Below are the 2015-2016 Research Priorities for the North American Meat Institute Foundation (Foundation) as developed by the Foundation’s Research Advisory Committee. These priorities are used when communicating with government agencies, interested stakeholders and the general public and are intended to show the broad scope and diverse food safety research needs of the industry. Shaded priorities are classified as Priority Focus and the Foundation will solicit proposals on those topics only during its Request for Proposals.

**Controlling *Salmonella* in Meat and Poultry Products**

**Pre-Harvest Pathogen Control**

- Develop a testing strategy that can predict high-*Salmonella* poultry flocks before slaughter that prevents “high event days” in ground poultry.
- Explore the concept of individual animals being “supershedders” and how the points throughout life from farm to harvest impact shedding. Research should:
  - Address if and how shedding correlates to internal levels of *Salmonella*.
- Identify likely sources of contamination, risk factors, and how to systematically intervene at the production facility, during transportation and lairage and the levels of *Salmonella* present on carcasses and meat products.
- Transportation has been identified as a risk factor for STEC and/or *Salmonella* contamination of hides for cattle delivered to processing plants. Develop practical intervention technologies to reduce levels of STEC and/or *Salmonella* that do not compromise animal welfare standards during transportation.
- Evaluate production practices, interventions and other technologies that are known to be effective against multi-drug resistant pathogens to ensure that resistance is not being increased.

**Post-Harvest Control and Innovative Intervention Technologies**

- Evaluate and determine the effectiveness of non-thermal and or non-chemical intervention technologies to reduce pathogen loads (STEC, *Salmonella* and/or *Listeria*) on meat and poultry products.
- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to thrive in processing environments, on food contact surfaces and/or on products.
- Evaluate whether commonly used interventions for beef carcasses are effective in reducing *Salmonella* on pork carcasses. Research should:
  - Include a protocol to allow for every carcass (beef or pork) to be continually sampled;
  - Determine if there other indicators that could be accurately and rapidly measured to determine an “event” day occurrence within a slaughter processing facility; and
  - Result in implementation in commercial environments.
- Develop more effective methods for sampling post-chill carcasses.
- Explore the concept of “internalized” versus external *Salmonella* contamination and demonstrate how this impacts interventions.
Post-Harvest Control and Innovative Intervention Technologies continued

- Explore the premise if internalized contamination is present in all lymph nodes or are only major lymph nodes an issue? Research should:
  - 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?
  - Investigate whether vaccination has an impact or correlation to internalization.

- 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.

- Identify the potential for *Salmonella* harbors within the post-harvest processing environment and interventions to reduce or eliminate the presence of *Salmonella* in the identified harbors.
  - Interventions should be validated for effectiveness.

- Investigate the prevalence of *Salmonella* in pork products using the 325 gram sample plan outlined in FSIS’ Microbiology Laboratory Guidebook.

- Determine the lowest level/concentration of commonly used and novel antimicrobial treatments that are effective in reducing *Salmonella* and/or STEC on meat and poultry products. Research should:
  - Address effectiveness in hot and cold carcasses; primals; parts; and trim.

- Identify likely sources of contamination (e.g. beef, pork, poultry), risk factors, and how to systematically intervene at the production facility, during transportation and lairage and the levels of *Salmonella* present on carcasses and meat products. Research should:
  - Compare effectiveness of carcass washing and trimming for reduction of *Salmonella* on carcasses;
  - Include an evaluation of current production methods; and
  - Evaluate the efficacy of non-water-based antimicrobial treatments in reducing STEC and/or *Salmonella* on beef trimmings.

- 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 and ingredients and thermal processes; and
  - Provide the necessary critical parameters needed for validation and modeling.

- Evaluate interventions used to inhibit microbial (STEC, *Salmonella* and/or *Listeria*) growth that can be used in the production of “natural” or organic products. Research should:
  - Explore synergistic combinations of antimicrobials and HPP or other non-thermal intervention technologies that reduce the time/pressure levels needed or that eliminate the survivor “tail”.

- 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.*; and
  - Evaluate interventions known to be cost-effective and consumer-accepted.
Information to Enhance Current and Future *Salmonella* Public Health Risk Assessments

- 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 determining the public health risk attributable to *Salmonella* in food and non-food sources.
- Identify factors that differ between pathogenic *Salmonella* serovars compared to non-pathogenic serovars and do they vary among species, environment, among other considerations such as competitive exclusion, etc.
- Develop a comprehensive quantitative *Salmonella* risk assessment determining 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.
- Evaluate mechanisms of horizontal gene transfer in *Salmonella* and the effects of different environments on horizontal gene transfer. Research should address how horizontal gene transfer can lead to emergence of *Salmonella* strains with increased virulence and/or antibiotic resistance phenotypes.
- Investigate the epidemiology of multi-drug resistant *Salmonella* within the entire food production chain and quantify the human health risks associated with these organisms.
- Throughout each step in the production chain, evaluate the commonly used interventions and determine the synergistic effects, if any, of the interventions throughout the continuum. Research should:
  - Address if certain practices at certain points in production chain are more effective in reducing the overall prevalence of pathogens.

Controlling Shiga Toxin-Producing *Escherichia coli* (STEC) in Fresh Beef Products

Note: STEC includes O157:H7, O26, O103, O111, O121, O45, and O145, as well as emerging serotypes.

Pre-Harvest Research (Pre-harvest is defined as the time period prior to cattle being slaughtered. Lairage has been identified as a risk factor for STEC contamination of hides for cattle delivered to processing plants)

- Evaluate genetic diversity of Shiga toxin-producing *E. coli* to determine if commonalities and virulence factors exist among serotypes that colonize cattle and cause human illness.
- 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 in cattle.
  - Determine the mechanism for intestinal colonization of STEC and corresponding opportunities for control.
- In feedlots known to be infected with STEC and/or *Salmonella*, identify and develop mitigations on cattle pre-harvest (two weeks prior to slaughter) to reduce/eliminate pathogen loads. Research should:
  - Address the potential for high shedding animals.
Pre-Harvest Research (Pre-harvest is defined as the time period prior to cattle being slaughtered. Lairage has been identified as a risk factor for STEC contamination of hides for cattle delivered to processing plants) continued

- Identify practical intervention technologies to reduce levels of STEC at lairage that do not compromise animal welfare standards.
- Develop commercially viable hide treatment technology that does not compromise animal welfare standards to reduce STEC load on cattle presented for harvest.
- Transportation has been identified as a risk factor for STEC and/or Salmonella contamination of hides for cattle delivered to processing plants. Develop practical intervention technologies to reduce levels of STEC and/or Salmonella that do not compromise animal welfare standards during transportation.

Post-Harvest Research (Post-harvest is defined as the time period following cattle being slaughtered.)

- Evaluate and determine the effectiveness of non-thermal and or non-chemical intervention technologies to reduce pathogen loads (STEC, Salmonella and/or Listeria) on meat products.
- Develop detection technologies that are based on detecting the pathogenic serotypes of STEC. The technology should be:
  - Based on 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.
- Develop improved post-harvest interventions that more effectively reduce the microbiological hazard with the intent to use within an establishment as a CCP. Research should:
  - 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.
- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, Salmonella and/or Listeria) ability to thrive in processing environments, on food contact surfaces and/or on products.
- Validate common cooking practices for non-intact beef, including ground beef. Research should address:
  - A range of temperatures, 60-65 C, 70-75 C, 75-80 C, etc., as included in the draft FSIS Risk Profile for STEC;
  - Recommended consumer cooking practices, e.g. 145 F and allow to rest at least 3 minutes;
  - Potential development of thermal resistance; and
  - Contain all the elements for the findings to be consistent with the FSIS Compliance Guidelines for Validating Cooking Instructions for Mechanically Tenderized Beef Products, 2015.
- Determine the most effective location(s) in the production chain for ground beef to apply interventions to maximize reduction of microbial contamination.
  - Consider if the application of pre-harvest interventions in a food safety system reduce STEC contamination in ground beef products; and if carcass washes and/or other post-harvest interventions in a food safety system reduce STEC contamination in ground beef products.
- Evaluate the effect of the plant environment (e.g. air, machinery, employees) in the role of transmission of STEC.
Post-Harvest Research (Post-harvest is defined as the time period following cattle being slaughtered.)

- Intervention technologies for STEC on carcasses. Research should:
  - Identify and validate novel technologies;
  - Validate existing and commonly used intervention technologies.
- Evaluate novel methods for reducing transfer of STEC from the hide to the carcass.
- Determine the lowest level/concentration of commonly used antimicrobial treatments that are effective in reducing STEC and/or *Salmonella* on carcasses. Research should:
  - Address effectiveness in hot and cold carcasses; primals; and trim.
- Evaluate the efficacy of non-water-based antimicrobial treatments in reducing STEC and/or *Salmonella* on beef trimmings. Identify and validate novel intervention technologies for STEC in trimmings. Research should:
  - Address the impact of the intervention on the organoleptic properties and shelf-life; and
  - Demonstrate that treated product would still qualify for the ground beef standard of identity.
- Evaluate the statistical validity of existing and alternative sampling methods for STEC in beef trim and finished products.
- Develop a standard protocol for validating finished product sampling, specifically in ground beef.
- Carcass sampling data for *E. coli* O157:H7 and other STEC demonstrate a much smaller prevalence than trimmings or ground beef. Research should evaluate the likelihood of a protected niche on the carcass that would reduce the pathogen exposure to antimicrobial interventions resulting in the aforementioned discrepancy. Research should:
  - Consider if pathogens are getting under the surface and therefore being protected from liquid intervention and heat pasteurization; and
  - Address sublethality injury.
- Evaluate interventions used to inhibit microbial (STEC, *Salmonella* and/or *Listeria*) growth that can be used in the production of “natural” or organic products. Research should:
  - Explore synergistic combinations of antimicrobials and HPP or other non-thermal intervention technologies that reduce the time/pressure levels needed or that eliminate the survivor “tail.”
- Identify and/or evaluate potential surrogate organisms for validating process controls for STEC. Research should:
  - Address feasibility in a commercial setting as well as bench top.
  - Provide the necessary critical parameters needed for validation and modeling.
- Develop a white paper explaining how STEC are controlled during slaughter and fabrication of beef cattle, dairy cattle and veal.

Information to Enhance Current and Future STEC Risk Assessments

- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to cause human illness.
- Address data needs identified in the FSIS Draft Risk Assessment for *E. coli* O157:H7 and the Draft Risk Profile for STEC.
- Identify which or what combination virulence factors cause human illness. Research should:
  - Determine how virulence could be monitored and biologically prevented.
Information to Enhance Current and Future STEC Risk Assessments continued

- Develop data to support future qualitative and quantitative risk assessments of STEC and to estimate the human health risk attributable to beef products.
- Throughout each step in the production chain, evaluate the commonly used interventions and determine the synergistic effects, if any, of the interventions throughout the continuum. Research should:
  - Address if certain practices at certain points in production chain are more effective in reducing the overall prevalence of pathogens.
- 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 and virulence factors.
- 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.

Controlling *Listeria monocytogenes* on Ready-to-Eat Meat and Poultry Products

Innovative Pathogen Intervention Technologies

- Evaluate and determine the effectiveness of non-thermal and or non-chemical intervention technologies to reduce pathogen loads (STEC, *Salmonella* and/or *Listeria*) on meat and poultry products.
- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to thrive in processing environments, on food contact surfaces and/or on products.
- 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 and ingredients; and thermal processes; and
  - Provide the necessary critical parameters needed for validation and modeling.
- Evaluate interventions used to inhibit microbial (STEC, *Salmonella* and/or *Listeria*) growth that can be used in the production of “natural” or organic products. Research should:
  - Explore synergistic combinations of antimicrobials and HPP or other non-thermal intervention technologies that reduce the time/pressure levels needed or that eliminate the survivor “tail”.
- Identify and validate bactericidal and/or bacteriostatic ingredients or treatments. 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.
Innovative Pathogen Intervention Technologies continued

- 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.

Operational Control and Monitoring of the Processing Environment

- Develop new and novel environmental monitoring strategies/detection/sampling methods to more effectively identify harborage sites. Research should:
  - Provide the necessary critical parameters needed for validation and modeling.
- Identify methods of preventing microbiological recontamination of sliced, diced, chopped and/or shredded RTE meats.
- Validate the expected impact of operational controls such as clean room technologies, facility and equipment cleaning procedures.
- Develop and validate measures of effectiveness of existing controls, including alternatively cured products. Research should:
  - Address issues specific to small and very small plants.
- 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.
- Determine if floor contact (i.e. worker shoes/boots, cart/pallet jack wheels, etc.) play a role in the transfer of *L. monocytogenes* in a processing environment. Research should:
  - Validate the efficacy of environmental interventions to control or inhibit the transfer.

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.

Information to Enhance Current and Future *Listeria* Public Health Risk Assessments

- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to cause human illness.
Information to Enhance Current and Future Listeria Public Health Risk Assessments continued

- Improve and augment epidemiological data on food attribution for listeriosis, both sporadic and outbreak cases. Research should recognize the following assumptions:
  - The Food and Drug Administration/Food Safety and Inspection Service Listeria Risk Assessment indicate 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.

Other Food Safety Research

Develop a peer-reviewed analysis of the public health food safety risk of antibiotic use and development of resistance in food.
This analysis should include the following:
- A meta-analysis approach;
- An analysis examining how subtherapeutic antibiotic use may or may not impact the food safety risk and the potential economic impact in the production of meat and poultry products;
- An analysis of whether the therapeutic, subtherapeutic or prevention treatment in animals increased the antibiotic resistance risk in humans. For example, in countries where subtherapeutic antibiotic use has been phased out, are there more foodborne illness outbreaks?
- A metric for what is considered a public health risk and what is considered a public health outcome.

Intervention Validation Review.
Conduct a review of the scientific literature to demonstrate the efficacy of various interventions and/or antimicrobials at a range of application concentrations. This review is intended to be used as acceptable scientific support as part of HACCP Systems Validation. The target audience is small and very small establishments.

Critical Parameters
Develop a review paper discussing necessary critical parameters in pre-requisite programs. The target audience is small and very small establishments.
Beef Specific Research Priorities

Pre-Harvest Pathogen Control

- Evaluate genetic diversity of Shiga toxin-producing *E. coli* to determine if commonalities and virulence factors exist among serotypes that colonize cattle and cause human illness.
- 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.*
- Explore the concept of individual animals being “supershedders” and how the points throughout life from farm to harvest impact shedding. Research should:
  - Address if and how shedding correlates to internal levels of *Salmonella*.
- Identify likely sources of contamination, risk factors, and how to systematically intervene at the production facility, during transportation and lairage and the levels of *Salmonella* present on carcasses and meat products.
- Transportation has been identified as a risk factor for STEC and/or *Salmonella* contamination of hides for cattle delivered to processing plants. Develop practical intervention technologies to reduce levels of STEC and/or *Salmonella* that do not compromise animal welfare standards during transportation.
- Evaluate production practices, interventions and other technologies that are known to be effective against multi-drug resistant pathogens to ensure that resistance is not being increased.
- Develop greater understanding of the ecology and epidemiology of STEC in cattle.
  - Determine the mechanism for intestinal colonization of STEC and corresponding opportunities for control.
- In feedlots known to be infected with STEC and/or *Salmonella*, identify and develop mitigations on cattle pre-harvest (two weeks prior to slaughter) to reduce/eliminate pathogen loads. Research should:
  - Address the potential for high shedding animals.
- Identify practical intervention technologies to reduce levels of STEC at lairage that do not compromise animal welfare standards.
- Develop commercially viable hide treatment technology that does not compromise animal welfare standards to reduce STEC load on cattle presented for harvest.

Post-Harvest Control and Innovative Intervention Technologies

- Evaluate and determine the effectiveness of non-thermal and or non-chemical intervention technologies to reduce pathogen loads (STEC, *Salmonella* and/or *Listeria*) on beef products.
- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to thrive in processing environments, on food contact surfaces and/or on products.
- Explore the concept of “internalized” versus external *Salmonella* contamination and demonstrate how this impacts interventions.
- Explore the premise if internalized contamination is present in all lymph nodes or are only major lymph nodes an issue? Research should:
  - 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?
  - Investigate whether vaccination has an impact or correlation to internalization.
Post-Harvest Control and Innovative Intervention Technologies *continued*

- **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.
- **Identify the potential for *Salmonella* harbors within the post-harvest processing environment and interventions to reduce or eliminate the presence of *Salmonella* in the identified harbors.**
  - Interventions should be validated for effectiveness.
- **Develop more effective methods for sampling post-chill carcasses.**
- **Develop detection technologies that are based on detecting the pathogenic serotypes of STEC.** The technology should be:
  - Based on 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.
- **Develop improved post-harvest interventions that more effectively reduce the microbiological hazard with the intent to use within an establishment as a CCP.** Research should:
  - 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.
- **Validate common cooking practices for non-intact beef, including ground beef.** Research should address:
  - A range of temperatures, 60-65 C, 70-75 C, 75-80 C, *etc.*, as included in the draft FSIS Risk Profile for STEC;
  - Recommended consumer cooking practices, *e.g.* 145 F and allow to rest at least 3 minutes;
  - Potential development of thermal resistance; and
  - Contain all the elements for the findings to be consistent with the FSIS Compliance Guidelines for Validating Cooking Instructions for Mechanically Tenderized Beef Products, 2015.
- **Determine the lowest level/concentration of commonly used and novel antimicrobial treatments that are effective in reducing *Salmonella* and/or STEC on meat and poultry products.** Research should:
  - Address effectiveness in hot and cold carcasses; primals; parts; and trim.
- **Identify likely sources of contamination (*e.g.* beef, pork, poultry), risk factors, and how to systematically intervene at the production facility, during transportation and lairage and the levels of *Salmonella* present on carcasses and meat products.** Research should:
  - Compare effectiveness of carcass washing and trimming for reduction of *Salmonella* on carcasses;
  - Include an evaluation of current production methods; and
  - Evaluate the efficacy of non-water-based antimicrobial treatments in reducing STEC and/or *Salmonella* on beef trimmings.
- **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 and ingredients and thermal processes; and
  - Provide the necessary critical parameters needed for validation and modeling.
Post-Harvest Control and Innovative Intervention Technologies continued

- Evaluate interventions used to inhibit microbial (STEC, Salmonella and/or Listeria) growth that can be used in the production of “natural” or organic products. Research should:
  - Explore synergistic combinations of antimicrobials and HPP or other non-thermal intervention technologies that reduce the time/pressure levels needed or that eliminate the survivor “tail.”
- 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.; and
  - Evaluate interventions known to be cost-effective and consumer-accepted.
- Determine the most effective location(s) in the production chain for ground beef to apply interventions to maximize reduction of microbial contamination.
  - Consider if the application of pre-harvest interventions in a food safety system reduce STEC contamination in ground beef products; and if carcass washes and/or other post-harvest interventions in a food safety system reduce STEC contamination in ground beef products.
- Evaluate the effect of the plant environment (e.g. air, machinery, employees) in the role of transmission of STEC.
- Intervention technologies for STEC on carcasses. Research should:
  - Identify and validate novel technologies;
  - Validate existing and commonly used intervention technologies.
- Evaluate novel methods for reducing transfer of STEC from the hide to the carcass.
- Determine the lowest level/concentration of commonly used antimicrobial treatments that are effective in reducing STEC and/or Salmonella on carcasses. Research should:
  - Address effectiveness in hot and cold carcasses; primals; and trim.
- Evaluate the efficacy of non-water-based antimicrobial treatments in reducing STEC and/or Salmonella on beef trimmings. Identify and validate novel intervention technologies for STEC in trimmings. Research should:
  - Address the impact of the intervention on the organoleptic properties and shelf-life; and
  - Demonstrate that treated product would still qualify for the ground beef standard of identity.
- Evaluate the statistical validity of existing and alternative sampling methods for STEC in beef trim and finished products.
- Develop a standard protocol for validating finished product sampling, specifically in ground beef.
- Carcass sampling data for E. coli O157:H7 and other STEC demonstrate a much smaller prevalence than trimmings or ground beef. Research should evaluate the likelihood of a protected niche on the carcass that would reduce the pathogen exposure to antimicrobial interventions resulting in the aforementioned discrepancy. Research should:
  - Consider if pathogens are getting under the surface and therefore being protected from liquid intervention and heat pasteurization; and
  - Address sublethality injury.
- Evaluate interventions used to inhibit microbial (STEC, Salmonella and/or Listeria) growth that can be used in the production of “natural” or organic products. Research should:
  - Explore synergistic combinations of antimicrobials and HPP or other non-thermal intervention technologies that reduce the time/pressure levels needed or that eliminate the survivor “tail.”
Post-Harvest Control and Innovative Intervention Technologies continued

- Identify and/or evaluate potential surrogate organisms for validating process controls for STEC. Research should:
  - Address feasibility in a commercial setting as well as bench top.
  - Provide the necessary critical parameters needed for validation and modeling.
- Develop a white paper explaining how STEC are controlled during slaughter and fabrication of beef cattle, dairy cattle and veal.
  - Conduct side by side comparisons of listeriocidal and/or listeriostatic efficacy of commercially-available antimicrobial agents in different RTE meat 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, uncured beef (e.g. roast beef).
    - 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.

Operational Control and Monitoring of the Processing Environment

- Identify methods of preventing microbiological recontamination of sliced, diced, chopped and/or shredded RTE meats.
- Validate the expected impact of operational controls such as clean room technologies, facility and equipment cleaning procedures.
- Develop and validate measures of effectiveness of existing controls, including alternatively cured products. Research should:
  - Address issues specific to small and very small plants.
- 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.
- Determine if floor contact (i.e. worker shoes/boots, cart/pallet jack wheels, etc.) play a role in the transfer of L. monocytogenes in a processing environment. Research should:
  - Validate the efficacy of environmental interventions to control or inhibit the transfer.

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.

Information to Enhance Public Health Risk Assessments

- Develop data to support future risk assessments of Salmonella and to estimate the human health risk attributable to beef products.
Information to Enhance Public Health Risk Assessments continued

- Develop a comprehensive quantitative *Salmonella* risk assessment determining the public health risk attributable to *Salmonella* in beef 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.

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

- Identify genetic factors through the use of whole genome sequencing or other similar technologies that may be involved or interact with the regulation of genes that influence a pathogen’s (STEC, *Salmonella* and/or *Listeria*) ability to cause human illness.

- Develop new and novel environmental monitoring strategies/detection/sampling methods to more effectively identify harborage sites. Research should:
  - Provide the necessary critical parameters needed for validation and modeling.

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

- Address data needs identified in the FSIS Draft Risk Assessment for *E. coli* O157:H7 and the Draft Risk Profile for STEC.

- Identify which or what combination virulence factors cause human illness. Research should:
  - Determine how virulence could be monitored and biologically prevented.

- 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 and virulence factors.

- 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.
Other Priorities of Interest

Develop a peer-reviewed analysis of the public health food safety risk of antibiotic use and development of resistance in food.

This analysis should include the following:

- A meta-analysis approach;
- An analysis examining how subtherapeutic antibiotic use may or may not impact the food safety risk and the potential economic impact in the production of meat and poultry products;
- An analysis of whether the therapeutic, subtherapeutic or prevention treatment in animals increased the antibiotic resistance risk in humans. For example, in countries where subtherapeutic antibiotic use has been phased out, are there more foodborne illness outbreaks?
- A metric for what is considered a public health risk and what is considered a public health outcome.

Intervention Validation Review.

Conduct a review of the scientific literature to demonstrate the efficacy of various interventions and/or antimicrobials at a range of application concentrations. This review is intended to be used as acceptable scientific support as part of HACCP Systems Validation. The target audience is small and very small establishments.

Critical Parameters

Develop a review paper discussing necessary critical parameters in pre-requisite programs. The target audience is small and very small establishments.