

Tactic Quick Guide
Preliminary FY22 Tactics



Safety & Product
Innovation Committee

SAFETY & PRODUCT INNOVATION COMMITTEE TACTIC OVERVIEW

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29-39	2212-A	A Strategy for Improving Consumer Perceptions of Beef and Beef Production Systems	USCA

Contractor: National Institute of Animal Agriculture (NIAA)

Subcontractor:

Tactic#: 2231-A: 11th Annual NIAA Antibiotics Symposium

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
<ul style="list-style-type: none"> <input type="checkbox"/> Drive adoption of traceability <input type="checkbox"/> Identify & address export customer needs and values <input type="checkbox"/> Collaborate with targeted partners to promote U.S. beef in foreign markets <input type="checkbox"/> Invest in research, marketing & education programs 	<ul style="list-style-type: none"> <input type="checkbox"/> Measure, document, improve & communicate the net environment impact of beef production <ul style="list-style-type: none"> ■ Educate medical, diet & health professionals about beef & beef production ■ Align and collaborate with traditional & nontraditional partners to tell the positive story of beef production <input type="checkbox"/> Engage positively in the sustainable nutrition conversation <ul style="list-style-type: none"> ■ Expand efforts in education the general public about BQA program & it's impact on animal well-being <input type="checkbox"/> Expand BQA program to include verification <input type="checkbox"/> Develop a direct-to-consumer beef safety campaign 	<ul style="list-style-type: none"> <input type="checkbox"/> Use innovative methods & technologies to value carcasses based on eating satisfaction & red meat yield 	<ul style="list-style-type: none"> <input type="checkbox"/> Promote the role of beef in a health & sustainable diet <input type="checkbox"/> Implement a marketing campaign that communicates beef's advantage compared to alternative proteins <input type="checkbox"/> Develop targeted marketing programs focused on the highest opportunity market segments <input type="checkbox"/> Cultivate collaborative promotion partnerships <input type="checkbox"/> Promote innovative online marketing, packaging & shipping solutions to enable the direct marketing of beef <input type="checkbox"/> Engage consumers in a memorable beef eating experience <input type="checkbox"/> Develop a more interactive & exciting beef purchasing experience <input type="checkbox"/> Promote underutilized beef cuts & new variety meat product 	<ul style="list-style-type: none"> <ul style="list-style-type: none"> ■ Demonstrate beef's positive sustainability message & key role in regenerative agriculture <input type="checkbox"/> Defend beef's product identity <input type="checkbox"/> Ensure beef's inclusion in dietary recommendations <input type="checkbox"/> Drive continuous improvement in food safety <input type="checkbox"/> Develop crisis management plans 	<ul style="list-style-type: none"> <input type="checkbox"/> Attract innovative & intellectual capital into the beef industry <ul style="list-style-type: none"> ■ Encourage the cooperation & collaboration of existing industry advisory committees to identify & prioritize research efforts

Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Tactic Description:

The 11th Annual NIAA Antibiotic Symposium will continue the work and collaborations established in prior symposia, funded in part by the Beef Checkoff. The Symposium will focus on continued knowledge and insights about responsible antibiotic use and the primary efforts aimed at combating antimicrobial resistance (AMR). All components of the Symposium impact the beef value chain:

- 1) **Science:** understanding causal links, resistance mechanisms, bacterial genomics, the microbiome, current/future research, and more.
- 2) **Alternatives:** preventative and intervention strategies, ensuring antibiotic stewardship, needs and challenges, innovation, and technology.
- 3) **Communication:** How to effectively engage beef producers with reliable and information, which can be shared when beef producers are engaging with influencers and consumers.
- 4) **Education:** How are colleges and universities preparing the next generation of animal agriculture leaders to utilize antibiotics responsibly while engaging in AMR conversations and solutions?

Researchers who explore the consumer decision-making process continually find that shared values are what drive human decision-making (The Center for Food Integrity, 2009). Upon establishment of shared values, messengers (beef producers) can then share scientific and economic facts that will also be used within the decision-making process. The 2021 Symposium will ensure beef producers and their fellow attendees are prepared to engage with influencers and consumers through shared values while also having the knowledge and insights about the science behind responsible antibiotic use and measures to address antimicrobial resistance (AMR) by animal agriculture leaders. Each of these areas will be addressed in the content that will drive improvements in how animal agriculture communicates and engages, leading with common values and science.

The Symposium is unique in its design as it follows the **One Health** approach. **One Health** recognizes the health of people is connected to the health of animals and the environment. Building upon the 2020 Symposium and current societal drivers, the Symposium will more significantly explore and connect the responsible use of antibiotics to environmental stewardship.

The Symposium creates a synergistic environment where stakeholders from the Centers for Disease Control & Prevention (CDC), the U.S. Food & Drug Administration (FDA), United States Department of Agriculture (USDA), American Veterinary Medical

Association (AVMA), National Institute for Antimicrobial Resistance Research and Education (NIAMRRE), state public health offices, and experts from all points along the beef (animal agriculture) supply chain (producers, packers, retailers, etc.), industry associations, and other animal agriculture leaders can come together to celebrate the progress and diligent efforts of industry and veterinary medicine and the work that has broadened the **One Health** collaboration with human medicine and environmental activities. In addition, the Symposium fosters shared learning, networking, and collaboration as, together, food and agriculture system leaders continuously improve the responsible use of antibiotics in animal agriculture while ensuring animal agriculture is doing its part to combat antimicrobial resistance (AMR).

Through keynote addresses, panel conversations and breakout sessions that allow for further exploration and application of knowledge, beef producers will leave the 2021 Symposium and follow-up conversations with skills, knowledge, and insights to more effectively engage with key opinion leaders as they preserve and enhance trust in beef production, safety, and products. Farmers and ranchers also will leave with additional resources to add to the 2020 toolkit of resources to ensure they are able to engage with influencers and consumers on a variety of platforms – social media, traditional media, in-person, etc.

As society continues to come out of the COVID-19 pandemic, NIAA and its planning committee for the 2021 Symposium are planning a hybrid Symposium setting – in-person and virtual options, for attendance.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- 175 stakeholders from the following segments will attend the 2021 Symposium: Animal agriculture leaders (including beef producers), processors, retailers, research scientists, academia, environmental NGOs, human health professionals, and government. Success is:
 - At least 80 percent of attendees sharing that the Symposium improves their knowledge and understanding of responsible antibiotic use and measure to combat AMR.
 - A successful Symposium will have 80 percent of attendees reporting increased knowledge and skills about communicating with influencers and consumers.

- Engage at least two state beef councils in pre- and post-Symposium media interviews, such as commercial radio, podcasts, farm news, etc. that reach a minimum of 20,000 beef producers with key take-aways advanced by the Symposium agenda.

CBB/BPOC Funding Request: \$52,500

Contractor: National Institute of Animal Agriculture (NIAA)

Subcontractor:

Tactic#: 2231-B: Beef Producer Engagement with the Centers for Disease Control and Prevention (CDC)

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
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Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
☐	☐	☐	☐	■	■

Tactic Description:

Previously, the Beef Checkoff has provided specific funding for beef producers to engage in antibiotic symposia events and a subsequent meeting with the Centers for Disease Control and Prevention (CDC) and related stakeholder groups. Building on the positive outcomes of previous producer engagement with the CDC, a group (approx. 15 to 20)* of state beef council producer leaders will attend and participate in the Antibiotic Symposium and after the Symposium at least 15 to 20 beef producers will attend meetings at the CDC in Atlanta, GA.

Beef producers will be empowered to use face-to-face presentations to share information on both scientific developments learned at the Symposium and at the CDC meeting specifically within the beef industry to influence their peers’ commitment toward continuous improvement, related to responsible antibiotic use. In addition, they will share the results of communication strategies and effectively communicating the safety and wholesomeness of beef.

This tactic includes support for working with Qualified State Beef Councils (QSBCs) to identify targeted in-person and online tools and events that can be leveraged to engage beef producers in important antibiotics-related conversations, that can be conducted via online webinars, state and regional cattle association meeting presentations, unique social media events, sponsored producer influencer events, etc.

*When NIAA works with QSBCs, if more beef producers are interested in taking part in this tactic, NIAA will work with CDC to offer additional sessions. Group size is limited to 15-20 to create an optimum environment for learning, conversation, and collaboration.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- Between 15 to 20* beef producers will participate in a tour, presentations, demonstrations, and discussions with officials from the Centers for Disease Control, engaging in open dialogue, questions on next steps in communication and collaboration opportunities.
 - A minimum of five (5) beef producer participants will further engage with CDC leaders to serve as trusted resources on information related to

farm/ranch practices. This will be measured via three-month, six-month and twelve-month surveys.

- At least two (2) CDC professionals will visit/tour a beef farm/ranch.
- Create a short video featuring beef producers, and professionals from CDC, FDA or USDA to share the responsible use of antibiotics across the beef value chain. Share the video with a minimum of two influencer-based organizations such as the Food Marketing Institute, Grocery Manufacturers Association, National Restaurant Association, American Academy of Pediatrics, etc.

*As NIAA invites state beef council leaders to participate, if more producers are interested – than 15-20, NIAA will determine if additional meetings/interactions can be planned so more beef producers can engage with CDC.

CBB/BPOC Funding Request: \$42,500

Contractor: National Institute of Animal Agriculture (NIAA)

Subcontractor:

Tactic#: 2231-C: Antimicrobial Resistance Communication Support and Distribution to Amplify Supporting Messaging for Producer Education and Influencer Engagement

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
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Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
☐	☐	☐	☐	■	■

Tactic Description:

Previous symposia have included information on compelling research and scientific updates, innovative alternatives, and new technologies, along with sessions designed to help understand communication strategies to communicate to food system leaders, the media, and more effectively to consumer influencers down the line. The 2021 Symposium will build upon feedback and insights from previous symposia and will take communications about responsible antibiotic use and antimicrobial resistance (AMR) from *Good to Great*. After all, repetition is key to gaining proficiency in a skillset area and communication is no different – especially on topics that are complex and, at times, controversial. This tactic allows beef producers to gain proficiency.

This tactic is aimed at Ensuring Antibiotic Stewardship, Ensuring Beef Safety, Protecting Beef’s Image and Engaging Beef Advocates. Keynote presentations, panelist discussion points, slide decks, white papers, talking points, web pages, resources and more will be shared, during and post-event, using influencer networks and social media to reach more stakeholders.

A variety of collaborations will be targeted within this tactic and will include partnerships with the National Institute for Antimicrobial Resistance Research and Education (NIAMRRE), QSBCs, and allied industry NGOs.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- At least three (3) communication collaborations with stakeholders will reach at least 250,000 producers and key opinion leaders via social media (Facebook, Twitter, YouTube and LinkedIn) by September 30, 2022. These may include, but are not limited to interviews, videos, podcast, and proceedings.
- Quarterly follow-up meetings with state beef council leaders will be hosted to ensure the knowledge and insights garnered during Symposium and the CDC visit(s) are useful and affecting change within their engagements with other producers and thought leaders. This will be measured via pre- and post-event surveys. Success will be:
 - A minimum of 80 percent of beef producers attending rating the usefulness and change affected via surveys at least four (4) out of five (5) on a Likert Scale.

- A minimum of five (5) beef producers' sharing their story via consumer-focused social media channels – Facebook, Instagram, YouTube, etc. reaching a minimum of 500 followers (average 100 per beef producer) with at least 10 percent of followers engaging with the posts – commenting, sharing, following links to resources, etc.

CBB/BPOC Funding Request: \$20,000

Contractor: National Institute of Animal Agriculture (NIAA)

Subcontractor:

Tactic#: 2232-A: Advancing Investment, Innovation, and Technology in Animal Agriculture

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
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Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Tactic Description:

To adequately address the lack of investment and innovation in animal agriculture [beef] production, the gap(s) between technologists, entrepreneurs, and animal agriculture leaders must be narrowed or eliminated. Building of capacity and knowledge are needed to advance investment, innovation, and technology in animal agriculture. Through this tactic, the National Institute for Animal Agriculture (NIAA) will bring together leaders from across the animal agriculture sector of today's food system to establish an educational continuum that will foster learning, knowledge, and collaboration. Areas of initial interest that have been identified are:

- Antimicrobial alternatives
- Food safety technologies
- Supply chain innovations – transportation, processing, distribution, etc.
- Improved genetics for quality, nutrient profile, sustainability, etc.
- Enhanced environmental stewardship
- Improved animal welfare

Currently, most accelerators and organizations working to foster greater innovation in food and agriculture – like many other industries, rely on a “shark tank” or “Ag Tech Idol” approach. While this allows for limited capacity building and the highlighting of one or two technologies and entrepreneurs, it does not allow for adequate capacity building – increased understanding of the true needs of animal agriculture [beef], limitations within segments of the value chain, nuances between production systems, etc., and an enhanced desire to focus within the food and agriculture industry and/or animal agriculture space. A new approach is needed.

NIAA, its members, and partners have a model that not only cultivates investment in beef industry research, marketing, and innovation but a model that leverages multi-specie resources, enhances the likelihood of needed and functional innovations, and de-risks the typical cycle of start-up organizations and technologies.

NIAA's model will meet the needs of:

- Food and agriculture industry sponsors by building an ecosystem to drive business growth,
- Technologists and entrepreneurs through investment, partnerships, access to knowledge, concept validation, etc.,
- Investors via preliminary vetting, and
- Animal agriculture with new ideas and concepts that truly address needs

To not adopt this new approach will lead to a continuation of discouraged investors and disillusioned technologists and innovators who do not develop the skills and knowledge needed to be successful. Both will further exacerbate the chasm between investment in on-farm/ranch technologies and “down-stream” and the chasm between animal and plant agriculture.

Furthermore, the NIAA model can allow technologists and entrepreneurs access to extensive due diligence for their technologies, allow animal agriculture [beef] leaders opportunities for on-going engagement with technologists and entrepreneurs, mentoring between seasoned animal agriculture leaders and those entrepreneurs new to the sector, and the ability to measure success beyond simple return on investment.

The NIAA model will foster in technologists and entrepreneurs:

- Personal development
- Commercial skills development
- Practical experiences
- Mentoring
- Leadership

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- By September 30, 2022, 20 technologists/entrepreneurs will have begun their *NIAA Advancing Investment, Innovation, and Technology in Animal Agriculture* experience. Selected individuals will have been extensively vetted by the NIAA selection panel – including leaders from the beef segment of the animal agriculture sector of today’s food system.
- Technologists selected for the first cohort will have at least four (4) innovations or technologies that specifically address challenges identified by the NIAA selection panel – including leaders from the beef segment of the animal agriculture sector of today’s food system.
- By September 30, 2022, organizations participating in *NIAA’s Advancing Investment, Innovation, and Technology in Animal Agriculture* will have pledged/secured a minimum of \$25 million in investment capital – venture capital, private investment, government grants, etc.
- Initial survey results of participants and stakeholders will demonstrate at least an 85 percent satisfaction rate with the *NIAA Advancing Investment, Innovation, and Technology in Animal Agriculture*.

CBB/BPOC Funding Request: \$275,000

Contractor: National Cattlemen’s Beef Association

Subcontractor:

Tactic#: 2211-A: Safety Research and Scientific Affairs

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
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Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Tactic Description:

NCBA, on behalf of the Beef Checkoff, builds the science-based evidence in pre-harvest beef safety used to inform decisions that maintain and improve beef safety throughout the supply chain. Program results also inform communications about the industry's commitment to ensuring the safety of beef.

Results generated through this program are targeted at the scientific community including academia, beef safety decision makers throughout the industry (feedlot operators, packers, processors, retail, foodservice) and regulatory sectors, as well as state beef councils and other Checkoff program areas that communicate or manage beef safety issues (pre- and post-harvest).

Over time, this program has evolved from a single pathogen focus (*E. coli*) to address several potentially harmful bacterial, chemical or physical threats to beef safety. As the microbial environment evolves, other pathogens such as *Salmonella* challenge beef's safety. Today, consumers expect beef to be safe from pathogens and other safety threats, but also that the beef industry takes steps to evolve and improve the safety of the beef they purchase. Research in this program has been used to respond to inquiries from the industry, media, regulatory and other thought leaders about the industry's commitment and progress toward addressing these consumer/influencer concerns.

With the new LRP, a new research roadmap has been developed with an industry expert advisory group. The roadmap focuses on pathogen mitigation strategies, harbors, and physiology. In 2022, projects will be funded to fill knowledge gaps in each pillar of the roadmap. Research outcomes will be shared with advisory groups developing safety guidance, and scientific and regulatory communities in public forums/symposia (i.e., Beef Industry Safety Summit and other scientific forums), through written materials, visual tools or in-person meetings. Strategic planning sessions will be conducted as needed with third-party experts to refine beef safety research gaps. This tactic directly addresses the demand drivers of eating experience and how a food is raised/grown that influence consumption and preference.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- Conduct a minimum of three original scientific research projects focused on the new research roadmap pillars of mitigation strategies, harbors and physiology of pathogens.
- Showcase safety research program content through three venues such as the Beef Industry Safety Summit, scientific conferences, or forums hosted by other entities.
- Disseminate a minimum of five beef safety research results in support of the new research roadmap posted on BeefResearch.org.

CBB/BPOC Funding Request: \$ 1,097,600

Contractor: National Cattlemen’s Beef Association

Subcontractor:

Tactic#: 2211-C: Product Research and Culinary Expertise

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
<ul style="list-style-type: none"> <input type="checkbox"/> Drive adoption of traceability <input type="checkbox"/> Identify & address export customer needs and values <input type="checkbox"/> Collaborate with targeted partners to promote U.S. beef in foreign markets <input type="checkbox"/> Invest in research, marketing & education programs 	<ul style="list-style-type: none"> <input type="checkbox"/> Measure, document, improve & communicate the net environment impact of beef production <input type="checkbox"/> Educate medical, diet & health professionals about beef & beef production <input type="checkbox"/> Align and collaborate with traditional & nontraditional partners to tell the positive story of beef production <input type="checkbox"/> Engage positively in the sustainable nutrition conversation <input type="checkbox"/> Expand efforts in education the general public about BQA program & it’s impact on animal well-being <input type="checkbox"/> Expand BQA program to include verification <input type="checkbox"/> Develop a direct-to-consumer beef safety campaign 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> Use innovative methods & technologies to value carcasses based on eating satisfaction & red meat yield 	<ul style="list-style-type: none"> <input type="checkbox"/> Promote the role of beef in a health & sustainable diet <input checked="" type="checkbox"/> Implement a marketing campaign that communicates beef’s advantage compared to alternative proteins <input type="checkbox"/> Develop targeted marketing programs focused on the highest opportunity market segments <input type="checkbox"/> Cultivate collaborative promotion partnerships <input type="checkbox"/> Promote innovative online marketing, packaging & shipping solutions to enable the direct marketing of beef <input checked="" type="checkbox"/> Engage consumers in a memorable beef eating experience <input type="checkbox"/> Develop a more interactive & exciting beef purchasing experience <input checked="" type="checkbox"/> Promote underutilized beef cuts & new variety meat product 	<ul style="list-style-type: none"> <input type="checkbox"/> Demonstrate beef’s positive sustainability message & key role in regenerative agriculture <input type="checkbox"/> Defend beef’s product identity <input type="checkbox"/> Ensure beef’s inclusion in dietary recommendations <input type="checkbox"/> Drive continuous improvement in food safety <input type="checkbox"/> Develop crisis management plans 	<ul style="list-style-type: none"> <input type="checkbox"/> Attract innovative & intellectual capital into the beef industry <input type="checkbox"/> Encourage the cooperation & collaboration of existing industry advisory committees to identify & prioritize research efforts

Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Tactic Description:

NCBA, on behalf of the Beef Checkoff, leads the primary product quality focused initiative in the U.S. This program generates unique scientific research to reduce product inconsistencies, and to improve beef eating satisfaction and consumer taste perceptions. This tactic also delivers peer-reviewed meat science research to document how taste develops in beef products and demonstrate methods for taste consistency with the goal of generating more repeat beef purchases.

In 2022, product quality research project ideas will be solicited from and executed at universities and scientific institutions to improve beef's quality and taste by evaluating pre- and post-harvest factors that impact the three specific palatability attributes of beef flavor, tenderness and juiciness. Industry expert partners will assist in selecting research projects for funding that align with the program's current research roadmap.

Research findings will be shared via public conferences (i.e., the annual Reciprocal Meats Conference), written materials, visual tools and/or in-person meetings. Research results and insights, as well as technical expertise will be delivered to multiple audiences including academic scientists and scientific organizations (i.e., the American Meat Science Association), and technical experts or industry scientists at supply chain partners such as packers, processors, foodservice and retail, other Checkoff programs (i.e., consumer marketing), state beef council partners, and allied industry stakeholders and influencers (i.e., USMEF). This ensures Checkoff programs and external partners have a key point of contact for knowledge on beef products, strategic insight on cut utilization, product inquiry responses, etc.

NCBA, on behalf of the Beef Checkoff, also provides culinary support for other tactics, industry partners and state beef council programs. In 2022, this program will extend beef cookery expertise to support numerous Checkoff audiences in the execution of their programming to ensure beef recipes and related content cast beef as the top protein.

Taste is beef's top demand driver and the top reason consumers chose beef. To protect this most important product attribute, this tactic directly addresses the demand drivers of eating experience, convenience/versatility and price.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- Conduct a minimum of five original scientific research projects focused on the pillars of the new research roadmap and improving product quality and taste consistency.
- Showcase product quality research program content through a minimum of three avenues including scientific conferences, peer review articles, and the www.beefresearch.org website.
- Disseminate a minimum of five product quality research results in support of the new research roadmap posted on BeefResearch.org.
- Provide culinary expertise to other national or state partner programs that showcase beef's unique attributes through eight interactions.

CBB/BPOC Funding Request: \$1,060,800

Contractor: Foundation for Meat and Poultry Research and Education

Subcontractor:

Tactic#: 2210-A: Post-harvest Beef Safety Research, Knowledge Dissemination and Stakeholder Engagement

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
<ul style="list-style-type: none"> <input type="checkbox"/> Drive adoption of traceability <input type="checkbox"/> Identify & address export customer needs and values <input type="checkbox"/> Collaborate with targeted partners to promote U.S. beef in foreign markets <input type="checkbox"/> Invest in research, marketing & education programs 	<ul style="list-style-type: none"> <input type="checkbox"/> Measure, document, improve & communicate the net environment impact of beef production <input type="checkbox"/> Educate medical, diet & health professionals about beef & beef production <input type="checkbox"/> Align and collaborate with traditional & nontraditional partners to tell the positive story of beef production <input type="checkbox"/> Engage positively in the sustainable nutrition conversation <input type="checkbox"/> Expand efforts in education the general public about BQA program & it's impact on animal well-being <input type="checkbox"/> Expand BQA program to include verification <input type="checkbox"/> Develop a direct-to-consumer beef safety campaign 	<ul style="list-style-type: none"> <input type="checkbox"/> Use innovative methods & technologies to value carcasses based on eating satisfaction & red meat yield 	<ul style="list-style-type: none"> <input type="checkbox"/> Promote the role of beef in a health & sustainable diet <input type="checkbox"/> Implement a marketing campaign that communicates beef's advantage compared to alternative proteins <input type="checkbox"/> Develop targeted marketing programs focused on the highest opportunity market segments <input type="checkbox"/> Cultivate collaborative promotion partnerships <input type="checkbox"/> Promote innovative online marketing, packaging & shipping solutions to enable the direct marketing of beef <input type="checkbox"/> Engage consumers in a memorable beef eating experience <input type="checkbox"/> Develop a more interactive & exciting beef purchasing experience <input type="checkbox"/> Promote underutilized beef cuts & new variety meat product 	<ul style="list-style-type: none"> <input type="checkbox"/> Demonstrate beef's positive sustainability message & key role in regenerative agriculture <input type="checkbox"/> Defend beef's product identity <input type="checkbox"/> Ensure beef's inclusion in dietary recommendations <input checked="" type="checkbox"/> Drive continuous improvement in food safety <input type="checkbox"/> Develop crisis management plans 	<ul style="list-style-type: none"> <input type="checkbox"/> Attract innovative & intellectual capital into the beef industry <input checked="" type="checkbox"/> Encourage the cooperation & collaboration of existing industry advisory committees to identify & prioritize research efforts

Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Tactic Description:

Food safety is critical to ensuring consumer confidence in the beef products they choose to buy and feed their families. While current levels of pathogen contamination on beef remain relatively low, there continue to be areas for improvement in its safety profile. Sampling results from the Food Safety and Inspection Service (FSIS) show the prevalence of Shiga toxin-producing *Escherichia coli* (STEC) O157:H7 at 0.30 percent for raw ground beef components and 0.19 percent for ground beef in calendar year (CY) 2020.¹ In June 2020, FSIS announced plans to expand routine verification testing to include the six non-O157 STECs (O26, O45, O103, O111, O121, or O145) in addition to *E. coli* O157:H7, to ground beef, bench trim, and raw ground beef components other than raw beef manufacturing trimmings.² The agency also intends to test for these non-O157 STECs in retail ground beef and imported raw beef products. This expansion could have a significant impact on the number of beef samples testing positive for STEC as FSIS estimates that for every one O157:H7 positive there are 2-3 non-O157 positives.³

There are additional pathogens of concern on beef products. The prevalence of *Salmonella* spp. on raw ground beef components is 7.14 percent and 2.2 percent in raw ground beef in CY 2020.⁴ FSIS' "Nationwide Microbiological Baseline Data Collection Program: Beef-Veal Carcass Survey," conducted from August 2014 – December 2015 showed 27 percent of beef carcasses tested positive for *Salmonella* post hide removal.⁵ Because of the public health concerns around *Salmonella*, FSIS issued a "Roadmap to Reducing *Salmonella*" as well as held a

¹ Sampling Results for FSIS Regulated Products.

https://www.fsis.usda.gov/sites/default/files/media_file/2021-04/sampling_project_results_data.pdf. Accessed June 22, 2021.

² FSIS Notice and request for comments: Expansion of FSIS Shiga Toxin-Producing *Escherichia coli* (STEC) Testing to Additional Raw Beef Products. 85 *Fed. Reg.* 34397-34402 (June 4, 2020).

³ Personal Correspondence. KatieRose McCullough, Ph.D., MPH and Paul Kiecker, Administrator, FSIS

⁴ Sampling Results for FSIS Regulated Products.

https://www.fsis.usda.gov/sites/default/files/media_file/2021-04/sampling_project_results_data.pdf. Accessed June 22, 2021.

⁵ Nationwide Microbiological Baseline Data Collection Program: Beef-Veal Carcass Survey. <https://www.fsis.usda.gov/node/1968>. Accessed June 22, 2021.

public meeting on the state of science in 2020.^{6,7} Together, these activities outline programs that FSIS and industry can undertake to reduce *Salmonella* on meat products, including performance standards and research among other efforts. Contamination of ready-to-eat meat and poultry, which is not broken out by species, by *Listeria monocytogenes* has remained relatively steady at less than one-half of one percent over the last few years.⁸

Research shows that post-harvest, multiple hurdle beef safety interventions and other process controls are effective in reducing the prevalence of pathogenic bacteria. However, the threat posed by pathogens is not static, rather it is constantly emerging and antimicrobial interventions and other process controls must be constantly upgraded to address these emerging threats. Without these continuous improvements, incidence levels would have most likely increased. Many of the interventions and process controls now used in the beef industry are the result of Checkoff-funded research and continued investment is necessary for further improvement.

According to the Centers for Disease Control and Prevention 2019 FoodNet report, *Salmonella* is the second most common source of infection, and the incidence has not declined compared with the previous three years.⁹ The report notes STEC illnesses increased by 34 percent when comparing 2019 to 2016-2018 data, while illnesses attributed to STEC O157:H7 appear to be decreasing.¹⁰ The incidence of illnesses attributed to *Listeria* has remained relatively unchanged for the past several years at 0.3 cases per 100,000 population.

The Interagency Food Safety Analytics Collaboration (IFSAC) released foodborne illness attribution estimates for 2018 in late 2020. IFSAC used outbreak data to update previous analyses to estimate which foods are responsible for illness related to

⁶ FSIS Roadmap to Reducing Salmonella: Driving change through Science Based policy. <https://www.fsis.usda.gov/wps/wcm/connect/388d5b27-b821-42ba-a717-526f3bc68b4a/FSISRoadmaptoReducingSalmonella.pdf?MOD=AJPERES>. Accessed June 22, 2021.

⁷ <https://www.federalregister.gov/documents/2020/08/14/2020-17827/salmonella-state-of-the-science>. Accessed June 22, 2021.

⁸ Tables & Results Microbiological Testing Program for RTE Meat. <https://www.fsis.usda.gov/science-data/data-sets-visualizations/microbiology/microbiological-testing-program-rte-meat-and-3>. Accessed June 22, 2021.

⁹ Tack DM, Ray L, Griffin PM, et al. Preliminary Incidence and Trends of Infections with Pathogens Transmitted Commonly Through Food — Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 2016–2019. MMWR Morb Mortal Wkly Rep 2020;69:509–514. DOI: <http://dx.doi.org/10.15585/mmwr.mm6917a1>.

¹⁰ Centers for Disease Control and Prevention. Foodborne Disease Active Surveillance Network (FoodNet) 2019 Preliminary Data: Tables. <https://www.cdc.gov/foodnet/reports/prelim-data-intro-2019.html>. Accessed June 22, 2021.

Salmonella, *Escherichia coli* O157, *Listeria monocytogenes*, and *Campylobacter*. IFSAC considers these priority pathogens because of the frequency (estimated 1.9 million illnesses each year combined) and severity of illness they cause, and because targeted interventions can significantly reduce these illnesses. The report noted that *Salmonella* illnesses came from a wide variety of foods, with more than 75 percent coming from seven food categories, including beef. Also, nearly 75 percent of *E. coli* O157 illnesses were linked to vegetable row crops, e.g., leafy greens, and beef. Specifically, beef is estimated cause 5.7 percent of *Salmonella* illnesses and 25.5 percent of STEC O157 illnesses.¹¹

There have been several high profile pathogen outbreaks attributed to ground beef. In 2018, there were 18 illnesses associated with *E. coli* O26 in four states, 33 percent of those infected were hospitalized and there was one death. There was also an outbreak of *Salmonella* Newport beginning in 2018 and ending in 2019 which resulted in over 400 illnesses in 40 states with 34 percent requiring hospitalization. It is clear pathogens in beef remain a critical public health concern and ground beef remains a significant vulnerability. *Healthy People 2030* have set public health goals to reduce illnesses attributed to STEC, *Salmonella* and *Listeria* as well as to reduce outbreaks attributed to STEC, *Campylobacter*, *Listeria*, and *Salmonella* infections linked to beef.¹² It is clear regulatory and public health agencies are committed to reducing foodborne illnesses attributed to beef.

Like pathogens, science and detection technologies have also continued to evolve. Public health officials and regulatory agencies are using whole genome sequencing (WGS) technology for genetic typing of bacteria, including pathogens relevant to food safety. WGS allows for significant improvement in foodborne disease outbreak detection and source traceback compared to earlier technologies. To improve public health, it is important to gain a better understanding of the virulence factors of pathogens found on beef. Learning why and how pathogens cause illness will enable the beef industry to more appropriately target interventions to minimize their presence and make improvements in public health.

The economic burden of illness is another factor in the costs associated with pathogen contamination. According to the U.S. Department of Agriculture's Economic Research Service, illnesses attributed to *Salmonella* cost \$3.6 billion, STEC (non-O157 and O157) cost nearly \$300 million, and *Listeria* costs \$2.8 billion in the 2013.¹³ These

¹¹ Interagency Food Safety Analytics Collaboration. Foodborne illness source attribution estimates for 2019 for *Salmonella*, *Escherichia coli* O157, *Listeria monocytogenes*, and *Campylobacter* using multi-year outbreak surveillance data, United States. Atlanta, Georgia and Washington, District of Columbia: U.S. Department of Health and Human Services, CDC, FDA, USDA/FSIS. December 2020.

¹² <https://health.gov/healthypeople/objectives-and-data/browse-objectives/foodborne-illness>. Accessed June 22, 2021.

¹³ Hoffmann, Sandra, Bryan Macculloch, and Michael Batz. *Economic Burden of Major Foodborne Illnesses Acquired in the United States*, EIB-140, U.S. Department of Agriculture,

costs resulted from medical costs, lost productivity, and death. There are no acceptable levels for pathogenic organisms in beef products as evidenced by the level of foodborne illnesses in the United States. Because *Salmonella* is a significant source of illnesses, hospitalizations, deaths and related costs, research efforts focused on mitigating this threat in the beef supply will continue to be a key priority.

Another beef industry cost associated with pathogen contamination is the reduced value of products testing positive. When a raw material or finished product tests positive for a pathogen, it cannot enter commerce unless it is thermally processed. If the product has already entered commerce, the product is subject to a recall. In both cases, a substantial reduction in value for the pathogen positive product and significant recall costs are incurred by the packer or processor.

The total costs of safety interventions and processes, medical and missed opportunity claims, recalls and reduced value of contaminated products cannot always be passed on to consumers. Most often these costs are borne by the industry and eventually passed on to beef producers through reduced live cattle values. Accordingly, there is a direct economic incentive for beef producers to invest in beef safety research to further reduce pathogenic contamination levels in raw materials and finished products to increase the value of their cattle and their return on investment.

For the foregoing reasons, foundational, applied research is the focus in this program. Integrated communication and educational initiatives will ensure that the data collected are shared with targeted audiences for application across the processing sectors. Outreach with stakeholder groups will inform and impact collaborative research and communication programs addressing the safety of U.S. beef products.

The beef industry must consistently produce products that are safe and wholesome to maintain and bolster consumer trust and grow demand. International and domestic consumers must have confidence that the U.S. beef items they and their families consume are produced using the best processes available, which are supported by science-based research. The threats in the microbial environment are constantly evolving and posing new risks to the safety of the beef supply. These changes can lead to new regulatory initiatives and require adaptations or scientific support for compliance. Yet, not all research is applicable to all facilities as they vary in size, capacity and types of beef products produced. It is imperative that the beef processing industry have access to the most up- to-date science-based research to mitigate both current and emerging threats. A one size fits all approach does not work when ensuring safe beef. As a result, while there may be a large body of scientific evidence in the literature, post-harvest beef safety research investments must continue to address these differences and emerging challenges. This tactic provides practical,

Economic Research Service, May 2015.

https://www.ers.usda.gov/webdocs/publications/43984/52807_eib140.pdf?v=42136.

Accessed June 22, 2021.

science-based research that can be used by in-plant personnel and others to ensure the safety of the U.S. beef supply.

A standing advisory committee of industry and academic experts and practitioners will establish research priorities and evaluate proposals. As needed, a select group of beef industry members may be identified to develop and evaluate specific research projects in consultation with the standing advisory committee. Based upon their recommendations, contracts are awarded based on merit and priority need. Funding partners are identified as appropriate. After the award, the research contracts will be closely monitored to ensure timely and complete research work products are available for distribution to the industry.

Research findings will be disseminated to stakeholders and safety professionals through many means. Investigators will present their research at regional, national and international technical conferences as well as publish work in peer-reviewed materials. Research findings will also be shared with regulatory agencies to ensure they have all the evidence when making decisions impacting beef safety. AR activities and related outcomes will be shared during sponsorship events and exhibits. The dissemination of research findings to the food safety community will aid the safety of, and consumer confidence in, beef products.

Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

- Manage the execution of a minimum of three research projects addressing current knowledge gaps. Topics may include but are not limited to: developing rapid methods for quantitative *Salmonella*; determining and evaluating factors that correlate to high event periods; identifying and validating antimicrobial interventions to reduce pathogen contamination of raw ground beef components intended for use in ground products; investigating efficient and sustainable application of antimicrobials to reduce pathogens on beef products; evaluating 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.); developing new and novel environmental monitoring strategies, detection, and/or sampling methods to more effectively identify pathogen harborage sites; identifying methods to detect biofilm formation and removal as affected by different surfaces used in harvesting cattle and processing beef.
- Assess research impact over time by cataloging citations for research funded by the Beef Checkoff and administered by the Foundation. Identify 12 references citing Beef Checkoff funded research used as a foundation for other research projects, to develop regulatory guidelines, standard operating procedures or best practices by the end date of this AR.

- Facilitate the dissemination of research data and knowledge sharing through at least cumulatively four meetings, webinars, documents or other events targeted to safety professionals.
 - Reaching at least 1,000 stakeholders through combined activities
 - Newsletter distribution will achieve at least 28 percent open rate.
- Conduct a webinar series, at least two per year, to highlight post-harvest safety research funded by the Beef Checkoff. Target cumulative audience of 500 food safety practitioners and interested stakeholders.

CBB/BPOC Funding Request: \$600,000

Contractor: United States Cattlemen’s Association

Subcontractor:

Tactic#: 2212-A: A Strategy for Improving Consumer Perceptions of Beef and Beef Production Systems

LRP Initiatives Addressed by this Tactic

Drive Growth in Beef Exports	Grow Consumer Trust in Beef Production	Develop & Implement Better Business Models & Value Distribution Across All Segments	Promote & Capitalize on the Multiple Advantage of Beef	Improve the Business & Political Climate of Beef	Safeguard & Cultivate Investment in Beef, Industry Research, Marketing & Innovation
<ul style="list-style-type: none"> <input type="checkbox"/> Drive adoption of traceability <input type="checkbox"/> Identify & address export customer needs and values <input type="checkbox"/> Collaborate with targeted partners to promote U.S. beef in foreign markets <input type="checkbox"/> Invest in research, marketing & education programs 	<ul style="list-style-type: none"> ■ Measure, document, improve & communicate the net environment impact of beef production <input type="checkbox"/> Educate medical, diet & health professionals about beef & beef production <input type="checkbox"/> Align and collaborate with traditional & nontraditional partners to tell the positive story of beef production <input type="checkbox"/> Engage positively in the sustainable nutrition conversation <input type="checkbox"/> Expand efforts in education the general public about BQA program & it’s impact on animal well-being <input type="checkbox"/> Expand BQA program to include verification <input type="checkbox"/> Develop a direct-to-consumer beef safety campaign 	<ul style="list-style-type: none"> <input type="checkbox"/> Use innovative methods & technologies to value carcasses based on eating satisfaction & red meat yield 	<ul style="list-style-type: none"> ■ Promote the role of beef in a health & sustainable diet <input type="checkbox"/> Implement a marketing campaign that communicates beef’s advantage compared to alternative proteins <input type="checkbox"/> Develop targeted marketing programs focused on the highest opportunity market segments <input type="checkbox"/> Cultivate collaborative promotion partnerships <input type="checkbox"/> Promote innovative online marketing, packaging & shipping solutions to enable the direct marketing of beef <input type="checkbox"/> Engage consumers in a memorable beef eating experience <input type="checkbox"/> Develop a more interactive & exciting beef purchasing experience <input type="checkbox"/> Promote underutilized beef cuts & new variety meat product 	<ul style="list-style-type: none"> ■ Demonstrate beef’s positive sustainability message & key role in regenerative agriculture <input type="checkbox"/> Defend beef’s product identity <input type="checkbox"/> Ensure beef’s inclusion in dietary recommendations <input type="checkbox"/> Drive continuous improvement in food safety <input type="checkbox"/> Develop crisis management plans 	<ul style="list-style-type: none"> ■ Attract innovative & intellectual capital into the beef industry ■ Encourage the cooperation & collaboration of existing industry advisory committees to identify & prioritize research efforts

Committee(s) to Score this Tactic

Consumer Trust	Domestic Marketing	International Marketing	Nutrition & Health	Safety & Product Innovation	Stakeholder Engagement
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Tactic Description:

The beef industry seemingly is under continuous assault on multiple fronts. These attacks frequently are aimed at consumers of beef, bombarding them on a daily basis with negative commentaries concerning purported contributions of beef to human health disorders such as heart disease, issues with the microbiological safety of beef products, the adverse environmental impact of beef production, its role in the development of antimicrobial resistance, and a myriad of other problems. **This project aims to tackle three important areas affecting consumer perceptions of beef by implementing a simple feeding strategy:** 1) Enrichment of beef with omega-3 fatty acids; 2) Decreasing production of greenhouse gas; and 3) Decreasing reliance on in-feed antibiotics.

Fatty Acid Profiles

For decades, beef has been scorned as a source of saturated lipids that contribute to a variety of human disease conditions, including cardiovascular disease and certain types of cancer.

As a current example, the USDA *Dietary Guidelines for Americans, 2020-2025* recommends decreasing meat consumption and increasing consumption of foods, such as fish, that contain greater proportions of long-chain polyunsaturated fats, most notably eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The long-chain fatty acids EPA, DHA, and alpha-linolenic acid (ALA), are part of a larger family known as omega-3 fatty acids. Recognized for their anti-inflammatory effects and other health benefits, the omega-3 fatty acids admittedly play important roles as basic building blocks for synthesis of endocrine hormones and signaling molecules that are integral to proper immune function, as in development of infant brain function. Certain species of marine fishes are routinely recommended as sources of omega-3 fatty acids, but beef also can be an excellent source of omega-3 fats when cattle are fed diets containing the appropriate feed ingredients. Immature grasses and legumes that cattle consume contain appreciable quantities of ALA, hence the tendency for grass-fed beef to contain greater proportions of omega-3 fats compared to other sources of animal protein. Additionally, we have repeatedly demonstrated through research (LaBrune et al., 2006) that it is possible to markedly increase omega-3 fat content of beef from grain-fed cattle by altering cattle diets to include ingredients such as flaxseed, which is consistently high in ALA, and marine algae products, which contain substantial amounts of EPA and DHA. All of these fats are deposited within the edible tissues of the beef carcass, favorably impacting the ratio of omega-6:omega-3 fatty acids. We also fed omega-3

enriched beef to rats and observed a variety of health benefits (Medeiros et al., 2007), indicating that beef enriched with omega-3 fatty acids can be a viable alternative for delivery of desired omega-3 fats in human diets.

For a production system in which beef fat is recognized as having healthful attributes, the fat itself becomes an important driver of carcass value. Value of middle meats increases for recognizable changes in fatty acid profiles. More importantly, trimmable fats, rather than being rendered to produce animal feeds, become prized components of the carcass, and when combined with lean beef can yield high-value ground beef products. Organ meats, such as livers, kidneys, hearts, and tongues, have notably high concentrations of omega-3 fatty acids when cattle are fed diets high in omega-3 fat sources, and thus take on greater value as well.

Antibiotic Use and Liver Abscesses

Our early research with omega-3 fat supplementation to cattle focused on controlling bovine respiratory disease in cattle, a condition that is characterized by bacterial infection and oftentimes exaggerated inflammation. Flaxseed is a relatively concentrated source of alpha-linolenic acid (ALA), and portions of the ALA from flax are metabolized in the animal's body to produce EPA. It is EPA that serves as the key intermediate for formation of anti-inflammatory substances involved in the immune response. We later determined it was possible to supplement EPA directly to the diet. The most concentrated sources of EPA (as well as DHA) are the marine algae, including the green microalgae, *Nannochloropsis*. Providing supplemental sources of ALA and EPA attenuated incidence and severity of respiratory disease. Effectively, cattle health was improved through sound nutrition, making it possible to decrease our reliance on therapeutic antibiotic drugs. Antibiotic use in livestock production is a prominent subject, owing to the impact of persistent use on development of antibiotic resistant strains of bacterial pathogens. In feedlot cattle, the most widespread use of in-feed antibiotics (tylosin) is aimed at prevention of liver abscess, an infectious disease condition in which the liver is colonized by *Fusobacterium necrophorum* and other pathogenic bacteria. It is conceivable that dietary supplements of ALA/EPA could play a part in decreasing incidence of liver infections, thus avoiding costly liver condemnations, excess carcass trim loss, and adverse effects on liver function.

Environmental Impact and Greenhouse Gasses

Beef is increasingly derided for its purported deleterious effects on the environment, with critics citing poor air quality, production of methane gas, poor feed conversion, and poor water use efficiency as reasons for abandoning beef as a protein source. These messages resonate with some consumers of beef, and clearly can influence demand. Efforts to combat this rhetoric are warranted. Moreover, methane gas represents a significant loss of dietary energy that ranges from 6 to 13% of total energy intake in cattle. Capturing this energy and converting it to edible carcass components likely will yield improvements in feed efficiency, while at the same time demonstrating a concerted effort to mitigate environmental impact of beef production. Past research has

demonstrated that long-chain fatty acids can decrease methane production in the rumen. Longer chain fats, such as EPA and DHA, are particularly inhibitory to methanogenic archaea (Fievez et al., 2003). Studies with flax also have revealed potential for attenuating ruminal methane production (Martin et al., 2016), which support by observations of suppressed activity of methanogenic organisms in the rumen (Li et al., 2012; Vargas et al., 2020).

Technologies that increase production efficiency also can have indirect effects on the amount of methane generated per unit of meat produced. In studies with other species, including humans, omega-3 fatty acids have been shown to stimulate skeletal muscle growth (McGlory et al., 2019). Research by Aas and co-workers (2003) suggests that this may be due, in part, to increases in energy assimilation at the cellular level. On a more applied level, research we conducted feeding marine algae to cattle resulted in a 5-10% improvement in feed efficiency with only 50 to 150 grams of algae (roughly 2-5 ounces) fed per animal daily, clearly demonstrating potential for improving sustainability of beef production.

Objectives

1. Characterize changes in fat profiles throughout the beef carcass in response to feeding a mixture of flaxseed and *Nannochloropsis* microalgae as sources of omega-3 fatty acids.
2. Evaluate impact of long-chain fatty acids on skeletal muscle metabolism (live animal).
3. Evaluate impact of omega-3 fatty acids on post-mortem changes in muscle tissue.
4. Evaluate sensory attributes and retail display characteristics of beef containing elevated concentrations of long-chain omega-3 fatty acids.
5. Evaluate changes in production of methane gas in response to adding flaxseed/microalgae to diets of finishing cattle.
6. Evaluate potential for decreasing incidence of liver abscess in feedlot cattle response to feeding a mixture of flaxseed and microalgae.

Materials and Methods

Live Animal Phase

Cattle and Treatments. The study will utilize 28 feedlot pens, each containing 25 yearling steers. Cattle will be identified with uniquely numbered ear tags and RFID tags; vaccinated against common viral and clostridial pathogens, treated for internal and external parasites, and implanted with a combination trenbolone acetate/estradiol implant. Cattle will be blocked by initial body weight and allocated randomly within blocks to feedlot pens. A pH measuring bolus will be inserted into two animals selected at random from each pen. Pens then will be assigned to one of two dietary treatments. Basal diets will consist of steam-flaked corn, a roughage source, vitamins, minerals, and Rumensin. Treatments will consist of a control diet and an omega-3 enriched diet containing 5% (dry basis) of an extruded blend of flaxseed and dried *Nannochloropsis* microalgae. Diets will contain no Tylosin or other antibiotics and will be fed twice daily. Cattle will be reimplanted after approximately 75 days using a trenbolone acetate/estradiol implant. All cattle will be feed ractopamine hydrochloride for the final 28-42 days on feed. After approximately 150 days on feed, cattle will be harvested at a commercial abattoir. Live animal performance measurements will include weight gain, feed consumption, and feed efficiency.

Diet Characterization. Dietary ingredients will be sampled daily, composited by month, and monthly samples will be analyzed for contents of dry matter, total nitrogen, starch, total lipid, fatty acid profile, acid detergent fiber, calcium, potassium, and phosphorus.

Methane measurements. Methane production by cattle will be estimated using the Greenfeed system. These devices are equipped with a baiting station to lure animals to the device, an RFID identifier, methane sensor, and communications equipment for data transfer and storage. Methane concentration in eructated gases is measured as animals enter the hood to secure the bait. Two Greenfeed units will be utilized, and units will be rotated through pens at approximately 10-day intervals throughout the study to capture methane measurements from all pens of cattle over the course of the experiment.

Monitoring Ruminal pH. Ruminal pH will be monitored using indwelling radio frequency pH boluses (smaXtec). Boluses record pH at 10-minute intervals throughout the study, and data are transmitted via radio frequency to data collection ports and uploaded to a cloud database. Ruminal pH will be analyzed to determine differences in time spent below important pH thresholds.

Skeletal Muscle Protein Metabolism. Increasing the efficiency of muscle protein accumulation is a major focus of beef cattle producers. Postnatally, muscle growth only occurs through enlargement of the muscle cells until the genetic potential of the beef animal is achieved. Muscle hypertrophy is controlled by the rates at which protein synthesis and degradation occur. Intracellularly, these processes are controlled by the mammalian target of rapamycin (mTOR) pathway. To evaluate effects of diet on protein

metabolism, University of Georgia personnel will evaluate skeletal muscle samples taken from a subpopulation of cattle from the larger trial ($n = 14/\text{treatment}$). Biopsies samples will be taken from the semitendinosus muscle at days 0, 50, 100, and harvest. Approximately 500 mg of muscle will be collected, flash frozen in liquid nitrogen, and shipped to the University of Georgia for analysis. Proteins will be separated by electrophoresis, transferred to nitrocellulose membrane, and probed for total and the phosphorylated state of 4 proteins associated with up regulation of protein synthesis. Additionally, 3 proteins associated with muscle protein degradation will also be measured. Protein expression will be measured by densitometry and the ratio of phosphorylated to total protein will be measured.

Harvest Phase

Carcass Evaluation and Liver Abscess Incidence and Severity. After approximately 150 days on feed, cattle will be harvested at a commercial abattoir. Incidence and severity of liver abscesses and hot carcass weight will be assessed on the day of harvest. Livers will be characterized with respect to incidence and severity using the scoring system described by Brown et al. (1975), where a score of 0 is assigned to livers with no abscess, A- to a mild abscessed liver (one or two small abscesses or with inactive scars), A⁰ to a moderate abscessed liver (with one or two large abscesses or multiple small abscesses), or A+ to a severely abscessed liver, defined as containing various large abscesses, with inflammation surrounding the abscess, and often seen adhered to adjacent tissue. After approximately 24-48 of refrigeration, marbling score, 12-th rib fat thickness, ribeye area, percentage of dark cutting beef, and USDA yield and quality grades will be determined for each carcass.

Post-Harvest Evaluation of Carcass Tissues.

One side of the chilled carcass will be retained from a single animal representing each feedlot pen (28 sides in total; 14 per treatment). Sides will be transported to the Kansas State University Meats Laboratory for fabrication, and components of the sides will be distributed among collaborators at North Dakota State University, University of Georgia, and Kansas State University. Striploins will be sent to North Dakota State University; rib sections, briskets, and tenderloins will be retained by Kansas State University; and the remaining portions (chucks, plates, and rounds, and trim) will be sent to the University of Georgia. Analyses of carcass tissues at each location are described below:

Kansas State University researchers will focus on characterization of fatty acids profiles in 20 different meat cuts and fat depots across the carcass, including: ground chuck (80% lean, 20% fat); ground round (90% lean, 10% fat); brisket flat; brisket point; chuck (3 muscles); rib steaks; striploin steaks; tenderloin; sirloin cap; top sirloin; bottom sirloin; flank; skirt; diaphragm; top round; bottom round; internal fat; and belly fat. Tissue samples will be ground, freeze dried, lipids will be extracted; and profiles of long-chain fatty acids will be determined by gas chromatography. Additionally, descriptive sensory profiling will be performed by a trained panel for whole muscle meats at the Sensory Analysis Center within the Department of Food, Nutrition, Dietetics, and Health.

North Dakota State University researchers will focus on postmortem changes in skeletal muscle tenderness, as well as color stability of meat during a simulated retail display. Analysis for Warner-Bratzler shear force to determine cooked meat tenderness will be conducted on consecutive strip steaks from 72 hours and 10 days of aging. Analysis will be conducted on fresh steaks that have not been frozen. Strip steaks (2.5 cm thick) will be cooked on clam shell grills to 71°C in accordance to American Meat Science Association cookery guidelines (AMSA, 1995). Steaks will be chilled before coring and shearing. Six 1.7 cm cores will be taken parallel to muscle fibers and sheared once through with a Warner-Bratzler machine. Peak force will be recorded for each core and averaged for each steak.

Color shelf-life will be determined in accordance with AMSA guidelines (2012). Briefly, d-10 aged strip steaks (2.5 cm) will be placed in foam trays and overwrapped with pvc film and placed on flat shelving at 2°C under continuous LED light for 8 days. Shelf placement will be rotated daily. Objective color (L^* , a^* , and b^*) values will be taken from the average of two readings on the cut surface of the steak. Additionally, visual appraisal of percentage of discoloration will be recorded. Also, steaks will be imaged every second day with a spectral camera utilizing visible and near-infrared wavelengths and submitted for hyperspectral analysis to the NDSU Meat quality lab (Sun et al., 2018). Results of analysis will include changes in color, texture, and reflectance over storage time.

SDS-PAGE and Western blot procedures for detection of troponin-t and desmin degradation and calpain 1 autolysis will be conducted on aged samples in accordance with Howard 2016. Procedures for SDS-PAGE and western blot will be conducted on p70-S6K1 and PDG1- α to evaluate skeletal muscle protein accretion pathways. Briefly, homogenate samples will be loaded onto polyacrylamide gels where proteins will be separated by molecular weights. Separated proteins will be transferred onto PVDF membranes for antibody incubation and detection. Each antibody used will be optimized for dilution factor, sample protein load, and incubation times to ensure detection within linear ranges of standard controls.

Casein zymograms will be conducted on samples from 72 hrs and 10 days of age to evaluate residual calpain 1 and calpain 2 activity in accordance with Hayes et al. 2016. Briefly, the sarcoplasmic fraction of skeletal muscle proteins will be separated on non-denaturing gels infused with casein as a substrate. Gels will be submerged in an incubation buffer containing calcium that will activate any residual calpain. Clear zone size will be indicative of residual calpain activity indicating if calpain had been activated during aging.

Proteasome activity assay will be determined in muscle samples using a 20S proteasome activity assay kit (Sigma-Aldrich, Temecula, CA, USA) based on the detection of the fluorophore 7-amino-4-methylcoumarin after its cleavage from a labeled substrate.

University of Georgia researchers will focus on evaluation of different ground beef products after harvest. In the United States ground beef accounts for approximately 60% of total beef sales (consumption) including the retail and HRI segments. Ground beef's position in the market and price point make it an ideal target for value added utilization with wide and rapid adoption. However, the same market positioning of ground beef dictates that value added technologies must also maintain or improve the consumer's perception of product quality. Ground beef can be found in various package forms (chubs, case ready master pack, vacuum packaged, modified atmosphere packaged, small or large packaged frozen patties, and retail prepared oxygen permeable packages), fat contents (96/4, 90/10, 85/15, 80/20, 73/27, 70/30), and anatomical locations (ground chuck, ground round, custom blends, and general ground beef from whole carcass trim). Packaging style has large impact on ground beef quality preservation, oxidation, and color stability with IQF, boxed patties (retail and HRI) > vacuum package (primarily retail) > master pack case/cook ready (retail and HRI) > retail prepared oxygen permeable. Fat content of ground beef impacts eating satisfaction, rate of oxidation, and color stability. Ground beef fat content influences consumer purchase decisions relating to price point (greater fat content is usually lower cost), eating satisfaction, and perceived health benefits/implications (lower fat content) with 80/20 and 90/10 blends being common in both retail and HRI having the ability to meet both palatability and perceived health concerns. Furthermore, anatomical location of ground beef is also intrinsically tied to fat content (chuck having a greater proportion of fat than round), color and color stability (different proportions of red:white fiber type, and OCR), and lipid composition profiles (saturated:unsaturated, and n6:n3). Previous research examining the feeding of different microalgae products to cattle has shown that it was able to decrease the saturated:unsaturated and n6:n3 ratios of the longissimus lumborum, but subsequently hastened the rate of lipid oxidation and reduced the color stability of longissimus steaks in simulated retail display. To date, a comprehensive study has not been conducted to examine the interaction of packaging method, fat content, and anatomical location on beef fed a microalgae product during the finishing phase. Ground beef's market position, packaging options, and blend formulations (both anatomical and fat content) warrant further investigation.

Grinds will be prepared from the carcass sides ($n = 14/\text{treatment}$) to evaluate ground beef quality and shelf-life color stability analyses. Cuts from the chuck (IMPS 115 or 114 + 116A/C +116B) and round (IMPS 159/163 or 167 + 168 + 171) will be collected in a manner to maintain individual animal ID, vacuum packaged and shipped to the University of Georgia Meat Science Technology Center. Upon arrival to the UGA MSTC cuts from the chuck and round from each animal will be formulated to meet ground chuck 80/20 and ground round 90/10 standards. Patties will be formed using a Patty-O-Matic (114g and 1.27 cm thick) and will be randomly assigned to packaging style including IQF bulk frozen box, case ready master pack (patties in Styrofoam trays with polyvinyl chloride overwrap placed in impermeable bags flushed with 80% N₂/20% O₂), retail prepared Styrofoam trays with polyvinyl chloride overwrap, or vacuum packaging. From each animal*feed treatment*anatomical source additional patties will be randomly assigned, IQF, and vacuum packaged for subsequent fatty acid analysis (N = 60), Allo-

Kramer shear force analysis (N = 60), proximate analysis (N = 60), trained sensory analysis (N = 60), and consumer sensory analysis (N = 200).

Patties subjected to IQF bulk frozen box storage (N = 360/assay) will be stored (-20°C) for 0, 7, 14, 21, 28, and 35 d. On the respective days patties will be subjected to lipid oxidation analysis (TBARS), objective cooked internal color (71°C) analysis, cooked subjective odor analysis, and Allo-Kramer shear analysis.

Mother pack patties will be boxed and placed in cold ($0 \pm 1^\circ\text{C}$) dark storage for 10 days. Master packs will be sampled for gas concentrations, opened, and a patty from each pack (N = 60) will be selected for CO₂ saturation. Another patty from each pack (N = 60) will be frozen (-80°C), vacuum packaged, and used for consumer panel evaluation. Subsequently, trays containing the patties will be placed in retail coffin meat display cases ($0 \pm 2^\circ\text{C}$). On day 0, 1, 2, 3, and 4 packages designated for TBARS analysis will be opened and raw subjective odor will be scored. The TBARS patties will then be vacuum packaged and frozen (-20°) until analysis. Every 12 hours objective and subjective color analysis will be conducted on day 4 patties for repeated measures and color change over time. Additionally, patties will be collected on each day and cooked (71°C) for internal objective color analysis (N = 300/analysis).

To simulate retail manufacturing of ground beef the patties randomly assigned to polyvinyl chloride overwrap will be placed in 2S trays, wrapped, and placed in coffin retail display cases ($0 \pm 2^\circ\text{C}$) for 0, 1, 2, 3, 4, and 5 days. Objective and subjective color will be recorded every 12 hours on day 5 samples. On the respective day's samples marked for TBARS analysis will be opened and scored for subjective odor analysis followed by vacuum packaging and storage (-20°) until further analysis (N = 360/analysis).

Ground beef samples designated for vacuum packaging will be placed in non-shrink vacuum pouches, vacuum sealed and placed in cold ($0 \pm 1^\circ\text{C}$) dark storage for 7 days. After 7 days the vacuum packages will be placed in coffin retail display cases ($0 \pm 2^\circ\text{C}$) for 0, 1, 2, 3, 5, 7, 10, and 13 days. Each day subjective and objective color scores will be measured on day 13 patties. Additionally, on the respective days the vacuum package will be opened and scored for subjective odor followed by resealing and storage (-20°C) for TBARS analysis.

Application to the Beef Industry

In this project we propose to evaluate a novel feeding strategy aimed at overcoming several key obstacles for beef demand. The production method is designed to: 1) alter the composition of beef to produce a fat profile that is perceived to be more healthful; 2)

alleviate the necessity for in-feed antibiotics; and 3) improve energy capture during the feedlot phase of production to decrease environmental footprint of beef production.

Research outcomes will be presented at industry events and disseminated via industry publications.

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Measurable Objectives

(For tactics \$100,000 or less two measurable objectives are required, and for tactics over \$100,000 at least three to five measurable objectives are required by the Checkoff Evaluation Committee):

1. Characterize changes in fat profiles throughout the beef carcass in response to feeding a mixture of flaxseed and *Nannochloropsis* microalgae as sources of omega-3 fatty acids.
2. Evaluate impact of long-chain fatty acids on skeletal muscle metabolism (live animal).
3. Evaluate impact of omega-3 fatty acids on post-mortem changes in muscle tissue.
4. Evaluate sensory attributes and retail display characteristics of beef containing elevated concentrations of long-chain omega-3 fatty acids.
5. Evaluate changes in production of methane gas in response to adding flaxseed/microalgae to diets of finishing cattle.
6. Evaluate potential for decreasing incidence of liver abscess in feedlot cattle response to feeding a mixture of flaxseed and microalgae.

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