Salmonella Contamination of Swine Carcasses and Pork Products

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Summary and Implications

This paper includes results from two separate studies: one surveyed the level of contamination at four points during the slaughter and processing of chilled pork; the second study surveyed ground pork from 17 companies representing five different segments of ground pork distribution. Regarding the carcass study, the highest percentage of *Salmonella* spp. isolated from the different sampling sites by a swab method, for both pork loin and ham surfaces, was 4.4% after the singeing step of the slaughter process. Overall, 1.7% of all pork samples showing positive isolations for *Salmonella* spp., however, there were no *Salmonella* spp. found in one of the three plants surveyed. *Salmonella* were isolated primarily from pork before fabrication and refrigerated storage. A continous reduction in the numbers of *Salmonella* spp. isolates was detected from the point of singeing to the point of fabrication. No *Salmonella* spp. were isolated from vacuum-packaged pork stored for 36 days at 2EC.

The purpose of the ground pork project was to survey current sources of ground pork, and to determine the effects of different handling methods and raw material sources on the microbial quality of ground pork. There were no significant differences in the microbial counts, or prevalence of selected organisms, between the different types of companies from which the ground pork was obtained. Estimated variance among locations, samples and sample duplicates show that additional ground pork samples are needed to strengthen the results of this study.

Introduction

Foodborne illness is a worldwide problem in developed and developing nations alike. Reports show that pathogenic organisms found in foods cause thousands of individual cases, hundreds of outbreaks, and several deaths each year in the United States. Of all foodborne illnesses, those caused by bacteria are the most common (U.S.D.A., 1989).

Pathogenic bacteria can be found in fresh meats as well as other foods and can be transmitted to consumers and occupationally-exposed people (Bryan, 1980). Meat and meat products have been implicated in the transmission of human pathogens such as *Staphylococcus aureus, Salmonella* spp., *Listeria monocytogenes, Yersinia enterocolitica, and Clostridium perfringens* (Amemiya et al., 1989; Bean and Griffin, 1990; and Ooosterom, 1991). These bacteria enter the slaughtering plants in or on the live animals and personnel, and there are no inspection procedures specifically directed toward these organisms.

The cost of illness, death, and business lost due to bacterial foodborne diseases is high. Some pathogenic bacteria that cause economically important foodborne diseases in the United States include: *Salmonella* spp. [$4.0 billion in economic losses anually], *S. aureus* [$1.5 billion], *L. monocytogenes* [$313 million], *Yersinia enterocolitica* [$109 million], and *Clostridium perfringens* [$123 million] (Todd, 1989).

Comprehensive surveys of the incidence of *Salmonella* spp. on fresh pork in modern, high speed U.S. pork plants are not abundant. A few studies have evaluated the prevalence of selected pathogens at different locations on pork carcasses. However, sampling occurred generally at one point during either slaughter or fabrication. Childers et al. (1977) showed positive isolations for *Salmonella* spp. varying from 0 to 22% on pork carcass cavities following the evisceration process.

Even less research has been conducted on pork carcasses at multiple sampling points throughout the slaughter and fabrication processes, to determine effects of processes on prevalence of pathogens. Epling et. al. (1993) found positive isolations of *Salmonella* spp. on swabbed ham surfaces of 12 to 20% of freshly slaughtered pork carcasses (just prior to chilling), 12 to 21% of conventionally chilled (4EC air for 20 hours) carcasses, and 17% of spray-chilled pork carcasses.

Additional research is needed to evaluate the prevalence of *Salmonella* spp. at multiple sampling points throughout the slaughter and fabrication processes of fresh pork. The objective of the first study of this paper was to determine the prevalence of *Salmonella* spp. on pork carcasses during slaughter, fabrication, and refrigerated, vacuum-packaged storage.

There also is little published data available regarding the bacterial quality of ground pork. Previous research has shown that handling conditions, raw materials sources, and the type of companies handling ground beef could affect the microbial quality of ground beef, but similar information is lacking for ground pork. Guidelines have been established in some states for maximum microbial counts of fresh meats and ground beef, but no limits have been established for ground pork (Wehr, 1982).

Ground meats have a greater surface area than either trimmings or meat cuts, which enhances the growth of aerobic bacteria (Jay, 1992). Also, ground meats may be made from either trimmings from different cuts or from grinding intact primal cuts, such as picnic shoulders, in the case of pork. The intensity of human handling involved in generating trimmings, compared to primal cuts, would be expected to further increase the microbial counts of final ground product.

The objectives of the second study of this paper were to evaluate microbial contamination levels and presence of *Salmonella* spp. of ground pork made from different raw materials; handled either fresh or frozen; obtained from five different areas of meat distribution, including commercial and institutional food service establishments, retail supermarkets, purveyors, and pork slaughter/fabrication plants.

Materials and Methods

Pork Carcass Project

For sample collection, three U.S. pork slaughtering plants located in the Midwest were chosen because they were typical of modern pork slaughtering plants, and had comparable line speeds (approximately 960-1000 head/hour). The three plants were visited at random on three different occasions each. Fifteen pork carcasses were selected randomly at the areas immediately after singeing and polishing and after the final rinse on the slaughter floor on the first day of sample collection. The next day, 15 different carcasses from the previous day's slaughtering process were swabbed after an 18- to 24-hour period in the carcass coolers. All carcasses were swabbed on the dorsal side of the ham and the midpoint of the loin. The sides of the carcass to be swabbed were chosen at random to allow for any differences in the amount of handling done by the production personnel (Gerats et al., 1981). Also from the same slaughter day, 15 boneless loins were swabbed on the ventral side, immediately before packaging. Hams were not swabbed in the cutting and fabrication areas.

The sampling of the carcasses was done by using a moistened-swab technique. The boneless loins also were swabbed in this manner to maintain consistency of sample collection for later comparisons. The pork carcasses were swabbed on line, as they passed by, so as to minimize the disruption of normal production. The boneless loins were sampled on nearby tables in the packaging area to avoid interference of work in the plants. The personnel involved wore sterile surgical gloves at all times to prevent cross-contamination.

During swabbing, sterile cotton swabs were first aseptically dipped into a 9-ml. screw-cap test tube containing sterile 0.1% phosphate buffer saline (PBS) solution adjusted to a 7.0-7.2 pH. Next, while being held at approximately a 30E angle, the swabs were stroked across the meat surface firmly and uniformly 12-15 times inside a 100-cm^2 template. The swabs were then rotated and stroked another 12-15 times perpendicular to the first swabbing direction.

After the swabbing procedure, the swabs were placed into the screw-cap test tubes containing PBS solution. The tubes were then placed in test tube racks and stored on ice and transported to the Iowa State University Meat Laboratory for the microbiological testing. Upon returning to the ISU Meat Laboratory, all sample tubes were vortexed for 20-30 seconds using a Super-Mixer (Curtin Matheson Scientific, Inc.) and serially diluted with 0.1% PBS, according to standard procedures.

At each plant, five vacuum-packaged pork loins were obtained, transported to Iowa State University, Ames, Iowa for refrigerated storage (2EC, Site-E, Table 1) for 36 days and bacteriological testing.

The isolation methods used in this study were obtained from the U.S. Food and Drug Administration's Bacteriological Analytical Manual (1984). Tubes containing the swabs were agitated in a vortex mixer for 20-30 seconds, and 0.5-ml. portions of the sample suspension were used for isolation procedures.

For isolation and identification of *Salmonella* spp., samples were pre-enriched in lactose broth (Difco, Detroit, MI) and incubated for 24 " 2 hours at 35EC. Further enrichment was achieved by transfer into tetrathionate broth (Difco, Detroit, MI) and incubation for 24 " 2 hours at 42EC. Confirmation was done by plating growth from tetrathionate broth in Brilliant Green and Salmonella Shigella Agar (Difco, Detroit, MI) and incubating for 48 " 2 h at 37EC. Typical colonies were identified by Triple Sugar Iron (Difco, Detroit, MI) and Lysine Iron Agar tests (Difco, Detroit, MI).

The prevalence of each isolate was analyzed by using the Statistical Analysis System, according to General Linear Model (GLM) procedures (SAS, 1986). First, an analysis of variance was performed by using a randomized complete-block design with replications being the blocking variable. The "treatments" in this design followed a factorial structure with "locations" and "types" (loin vs. ham) as factors.

Ground Pork Project

Ground pork samples were obtained from commercial and institutional food service operations, supermarkets, purveyors or processors, and pork slaughter/fabrication plants. Samples were classified by how each company received and handled ground pork, such as fresh (never frozen), frozen, fresh then frozen before cooking or selling, frozen then thawed before cooking or selling, and fresh/frozen and thawed before cooking or selling. Samples were also classified according to these factors: if the ground pork was preground before the company purchased the raw materials, if the ground pork was ground on the premises of the company, or both. Finally the samples were classified by composition of the raw materials used in making the product, including sow butt/picnics, sow trimmings, butcher butts/picnics, butcher trimmings, and miscellaneous trimmings. A minimum of three samples were obtained on three different days from each company and all sampling was done in duplicate. Tissue samples were used in the following methods.

Presence of *Salmonella* spp. was detected using the 1-2 Test7 (Biocontrol Systems, Bothel, Washington). A 25 g. ground pork sample was homogenized in 225 mL. lactose broth, using a stomacher. The sample was incubated for 24 "2 hours. at 35EC. One mL of the pre-enriched sample was transferred into 9 mL. tetrathionate brilliant green broth, and

incubated for 24 hours. at 42EC. For the 1-2 Test7, 1.5 mL. of the TBG broth was transferred into the 1-2 Test chamber and incubated dfor 24 hours. at 37EC. Presumptive positive samples were confirmed by triple streaking onto Hektoen Enteric and SLD pre-poured plates and incubated for 24 hours. at 37EC.

Results and Discussion

Pork Carcasses

An overall average of 1.7% of all pork carcass samples showed positive isolations for *Salmonella* spp. (Table 1). The highest percentage of *Salmonella* spp. isolated from the different sampling sites, for both loins and hams, was 4.4% after singeing (Site A, Table 1). There were no *Salmonella* found in one of the three plants.

A continuous reduction in the numbers of *Salmonella* isolates was detected from the point of singeing (4.4% at Site A) to after the final wash at the end of the slaughter process (1.1% at Site B), and after 24-hour chilled storage (0.4% at Site C, Figure 1). The numbers of *Salmonella* spp. were almost unchanged between samples from carcasses after 24-hour chilled storage (0.4% at Site C) and those from loins before packaging (0.2% at Site D, Table 1). *Salmonella* spp. was not detected in vacuum-packaged pork loins stored for 36 days at 2EC (Site E, Table 1).

This study shows that, although plants may be of similar overall design and line speed, pathogenic bacterial counts on carcasses at different points during processing can differ significantly (Table 1). Undoubtedly, differences in equipment layout and operating protocols (such as personnel training and hygiene, and equipment and plant sanitation) exist among plants.

The relatively low levels of *Salmonella* detected in this study probably were caused by the combination of processing steps. The singeing treatment during slaughtering procedures destroys microorganisms on carcass surfaces exposed to heat, but the heat treatment over all surfaces of the carcass is usually uneven, and organisms in deeper layers of the surface tissue can be protected from the heat (Kampelmacher et al., 1961). The gradual reduction in the number of *Salmonella* isolates after the final wash (Site B) and after 24-hour chilled storage (Site C) probably was due to the physical removal of cells during the washing of carcasses, as well as the less than optimal temperatures for growth of Salmonella after the 24-hour chilled storage. Kelly et al. (1982) observed that washing or spraying fresh lamb carcasses with hot or cold water or with chlorinated water reduced microbial counts. Dockerty et al. (1970) also determined that washing of carcasses reduced mesophilic counts. There are only few studies on the growth of *Salmonella* spp. on vacuum-packaged fresh meat because the temperatures at which such a product is stored are not conducive to the growth of this pathogen. The optimum growth temperature for *Salmonella* is 35E-37EC, with the lowest growth temperature reported in a food being 6.7EC (Angelotti et al., 1961). That *Salmonella* was not detected in vacuum-packaged loins stored for 36 days at 2EC (Site E) also would be attributed to low storage temperatures.

Ground Pork

The highest incidences (and ranges) of *Salmonella* spp. were found in ground pork obtained from purveyors or processors and supermarkets (Table 2). The lowest incidences (and ranges) of *Salmonella* spp. were found in ground pork obtained from packers and institutional food service establishments. Processors, purveyors and supermarkets are the most likely of the types of companies surveyed in this study to handle fresh (unfrozen) ground pork, from numerous suppliers, suggesting that cross-contamination from packers other than the three surveyed in this study may have caused the higher incidence of *Salmonella* spp.

The results of this study indicate that taking as few as 6 samples from each company resulted in very high mean square error values for *Salmonella* spp. (Table 2). This might have some practical significance for companies attempting to make conclusions about product safety or equipment sanitation, based on small numbers of samples.

Preground pork was used primarily at foodservice establishments, while pork was ground on-site by packers, processors, and supermarkets.

There were no significant differences found in positive isolations of *Salmonella* spp. between ground pork made from different raw material sources (Table 2).

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Table 1. Percent positive isolations of *Salmonella* spp., from fresh pork loins and hams, during slaughter and processing at four sampling locations in three pork plants.

	Sampling sites in pork plants[a]							
	A[b]		B[b]		C[b]		D[c]	E[d]
Overall	4.4		1.1		0.4		0.2	0
	Ham	Loin	Ham	Loin	Ham	Loin	Loin	Loin
Plant #1	15.5	11.1	0	0	2.2	0	0.7	0
Plant #2	0	0	4.4	2.2	0	0	0	0
Plant #3	0	0	0	0	0	0	0	0

[a] Sampling locations in pork plants included: A - carcasses after singeing and polishing, B - carcasses after final rinse on slaughter floor, C - carcasses after 24 hr. chill, D - boneless loins, just prior to packaging, E - 36 days storage at 2°C.

[b] percent positive isolations from 270 ham and loin samples

[c] percent positive isolations from 135 loin samples

[d] percent positive isolations from 45 loin samples

Table 2. Comparison of percent positive isolations for *Salmonella* spp. from commercially available ground pork, obtained from different types of companies, using different handling methods, and raw material sources.

	Types of Companies				
	Packer	Processor/ purveyor	Institutional foodservice	Commercial food service	Retail supermarkets
N	18	30	18	16	18
Salmonella spp.	0%	18.8%	0%	12.5%	20.0%
Ranges	(0%)	(0-66.7%)	(0%)	(0-33.3%)	0-33.3%)

	Grinding Methods	
	Preground	Ground On-Site
N	30	66
Salmonella spp.	5.9%	10.3%
Ranges	(0-33.3%)	(0-66.7%)

	Handling Conditions	
	Fresh	Frozen
N	36	42
Salmonella spp.	6.3%	9.5%
Ranges	(0-66.7%)	(0-66.7%)

	Raw Material Sources	
	Sow	Butcher
N	24	72
Salmonella spp.	18.2%	9.8%
Ranges	(0-33.3%)	(0-33.3%)

*Significantly different ($P<0.05$)