FOUNDATION FOR MEAT & POULTRY RESEARCH EDUCATION

2018-2019 Industry Research Needs

Below are the 2018-2019 Industry Research Needs for the Foundation for Meat and Poultry Research and Education (Foundation) as developed by the Foundation's Research Advisory Committee. These priorities address: pathogens on fresh and ready-to-eat meat and poultry products; other food safety issues; product quality; and nutritional sciences. The priorities are used when communicating with government agencies, interested stakeholders and the general public, and are intended to show the broad scope and diverse research needs of the industry. The Foundation issues a separate Request for Proposals annually on selected research priorities, which are also noted in this document.

Cross Sector Food Safety Research Needs

- Use whole genome sequencing and other emerging technologies to evaluate the genetic factors allowing bacterial pathogens (STEC, *Salmonella* and/or *Listeria)* to live and thrive in processing environments, on food contact surfaces and/or on products. Research should include how these pathogens survive, and how the environmental and genetic factors influence virulence. *

- Evaluate mechanisms of horizontal gene transfer in pathogens in different environments. Research should address how horizontal gene transfer can lead to emergence of pathogen strains with increased virulence and/or antibiotic resistance phenotypes.

- Evaluate the commonly used food safety interventions throughout each step in the production chain, and determine the synergistic effects, if any, of the interventions throughout the continuum. Research should:
    - Address if certain practices at certain points in the production chain are more effective in reducing the overall prevalence of pathogens.

- Identify the combination of virulence factors that cause human illness. Research should:
    - Determine how virulence could be monitored and biologically prevented.
    - A subset of *Salmonella* serovars with high virulence should be identified, as well as a subset of serovars with low virulence. Determine the attribution of human illnesses based of virulence level.

- What factors should you consider when evaluating regulatory whole genome sequenced isolates, *e.g.* type of pathogen; relatedness of sequences; in plant location of pathogen; potential for harborage or continual reintroduction; what can be learned; among other factors.*

- Develop guidelines for validating in plant allergen control processes. The guidelines should include how to design an allergen validation program with a related decision tree for product disposition when there is a potential positive result for allergen contamination.

Pre-Harvest Pathogen Control

(Pre-harvest is defined as the time period before food production animals are slaughtered.)

- Transportation and lairage of food production animals has been identified as a risk factor for exterior pathogen contamination on animals prior to slaughter. Develop practical intervention technologies to reduce levels of exterior pathogens that do not compromise animal welfare standards during transportation and lairage.

- Identify likely sources of contamination, risk factors, and how to systematically intervene at the production facility, during transportation and lairage and the levels of STEC, *Salmonella, Campylobacter* or other foodborne pathogens present on/in carcasses and meat products. Specifically:
    - Explore the concept of identifying high-concentration STEC, *Salmonella, Campylobacter* or other foodborne pathogens on/in animals or flocks from farm to slaughter, and determine if certain points impact an increased load of STEC, *Salmonella, Campylobacter* or other foodborne pathogens on/in the animal. Research should:
        - Develop a testing strategy that can predict high-concentration STEC, *Salmonella, Campylobacter* or other foodborne pathogens on/in animals or flocks before slaughter to prevent contamination on carcasses, primals, parts and ground product.
        - Determine if and how "high-concentration" or high-shedder on/in animals or flocks correlates to internal colonization levels of STEC, *Salmonella, Campylobacter* or other foodborne pathogens.
    - Develop a commercially viable hide treatment technology that does not compromise animal welfare standards to reduce foodborne pathogen load on cattle or pigs presented for slaughter.

- Develop economically viable strategies for pre-harvest interventions. Research should address any obstacles in commercial adoption, including, but not limited to, regulatory approval, non-economic barriers, *etc*.

- Develop greater understanding of the ecology and epidemiology of STEC, *Salmonella, Campylobacter* or other foodborne pathogens in cattle, pigs and poultry. Determine the mechanism for internal colonization and corresponding opportunities for control.

- Explore the premise that internalized contamination is present in food production animals. Research should:
    - When appropriate, determine if all lymph nodes, or only major lymph nodes, are an issue, and address mitigation techniques (*e.g*. lymph node removal, antimicrobial application) for the identified sources of internalized contamination. Are these techniques implementable under normal commercial conditions?
    - Develop live animal intervention strategies to prevent or reduce *Salmonella* colonization within the lymphatic system.
    - Investigate whether vaccination has an impact on, or correlation to, internalization.

Post-Harvest Research

(Post-harvest is defined as the time period after which food animal are slaughtered.)

- Develop detection technologies that are based on detecting the pathogenic serotypes of STEC, *Salmonella, L. monocytogenes,* and other foodborne pathogens. The technology should:
    - Address virulence factors;
    - Address the heterogeneity of commercial samples; and
    - Ensure detection of virulence factors are from one serotype or cell.
    - The technologies and protocols should be clearly defined to enable direct comparison with existing technologies.

- Evaluate real-time or near real-time *Listeria* sampling and testing technologies.

- Develop improved and validated quantitative methods for *L. monocytogenes* detection in foods and environmental samples.

- Develop methods for quantitative *Salmonella* enumeration or methods based on virulence factors rather than serotypes, and demonstrate how these methods can be used to improve public health. Research should:
    - Address any obstacles in commercial adoption, including, but not limited to, regulatory approval, non-economic barriers, *etc*.
    - Develop guidance on how to implement new technologies and methods, including the documentation required by industry to gain regulatory approval.

- Evaluate interventions and typical natural and dry cure industry practices to address pathogens of concern. Research should address gaps in the literature relating to *Trichinella spiralis*, *Toxoplasma gondii*.

Innovative Pathogen Intervention Technologies

- Determine the lowest level/concentration of commonly used and novel antimicrobial treatments that are effective in reducing foodborne pathogens on meat and poultry products. Research should address effectiveness in hot and cold carcasses; primals; parts; and trim. Research should:
    - Address existing FSIS and FDA regulations (*e.g.* FSIS Supplementary Guidance, FDA approval status);
    - Define the meaning of bacteriostatic and bactericidal in the context of existing regulations; and
    - Include an evaluation of the impact on sensory attributes, cost and application method.

- Evaluate and determine the effectiveness of non-thermal and non-chemical intervention technologies to reduce pathogen loads on meat and/or poultry products.

- Determine the most effective location(s) in the production chain for ground meat, ground poultry and poultry parts to apply interventions to maximize reduction of microbial contamination.
    - Consider if the application of pre-harvest interventions in a food safety system reduces foodborne pathogen contamination in ground meat and poultry products, and if carcass washes and/or other post-harvest interventions in a food safety system reduce pathogen contamination in ground meat and poultry products.

- Identify likely sources of contamination, risk factors, and how to systematically intervene at the production facility to reduce the levels of foodborne pathogens present on carcasses and meat products. Research should:
    - When appropriate, identify if current production methods influence pathogen load;
    - Identify and/or develop and validate novel or improved interventions; address any obstacles in commercial adoption, including, but not limited to, regulatory approval, non-economic barriers, *etc*.; and evaluate interventions known to be cost-effective and consumer-accepted.
    - Compare effectiveness of carcass washing and trimming for reduction on carcasses; and
    - Evaluate the efficacy of non-water-based antimicrobial treatments in reducing pathogens on trimmings or ground meat and poultry products. Research should address the impact of the intervention on the organoleptic properties and shelf-life, and demonstrate that treated product would still qualify for any standard of identity requirements.

- Determine the effectiveness of existing or new intervention technologies on multiple serovars of *Salmonella.* Research should:
    - Determine if there are markers or factors that make certain serovars more resistant or susceptible to interventions.
    - Provide justification for serovars included in the proposal.

- Validate existing and commonly used intervention technologies for *L. monocytogenes* and how they impact *Salmonella* survival in fully-cooked RTE meat and poultry products, specifically dried, cured and non-fermented products. Research should:
    - Address additives, ingredients and thermal processes; and
    - Provide the necessary critical parameters needed for validation and modeling.

- Conduct side by side comparisons of listericidal and/or listeriostatic efficacy of commercially-available antimicrobial agents in different RTE meat and poultry formulations with the goal of achieving enough data to generate a model (*e.g.* such as http://dmripredict.dk/Default.aspx).
    - RTE meat systems to evaluate include, but are not limited to: whole muscle, cured pork (*e.g.* ham); whole muscle, uncured beef (*e.g.* roast beef); whole muscle, uncured poultry; emulsified, cured pork.
    - Antimicrobials to evaluate include, but are not limited to: 56% lactate, 4% sodium diacetate (10+ year historical market reference); vinegar and dried vinegar powders (brand A, B, and C); lemon juice and vinegar; lactate and potassium acetate at varying ratios; lactate, diacetate, potassium acetate at varying ratios; sodium propionate; others.

- Determine the likelihood of a protected niche, which could include pores/follicles in poultry skin, on the carcass that would reduce the pathogen exposure to antimicrobial interventions resulting in increased risk in ground meat and poultry products. Research should:
    - Consider if pathogens are getting under the surface or in pore/follicles and therefore being protected from liquid intervention and heat pasteurization; and
    - Address sublethality injury.

Evaluate and validate short time (less than one hour), high temperature (above 212°F) cooking processes without relative humidity on the lethality of *Salmonella* in large and small meat and poultry products. 9 CFR 318.17(a)(1) and 381.150 (a)((1))

- Research may be in the form of a challenge study.
- Determine the effect of dehydration on pathogen mortality during impingement cooking processes.
- An example of products of concern are marinated and marinated/breaded poultry products (bone-in and boneless). These products are often processed in a continuous cook oven and moisture must be managed to prevent the breading from falling off during cooking.

Evaluate permeability and denaturation of collagen casings during processing with and without relative humidity, including thermal processing, drying and fermentation. For example, a product cooked in a natural casing and then dried.

Evaluate and validate growth and toxin formation of *Staphylococcus aureus* under typical processing conditions as well as deviations (outside of 50-130°F in six hours) for low temperature cooked products, *e.g.* non-cured medium rare roast beef, bacon, cured hams.

Evaluate *Clostridium perfringens* growth during cooling in large diameter cured and uncured products beyond 120-80°F range in one hour and 80-55°F in five hours as prescribed under Option 2 in Appendix B. 9 CFR 318.17(a)(2) and 9 CFR 381.150 (a)(2)

- Research should evaluate worse case scenarios during the cooling process while limiting potential growth of *C. perfringens*.
- Determine the effect of antimicrobials on *C. perfringens* and *Bacillus cereus* during chill deviations outside of Option 2 and for large, non-cured items, specifically, cooling from 120°F–80°F in 3–4 hours and 80°F–55°F in 3–4 hours.

Update models used commonly for evaluating pathogen growth during process deviations. Pathogens can include *C. perfringens*, *C. botulinum* and *Bacillus cereus* among others.

- Temperature ranges of concern include cooling from 120°F–80°F in 3–4 hours and 80°F–55°F in 3–4 hours.

Examine the outgrowth of *Clostridium perfringens* growth during cooling in partially cooked or partially heat treated products. 9 CFR 318.23(c)(1) and 9 CFR 381.150(b)

- Research should focus on cooling times related to outgrowth under conditions as outlined in Appendix B. Investigate which Options outlined in Appendix B are suitable regarding growth and presence of vegetative cells in these products.

Determine the maximum cooling rates that are thermodynamically possible for non-cured beef and turkey products chilled in air-blast chillers.

- Research should include challenge studies to determine outgrowth of *Clostridium perfringens* during max-chill cooling.

Evaluate growth and toxin formation of *Bacillus cereus* and *Clostridium perfringens* under typical processing conditions as well as deviations (outside of 50-130 F in 6 hours) for low temperature cooked products, *e.g.* non-cured medium rare roast beef, bacon, cured hams.

- Research should include a growth comparison to determine if a process that controls *C. perfringens* also controls *B. cereus* in multiple products, species, formulations (cured and uncured) and processes.

- Evaluate common production processes used during the production of alternatively cured bacon and ham to better understand the lethality of certain thermal processes and cooling procedures that are currently being extrapolated from Appendices A and B. The research should explore the addition of nitrite and nitrate, including preconverted, as an ingredient in alternatively cured bacon(s) and ham(s), especially for the production of clean label, "natural" or organic products. Research should:
  - Validate cooking time, temperature, humidity parameters under various conditions/scenarios in products, including slow cook and slow come up times. *L. monocytogenes, Staphylococcus aureus, Clostridium perfringens, Salmonella* outgrowth should be evaluated and challenge studies would be appropriate, especially as it considers conditions such as overloaded ovens.
  - Validate cooling times as it relates to outgrowth and lethality under the same conditions as outlined above.
  - Evaluate the effect of non-continuous cooling as it relates to slow come up time in these alternatively cured products.

- Evaluate common production processes used during the production of uncured meat and poultry products to better understand the lethality of certain thermal processes and cooling procedures that are currently being extrapolated from Appendices A and B. The research should explore the addition of any ingredient that may influence the critical food safety parameters used during the production of clean label, "natural" or organic products. Research should:
  - Validate cooking time, temperature, humidity parameters under various conditions/scenarios in products, including slow cook and slow come up times. *L. monocytogenes, S. aureus, C. perfringens, Salmonella* outgrowth should be evaluated and challenge studies would be appropriate, especially as it considers conditions such as overloaded ovens.
  - Validate cooling times as it relates to outgrowth and lethality under the same conditions as outlined above.
  - Evaluate the effect of non-continuous cooling as it relates to slow come up time in these uncured products.

- Evaluate ingredients, antimicrobial treatments, or other non-thermal intervention technologies used to inhibit microbial (STEC, *Salmonella, Listeria* and/or *Campylobacter*) growth that can be used in the production of clean label, "natural" or organic products, including RTE and fresh meat and poultry parts and products. Research should:
  - Explore the addition of ingredients, antimicrobial treatments, or other non-thermal intervention technologies that reduce the time/treatment exposure levels needed or that eliminate the survivor "tail." When appropriate, the synergistic combinations of the ingredients, antimicrobial treatments, and non-thermal technologies should be evaluated.
  - Fresh meat products could include enhanced products, patties, links, *etc*.

- Identify and validate interventions to inhibit STEC on pork including carcasses, primals, trim and ground product. Interventions should be approved for use in the U.S.*

- Identify and validate interventions and novel application methods to reduce pathogen contamination of beef and pork head or cheek meat. Interventions should be approved for use in the U.S.*

- Identify and validate interventions and novel application methods to reduce pathogen contamination of poultry parts. Interventions should be approved for use in the U.S.*

- Identify and validate antimicrobial interventions to reduce pathogen contamination of beef edible variety meats. Interventions should be approved for use in the U.S. and ideally the major export markets for the specific variety meats.

- Identify and validate antimicrobial interventions to reduce pathogen contamination of beef edible variety meats intended for use in ground products. Interventions should be approved for use in the U.S. and ideally the major export markets for the specific variety meats.*

- Investigate efficient and sustainable application of antimicrobials to reduce pathogens on meat and poultry carcasses as well as primals and parts. The proposals should evaluate:
  - Water reduction and reuse, specifically efficacy during treatment period;
  - Reuse of antimicrobial treatments, specifically efficacy during "lifespan" of reuse treatment, including decay rate of efficacy; and
  - Type of application--both existing and novel technology.*

- Evaluate commonly used antimicrobial interventions at and above current regulatory level of water pick up, *e.g.* above the 0.49%, to determine if efficacy is improved with usage above the processing aid threshold.*

Operational Control and Monitoring of the Production and Processing Environment

- Develop more effective or novel methods for sampling post-chill carcasses.
- Evaluate the statistical validity of existing and alternative sampling methods for STEC, *Salmonella,* and other foodborne pathogens in trim, ground and finished meat and poultry products.
- Develop a standard protocol for validating finished product sampling, specifically in ground meat and poultry products.
- Evaluate novel methods for reducing transfer of foodborne pathogens from the exterior of the animal during production to the carcass.
- Identify and/or evaluate potential surrogate organisms for validating process controls for STEC, *Salmonella,* and other foodborne pathogens. Research should:
    - Address feasibility in a commercial setting as well as bench top.
    - Provide the necessary critical parameters needed for validation and modeling.
- Identify methods to determine biofilm formation and removal as affected by different surfaces used in the meat industry. Research should focus on methods to detect and measure biofilm presence; cleaners to remove biofilms; and be applicable in a commercial setting.
- Develop new and novel environmental monitoring strategies, detection, and/or sampling methods to more effectively identify harborage sites, including dual jurisdiction facilities. Research should provide the necessary critical parameters needed for validation and modeling.
    - Identify factors contributing to and influencing the ecology of facilities.
    - Identify and mitigate factors contributing to the development of harborage sites.
- Identify the potential for *Salmonella* harbors within the post-harvest processing environment and determine interventions to reduce or eliminate the presence of *Salmonella* in the identified harbors, which should be validated for effectiveness.
- Evaluate the effect of the plant environment (*e.g.* air, machinery, employees) in the role of transmission of foodborne pathogens in non-RTE processing and in dual jurisdiction facilities. Research should validate the expected impact of operational controls such as clean room technologies, facility and equipment cleaning procedures.
- Identify methods to prevent microbiological recontamination of sliced, diced, chopped and/or shredded RTE meats.
- Develop and validate measures of effectiveness for existing controls, including alternatively cured products. Research should address issues specific to small and very small plants.

Post-Production Research

- Identify and examine potential transmission and/or contamination vectors in a retail deli environment, including personnel and non-meat RTE deli products.
- Identify interventions to reduce the transmission and/or cross-contamination of *L. monocytogenes* in the retail deli environment.

Other Food Safety Research

- Evaluate current therapeutic and subtherapeutic antibiotic treatment options and determine how resistance is developed and transmitted among humans, animals, and other living organisms. Research should also address whether use impacts the food safety risk, *i.e.* pathogen shedding or changes in microbiome, animal welfare, and the potential economic impact in the production of meat and poultry products.

- Develop novel therapeutic and subtherapeutic antibiotic alternative treatment options and determine how resistance is developed and transmitted among humans, animals, and other living organisms. Research should also address whether use impacts the food safety risk, *i.e.* pathogen shedding or changes in microbiome, animal welfare, and the potential economic impact in the production of meat and poultry products.

- Develop a review paper discussing necessary critical parameters in pre-requisite programs. The target audience is small and very small establishments.
    - Including how to build effective prerequisite programs related to employee hygiene, facility and equipment cleaning, pest control, foreign materials, and suppliers, among others.

Information to Enhance Current and Future Public Health Risk Assessments

Salmonella

- Develop data to support future risk assessments of *Salmonella* and to estimate the human health risk attributable to beef, pork and/or poultry products.

- Develop a comprehensive qualitative risk assessment to determine the public health risk attributable to *Salmonella* in food and non-food sources.

- Identify factors that differ between pathogenic *Salmonella* serovars (including Dublin, Newport, and I 4,[5],12:i:-) compared to non-pathogenic serovars, and assess their effect on the ecology and whether they vary among species, environment, and other factors, such as competitive exclusion, *etc*.

- Investigate the epidemiology of multi-drug resistant *Salmonella* within the entire food production chain and quantify the human health risks associated with these organisms.

- Develop a comprehensive quantitative *Salmonella* risk assessment to determine the public health risk attributable to *Salmonella* in beef, pork, chicken, turkey and RTE products. The risk assessment should:
    - Address differences in isolates identified from carcass testing compared to product specific testing such as ground product or parts;
    - Identify data gaps among the commodity classes, *i.e*. address data gaps on effective interventions on trim and final ground product across all specie commodity classes; and
    - Assist in developing and implementing effective food safety process management programs to prevent pathogen contamination.

STEC

- Address data needs identified in the FSIS Draft Risk Assessment for *E. coli* O157:H7 (Ground Beef, Intact and Non-Intact Beef) and the Draft Risk Profile for STEC.

- Develop data to support future qualitative and quantitative risk assessments of STEC and to estimate the human health risk attributable to beef products.

- Develop a metric to determine the public health improvement for STEC illnesses based on specific virulence factors. Research should:
    - Demonstrate that identifying virulence factors have improved public health; and
    - Address if a correlation exists between PCR detection of a virulence gene and actual expression of virulence.

- Determine and evaluate factors that correlate to high event periods (HEP). Research should:
    - Investigate if there are genetic markers or strains that travel together;
    - Address other factors leading to HEP that may result in HEP;
    - Assess potential unknowns; and
    - Identify data gaps that may cause HEP.

Listeria

- Improve and augment epidemiological data on food attribution for listeriosis, both sporadic and outbreak cases. Research should recognize the following assumptions:
    - The FDA/FSIS *Listeria* Risk Assessment indicates ready-to-eat deli items are responsible for a majority of foodborne listeriosis cases in the U.S.
    - Determine the absolute risk of consumption of RTE foods compared to actual risk.
        - Research should address meat and non-meat RTE foods, product composition, ingredients, production practices, susceptible populations and infectious dose, *etc*.
    - Identify data gaps in the attribution of listeriosis cases related to distribution, retail and consumption of deli-sliced meats, specifically meats sliced in retail delis.
    - Identify and examine potential transmission and/or contamination vectors in a retail deli environment, including personnel and non-meat RTE deli products.
    - Identify interventions to reduce the transmission and/or cross-contamination of *Lm* in the retail deli environment.

Product Quality

- Evaluate the effect of different interventions alone or in combination with different types of packaging methods on the microbial ecology of different products in relation to storage life, discoloration and product quality.*

- Determine processing options for woody breast chicken.

- Evaluate methods and mitigation strategies to control and measure sporeformers on raw products prior to packaging to minimize or eliminate adverse quality outcomes like discoloration and blown bags.*

Nutritional Sciences

- Conduct menu modeling and other analyses to demonstrate that fresh and processed meat and poultry items can be a component of the dietary pattern recommended by the *Dietary Guidelines for Americans.**

- Prepare comprehensive white paper(s) to assess what is currently known and any potential data gaps on the mechanistic development of cancer in humans for processed meat and poultry product components.

- Risk-benefit analysis on the consumption of fresh and processed meat and poultry products as a component of a healthy diet and lifestyle.*