RESEARCH REPORT
PORK SAFETY

Title: Estimating the National Prevalence of Salmonella spp. in Lymph Nodes from Market Hogs and Sows – (NPB #16-120)

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Date Submitted: **October 4, 2018**

Industry Summary: The objective of this research was to estimate the degree to which lymph nodes serve as a harborage area for *Salmonella* in both market hogs and sows, and the frequency at which positive results are potentially impacted by carcass chilling method. Sampling was conducted at twelve (n = 12) USDA inspected establishments that slaughter swine in the Northern region. This data was combined with research conducted by Texas A&M University (n = 9) in order to determine the National prevalence by geographic region, northern (Penn State) or southern (Texas A&M) region, from pork carcasses at slaughter facilities. At each of the 12 establishments, left and right pairs of superficial inguinal lymph nodes (n = 25 pairs) were extracted from chilled carcasses (except sow operations) from the previous slaughter day and pooled by animal (n = 300 (Northern establishments); n = 207 (Southern establishments); N = 507 Nationwide). Lymph nodes were identified and shipped via overnight carrier for determination of *Salmonella* prevalence. Prevalence data for *Salmonella* was separated for market hogs (6.4% positive) and sows (37% positive). The chilling method (conventional – 20% positive, other – 2.7% positive, or blast – 1.3% positive) for market hog samples was also evaluated. Results from this research would suggest that production stage (sow vs market hog) and chilling type are significant factors ($P < 0.05$) affecting *Salmonella* prevalence. Chill method (conventional vs blast and other) was also significant ($P < 0.017$) when compared to samples from Southern establishments, suggesting that cooling capacity is critical, regardless of initial prevalence.

Keywords: *Salmonella* spp., Lymph Nodes, Market Hogs, Sows, Chilling

These research results were submitted in fulfillment of checkoff-funded research projects. This report is published directly as submitted by the project's principal investigator. This report has not been peer-reviewed.

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Scientific Abstract: The lymph nodes of swine are known to be harborage sites for *Salmonella* spp. and may play a role in carcass contamination during carcass fabrication and further processing of meat products sold at both wholesale and retail. Since most lymph nodes are below the skin surface, many antimicrobial interventions used to combat pathogen contamination may be ineffective. Although swine lymph nodes are a known source of the pathogen, it is unclear as to how prevalent *Salmonella* may be at the National level. To bridge this knowledge gag, a study was conducted to gain a more accurate estimate as to the National prevalence of *Salmonella* spp. in lymph nodes from both sows and market hogs and to determine the effect of chilling method on prevalence rates found in carcass from market hogs. Superficial inguinal Lymph node pairs (left and right; n = 25) were excised from both sows and market hogs from twelve (n = 12) USDA inspected swine slaughter establishments in the Northeast and Midwest regions of the United States. The lymph node pairs were pooled by individual animal (N = 300), labeled for identification, and shipped via overnight carrier to the lab for determination of the presence of *Salmonella*. Results of this study indicate that prevalence rates in the northern region were 37% and 6.4% for sows and market hogs respectively. This data was combined with samples (N = 207) taken in the southern region of the United States. Prevalence rates for *Salmonella* was not different ($P > 0.05$) for lymph node pairs from market hogs, regardless of production region. Positive samples from market hogs by carcass chilling type. Samples from conventionally chilled (~36-38°F air only; 20% positive) carcasses were significantly different ($P > 0.05$) when compared to samples from both blast chill (1.3% positive) or other (2.7% positive) chilling methods. Regardless of production region, conventionally chilled carcasses had higher positive sample rates ($P > 0.05$) when compared to all other methods of carcass chilling. Sows from the northern region had significantly higher ($P < 0.05$) positive samples (37% positive) when compared to sows from the southern region (4.8%). More investigation is needed to determine the cause for this difference.

Introduction:

Salmonella spp. continues to be one of the primary food safety hazards in pork products. According to the Centers for Disease Control and Prevention, nontyphoidal *Salmonella spp.* is estimated to cause over 1,000,000 illnesses annually, with an estimated 19,000 individuals hospitalized and 380 deaths per year (CDC, 2012 & 2014). Lymph nodes in pork and pork carcasses, as well as other meat animals (beef cattle), have been shown to be a potential site of contamination (Larsen et al., 2003; Vieira-Pinto et al., 2005; Arthur et al., 2008; Brichta-Harhay et al., 2012). This is reasonable to consider since *Salmonella spp.* is ubiquitous in the production environment. Broadway et al. (2015) suggested a possible correlation with oral inoculation of hogs by *Salmonella spp.* with the colonization of the pathogen in musculoskeletal lymph nodes. This suggests that oral colonization from the swine production environment may be a contamination source during fabrication of pork carcasses. The United States Department of Agriculture – Food Safety and Inspection Service (USDA-FSIS) considers the presence of *Salmonella spp.* in meat and poultry as an adulterant, and although poultry is more commonly associated with the pathogen, recalls linked to pork and *Salmonella spp.* have occurred (USDA-FSIS, 2015). To address this problem in swine, it is first important to gain an estimate of the prevalence of *Salmonella* spp. that may be present in swine lymph nodes, so that swine producers and meat processing establishments may implement intervention strategies to decrease the risk of foodborne illness by *Salmonella* spp. from pork consumption. Although the ecology of *Salmonella spp.* in lymph tissue in the live animal is not well understood, further information is needed to determine a nationwide estimate of the presence of *Salmonella* spp. in lymph nodes from both market hogs and sows.

Objectives:

1. Determine the prevalence of *Salmonella* spp. in lymph nodes from sows.
2. Determine the prevalence of *Salmonella* spp. in lymph nodes from market hogs.
3. Determine the impact of carcass chill method on rates of *Salmonella* prevalence.

Materials & Methods:

Sample Collection – Lymph nodes (superficial inguinal) were collected from left and right sides of 25 carcasses at each of twenty-one swine slaughter facilities that agreed to participate in the research. Table 1 shows the facility location (city, state) and breakdown of data collection by region (northern or southern) of the establishments participating.

Table 1. List of swine slaughter establishment participating by region

North (Penn State)		**South (Texas A&M)**	
Sows (n = 4)	*Market Hogs (n = 8)*	*Sows (n = 5)*	Market Hogs (4)
Hillsdale, MI	Beardstown, IL	Holton, KS	Brookshire, TX
Simpsonville, KY	Delphi, IN	Knoxville, TN	Guymon, OK
Watertown, WI	Hatfield, PA	Newbern, TN	Johnson City, TX
Xenia, OH	Hazelton, PA	Pontotoc, MS	Warsaw, NC
	Logansport, IN	Union City, TN	
	Louisville, KY		
	Ottumwa, IA		
	Souderton, PA		

Carcass chilling method (conventional, blast and other) for market hog establishments was also recorded. Conventional chill was defined as standard refrigeration cooler temperatures (~ 36-38°F) without the addition of high speed fans and/or sprinkler systems to facilitate quicker chill times. The 'other' category was any combination of blast chill or conventional chill in combination with a water sprinkler system in the cooler. A total of 300 lymph node sets were collected at establishments in the northern region and placed together as pairs in a sterile, 3mil plastic wire tear top bag (model EPL-7012E, Labplas, Inc., Ste-Julie, Quebec, CA). Sample bags were identified by label and packed into an insulated shipping container with frozen gel packs (model 512; Koolit® Refrigerants, Franklin, MA, USA). Coolers were shipped via overnight carrier to the Animal Disease Research and Diagnostic Laboratory in Brookings, SD.

Determination & Quantification of *Salmonella* – Upon receipt of the lymph nodes, pairs were aseptically removed from the plastic bags, trimmed of surface fat tissue and pulverized, according to procedure outlined in Haneklaus *et al.* (2012), and pooled together to represent one single animal. The presence of *Salmonella* on pulverized lymph nodes was determined using methods outline in USDA laboratory procedure (USDA-FSIS MLG v.4.09; Identification of *Salmonella* from Meat, Poultry, Pasteurized Egg, and Catfish Products and Carcass and Environmental Sponges (USDA-FSIS, 2014).

Statistical Analysis – Microbiological results were analyzed using JMP Pro Software (SAS Institute, Inc. Cary, NC) version 13.1.0. Fishers exact test was utilized to analyze differences in contingency tables for region (north vs. south) and production stage (sow vs. market). A

significance level (α = 0.05) was used to determine statistical difference in prevalence between region, type and chill method.

Results:

Percent positive lymph node samples by production stage and geographic region are displayed in Table 2. *Salmonella* prevalence differed significantly (*P < 0.05*) by production stage for both north and south regions. Sows in the north region resulted in *Salmonella* positive lymph nodes at rates higher than market hogs (37% positive vs 6.4% positive). This result differs in the south region, where market hogs (13% positive) had a higher prevalence (*P < 0.05*) for *Salmonella* when compared to sows (4.8% positive).

Table 2. Percent positive lymph node samples by production stage and geographic region

	Geographic Region	
Production Stage	North	South
Market Hog	6.4% (13/202) A, X	13.0% (13/100) A, X
Sow	37.0% (37/100) B, X	4.8% (5/105) B, Y

A,B: Values within a column lacking a common letter differ (*P* < 0.05).
X,Y: Values within a row lacking a common letter differ (*P* < 0.05).

Table 3 shows the percent positive samples of lymph node tissue from market hogs by geographic region and carcass chilling method (conventional, blast or other). Conventional chill method resulted in the highest (20% positive) *Salmonella* prevalence rate, regardless of geographic region. Blast chilling of carcasses resulted in <1% (1 out of 102 samples) positive rate for both north and south regions combined.

Table 3. Percent positive lymph node samples by geographic region and carcass chill method

	Geographic Region	
Carcass Chill Method	North	South
Conventional	20% (10/50)	20% (10/50)
Blast	1.3% (1/77)	0% (0/25)
Other[a]	2.7% (2/75)	12% (3/25)

[a]Other Chilling method was defined as conventional or blast chill in combination with alternative systems (e.g. sprinkler system)

Discussion:

This research is the first of its kind to gain an estimate of *Salmonella* prevalence rates from pork produced and harvested in the United States. Results from this study on overall prevalence (13.4% positive) of Salmonella in superficial inguinal lymph nodes from swine agree with work published by Vieira-Pinto *et al.* (2005) for their investigation of lymph nodes from the mandible (12.9% positive) and distal small intestine (ileum; 13.9% positive) from slaughtered swine in Portugal. O'Connor *et al.* (2006) investigated the prevalence of *Salmonella* antibodies found in diaphragm tissue from swine, and results after separating low volume producers (18.9% prevalence) from high volume producers (19.7% prevalence) in Iowa swine herds, indicated a similar exposure to *Salmonella* during production. These results agree with *Salmonella*

prevalence rates in the current study from swine harvested in the north geographic region (16.6%). Other research by Bahnson *et al.* (2006) showed a 68.5% prevalence rate of *Salmonella* in Midwest swine herds (100 out of 146 herds). Although little data exists from swine harvested or produced in the southern U.S., it is worth further investigating the factors that may contribute or allow for a higher prevalence of *Salmonella* from sows harvested in northern regions of the U.S.

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