RESEARCHREPORT

INTERNATIONAL TRADE

Title: Pork variety meat offal global safety and quality literature search and industry survey **– NPB #15-200**

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Industry Summary: The ability of the pork industry to enhance profitability is best found through the utilization of low value products that are not commonly accepted for consumption in the United States, ie offal products. Recent analysis has indicated great potential to add value to pork if offal and specifically variety meats can be exported. The goal of this project was to conduct a literature review to determine what information currently exist related to the real and perceived safety of US pork offal versus pork offal from other countries and to determine the opportunity and utilization of such products. A review of literature was conducted across both scientific and trade journals to determine previous research/ analysis conducted. This review found little previous documented research conducted. In addition, while interest/ current export practices among packers/ processors varied greatly, the opportunity to explore such markets around the globe with a variety of products exist and could be economically advantageous.

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Scientific Abstract: Pork offal and bone products are often highly acceptable in the global market and may be widely utilized, and may provide essential nutrition in human diets. Animal organs and glands can impart a variety of flavors and textures to food products while increasing the nutritional value of the food (Lui, 2002). In Southeast Asia, offal including brain, heart, kidney, liver, lung, spleen, tongue, pancreas, stomach, testes and thymus are often consumed (Lui, 2002). Pathogenic bacterial contamination must be avoided in the export and sale of pork variety meats. A previous study in Lancaster County, England suggests that 6% of pork offal samples for retail sale were contaminated with *C. jejuni* or *C. coli.* Recent Studies funded by the National Pork Board has indicated that most pork lungs and a high percentage of hearts, livers and kidneys are also contaminated by Salmonella, spp. It is believed that often, this contamination is possibly due to cross contamination during the harvest and processing of the animals. Limited research in the global safety of pork offal suggests that further work is needed to better understand the prevalence level in various products, the routes of transmission and possible hurdle approaches to minimizing product contamination, thus enhance both product shelf life and safety.

Introduction: A recent regression analysis showed that for every $1 million of muscle meat exported, live hog value increases by $0.05/CWT but for every $1 million of variety meat exported, live hog value increases by $0.20/CWT. The US pork industry produces more than five million metric tons of pork variety meats and pork by-products each year, yet it exports less than a half million metric tons of these products. This suggests that a significant portion of US pork carcasses are currently rendered to make blood meal, meat and bone meal, fat and grease. These rendered products are all of low value but are often highly valued in specific countries and in many cases sell for price premiums that are many multiples of the US price. Also, consumers in many target countries often lack adequate, high quality protein in their diets. The elimination of a price wedge between the US and international prices would allow these consumers to purchase products that are highly valued in local cuisine and, in so doing, increase the nutritional value of their diets. The removal of this price wedge would also increase the value of live hogs in the US and reduce the breakeven cost of producing muscle meats for the US consumer. The desire to enhance pork value although laudable, is difficult to achieve in an industry that has already taken advantage of most opportunities to add value in the muscle products as well as many by-products. However, the opportunity to add value to export products not normally consumed in the US offers a unique opportunity to the US pork industry. Pork offal, especially bone items, a rich and economical source of essential nutrients, are underutilized and even detrimental to value in many situations. Although the meat industry employs several practices to merchandize bones, only a few of them have been adapted for use in by-products due to the product's value. Thus, issues still exist for variety item export meats due to concerns about profitability and market share. Currently, there is little information available for best management practices that exist to optimize value of bone utilization, especially for export. The current study will attempt to better understand possible methods of optimization on pork bones for use in the export market

Objectives: The objective of this proposed project is to:

- Conduct a literature and industry review of the past and current safety and quality of pork offal products in the global market.

Materials & Methods: Industry Survey and Database Search

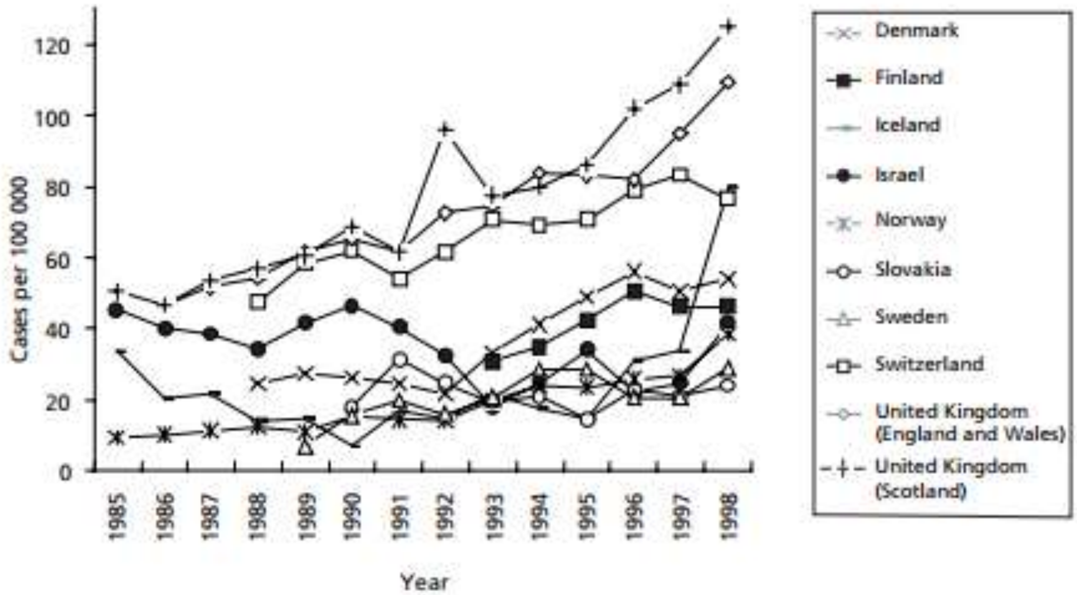
Eight to twelve industry executives will be selected for survey. Once selected, each will be surveyed about knowledge of previous, current and potential future offal product processing, market and utilization including safety, quality and profitability. A standard survey will be developed for distribution in an attempt to garner consistent informational sources.

The data base literature review will include a literature search in Web of Knowledge, which includes the following databases: Web of Science, BIOSIS Citation Index, BIOSIS Previews, CAB Abstracts, Current Contents Connect, Data Citation Index, Derwent Innovations Index, MEDLINE, Zoological Record, and Journal Citation Reports. The search string will be designed using the terms/ phrases that related to the pork bone utilization and marketing. Further refinement will be conducted as initial results indicate database tendencies.

Results:

Minimizing the risk of foodborne illness transmission through pork offal products is of high importance. Incidence of the two most common foodborne pathogens in Europe, *Salmonella* and *Campylobacter*, have increased dramatically during the last several decades (WHO, 2004).

Fig. 2.1. Reported incidence of campylobacteriosis in selected European countries, 1985–1998



Source: Tirado & Schmidt, 2000.

The region with the highest per capita occurrence of foodborne illness is Africa, where approximately 9 million individuals contract foodborne illness annually, and approximately 137,000 people die each year (WHO, 2015). On the African continent, non-typhoidal *Salmonella* causes most fatal cases of foodborne illness (WHO, 2015).

Though the Southeast Asia region has a lower rate of foodborne illness per 100,000 people, the region's higher overall population results in a greater total number of foodborne infections (150 million annually) and deaths caused by foodborne illness (175,000 annually) (WHO, 2015). However, unlike in the African region, most foodborne illness and deaths in Southeast Asia are the result of aflatoxin, a toxin produced by mold that can grow on improperly stored grains (WHO, 2015).

Pathogenic bacterial contamination must be avoided in the export and sale of pork variety meats. *Yersinia enterocolitica* 4:O3 was isolated from 16 of 19 swine herds in a recent study (Fredriksson et al., 2001, Germany), and 10% of all fecal samples in this study tested positive for *Y. enterocolitica*. Healthy pigs may carry and transmit *Y. enterocolitica*, particularly in the tonsils, as 60% of tonsil samples from non-symptomatic pigs tested positive for *Y. enterocolitica* 4:O3 (Fredriksson et al., 2001, Germany). For this reason, the study authors recommend that tonsils and tongue be removed with the head during hog harvest to prevent cross-contamination (Fredriksson et al., 2001, Germany). *Campylobacter jejuni* type 1 of serotypes 1 and 2 is implicated in human cases of *Campylobacter enteritis*, and 89.5% of Campylobacter isolates from pork offal were of this serotype (Bolton et al., 1985, Great Britain). Considering different organ tissues, *C. jejuni* was more prevalent in liver samples (28.5% occurrence) than spleen or kidney samples (3.2% occurrence) (Alecu & Botus, 2008, Romania). Additionally, *Campylobacter coli* was more prevalent in fecal samples than organ tissue samples, observed at rates of 50% and 30%, respectively (Alecu & Botus, 2008, Romania), and direct isolation as compared to use of enriched media produced similar data in identifying *C. coli* in porcine fecal and organ tissues (Alecu & Botus, 2008, Romania). A recent study in Lancaster County, England suggests that 6% of pork offal samples for retail sale were contaminated with *C. jejuni* or *C. coli* (Bolton et al., 1985, Great Britain). The same study indicates that blanching offal products in boiling water for 30 seconds resulted in a significant decrease in *Campylobacter* isolation (Bolton et al., 1985, Great Britain). Another study in the

United Kingdom found that offal products had higher levels of *Campylobacter* contamination than whole muscle products from the same species (Kramer et al, 2000, Great Britain). Furthermore, a study by Altrock et al. examining factors coinciding with presence of *Salmonella* bacteria in pork products found rations containing pelleted feed increased the incidence of *Salmonella* (2000, Germany). However, 1.2% of samples of animal feeds tested positive for Salmonella in a 2013 study in the United Kingdom.

Viral contamination must also be avoided in pork variety meats. Hepatitis E is of particular concern, as a strong correlation between consumption of raw figatella (a raw pork liver product) and human illness has been observed through viral genetic testing (Colson et al., 2010, France), and 40% of autochthonous Hepatitis E infections are caused by the consumption of raw pork liver (Pavio et al., 2014, France). Studies by Berto et al. (2012, Great Britain) and Feagins et al. (2008, United States) indicated that 11% of commercially available pig livers in the United States are contaminated with Hepatitis E virus, 10% of sausage samples at a retail outlet tested positive for Hepatitis E, and 25% of retail surfaces tested positive for Hepatitis E virus when swabbed. Research by Feagins et al. (2008, United States) suggests cooking pork liver harboring Hepatitis E by boiling for five minutes or stir frying at 191^{0}C for 5 minutes resulted in no transmission of the virus when that contaminated, cooked pork liver was fed to healthy pigs.

Another potential risk in international trade of pork variety meats is the transmission of viruses to live hogs through the feeding of contaminated, uncooked food wastes. Of primary concern are Foot and Mouth Disease, Classical Swine Flu (Hog Cholera), African Swine Flu, and Swine Vesicular Disease (Farez & Moreley, 1997). Hogs with active infections of these disease at harvest may exhibit virus in organ tissues. Additionally, hogs may be carriers of African Swine Flu, expressing the virus in the lymph nodes, tonsils, kidneys, spleen and bone marrow, but be asymptomatic (Farez & Moreley, 1997). These viruses can each be detected in offal and processed pork products after months and, in some cases years, of storage at chilled or frozen temperatures (Farez & Moreley, 1997). Water activity, pH, moisture:protein ratio, processing and storage temperatures, salinity, and additive ingredients all impact the survival of these viruses (Farez & Moreley, 1997). Furthermore, Classical Swine Flu is susceptible to rapid cycling a freezing and thawing, though the virus exhibits long survival times at constant frozen temperatures (Farez & Moreley, 1997). Finally, each of these four viruses are inactivated by cooking to an internal temperature of 69^{0}C, though time needed at this temperature for complete inactivation varies from virus to virus (Farez & Moreley, 1997).

Novel active packaging techniques can mitigate risk of foodborne disease transmission from microbial sources. Active package is defined by (Quintavalla & Vicini, 2002) as "a type of packaging that changes the condition of the packaging to extend shelf-life or improve safety or sensory properties while maintaining the quality of the food. This can be accomplished by scavenging oxygen, moisture or ethylene, emitting ethanol or flavors or carrying out antimicrobial activities" (2002). Incorporation of antimicrobials can control pathogens and/or spoilage organisms by decreasing their growth rate, decreasing the maximum obtainable population size or extending the log phase (Quintavalla & Vicini, 2002). Types of antimicrobial packaging include synthetic polymers, edible films, organic acids and their salts, enzymes, bacteriocins, compounds such as silver zeolites and fungicides (Quintavalla & Vicini, 2002). Edible films and coatings are of particular interest in shipping pork offal products internationally. Edible films and coatings can be made from polysaccharides, proteins and/or lipids, and have the advantages of biodegradability, edibility, biocompatibility and aesthetic appearance, while providing barrier properties to oxygen and physical stress of shipping (Quintavalla & Vicini, 2002). Furthermore, edible films and coatings may incorporate antioxidants or antimicrobials that are approved for use directly on meat surfaces (Quintavalla & Vicini, 2002). Two specific examples of active packaging and incorporation of antimicrobials into edibles films and casing are silver zeolite and cellulose casings with pediocin or nisin. Silver zeolite is a popular packaging component in Japan, which inhibits many metabolic enzymes of microbes, making it a strong and versatile antimicrobial agent (Quintavalla & Vicini, 2002). Pediocin is a *Pediococcus*-derived bacteriocin, and, when used in combination with a chelating agent, has been shown to completely inhibit *Listeria monocytogenes* on ham, turkey and beef (Quintavalla & Vicini, 2002). This bacteriocin can be incorporated into cellulose casings used in sausage products.

Heavy metals such as lead and cadmium may accumulate in pork offal, and should therefore be quantified and monitored to prevent adverse effects to human health. Analysis of multiple tissue samples showed the highest lead concentrations in hair and feces, while lead concentrations were highly correlated between blood, bone, kidney, liver, spleen and lung samples, suggesting that blood analysis of live animals can indicate overall lead levels across all tissues (Gyori et al., 2005, Hungary). Likewise, cadmium levels were highly correlated between kidney, liver, spleen, lungs and feces, so fecal analysis can serve as an on-farm indicator of overall cadmium levels (Gyori et al., 2005, Hungary). The same study suggested that, of the tissues analyzed, cadmium levels were highest in the kidneys (Gyori et al., 2005, Hungary). Genetic factors were not shown to impact cadmium accumulation in pig livers (Tomovic et al., 2011, Serbia).

Organic toxins can also accumulate in pork offal products. Dioxin can be found in unexpectedly high levels in gelatin derived from pork bones and hides due to malfunctions in the filtration step of collagen processing (Hoogenboom et al., 2007, Netherlands). Another toxin of concern is Ochratoxin A. Ochratoxin A originates from mold-contaminated feeds and can accumulate in hog organs, which can then be further concentrated in humans who ingest hog organ tissues (Petzinger & Ziegler, 2000, country not specified). This is not an issue in ruminants, because ruminant gut microbes breakdown Ochratoxin A (Petzinger & Ziegler, 2000, country not specified). Observed especially in eastern Europe, Ochratoxin A can lead to nephropathies in humans (Canela et al., 1994, Spain) and is reported to have carcinogenic, genotoxic, teratotoxic, immunotoxic and nephrotoxic properties (Petzinger & Ziegler, 2000, country not specified). Furthermore, Ochratoxin A has an extremely long serum half-life, detected at least 840 days after ingestion (Petzinger & Ziegler, 2000, country not specified). Levels of Ochratoxin A have been measured as high as 8 µg/kg in pork offal and blood sausage, while in humans, the daily tolerable intake of Ochratoxin A is 5ng/kg of body weight (Petzinger & Ziegler, 2000, country not specified).

Industry Survey

Industry response varied great in many aspects. Current range of offal exports were from 0- 100% of production. Many respondents reported an expectation of export demand of offal products rising over the next immediate future. One of the largest obstacles to exportation seen is the usage of growth promotants (Ractopamine) by China and the slow response by the US producer.

As far as the types of products with the greatest export potential, many processors identified hearts, kidneys, livers, heads, tails, ears and feet. An opportunity to export bones for soups, stocks, retail and food service uses also exists though obstacles are present from a logistical standpoint.

Most respondents listed China, Mexico, Taiwan, South Korea and Canada as the major countries to target for future export growth of pork offal products. While most respondents considered US offal products safer than in the past and acceptable in safety, some did think the US lags behind other countries in providing the safety products possible.

Discussion: Pork offal, specifically variety meats items, are the last frontier of value-added merchandizing to explore from the highly value-added porcine animal! If the recent scenario presented that indicated for every $1 million of variety meat exported, live hog value increases by $0.20/CWT and the industry exports less than 10% of these products then a tremendous economic opportunity exist for the US pork industry. As the US pork industry searches to capitalize on this little valued by-product that the majority of the world has commonly accepted as a readily consumable animal protein source, it needs only determine a way to assure the safety and extend the shelf life of products destined for export. This added value to a current low value byproduct with little future for enhancement in the US market will allow for a greater return to the entire pork value chain by providing a substantial demand in pork exports.

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