

# RESEARCH ABSTRACT



## INTERNATIONAL TRADE

**Title:** Review of Literature and Needs Assessment for Use of Pathogen Reduction Technologies (PRTS) In Fresh Pork – NPB #12-213

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United States is the world's third-largest pork producer and the largest pork exporter. In 2012, U.S. pork production was about 10.4 million metric tonnes (MT), over 2.3 million MT of which was exported (ERS-USDA, 2013). Per capita pork consumption in the U.S. has been estimated to be approximately 46.2 lb per year and has been relatively steady over the past decade (National Pork Board, 2013). Since domestic pork consumption is stagnant, the leading importers of U.S. pork (Japan, Mexico, China and Canada) are critically important to profitability of the U.S. pork industry (USMEF, 2013). Food safety and regulatory issues are a major concern in both foreign and domestic markets for U.S. pork. Based on prevalence and the cost associated with illness, the primary foodborne pathogens of concern in fresh pork include non-typhoidal *Salmonella enterica*, *Campylobacter spp.*, and *Yersinia enterocolitica* (Buzby et al., 1996; Fosse et al., 2009).

#### Interventions Applied to Pork

The commitment of the pork industry to food safety was documented in a survey of major packers that found the following interventions were commonly applied during swine processing in the U.S.: pre-evisceration washes and application of peroxyacetic acid; post-evisceration steam vacuuming; final wash application of acetic, lactic, hypobromous or peroxyacetic acid, as well as aqueous ozone and/or hot water; re-conditioning application of lactic acid; cooler application of citric acid; pre-fabrication application of peroxyacetic acid and aqueous ozone; and, application of acetic or peroxyacetic acid to primals and trim.

Scalding pork carcasses has been reported to reduce *Campylobacter*, *Salmonella* and *Escherichia coli* counts from  $10^6$ /ml to less than 10/ml (Sorquist and Danielsson-Tham, 1990). Similar results were found for *Yersinia spp* (Sorquist and Danielsson-Tham, 1990). Pearce et al. (2003) reported that 1% of pork carcasses were positive for *Salmonella* following scalding.

Total viable bacterial counts have been reported to be  $< 2.0$  CFU/cm<sup>2</sup> following scalding; however, 12% of carcasses have been found to be positive for *Enterobacteriaceae* following scalding (Spescha et al., 2006).

FSIS has approved several organic acids and their salts as antimicrobial interventions to be used during pork production (FSIS, 2013b). Lactic acid at a concentration of 2 to 5% and a temperature of 55°C has been approved for application to pork primals and trim. *Salmonella* Typhimurium can be reduced to an undetectable level on the surface of pork after treatment with a 2% lactic acid solution for 30 seconds (van Netten et al., 1995). A combination of hydrochloric and citric acid at a concentration of 1 to 2%, a pH value of 1.5, applied at a pressure of 2.07 to 27.5 BAR, for 2 to 5 seconds has been approved for pork carcasses (FSIS, 2003).

The issue with the use of organic acids and other chemical interventions by the pork industry is not effectiveness; rather it is the highly specific parameters (e.g., concentration, temperature, pressure, etc.) that these compounds have been approved to be used at. The extreme (high and low) parameters at which chemical interventions are effective for application to beef carcasses have been defined (Pittman et al., 2013). The result of this work was determination of an acceptable range over which organic acids and other interventions could be used as part of a HACCP system. Conduction of such a study by the pork industry would allow multiple producers who use the same intervention, at different application parameters, the ability to cite one study that would provide supporting documentation for the intervention.

Chilling improves pork quality and slows the growth of bacteria (Huff-Lonergan, 2000). In the U.S., rapid (-5° C for 2 h) or ultra-rapid (-30° C for 30 min) chilling are utilized by the pork industry prior to tempering carcasses for approximately 24 h at 0° C (Cutter, 2003). Cooper (1968) and James et al. (1983) found that the anti-microbial properties of the two chilling

methods were not different. Later work reported that blast or ultra-rapid chilling was able to reduce populations of *C. coli* to non-detectable levels, whereas this was not observed with conventional chilling (Chang et al., 2003). Nesbakken et al. (2008) published similar findings and determined that the prevalence of *Campylobacter spp.* on pork carcasses was reduced from over 50% to less than 2% following blast chilling. Chang et al. (2003) found that blast chilling may also reduce *L. monocytogenes* and *S. Typhimurium* counts by 0.4 to 1.1 log CFUcm<sup>2</sup>. Some large scale packers chill carcasses and then apply citric acid during the tempering phase.

Citric acid has been reported to decrease aerobic plate counts and total coliforms in pork loins treated with a 1.5% solution and stored for 14 d (Fu et al., 1994). Pittman et al. (2011) found that citrus essential oils (CEO) reduced populations of generic *E. coli* that served as surrogates for *E. coli* O157-H7 and *Salmonella spp.* on beef brisket flats. The previous work reported CEO were an effective intervention against *E. coli* O157-H7 and *Salmonella spp.* during refrigerated storage. No works exist that have summarized the effectiveness of citric acid as an intervention applied to pork carcasses, particularly when applied at refrigerated temperatures. Application of organic acids during chilling requires further exploration to be validated as an effective microbial intervention to be used during pork production.

The use of gamma rays to control *Trichinella* in fresh or previously frozen pork was permitted by the amendment of the Federal Meat Inspection Act in 1986. In 1999, FSIS amended its regulation to allow the use of radiation on refrigerated and frozen uncooked meat and on meat by-products to eliminate or reduce foodborne pathogens or to extend shelf life (FSIS, 1999). According to the Code of Federal Regulations Title 21, Volume 3, to control *Trichinella* in pork carcasses or fresh, non-heat-processed cuts of pork carcasses, the U.S. Food and Drug Administration (FDA) permits the use of irradiation at a level of 0.3 to 1.0 kGy (U.S.

FDA, 2013). Pork can be labeled as “certified” if companies prove that viable trichinae have been inactivated by irradiation. In 2009, 57 countries had approved the use of irradiation (IAEA, 1999; Kume et al., 2009). The biggest concerns when pork is irradiated are quality issues such as lipid and pigment oxidation; consequently, in the U.S., only around 80,000 tons of pork are irradiated each year (Kume et al., 2009).

### Challenges and GAP Analysis

On August 28, 2013, the USDA-FSIS announced that it would consider expanding testing for *Salmonella* to classes of meat products not currently subject to routine sampling; among these were pork trim and ground pork (FSIS, 2013a). The prevalence of *Salmonella* at various stages of swine production was summarized to be 1% to 75% in various pre-harvest production environments (Baer et al., 2013). However, prevalence of *Salmonella* on pork carcasses was 1.7% in 2011, which was lower than the baseline prevalence of 8.7% reported by USDA Food Safety and Inspection Service (FSIS) in 1996 (FSIS, 1996; Englejohn, 2013). Another report found fewer than 4% of pork carcasses were positive for *Salmonella spp.* post-chilling, and only 0.6% of positive samples were enumerable (Schmidt et al., 2012). These trends demonstrate commitment by the pork industry to developing effective pre- and post-harvest interventions to control pathogens and spoilage bacteria. Nevertheless, regulatory actions may dictate the need for further control of *Salmonella* in all red meat species.

Prevalence of *Salmonella* in other tissues of pork carcasses such as the lymphatic system must be fully determined. The structure of the swine industry could allow for a more integrated approach to food safety than any other red meat industry. Continued research on vaccination could be the best approach to address *Salmonella* concerns in live animals. Development of phage therapy could offer an alternative to vaccination that might be effective if applied at the

correct time before harvest and if phages are developed for multiple serotypes of *Salmonella* and possibly *Campylobacter*. Few works exist that have evaluated the control of *Yersinia enterocolitica* in the U.S. swine population. Data exist that show a high prevalence of the pathogen in pigs. Further research is required by the U.S. swine industry to address potential concerns with *Y. enterocolitica*.

The emergence of antimicrobial resistant strains of *Salmonella* and *Campylobacter* cannot be ignored by the swine industry. No data currently exist on the use of antibiotics or growth promotants by the swine industry. Some work conducted in the U.S. has reported an increase in the antibiotic resistance of bacteria common to swine (Haley et al., 2012). *Salmonella* and *Campylobacter* should be the safety issues of greatest concern to the swine industry, particularly in production of fresh pork. Identification by CDC (2013) of antibiotic use in livestock as a contributing factor to the serious threat of resistant strains of *Campylobacter* should be concerning to the swine industry. The antibiotic residue issue in pork is now at a level that surpasses the dairy industry (FSIS, 2011). The incidence of pathogens on pork carcasses has been reduced, but the safety issues associated with the pathogens found on pork are dramatically more complex. Science based solutions to validate interventions and production practices must be found to improve the safety of U.S. pork.