Feed and feed trucks as sources of *Salmonella* contamination in swine

Paula J. Fedorka-Cray, PhD; Alex Hogg, DVM, MSc; Jeffrey T. Gray, PhD; Kenneth Lorenzen, DVM; Jaime Velasquez, DVM; Paul Von Behren, DVM

Summary

Purpose: To investigate whether feed trucks and feed could be sources of *Salmonella* contamination in swine operations.

Materials: Five hundred forty-nine swab samples were taken from approximately 25 different places in the grain box on 22 different feed trucks and cultured for *Salmonella* spp. In addition, a sample of the feed components from 17 of those trucks was cultured for the presence of *Salmonella*.

Results: Culture of both truck swab and feed samples indicate that *Salmonella* was present on five of the 22 (22.7%) trucks. A total of 549 swabs were cultured and the rate of isolation was 0.7% (four of 549 positive for *Salmonella*). Positive swabs were recovered from three trucks for a recovery rate of 13.6%. Feed was submitted for 17 of 22 trucks and *Salmonella* was recovered from four of 17 samples (23.5%). However, positive swabs and feed samples only matched for two trucks. No trucks had been used to transport livestock within the past 30 days nor were any trucks cleaned or disinfected between loads.

Implications: While sample prevalence of *Salmonella* in feed trucks is low (0.7%), the overall contamination rate for feed trucks is much higher (22.7%). The presence of positive feed samples suggests that feed could be a source of *Salmonella* contamination for swine.

Keywords: swine, *Salmonella*, feed, trucks, food safety

Received: October 3, 1996
Accepted: April 15, 1997

PJF: United States Department of Agriculture: Agricultural Research Service, Richard Russell Research Center, 950 College Station Road, Athens, Georgia 30605–2720, e-mail: pcray@ars.usda.gov; AH: MVD Laboratories, Inc.; JTG: University of Osteopathic Medicine and Health Sciences; KL: Sutton Veterinary Clinic; JV: Universidad de Antioquia; PVB: private practitioner

Disclaimer:

Product names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

This article is available on the AASP Web site at:

http://www.aasp.org/shap/issues/v5n5/index.html

Salmonella spp. are ubiquitous in nature, having been recovered from nearly all vertebrates,[1] and are associated with foodborne illness in human beings.[2] Human infection with *Salmonella* typically occurs when contaminated food products are ingested, resulting in severe gastroenteritis. Contaminated swine, cattle, and poultry have been implicated as sources of human infections,[2,3] and humans themselves have been demonstrated to be both short- and long-term carriers.[4,5] Additionally, swine have been observed to be carriers of *S. typhimurium*,[6–8] a serotype generally associated with Salmonellosis in humans, and *S. choleraesuis*.[9–11] Factors that influence the epidemiology of salmonellosis in animals and humans include by-product meals, feed components, mixed feeds, water, farm and slaughter animals, abattoirs, by-product plants, transport, waste water, milk, and other dairy products.[12]

Salmonella is now considered to be a geonosis, not just a zoonosis,[13] making *Salmonella* contamination of animals, feedstuffs, and the environment a global concern. Since 1961, the Swedish government has mandated that all isolations of *Salmonella* from animals, feedstuffs, and the environment in Sweden be reported to the Board of Agriculture.[14] *Salmonella* infections in swine are responsible for millions of dollars in lost revenue to the swine industry,[15,16] prompting a worldwide interest in the production of "*Salmonella*-free" feeds and foods in Europe, Canada, and the United States.[12]

In pigs, observed sources of contamination include rodents, insects, humans, and contaminated feed and feedstuffs.[17] Flies and dust can also act as mechanical vectors that spread *Salmonella* throughout the facility or environment.[18,19] It is well known that animal feeds frequently contain *Salmonella* and that animals fed contaminated feed often become infected.[20] The rate of contamination of animal protein delivered to a large feed mill in the southeastern part of the United States was reported over a 10-month period.[21] Of 311 samples, 68% contained one or more of the 68 *Salmonella* serotypes identified in the study. Eighty-six percent of the meat meal and 18% of the fish meal sampled was found to be contaminated. In another study to determine the prevalence of *Salmonella* in swine feeds, 2.8% of the feeds and feed ingredients taken from farm environments were positive for *Salmonella*.[22]

Salmonella spp. contamination in rendered products and finished feed is most likely due to recontamination from rodents and fomites in the environment of the respective processing plants. Recently, an FDA survey of animal and plant protein processors demonstrated that 56.4% of the animal protein and 36% of the vegetable protein products

taken from 124 processors were positive for *Salmonella*.[23]

Global concerns about the potential for *Salmonella* contamination to create health problems in both humans and animals require investigation of all potential sources of *Salmonella* contamination.[24] Although feed trucks are not included in the official list of hazard analysis critical control points (HACCP) in swine production, it is possible that feed trucks might serve as a source of *Salmonella* contamination on swine farms. Because there is a paucity of information regarding *Salmonella* contamination originating in feed trucks, this study investigates the transportation of feed and feed ingredients in trucks as a source of *Salmonella* contamination.

Materials and methods

Sample collection

Culture transport swabs (Difco; Surrey, United Kingdom) in Cary-Blair medium were used to take samples from approximately 25 different areas of the grain box on 22 different trucks in Nebraska, Illinois, and Missouri (Figure 1). Each truck grain box was swabbed in 25 different locations to have a high probability of recovering *Salmonella* spp. Care was taken when swabbing the bottom of the truck to avoid stepping in the area that was to be sampled. Prior to use, all swabs were moistened in PBS (0.02 mol/L, pH 7.2). After the samples were collected, the swabs were returned to the transport tubes containing the medium.

A sample of the feed being hauled by 17 of the 22 trucks (5–10 g) was placed into the remaining PBS (approximately 25 mL) for culture.

All samples were shipped by overnight mail to the laboratory for processing.

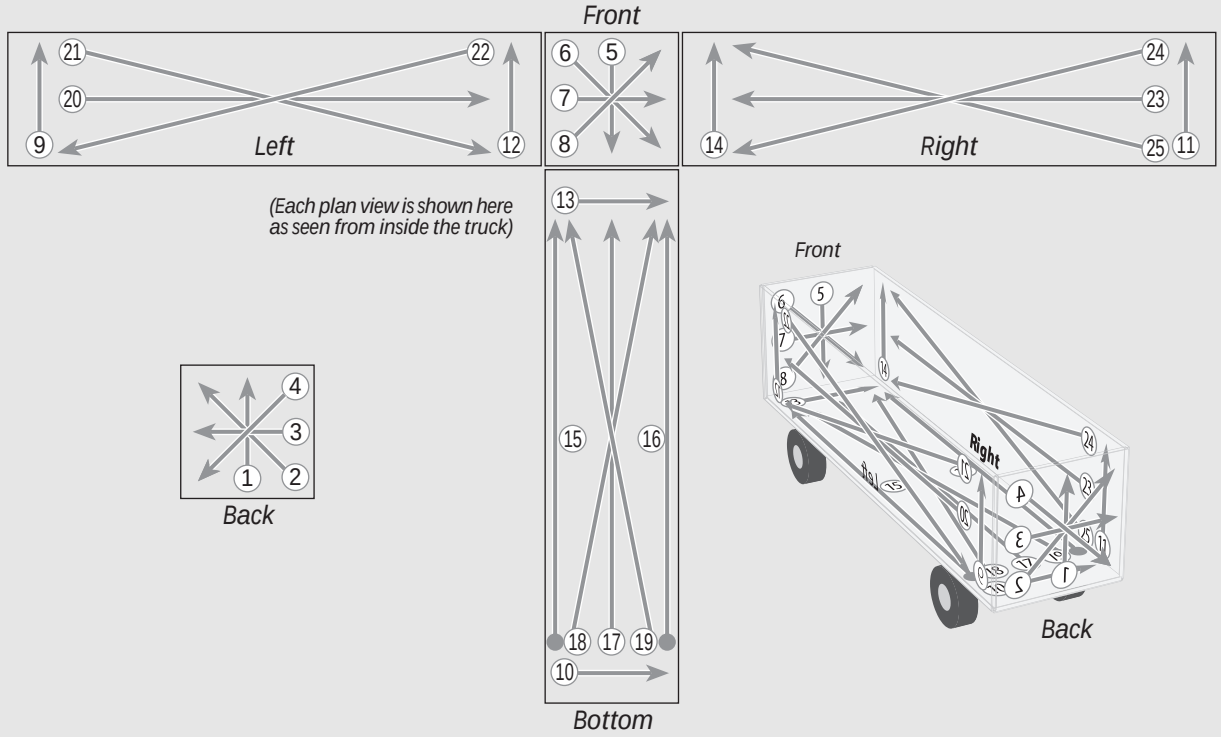
Qualitative bacteriology

All swabs were qualitatively analyzed for the presence of *Salmonella* by a modification of methods previously described.[9–11] Briefly, the swab was removed from the transport medium and placed into a tube containing Tetrathionate (Tet) broth (Acumedia; Baltimore, Maryland). Then, an additional sterile swab was inserted into the remaining medium in each transport tube, rotated, removed, and placed into a separate tube containing GN Hajna (GN) broth (Acumedia).

The Tet broth culture was incubated for 48 hours. The GN broth was incubated for 24 hours. After this initial incubation, both Tet broth and GN cultures (approximately 100 µL) were subcultured into Rappaport Medium (R-10) (Difco; Detroit, Michigan) and incubated at 37°C for 24 hours. The R-10 broth was then streaked onto brilliant green agar with sulfadiazine (BGS) plates (Acumedia).

All BGS plates were incubated overnight at 37°C. Colonies exhibiting typical salmonellae-like morphology were transferred to triple sugar iron agar and lysine iron agar slants for biochemical confirmation. All slants were incubated overnight at 37°C. Presumptive positive isolates were serogrouped with *Salmonella* typing sera (Difco; Detroit,

Figure 1



Schematic drawing of the 25 areas within the feed trucks that were swabbed

Arrows indicate direction in which the swab was dragged against the truck. Numbers indicate the order in which swabs were obtained.

Michigan) prior to being submitted to the National Veterinary Services Laboratories in Ames, Iowa, for serotyping.

Based on information obtained by the investigators, a survey for each truck was also completed to ascertain:

- whether the truck had been used to transport livestock within the past 30 days;
- whether the truck had been washed and/or disinfected or steamed between loads;
- whether the truck was open to environmental contaminants; and
- whether there were any visible signs of environmental contamination.

Results

Salmonella was cultured from the truck swabs or feed samples from five of the 22 trucks (22.7%) (Table 1).

Of the total of 549 truck swabs cultured, the rate of *Salmonella* isolation was 0.7% (four of 549). Positive truck swabs were recovered from three trucks (trucks 19, 20, and 22) for a recovery rate of 13.6%. Only one sample from the bottom of the truck was positive. The other positive swabs were obtained from the left side, back of grain box, and front of grain box.

Salmonella was recovered from four of the 17 feed samples (23.5%) taken from the trucks. However, positive swabs and feed samples only matched for two trucks.

The shipment hauled prior to the meat and bone meal shipment sampled from one truck (truck 10) contained Tylan 40™, an antibiotic commonly used as a feed additive. While all truck swabs were negative for *Salmonella*, the meat and bone meal sample from truck 10 was positive.

Some part of the shipment on three of the 22 trucks (trucks 16, 17, and 18) had been exposed to environmental contaminants. Truck 16 also had a positive feed sample. However, only one truck (truck 21) had visible signs of environmental contamination (but was not among those identified on the survey as having been open to contamination); the contaminant was identified as soybean mold.

The feed types found positive for *Salmonella* included meat/bone meal, fish, bonemeal, meatmeal, and soybean meal.

The survey revealed that none of the trucks included in this study had been used to transport livestock within the past 30 days nor had any been cleaned or disinfected between loads.

Table 1

Summary of truck contents and bacteriology results

Truck ID	Feed type	Positive swabs (n=25)	Serotype	*Salmonella* in feed	Serotype
1	corn	0		–	
2	corn	0		–	
3	corn	0		–	
4	corn	0		–	
5	ADM	0		–	
6	ADM	0		–	
7	Dical	0		–	
8	limestone	0		–	
9	corn	0		–	
10	meat and bone meal*	0		+	*S. oranienburg*
11	corn	0		nt	
12	corn	0		nt	
13	corn	0†		nt	
14	soybean meal	0		nt	
15	corn	0		nt	
16	meat	0		+	untypable 6,7 K-monophasic
17	meat scraps	0		–	
18	bone meal	0		–	
19	fish meal	1	*S. derby*	+	*S. infantis*
20	meat scraps	2	one swab *S. orion* and *S. montevideo*; one swab *S. infantis* and *S. montevideo.*	–	
21	soybean meal	0		–	
22	soybean meal	1	*S. infantis*	+	untypable rough "o": y-1,5

* Tylan-40 in truck in previous shipment prior to loading meat and bone meal

† n = 24 for this truck

Discussion

While sample prevalence of *Salmonella* in feed trucks in our study was low (0.7%), the overall contamination rate for feed trucks was much higher (22.7%). A positive feed sample did not necessarily mean that the truck was positive. However, the low sample (swab) prevalence we observed may be attributed to the limited surface area swabbed. Recovery of present pathogens may be improved by increasing the surface area sampled. One such method may include the use of drag swabs.[25] Culture transport swabs were used in this study because they are easy to use and because the samples were placed into transport medium prior to shipment.

The positive feed samples (from trucks 10, 16, 19, and 22) might have served as a source of *Salmonella* contamination in the herds feeding those feeds—there is anecdotal evidence suggesting a positive correlation between serotypes found in contaminated swine feed and those in pigs fed that feed.[26] However, because we did not measure the numbers of *Salmonella* or match the serotypes found in the samples to serotypes found in the pigs eating that feed, we can only speculate as to the impact of this potential contaminant on the prevalence of *Salmonella* infection in the herds. Additionally, the feed samples we collected were smaller than those collected for previous studies, reinforcing the observation that *Salmonella* is ubiquitous and may represent a possible source of contamination for animals.[22]

Salmonella in pig feed can generally be killed or reduced by pelleting. Pellet feeding in a contaminated environment can result in a distinct decrease in infection by *Salmonella* during the life of the pigs and after slaughter.[27] It may be possible to prevent infection by using pellets in feed preparation.[28] If the concentrations of *Salmonella* within the feed were sufficiently high, and were not killed in significantly high numbers during pelleting, it would be possible for pigs to become infected with *Salmonella* after ingestion of this contaminated feed. Low levels of contamination would probably be significantly reduced or eliminated by pelleting while higher levels may not. Therefore, the use of properly processed feed cannot be overemphasized.

It is interesting to note that 22.7% of the trucks and 23.5% of the feed were positive for *Salmonella*. When compared to the prevalence of *Salmonella* found in feeds on the farm (2.8%),[22] this reduces by approximately 86% the prevalence of contamination potentially present on trucks prior to processing, although further research is needed to test this hypothesis.

Purchasing feed ingredients free of *Salmonella* spp. is the most effective way to prevent infection of a herd via feedstuffs. To minimize the likelihood of cross-contamination between batches of feed, the equipment, storage bins, and transportation vehicles should be sanitized.[29]

When designing a control program, it's important to know the survival and proliferation rates of *Salmonella*. *Salmonella* survives as long as 14 weeks in poultry feed and meat and bone meal.[27] *Salmonella* can increase from one organism per mL in liquid feed immediately after it is prepared to 200,000 organisms per mL after 48 hours at 20°C (68°F) and at 28°C (82°F).[20] In Denmark, commercial mills are required to heat-treat swine feeds to a minimum of 81°C (178°F) to kill *Salmonella*.[30] Because none of the trucks were cleaned or disinfected between loads, it is possible that the contaminant was passed to subsequent loads on the trucks from which we obtained *Salmonella*-positive samples.

Recovery of positive samples from more trucks containing meat, bone, or fish meal than those containing vegetable-based feeds supports the observations made in an FDA study, which reported that *Salmonella* was recovered from 62% of animal processor plants versus 37% vegetable processor plants.[23]

The *Salmonella* serotypes that were isolated in this study—*Salmonella oranienberg*, *S. orion*, *S. montevideo*, and *S. infantis*—are not listed among the 10 top serotypes recovered from swine as reported by the National Veterinary Services Laboratories.[31] Without confirming recovery of these serotypes from animals after being fed feed contaminated with these serotypes, the significance of the presence of these serotypes in feed is unknown. Only *S. montevideo* was recovered during the FDA survey.[23] However, the presence of *S. oranienberg*, *S. infantis*, and *S. montevideo* may be a food safety concern as all three serotypes are listed in the top 20 serotypes recovered from humans.[32–34]

Implications

- The recovery of *Salmonella* from the truck swabs taken in this study suggest that feed trucks might serve as a potential source of contamination.
- Proper sanitation methods between loads, including washing with a disinfectant and hot water, should be implemented to minimize the likelihood that the truck would contribute to contamination of subsequent loads.

References

1. Taylor J, McCoy JH. *Salmonella* and Arizonae infections and intoxications. In Riemann, H (ed.) *Foodborne Infections and Intoxications*. Academic Press:New York, New York. 1969;3–72.

2. Bean NH, Griffin PM. Foodborne disease outbreaks in the United States 1973–1987: pathogens, vehicles and trends. *J Food Prot*. 1990; 53:804–817.

3. Lammerding AM, Garcia MM, Mann ED, Robinson Y, Dorward WJ, Truscott RB, Tittiger F. 1988. Prevalence of *Salmonella* and thermophilic *Campylobacter* in fresh pork, beef, veal and poultry in Canada. *J Food Prot*. 1988; 51:47–52.

4. Buchwald DS, Blaser MJ. A review of human salmonellosis. II. Duration of excretion following infection and nontyphi *Salmonella*. *Rev Infect Dis*. 1984; 6:345–356.

5. Kotova AL, Kondratskaya SA, Yasutis IM. 1988. *Salmonella* carrier state and biological characteristics of the infectious agent. *J Hyg Epidemiol Microbiol Immunol*. 1988; 32:71–78.

6. Wood RL, Pospischil A, Rose R. 1989. Distribution of persistent *Salmonella* typhimurium infection in internal organs of swine. *Am J Vet Res*. 1989; 50:1015–1021.

7. Wood RL, Rose R. Populations of *Salmonella typhimurium* in internal organs of experimentally infected carrier swine. *Am J Vet Res*. 1992; 53:653–658.

8. Fedorka-Cray PJ, Whipp SC, Isaacson RE, Nord RE, Lagar K. Transmission of *Salmonella typhimurium* to swine. *Vet Microbiol*. 1994; 41:333–344.

9. Gray JT, Fedorka-Cray PJ, Stabel TJ, Ackermann MA. Influence of inoculation route on the carrier state of *Salmonella choleraesuis* in swine. *Vet Microbiol*. 1995; 47:43–59.

10. Gray JT, Stabel TJ, Fedorka-Cray PJ. Effect of dose on persistence of *Salmonella choleraesuis* infection in swine. *Am J Vet Res*. 1996; 57:313–319.

11. Gray JT, Fedorka-Cray PJ, Stabel TJ, Kramer TT. Transmission of *Salmonella choleraesuis* to naive swine. *Appl Environ Microbiol*. 1996; 62:141–146.

12. Durand AM, Giesecke WH, Barnard ML, VanDer Walt ML, Steyn HC. *Salmonella* isolated from feeds and feed ingredients during the period 1982–1988: Animal and public health implications. *Onderstepoort Jr Vet Res.* 1990; 57:175–181.

13. McChesney DG: *Salmonella* in animal feeds. *FDA Vet*. 1991; 6 (1):3–4.

14. Martensen L, Holmberg T, Hurvell B, Rutquist L, Sanastedt K, Wierup M. *Salmonella* isolated from animals in feedstuffs in Sweden during 1978–1982. *Nord Vet Med.* 1984; 36:371–393.

15. Sockett PN. The economic implications of human *Salmonella* infections. *J Appl Bacteriol*. 1991; 71:289–295.

16. Todd ECD. Preliminary estimates of costs of foodborne disease in the United States. *J Food Prot*. 1989; 52:595–601.

17. Clarke RC, Gyles CL. *Salmonella*. In Gyles CL, Thoen CO (eds). *Pathogenesis of Bacterial Infections in Animals*. 2nd ed. Iowa State University Press, Ames, IA. 1993;133–153.

18. Edel W, van Schothorst M, Guinee PAM, Kampelmacher EH. Effect of feeding pellets on the prevention and sanitation of *Salmonella* infection in fattening pigs. *Zbl Vet Med B*. 1970; 17:730–738.

19. Edel W, Guinee PAM, van Schothorst M, Kampelmacher EH. *Salmonella* infections in pigs fattened with pellets and unpelleted meal. *Zbl Vet Med B*. 1967; 14:393–401.

20. Linton AH, Jennet NE. Multiplication of *Salmonella* in liquid feed and its influence on the duration of excretion in pigs. *Res Vet Sci II*. 1970;452–457.

21. Williams LP, Vaughn JB, Blanton V. A ten-month study of *Salmonella* contamination in animal protein meals. *JAVMA*. 1969; 155:167–174.

22. Harris IT, Fedorka-Cray PJ, Gray JT, Thomas LA, Ferris K. Prevalence of *Salmonella* organisms in swine feed. *JAVMA*. 1997; 210:382–385.

23. McChesney DG, Kaplan G, Gardner P. FDA survey determines *Salmonella* contamination. *Feedstuffs*. 1995;20–23.

24. D'Aoust JY, Maishment C. Preenrichment conditions for effective recovery of *Salmonella* in foods and feed ingredients. *J Food Prot*. 1979; 42:153–157.

25. Opara OO, Mallinson ET, Tate CR, Carr LE, Miller RG, Stewart L, Kelleher C, Johnston RW, Joseph SW. The effect of exposure, storage times, and types of holding media on the drag-swab monitoring technique for *Salmonella*. *Avian Dis*. 1992; 36:63–68.

26. Berends BR, Urlings HAP, Snijders JMA, Van Knapen F. Identification and quantification of risk factors in animal management and transport regarding *Salmonella* spp. in pigs. *Intl J Food Microbiol*. 1996; 30:37–53.

27. Juven BJ, Cox NA, Bailey JS, Thomaon JE, Charles OW, Shutze JV. Survival of *Salmonella* in dry food and feed. *J Food Prot*. 1984; 47;6:445–448.

28. Edel W, van Schothorst M, Guinee PAM, Kampelmacher EH. *Salmonella* in pigs on farms feeding pellets and on farms feeding meal. *Zbl Bakt Hyg I*. 1974;314–323.

29. Cantor AH. Elimination of *Salmonella* at source — an overall program for feed mfg. and meat processors. *Proc of Alltech 6th Ann Symp Alltech Tech. Pub.* 1990.

30. Anonymous. Shake test shows feed size. *Pig Inter*. 1995; 25;4:20.

31. Ferris KE, Thomas LA. *Salmonella* serotypes from animals and related sources reported during July 1994 - June 1995. *Proc USAHA Ann Mtg.* 1995;510–524.

32. CDC Annual Summary, *Salmonella* surveillance. 1992.

33. Meehan PJ, Atkeson T, Kepner DE, Melton M. A foodborne outbreak of gastroenteritis involving two different pathogens. *Am J Epidemiol.* 1992; 136:611–616.

34. Hatakka M. *Salmonella* outbreak among railway and airline passengers. *Acta Vet Scand*. 1992; 33:253–260.