dogs, the risk may come from the following: a) under processing; b) cross contamination post-processing from the plant environment extensively contaminated with *Listeria*, as a recent study of 41 plants has shown (*35*); and c) from the ability of *L. monocytogenes* to grow at >0°C in meat even under vacuum (*15*), and reach infective levels at the time of product consumption (*2*). In this case, products consumed long beyond their expiration date will pose the highest risk.

The prevalence of *Listeria* spp. in fresh turkey meat has not been studied systematically other than by Kwantes and Isaac (*18*) who found 1/4 turkeys positive for *L. monocytogenes*. The present study is the first of its kind in the literature as far as we know. The presence of *Listeria* spp. in 32.2% and of *L. monocytogenes* in 15% of turkey wings,

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legs, and tails is within the ranges reported in the literature for chicken parts (*4,6,9,10,13,18,23,26,28*).

L. welshimeri, a rarity in chicken parts (*13*) was the most prevalent *Listeria* in fresh turkey parts. *L. innocua*, the dominant *Listeria* in chicken meat (*13*), was a rarity in turkey meat.

The prevalence of *Listeria* spp. in the various sites of a turkey processing plant is reported for the first time. *Listeria* spp. were not isolated from any of the feather composites or intestinal content samples. Feathers were evaluated as an indicator of environmental contamination of birds and intestinal contents as an indicator of endogenous infection. These findings are similar to our earlier study of chicken (*13*). Whether the turkeys are the reservoir of incoming *Listeria* in the plant can not be proven since our sample size was small, and there is no published data on the prevalence of *Listeria* in turkeys at the farm level. The prevalence may vary with lot of birds, as we have found before, for *Campylobacter jejuni* (*12*). The birds are probably carriers at unknown rates and once the slaughterhouse environment is contaminated, *Listeria* may establish itself in the plant in places similar to those reported for dairy and meat processing plants (*8,32,35*).

No *Listeria* was detected in the scalding water overflow probably because of the lethal effect of hot water. *Listeria* spp. were present in feather picker drip water (13.4%), chiller water overflow (6.7%), and recycled water for cleaning gutters (33.3%). These findings demonstrated the significance of defeathering machine, chillers, and recycled water in product cross-contamination and environmental contamination, as shown before for *C. jejuni* (*12,34*) and *Listeria* (*13*) in poultry processing plants. The presence of *L. monocytogenes* in poultry packing plant effluent at levels >16,000 cells/L has been shown repeatedly in the UK (*33*).

Listeria spp. and *L. monocytogenes* were present in 26.7 and 13.3% of mechanically deboned meat. These levels of contamination are very close to the ones found for chicken meat (*13*), and reflect the fact that this meat is in essence a composite sample and should have the highest *Listeria* prevalence of all edible turkey parts.

The presence of *Listeria* in the feces of various human groups has been studied and reviewed (*27*). Carriers in red meat and poultry plants ranged from 0.47 to 12.8% (*9,24,27*). The contribution of human fecal carriers to product contamination should be insignificant as these people may be considered victims of their exposure to *Listeria* originating from animals rather than being themselves a true fecal reservoir. In contrast handlers may play a major role in spreading the contamination to turkey parts as they move along the various stages of processing. This is supported by the data of tables 4 and 5 and our study on chicken. While cross-contamination among turkey parts can contribute to the spreading of *Listeria*, hands or gloves of handlers once contaminated can more widely spread the agent because of the volume of parts handled. Such spreading is further amplified by the contribution of additional handlers along the line, like those hanging the birds after chilling, those cutting them into parts, and others packaging them. As Table 5 has shown, the prevalence of *Listeria* spp. increased from 16.7 to 33.3 and then to 40.0% as the turkey carcasses and parts moved through station A, B, and C (hanging, cutting, packaging), respectively. Overall, 30% (27/90) of the product handlers carried *Listeria* spp. in their hands and gloves. The corresponding figure for our chicken study was 46.7% (35/75) (*13*). An evaluation of 4 red meat plants in Czechoslovakia (*9*) over a 2 year period demonstrated the presence of *L. monocytogenes* in 25.6% (22/86) of the hands and 23.2% (20/86) of the gloves of meat handlers.

A significant overall increase in the prevalence of *Listeria* spp. was observed in the retail packages of wings, legs, and tails of Company A as compared to the prevalence of the same products immediately after packaging. (Table 4). Of the nine combinations concerning three products (wings, legs, and tails) and three listeria (*Listeria* spp., *L. monocytogenes*, and *L. welshimeri*), in eight there was increase in prevalence, and in one there was slight decrease. *L. monocytogenes* prevalence increased in all three products with time. In the absence of *Listeria* counts in the turkey parts, the question of whether growth of the agent took place during storage in the supermarkets can not be answered with certainty. Increase in prevalence may reflect true growth of *Listeria* from undetectable to detectable levels.

Although *Listeria* spp. and *L. monocytogenes* were present in relatively high proportion of retailed packaged turkey parts, no indication of the numbers of the agent was obtained in this study. Gilbert et al. (*14*) in their recent report indicated that in the U.K. cooked poultry meat carried $<10^2$ *L. monocytogenes* cells/g. Levels as high as 1000/g have been reported for fresh red meat (*16,29*).

In conclusion, this study reenforced previous reports that along with raw poultry meat, turkey meat also is a major food source of *L. monocytogenes*. The recent case of listeriosis from turkey franks and the presence of *L. monocytogenes* in many unopened packages may be a reflection of the significant contamination of raw turkey meat with *Listeria* from which cooked products may get cross-contaminated. This study as well as the previous one concerning poultry meat (*13*), have demonstrated that through improvement in certain practices at the slaughterhouse level there is a good possibility of minimizing the high *Listeria* prevalence in the finished products. This can be accomplished through strict adherence to Good Manufacturing Practice (GMP) standards (*35*) and new innovations in type and schedule of hand and glove sanitizing.

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