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Salmonella as a Foodborne Pathogen in Pork

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Introduction

In 1885, the veterinary scientist, Daniel E. Salmon, discovered the first strain of Salmonella. Since then, Salmonella have been isolated from the intestinal tract of all vertebrates (animals with a spinal column) where researchers have cared to look, including pigs and humans. Of the more than 2400 serovars of Salmonella, all seem to be capable of causing disease in humans. Some serovars (called host-adapted) are especially adapted to a single host such as Salmonella Typhi in humans, Salmonella Choleraesuis in pigs, and Salmonella Pullorum in poultry. Salmonella Typhimurium and Salmonella Dublin are two of the well-known serovars that are non-host adapted (able to infect any vertebrate). The severity of the disease in humans (and other animals) resulting post infection depends on the strain, the infectious dose, and the state of health (especially the level of immunocompetence) of the individual infected. Children are the most likely to get salmonellosis. Young children, the elderly, and the immunocompromised are the most likely to have severe infections.

Salmonella has been known to cause illness for over 100 years and Salmonella Typhimurium and Salmonella Enteritidis are among the most common causes of food poisoning in the United States. Every year in the US, approximately 80,000 cases of salmonellosis are reported and 580 persons die. Because many milder cases are not diagnosed or reported, the actual number of infections may be twenty times greater. It has been estimated that 95% of cases are from foodborne transmission (Mead, et al., 1999). Various studies have indicated that salmonellae can be present in 0-48% of pork carcasses. Although Salmonella can cause disease in pigs, in most cases, infected pigs show no signs of illness.

The most common cause of infection

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is eating improperly prepared or stored foods that are contaminated with Salmonella. When food is improperly handled the Salmonella are able to proliferate, increasing the dose ingested. Unsurprisingly, Salmonellosis is more common in the summer than winter. Anything contaminated with these bacteria that is not heated to destroy the bacteria before being eaten, may cause illness. After ingestion, the Salmonella sets up an inflammatory response. Symptoms begin within 1 to 3 days and may include abdominal pains, diarrhea, fever, and sometimes vomiting. The illness usually lasts 4 to 7 days, and most people recover without treatment. However, in some persons the diarrhea may be so severe that the patient needs to be hospitalized. In these patients, the Salmonella infection may spread from the intestines to the blood stream, and then to other body sites and can cause death unless the person is treated promptly with antibiotics. In recent years, concerns have been raised, as particular strains of Salmonella have become resistant to traditional antibiotics in both animals and humans. These resistant strains are more difficult to treat in severely ill patients.

Responsibility:

The recent trend in food safety worldwide but especially in the USA has been towards an inspection and surveillance system based more on risk analysis rather than the traditional visual (organoleptic) approach to meat inspection. Packing plants (abattoirs) are now expected to develop and implement plans that will minimize the risk of bacterial contamination. Such plans should logically include preharvest (on-farm) control (which is a component of Salmonella control in other countries) but this has not been done partially because we have such a poor understanding of what we could reliably and economically implement at the farm level. Underlying that lack of implementation is our poor understanding of the epidemiology of Salmonella at the farm level. As a consequence, the meat industry and consumers shoulder most of the burden of helping to ensure a Salmonella-safe product. Plant hygiene and employee training are important components for the meat industry while consumers are recommended to:

* wash their hands before preparing foods and eating, after using the bathroom or changing diapers, and after handling pets
* refrigerate foods soon after purchase
* check expiration dates and dispose of any outdated food and
* clean all food preparation areas with a diluted solution of bleach and water, then rinse before and after food preparation.

Pork as a hazard:

Pork is a major cause of foodborne salmonellosis throughout the world. A recent study of pork in U.S. retail stores found 9.6% of samples were contaminated (Duffy et al., 2000). However, in the US, more cases of salmonellosis are linked to other foods (e.g, poultry, dairy products, beef) than pork probably because the fear of Trichinella encourages people to more thoroughly cook pork. In Denmark in 1993, pork was the most important source of foodborne salmonellosis. Pork contaminated with Salmonella Infantis accounted for an outbreak of more than 500 registered cases (20 cases per 100,000 inhabitants) (Wegener and Baggesen, 1996). Although slaughter equipment is often the immediate source of contamination, the initial source is the carrier pig and transmission is thought to occur by pig-to-pig contact or from exposure to the contaminated environment (Berends et al., 1996). The handling and transport of pigs prior to slaughter can increase the prevalence of Salmonella spp. (Newel and Williams, 1971).

On-farm factors:

The increasingly popular method of raising pigs in multiple-site production systems, using all-in/all-out management of finishing pigs, seems to have no benefit in reducing the prevalence of salmonella

compared with conventional farrow-to-finish systems (Davies et al., 1997). Generally, pathogens are introduced into farms with replacement pigs and Salmonella is probably no exception. However, Dutch investigators have concluded, after much research, that on-farm contamination cycles are so important that the significance of other factors is difficult to assess. In addition, other Dutch researchers concluded that replacement breeding stock were not a significant source (Berends et al., 1996). Certainly, even after depopulation and rigorous cleaning and disinfection of facilities in North Carolina we were still able to culture Salmonella from barn floors. Pig feed is a well-documented source of Salmonella; however, its role in the total process is questionable. Salmonella spp isolated from feed on-farm are seldom the same as those isolated from pigs or human foodborne cases.

What can a farmer do?

Pen hygiene:

In any discussion of on-farm Salmonella control, one is sure to encounter those promoting the benefits of pen hygiene. In fact, Berends et al. (1996) stated that pen hygiene was the most important factor. But this area is still not clear. Recent studies have found that cleaning and disinfection actually was associated with increased Salmonella infection (Stege, et al., 2000; van der Wolf, et al., 2001). An investigation in North Carolina, found that Salmonella counts were higher in clean pens as compared to pens with more built up fecal material (Funk et al., 1999). In contrast, recent studies have shown that intensive cleaning and disinfection can decrease Salmonella in broiler houses (Davies and Wray, 1996).

Feeding practices:

Danish researchers have found that liquid feeding and mixing feed on-farm have decreased Salmonella prevalence as compared to dry and purchased feeds. The beneficial effect of home-mixing feeds in Denmark may be related to the larger particle size of the home-mixed feeds (typically rolled grain) compared to the finer-ground, purchased, heat-treated, pelleted feed. The possible benefits of decreasing Salmonella by feeding a coarser feed would have to be balanced against the loss in feed efficiency. The Dutch have reported that feeding whey decreases Salmonella infection. The effect of the latter may be attributable to the low pH (more acidic). If that is the case, there may be some opportunity for adding organic acids to the feed or water. The opportunity for feeding bacterial cultures to promote "competitive exclusion or the Nurmi effect" still exist and recent results have been promising (Anderson et al., 1999).

Pest control:

Rats and mice can carry and excrete Salmonella spp. and must be regarded as a risk for the introduction and perpetuation of Salmonella into a swine unit. However, most work has been carried out with Salmonella Enteritidis and around poultry units and this may not reflect the situation for swine. Although wild birds can carry Salmonella the incidence of carriage appears to be low and birds generally carry Salmonella only transiently. Similar to birds, cockroaches can also carry Salmonella but it is likely only transitory and reflect the general contamination of an area rather than a source of infection for pigs. Salmonella spp. can also establish and multiply in flies. Regardless of Salmonella control, swine units should have a rodent, cockroach, and fly control program and exclude birds from swine houses to prevent other diseases.

Vaccination:

Although there is a history of successful vaccination with host-specific serovars (e.g., typhoid vaccines, for Salmonella Typhi, as are commonly prescribed for travelers to endemic areas) there has been little-to-no success in developing a vaccine for non-host-specific serovars such as Salmo-

nella Typhimurium or Salmonella Dublin. Despite a lot of effort, the poultry industry has not been successful in developing a vaccine for Salmonella Enteritidis.

One vaccine produced in the USA by Boehringer Ingelheim Vetmedica, Inc. (Enterisol SC-54) is recommended for use in healthy, susceptible swine, one day of age or older, as an aid in the prevention of salmonellosis in swine caused by Salmonella Choleraesuis var kuzendorf. The avirulent live-culture vaccine can be administered intranasally or via the drinking water. The company claims that reducing the prevalence of salmonellosis eliminates stress that can slow animal growth and that is worth up to $13.28 per head. In field trials, compared to non-vaccinated pigs, vaccinated pigs had a significantly lower prevalence of Salmonella detected by culture of ileocecal lymph nodes collected at slaughter. Although Salmonella Choleraesuis can be a severe pathogen for pigs it is only rarely associated with disease in humans; however, when it is, the disease is usually serious. In swine, researchers have demonstrated that Salmonella Choleraesuis vaccine provides some cross-protection to other Salmonella; however, its utility in the field remains questionable.

Summary:

Foodborne salmonellosis is a serious problem and one that must be addressed by our industry. Unfortunately, we have much to learn about how we can implement pre-harvest control. Until that time, farmers should strive to improve pen hygiene, implement an aggressive rodent control program and endorse post-harvest irradiation of pork. While irradiation should not be adopted as an excuse for poor pre-harvest control, it is the best technique available at the moment for decreasing the contamination of pork and subsequently the incidence of salmonellosis in consumers-our ultimate customers.

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