**Annual / Final report**

**1.** **Collaborations**

**Stations**

*“Highlight collaborations you have had in the past year with other members of W4177. Include future, ongoing, and completed research in this past year.”*

**Idaho/Indiana**

Inprogress dry aging project looking at metabolomics.

**Idaho/Nevada/Mississippi**

Dahlgren, C., H. Goodson, S. Wang, **A. de Mello, M.J. Colle**, W. Schilling, and **T. Dinh**. 2022. Effect of electrical stimulation on total peptide and free amino acid content in beef. Proc. 2022 Reciprocal Meat Conf. 113.

Wang, S., K. Virellia To, C. Dahlgren, C. Fornes, H. Hessler, X. Zhang, Y, Campbell, B. Buseman, **P.D. Bass, M.J. Colle,** M.W. Shilling, and **T. Dinh.** 2021. Free amino acid content in *longissimus lumborum* and *semimembranosus* muscles from electrically stimulated beef carcasses. Proc. 2021 Reciprocal Meat Conf. 58.

**Kentucky/Colorado**

Zhai, C.; **Suman, S.P.**; Li, S.; **Nair, M.N.**; Beach, C.M.; Edenburn, B.M.; Boler, D.D.; Dilger, A.C.; Felix, T.L. 2022. Ractopamine-induced remodeling in the mitochondrial proteome of postmortem longissimus lumborum muscle from feedlot steers. Livestock Science, 260: 104923.

**Kentucky/Mississippi**

Wang, S.; To, K.V.; Dahlgren, C.B.; Sajeev, D.; Rivera, D.; Schilling, M.W.; **Suman, S.P.**; **Dinh, T.** Lean color and oxidative biomarkers in post-rigor longissimus muscle from beef cattle injected with hydrogen peroxide. American Meat Science Association Annual Reciprocal Meat Conference, August 2021, Reno, NV. Abstract # 45.

**Dinh, T.**; Li, S.; **Suman, S.P.**; Chen, J.; Zhu, H. Post-translational modification of myoglobin in post-rigor longissimus lumborum muscle from beef cattle injected with hydrogen peroxide. American Meat Science Association Annual Reciprocal Meat Conference, August 2021, Reno, NV. Abstract # 46.

**California/South Dakota**

**Fausti, S. W.,** Gonzalez, A**.** Qasmi, B.A., and **Underwood, K.** Auction Winners, Bid Price Endogeneity, and Consumer Preferences for Bison and Beef. Accepted for publication in 2022 in the Journal of Economic Insight.

**Faustii, S. W.,** Diersen, M.A., and VanDerSluis, E. An Evaluation of Supply Chain Disruptions on Alternative Marketing Arrangement Decisions of Fed Cattle Producers. Selected Paper presented at the 2022 Western Agricultural Economics Association’s Annual Meeting June 26 – 28, 2022 La Fonda on the Plaza Santa Fe, NM.

**Indiana/Texas**

Tuell, J., Nondorf, M.J., Abdelhaseib, M., Setyabrata, **D. Legako, J.F., Kim, Y.H.B**.\* 2022. Beef quality, biochemical attributes, and descriptive sensory scores of gluteus medius, biceps femoris, and tensor fasciae muscles subjected to combined tumbling and postmortem aging. J. Food Science. DOI: 10.1111/1750-3841.16298.

Setyabrata, D., **Vierck, K.**, Sheets, T.R., **Legako, J.F**., Cooper B.R., Johnson, T.A., **Kim, Y.H.B.**\* 2022. Characterizing the flavor precursor and liberation mechanisms of various dry-aging methods in cull beef loins using metabolomics and microbiome approaches. Metabolites. 12:472.

Setyabrata, D. Xue, S., Vierck, K., **Legako, J., Kim, Y.H.B**.\* 2022. Impacts of various dry-aging methods on meat quality and palatability attributes of beef loins (M. longissimus lumborum) from cull cow. Meat and Muscle Biology. 6:1-15

Setyabrata, D., Cooper B.R., Sobreira, T.J.P., **Legako, J.F.**, Martini, S., **Kim, Y.H.B**.\* 2021. Elucidating mechanisms involved in flavor generation of dry-aged beef loins using metabolomics approach. Food Research International. 139:109969.

**Michigan/Kansas**

Dong, Z., **M.G.S. McKendree, and G.T. Tonsor.** “Price Pass-Through and Capacity Impacts in the U.S. Beef Industry” Paper presentation at the Agricultural and Applied Economics Association Annual Meeting, Virtual Presentation, July 31- August 2, 2022.

**Nebraska/Texas**

A project designed to decipher dry aging flavor development is in progress with committee members from Nebraska and Texas.

**Oregon/Texas/Kentucky**

J. V. Cooper, **S. P. Suman**, K. S. Burdick, P. Sutovsky, S. M. Lonergan, and **C. L. Lorenzen**. 2022. Muscle color attributes and myoglobin exhibit relationships with tenderness measurements and calpain-1 abundance in beef. Meat Sci. 180:108824.

Texas/Colorado/Idaho

Information from the proposed National Beef Quality Audit – 2021 is being collected in a comparable manner to previous audits, which allows identification of past and present trends.

**Objectives**

* To assess the current transportation modes and distances, mobility status, and quality characteristics of U.S. fed steers and heifers and market cows and bulls.
* To obtain USDA beef grading information and other carcass characteristics from U.S. fed steers and heifers, and selected carcass assessments from market cows and bulls
* To analyze instrument grading information from a number of beef processing establishments to determine monthly, seasonal, and audit-to-audit comparisons in various carcass value-determining traits.

Texas/Oregon

The National Beef Tenderness Survey – 2021 has the following objectives:

* To determine tenderness and other sensory characteristics of US retail and foodservice steaks using WBS force and consumer sensory panels.
* To collect grade, brand, and other label claims from steak packages collected for the survey.
* To assess tenderness and other sensory characteristics of various types of ground beef found at retail using shear force and consumer sensory panels.
* To collect market data on type (lean point, primal-specific, packaging type, etc.) for ground beef in the retail cases of each store.

**2.** **Accomplishments**

**Station – PI name(s)**

*“Please list what research projects or objectives your station completed or partially completed last year. Explain how the outcomes of your research are related to the goal of our project.”*

**Arizona – Duane Wulf**

Research at the University of Arizona determined the consumer acceptance of beef steaks and ground beef from beef-on-dairy crosses across three USDA quality grades. Research was also conducted to determine the effect of one F94L myostatin allele on beef carcass quality and yield grade traits, boxed beef and retail yields, muscle volume distribution, strip steak dimensionality, steak shear force, and steak sensory ratings.

**California - Jim Oltjen**

Between the influence of the “food elite” on social media and increasing public concerns over climate change, consumer demand for grass-fed beef has increased considerably. Although many consumers perceive grass-fed beef as more environmentally friendly than grain-fed beef, there is a dearth of research available to address these consumer claims. In order to answer both consumer and producer concerns, we performed an experiment that evaluated the environmental footprint (i.e., water, land, greenhouse gasses, and energy), beef quality, and economic out­come of four beef cattle production systems on the West coast. The four systems included conventional beef finished on grain for 128 d, steers grass-fed for 20 mo, steers grass-fed for 20-mo with a 45-d grain finish, and steers grass-fed for 25 mo. We found that varying grass-fed and grain-fed production systems resulted in different environmental effects. The conventional system produced the lowest greenhouse gas foot­print but required the highest energy input. The grass-fed for 20 mo used the least amount of water but produced the greatest greenhouse gas. In conclusion, this study illustrated the complexities underpinning beef sustainability; no system resulted in absolute economic, meat quality, and environmental superiority.

**California– Payam Vahmani and Xiang Yang**

Vahmani’s contribution to the project is in the area of Objective 3: “Improve nutrient profile of beef and identify constituents of beef that influence flavor and healthfulness. Create knowledge on the relationship between human disease mechanisms and the nutritional profile of red meat.” The PI is studying how rumen-derived fatty acids including trans fatty acids affect beef quality and healthfulness. The PI is currently investigating the effects of beef trans fatty acids on adiposity, insulin and glucose homeostasis and inflammation in diet-induced obese/diabetic mice. The PI is also investigating how different beef production systems/feeding strategies influence content and profiles of trans fatty acids in beef.

Yang lab is working on the evaluation of pre- and post- harvest factors, such as diet, management practices, packaging methods on meat quality (sensory, shelf life) and meat safety (prevalence of foodborne pathogens, magnitude of antimicrobial resistance).

**California - Scott Fausti**

Objective 2:

Project 1: Completed work on consumer panel study evaluating consumer sensory taste preferences and willingness to pay using experimental methods.

Project 2: Began working on the effect of the COVID supply shock on the premium and discount structure for carcass quality characteristics.

**California - Gabriele Maier**

We finished a three-year study on monensin supplementation in stocker steers on pasture. Various amounts of monensin, an ionophore, were supplemented in a mineral mix that was offered free-choice to groups of stockers that were rotated through different pastures. Monensin suppresses palatability, so higher doses of monensin in a mineral mix does not necessarily result in higher consumption of monensin and consequently higher weight gain. We found that all doses of monensin, designed to deliver 50 mg, 125 mg and 200 mg in a mineral mix consumed at the target of 2 ounces per day led to increased weight gain over control. However, blood selenium levels were significantly lower in the group offered the mineral mix with the highest monensin concentration. Therefore, the highest dose may potentially be suppressing the consumption of mineral to a degree that may compromise cattle health and immunity.

**Colorado - Mahesh Nair and Keith Belk**

Colorado State University (CSU) has been actively engaged in several research projects during the past year focusing on palatability, processing, marketing of beef, prevention of food-borne illness, and consumer preferences for beef. Research was undertaken to examine the Rapid Evaporative Ionization Mass Spectrometry (REIMS) to predict beef flavor. Additionally, research was undertaken to evaluate the impact of high pulmonary arterial pressure on meat quality and mitochondrial functionality in postmortem muscles.

**Idaho – Phil Bass and Michael Colle**

Beef meat science faculty efforts at the University of Idaho have been conducting research through the past year with focus on beef carcass quality, tenderness, color, and dry aging. Focus has been on heavy weight carcasses and the effect of those carcasses on the merchandising of beef round cuts. Research has been conducted on beef chuck rolls and short ribs with the introduction of rosemary extract and acerola cherry powder in combination with one another as topical antioxidants to improve color stability in a retail setting. Research into commercial dry aged beef facilities were investigated for palatability differences and metabolomics. Lastly, various beef cuts were evaluated for use in finger steaks in order to add value to undervalued cuts.

**Indiana - Brad Kim**

Dr. Brad Kim at Purdue University has been working on determining the impacts of post-harvest processing factors (developing “Smart Aging”, in particular) on meat quality attributes. In this reporting period, Dr.Kim’s group worked on a couple of beef projects – 1) NCBA funded fresh beef tumbling and 2) continue working on USDA-AFRI grant – cull cow dry-aging projects.

Numerous strategies have been employed to accelerate the tenderization process through physical disruptions to muscle structure and/or endogenous proteolytic enzymes. However, there exists a pressing need for developing natural post-harvest processing systems that produce beef products with improved eating quality attributes, given the growing consumer demand for natural/minimally processed fresh meat products. Simple tumbling of vacuum packaged fresh meat sections without the use of brines may represent a feasible natural means of improving fresh beef quality and palatability. The objectives of this study were to (1) demonstrate feasibility of the tumbling of vacuum packaged fresh beef on improving quality attributes and proteolysis of beef *M. Longissimus lumborum* muscles, (2) evaluate the combined tumbling and aging process of varying durations on quality and consumer palatability of beef *M. Longissimus lumborum* and *M. Semitendinosus*, and (3) utilize the optimal tumbling duration to improve quality attributes across three beef sirloin muscles (*M. Gluteus medius, M. Biceps femoris*, and *M. Tensor fasciae latae*)

Beef from cull cows has been traditionally perceived as low-quality/low-value meat due to inferior flavor and tenderness. The ultimate goal of our research program is to establish novel meat aging processes that can be applied to improve quality attributes of cull cow beef and foster the profitability and sustainability of the beef industry. Our central hypothesis is that, through application of optimal dry-aging, the palatability attributes of meat will be significantly improved via the liberation of flavor-related compounds. For the current reporting period, we identified flavor-related chemical compounds that positively impact meat quality attributes of dry-aged loins from cull cow along with descriptive sensory analysis.

**Kansas - Glynn Tonsor**

A host of beef demand research continues at KSU. This includes ongoing expansion of the Meat Demand Monitor and other projects. In addition, multiple projects focused on packing capacity and price reporting in the beef-cattle industry continue.

**Kentucky – Surendranath Suman**

Post-translational modifications (PTM) in myoglobin (Mb) can influence fresh meat color stability. Dietary supplementation of vitamin E improves beef color stability by delaying lipid oxidation–induced Mb oxidation and influences proteome profile of postmortem beef skeletal muscles. Nonetheless, the influence of vitamin E on Mb PTM in postmortem beef skeletal muscles has yet to be investigated. Therefore, the objective of the current study was to examine the effect of dietary vitamin E on Mb PTM in postmortem beef longissimus lumborum muscle. Beef longissimus lumborum muscle samples (24 h postmortem) were obtained from the carcasses of 9 vitamin E–supplemented (VITE; 1,000 IU vitamin E diet/heifer·d-1 for 89 d) and 9 control (CONT; no supplemental vitamin E) heifers. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis was used to separate Mb from other sarcoplasmic proteins of beef longissimus lumborum muscle. Tandem mass spectrometry identified multiple PTM (phosphorylation, acetylation, 4-hydroxynonenal alkylation, methylation, dimethylation, trimethylation, and carboxymethylation) in the protein bands (17 kDa) representing Mb. The amino acids susceptible to phosphorylation were threonine (T) and tyrosine (Y), whereas lysine (K) residues were prone to other PTM. The same sites of phosphorylation (T34, T67, Y103), carboxymethylation (K77, K78), and 4-hydroxynonenal alkylation (K77, K78, K79) were identified in Mb from CONT and VITE samples, indicating that these PTM were not influenced by the vitamin E supplementation in cattle. Nonetheless, differential occurrence of acetylation, methylation, dimethylation, and trimethylation were identified in Mb from CONT and VITE samples. Overall, a greater number of amino acids were modified in CONT than VITE, suggesting that the supplementation of vitamin E decreased the numbers of post-translationally modified residues in Mb. Additionally, PTM at K87, K96, K98, and K102 were unique to CONT, whereas PTM at K118 were unique to VITE. These findings suggested that dietary supplementation of vitamin E in beef cattle might protect amino acid residues in Mb—especially those located spatially close to proximal histidine—from undergoing PTM, thereby improving Mb redox stability.

**Michigan**

Michigan State University (Melissa McKendree) and Glynn Tonsor (Kansas State University) began working on a project to investigate price transmission in the beef industry and how capacity utilization at the feedlot level impacted these price transmissions.

**Nebraska - Gary Sullivan**

Efforts by Nebraska have focused on Objectives 1 and 3. For objective 1, research has focused on the impacts of organic acids treatment on the microbial communities in raw beef during extended storage, evaluation of the safety of steaks sous vide cooked at different temperatures, and the use of high pressure processing to improve the color and value of dark cutting beef. In objective 3, the evaluation of factors that impact flavor development in dry-aged beef.

**Nevada - Amilton de Mello**

Nevada focuses on the objectives 1 and 3 of this project. Research efforts have been made to elucidate the nutrigenomics effects of dietary treatments on expression of non-coding RNAs in beef. De Mello’s research has demonstrated that different feeding strategies alter the microRNA profile of beef. MicroRNAs (miRs) are small non-coding RNAs that are resistant to post-mortem degradation and are more reliable biomarkers of animal health and quality attributes when compared to large RNA sequences used to identify gene expression in tissues obtained after slaughter. In addition, miRs modulate up to 60% of protein expression by silencing genes. Therefore, if beef-derived human-homologous miRs can be absorbed in the intestines of recipients, the expression of genes associated with metabolic pathways that modulate homeostasis can also be silenced. Research trials conducted by the De Mello lab demonstrated via gene ontology biological processes that animal diets modulate animal health and development. Small RNA-seq also indicated that miRs are reliable biomarkers for tenderness. These 2 accomplishments are directly associated with the objective 1 of this project since: 1. It allows the livestock industry to improve animal health and development by using precise diets to decrease losses caused by animal mortality in feedlots; and 2. Provides the industry with a precise technique to predict tenderness using reliable molecular biomarkers, and certify U.S.beef as tender in the domestic and international markets using international standards such as the ASTM (American Society for Testing and Materials). Regarding the objective 3, De Mello demonstrated that exogenous beef-derived miRs can be absorbed in mice intestines and can eventually alter homeostasis. Further research will be conducted to elucidate epigenetics effects on mice aiming to determine ideal dietary patterns of beef consumption that lead to benefits to human health and chronic disease prevention.

**Texas**

The National Beef Quality Audit – 2021 is near its completion.

The National Beef Tenderness Survey – 2021 is completed and manuscripts are being prepared.

**Tennessee – Charley Martinez and Phillip Myer**

I. Basic and applied research was conducted to examine

· The microbial populations and associated changes within the gut as a function of varying feed efficiency phenotypes

· Metabolomes from cattle divergent in feed efficiency

· Production effects on the rumen microbiome

· Understanding the impact of the rumen microbiome on beef cattle performance

· Effects of rumen content exchange on bacterial community dynamics and production-relevant parameters

· The effects of a moderate and aggressive implant strategy on the ruminal microbial community and metabolome in steers

This station activities continued to facilitate the collaboration between Zamorano University and the University of Tennessee Institute of Agriculture. Zamorano is an international agriculture-centric university in Honduras that focuses on addressing challenges in Latin America; such as conservation of natural resources, rural transformation, and development of internationally competitive agricultural and agro-industries. In the past year, station participants hosted two interns from Zamorano University as part of the internship program. Future research collaborations and UTIA graduate students are anticipated. Educationally and professionally, this collaboration has and will continue to result in the education and training of future food and animal scientists and workforce, with a gained understanding and appreciation of the importance of sustainable agriculture and food safety. This program has and will continue to develop effective teaching techniques that meet the needs of a wide range of students of varying demographics.

Project output was used in multiple courses, Extension programs, research centers, and public outreach. Outreach activities were undertaken to reach children interested in science who are not usually aware of these research activities and to increase their interest in science. This was conducted at the elementary level via several 1-hour "Meet the Expert" sessions for 5th-grade students in Knoxville, TN on science experiments in biology and animal science, and career opportunities in science and agriculture.

These activities are in line with supporting a better understanding of beef production, health, and biosecurity to support the competitiveness and value of U.S. Beef. The analyses discussed below have increased the knowledge base of master students, industry professionals, producers, government policy makers, and academics. The project's impact reached multiple national and international audiences. The results from these analyses were used to create peer-reviewed manuscripts and were presented at academic conferences. Manuscripts were also disseminated to policy makers and co-collaborators at USDA agencies. These analyses have been presented across multiple national and international conferences of academics, professionals, government agencies in multiple disciplines including economics, veterinary sciences, and social sciences.

II. Livestock and Meat Supply Chain Resilience and Constraints Project (Tennessee, Mississippi, Indiana)

The U.S. meat processing industry faced significant challenges in 2020 during the COVID-19 pandemic that highlighted how readily meat processing can become the key bottleneck in the livestock and meat supply chain. The goal of this project is to analyze and better understand resiliency in the livestock and meat supply chain. The analysis provides actionable findings for areas of potential investment or strategic adjustments in the sector to improve resilience and reduce the risk of bottlenecks that negatively impact producers of livestock, meat processors, retailers, and consumers of meat products. The University of Tennessee collaborated with Purdue University, Mississippi State University, and the Office of the Chief Economist (USDA) to better understand supply chain and production resiliency in livestock production. The project had 3 parts, below highlights what objectives and tasks that were done by University of Tennessee in this project that are related to this project:

**Part 1: Supply Chain Resiliency Metrics**

Task 1: What is supply chain resilience and what are viable metrics for the meat sectors?

Complete literature review of supply chain resiliency measurements for various segments of the economy.

* Identify measurements that might be applied to meat (beef, pork, and poultry) processing segments
  + Consider: Food at home and food away from home
* Develop and test alternative supply chain resiliency metrics for the meat industry
  + Trucking, labor, cold storage, etc.

Task 2: Provide an assessment of current “normal” and max effective capacity for cattle and hogs (and poultry if possible) slaughter and processing in the U.S. This assessment would include, to the extent possible, detail on very small and small Federally Inspected (FI) facilities, and non-federally inspected (NFI) facilities.

* Evaluate how identified metrics performed using historical data were available

Task 3: Provide an assessment of the 1, 5, and 10-year outlook for the meat processing sector (hogs, cattle, and overall) in the context of current livestock and meat supply and demand conditions.

* Forecast identified metrics with the outlook projections.

**Part 2: Recommendations and tradeoffs on addressing constraints and making potential resilience improvements**

Task 1: Combining results from part 1 and part 2, provide strategic recommendations on how additional resilience might be added to U.S. meat processing and how supply chain constraints might be minimized. Potential benefits will be presented relative to costs and other tradeoffs and within the context of the outlooks provided above. Recommendations may include widely discussed and innovative ideas such as:

* Additional greenfield or brownfield capacity (including scale alternatives), firm ownership structure alternatives, plant size alternatives, synergistic layered/ multi-prong approaches, additional cold storage, additional animal feeding/holding capacity, robotics, etc.
* Recommendations may be grouped into categories (e.g. labor, capacity, structural, etc).
* Aspects of recommendations to discuss may include geography, species, plant ownership structure, firm structure, timing, scale, private versus public investment, policy

**3.**  **Short-term Outcomes**

**Station – PI name(s)**

*“Please, provide meaningful but summarized details about the outcomes”*

**Arizona – Duane Wulf**

Beef steaks (longissimus and gluteus medius) and ground beef from beef-Holstein cross carcasses were equal in palatability and consumer acceptance to commodity beef. Beef steaks (longissimus and gluteus medius) and ground beef from beef-Jersey cross carcasses were equal or slightly superior in palatability and consumer acceptance to commodity beef. In carcasses from beef-on-dairy matings, one copy of the F94L myostatin allele resulted in a great number of Type II muscle fibers, larger ribeye areas, improved yield grades, lower marbling scores, increased boxed beef and retail cut yields, and less angular strip steak shape, with little to no effect on cooked steak shear force or sensory panel ratings.

**California - Jim Oltjen**

In terms of animal performance compared to the conventional system, grass fed beef production resulted in lower dressing percents, lower carcass weight and lower quality grades. This decrease in performance illuminates one of the greatest impediments of producing grass-fed beef. The increased days on feed and decreased HCW resulted in higher costs per kg of HCW for the GF45 and grass-fed systems. However, with the continuing increase in demand for niche market beef, producers may be able to overcome this finan­cial obstacle. The varying grass-fed and grain-beef production systems re­sulted in systematic and proportional trade-offs. In the conventional system, despite having the lowest Greenhouse Gas footprint, it had the highest energy and smog footprints. Water use in the grassfed systems were great due to irrigated pasture use. Trade-offs were also observed for land occupation, with the grassfed systems resulting in the highest land footprint (due to the large amount of rangeland required) but required minimal cropland. Grass-fed beef is more costly to produce and requires consumers to pay more.

**California- Payam Vahmani and Xiang Yang**

Research conducted in Vahmani lab showed that trans10-18:1 is consistently the predominant trans fatty acid in beef from cattle finished on grain-based diets, while trans11-18:1 (vaccenic acid; VA) is consistently the predominant trans fatty acid in beef from cattle finished on forage-based diets. Preliminary findings from the mouse study indicates that feeding a high fat diet containing beef fat biofortified with VA and conjuagted linileic acid (CLA) worsens insulin resistant and liver steatosis compared to mice fed a high fat diet containing an equivalent amount of cis fatty acids (oleic acid and linoleic acid). In addition, the PI has tested the health effects of pure trans 18:1 isomers (trans10-18:1 [predominant trans fatty acid in grain-finished beef] vs. trans11-18:1 [predominant trans fatty acid in grass-fed beef]) in a high-fat fed obese/diabetic mouse model. Our preliminary results suggest that both isomers increase insulin resistance and glucose intolerance in high-fat fed mice, whereas cis9-18:1 (oleic acid) was protective.

Research conducted in Yang lab demonstrated the shelf life and consumer preferences on beef derived from cattle raised at different feeding systems in California. Our results indicated that an increased grazing period may improve the color and oxidative stability of beef, while a short supplementation with grain may improve eating quality. Currently we are characterizing and comparing the fecal resistome of cattle raised in various grass-fed and grain-fed feeding systems in the Western United States. The preliminary results indicated that antimicrobial resistant bacteria are present in the feces of the animals regardless of the feeding systems they are raised under. Compared to grass feeding system, conventional livestock feeding systems that utilized antibiotics therapeutically or prophylactically may enrich the diversity of the antimicrobial resistance genes in animals' feces, which may increase the potential transmission of AMR to human via contaminated meat, and contributes to a higher level of risk of AMR in human.

**California - Scott Fausti**

Objective 2:

Project 1 outcomes associated with the ground bison versus beef consumer preference study. Empirical evidence confirms the related good hypothesis by verifying that bid prices are endogenous in a multiproduct, multi-round auction design. Auction winner participants in the beef 93% and beef 80% categories ranked bison sensory characteristics (overall like, texture, juiciness, and flavor) lower relative to the bison sensory rankings by bison auction winners. Beef 93% and beef 80% auction winners also had lower bid prices for bison relative to bison auction winners. This finding suggests consumer sensory preferences influence auction participant bidding behavior.

Project 2 outcomes associated with Covid supply shock on financial risk faced by fed cattle producers who sell on a grid. The focus is on if the supply shock affected the financial risk producers face when selling on a grid pricing system. Preliminary findings suggest COVID supply shock did affect the level of risk producers face when selling on a grid.

**Colorado - Mahesh Nair and Keith Belk**

Our research demonstrated that Rapid Evaporative Ionization Mass Spectrometry (REIMS) analysis of raw meat coupled with optimized chemometrics can characterize consumers’ overall acceptance, flavor acceptance (overall flavor and beefy flavor), and juiciness acceptance of cooked meat with greater than 81% accuracy. In other words, the probability of misprediction for each of these model sets is less than 19%. This study represents a significant step in linking high throughput chemical profiling with consumer acceptance of meat products. Studies on mitochondrial function in cattle with high pulmonary arterial pressures (PAP) indicated that mitochondrial integral function (membrane integrity or/and protein function) declined faster

in high PAP than low PAP muscle at early postmortem. Moreover, the strip loin steaks from high PAP animals had lower color stability than those from the low PAP animals during simulated retail display, which could be partially attributed to the loss of muscle mitochondrial function at early postmortem in high PAP muscle.

**Idaho – Phil Bass and Michael Colle**

The deep portion of the top round of larger carcasses takes longer to chill and therefore has a more rapid pH decline. This negatively affects the shelf-life of the top round. Regardless of carcass size, the deep portion of the top round has poorer color stability and is tougher than the superficial portion of the top round. Merchandising research utilizing an online survey has demonstrated distinct willingness to purchase differences between the two cuts. Dry aging microbiome work has demonstrated that the microbiome of molds and bacteria of different commercial dry-aging facilities is indeed different. Differences in environment demonstrate unique dry-aging conditions resulting in distinctly different microbial populations on dry-aged beef. Flavor boldness has also been shown to be different among commercial dry-aging facilities. Rosemary extract and acerola cherry powder are effective antioxidants for extending the color stability of beef chuck rolls and short ribs and has led to follow-up research opportunities.

**Indiana - Brad Kim**

Dr. Kim’s group determined that repetitive micro chemo-mechanical forces of muscle tissue using tumbling of fresh beef sections resulted in substantial cellular structural dislocation. Consequently, the mechanical forces may result in an increase of cytosolic free Ca2+ through cellular disruption, subsequent activation of calpains, and thus improvement in myofibrillar protein fragmentation. Furthermore, Dr. Kim completed consecutive studies (funding support from NCBA and IBC) that found simple mechanical tumbling processing, without the use of any brine enhancement, resulted in an immediate improvement in tenderness (almost 40% increase) and a substantial decrease in required aging times (up to 70%) of fresh beef loins. Currently, with follow-up funding support from NCBA, Dr. Kim’s group is working on developing a transformative tumbling prediction model using AI-based machine learning approaches.

For our continued cull cow dry-aged beef study, the metabolomics platform detected 1407 compounds, in which 60 metabolites were significantly affected by treatments. PCA analysis exhibited distinct clusters of metabolites between dry-aged and wet-aged treatments. DA samples had more amino acids/peptides metabolites present compared to DWA and UDA samples. Similarly, higher abundance of carbohydrate and organic acids species were identified in the dry-aging treatments. Volatile analysis results showed that dry-aging generated more volatile compounds, such as hydrocarbon, alcohol groups, sulfur containing compounds, which have been often related to desirable flavor in beef product, compared to WA. This observation potentially indicates that different post-harvest aging methods could affect the liberation of flavor related compounds of beef.

**Kentucky – Surendranath Suman**

The innovative data from this work indicated that dietary vitamin E protects amino acid residues in beef Mb from undergoing PTM, thereby improving Mb redox stability and fresh beef color stability

**Michigan**

Our preliminary results found that feedlot capacity utilization does impact fed to feeder cattle and corn to feeder price transmissions.

**Nebraska - Gary Sullivan**

Nebraska hosted a Global Processing Workshop with the US Meat Export Federation for 23 international participants. The programming focused on adding value to lower cost US beef and pork cuts through classroom presentations and participants developing ready-to-cook and ready-to-eat convenience beef and pork items. Research Poster presentations were made at the Reciprocal Meat Conference, American Society of Animal Science Annual Meeting, and Institute of Food Technologist Annual Meeting on results related to the application of high pressure processing to improve the color of dark cutting beef and changes in microbial spoilage communities in raw beef during extended storage.

**Nevada - Amilton de Mello**

Different expressions of genes from animals fed a grain-based or a grass-based diet were demonstrated in two distinct hierarchical clusters. The gene ontology biological process showed that the regulation of filopodium assembly, kidney and nervous system development, energy homeostasis, 5-methylcystoine catabolic process, regualtion fo transcription from RNA polymerase II promoter and collagen fibril organization were upregulated when animals were fed the grain-based diet. On the other hand, grain-based diets down regulated gene expression of genes that modulate the tricarboxylic acid cycle, response to selenium ion, negative regulation of protein processing, negative regulation of lipopolysaccharide-mediated signaling pathway, MAPKKK activity, positive regulation of actin cytoskeleton reorganization, and inactivation of MAPK activity. A total of 15 miRs that modulate more than 400 genes associated with angiogeneis, carcinomas, feed efficiency, adipogenesis, obesity, diabetes, tumor metastasis and growth development and lactation were differentially expressed in beef fed grain or grass. When mice were fed a beef-free and a beef-only diet, the expression of miR-486 in the intestines was two-fold higher in mice fed beef. Previously, the miR-486 was identified as the 4th most expressed miR in digested beef and targets and can modulate more than 174 genes. Results suggested that beef derived miRs can be absorbed in the intestines. Further research will be conducted to evaluate the effects of meat on nutrigenomics and alterations in metabolism and phenotype of mice.

**Texas – Jeff Savell, Rhonda Miller, and Kerri Gehring**

For the National Beef Tenderness Survey, beef retail steaks were sampled at stores across eleven U.S. cities, and beef foodservice steaks were purchased from six U.S. cities. Cities were chosen to represent a broad geographical range from former surveys. Approximately 66.4% retail packages included a form of branding on the label. Cooked steaks were evaluated using Warner-Bratzler shear (WBS) force and consumer sensory panels. The retail tenderloin had the lowest (*P*< 0.05) WBS force value compared to other cuts. The retail steak with the greatest WBS force value was the top sirloin. Foodservice ribeye and top loin steaks had higher (*P*< 0.05) WBS force values compared to the tenderloin. Retail top blade, bone-in ribeye, Porterhouse, and tenderloin steaks all had 100% in the “very tender” category (< 31.4 N). There were no (*P*> 0.05) differences in USDA quality grade groups for foodservice steaks using WBS force. Retail tenderloin received the highest (*P*< 0.05) consumer rating for overall like, tenderness like, tenderness level, flavor like, and juiciness like. There were no (*P*> 0.05) difference, between the four foodservice cuts on consumer sensory rating for overall like, tenderness like, tenderness level, flavor like, and juiciness like. USDA quality grade for foodservice steak showed no (*P*> 0.05) differences for overall like, tenderness like, tenderness level, flavor like, and juiciness like. Ribeye, top loin, top sirloin, and tenderloin foodservice cuts reported no (*P*> 0.05) difference that USDA quality grade had on consumer rating for overall like, tenderness like, tenderness level, flavor like, and juiciness like. All WBS force values for retail steaks have decreased compared to past surveys. However, sensory ratings for both retail and foodservice were comparable to previous surveys.

**Tennessee – Phillip Myer and Charley Martinez**

I. Regarding Ruminant Health Projects

The global human population is expected to exceed almost 10 billion by the year 2050. To sustain such population growth, global demand will require 70 percent more food, creating a 50 percent increase in the demand for beef and dairy products on existing resources. In this context, such increases will have to come from efficiency-enhancing technologies, and current livestock systems will need to progress towards improving the efficiency of feed utilization in ruminants in order to improve the safety, value, competitiveness, and domestic and international marketability of U.S. beef products. Regarding beef cattle, the ability to approach such advances requires examination of the nutritional status of the ruminant, which is influenced by many factors, including diet, management, host genetics, and the diverse symbiotic microbiota colonizing the gastrointestinal tract (GIT). The GIT of cattle contains a diverse microbial community that aids in digestion by fermentation of the feed. In turn, the fermentation products of the microbial community dictate the nutrient profile that the animal receives. With advances in high-throughput sequencing technologies, researchers have been able to interrogate specific microbial communities at great depth, revealing significant differences within these communities that would not otherwise be detectable using culture-based methodologies. This has enabled the enhanced study of the structure and function of the ruminal and GIT microbial communities and their associations with nutritional and management parameters. To dissect the microbiological mechanisms explaining differences in cow/calf feed efficiency, we have focused on using a microbiome approach within the rumen and lower GIT of beef cattle to develop insights into the association of management strategies, nutritional inputs, and ultimately feed efficiency with shifts in microbial populations, microbial gene expression, and digestion/fermentation. In summary, this project is focused on elucidating the molecular and microbiological mechanisms involved in the efficiency of feed utilization with the intent to focus on beef value at all levels of production. This multi-disciplinary approach to investigate food safety, food security, and beef production sustainability permits the evaluation of production-level impacts on the competitiveness and value of U.S. Beef. This station has studied a) the microbial populations and associated changes within the gut as a function of varying feed efficiency phenotypes, b) metabolomes from cattle divergent in feed efficiency and c) production effects on the rumen microbiome.

II. Livestock and Meat Supply Chain Resilience and Constraints Project

Historically, producers and market participants in the beef and cattle market have never had a publicly available measure that shows max and operational slaughter capacity. This project has generated an interactive-up to date national slaughter capacity dashboard that will be soon publicly available. This dashboard displays weekly slaughter capacity utilization (nationally) along with fed cattle market price. This innovation allows fed cattle market participants and other stakeholders a measure to better understand what is occurring in the fed cattle market.

***4.*** **Outputs**

**Station – PI name(s)**

*“Please, provide items such as published or submitted manuscripts, abstracts, technical reports, awards, graduate students who graduated, grants received, invitations to be a speaker, presentations given, etc…”*

**Arizona - Duane Wulf**

In the past year, Dr. Wulf has made two invited scientific presentations regarding this research and published two abstracts. Dr. Wulf has obtained a grant from National Cattlemen’s Beef Association for research in this area as well as a research grant from industry.

**California- Payam Vahmani and Xiang Yang**

Since last year Vahmani Lab published 3 research articles, one review article and 2 abstracts related to beef fatty acid composition and healthfulness.

In the past year, Yang lab published 5 manuscripts on different peer-reviewed journals, and 5 abstracts on different topics related to meat quality and safety.

**California - Scott Fausti**

Had one referred journal article accepted for publication. Presented one paper at a regional professional meeting.

**Colorado - Mahesh Nair and Keith Belk**

In the past year, Dr. Nair published 8 peer-reviewed manuscripts and 8 abstracts related to beef quality and postmortem biochemistry. Additionally, several invited talks were given at scientific conferences and industry meetings.

**Idaho – Phil Bass and Michael Colle**

Since last year Idaho published 3 peer-reviewed manuscripts and 5 abstracts; all related to beef quality and improvement. Additionally, Drs. Bass and Colle were frequently invited speakers at state and regional events. Furthermore, 2 undergraduate students from the lab completed their B.S. Degrees.

**Indiana - Brad Kim**

·Published several peer-reviewed articles and presented research abstracts/proceeding papers.

·Served as invited speaker at national and international scientific meetings/seminars.

·Trained 3 Phd and 1 MS students, 4 visiting scholars and 2 undergraduate students for their research projects

**Kansas – Glynn Tonsor**

In the past year, 3 PhD and 1 MS students have worked on beef-cattle economics topics associated with this project. 7 peer-review publications were made last year.

**Kentucky – Surendranath Suman**

Dr. Surendranath Suman received the Distinguished Research Award of the American Meat Science Association (2022). Additionally, Kentucky has published 4 peer-reviewed journal articles and 7 conference abstracts from this project in the last year. Dr. Suman delivered 2 invited plenary lectures at international virtual conferences (in India and China) on fresh meat quality.

Michigan

1. One conference presentation
2. Training of one PhD Student

**Nebraska - Gary Sullivan**

Outputs related to this project included 1 peer reviewed manuscript, 4 conference proceedings abstracts, and one university research reports.

**Nevada - Amilton de Mello**

De Mello was awarded an Achievement Award by the American Meat Science Association (AMSA) in 2022, published 4 peer-reviewed articles, 5 conference abstracts, gave a presentation at the AMSA Reciprocal Meat Conference, was awarded an international lecture scholarship to teach an advanced meat science course in South America, and was appointed as the Fred and Alice Ottoboni Meat Science Chair at the University of Nevada, Reno. Francine Giotto, a Ph.D. student under de Mello was awarded the 3rd place in the AMSA-RMC Student Research competition in 2022.

**Texas – Jeff Savell and Kerri Gehring**

We had two master’s students work on the National Beef Tenderness Survey – 2021. We have had two master’s students and one Ph.D. student work on the National Beef Quality Audit – 2021.

**Tennessee-Phil Meyer and Charley Martinez**

We had: 10 published manuscripts and numerous conference proceedings, 1 PhD graduate, 1 MS graduate, and currently still have numerous graduate (PhD and MS) students.

**5.** **Activities**

**Station – PI name(s)**

*“Please, provide details about your research projects”*

**Arizona – Duane Wulf**

There is currently one graduate student and four undergraduate students working in our lab.

**California - Jim Oltjen**

We performed an experiment that evaluated the environmental footprint (i.e., water, land, greenhouse gasses, and energy), beef quality, and economic out­come of four beef cattle production systems on the West coast. The four systems included conventional beef finished on grain for 128 d, steers grass-fed for 20 mo, steers grass-fed for 20-mo with a 45-d grain finish, and steers grass-fed for 25 mo. We found that varying grass-fed and grain-fed production systems resulted in different environmental effects. The conventional system produced the lowest greenhouse gas foot­print but required the highest energy input. The grass-fed for 20 mo used the least amount of water but produced the greatest greenhouse gas. In conclusion, this study illustrated the complexities underpinning beef sustainability; no system resulted in absolute economic, meat quality, and environmental superiority.

**California - Payam Vahmani**

Vahmani Lab: Lab/research training was provided to two grad students, 4 undergrad interns in the area of meat lipid analysis, bovine adipocyte culture, and beef-derived fatty acids bioactivity assessment.

Yang Lab: Currently there are 2 M.S. and 3 Ph.D students working in my lab. Two PhD. students passed their Preliminary Exams and are preparing for the Qualifying exams. One Ph.D. candidate passed his QE last year and is wrapping up to graduate in Spring 2023.

**California - Scott Fausti**

Going into semi-retirement spring 2023. Continue to work on COVID supply shock issues affecting the fed cattle market until then.

**Colorado - Mahesh Nair and Keith Belk**

Currently training is being provided to 8 graduate students and several undergraduate students. Also, 2 M.S. and 2 Ph.D. degrees were awarded during this time. Additionally, the The following activities were taken up by the PIs (Keith Belk and Mahesh Nair) for knowledge dissemination.

1. Hosted large workshops to discuss industry issues and present research findings.

2. Served as invited speakers at scientific meetings to present research.

3. Served as members of advisory boards for research foundations.

4. Integrated research findings into university courses and curriculum.

5. Published numerous peer-reviewed articles

**Idaho – Phil Bass and Michael Colle**

Hands on meat lab and research lab training were provided to 7 graduate and 12 undergraduate students in Meat Science. Numerous producer, processor, and retailer workshops were held this past year focusing on improving meat quality.

**Indiana - Brad Kim**

In this reporting period, Dr. Kim was invited to give invited keynote plenary lectures at both national and international conferences/seminars, including 2022 American Society of Animal Science (ASAS), Oklahoma City, USA, the 19th Asia-Australasian Animal Production (AAAP) Animal Science Congress, Jeju Island, Korea, and a virtual presentation for Zhejiang University, China. Some of the results of the current projects were also disseminated through online media coverage such as Meatingplace besides peer-review journal article publication. Kim lab graduate students (Derico Setyabrata, Jacob Tuell, and Maha Abdelhaseib) attended the 2022 RMC meeting to present some of their findings of the current projects and to participate in the graduate research competition in the PhD/MS division.

**Kentucky – Surendranath Suman**

Research training was provided to Shuting Li (Research Lab Technician) and Koushik Mondal (MS Student) on muscle proteome isolation, spectrophotometry, two-dimensional electrophoresis, gel image analyses, analyses of proteomic data, and evaluation of meat color stability.

**Michigan**

Research training was provided to Zekuan Dong, PhD student, in Agricultural, Food and Resource Economics at Michigan State University.

**Nebraska - Gary Sullivan**

Two Ph.D. students are conducting research in this area. One undergraduate student who worked on projects in this area started a M.S. program in Meat Science focused on microbial safety. A workshop for 23 international meat processors was conducted to enhance the utilization and ultimately value of US exports.

**Nevada - Amilton de Mello**

De Mello trained 3 Ph.D. graduate students, conducted research trials to evaluate the effects of growth additives on transcriptomics of animal tissues, collaborated with PIs from other institutions, and received a visitor scientist from Czech Republic in his program.

**Tennessee – Charley Martinez and Phillip Myer**

Activities include research from multiple participants, presentations, invited lectures and discussions, student development, Extension outreach, teaching curriculum development, and multidisciplinary collaborations.

I. Ruminant Health

For the Ruminant Health projects, this multi-state project permitted the attendance to numerous annual meetings: The American Society of Animal Science Annual Meeting, the American Society of Animal Science Southern Section meeting, the American Society for Microbiology Microbe annual meeting, to name a few. Conferences were attended to promote research regarding the outcomes of this project, which were disseminated by graduate students in the program and the project director.

II. Livestock

We have opened an eye-tracking lab this past year, and findings from this project will help advance research in the future. Specifically, the question of, “how to enhance the competitiveness and value of US beef?” can be thought about moving forward in the coming research. Specifically, what information is used by producers to make decisions for their operation. Understanding how information is used can aid in understanding how to answer the aforementioned question for US cattle producers.

For the Ruminant Nutrition and Health and the Livestock projects, this multi-state project has also aided in the training and development of 8 graduate students who are currently enrolled or have graduated from the current research program and actively participated in the project this past cycle. Due to the multi-faceted nature of the project, the students are active in laboratory/bench research, light bioinformatics, physical sampling and animal handling, data and statistical analyses, eye-tracking, and research manuscript preparation.

**6.** **Milestones**

**Station – PI name(s)**

*“Please, mention about your milestones related to our project”*

**Arizona – Duane Wulf**

We have completed two major research projects in this area during the past year and have analyzed the results. Manuscripts are in preparation.

**California- Payam Vahmani and Xiang Yang**

Vahmani lab has completed two research projects related to bioactivity and health effects of beef-derived trans fatty acids. Two manuscripts are being prepared for publication.

**California - Scott Fausti**

Had one referred journal article accepted for publication. Presented one paper at a regional professional meeting.

**Colorado - Mahesh Nair and Keith Belk**

Dr. Mahesh Nair got his tenure and got promoted as Associate Professor. Several research projects were completed and multiple grants were secured during the past year.

**Idaho – Phil Bass and Michael Colle**

Both Dr. Bass and Dr. Colle recently submitted the Promotion and Tenure Packet at the University of Idaho. Combined, Dr. Bass and Dr. Colle have been able to secure external funding for a variety of meat quality related projects totaling $270,060 this past year.

**Indiana - Brad Kim**

Dr.Kim is currently leading USDA-AFRI funded project and NCBA funded projects as a lead PI. We will also work on finalizing our working manuscripts and submit these manuscripts to peer-review journals for publication.

**Michigan - Melissa McKendree**

Melissa McKendree submitted her tenure packet at Michigan State University. She has been working on a USDA NIFA grant proposal related to beef traceability.

**Nevada - Amilton de Mello**

De Mello identified reliable molecular biomarkers for meat quality attributes and generated scientific evidence that beef-derived RNA can be absorbed in the intestines of recipients.

**Kentucky – Surendranath Suman**

We have characterized the effects of dietary vitamin E on post-translational modifications in myoglobin from beef longissimus lumborum muscles. As a PI or Co-PI, Dr. Suman was able to secure external research funding and equipment grant totaling $958,000 in the last year.

**Nebraska - Gary Sullivan**

We finalized 3 research projects with manuscripts under preparation. One project was initiated.

**Tennessee – Charley Martinez and Phillip Myer**

Milestones include dissemination to multiple, disciplinary and cross-disciplinary peer-reviewed journals. An applied outreach website was continued as a result of this project. The website aims to offer the audience the opportunity to learn more about the role of the rumen and lower gut microorganisms and their impact on the host's performance and health. Monthly, this page features a microbe found in the gut of ruminants.<http://rumenmicrobes.utk.edu>. Student internships provided professional and student development for both US students and those from Zamorano University.

Additionally, output from Tennessee objective 3 (livestock) will be displayed on the newly formed UT Center of Farm Management website (http://farmmanagement.tennessee.edu).

**7.** **Impact Statements**

**Station – PI name(s)**

*“Please, define your long term goals and how they will enhance the competitiveness and value of US beef”*

**Arizona – Duane Wulf**

Our research aims to improve the efficiency of production as well as enhance product quality consistency of US beef products. Lower costs of production, coupled with high product quality will enhance the competitiveness of US beef in the world marketplace.

**California - Jim Oltjen**

Grass Fed beef production and value in the West has been better characterized.

**California– Payam Vahmani**

The research conducted at Vahmani lab will improve our understanding of the nutritional characteristics and healthfulness of beef from different production systems.

**California - Scott Fausti**

Identified economic factors that influence consumer preferences for ground bison relative to ground beef. Identified economic factors that affect competitive bidding behavior in an auction experiment. Established protocols when conducting market research using an consumer auction structure that is designed as a multiproduct, multi-round Vickery 2nd price auction.

**Colorado - Mahesh Nair and Keith Belk**

The research conducted at Colorado State University will improve our understanding of postmortem metabolism and beef quality development, especially of quality parameters such as color, tenderness, and flavor**.**

**Idaho – Phil Bass and Michael Colle**

The previous and ongoing research at Idaho continues to work to improve product quality and consistency. Our main goal is always to find ways to increase beef consumption and acceptance which thereby adds value to all segments of the beef industry.

**Indiana - Brad Kim**

Dr. Kim’s research program centers around three major research objectives: 1) identify fundamental biochemical mechanisms governing meat quality attributes, such as color, tenderness, flavor, water-holding capacity and juiciness, 2) develop innovative technologies from the live animal pre-harvest to the post-harvest chain of events to improve meat quality, and 3) identify and develop novel meat or non-meat ingredients to create values from underutilized low-value sources.

**Kansas– Glynn Tonsor**

Demonstrative impact follows from the 2022 Meat Science paper co-authored with Jayson Lusk. Consistent with the article’s title (“U.S. Perspective: Meat Demand Outdoes Meat Avoidance”) this recent piece uses both USDA and Meat Demand Monitor data to document strong historical and recent beef demand in the U.S. Given how this differs from a prevalent narrative of meat avoidance growing, this is important and aligns with this project.

**Kentucky – Surendranath Suman**

Our long-term goal is to characterize biochemical mechanisms governing fresh beef color stability and to develop innovative strategies to enhance quality of US beef. The current research in Kentucky examines fundamental and applied aspects of beef color stability with the ultimate long-term goal to improve color stability of US beef and enhance consumer acceptance of fresh beef at the point of sale. This in turn will contribute to the competitiveness of US beef industry domestically and in global marketplace.

**Nevada - Amilton de Mello**

De Mello generated ground-breaking research about the role of meat-derived nano and femto-nutrients. Nevada’s research was the first to report that beef RNA resits post-mortem degradation, is bioavailable in the intestines after digestion, and can be absorbed. MicroRNAs that are absorbed can silence genes associated to metabolic pathways linked to homeostasis and chronic diseases. Nevada’s goal is to elucidate the epigenetics effects of meat consumption on human health and develop guidelines for optimal nutrition programs.

**Michigan- Melissa McKendree**

The long term goal is to understand how prices and therefore marketing information are transmitted between different members of the beef value chain, including how these relationships change with market events. Understanding this information is key to having a competitive beef industry.

**Nebraska - Gary Sullivan**

We conduct research that enhances the value of US beef by improving the quality, shelf life, safety, utilization, and consumer acceptance of beef products.

**Tennessee – Charley Martinez and Phillip Myer**

Long term major goals of the project are:

1. Improve understanding of biosecurity policies to mitigate risk of adverse health or disease events within the U.S. beef industry. Determine how alternative indemnity policy situations and governmental cost share programs impact voluntary biosecurity efforts and hence competitiveness of U.S. beef.

2. Identify ongoing market risk associated with domestic livestock protocols to the U.S. beef industry. Improve quality, safety, and domestic and international marketability of U.S. beef products by examining palatability attributes, developing and applying novel food safety interventions, exploring metagenomics to investigate food safety and antimicrobial resistance, increasing shelf life, developing novel products from variety meat items, and developing innovate carcass fabrication techniques.

3. Identify market opportunities and production decisions that benefit US cattle producers with the objective of enhancing competitiveness and value of US beef.

These goals provide better understanding of beef nutrition/health and how those protocols affect production and marketability of U.S. beef.

**8.** **Publications**

**Station – PI name(s)**

*“Please, list all your publications related to the scope of our project”*

**Arizona – Duane Wulf**

Mairena, C.A., D.M. Wulf, B.E. Waller, S.R. Garcia, B.J. Johnson, and D.R. Woerner. 2022. Characterizing sensory attributes on various beef muscles utilizing the F94L myostatin gene in beef-on-dairy breeding systems. Proc. 2022 Reciprocal Meat Conf. 42.

Waller, B.E., S.R. Garcia, D.R. Woerner, B.J. Johnson, and D.M. Wulf. 2022. Utilizing the F94L myostatin gene mutation to improve carcass characteristics and cutout in beef X dairy crossbred cattle. Proc. 2022 Reciprocal Meat Conf. 13.

**California - Jim Ottjen**

Klopatek, S.C., E. Marvinney, T. Duarte, A. Kendall, X. Yang and J.W. Oltjen. 2021. Grass-fed vs. grain-fed beef systems: performance, economic, and environmental trade-offs. Journal of Animal Science, skab374, https://doi.org/10.1093/jas/skab374

**California- Payam Vahmani**

Alves, S. P., P. **Vahmani**, C. Mapiye, T. A. McAllister, R. J. B. Bessa, and M. E. R. Dugan. 2021. Trans-10 18:1 in ruminant meats: A review. Lipids 56(6):539-562. doi: 10.1002/lipd.12324

Chen, Y. Y., A. Kommadath, P. **Vahmani**, J. Visvalingam, M. E. R. Dugan, and X. Yang. 2021. Transcriptome Analysis of Listeria monocytogenes Exposed to Beef Fat Reveals Antimicrobial and Pathogenicity Attenuation Mechanisms. Applied and Environmental Microbiology- 87(9): e03027-20. doi: 10.1128/AEM.03027-20

Lam, S., A. Kommadath, Ó. López-Campos, N. Prieto, J. Aalhus, M. Juárez, M. E. R. Dugan, and P. **Vahmani**. 2021. Evaluation of RNA quality and functional transcriptome of beef longissimus thoracis over time post-mortem. PLOS ONE 16(5):e0251868. doi: 10.1371/journal.pone.0251868

Barragán, W., J. L. Aalhus, G. Penner, M. E. R. Dugan, M. Juárez, Ó. López-Campos, P. **Vahmani**, J. Segura, J. Angulo, and N. Prieto. 2021. Authentication of barley-finished beef using visible and near infrared spectroscopy (Vis-NIRS) and different discrimination approaches. Meat Science 172:108342. doi:<https://doi.org/10.1016/j.meatsci.2021.108342>

**California - Scott Fausti**

**Fausti, S. W.,** Gonzalez, A. Qasmi, B.A., and **Underwood, K.** Auction Winners, Bid Price Endogeneity, and Consumer Preferences for Bison and Beef. Accepted for publication in 2022 in the Journal of Economic Insight. Forthcoming.

**Colorado - Mahesh Nair**

**Refereed Journal Articles**

Zhai, C., Schilling, B., Prenni, J.E., Brooks, C., Legako, J., Miller, R., Hernandez-Sintharakao, M.J., Gifford, C.L., Delmore, R., Nair, M.N.\* (2022). Evaluation on ability of rapid evaporative ionization mass spectrometry to differentiate beef flavor based on consumer preference. *Journal of Food Science and Technology.* [*https://doi.org/10.1007/s13197-022-05562-6*](https://doi.org/10.1007/s13197-022-05562-6)

Karney. E.D., Nair, M.N.\*, Rice, E., Thompson, T.W., Belk, K.E., Woerner, D.R. (2022). Effects of extended postmortem aging on beef muscles of differing quality grade during retail display Accepted in *Meat and Muscle Biology.*

Hernandez-Sintharakao, M.J., Swenson, J.K., Nair, M.N.\*, Geornaras, I., Engle, T.E., Belk, K.E., Woerner, D.R. (2022). Changes in the flavor profile of ground beef resulting from the application of antimicrobial interventions. *Meat and Muscle Biology.* 6: 13495, 1–12.<https://doi.org/10.22175/mmb.13495>

Zhai, C., Suman, S.P., Li, S., Nair, M.N.\*, Beach, C.M., Edenburn, B.M., Dilger, A.C., Boler, D.D., Felix, T.L. (2022). Ractopamine-induced changes in the mitochondrial proteome of postmortem longissimus lumborum muscle from feedlot steers. *Livestock Science.* 260, 104923.<https://doi.org/10.1016/j.livsci.2022.104923>

Djimsa, B., Nair, M.N.\*, Hess, A.M., Belk, K.E., Woerner, D.R. (2022). The impact of carcass size, chilling, and electrical stimulation on beef postmortem temperature and pH decline. *Meat and Muscle Biology.* *6(1): 13893, p.1-16.*<https://doi.org/10.22175/mmb.13893>

Ramanathan, R., Lambert, L.H., Nair, M.N., Morgan, B., Feuz, R., Mafi, G., Pfeiffer, M. (2022). Economic and natural resources loss due to beef discoloration, *Meat and Muscle Biology, 6(1): 13218, p.1-8.* doi:<https://doi.org/10.22175/mmb.13218>

Zhai, C., Li Puma, L.C., Chicco, A.J., Omar, A., Delmore, R.J., Geornaras, I., Speidel, S.E., Holt, T.N., Thomas, M.G., Enns, R.M., & Nair, M.N\*. (2022). Pulmonary arterial pressure in fattened angus steers at moderate altitude influences early postmortem mitochondria functionality and meat color during retail display. *Journal of Animal Science* 100, 2,<https://doi.org/10.1093/jas/skac002>

Zhai, C., Lonergan, E., Lonergan, S., Nair, M.N.\* (2022). Housekeeping proteins in meat quality research: Are they reliable markers for internal controls in western blot? - A mini review. *Meat and Muscle Biology* 6: 11551, p.1-15. doi:<https://doi.org/10.22175/mmb.11551>

Abstracts

Gonzalez, S, Nair, M.N., Belk, K.E. Diversity in global production systems allows beef to hit consumer targets in a range of markets. In proceedings of 68th International Congress of Meat Science and Technology, August 2022, Kobe, Japan. Paper # 4.23.

Zhai, C., Hernandez-Sintharakao, M.J., Rice, E.A., Thompson, T.W., Bechtold, E.R., Prenni, J.E., Woerner, D.R., Nair, M.N. Comparison of two types of electrodes used in rapid evaporative ionization mass spectrometry on the ability to differentiate lamb flavor performance. American Meat Science Association Annual Reciprocal Meat Conference, Jun 12 – 15, 2022, Des Moines, IA, Abstract # 93.

Zhai, C., Lonergan, S.M., Huff-Lonergan, E., Johnson, L.G., Steadham, E.M., Brown, K., Prenni, J.E., Nair, M.N. Lipid peroxidation products influence calpain-1 activity and autolysis in vitro. American Meat Science Association Annual Reciprocal Meat Conference, Jun 12 – 15, 2022, Des Moines, IA, Abstract # 166.

Smith, C.L., Geornaras, G., Metcalf, J., Morgan, J. B., Nair, M.N. Understanding muscle-specific discoloration and microbial spoilage of beef steaks using 16S rRNA sequencing. American Meat Science Association Annual Reciprocal Meat Conference, June 12- 15, 2022, Des Moines, IA, Abstract # 56.

Gonzalez Sanchez, S.V., Geornaras, I., Nair, M.N., Morgan. J.B. Evaluation of Suspended Fresh® on beef retail shelf-life and quality characteristics. Reciprocal Meat Conference Annual Meeting 75th. Abstract number 77.

Rice, E.A., Thompson, T.W., Pinnell, L.J., Weinroth, M.D., Doster, E., Noyes, N.R., Parker, J.K., Anderson, C., Crone, K., Belk, K.E., Nair, M.N., Morley, P.S. Evaluation of the impact of avian, bovine, and porcine fecal resistome on subsequent resistomes throughout production. American Meat Science Association Annual Reciprocal Meat Conference, June 12 - 15, 2022, Des Moines, IA, Abstract # 127.

Hernandez-Sintharakao, M.J., Sarchet, C., Prenni, J., Woerner, D., Nair, M. N. Ability of rapid evaporative ionization mass spectrometry (reims) to predict beef tenderness, juiciness, and flavor. 2022. American Meat Science Association Annual Reciprocal Meat Conference, Des Moines, IA. Abstract #99.

Sarchet, J.C., Hernandez-Sintharakao, M., Nair, M.N., Gredell, D.A., Legako, J.F., Miller, M.F., Brooks, J.C., Woerner, D.R. Predicting animal identity and age of longissimus lumborum steaks using rapid evaporative ionization mass spectrometry (REIMS). American Meat Science Association Annual Reciprocal Meat Conference, Des Moines, IA. Abstract #96

**Idaho – Phil Bass and Michael Colle**

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**Nevada - Amilton de Mello**

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**Tennessee – Charley Martinez and Phillip Myer**

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