The research projects listed below are funded in whole or part by the Beef Checkoff and are intended to help ensure a safe and nutritious beef supply.

Funded by Beef Farmers and Ranchers

Current Research Projects — July 2023

Creating Alternative Support for Lethality and Stabilization for Heat Treated and Fully Cooked Meat and Poultry Products, University of Wisconsin, HansonTech
Nearly all meat processors in the United States utilize USDA, FSIS Appendix A and B to ensure adequate thermal lethality and stabilization is achieved for partially and fully cooked products. Through the development and release of updated versions in 2017 and 2021, and the realization that a host of potential food safety vulnerabilities exist, the widespread usefulness and in-plant practical application of these guidance documents has become a significant concern and practical challenge to implement. The primary objective of this study is to develop a scientific-based, regulatory-supported, and industry-useful thermal processing and cooling resource (*e.g.* cooking and cooling food safety handbook) for validating pathogen destruction and control, and regulatory compliance for partially and fully cooked meat products that can be used in conjunction with or in lieu of USDA, FSIS Appendix A & B.
Funded in part by the Foundation for Meat & Poultry Research & Education

Enhanced Characterization of Sequence Differences Among *Salmonella* isolates within SNP Clusters Identified by the NCBI Pathogen Detection System, USDA-ARS, Meat Animal Research Center
This research intends to better understand the full picture of relatedness within critical *Salmonella* serovars of interest by performing a comparative genomic analyses on currently available data within the Pathogen Detection Isolates Browser (PDIB). An analysis pipeline will be developed to catalogue *Salmonella* SNP cluster diversity in the NCBI PDIB with the goal of producing a white paper to enhance industry use and understanding of this tool, and to enhance public health actions and general understanding of *Salmonella* genomics by identifying isolates for closed genome sequencing that are within 50 SNP differences.

Developing a Quantitative *Salmonella* Baseline from Ground Beef in the United States, Texas Tech University, Kansas State University, University of Georgia, USDA-ARS, Meat Animal Research Center, Food Safety Net Services
The *Salmonella* level in ground beef across the U.S. is unknown. As a result, risk assessments and understanding the public health impact of potential *Salmonella* control programs across the industry are not always accurate. This study intends to conduct a representative *Salmonella* baseline and develop a blinded quantitative *Salmonella* baseline for the U.S. beef industry representing season and geographical waves.

Novel TaqMan assays for the specific detection and simultaneous differentiation of virulent and avirulent non-O157 Shiga toxin-producing *Escherichia coli* strains, Florida State University, USDA-ARS, U.S. Meat Animal Research Center
This study intends to standardize six multiplex TaqMan assays for the identification of virulent strains of *E. coli* O26, O111, O45, O103, O121, and O145 serogroups. Further, it will demonstrate the applicability of the standardized assays in inoculated food samples and red meat enrichments from national red meat surveillance programs through a direct comparison with the FSIS MLG 5C.01 reference method.

Effects of proportioning meat and plant-based protein-rich foods within the U.S. Healthy Eating Pattern on cardiovascular disease risk factors, Purdue University
This project will assess the effects of consuming different proportions of red meat and plant-based, protein-rich foods incorporated into a U.S. Healthy Eating Pattern on cardiovascular disease risk factors in adults at high risk of developing a heart-related disease.
Funded in part by the Foundation for Meat & Poultry Research & Education

Recently Completed Research

Dietary modeling the nutritional impact of removing/adding/substituting meat and poultry servings to the healthy dietary patterns, Nutrition Impact LLC, NutriScience LLC
This project modeled the effect of removing or adding a serving of minimally processed and further processed meat and poultry or substituting a serving of various foods with a serving of minimally processed and further processed meat and poultry on nutrient profiles in the healthy dietary patterns identified in the Dietary Guidelines for Americans, 2020-2025.
Funded in part by the Foundation for Meat & Poultry Research & Education

Impact of sanitization and natural biofilm communities on *Salmonella* prevalence at processing plants, USDA-ARS, U.S. Meat Animal Research Center
This project evaluated the efficacy of commercial sanitizers against *Salmonella* harbored within environmental mixed biofilms by measuring biofilm forming ability and community structure of environmental biofilms before and after sanitization. It then compared environmental microbial communities and *Salmonella* survival in mixed biofilms before and after sanitization to determine the impact of different sanitizers on controlling *Salmonella*.

Using empirical evidence, modeling, and risk assessment methods to estimate the public health impact of incorporating enumeration and virulence as part of the criteria for evaluation of *Salmonella* contamination in ground beef in the US, EpiX Analytics, Colorado State University
The EpiX analytics team incorporated novel genomics methods into a fully quantitative risk assessment. The genomics methods allowed for the identification and differential targeting of Salmonella serovars into higher- and lower-virulence groups. The results of the risk assessment show that considering quantitative criteria to target higher virulence serovars combined with high rates of combo testing can significantly reduce human salmonellosis. Although low virulence serovars cause salmonellosis, targeting these serovars only slightly improved the reduction of illnesses. Using modeling, *Salmonella* prevalence in beef products significantly increased along with the number of cattle coming from the Southwest and Midwest regions. Additionally, prevalence was significantly higher in the summer season and increased with the distance cattle traveled from source to slaughter. There were no significant associations between region or season with high-virulence *Salmonella* serovars.

Risk assessment model to assess the impact on public health of ground beef lots based on the contamination level and presence of highly virulent or multidrug resistant strains, University of Minnesota
This project developed a risk assessment model using existing Food Safety and Inspection Service prevalence and enumeration data to assess the impact of ground beef lots characterized by contamination level and presence of highly virulent or multidrug resistant strains on public health. Overall, this study found that the removal or diversion of contaminated ground beef lots containing *Salmonella* above threshold levels of 10MPN/g and 1MPN/g would result in a 13.6% and 36.7% reduction of annual salmonellosis illnesses, respectively. Risk to consumers is highest when cooking at home and from frozen rather than in restaurants or using fresh/thawed product. It's possible that up to 12.4% of infections are MDR, which complicates treatment and increases the burden of disease. Highly virulent serotypes account for 96.7% of annual illnesses despite only having a prevalence of 13.7% in ground beef samples. Focusing salmonellosis reduction efforts on redirecting highly contaminated ground beef lots and highly virulent *Salmonella* serotypes from NRTE products appear to be the most effective risk prevention strategies. Model estimates will become more precise with improved understanding of virulence categorization due to illness estimate sensitivity to high virulence serotype prevalence. Reliable cross-contamination coefficients in various preparation settings would bolster the interpretation of these models moving forward.

Recently Completed Research

Effects of deep cleaning sanitation on biofilms and pathogens, USDA-ARS-Meat Animal Research Center

The study suggested that deep cleaning sanitization might disrupt the pre-existing microbial community and alter the natural population composition. Disruption of the environmental biofilm community may have unexpected effects resulting from the lack of competition within the multispecies mixture and the survival/recruitment of species with high colonizing capability to the community.

Improving Validation Methods for *Salmonella* Lethality on the Surface of Multiple Impingement-Cooked Meat and Poultry Products, Michigan State University, University of Wisconsin

The study identified critical limits (i.e., humidity, air velocity, surface time-temperature), relative to achieving target *Salmonella* lethality on the surface of impingement-cooked products. Process humidity and product variability should be considered in regulatory requirements and process validations. Findings are intended to improve the ability of the meat and poultry industry to comply with Appendix A or provide alternatives for lethality support.

Funded in part by the Foundation for Meat & Poultry Research & Education and the National Pork Checkoff.

Evidence-based, quantitative risk assessment to control salmonellosis attributable to ground beef: Evaluating and mitigating the contribution of lymph nodes to *Salmonella* contamination, University of Nebraska-Lincoln, U.S. Meat Animal Research Center, USDA ARS, Michigan State University, The University of Vermont, University of California

This project characterized the distribution of both prevalence and concentration of *Salmonella enterica* in bovine deep tissue lymph nodes (DTLNs) by lymph node type, production source, region and season using systematic review and meta-analysis approaches. The relative contributions of DTLNs and the efficacy of their removal at processing on salmonellosis risk associated with ground beef consumption will be evaluated using a quantitative microbial risk assessment approach.

Effect of clean label antimicrobials on the inhibition of *Clostridium perfringens* and *Bacillus cereus* during extended cooling of uncured beef and poultry products, University of Wisconsin-Madison, Cargill

This study compared the effect of clean label antimicrobial ingredients on the inhibition of *Clostridium perfringens* and *Bacillus cereus* in model uncured beef and poultry products, having different moisture, pH, and salt contents, with a primary focus on extending Phase 1 cooling from 120 to 80°F. Data revealed no growth of *Bacillus cereus* in the uncured turkey or beef treatments when Phase 1 cooling was extended to 5 hours regardless of antimicrobial treatment. As excepted, *C. perfri*ngens grew rapidly in Control treatments without antimicrobials; populations increased over an average 2.5 logs when Phase 1 cooling was extended to three hours and populations reached stationary phase when Phase 1 cooling was extended to four or five hours. All dry vinegar and cultured sugar vinegar ingredients tested inhibited *C. perfringens* growth compared to the control without antimicrobials. Level of inhibition was similar among the four dry vinegar suppliers, with 1.25% dry vinegar sufficient to limit growth to 1-log or less in both uncured turkey and beef when Phase 1 cooling was extended to 3 hours. However, when Phase 1 cooling was extended to 5 hours, all of the formulations supported > 1-log increase even when used at a 1.25% level. Greater variation was observed among the four suppliers of cultured sugar-vinegar ingredients. All four ingredients inhibited growth of *C. perfringens* when Phase 1 cooling was extended to 3 hours when ingredients were used at 1.25%. The addition of 1.25% CSV-A and 0.75 and 1.25% CVS-D inhibited growth in turkey even when Phase 1 cooling was extended to 5 hours (15 h total cool), but inhibition was inconsistent in beef.

Funded in part by the Foundation for Meat & Poultry Research & Education

Recently Completed Research

Meat as a First Solid Food on Risk of Overweight and Neurodevelopment in Infants, University of Colorado Anschutz Medical Campus, University of Colorado Denver

Early complementary feeding is a unique and malleable period to prevent rapid weight gain and later obesity, and is also a critical phase for neurodevelopment. Meat is an excellent source of high-quality protein and micronutrients, which are critical for the normal development of older infants. Although COVID significantly impacted the progress of the study, investigators were able to retain all the study outcomes (growth, body composition, sleep and neurodevelopment), and also added gut microbiota assessment as it interacts with other health outcomes measured. Findings are being reported in manuscripts addressing: growth and body composition changes over time and between groups; changes in gut microbiota over time and between groups, and its association with growth; changes in sleep activity and neurodevelopment over time and between groups; interplay of gut microbiota, sleep and infant growth; and serum metabolomics and other -omics related findings. Findings from this study will be generalizable and help inform future dietary guidance.

Funded in part by the Foundation for Meat & Poultry Research & Education

Maximizing the dietary pattern of older adults: the effects of protein intake on protein kinetics, University of Arkansas for Medical Sciences

The overall project goal was to demonstrate how easily prepared animal-based protein-rich food sources can be used by older adults to increase protein intake within pre-existing dietary patterns. The impact of this study on the meat and poultry industry is a positive one in all regards. First, in the format of a 2-meal consumption pattern in older individuals, the findings demonstrate a positive effect of consuming a double the recommended dietary allowance (RDA) amount of high-quality protein. These results also indicate that the RDA (literally defined as the amount of protein required to maintain protein balance) and the commonly consumed NHANES amount are insufficient protein intakes in the 2-meal format for older individuals. The divergent results of improved whole-body protein balance without affecting skeletal muscle, together with previous findings, suggest that an additional feeding of high-quality protein is required to improve skeletal muscle turnover. This recommendation is consistent with the potential ingestion of a pre-prepared quality protein source that is common to the meat and poultry industry.

Funded in part by the Foundation for Meat & Poultry Research & Education

Current Knowledge and Gaps on the Mechanistic Development of Cancer in Humans Associated with Processed Meat and Poultry Product Components, University of Wisconsin-Madison

This review summarizes data in the scientific literature which explain, mechanistically, how components found in processed meats and poultry products might contribute to carcinogenesis. Components discussed include those intrinsic to red meat and poultry as well as those which might be contaminants in red meat and poultry. The review also examines ingredients used in processed meat and poultry products and, importantly, processed-induced contaminants. A discussion of the strengths, weaknesses, and gaps in current knowledge related to potential mechanisms of carcinogenesis related to processed meats and poultry products is presented.

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