**Project/Activity Number: W5177**

**Project/Activity Title: Enhancing the Competitiveness and Value of U.S. Beef**

**Period Covered: September 2023 to June 2024**

**Date of This Report: 8/21/2024**

**Annual Meeting Date(s): 6-16-2024**

**Participants:** Brad Kim, Michael Chao, Mahesh Nair, Gary Sullivan, Phil Bass, Carol Lorenzen, Michael Colle, Payam Vahmani, Kerri Gehring, Chaoyu Zhai, Derico Setyabrata, Tracey Scheffler, Amilton de Mello, Ana Paula Salim, Duane Wulf

**Brief summary of minutes of annual meeting:**

The meeting was called to order by Michael Colle at 2:00 pm Central Time. A welcome and brief announcements were made. Michael Colle announced that he will be stepping down from chair once the final report is submitted.

The administrative report was shared as a ppt with the project members to review on their own time.

Station reports were then shared beginning with Payam Vahmani who shared that a bacterium (*Cutibacterium acnes* AP1) could contribute to high *t*10 fatty acid content of beef. Phil Bass discussed alternative fabrication of heavyweight beef carcasses and its effect on meat quality and fiber type. Brad Kim shared information on their freeze-thaw of beef products study as well as long-term aging. Ana Paula Salim (Dr. Suman’s lab) discussed aging influence on color, lipid oxidation, and tenderness of biceps femoris cuts in lamb. Tracey Scheffler visited on her work looking at the variation in tenderness within *Bos Indicus* cattle with a focus on postpartum metabolism. There are differences in mitochondrial functionalities. Amilton de Mello shared his research on microRNA - they inhibit the translation of proteins. Some microRNAs are specific to beef. Carol Lorenzen has been working on moving the needle at NIFA to include meat in their funding programs. Kerri Gehring along with others on the project discussed the publication status of the beef quality audit. They also took a survey on the freezing the thawing process from different establishments - most had no idea how long it was taking to freeze. Liver abscesses in beef x dairy cattle was also discussed. Gary Sullivan and his team have been looking at using high pressure processing to improve the color of dark cutting beef. Additionally, they are looking at alternative curing of beef products and a genetic defect related to glycogen in cattle. Derico compared the freezing of steaks to roasts, shipping optimization of beef, flavor studies, and microbiome of fresh meat. Chaoyu is a new member and rebuilding the program at the University of Connecticut. Their team is working on proteomics/metabolomics. Mahesh Nair discussed the national beef quality audit, impact of long term deep chilling (-2C), and evaluating the interaction between bacterial growth and color. Duane Wulf discussed the F94 myostatin mutation in dairy x beef steers, fatty acid composition of grain and grass finished beef, and a new product that could reduce stress in beef cattle leading to improved product quality. Michael Chao shared his research looking at Alpha-gal syndrome. A tick bite leads to red meat allergies. Michael Colle discussed an upcoming project looking at genetically testing dairy x beef steers and recently finished projects focused on various aging strategies and a novel mustard extract.

Potential opportunities for the group to write a review paper on freezing/thawing of beef. Opportunity to have W5177 members present as part of reciprocation sessions at the 2025 Reciprocal Meat Conference. Several members have given or have been invited to give keynote speeches; they will send titles and conference names to Michael Colle. There will be a mid project review in the coming years. We need to encourage Agricultural Economists to participate in the meetings.

Meeting was adjourned

**Agenda:**

2:00 – 2:10 pm (CT) Call to order – Introductions

2:10 – 2:20 pm Administrative Report – Brett Hess

2:20 – 2:30 pm Chair and secretary report

2:30 – 3:40 pm Station reports (~10 min/station)

3:40 – 4:00 pm Discussion for possible collaborations

4:00 pm Adjourn

**Keynote Presentations:**

Scheffler, Tracey: 7/19/2023 - American Society of Animal Science Meeting, Albuquerque, NM. Meat Science and Muscle Biology Symposium: Relationships between mitochondrial energetics, muscle biology, and meat quality. (Presentation title: Mitochondria and meat quality: life, death, and the in-between). Discussed mitochondria function early postmortem and its potential roles in meat quality development (particularly proteolysis-mediated tenderization). The model systems included bovine muscles with different metabolic and contractile types, and longissimus from Bos taurus and Bos indicus cattle.

Bass, Phil: 8/12/2024 – Brazilian Animal Science Society Annual Meeting, Cuiaba, Brazil. Keynote Presentation (Presentation title: Beef production and technology in the United States.  Discussed historical and current numbers of cattle in the US, shared beef grading systems, explained new ideas for instrument grading and heavy weight carcass management.

Scheffler, Tracey: 8/20/24 – International Congress of Meat Science and Technology (ICoMST), Foz do Iguacu, Brazil. Keynote, Session 5: Muscle Biology & Meat Quality. (Presentation title: Resilience in life and death: metabolism and proteolysis in Bos indicus cattle)

**1.** **Collaborations**

**Idaho/Arkansas**

Thompson, J., M. Kibler, B. Dhal, B. Epperson, K. Puga, J. Van Buren, P. Bass, K. Smith, and M.J. Colle. 2024. Willingness to Pay for Alternate Merchandising Strategy of Beef Top Round.” Journal of Food Distribution Research. Accepted 2-12-24.

**Indiana/Oklahoma/Kansas/Kentucky**

Ramanathan, R., Denzer, M., Kiyimba, F., Harr, K., Suman, S., Hunt, M.C., Pfeiffer, M., Mafi, G.G., Kim, Y.H.B.,. 2023. Role of postmortem bioenergetics in beef colour chemistry. Italian Journal of Animal Science. 22:711-727.

**Kansas/New York**

Neill, C.L. and L.L. Britton. 2024. “Are All Meat Substitutes? A Basket and Expenditure Based Approach.” *Agribusiness: an International Journal*. Accepted 6-13-2024.

**Kentucky/Oklahoma**

Suman, S.P.; Wang, Y.; Gagaoua, M.; Kiyimba, F.; Ramanathan, R. 2023. Proteomic approaches to characterize biochemistry of fresh beef color. Journal of Proteomics, 281, 104893. DOI: https://doi.org/10.1016/j.jprot.2023.104893

Ramanathan, R.; Denzer, M.; Kiyimba, F.; Harr, K.; Suman, S.P.; Hunt, M.C.; Pfeiffer, M.; Mafi, G.G., Kim, Y.H.B. 2023. Role of postmortem bioenergetics in beef colour chemistry. Italian Journal of Animal Science, 22(1): 711-727. DOI: https://doi.org/10.1080/1828051X.2023.2240357

Ramanathan, R.; Kiyimba, F.; Suman, S.P.; Mafi, G.G. 2023. The potential of metabolomics in meat science: Current applications, future trends, and challenges. Journal of Proteomics, 283, 104926. DOI: https://doi.org/10.1016/j.jprot.2023.104926

Faustman, C.; Suman, S.P.; Ramanathan, R. 2023. The eating quality of meat: I Color. In Lawrie's Meat Science (Ninth Edition). ISBN: 978-0-323-85408-5. Edited by F. Toldra. Elsevier, Oxford, United Kingdom. Chapter 11, pp 363-392. DOI: https://doi.org/10.1016/B978-0-323-85408-5.00023-6

Ramanathan, R.; Suman, S.P.; Kiyimba, F.; Li, S.; Chen, J. 2023. Myoglobin post-translational modifications in high- and normal-pH beef. American Chemical Society Annual Meeting, March 2023, Indianapolis, IN. Abstract # 3825391.

**Texas/Colorado/Idaho/Oklahoma**

**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.

Smith, C.L., Thompson, T.W., Harr, K., Goretska, M., Mayer, T., Schwartz, T., Borders, S.E., Gehring, K.B., Bass, P., Pfeiffer, M., Mafi, G., Pendell, D., Morgan, B., Griffin, D., Savell, J.W., Scanga, J., **Nair, M.N.**, Belk, K. (2024) 2022 National Beef Quality Audit Phase 1: face-to-face and digital interviews. Accepted in *Translational Animal Science*. Volume 8, 2024, txae034,<https://doi.org/10.1093/tas/txae034>

Benjamin J. Carpenter, Thomas W. Dobbins, M. Sebastian Hernandez , Samantha N. Barker, Kaitlyn R. Loomas, Wesley N. Osburn and Jerrad F. Legako. 2024. Foods , 10, x.<https://doi.org/10.3390/xxxxx> (Accepted)

Smith, T. J., Bher, A., Auras, R., Bowser, T., Denzer, M. L., Alnajrani, M., Osburn, W., Mafi, G., Pfeiffer, M. & Ramanathan, R., (2024) “Effects of Sodium Nitrite and Tocopherol Incorporated Poly(Lactic Acid) Biodegradable Films on Dark-Cutting Beef Color”, *Meat and Muscle Biology* 8(1): 17006, 1-15. doi:<https://doi.org/10.22175/mmb.17006>

Borders, S. E., T. E. Schwartz, T. R. Mayer, K. B. Gehring, D. B. Griffin, C. R. Kerth, K. E. Belk, L. Edwards-Callaway, J. A. Scanga, M. N. Nair, J. B. Morgan, J. B. Douglas, M. M. Pfeiffer, G. G. Mafi, K. M. Harr, T. E. Lawrence, T. C. Tennant, L. W. Lucherk, T. G. O’Quinn, E. S. Beyer, P. D. Bass, L. G. Garcia, B. M. Bohrer, J. A. Pempek, A. J. Garmyn, R. J. Maddock, C. C. Carr, T. D. Pringle, T. L. Scheffler, J. M. Scheffler, A. M. Stelzleni, J. M. Gonzalez, K. R. Underwood, B. N. Harsh, C. M. Waters, and J. W. Savell. 2024. National Beef Quality Audit – 2022: Transportation, mobility, live cattle, and hide assessments to determine producer-related defects that affect animal welfare and the value of market cows and bulls at processing facilities. Transl. Anim. Sci. 8:txae033. doi:10.1093/tas/txae033

Gonzalez, A. A., E. P. Williams, T. E. Schwartz, A. N. Arnold, D. B. Griffin, R. K. Miller, K. B. Gehring, J. C. Brooks, J. F. Legako, C. C. Carr, G. G. Mafi, C. L. Lorenzen, R. J. Maddock, and J. W. Savell. 2024. National Beef Tenderness Survey – 2022: Consumer sensory panel evaluations and Warner-Bratzler shear force of beef steaks from retail and foodservice. Meat Muscle Biol. 8:Article 16997, 1-11. doi:10.22175/mmb.16997

**2.** **Accomplishments**

**Arkansas - Derico Setyabrata**

The meat science faculty at University of Arkansas has been conducting several research projects in the past year focusing on freezing processes, color stability, product shipping optimization and waste utilization.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

Beef is high in *t*10 fatty acids, which may reduce beef quality and healthfulness to consumers. It is known that *t*10 fatty acids originate from bacteria in the rumen, but these bacteria have been elusive. Here we identified a bacterium (Cutibacterium acnes AP1) that forms a *t*10 fatty acid (*t*10,*c*12-18:2) during biohydrogenation of linoleic acid. This bacterium and others forming t10 fatty acids could be important targets for improving the quality and healthfulness of beef.

Dr. Yang’s lab continues to work on the assessment of antimicrobial resistance in beef production. One of the projects was to evaluate the effects of a supplemental blend of essential oils and 25-hydroxyvitamin D3 on the fecal resistome of steers. The ongoing project is to evaluate how extended colostrum feeding affect cattle health, performance and magnitude of antimicrobial resistance.

**Colorado – Mahesh Nair and Keith Belk**

The meat science faculty at 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. The National Beef Quality Audit research was completed and published in a peer-reviewed journal. In addition, the effect of low temperature on beef palatability and shelf-life was also investigated. Co-PI Mahesh Nair was awarded the 2024 Research and Scholarship Award by the College of Agricultural Sciences at Colorado State University.

**Connecticut – Chaoyu Zhai**

The meat science faculty at the University of Connecticut (UConn) developed a new peptidomic workflow for animal tissue diagnosis with low cost, high sensitivity, and fast matching speed, as well as the first analytical method to investigate non-targeted proteome degradation, which will be submitted for patent in the following year. By using these two methods, UConn meat scientist has been actively engaged in several research projects during the past year focusing on the effects of preharvest and postharvest factors on bovine postmortem muscle proteolysis and its relation to meat quality development. Dr. Zhai’s first federal competitive grant application as primary investigator to NIFA was ranked as outstanding by the *Animal Nutrition, Growth, and Lactation* program and recommended for four-year funding ($650K) starting in August 2024.

**Florida - Tracy Scheffler**

Tracy Scheffler’s lab is involved in research projects focusing on quality and yield of Brahman carcasses, and proteolysis and tenderness of Brahman longissimus. Ongoing work includes investigation of mitochondrial functional properties in relation to meat quality attributes.

**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 and utilization of natural antioxidants to extend shelf life of beef patties. 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 both fresh and precooked beef patties utilizing a novel mustard extract alone and in combination with potato extract or rosemary extract. Aging strategies including freezing with dry ice and suspended fresh aging were evaluated. Lastly, various gluten free breddings were evaluated for use in finger steaks.

**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 several beef projects – 1) NCBA funded fresh beef tumbling and aged/frozen beef for better quality and 2) continue working on USDA-AFRI grant project - the impacts of extended postmortem aging on color and redox stability of different beef muscles

**Kansas - Michael Chao**

Michael Chao’s lab has investigated the use of electrostatic field (EF) to assist with the freezing process of beef striploins. The 4 EF treatments were 0, 2, 4, or 8 kV, and we measured how the EF application can affect beef color stability during the retail display of previously frozen beef striploins*.* In addition, we quantified alpha-gal content in different red meat products to provide a better understanding of how this allergen can trigger red meat allergy.

**Kentucky - Surendranath Suman**

Dr. Suman’s lab examined innovative strategies to improve color stability of fresh beef with the ultimate goal to enhance retail color shelf-life and minimize discoloration-induced sales loss in the beef industry.

**Oklahoma - Gretchen Mafi**

Researchers at Oklahoma State have completed several projects on factors impacting dark cutting beef, freeze/thaw cycles on palatability, purge loss and yield, and research to determine surface area effects on oxygen scavengers in modified atmosphere packages.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

A study was conducted to determine the impact of L-arginine (Arg) concentration on the ability of the endothelial nitric oxide synthase (eNOS) system to cure beef jerky and its effect on product attributes using two validated thermal processes. Arg treated samples showed no significant differences among concentration for any analysis with the exception of residual nitrite values at 1000 and 5000 ppm. It was observed that high temperature thermal processing treated samples tended to have slightly higher cured meat color values, a\* values and residual nitrate and nitrite values low temperature thermal processing. As length of storage increased, nitrosohemochrome and a\* values decreased as storage day. Results suggest that 1000 ppm Arg treated beef jerky thermally processed at higher temperatures were more similar to values observed for sodium nitrite treated control samples compared to the low temperature thermal processing.

A study was conducted to evaluate the impact of various combinations of refrigerated and frozen storage on quality and palatability attributes in ribeye roll and top sirloin butt subprimals and steaks. USDA Choice boneless ribeye rolls (*n* = 40) and top sirloin butts (*n* = 40) were aged under refrigeration for 21 d before being assigned to 1 of 4 treatments. Treatments included (1) Frozen subprimals/Frozen steaks, in which subprimals were frozen for 30 d, thawed for 7 d, and portioned into steaks that were frozen for 30 d, then thawed for 2 d before evaluation; (2) Frozen subprimals/Refrigerated steaks, in which subprimals were frozen for 30 d, thawed for 7 d, and portioned into steaks for evaluation; (3) Refrigerated subprimals/Frozen steaks, in which subprimals were portioned into steaks that were frozen for 30 d, then thawed for 2 d before evaluation; and (4) Refrigerated subprimals/Refrigerated steaks, in which subprimals were portioned into steaks for evaluation within 7 d of portioning. Beef steaks from the ribeye rolls and top sirloin butts were evaluated to determine the impact of storage treatments on purge, color, cooking yield, tenderness, and consumer acceptability. For both subprimals, purge varied (*P* < 0.0001) among steak treatments, with Refrigerated/Refrigerated being the lowest for both subprimals. For both steak types, cook yield was highest (*P* < 0.05) for Refrigerated/ Refrigerated treatment. Refrigerated/Refrigerated ribeye steaks had among the lowest Warner-Bratzler shear force values, and similar (*P* > 0.05) consumer ratings were observed for ribeye steaks. Frozen/Frozen top sirloin steaks had the lowest (*P* < 0.05) consumer ratings for overall liking, flavor liking, and juiciness liking. Storage conditions played a greater role in quality and consumer acceptability for top sirloin steaks than ribeye steaks. Overall, freezing both subprimals and steaks posed the greatest challenge in quality and palatability.

For the National Beef Tenderness Survey – 2022, beef retail steaks from establishments across 11 US cities and beef foodservice steaks from establishments in 6 US cities were evaluated by consumer sensory evaluations and Warner-Bratzler shear (WBS) force analyses. The retail tenderloin had the lowest (*P* < 0.05) WBS force value compared to other retail cuts. The retail steak with the greatest (*P* < 0.05) WBS force value was the top sirloin. Foodservice ribeye and top loin steaks had greater (P<0.05) WBS force values compared to the tenderloin. All retail top blade, bone-in ribeye, Porterhouse, and tenderloin steaks were categorized as“very tender” (<31.4 N). There were no (*P* > 0.05) differences in WBS force values among USDA quality grade groups for foodservice steaks. Retail tenderloin steaks received the highest (*P* < 0.05) consumer rating for overall like/dislike, tenderness like/dislike,tenderness level, flavor like/dislike, and juiciness like/dislike compared to all other retail cuts. There were no (P>0.05)differences among the 4 foodservice cuts for consumer sensory ratings of overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. There were no (*P* > 0.05) USDA quality grade differences for ribeye, top loin, top sirloin, and tenderloin foodservice steaks for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. Regardless of source (foodservice or retail), USDA grade group, or beef cut, measures of tenderness in this survey reveal ratings and values that should meet most consumer expectations in the marketplace.

The National Beef Quality Audit (NBQA)-2022 serves as a benchmark of the current market cow and bull sectors of the U.S. beef industry and allows comparison to previous audits as a method of monitoring industry progress. From September 2021 through May 2022, livestock trailers (*n* = 125), live animals (n = 5,430), and post-slaughter hide-on animals (n = 6,674) were surveyed at 20 commercial beef processing facilities across the U.S. Cattle were transported in a variety of trailer types for an average distance of 490.6 km and a mean transport time of 6.3 h. During transit, cattle averaged 2.3 m2 of trailer space per animal indicating sufficient space was provided according to industry guidelines. Of all trailers surveyed, 55.3% transported cattle from an auction barn to a processing facility. When surveyed, 63.6% of all truck drivers reported to be Beef Quality Assurance certified. The majority (77.0%) of cattle were sound when evaluated for mobility. Mean body condition scores (9-point scale) for beef cows and bulls were 3.8 and 4.4, respectively, whereas mean body condition scores (5-point scale) for dairy cows and bulls were 2.3 and 2.6, respectively. Of cattle surveyed, 45.1% had no visible live animal defects, and 37.9% had only a single defect. Of defects present in cows, 64.6% were attributed to an udder problem. Full udders were observed in 47.5% of all cows. Nearly all cattle were free of visible abscesses and knots (97.9% and 98.2%, respectively). No horns were observed in 89.4% of all cattle surveyed. Beef cattle were predominantly black-hided (68.9% and 67.4% of cows and bulls, respectively). Holstein was the predominant dairy animal observed and accounted for 85.7% of the cows and 98.0% of the bulls. Only 3.1% of all animals had no form of identification. Findings from the NBQA-2022 show improvements within the industry and identified areas that required continued education and research to improve market cow and bull welfare and beef quality.

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

**Arkansas - Derico Setyabrata**

Our research indicated that when frozen using consumer freezing methods, beef frozen in steak format generated lower color quality compared to beef frozen in bigger (section) format. Additionally, the steak freezing generated more off-flavor compounds and a trend of lower acceptability from consumers. Study identifying alternative methods to process dry-aged trims showed that sousvide and dehydration generated the highest log reduction, followed by hot water and acid spray.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

Our project identified a bacterium (*Cutibacterium acnes* AP1) that forms *t*10,*c*12-18:2 during biohydrogenation of linoleic acid. This bacterium could contribute to high *t*10 fatty acid content of beef.

The essential oil project revealed that although the dietary supplementation of essential oil or monensin was not found to affect resistome composition, there are some differences in the abundance of fecal antimicrobial resistance determinants in cattle. Additional microbiome analysis showed that microbial composition remained similar among the treatment groups on early days of production, and the fecal microbiome became more distinct by treatment groups at the end of production. This change indicates the effects of the dietary supplementation of either monensin or essential oils could have become more pronounced over time. The findings from this study indicated that the utilization of monensin or essential oils did not alter the resistome of pen floor feces in cattle. The application of monensin, classified as an ionophore, may not contribute to an increase in the magnitude of antimicrobial resistance (AMR) in livestock production. This information holds significance for producers, as the ongoing use of monensin offers additional benefits to livestock production without increasing the risk of AMR.

**Colorado – Mahesh Nair and Keith Belk**

 The low temperature (LT) storage study evaluated the impact of 60, 75, or 90 d of LT storage (−2.7°C ± 0.3°C) on the palatability and shelflife characteristics of steaks from inside rounds (IR), bone-in ribeyes, and striploins (SL) from 10 (n = 10) upper two-thirds Choice beef carcasses. The shear force values decreased with increased storage time for all the cuts. Similarly, consumer tenderness rating scores increased with the LT storage time, particularly in IR and SL steaks. However, storage time did not influence the juiciness, flavor, and overall liking of any of the cuts. For all subprimals, the APC of LT60 steaks on days 0, 2, and 4 of the retail display were lower than those of LT75 and LT90 samples. Samples from LT60 presented a longer microbial retail shelf-life than those from LT75 and LT90 due to lower initial microbial loads following LT storage. However, the retail shelf-life of samples from LT75 and LT90 was similar. These results suggested it would be feasible to extend the storage time of beef while preserving or improving the sensory quality when held at optimal conditions above the freezing temperature.

**Connecticut – Chaoyu Zhai**

Dr. Zhai reinitiated the UConn Meat Science graduate program and recruited the first two meat science graduate students since 2012. From the projects completed by UConn meat science group, Dr. Zhai’s students are currently preparing 6 manuscripts, with topics focusing on muscle proteomics, postmortem mitochondrial biology, and peptidomics, and they will submit these works to high-impact scientific journals in the upcoming academic year.

**Florida - Tracy Scheffler**

Brahman cattle exhibited considerable variation in the rate and extent of proteolysis despite similar management conditions and genetic background. While calpain and calpastatin are contributing factors, Brahman longissimus also exhibits greater energy status, slower pH decline, and enhanced mitochondrial capacity compared with Angus, indicating that Brahman muscle may possess adaptations that enhance capacity to combat metabolic stress, thereby contributing to delayed proteolysis.

**Idaho – Phil Bass and Michael Colle**

Ground has been broken for the new Meat Science Innovation Center Honoring Ron Richard on the UI campus. Patties treated with mustard extract at all levels performed similarly to the positive controls at reducing oxidation. Freezing treatments of the rib and top sirloin could be beneficial to mitigate oxidation, but refrigeration treatments are more likely to result in greater consumer appeal at the retail level. Alternative aging and cold storage strategies could improve shelf-life and sensory attributes.

**Indiana - Brad Kim**

This study aims to elucidate the effects of different aging durations before freezing on quality attributes, physicochemical and biochemical properties, and sensory attributes of beef loins and sirloins, particularly under repeated freeze/thaw conditions. Our hypothesis is that aging meat before freezing will enhance the overall quality of frozen/thawed meat, even when it undergoes multiple freeze/thaw cycles. The results from both beef loin and sirloin studies conclusively show that aging prior to freezing significantly enhances meat quality attributes by reducing freeze/thaw loss and drip loss. This improvement in water-holding capacity is consistent across both types of meat. Both studies demonstrated the effect of aging on improving water-holding capacity which could alleviate the deteriorative effect of freezing and repeated freeze-thawing, as evidenced by reduced freeze-thaw losses and display losses. Aging would provide protective effects against water loss during freezing and thawing processes by creating a more permeable matrix with enhanced enzymatic activity. Tenderness exhibited significant improvements with aging. Meanwhile, repeatedly frozen sample was comparable to that of five-week-aged never-frozen control, suggesting a potential avenue for enhancing tenderness through strategic freezing. The sirloin study suggested that aged and double-frozen meat was more tender compared to other treatments. The consumer sensory panels in both studies did not report any negative impact of repeated freeze/thaw cycles on meat quality. Moreover, the panelists in the sirloin study reported improved tenderness and rated aged, double-frozen meat as premium quality meat compared to other treatments. The results of the present study suggest that developing an optimal aging/freezing strategy has a potential to improve meat quality attributes of frozen/thawed beef while consistently offering preservation benefits of freezing.

The muscle-specific response to aging-related discoloration was determined by examining mitochondria characteristics of various beef muscles. As aging time increased, all muscles showed decreased CIE *a*\* values with LL and ST maintaining higher redness throughout the aging periods (p<0.05). Hue angle and sensory discoloration values increased with aging (p<0.05), with no initial differences. MT swelling, indicating ptotic features in the color stability of various muscles during aging through multi-omics profiling approaches.more mitochondrial openings, increased with aging across all muscles (p<0.05), with IF the highest and LL the lowest in all aging periods. MT-lipid peroxidation was stable in LL and ST, but increased in other muscles, notably IF from day 42 (p<0.05). Also, IF had a considerable increase in oxidized cytochrome c during aging compared to other muscles, while LL had lower levels from 21 to 63 days of aging (p<0.05). These results indicate that the level of mitochondrial damage and the ability to reduce cytochrome c vary depending on individual muscle during aging. The results of the study found that LL and ST muscles demonstrated superior color stability, followed by GM and BF, with IF showing greater susceptibility to discoloration with aging. Prolonged aging resulted in different extents of mitochondria-mediated apoptosis across beef muscles, which may be attributed to the observed differences in color stability among muscle types with aging.

**Kansas - Michael Chao**

For the EF study, we found that the stronger EF (8 kV) provided a noticeable benefit to decrease purge loss of beef striploins after the samples have been thawed. In addition, we also noted that medium EF (4 kV) has the potential to improve the shelf-life of beef striploin. For the alpha-gal project, we have found that cooking is not an effective way to reduce alpha-gal content in red meat products. However, fermentation may be an effective way to reduce alpha-gal content in red meat products.

**Kentucky - Surendranath Suman**

Our research indicated that wet-aging for 21 days increased both tenderness and surface color of beef biceps femoris muscle, which is a tough muscle in beef hindquarters. The results demonstrated that aging positively influenced the color stability and tenderness of biceps femoris muscles. This information could be exploited as a post-harvest strategy to improve retail color stability and tenderness of beef biceps femoris and increase the value of this underutilized muscle.

**Oklahoma - Gretchen Mafi**

Our initial research indicates increased surface area of steaks while maintaining same weight in master bags will result in increased discoloration and decreased acceptability. The results demonstrate the need to further investigate oxygen scavenging capacity with different steak sizes and weights to maximize shelf-life.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

Research to date has demonstrated the feasibility of utilizing the amino acid L-arginine (L-arginine-HCl) as a substrate to activate the endothelial nitric oxide synthase enzyme system (eNOS) that occurs naturally in post rigor skeletal muscle from poultry, pork and/or beef. This represents an innovative method to generate nitric oxide and residual nitrite to cure meat and poultry products. We hypothesized that the addition of the amino acid L-arginine (1000-5000 ppm) activates the NOS system in post rigor skeletal muscle to generate nitric oxide (NO) for cured meat color development and residual nitrite for product shelf life and safety as an antimicrobial. Current research found the following processing parameters improved eNOS enzyme activity (pH~5.6, temperature ~37C and time at 37C > 45 minutes). This alternative curing system activates the eNOS enzyme to generate nitric oxide (NO) for development of cured meat color and residual nitrite for product shelf life and safety the following observations were noted: 1) different species of meat contain varying amounts of the eNOS enzyme (beef>pork>poultry), thus color intensity varies, 2) color fades during refrigerated storage 3) L-arginine treated products are more similar to nitrite treated products for cured meat flavor compared to L-citrulline or in combination (L-arginine/L-citrulline), 4) 1000 ppm L-arginine appears sufficient for enzyme activation and 5) L-arginine treated samples generate less intense cured meat color (measurement of the nitrosohemochromagen pigment) and less residual nitrite (potentially less risk for nitrosamine formation) compared to nitrite treated meat products.

**4.** **Outputs**

**Arkansas - Derico Setyabrata**

In the past year, 3 abstract related to the projects were published and several presentation were presented related to freezing and beef postmortem aging.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

The bacterium we isolated (*Cutibacterium acnes* AP1) is being deposited in a public culture collection (DSMZ), enabling study by other labs. Additionally, 2 peer-reviewed manuscripts were published related to trans fatty acids in beef.

One abstract about the essential oil project was accepted and will be presented at RMC this year. A manuscript is in preparation.

**Colorado – Mahesh Nair and Keith Belk**

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

**Connecticut – Chaoyu Zhai**

In the past year, Dr. Zhai published 1 publication related to beef quality. Dr. Zhai was also invited as speaker by American Meat Science Association, The Institute of Food Technologists, and American Society of Animal Science Annual Meeting.

**Florida – Tracy Scheffler**

In the past year, Tracy Scheffler published three peer-reviewed manuscripts related to postmortem metabolism and beef quality. She was also an invited speaker at the Meat Science and Muscle Biology Symposium held at the American Society of Animal Science annual meeting.

**Idaho – Phil Bass and Michael Colle**

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

**Indiana - Brad Kim**

In this reporting period, five peer-reviewed journal articles, 2 book chapters, 1 proceeding article and 4 conference abstracts were published.The PI Kim was invited to give a keynote lecture at the International Congress of Meat Science and Technology, Padova, Italy and at the International Symposium and Annual Meeting of Korean Society for Food Science of Animal Resources meeting, Korea.

**Kansas - Michael Chao**

Since last year, my lab published 6 peer-reviewed manuscripts and provided training to 3 graduate students and 1 undergraduate student researcher.

**Kansas - Logan Britton**

Concluded research focused on substitution and complementary purchasing behavior of U.S. consumers among plant-based meat alternative and traditional livestock products. The manuscript was accepted for publication in June 2024.

**Kentucky - Surendranath Suman**

The results from this project were published in 2023 as 1 book chapter, 4 peer-reviewed journal articles, and 1 conference paper. Dr. Suman delivered 2 invited lectures virtually (in South Africa and Canada) on beef color stability in 2023.

**Oklahoma - Gretchen Mafi**

Since last year, our lab has published 5 peer-reviewed manuscripts, completed training for 4 graduate students, and 3 undergraduate researchers.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

Since the 2023 report, our laboratory has co-authored two publications. Two invited in-state and one invited international lecture along with six abstracts were presented by graduate students.

For Savell and Gehring, three refereed journal articles, 9 abstracts were presented at the 69th Reciprocal Meat Conference, and 6 posters were presented at the 76th International Congress of Meat Science and Technology.

**5.** **Activities**

**Arkansas - Derico Setyabrata**

Training to 3 graduate students and 6 undergraduate students is currently ongoing. 1 MS student and 1 undergraduate was awarded for research presentation. Workshop was held this past year focusing on beef production.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

We identified a *Cutibacterium acnes* AP1 as a bacterium that can form *t*10,*c*12-18:2 at fast rates. It was isolated from rumen contents of a heifer by using media containing lactate and metronidazole. It formed *t*10,*c*12-18:2 from linoleic acid, a result confirmed by three methods (spectrophotometry, thin-layer chromatography, gas chromatography). The rate of formation was 67% faster than for *Cutibacterium acnes* DSM 1897, the type strain from human skin. The availability of this isolate and its ability to rapidly form *t*10,*c*12-18:2 make it a good subject for further study. Such study could help control formation of *t*10,*c*12-18:2 in the rumen and reduce *t*10 fatty acids in beef.

Four Ph.D. students are involved in the antimicrobial resistance projects. An additional 6 undergraduate students were trained to assist in the research projects.

**Colorado – Mahesh Nair and Keith Belk**

Currently training is being provided to 6 graduate students and several undergraduate students. Also, 2 M.S. and 2 Ph.D. degrees were awarded during this time. Additionally, the following activities were taken up by the PI (Mahesh Nair and Keith Belk) for knowledge dissemination.

* Hosted large workshops to discuss industry issues and present research findings.
* Served as invited speakers at scientific meetings to present research.
* Served as members of advisory boards for research foundations.
* Integrated research findings into university courses and curriculum.
* Published numerous peer-reviewed articles

**Connecticut – Chaoyu Zhai**

Dr. Zhai is currently training 2 graduate students and 1 undergraduate student. Dr. Zhai was also invited as speaker by American Meat Science Association, The Institute of Food Technologists, and American Society of Animal Science Annual Meeting.

**Florida – Tracy Scheffler**

Training is being provided to one graduate student (MS) and several undergraduate students. Research findings have been incorporated into courses, as well as extension programming aimed at producers (Beef Cattle Short Course) and consumers (Grill Masters).

**Idaho – Phil Bass and Michael Colle**

Hands on meat lab and research lab training were provided to 6 graduate and 7 undergraduate students in Meat Science. Numerous producer, processor, and retailer workshops were held this past year focusing on improving meat quality. The Beef 101 program kicked off this past year.

**Indiana - Brad Kim**

Two phd students, 1 MS student and 2 visiting post-doc were trained and assigned to the projects working on conducting biochemical analyses including meat quality, color and oxidative stability as well as metabolomics analyses. Along with peer-reviewed journal article publications, Dr. Kim gave multiple presentations at several universities and research institutes in Korea to present some of the key findings of the current research works during his research sabbatical periods in Korea.

**Kansas - Michael Chao**

My lab provided Sous vide and red meat allergy training at various regional meetings including the Kansas Cattlemen's day and Kansas Association of Meat Processor’s annual convention.

**Kansas - Logan Britton**

Training for one Ph.D. student is currently ongoing. The student participated in an international experimental design school in summer 2024. The Ph.D. student has developed a survey instrument to complete research objectives surrounding U.S. consumer attitudes and perceptions of meat from FMD-infected zones.

**Kentucky - Surendranath Suman**

Research training was provided to 3 trainees (1 MS student; 1 postdoctoral scholar; 1 lab staff) on evaluation of meat quality, muscle proteome isolation, spectrophotometry, two-dimensional gel electrophoresis, gel image analyses, and analyses of proteomic data. Dr. Suman delivered 2 invited lectures virtually (in South Africa and Canada) on beef color stability in 2023.

**Oklahoma - Gretchen Mafi**

Research training in meat color and packaging for 4 graduate students and 5 undergraduate researchers continues, as well as presentations to Oklahoma Beef Producers, retailers and Caribbean chefs/purveyors.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

Currently 4 MSc students and 1 PhD student are continuing our research efforts in developing an amino acid based alternative curing system. One MSc student has graduated since the last reporting period. Two invited in-state and one invited international lecture along with six abstracts were presented by graduate students. A presentation was also given at the A1364 Novel Foods and Innovative Manufacturing Technologies Program Director's meeting at UC-Davis.

For Savell and Gehring, currently 3 Ph.D. and 2 master’s students are working on a variety of beef quality and safety research projects. One Ph.D. and two master’s students completed their degree programs since the previous report.

**6.** **Milestones**

**Arkansas - Derico Setyabrata**

Research fundings were obtained this past year to conduct project related to meat color, shelf-life and quality.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

We have achieved an important milestone by identifying a bacterium that can form *t*10,*c*12-18:2 at fast rates. Future work will identify more bacteria using similar methods.

The essential oil project has been completed, and the colostrum project has finally started successfully after a two-year delay. Ph.D students have been trained to analyze metagenomics data.

**Colorado – Mahesh Nair and Keith Belk**

Several research projects were completed, and multiple grants were secured during the past year. In addition several graduate and undergraduate students were trained during this time period.

**Connecticut – Chaoyu Zhai**

Dr. Zhai’s first federal competitive grant application as primary investigator to NIFA was ranked as outstanding by the *Animal Nutrition, Growth, and Lactation* program and recommended for four-year funding ($650K) starting in August 2024.

**Florida – Tracy Scheffler**

Three manuscripts were published, and others are being prepared for submission or revision.

**Idaho – Phil Bass and Michael Colle**

Combined, Dr. Bass and Dr. Colle have been able to secure external funding for a variety of meat quality related projects this past year.

**Indiana - Brad Kim**

Dr. Kim has been serving as Editor in Chief for Meat and Muscle Biology journal (official journal of American Meat Science Association). Dr. Kim has secured multiple USDA-AFRI grants as a lead-PI and co-PI. We will also work on finalizing our working manuscripts and submit these manuscripts to peer-review journals for publication.

**Kanas-Michael Chao**

The alpha-gal research served as the preliminary data and helped us acquire a major grant to support the effort of cultivating the awareness of alpha-gal syndrome in rural Kansas.

**Kansas - Logan Britton**

Research funding has been secured through a USDA NIFA AFRI grant for three years. The project aims to investigate non-zoonotic disease outbreaks in the United States and their implications on the food and meat supply chain and markets.

**Kentucky - Surendranath Suman**

Extramural funding was secured to conduct research on fresh meat color. Research training was provided to 3 trainees (1 MS student; 1 postdoctoral scholar; 1 lab staff) on evaluation of meat quality, muscle proteome isolation, spectrophotometry, two-dimensional gel electrophoresis, gel image analyses, and analyses of proteomic data.

**Oklahoma - Gretchen Mafi**

Preliminary data collected on effectiveness of new packaging materials and continued work to maximize effectiveness of oxygen scavengers. Continued to secure external funding for meat quality projects.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

The third year of a 3-year A1364 A1364 Novel Foods and Innovative Manufacturing Technologies is currently being conducted. The objective is to evaluate the amino acid alternative curing system’s ability to prevent, reduce or eliminate the growth of Clostridium botulinum using a Clostridium sporogenes surrogate.

For Savell and Gehring, added a new research specialist (Spencer Tindel) to our lab.

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

**Arkansas - Derico Setyabrata**

The research in Arkansas is expected to further understand factors impacting beef quality and mechanism related to discoloration and shelf-life.

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

Our long-term goal is to manipulate the composition of beef fat and make beef more marketable to consumers. This goal directly enhances competitiveness and value of US beef.

The research projects conducted in Dr. Yang’s lab provide valuable insights into antimicrobial resistance in cattle production, serving as a valuable resource for producers, government regulators, and a source of education for consumers.

**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 quality parameters such as color, tenderness, and flavor. In addition, it will help to improve the shelf life and safety of beef products in the U.S.

**Connecticut – Chaoyu Zhai**

The research conducted at the University of Connecticut will improve our understanding of the relation between postmortem proteolysis and meat quality development, which will minimize beef quality defects to ensure the competitiveness and sustainability of US beef production.

**Florida - Tracy Scheffler**

Research conducted at the University of Florida aims to enhance the understanding of early postmortem metabolism and its influence on development of beef quality attributes. A major aim is to identify factors that contribute to variation in proteolysis, particularly in Bos indicus beef, in order to improve product quality and consistency.

**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 at Purdue University 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-Michael Chao**

Dr. Chao’s research at Kansas State University can be roughly categorized into 3 major areas: 1. Understanding the relationship between collagen characteristics and beef texture. 2. Using lipidomics and proteomics to understand the alterations of various beef quality attributes. 3. Improving the values of lower quality beef cuts.

**Kansas - Logan Britton**

The research conducted will help understand U.S. and international consumer behavior toward purchasing and consuming beef products. The results from this project could help stakeholders determine effective strategies, such as pricing, attribute callout, etc. to market products among different consumer segments.

**Kentucky - Surendranath Suman**

The results from this project could be exploited as a post-harvest strategy to improve retail color stability and tenderness of beef biceps femoris and increase the value of this underutilized muscle.

**Oklahoma - Gretchen Mafi**

Research in our lab continues to find methods to improve quality and improve retail color stability to reduce waste and improve efficiency and ultimately value.

**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

It is expected that investigating cofactors required to activate the eNOS enzyme will improve our knowledge and understanding of the chemical, physical, and biological properties of meat products cured via an amino acid alternative curing system this alternative curing method by eliminating the need for direct addition of sodium nitrite. We expect to achieve better understanding of the interconnected biochemical mechanisms contributing to the functionality of the NOS system in post rigor skeletal muscle which will be translatable into actionable compositions and processes with practical application in curing beef products.

From Savell and Gehring, several research projects were completed, and multiple grants have been awarded during the past year. In addition several graduate and undergraduate students were trained during this time period.

**8.** **Publications**

**California - Tim Hackmann, Payam Vahmani, Xiang Yang**

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**Colorado - Mahesh Nair and Keith Belk**

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**Florida – Tracy Scheffler**

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**Kansas- Michael Chao**

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**Texas - Wesley N. Osburn, Jeffrey W. Savell, Kerri B. Gehring**

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