

Salmonella in commercial swine from weaning through slaughter

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Abstract

Sixty swine on each of four farms in Iowa and on four farms in North Carolina were monitored for *Salmonella*, from weaning through kill. Two farms in each state used all-in-all-out (AIAO) management, while two were continuous flow. All pigs were individually identified, in North Carolina with ear tags and in Iowa with implanted microchips. Feces for culture and serum for Danish mixELISA were collected at weaning and approximately every eight weeks, with the fourth collection coming within 48 hours of slaughter. At slaughter, carcasses were swabbed using the FSIS method. Ileocecal lymph nodes, cecum, and/or colon were collected.

The results indicate that on-farm sampling is either fairly insensitive in detecting *Salmonella* infected hogs compared to in-plant tissue sampling or that there is significant infection during transportation and lairage. On the Iowa farms, 6 of 202 (3%) hogs were positive by fecal culture and 4 of 195 (2%) by ELISA at pre-slaughter, compared with 57 of 145 (39%) tissue positives. In North Carolina, 11 of 194 (6%) were fecal positive, 2 of 199 (1%) were ELISA positive, and 72 of 192 (38%) were tissue positive. This suggests that neither on-farm fecals nor serum ELISA testing will give an accurate picture of the of the in-plant culture results and the potential public health risks. The ELISA may, however, be more indicative of the intensity of infection on the farm. All carcass swabs were negative.

In comparing management systems, hogs from continuous flow farms in Iowa were tissue positive 16 of 51 (31%) while AIAO hogs were 41 of 94 (44%). In North Carolina, continuous flow farms had 42 of 80 (53%) tissue positives, while AIAO farms showed 30 of 102 (29%). It appears that, on these farms, the management system is not a critical control point for *Salmonella* and perhaps not even a control point.

The Iowa experience with microchip identification proved positive. Microchips were implanted during the first sampling. If retained for the first two weeks, there was a high degree of confidence that the chip could be followed through to the cooler, unless the hock region was excessively damaged at the plant.

Introduction

The implementation of the Pathogen Reduction and HACCP Regulation of 1996 required producers and processors to re-examine their respective roles in the control of physical, chemical, and microbial contamination of meat and poultry products. Within the HACCP framework is embedded a heightened attention to the microbial status of swine being presented to the processor, and to the on-farm activities that can be utilized to reduce this microbial load as active infectious and carrier states. This study compared the procedures in All-In-All-Out (AIAO) and continuous flow swine production systems which may influence the *Salmonella* status of swine offered for slaughter from two geographic regions during a 12 month period.

Salmonella can frequently be found on swine farms. A survey of producers with grower/finisher pigs from the major swine producing states (Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Pennsylvania, South Dakota, Tennessee, and Wisconsin) showed a 6% (414/6,655) sample prevalence and a 38% (58/152) herd prevalence (4).

A study of foodborne disease outbreaks between 1977 and 1984 showed that 11% of *Salmonella* outbreaks attributed to meats could be linked to pork (2). In comparing the ten most common serotypes of *Salmonella* recovered from swine in 1995 (5) with the list of the ten most common serotypes isolated from human disease (3), three serotypes, *S. typhimurium*, *S. heidelberg*, and *S. agona*, occur on both lists.

Materials and Methods

Sixty swine on each of four farms in Iowa and on four farms in North Carolina were randomly selected from their cohorts and were monitored for *Salmonella*, from weaning through kill. Two farms in each state used all-in-all-out (AIAO) management, while two were continuous flow. All pigs were individually identified at the first nursery visit, in North Carolina with ear tags and in Iowa with implanted microchips (AVID). The number of swine selected was calculated to provide a 95% statistical probability of detecting infection rates of >4-5%, depending on the sizes of

rates of >4-5%, depending on the sizes of the study cohorts.

Samples were collected at weaning and approximately every eight weeks, with the fourth collection coming within 48 hours of slaughter. One gm fecal samples were obtained using sterile fecal loops and were cultured using the methods of Fedorka-Cray et al. (4). Serotyping of isolates was done at the National Veterinary Services Laboratory (NVSL). Serum was collected for Danish mixELISA (1). All research animals were transported to a single abattoir in each state to reduce plant variability. At slaughter, carcasses were swabbed using the FSIS method. Ileocecal lymph nodes,

cecum, and/or colon were collected and 10 gm samples were cultured as above. Two seasonal cycles of sampling were conducted; the first is reported below. The second cycle has been finished but not completely tabulated.

Results

The *Salmonella* positives found on farm are given in Table 1, with the sequential sampling numbered 1 through 4. The abattoir results are shown in Table 2. Farms 1 and 2 in each state were the continuous flow farms, while farms 3 and 4 had AIAO management.

Table 1. *Salmonella* positives on farm.

	Fecal 1	ELISA 1	Fecal 2	ELISA 2	Fecal 3	ELISA 3	Fecal 4	ELISA 4
IA farm 1	0/60	0/60	0/59	0/56	0/58	1/57	0/60	2/59
IA farm 2	0/60	0/60	0/45	0/45	0/39	0/39	0/38	2/38
IA farm 3	0/60	0/60	0/55	0/55	0/51	0/51	6/51	0/45
IA farm 4	0/60	0/60	0/52	0/52	0/51	0/47	0/53	0/53
NC farm 1	1/60	0/60	6/59	23/60	0/55	11/55	9/30	0/31
NC farm 2	0/60	0/60	0/59	0/59	0/57	0/59	0/59	0/59
NC farm 3	7/60	0/60	0/57	0/57	19/53	6/54	2/49	0/49
NC farm 4	6/60	0/60	3/59	1/59	1/54	1/57	1/55	0/55

Table 2. *Salmonella* positives from the abattoir.

	Swab	Cecum	Colon	I-CLN
IA farm 1	0/59	N/A	5/22	2/22
IA farm 2	0/34	N/A	6/29	7/29
IA farm 3	0/50	9/49	15/49	9/49
IA farm 4	0/51	13/45	14/45	7/45
NC farm 1	0/31	16/31		11/31
NC farm 2	0/50	21/59		8/59
NC farm 3	0/49	21/49		5/49
NC farm 4	0/53	5/53		3/53

A listing of *Salmonella* serotypes recovered from fecal samples is given in Table 3. The serotypes recovered from tissues are listed in Table 4. The results from tissues from two farms are incomplete, so these farms are not listed. *Salmonella typhimurium (copenhagen)* is given as copenhagen in these tables.

Table 3. *Salmonella* serotypes isolated from fecal samples.

Farm	Visit 1	Visit 2	Visit 3	Visit 4
NC 1	anatum	derby, anatum, copenhagen	0	copenhagen
NC 2	0	0	0	0
NC 3	muenster	0	agona	0
NC 4	copenhagen, derby	derby	derby	pending
IA 1	0	0	0	0
IA 2	0	0	0	0
IA 3	0	0	0	typhimurium
IA 4	0	0	0	0

Table 4. *Salmonella* serotypes isolated from tissues.

Farm	Cecum/gut	Ileocecal lymph node
NC 1	anatum, heidelberg, kentucky, agona, bovis-morbificans, infantis, muenchen, copenhagen	copenhagen
NC 2	mbandaka, reading, copenhagen, derby, heidelberg, anatum	mbandaka, newport, heidelberg, derby
IA 1	derby, worthington, infantis, untypeable	copenhagen
IA 2	derby, C2*	derby, C2*
IA 3	worthington, derby, senftenberg	derby, copenhagen
IA 4	st. paul, infantis, untypeable, anatum, derby, senftenberg, typhimurium	derby, anatum, untypeable

* serogrouped but serotype not yet available.

Discussion

The results indicate that on-farm sampling is either fairly insensitive in detecting *Salmonella* infected hogs when compared to in-plant tissue sampling or that there is significant infection during transportation and lairage. On the Iowa farms, 6 of 202 (3%) hogs were positive by fecal culture and 4 of 195 (2%) by ELISA at pre-slaughter, compared with 57 of 145 (39%) tissue positives. In North Carolina, 11 of 194 (6%) were fecal positive, 2 of 199 (1%) were ELISA positive, and 72 of 192 (38%) were tissue positive. This suggests that neither on-farm fecals nor serum ELISA testing will give an accurate picture of the of the in-plant culture results and the potential public health risks.

The culture results from the tissues call into question the role of management. In Iowa, 16 of 51 (31%) hogs were positive from continuous flow farms, while 41 of 94 (44%) were positive from AIAO farms. In North Carolina, 42 of 90 (47%) of hogs from continuous flow farms were positive, compared to 30 of 102 (29%) from AIAO farms. While management type may prove to be a control point for *Salmonella* levels in commercial swine, it does not appear to be a critical control point.

Some of the discrepancy between fecal and tissue culture results may be due to sporadic fecal shedding. More frequent fecal sampling might be advantageous. The protocol for this experiment required 1 gm of fecal material but 10 gm of tissue for culture. It is possible that this resulted in the tissue culture being more sensitive than the fecal culture. However, some practical difficulties would

arise in the collection of 10 gm of feces from each of 60 animals. It is also possible that the stress of transportation resulted in the activation of previously quiescent infections.

The ELISA results may be more indicative of the intensity of infection. A transient enteric infection would be less likely to result in an immune response than would a generalized, systemic infection.

All carcass swabs were negative. The abattoirs appear to have good sanitation practices and an acetic acid rinse is used prior to chill where the samples were collected.

In comparing Tables 3 and 4, some serotypes found in feces were not seen in the tissues. However, an even greater number of serotypes were found in the tissues that were not seen in the feces. Table 4 shows that there were many more isolates from the intestinal tissues compared to the ileocecal lymph node. It is possible that many of the intestinal isolates are more transitory while those from the lymph nodes are more invasive or persist for longer periods. It has been shown that *Salmonella typhimurium* will persistently infect swine (6). In this study, *S. typhimurium* and *S. typhimurium (copenhagen)* were generally found in the lymph nodes and occasionally in other tissues. *S. derby* appeared equally in both tissues, while other serotypes were more likely to be intestinal.

The Iowa experience with microchip identification proved positive. Microchips were implanted during the first sampling. If retained for the first two weeks, there was a high degree of confidence that the chip could be followed through to the cooler, unless the hock region was excessively damaged at the plant. Of those animals which demonstrated the microchips at the second visit and were sampled in the cooler, 195 of 202 (97%) retained the chips.

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