FOUNDATION FOR MEAT & POULTRY RESEARCH & EDUCATION

2020-2021 Industry Research Needs

Below are the 2020-2021 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 minimally and further processed 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.

Minimally Processed Beef Safety

Pre-Harvest Pathogen Control

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

- Further investigate the microbiome of cattle that are *Salmonella* shedders. Research should focus on variables that lead or allow animals to become shedders for *Salmonella*, the prevalence of *Salmonella* shedders, and what level of contamination can be attributed to these animals. Research should also address the role that different environmental factors (diet, antibiotic use, *etc.*) have on the microbiome of cattle that shed STEC and *Salmonella*.

- Identify likely sources of contamination, risk factors, and how to systematically intervene at the production facility, during transportation and lairage to reduce the levels of STEC, *Salmonella,* or other foodborne pathogens present on/in carcasses and meat products.

- Explore the concept of identifying high-concentration STEC, and *Salmonella* on/in cattle from farm to slaughter, and determine if certain points in production impact an increased load of STEC, and *Salmonella*. Research should:
    - Develop a testing strategy that can predict high-concentration STEC, and *Salmonella,* in cattle or groups of cattle before slaughter to prevent contamination on carcasses, primals, parts and ground product.
    - Determine if and how "high-concentration" or high-shedder cattle correlates to internal colonization levels of STEC, and *Salmonella.*

- 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, and *Salmonella,* in cattle. Determine the mechanism for internal colonization and corresponding opportunities for control.

- Explore the premise that internalized contamination is present in cattle. 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.

- Explore novel ways *Salmonella* may internalized in cattle.

Post-Harvest Research

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

- Develop rapid detection technologies that are based on detecting the pathogenic serotypes and highly virulent subsets of STEC, and *Salmonella*. The technology should:
  - Address virulence factors;
  - 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.

- Develop rapid methods for quantitative *Salmonella* enumeration or methods based on virulence rather than serotypes. Research should:
  - Develop guidance on how to implement new technologies and methods, including the documentation required by industry to gain regulatory approval.
  - Testing technology should be compatible with the N60, N60 Plus and MicroTally sampling methods.

- 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 effectiveness of existing or new intervention technologies on multiple serovars of *Salmonella* commonly found in beef. Research could:
  - Target virulence attributes that are known to cause outbreaks or human illness
  - Target common beef serovars

- Identify and validate novel intervention application methods to reduce pathogen contamination of beef head or cheek meat. If interventions are not approved for use in the U.S., include a plan for obtaining approval in the U.S.

- Identify and validate antimicrobial interventions to reduce pathogen contamination of raw ground beef components 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 beef 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. – *Keep as need but no RFP*

- Evaluate the efficacy of interventions applied during grind to reduce *Salmonella* and STEC in ground beef. If interventions are not approved for use in the U.S., include a plan for obtaining approval in the U.S.

- Investigate the optimal areas in production to apply interventions (trim, in grind or post grind) to reduce *Salmonella* and STEC contamination. These areas may be different.

- Conduct a meta-analysis of different interventions used in the production of minimal processed beef items. The Foundation's validation database can be used as a reference for studies that can be incorporated in the meta-analysis.

- Evaluate novel methods for reducing transfer of foodborne pathogens from cattle hides during production to the carcass.

- Identify and/or evaluate potential surrogate organisms for internally systemic pathogens that may be used 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 the combination of virulence factors that cause human illness in pathogenic *Salmonella* and *E. coli*. Research should:
    - Determine how virulence could be monitored and biologically prevented.
    - Evaluate subsets of *Salmonella* and *E. coli*. that differ in virulence and show distinct differences in susceptibility to a variety of interventions.
    - Identify subsets of *Salmonella* serovars with high and low virulence and estimate the attribution of human illnesses based on virulence.

- Compare differences in the genetic variation and virulence expression between *Salmonella* and STEC that is known to cause human illness and those that are not.

- What factors should you consider when evaluating regulatory whole genome sequenced isolates, *e.g.* type of pathogen; relatedness of sequences; bacterial replication time in different environments; in plant location of pathogen; potential for harborage or continual reintroduction; what can be learned; among other factors. *– Keep as need but no RFP*

Production Environment Research

- Evaluate genetic factors that would allow bacterial pathogens (STEC, and *Salmonella)* or specific pathogen strains to live and thrive in plant environments from live animal to distribution. Research should include how these pathogens survive, assess the virulence phenotypes and what environmental factors have the ability to alter virulence and survival. Research would likely need to focus on the evaluation of the closed genomes of pathogens using next generation sequencing.

- Identify methods to detect biofilm formation and removal as affected by different surfaces used in harvesting cattle and processing beef. Research should focus on methods to detect and measure biofilm presence; cleaners to remove biofilms; and be applicable in a commercial setting.
  - 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. Research should validate the expected impact of operational controls such as clean room technologies, facility and equipment cleaning procedures.

- Evaluate mechanisms of horizontal gene transfer in pathogens in different plant environments. Research should address how horizontal gene transfer can lead to emergence of pathogen strains with increased virulence and/or antimicrobial resistance phenotypes. Research should be conducted outside of laboratory benchtop evaluations and in practical environments (such as simulated plant environments). Research would likely need to include evaluation of closed microbial genomes.

Information to Enhance Current and Future Public Health Risk Assessments

Salmonella

- 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, across large time periods, regions and other factors, such as competitive exclusion, *etc*.

- Develop a comprehensive quantitative *Salmonella* risk assessment to determine the public health risk attributable to *Salmonella* in different beef items compared to other meat and non-meat food items. 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

STEC

- Develop a metric to determine the public health improvement for STEC illnesses based on virulence attributes. 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.

Minimally Processed Pork Safety

Pre-Harvest Pathogen Control

(Pre-harvest is defined as the time period before food production animals are slaughtered.) All research should build on existing knowledge and research conducted targeting pre-harvest pork safety.

- Further investigate the microbiome of hogs that shed *Salmonella*. Research should focus on variables that lead or allow hogs to become *Salmonella* shedders. Research should also address the role that different environmental factors (diet, antibiotic use, *etc.*) have on microbiome and shedder status. Research should build on

- Develop greater understanding of the ecology and epidemiology of high concentrations of *Salmonella* in pigs. Determine the mechanism for internal colonization and corresponding opportunities for control. Research should evaluate identifying hogs with higher levels of colonized *Salmonella* from farm to slaughter. As well as determine if certain points can alter the load of, *Salmonella* in the animal and subsequent products. Research may address:
    - Develop a testing strategy that can predict high-concentration of *Salmonella,* in hogs or groups or hogs before slaughter with the aim to reduce contamination on carcasses, primals, parts and ground product.
    - Determine if and how "high-concentration" or shedding of *Salmonella* hogs correlate to internal colonization levels.

- Develop economically viable strategies for pre-harvest interventions including changes in production practices and novel feed additives. Research should address any obstacles in commercial adoption, including, but not limited to, regulatory approval, non-economic barriers, *etc*. As well as the effect of investigated preharvest interventions on post-harvest safety.

- Investigate the use of testing for *Salmonella* related antibodies identified in hogs antemortem and the relationship between results and internal colonization.

Post-Harvest Research

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

- Develop methods for quantitative *Salmonella* enumeration and methods based on virulence factors rather than serotypes. Identify *Salmonella* virulence attributes that can be utilized for rapid detection and control. Research should demonstrate how these methods can be used to improve public health.

- Identify combinations of virulence factors that cause human illness in pathogenic *Salmonella* . Research should:
    - Determine how virulence could be monitored and biologically prevented.
    - Evaluate serotypes that differ in virulence and show distinct virulence phenotypes for their susceptibility different interventions. – Keep as a need but no RFP
    - Identify subsets of *Salmonella* with high and low virulence and estimate the attribution of human illnesses based of virulence level.

- Evaluate and determine the effectiveness of non-thermal and non-chemical intervention technologies to reduce pathogen loads on pork products.

- Determine the most effective location(s) from harvest to shipping to maximize reduction of microbial contamination. Research should address or evaluate different interventions on products destined for ground pork.

- 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 novel methods for reducing transfer of foodborne pathogens from the exterior of the animal during production to the carcass in sow processing.

- 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 genetic factors that would allow *Salmonella* to live and thrive in different processing environments including slaughter to raw processing. Research may include:
  - Assess the virulence phenotypes of these pathogens and what environmental factors may alter virulence gene expression.
  - Determine the ability of environmentally colonized *Salmonella* to adapt (cold tolerance, acid-adaptive, ability to produce biofilm) and alter survivability to establish residence.

- 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. Research should be conducted outside of laboratory benchtop evaluations and in practical environments. Research would likely need to include evaluation of closed microbial genomes.- *Keep as only a research need, no RFP.*

- What factors should you consider when evaluating regulatory whole genome sequenced isolates, *e.g.* type of pathogen; relatedness of sequences; bacterial replication time in different environments; in plant location of pathogen; potential for harborage or continual reintroduction; what can be learned; among other factors. - *Keep as only a research need, no RFP*.

- Investigate levels of *Salmonella* throughout the lymphatic system of hogs (both market hogs and sows). Research may:
  - Identify specific lymph nodes of concern.
  - How to mitigate potential further contamination from lymph nodes to pork products.
  - Evaluate factors that may contribute to variation between different lymph nodes, across different production practices, regions and seasons.

Other Research Needs

- Evaluate the thermal stability and inactivation point of African swine fever in pork products. Investigate the possibility of a surrogate organism that can be utilized for challenge studies in place of African swine fever. – *Keep as need, no RFP*

- Evaluate and validate the African swine fever (ASF) PCR as a test for pork to facilitate product exports in the face of an ASF outbreak. Data must be robust enough to support submission to the U.S. Department of Agriculture's National Animal Health Laboratory Network's Technical Methods Work Group for methods validation of the PCR for this intended use. The proposal should address the development of sampling protocol(s) for whole muscle, ground, processed and offal products. - *Keep as need, no RFP*

Further Processed Meat and Poultry Safety

Product Safety Research

- Develop technologies that detect pathogenic subsets of *Salmonella,* and *L. monocytogenes.* Research may Identify combinations of virulence factors that cause human illness in pathogenic *Listeria* and *Salmonella*. Research should:
  - Determine how virulence could be monitored and biologically prevented.
  - Evaluate different virulence phenotypes for their susceptibility to a variety of interventions.
  - Identify subsets of *Salmonella and Listeria* with high and low virulence and estimate the attribution of human illnesses based of virulence level.
  - Focus on rapid and cost-effective solutions

- Develop improved and validated quantitative methods for *L. monocytogenes* detection in foods and environmental samples. – *Keep as a need but no RFP for now.*

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

- 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.
  - Further investigate and validate "surface lethality" concept on numerous products to address concern on desiccated *Salmonella*.
  - 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. *Keep as a need but no RFP.*

- 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 and cooling deviations during the cooling process while limiting potential growth of *C. perfringens*.
  - Determine the effect of different 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.*
  - Investigation into what other variables outside of those in Appendix B can influence pathogen outgrowth.

- 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.

- Evaluate common production processes used during the production of uncured meat and poultry products (with emphasis on larger multiple muscle products) to better understand the appropriate lethality and cooling. Research should explore the addition of any ingredient that may influence the critical food safety parameters used during the production of products including those that are clean label, "natural" or organic products. Research should consider:
  - 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,* 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 and develop pathogen models for cooking and cooling uncured meat and poultry items (such as roast beef and poultry) that have slow come up times and experience a deviation.
  - 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*.

- Explore innovative pathogen control measures and parameters. Controls evaluated should address pathogens such as *L. monocytogenes, S. aureus, and C. perfringens* growth and survival. Research should focus on potential controls outside of those well documented in existing safe harbors (such as Appendices A and B) and scientific literature.

- Conduct a meta-analysis of different interventions used in the production of minimal and further processed meat items. The Foundation's validation database can be used as a reference for studies that can be incorporated in the meta-analysis.

- Evaluate and validate lethality techniques for jerky and biltong products. Projects should address pathogen survival during processing Research should be able to serve as a guide for jerky and biltong processors.

- Evaluate and validate *Salmonella* lethality on slow cooked products (*i.e.,* BBQ) that use low wet bulb temperature and do not fit into current USDA lethality guidelines.

- What factors should you consider when evaluating regulatory whole genome sequenced isolates, *e.g.* type of pathogen; relatedness of sequences; bacterial replication time in different environments; in plant location of pathogen; potential for harborage or continual reintroduction; what can be learned; among other factors. - Holding pattern – *Keep as a need but no RFP*.

Environmental Safety Research

- Evaluate genetic factors that allow *Salmonella* and *Listeria* to live and thrive in processing environments, on food contact surfaces and on products, including in specific niches (*e.g.* areas with high or low temperatures, *etc*.). Research should include how these pathogens survive, assess the virulence phenotypes of these pathogens and if environmental factors could alter virulence gene expression. Research would likely need to focus on the evaluation of the closed genomes of pathogens using next generation sequencing.

- Evaluate mechanisms of horizontal gene transfer of pathogens in different environments and how different antimicrobials and plant disinfectants influence transfer. Research should address how horizontal gene transfer can lead to emergence of pathogen strains with increased virulence. Research should be conducted outside of laboratory benchtop evaluations and in plant environments. Research would likely need to include evaluation of closed microbial genomes.

- 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. 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 enteric pathogens harbors within the raw post-harvest processing environment and determine interventions to reduce or eliminate the presence of the pathogens in the identified harbors, which should be validated for effectiveness. Research could include comparing existing knowledge on *Listeria* harborages to enteric pathogens.

- Identify methods to prevent microbiological recontamination of sliced, diced, chopped and/or shredded RTE meats.

Post-Production Research

- Identify and examine potential transmission and/or contamination vectors in a retail deli and salad bar environment, including cross contamination from personnel and non-meat RTE deli products. Research should focus on possible interventions to reduce transmission in the retail deli and salad bar environment.

Other Research

- Evaluate the thermal stability and inactivation point of African swine fever in pork products. Investigate the possibility of a surrogate organism that can be utilized for challenge studies in place of African swine fever. – *Keep as a need but no RFP.*

- Evaluate and validate the African swine fever (ASF) PCR as a test for pork to facilitate product exports in the face of an ASF outbreak. Data must be robust enough to support submission to the U.S. Department of Agriculture's National Animal Health Laboratory Network's Technical Methods Work Group for methods validation of the PCR for this intended use. The proposal should address the development of sampling protocol(s) for whole muscle, ground, processed and offal products.- *Keep as a need but no RFP.*

Information to Enhance Current and Future Public Health Risk Assessments

Salmonella

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

- Develop a comprehensive quantitative *Salmonella* risk assessment to determine the public health risk attributable to *Salmonella* in beef, pork, chicken, turkey, further processed RTE products, and non-food sources. 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.

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 ability and reliability of online (rapid, automated) instruments to predict quality traits including tenderness, color stability, flavor, *etc*. Research should target species specific attributes were appropriate:
    - Poultry – sensory attributes including tenderness juiciness, flavor and more
    - Pork – water holding capacity, tenderness, color stability, flavor, and more
    - Beef – tenderness, color stability, flavor, and more

- Develop or evaluate technology to determine incidence of condemned product (liver abscess, lung suitability, and more). The aim of research should be online detection of abnormalities that result in condemnations that can be tracked back to evaluate preharvest conditions. – *Keep as a need, not RFP*

- Explore innovative value-added strategies that target lower quality product such as items that are predicted to be tough. Value added technologies may include packaging, processing (chemical or mechanical) or other treatments. Research can address concerns in beef, pork and poultry (concerns include woody breast chicken).

- 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.

- Investigate pre-harvest factors (genetics, nutrition, and other raising practices) that influence post-harvest pork quality attributes such as tenderness, juiciness, color, flavor, marbling and more. Research should build upon existing knowledge.

- Assess quality traits including sensory (color, texture, tenderness, flavor and more) from harvest or day zero of fabrication to aged product. Projects should build off existing research and be practical for in plant application.

- Investigate any changes in consumer attitudes towards meat items following the COVID-19 outbreak. Research should evaluate changing trends in consumer purchasing and preferences. Changes in trends may include shifts in ecommerce purchases, shifts in items preferences (marinated, cooked or heat and serve items, ground products, steaks or others), meal kit use, and more. After shifts are identified, research should determine potential food safety and quality pitfalls with consumer preferences changes. Pitfalls may include partial thawing, refreezing, and others.

Nutritional Sciences

- Risk-benefit analysis on the consumption of minimally and further processed meat and poultry products as a component of a healthy diet and lifestyle.
  - Research may address potential risks or implications associated with eliminating or reducing minimally and further processed meat products from the diet. This could include nutrition status, water use, and environmental implications, among other outcomes.
  - Investigate potential changes to the USDA Food Patterns to improve ease of meeting nutrient recommendations *for each stage of life*. Food patterns should include a variety of food choices within pattern.
  - Investigate the implications of reducing key nutrients that can be difficult to meet in in some dietary patterns. Nutrients of focus include iron, choline, vitamin D and E. – *RFP.*

- Evaluate for *each stage of life* current dietary patterns, and intakes of food groups and nutrients. Research should focus on nutrients of public health concern and nutrition-related chronic health conditions at different life stages (e.g. sarcopenia and the elderly). Research should build on existing knowledge. Research may include:
  - The relationship between dietary patterns consumed during pregnancy and risk of gestational diabetes.
  - The relationship between dietary patterns consumed during pregnancy and micronutrient status.
  - The relationship between dietary patterns consumed during lactation and human milk composition and quantity.
  - The relationship between dietary patterns consumed during lactation and infant developmental milestones, including neurocognitive development.
  - The relationship between dietary patterns consumed during lactation and post-partum weight loss.

- Evaluate the role of meat and poultry in various dietary patterns consumed at each stage of life and:
  1) Growth, size, body composition, and risk of overweight and obesity;
  2) Risk of cardiovascular disease;
  3) Risk of type 2 diabetes;
  4) Risk of certain types of cancer.
  5) Mortality

  Proposals should include how meat and poultry products fit in dietary patterns. Research may include modeling and other analyses, among other approaches. – *Keep as need, do not include on RFP.*

- Investigate the relationship between types of dietary fat consumed at each stage of life and neurocognitive development (birth to 18 years), neurocognitive health throughout aging, risk of cancer and all-cause mortality. Relationships could include developmental milestones.

- What is the relationship between complementary feeding (timing of introduction, types, and amounts) and developmental milestones, including neurocognitive development? Research should build upon existing knowledge.

- 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.

- Investigate the changes in the frequency of eating on nutrient consumption and health outcome.

- Conduct menu modeling demonstrating the role of minimally and further processed meat and poultry products in the healthy dietary patterns identified in the 2020-2025 Dietary Guidelines. – RFP

- Evaluate how different dietary patterns meet, have difficulty meeting or cannot meet amino acid requirements. – RFP

- Investigate the role of minimally and further processed meat in supporting immune health and contributing to a healthy gut microbiome as well as nutrients needs.