Microbiological Contamination Baselines of Beef Carcasses, Wholesale Cuts and Retail Cuts

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Summary

As a result of consumer concern about the microbiological safety of retail products, a study was conducted in six packing plants and six retail stores to determine microbiological contamination of carcasses, subprimals and retail cuts. Carcasses were sampled (by sponging or excising) after 24-72 h of chilling and subprimals were sampled during fabrication (by sponging) at the plants. These same subprimal lots were followed to the retail facility, sampled (by sponging) and allowed to proceed through the fabrication process. The resulting steaks/roasts from these subprimals were sampled immediately and after 48 h in simulated retail display (25-30°C). Carcass sponging recovered APC, TCC, and ECC of 4.1, 1.2, and 1.0 log CFU/100 cm^2, respectively, which were lower ($P \leq 0.05$) than those recovered by excising (6.6, 3.2, and 2.8 log CFU/100 cm^2, respectively). The overall frequency of *Salmonella* isolation from sponged and excised carcasses was 0.7% and 1.7%, respectively, while overall incidence of *L. monocytogenes* was 6.9% and 15.6%, respectively. Products displayed for 48 h had mean APC, TCC, ECC, and SAC of less than 6.8, 2.7, 1.8 and 2.4 log CFU/100 cm^2, respectively. Handling, fabricating, packaging, distributing and retailing introduced additional contamination, and allowed proliferation of microbes. This study provided the industry with valuable information regarding the extent and sources of possible microbial contamination, which may help industry personnel to continue to provide consumers with the safest product possible.

Introduction

Food safety is a major concern in the United States especially in the light of the frequency of food-borne pathogen related outbreaks associated with pathogenic bacteria such as *E. coli* O157:H7 and *Salmonella*. Research has demonstrated that beef packers are expending enormous time and resources, and generally succeeding, in efforts to prevent microbiological contamination and to minimize presence of pathogens on carcasses (Sofos *et al.*, 1996). However, it is essential, for protecting the public health, that determinations are made of the potential for contamination of the product in the fabrication, distribution and retailing sectors. Several factors, such as handling, fabricating, packaging, distributing and retailing could, potentially, cause increased contamination with, and/or proliferation of, microbes, making careful handling of product as it passes through packing, fabricating, transporting/distributing and retailing functions/sectors a necessity. The objectives of the study reported here were to determine baseline contamination levels of beef as it moved from slaughter through display at retail.

Materials and Methods

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The study was conducted in six slaughtering/dressing facilities (packing plants) across the United States. Each facility was visited for sample collection a total of two days (Friday and Monday) to assure that product was obtained when things were cleanest (at the beginning of the week) and likely to be least clean (at the end of the week). The samples were analyzed for aerobic plate counts (APC), total coliform counts (TCC), generic *Escherichia coli* counts (ECC), and the presence of *Salmonella* and *Listeria monocytogenes*. In addition, the retail cut samples were analyzed for *Staphylococcus aureus* counts (SAC).

Carcass evaluation (at the packing facility)

At each packing facility, 48 randomly selected carcasses (24 each day) were sampled by excising and by sponging, according to the procedure described in the United States Food Safety and Inspection Service (FSIS) Meat and Poultry Inspection, Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems; Final Rule (Federal Register, 1996). Carcass sampling was done such that an entire 8 h shift was represented in each day of sampling. For each carcass sampled, one side was sponged (Whirl-Pak™, Nasco, Modesto, CA) on the brisket, flank and round and the opposite side of the carcass was sampled by excision on the brisket, flank and round. Sponging vs. excising was alternated between sides (left vs. right) of carcasses after every twelve carcasses. All samples were taken after 24-72 h in the chill cooler, prior to the carcasses reaching the fabrication floor.

Two sponges were required to complete one sample. One sponge was analyzed for APC, TCC and ECC and for the presence of *Salmonella*, and the other sponge was analyzed for the presence of *L. monocytogenes.* Consecutive carcasses were sampled to obtain the two sponges required, thereby using the exact sites specified in the Federal Register (1996) for each sample. Two excision samples were also required to complete one sample. One sample was analyzed for APC, TCC and ECC and for the presence of *Salmonella*, and the other sample was analyzed for the presence of *L. monocytogenes.* Consecutive carcasses were sampled to obtain the two samples required, thereby using the exact sites specified in the Federal Register (1996) for each carcass.

Subprimal evaluation (at the packing and retail facilities)

Two types of subprimals (chosen from among the inside round, chuck blade, top butt, clod, bottom round, striploin or shortloin, depending on the cuts frequently purchased by the cooperating retailers) were evaluated in each of the two facilities (packing plants and retail store). The subprimal types chosen and sampled at each packing plant were the same subprimal types sampled at the corresponding supermarket. The first sampling took place at the beef slaughtering facility prior to the vacuum packaging machine and the second sampling took place at the retail facility just prior to fabrication of the retail cuts. Each subprimal was placed on a clean surface and a 10 x 10 cm area was sponged (Whirl-Pak™) on both the fat and lean sides, separately, for microbiological analysis, following the sponging procedure outlined for the carcass sampling. For each packing facility and retail facility, a total of 48 cuts of each type of subprimal (24 each day) were sampled during the two-day period at the beef slaughtering facility and a total of 48 cuts of each type of subprimal (24 each day) were sampled during the two-day period at the retail facility. Two sponges were required to complete one sample. One sponge was analyzed for APC, TCC and ECC and for the presence of *Salmonella* and the other sponge was analyzed for the presence of *L. monocytogenes*. Adjacent sampling sites (for the fat side and lean side, separately) on the subprimal were used in order to obtain the two sponges required for analysis.

Retail cut evaluation

Retail cuts were sampled in the form of steaks or roasts at one retail store for each packing plant. The samples were taken after fabrication of the subprimals and prior to the retail cuts being placed in simulated retail display and also after 48 h of simulated retail display (30-38^{o}F). Samples for data collection at 48 h were placed in the back of each store, in storage rooms at which the temperature required to simulate the retail case storage could be maintained (this prevented their accidental sale to consumers and subsequent loss of samples). Two sponges were required to complete one sample. One sponge was analyzed for APC, TCC, ECC, and *Staphylococcus aureus* counts (SAC) and for the presence of *Salmonella*, and the other sponge was analyzed for the presence of *L. monocytogenes*. For each packing facility, a total of 96 retail cuts were evaluated at the retail facility during the two-day period (48 before simulated retail display and 48 after simulated retail display). Each day, immediately following fabrication of the subprimals, half of the retail cuts (12/day, 24 total) were sponged on the lean side and discarded, and the other half of the retail cuts (12/day, 24 total) were placed in simulated retail display for 48 h before being sponged on the lean side and discarded.

Microbiological Analyses

Samples were analyzed according to procedures described in the Microbiology Laboratory Guidebook of USDA, and the Compendium of Methods for the Microbiological Analysis of Foods.

Statistical analyses

The data were converted to log CFU/100 cm^2 and analyzed by the general linear model and mixed model procedures of SAS (1990). Means and standard deviations were calculated and when F-values were significant at the $P \leq 0.05$ level, mean differences were separated by the least significant difference procedure (SAS, 1990).

Results and Discussion

There were significant ($P \leq 0.05$) differences in microbial counts among plants and among the various cuts at the packing plant. As expected, the carcass excision samples had higher counts than the carcass sponge samples for APC, TCC and ECC at all plants (Table 1). The subprimal retail samples had generally higher counts than the subprimal samples taken from the plant for APC, whereas the subprimal samples taken at the plant had generally higher TCC and ECC than the subprimal samples taken at the retail facility (Table 2). The retail cuts (steaks/roasts) had lower APC and TCC than the subprimal cuts at the retail facility indicating that clean and sanitary retail-cutting procedures were employed at retail stores (Table 2). The low recovery of SAC on final retail cuts indicates some, but low, product contamination from the retail employees. There was a low recovery rate for ECC indicating that fecal contamination of carcasses was kept to a minimum. Overall, *Salmonella* isolation frequency for the sponged and excised carcass samples was 0.7% and 1.7%, respectively (data not presented in tabular form). Overall, *L. monocytogenes* isolation frequencies for the sponged and excised samples were 7.9% and 15.6%, respectively (data not presented in tabular form).

There was some evidence of bacterial growth during packaging and shipping of product, but the overall cleanliness of the process in both the processing and retail facilities allowed the sale of products with low microbiological contamination. There did not seem to be a problem with fecal contamination or contamination with pathogens such as *Salmonella* and *S. aureus*,

however, there seemed to be a definite concern regarding *L. monocytogenes* contamination at the processing and retail stages.

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Tables

Table 1: Effect of sampling procedure (sponging or excising) on means (SD) (log CFU/100 cm^2) of aerobic plate counts (APC), total coliform counts (TCC), generic *E. coli* counts (ECC) for each of the six slaughtering and corresponding retail facilities.

	APC		TCC		ECC	
Plant	SP	EX	SP	EX	SP	EX
1	4.1^{bc} (1.3)	6.8^{bc} (1.4)	1.0^{b} (0.3)	3.2^{ab} (0.8)	1.0^{b} (0.1)	2.8^{ab} (0.2)
2	4.8^{a} (1.1)	7.1^{a} (0.9)	1.7^{a} (0.8)	3.7^{a} (1.0)	1.4^{a} (0.5)	2.8^{ab} (0.5)
3	4.2^{b} (0.8)	6.7^{ab} (1.0)	1.2^{b} (0.4)	3.4^{ab} (0.7)	0.9^{b} (0.1)	2.9^{a} (0.4)
4	3.6^{c} (0.7)	5.8^{c} (0.7)	1.0^{b} (0.2)	2.8^{c} (0.6)	1.0^{b} (0.2)	2.6^{c} (0.1)
5	3.8^{bc} (0.6)	5.8^{c} (0.9)	1.1^{b} (0.4)	3.0^{bc} (0.7)	0.9^{b} (0.0)	2.7^{bc} (0.6)
6	4.0^{bc} (0.8)	7.2^{a} (1.4)	1.0^{b} (0.2)	3.1^{bc} (0.9)	0.9^{b} (0.0)	2.7^{bc} (0.1)

$^{a-c}$ Values within a column with the same superscript letter are not significantly ($P > 0.05$) different.

Table 2: Effect of product type (carcasses, subprimals and retail cuts) for the sponge procedure on means (SD) (log CFU/100 cm^2) of aerobic plate counts (APC), total coliform counts (TCC), generic *E. coli* counts (ECC) and *S. aureus* counts (SAC) for the six slaughtering and corresponding retail facilities combined.

Location	Product	Surface	APC (SD)	TCC (SD)	ECC (SD)	SAC (SD)

Plant	Carcass	Fat	4.1^{f}(1.1)	1.2^{c}(0.5)	1.4^{c} (0.3)	N/A
	Subprimal 1	Fat	5.2^{de}(1.6)	2.6^{a}(1.2)	2.1^{b}(1.1)	N/A
		Lean	4.9^{e}(1.6)	2.6^{a}(1.3)	2.2^{ab}(1.2)	N/A
	Subprimal 2	Fat	5.2^{de}(1.4)	2.7^{a}(1.2)	2.2^{ab}(1.2)	N/A
		Lean	5.0^{e}(1.4)	2.7^{a}(1.2)	2.3^{a}(1.2)	N/A
Retail	Subprimal 1	Fat	6.1^{a}(1.0)	2.6^{a}(0.9)	1.5^{c}(0.4)	N/A
		Lean	6.0^{ab}(0.9)	2.4^{a}(0.9)	1.6^{c}(0.4)	N/A
	Subprimal 2	Fat	5.9^{ab}(1.1)	2.4^{a}(1.1)	1.5^{c}(0.2)	N/A
		Lean	5.8^{ab}(1.1)	2.3^{ab}(1.1)	1.5^{c}(0.3)	N/A
	Steak (0 h) 1	Lean	5.4^{cd}(0.9)	2.2^{b}(0.8)	1.4^{c}(0.2)	1.7(0.5)
	Steak (0 h) 2	Lean	5.1^{c}(1.1)	2.0^{b}(0.6)	1.4^{c}(0.0)	1.6(0.4)
	Steak (48 h) 1	Lean	5.6^{bc}(1.1)	2.1^{b}(0.7)	1.5^{c}(0.3)	1.7(0.5)
	Steak (48 h) 2	Lean	5.5^{bc}(1.3)	2.1^{b}(0.7)	1.5^{c}(0.2)	1.7(0.5)

N=101-288.

N/A = These samples were not analyzed for SAC.

$^{a-d}$ Values within a column with the same superscript letter are not significantly (P > 0.05) different.

Table 3: Effect of sampling procedure (sponging or excising) on the percent positive *Salmonella*, *Listeria* spp., and *Listeria monocytogenes* for each of the six slaughtering and corresponding retail facilities.

	*Salmonella**		*Listeria* spp.*		*L. monocytogenes**	
Plant	SP	EX	SP	EX	SP	EX
1	0.0 (0/48)	0.0 (0/48)	4.2 (2/48)	10.4 (5/48)	0.0 (0/48)	0.0 (0/48)
2	0.0 (0/48)	0.0 (0/48)	0.0 (0/48)	4.2 (2/48)	0.0 (0/48)	2.1 (1/48)
3	0.0 (0/48)	6.3 (3/48)	14.6 (7/48)	14.6 (7/48)	2.1 (1/48)	0.0 (0/48)
4	0.0 (0/48)	0.0 (0/48)	8.3 (8/48)	25.0 (12/48)	2.1 (1/48)	0.0 (0/48)
5	4.2 (2/48)	2.1 (1/48)	20.8 (10/48)	64.6 (31/48)	20.8 (10/48)	62.5 (30/48)
6	0.0 (0/48)	2.1 (1/48)	16.7 (8/48)	31.3 (15/48)	16.7 (8/48)	29.2 (14/48)

* Percent of samples positive (# positive/total samples x 100).