Research Note

Resting Pigs on Transport Trailers as an Intervention Strategy To Reduce Salmonella enterica Prevalence at Slaughter†

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MS 04-540: Received 30 November 2004/Accepted 28 March 2005

ABSTRACT

Recent research has shown that much preharvest Salmonella enterica infection in pigs occurs immediately before slaughter during this rest period in the contaminated abattoir holding pens. The objective of this study was to evaluate a potential intervention strategy to reduce the prevalence of S. enterica-positive pigs at slaughter, which consisted of resting pigs prior to slaughter on their transport vehicle, instead of in the abattoir holding pen. Additionally, the effect of transportation of pigs from farm to the abattoir on S. enterica prevalence was investigated. A total of 120 animals were included in the experiment, divided in four replicates (n = 30 pigs per replicate). Fecal samples were collected from each animal at the farm and at the abattoir, where 15 randomly chosen pigs were unloaded and moved to a holding pen, while the remaining 15 pigs stayed in the transport trailer. After approximately 1.5 h of resting, both groups were slaughtered. Samples collected included distal ileum portion, cecal contents, and ileocecal lymph node. The overall S. enterica prevalence (pigs positive in at least one of the samples collected at slaughter) was higher for pigs held in the abattoir pens (40.7% versus 13.3%, P < 0.05). There was no difference (P > 0.05) for the S. enterica prevalence before and after transportation from farm to abattoir (5.8% versus 0.8%, respectively). This study demonstrates that resting pigs on the transport vehicle has the potential to decrease S. enterica levels entering the abattoir.

Food safety is a defining issue in the global pork market, and Salmonella enterica is of great concern for the pork production industry. Although the S. enterica contaminating the slaughter and processing line in the abattoirs originates from the production farms, the perimarketing portion of the production chain (particularly, the preslaughter holding) has been demonstrated to constitute a putative factor for the carriage of S. enterica into the abattoirs (9, 15, 17).

Prior to slaughter, pigs are held for a period of time to recover from the physiological changes attributed to transport, improve meat quality, and maintain a constant supply for the slaughter line (3, 20). However, we have demonstrated (7, 9, 15) that (i) abattoir holding pens are highly contaminated with S. enterica, (ii) swine exposed to a S. enterica-contaminated environment can become rapidly infected, and (iii) much of the preharvest S. enterica infection in pigs occurs immediately before slaughter during this rest period in the contaminated abattoir holding pen. Consequently, at slaughter, the intestinal tract of the pigs and its associated lymph nodes are frequently contaminated or infected with S. enterica and provide the main source from which the bacteria may be spread in the abattoir, contaminating the slaughter line, carcasses, and other food products (1, 9, 13, 15, 18, 22). Each lot introduces new contaminants into the plant environment. The more S. enterica pigs carry into the abattoir, the greater the risk of equipment and final product contamination.

Intervention strategies to reduce the occurrence of S. enterica infections during the preslaughter holding period are necessary in order to reduce the number of pigs carrying the bacteria into the slaughter process, consequently reducing the risk of pork and pork product contamination. An alternative to the preslaughter holding (lairage) of pigs in abattoir pens is presented in this report. The objective of this study was to evaluate a potential intervention strategy to reduce the prevalence of S. enterica-positive pigs at slaughter, which consisted of resting pigs prior to slaughter on their transport vehicle instead of in the abattoir holding pen.

Additionally, a secondary objective of this study was to evaluate the effect of transport on S. enterica prevalence. Many believe that the number of pigs shedding S. enterica will be increased after transportation and its associated stress. However, limited investigations have been conducted on the potential effects of transportation stress or feed withdrawal or both on S. enterica shedding in swine (10, 21). Currently, there are still no conclusive data showing a direct association between transport and increased shedding of S. enterica.

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† Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement of the U.S. Department of Agriculture.

footnote1

footnote2
TABLE 1. Frequency of *Salmonella enterica*-positive samples for pigs held prior to slaughter in abattoir pen or in transport trailer

<table>
<thead>
<tr>
<th>Replicate</th>
<th>Pigs held in abattoir pen</th>
<th>Pigs held in transport trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DI CC ICLN Any</td>
<td>DI CC ICLN Any</td>
</tr>
<tr>
<td>1</td>
<td>6/15 7/15 0/15 8/15</td>
<td>2/15 2/15 0/15 3/15</td>
</tr>
<tr>
<td>2</td>
<td>4/14 4/14 0/14 5/14</td>
<td>0/15 2/15 0/15 2/15</td>
</tr>
<tr>
<td>3</td>
<td>7/15 2/15 0/15 7/15</td>
<td>2/15 1/15 0/15 3/15</td>
</tr>
<tr>
<td>4</td>
<td>2/15 3/15 0/15 4/15</td>
<td>0/15 0/15 0/15 0/15</td>
</tr>
<tr>
<td>Overall</td>
<td>(32.2%) B (27.1%) B (0%) B (40.7%) B</td>
<td>(6.7%) C (8.3%) C (0%) B (13.3%) C</td>
</tr>
</tbody>
</table>

a Values are number of positive samples/number of samples collected. Sample types collected: DI, distal ileum; CC, cecal contents; ICLN, ileocecal lymph node; Any, combination of all sample types collected.

b Statistical comparison (chi-square) between treatments (based on the same sample type). Means with different letters in the same row are significantly different (P < 0.05).

MATERIALS AND METHODS

Experimental design and sampling. A total of 120 grower-age pigs (20 to 25 kg) were included in the experiment, divided in four replicates (n = 30 pigs per replicate). Animals used in the first two repetitions of the experiment were from one herd, and animals used in the last two repetitions were from a different herd. This study was conducted in a very small commercial abattoir (ca. 80 pigs per day) and using young pigs to control several logistic-related variables (e.g., unloading and moving pigs to the holding pen, moving pigs from the holding pen to slaughter, slaughter line speed, cross-contamination, and others) present in large commercial abattoirs that frequently interfere in the experiment, causing confounding, as previously experienced by our research team (8, 16). The small size of the plant allowed for moving the pigs very quickly from the transport trailer to the holding pen, and from the holding pen or transport trailer to the slaughter line (ca. 2 min). In large abattoirs, the time necessary to move pigs around may be 30 to 45 min. On the farm, prior to loading, five floor swabs (100-cm² gauzes) were collected from the transport trailer, and a 1-g fecal sample was collected from each pig (directly from rectum). Pigs were loaded and immediately transported for 3 to 4 h. Upon arrival at the abattoir, a 1-g fecal sample was again collected (individual samples collected directly from rectum), and 15 randomly chosen pigs were unloaded and moved to a holding pen, while the remaining 15 pigs stayed in the transport trailer. Before placing in the holding pen, five floor swabs (100-cm² gauzes) and one water sample from the drinker were collected to verify preexisting contamination. After approximately 1.5 h of resting, both groups were slaughtered. Individual samples were collected in the slaughter line; they included distal ileum portion (10 cm), cecal contents (10 g), and ileocecal lymph node. All samples were transported to the research laboratory at the National Animal Disease Center, located in Ames, Iowa, and individually processed for the isolation and identification of *S. enterica*.

Bacteriological procedures. Bacteriological culture methods used included primary enrichment in tetraphionate broth (90 ml) for 24 h at 37°C, followed by sequential enrichment in Rappaport-Vassiliadis broth (9.9 ml) containing 20 μg/ml of novobiocin (Sigma Chemical Co., St. Louis, Mo.) incubated for 24 h at 42°C, and again in Rappaport-Vassiliadis broth (9.9 ml) for another 24 h at 42°C. From the last enrichment step, isolation was conducted using xylose-lysine-tergitol-4 and brilliant green sulfur agars (incubated at 37°C for 24 and 48 h). Suspect colonies (two per plate) were picked and transferred to Rambach agar plates (incubated at 37°C for 24 h) for presumptive identification (6, 12, 14) and subsequently submitted for serotyping (according to the Kauffman-White scheme) at the National Veterinary Service Laboratory, located in Ames, Iowa. All media used in this study were acquired from Difco (Difco, Becton Dickinson, Sparks, Md.).

Statistical analysis. *S. enterica* prevalence for the studied treatments (i.e., preslaughter holding in the abattoir pen or on the transport trailer) was determined based on each sample type collected and for any sample type (i.e., prevalence of pigs positive in at least one of the samples collected). Proportions were compared by chi-square, and the significance level applied was P < 0.05.

RESULTS AND DISCUSSION

This study emphasizes that the highly contaminated environment of the abattoir lairage facilities (i.e., the preslaughter holding pens) is the main reason for the frequently observed increase in *S. enterica* prevalence at slaughter in swine. Results for the prevalence of *S. enterica* in pigs from both treatments are presented in Table 1. Overall, the prevalence of *S. enterica* was significantly lower (P < 0.05) for pigs held prior to slaughter on the transport trailer than for pigs held in abattoir pens.

Floor swabs collected from the holding pens were frequently found to be positive for *S. enterica* (95%, 19 of 20), and a variety of serovars was found (Table 2) prior to the pigs entering for the preslaughter resting period. This finding corroborates previous investigations (11, 15, 17), where abattoir holding pens were also found to be highly contaminated with *S. enterica*. Additionally, water samples taken directly from the drinkers available to the animals were also found to be frequently contaminated (50%, 2 of 4) with *S. enterica*, supporting our previous report (15), where 33% of water samples were found to be contaminated with *S. enterica*. These observations are important and indicate that more attention is needed on the microbiological quality of the water provided to the animals during the preslaughter resting period and its potential effect on *S. enterica* prevalence at slaughter. In this study, pigs held on the transport trailer had no access to water.

Samples collected from the floor of the transport trailer prior to loading the pigs were rarely found to be positive for *S. enterica* (5%, 1 of 20). It is noteworthy that the trailer...
TABLE 2. Salmonella enterica serovars isolated from pigs at slaughter, transport trailer, and abattoir holding pen

<table>
<thead>
<tr>
<th>Replicates</th>
<th>Pigs held in pen</th>
<th>Pigs held in trailer</th>
<th>Holding pen floor</th>
<th>Trailer floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Derby (12)</td>
<td>Derby (5)</td>
<td>Infantis (7)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Infantis (14)</td>
<td>Infantis (2)</td>
<td>Saint Paul (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saint Paul (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Anatum (16)</td>
<td>Anatum (4)</td>
<td>Anatum (10)</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Derby (13)</td>
<td>Typhimurium (4)</td>
<td>Derby (5)</td>
<td>Anatum (2)</td>
</tr>
<tr>
<td></td>
<td>Breedeney (2)</td>
<td></td>
<td>Infantis (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saint Paul (2)</td>
<td></td>
<td>Newport (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ohio (2)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Typhimurium (9)</td>
<td>None</td>
<td>Typhimurium (11)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Untypeable (1)</td>
<td></td>
<td>Typhimurium (11)</td>
<td>Agona (1)</td>
</tr>
</tbody>
</table>

*a Number of isolates identified are indicated in parentheses.

used in this study was never disinfected during the experiment. However, right after concluding each repetition, the trailer was thoroughly washed with water under pressure and scrubbed and rested for at least 2 weeks between repetitions of the experiment. By the time its floor was sampled, prior to loading pigs for each repetition, it was found to be clean and dry.

One of the objectives of resting pigs prior to slaughter is to improve meat quality (3, 20). However, as previously mentioned, this study was conducted using grower-age pigs (20 to 25 kg) as opposed to market weight pigs (i.e., finishing pigs). As a result, it was not possible to evaluate the meat quality impact of resting in the pen versus the trailer. The evaluation of this potential effect should be conducted using market-age pigs in order to be valid. On the other hand, using grower-age pigs should have no effect on the applicability of the results found regarding S. enterica prevalence. The prevalence found after exposure to the contaminated abattoir holding pen is in agreement with the prevalence reported in market-age pigs (1, 9, 13, 16, 18). Moreover, grower-age pigs have been frequently used as model to study the pathogenesis of S. enterica infection in swine (2, 5, 23, 24).

This study suggests that transportation of the pigs from farm to abattoir has no effect on S. enterica prevalence. Of the 120 pigs, 7 (5.8%) were S. enterica–positive prior transportation, and only 1 pig (0.83%) was positive after transport ($P < 0.05$). Our results are in contrast with previous reports of increased prevalence after transport (10, 21). This evidence is reinforced by the relatively low prevalence found in the group of pigs held on the transport trailer at slaughter (13.3%), even though the estimate was based on multiple samples (i.e., distal ileum portion and cecal contents) increasing the probability of finding positive animals, and, consequently, a higher prevalence. Although this type of sampling increases the sensitivity for the identification of positive animals, the prevalence found was comparable to the estimate based on pretransport and posttransport fecal samples (1 g), which have been demonstrated to have a very low diagnostic sensitivity (4). Our results question whether transportation of pigs and its associated stress have a significant impact on S. enterica prevalence at slaughter. However, further investigation is still necessary to understand the potential complex effect of handling, transporting, and mixing of pigs on S. enterica prevalence and shedding.

A recent study (19) explored the cost effectiveness of interventions to control S. enterica in the pork production chain and concluded that, with respect to the prevalence reduction, the lairage seems to be the most cost-effective stage for intervention. Our results are in agreement with this conclusion. It seems reasonable to assume that intervention measures that aim to reduce the exposure of pigs to S. enterica (i.e., reduce the risk of infection) should be the most effective in reducing the amount of bacteria entering the abattoir. In this study, we pursued the idea of resting animals on their transport vehicle, based on the observation of a common practice in the poultry industry. However, other alternatives, such as cleaning and disinfection of the lairage environment, do exist and should be evaluated.

Results obtained in this study indicate that, except for unloading logistics, the possibility of resting pigs on the transport vehicle has the potential to decrease S. enterica levels entering the abattoir. As mentioned, it is a common practice in the poultry industry to hold birds on trailers before slaughter. The trailers are generally parked under shade with large fans blowing on both sides of the birds for temperature control. Unloading logistics for large-scale pig slaughter (1,000 head per h) may prevent truck holding. However, side-unloading trailers as opposed to rear-unloading trailers may allow for sufficiently rapid unloading. This study indicates that considerations for substantial changes in the traditional abattoir receiving practices may be worth considering.

ACKNOWLEDGMENTS

The authors thank Robert Schneider, Carol Wiltsey, Ellen Harbaugh, Jared Gailey, and Adrienne Norgrant for technical assistance. The cooperation of the plant personnel was fundamental for the success of this study. This project was funded by USDA:CSREES National Research Initiative Competitive Grants Program (2011-35212-10864).

REFERENCES