SOURCES OF SALMONELLAE CONTAMINATION OF MEAT FOLLOWING APPROVED LIVESTOCK SLAUGHTERING PROCEDURES. II

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Abstract

Samples were taken from 218 animals of 3 species slaughtered at 3 plants to determine the spread of bacterial contamination during slaughter. Salmonellae and *Escherichia coli* were cultured from swabs taken of the equipment during slaughter, from various carcass sites, and from fecal samples. The study indicated that some equipment contamination occurred during slaughter and that carcass washing did not remove contaminants but simply washed them lower on the carcass. Rumen/cecum samples were most effective for isolation of salmonellae from the gastrointestinal tract. The average level of salmonellae contamination of the carcass for all species was 10% and of the processed product, 2%. There were no salmonellae isolated from cattle carcasses. Isolation of the bung (rectum) with a plastic bag did not reduce contamination but sterilization of the bung dropper's knife between carcasses reduced the incidence by an average of greater than 50%. Salmonellae were isolated from boneless mutton but not from raw or cooked pork and beef products. Isolations from the hide were closely related with carcass contamination. Enrichment and non-enrichment media isolations of salmonellae were closely related.

In spite of the large amount of work that has been done to reduce its incidence, salmonellosis remains as one of the major food-borne hazards to human health. In a review of the literature, Newell and Williams *(10)* reported that excretion of salmonellae by livestock increased from the farm to the slaughtering plant. They also reported various factors in slaughtering plant design, such as air movement and carcass washing, which affect salmonellae contamination of the carcass. Pether and Gilbert *(11)* demonstrated that *Salmonella anatum* survived for 3 h on the fingers of food plant workers and that organisms could be isolated from workers' hands following a 15-sec handwash with warm water. Minimal inoculation of workers' hands was sufficient to contaminate meat products. *Escherichia coli* was also isolated from the fingers of 13 out of 110 butchers.

Knivett *(7)* reported that 25% of the carcasses of chickens subclinically infected with *S. typhimurum* and subsequently treated with furazolidone were found to be contaminated following processing. Chlorination of the carcass chill water at the level of 200-250 ppm significantly reduced the number of contaminated carcasses. Bicknell *(3)* reported on *S. aberdeen* infection in a cattle herd grazing land irrigated with sewer effluent. There were no reported human cases of salmonellosis from the area of the effluent.

Matches and Liston *(8)* reported that salt concentrations sufficient to prevent growth of salmonellae at low temperatures might not be sufficient to prevent growth at higher temperatures. Also, they found that salmonellae could grow only over a narrow pH range at low temperatures *(9)*. In two articles Ray et al. *(13, 14)* indicated that samples of non-liquid products taken at the beginning of a day's production were more likely to give accurate data on salmonellae contamination that those taken later. In a companion paper *(14)* there authors reported that extended storage may reduce salmonellae contamination but will not eliminate it completely.

Enkiri and Alford *(5)* reported that low-incidence strains of salmonellae were more susceptible to dry and frozen storage while higher-incidence serotypes showed longer survival in frozen storage. Stersky et al. *(15)* reported that survival of air-borne *S. newbrunswick* was quite variable in a food processing plant and that long-term survival could present a definite public health hazard. Baldwin et al. *(2)* presented evidence to show that microwave heating of some fish products did not kill all salmonellae. Three hundred ninety seconds were required to obtain a lethal dose in some fish products, a period which exceeds the normal heat time in microwave ovens.

Bailey et al. *(1)* traced an outbreak of *S. panama* enteritis to infected ham from a plant in which one worker was excreting the organism. Sewer samples from the plant also yielded the organism. After removal of the infected worker the organism could no longer be isolated from the sewage. A later human outbreak was traced to infected hams that had been served in the plant canteen. Examination of swine subsequently slaughtered at the plant was negative. Price et al. *(12)* reported that pooling of pre-enrichment lactose broth culture was effective in screening multiple blood samples.

TABLE 1. SALMONELLAE AND *E. coli* ISOLATIONS FROM 74 CATTLE

Locations	Control (32)		Bung bagged (25)		Bung knife sterilized (16)	
	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)
Body cavities	0	62	0	49	0	29
Midline	0	73	0	44	0	19
Vertebra and neck	0	42	0	40	0	38

TABLE 2. SALMONELLAE AND *E. coli* ISOLATIONS FROM 64 SWINE

Locations	Control (34)		Bung bagged (10)		Bung knife sterilized (20)	
	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)
Body cavities	17	49	7	70	2	38
Midline	24	62	0	40	15	20
Vertebra and neck	19	51	10	60	5	25

TABLE 3. SALMONELLAE AND *E. coli* ISOLATIONS FROM 40 SHEEP

Locations	Control (30)		Bung knife sterilized (10)	
	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)
Body cavities	5	70	0	50
Midline	17	42	0	50
Neck	0	69	0	0

TABLE 4. SALMONELLAE AND *E. coli* ISOLATIONS FROM 19 CATTLE AND 21 SWINE BEFORE AND AFTER WASHING

Locations	Before washing		After washing	
	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)
Pelvic cavity	2	33	2	43
Abdominal cavity	5	48	0	53
Midline	5	63	5	45
Thoracic cavity	2	45	2	48
Vertebra	2	40	5	40
Neck	2	50	2	45

This research was the continuation of a previous, more limited study *(4)*.

EXPERIMENTAL METHODS

Microbiological samples from cattle, swine, and sheep were taken at 3 meat packing plants on 1 day each month for 19 months. Approximately 12 animals of the same species were sampled each month. Animals to be sampled the following day were randomly selected from the holding pens and identified. A sterile swab was user to take samples from the rectum at the time of arrival at the plant and immediately before slaughter. The animal's temperature was taken on arrival and before slaughter. Five 10-g samples of holding pen droppings were taken on the day of slaughter.

Before the beginning of slaughter a 100-ml sample of hog-scald-tank water was taken. A 100-inch^2 area of two viscera pans and the head wash cabinet was swabbed midway through the day's operations using a sterile template to describe the area. Two 100-ml samples of water from the sterilizers were taken during the day's operations and the temperature recorded. With two sterile swabs an area of approximately 100-inch^2 on each carcass was swabbed from the midline, the abdominal cavity, the thoracic cavity, the pelvic cavity, sawed vertebral surfaces, and the neck. During the last one-third of the study the ventral surface of the hide was also swabbed before opening. Ten-gram samples of rumen contents from cattle and sheep and swabs of cecal contents of swine were taken. Swine cecal contents were too watery to permit collection of solid samples. All samples were immediately chilled and held at 3 C until cultures were initiated.

Carcass identity was maintained throughout the processing operation. After further processing, consumer-size packages of products manufactured with meat from the sampled carcasses were taken. Both raw and cooked products were sampled. Since the sheep slaughtering plant produced only boneless manufacturing mutton, samples of boneless mutton were taken. All product samples were frozen at −18 C until analyzed.

The samples of fecal material were divided and handled in the same manner as the two swabs. Difco media were used in this study. The two swabs and two fecal material samples were used to initiate cultures in lactose broth and tetrathionate broth, both of which were incubated for 24 h at 35 C. After incubation the tetrathionate broth was used to inoculate brilliant green sulfadiazine (BGS) and salmonella - shigella (SS) agars which were incubated for 24 h at 35 C; and the lactose broth was used to inoculate tetrathionate broth and eosin-methylene blue (EMB) agar. The EMB agar was incubated for 24 h at 35 C. Presumptive *E. coli* colonies were confirmed using IMVIC reactions. Nine typical salmonellae colonies per plate were inoculated into triple sugar iron and lysine iron agar and incubated for 24 h at 35 C. Those showing typical salmonellae reactions were confirmed by somatic and flagellar antigens. Processed meat samples were handled in the same manner using a 30-g sample according to the methods described by Galton et al. *(6)*.

RESULTS AND DISCUSSION

During the 19-month sampling period 93 cattle, 85 swine, and 40 sheep were sampled. The number of sheep sampled is low because the cooperating plant closed and there were no other sheep slaughtering facilities within a reasonable distance.

For the first 6 months samples were collected from animals slaughtered using routine procedures to establish a base-line of salmonellae and *E. coli* incidence. These incidence rates are shown in Tables 1-3 in the "Control" column. Following this, the role of carcass washing in spreading contamination was investigated (Table 4). It appears that washing has little effect on the level of carcass contamination. From these data, one must question the practice of permitting large amounts of fecal material to be washed off of the carcass instead of being trimmed.

Two modifications of slaughtering practices to reduce carcass contamination were evaluated. One was bagging the bung (rectum) at the time of dropping. A large, non-sterile plastic bag was placed over the bung and tied in place before dropping it into the abdominal cavity. As seen in Tables 1 and 2 bung bagging had some effect on reducing car-

cass contamination in cattle but in swine it decreased the level of salmonellae contamination. Apparently the pelvic cavity became contaminated from the worker's hands and knife during bung dropping with the outside of the plastic bag being contaminated in the pelvic cavity and contaminating other parts of the carcass. This technique was not used on sheep since the bung is not routinely tied during evisceration.

The second modification was to sanitize the butcher's knife immediately before dropping the bung. These results are shown in Tables 1-3. This technique was successful in reducing both salmonellae and *E. coli* contamination in all species. In the case of sheep, the results may not be accurate since the sheep bung-dropper understood very little English and probably did not sterilize his knife as intended.

TABLE 5. SALMONELLAE AND *E. coli* ISOLATIONS FROM EQUIPMENT IN SWINE, CATTLE, AND SHEEP SLAUGHTER PLANTS

	Swine - 8 times		Cattle - 7 times		Sheep - 4 times	
Locations	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)	Sal. (%)	*E. coli* (%)
Sterilizers (174-180)	0	0	0	0	0	0
Viscera pans	13	38	0	29	50	75
Head cabinet	—	—	14	43	—	—
Scald tank (137-144)	13	0	—	—	—	—

TABLE 6. SALMONELLAE ISOLATIONS FROM INTESTIONAL AND FECAL SAMPLES OF SWINE, CATTLE AND SHEEP

Location	Swine (%)	Cattle (%)	Sheep (%)
Rectal after arrival	13	0	20
Rectal before slaughter	22	1.5	20
Rumen or cream	32	3	38
Pen droppings	23	9	10

TABLE 7. SALMONELLAE ANL *E. coli* ISOLATIONS FROM SAMPLES OF RAW AND COOKED PROCESSED PRODUCTS

	Raw		Cooked	
Products and number of samples	Sal. (%)	— *E. coli* (%)	Sal. (%)	— *E. coli* (%)
Beef				
Bonless - 13	0	0	—	—
Hamburger - 11	0	0	—	—
Pork				
Chops - 13	0	0	—	—
Sausage - 27	0	0	0	0
Mutton				
Bonless - 20	10	0	—	—

TABLE 8. SALMONELLA AND *E. coli* ISOLATIONS FROM HIDE AND CARCASS OF CATTLE AND SWINE

	Swine (23)		Cattle (19)	
Location	Sal. (%)	— *E. coli* (%)	Sal. (%)	— *E. coli* (%)
Hide	13	37	0	57
Carcass	22	57	0	63

Equipment isolations are shown in Table 5. It does not appear that equipment sanitizing was adequate in all cases. Perhaps 180 F water should be used on both the visera pan and head wash cabinet between each carcass instead of only when they have been obviously contaminated. Though the sterilizer temperatures were sometimes below 180 F no isolations were made from the water. Salmonellae was isolated from the hog scald tank water one time.

Table 6 shows the isolations of salmonellae from the rectum after arrival and before slaughter, from holding pen droppings, and from the rumen or cecum, depending upon the species. As expected, the number of isolations increased between the time of arrival and the time of slaughter *(10)*. However, rumen/cecum isolations were highest of all, perhaps indicating that this might be the best location for sampling. Results from the processed meat samples are in Table 7. *E. coli* was not isolated from the processed products and salmonellae were isolated only from 2 boneless mutton samples.

E. coli contamination of the carcass was high in all species, averaging 59% in cattle, 54% in swine, and 60% in sheep. Salmonellae isolations were zero from cattle, 20% from swine, and 7% from sheep. Some of the sheep slaughtered during the study were in poor condition and stress by drought and may have been excreting organisms in excess of what would normally be expected.

To monitor the hide's role in carcass contamination, sterile swabs were made of the midline area before opening the hide or skin (swine) for evisceration. The skin of 23 swine was sampled after removal from the dehairer and 19 cattle were sampled before opening the midline. No sampling was done on the hide of sheep. These results are in Table 8. A total of 100 isolations of salmonellae were made. Of this number 55 were made on both enrichment (lactose and tetrathionate) and non-enrichment (tetrathionate only) media. Twenty nine isolations were made on non-enrichment media only and 16 were made on enrichment media only.

The average level of salmonellae contamination of the carcass was 10% and of the processed products, 2%. This study does not show salmonellae to be a problem in cattle but that a problem does exist in swine. The salmonellae isolations from sheep must be evaluated carefully in view of the unusual climatic conditions existing at the time of the study. Sterilization of the bung dropper's knife reduced salmonel-

lae contamination from 10% to 2.5% and *E. coli* contamination from 58% to 30%.

The following bioserotypes of *Salmonella* were detected: S. *java*, 21.15%; S. *derby*, 24.04%; S. *anatum*, 15.38%; S. *newlands*, 10.58%; S. *heidelberg*, 7.00%; S. *oranienberg*, 6.00%; and miscellaneous and those not assignable to types, 15.85%.

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