National Program 101 Food Animal Production

National Program Annual Report: FY2018

NP 101 Mission Statement:

Conduct research to improve food animal production efficiency, industry sustainability, animal welfare, product quality and nutritional value while safeguarding animal genetic resources.

Introduction

Food animal agriculture contributes substantially to the U.S. economy. For example, 2017 estimates from the National Agricultural Statistics Service indicate that receipts for cattle and hogs were $83 billion. Aside from the economic value, food animals convert plant materials into animal products that are excellent sources of high biological value protein and contain nutrients like vitamin B12 that are essential for human health. Some food animals convert forages (e.g., grasses, alfalfa), which are unsuitable for human consumption into human food products. These forages are grown on marginal lands that are also unsuitable for human edible crop production. The nutrient density of food animal products fills a vital role in the diets of people around the world as valuable sources of high quality protein, fatty acids, vitamins and minerals.

Despite these clear benefits, food animal production also has some real challenges. As technologies that improve the efficiency of animal production are developed, they must not compromise the health and well-being of food animals, and continued improvement in the well-being of animals in a production setting are needed. In addition to animal well-being concerns, recent reports draw attention to the potential negative impact of food animal production on the environment, including livestock contribution to greenhouse gas generation, contributions of livestock manure and production of feed for livestock to nitrogen and phosphorus contamination of water resulting in algal blooms and degradation of wildlife habitat. Animal wastes can contribute to the prevalence of pathogenic microorganisms in the environment. A subset of this issue is the recent public concern expressed regarding the contribution of food animal production to the development of microorganisms that are resistant to medically important antibiotics. These concerns have led to a ban on the use of antibiotics for growth promotion, and suggestions to restrict their use for disease prevention in animals. Should this ability be restricted, the potential effects on animal well-being would be negative.

Thus, research is needed to improve production efficiency, which would reduce the feed and other environmental resources that are needed for livestock production. Better methods are needed to ensure that raising livestock does not contribute unnecessarily to environmental degradation and contamination. Viable alternatives to antimicrobials in food animal production are also needed, to replace the production efficiencies that these compounds offer to livestock production. This research has two goals: (1) restore the growth improvement that was once

available through the use of antimicrobials and (2) reduce disease incidence, to reduce the need for preventive use of antibiotics.

Given the health benefits of food animal products, dramatic improvements in production efficiencies developed by ARS scientists will help ensure international food security and directly impact human health by reducing the real cost of nutritionally valuable animal products, making animal products more available to those populations most in need.

Studies within this program that identify indicators of animal stress and methods to alleviate stress in the production environment will ensure that as production efficiency improves, so does animal well-being in those production systems. Improvements in food animal production efficiencies will reduce food animal wastes. Reductions in the numbers of breeding animals to maintain production reduce the livestock waste environmental footprint. Ongoing improvements in food animal nutrition and other production efficiencies reduce grain requirements and manure production, and science-based animal waste management strategies provide for the beneficial return of animal waste nutrients to the environment. Improvements in production efficiency will reduce microbial pathogen contamination of the environment and greenhouse gas emissions from livestock production systems and ensure that livestock production remains environmentally sustainable.

Future directions

Animal genomics is a major emphasis of the Food Animal Production National Program. Much of our work has been focused on exploiting the additive genetic component of traits in various livestock species through the use of sophisticated genomic technologies. The best example of this in livestock is in dairy cattle, where the structure of the industry in the United States, along with relatively high individual animal value and long generation intervals, have combined to make genomic selection very successful. Research to add useful traits to dairy selection indices, and fully implement additive genomic selection in other livestock species, will be a focus going forward. But we will also need to begin to go beyond additive genetic selection to incorporate things like the interactions between the environment and the additive genetic component, to be able to best fit animals to their environment. Some work in this area has already been done, but much more is needed. In addition, we also need to go beyond the additive genetic component of inheritance and including components like epigenetics and heterosis in our selection methods. Fifty percent of beef cattle, and nearly all swine and poultry in the United States, are crossbred animals. Crossbreeding is done to take advantage of heterosis, which is the improvement in a trait that results from dominant effects of some gene alleles on other gene alleles at various genetic loci. It should be possible to optimize heterosis using genomic technologies, and research is needed to explore this possibility.

It has been typical of livestock research to consider the animal as a single individual, interacting with its environment, and controlled by its individual genome. However, it has always been true that individual animals all exist as a collection of organisms consisting of the individual and its microbiome, and it is only recently that we have technologies that can address this fact. We have ongoing research in all livestock species to measure the effect of the

microbiome on the function of the individual, and its consequences for health and production efficiency. In the future, we will begin to manipulate the microbiome in beneficial ways, to increase feed efficiency, reduce pathogens, and reduce environmental impacts of livestock. Methane production by cattle falls into this last category. Methane is entirely a product of the cattle microbiome, and not only represents a potent greenhouse gas, but also represents wasted feed energy. Although it is likely to be challenging, our goal is to reduce cattle methane production to zero, adjusting the microbiome so that the feed energy that is lost currently to methane production will be incorporated into products useful to the cow, without decreasing feed intake or growth rates of cattle.

Raising livestock is labor intensive. The production systems in which many of our food animal species are raised continue to grow larger, because the fixed costs of an operation are more economically distributed over larger numbers of animals. Expanding animal numbers and labor expense can combine to reduce the ability to optimally manage every animal. To make the production system work, farmers manage for the average animal, or manage so that a high percentage of the animals can produce optimally. The former results in reduced production of animals needing more resources, and the latter results in significant overapplication of resources to underperforming animals. Improvements in electronic technologies over the last 40 years are now beginning to make it feasible to monitor individual animals for a variety of parameters like body temperature and feed intake that could be exploited to manage individual animals and reduce these inefficiencies. To make this a reality, new sensors, data infrastructure, and decision support tools are needed. Data handling capabilities have been increasing by 10-fold every 5 years over the last 4 decades and will likely continue at this rate, so what is not feasible now may be easy in 20 years. To take full advantage of these changes, research is needed now to develop the methods that will lead to the greatest improvements in livestock management.

Program staffing, funding, and collaborations

During FY 2018, National Program 101 (NP 101) had 82 full-time scientist positions working at 13 locations across the United States. Twenty-one appropriated research projects in NP 101 were approved through the ARS Office of Scientific Quality Review this past year. In FY 2018, appropriated funding for NP101 was $57 million; and total funding was $59 million including extramural awards. Three new inventions were disclosed and 1 patent awarded. Additional technology transfer included 9 Material Transfer Agreements and 3 Material Transfer Research Agreements.

In 2018 NP 101 scientists participated in research collaborations with scientists in:

Australia, Austria, Belgium, Brazil, Canada, China, Denmark, England, Finland, France, Germany, Ireland, Israel, Italy, Macedonia, Malawi, Mexico, Netherlands, New Zealand, Nigeria, Norway, Romania, South Africa, Spain, Sweden, Switzerland, Turkey, Uganda, United Kingdom and Uruguay.

New scientists in NP 101 2018:

Dr. Brittany Harlow, Post-Doctoral Fellow, Forage-Animal Production Research, Lexington, Kentucky.

Dr. Tom Murphy, Research Geneticist, Genetics, Breeding and Animal Health Research Unit, Clay Center, Nebraska.

The following scientists retired in 2018:

Dr. Glen Aiken, Research Leader, Forage-Animal Production Research, Lexington, Kentucky.

Dr. Melvin E. Tooker, Animal Scientist, Animal Genomics and Improvement Laboratory, Beltsville, Maryland.

The distinguished record of these scientists is recognized world-wide and they will be missed at NP 101.

The following scientists in NP 101 received prominent awards in 2018:

Dr. John B. Cole, Beltsville, Maryland, received the Outstanding Service Award from the National Dairy Herd Information Association (DHIA) at the 53rd National DHIA Annual Meeting in San Antonio, Texas, on March 6-8, 2018.

Dr. Mary Beth Hall, received the Federal Laboratory Consortium Midwest Regional Award for Excellence in Technology Transfer for Starch Analysis and Application for Animal Feeds and Pet Foods.

Dr. Mary Beth Hall, received the American Dairy Science Association Nutrition Professionals Inc. Applied Dairy Nutrition Award, 2018.

Dr. Prasanna H. Gowda, received the 2018 Laj Ahuja Agricultural Systems Award and Soil Science Society of America (SSSA) Fellow Award at the 2018-2019 International Soils Meeting: Soils Across Latitudes in San Diego, California.

Major Accomplishments in 2018

This section summarizes significant research results for Fiscal Year 2018 that addressed specific components and anticipated products of the 2018– 2022 action plan for the Food Animal Production National Program. Within each section, selected accomplishments of individual research projects in NP 101 are presented. These accomplishments are highlighted here due to their significance and alignment to action plan components and anticipated products. They are a subset of accomplishments within the program. To see all the accomplishments for each project within the program, please visit the USDA ARS National Program 101 website:

https://www.ars.usda.gov/animal-production-and-protection/food-animal-production/

Many of the projects are the result of significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA - ARS research and allow scientists to tackle larger problems that could not be addressed without such collaborations. Improved food animal production efficiencies decrease the real cost of animal products, making the products more available to people worldwide, and decreasing the environmental footprint of animal production.

Accomplishments are listed below that correspond to each of the Components and Problem Statements of the *Action Plan National Program 101 Food Animal Production 2018 – 2022*. Following each accomplishment, the corresponding anticipated product from the NP101 Action plan is indicated.

Component 1: Improving Production and Production Efficiencies and Enhancing Animal Well-Being across Diverse Food Animal Production Systems

Problem Statement 1A: Improving the Efficiency of Growth and Nutrient Utilization

Rumen microbiome community profiles are associated with feed efficiency.

Feed costs are estimated to be 60% of the total cost of raising cattle. Improvements in feed efficiency, and subsequent reduction in manure and other wastes generated, will reduce feed inputs and environmental impact. In cattle, microbes in the rumen degrade forages into metabolites that can be used by the cow for growth. However, how much the rumen microbial composition affects feed efficiency in beef cattle is unclear. ARS researchers at Clay Center, Nebraska, and collaborators at the University of Nebraska characterized the rumen microbial communities (microbiomes) of two large animal cohorts (125 heifers and 122 steers) to identify specific bacterial members associated with feed efficiency traits in beef cattle. A rumen sample was obtained from each animal for bacterial community profiling. This innovative study showed that the species and abundance of the microbes present in the rumen account for 20% of the variation in feed efficiency. These data demonstrate the magnitude of the effect of microbial composition on feed efficiency and will inform future strategies to alter rumen microbial communities to improve feed efficiency in cattle.

Anticipated product: Comprehensive characterization of digestive system microflora in livestock species, including the organisms present and their prevalence, and identification of those species that are correlated with improved performance, nutrient utilization efficiency, and reduced environmental impact.

Demonstrating the impact of eliminating animal agriculture.

Farmed animals provide essential nutrients in human diets, but also produce greenhouse gases and use food resources that could potentially be used by people. ARS scientists in Madison, Wisconsin, in collaboration with scientists at Virginia Tech, Blacksburg Virginia, evaluated the hypothetical impact of eliminating farmed animals from U.S. agriculture and converting to a plant-only system. Without animals, substantially more food could be produced. However, with the U.S. population reliant on the crops grown in the United States and currently imported, a

plants-only diet without supplementation would require more calories to meet some required nutrients, and have more nutrient deficiencies, than a diet containing animal products. Nutrients such as vitamin B12 and certain fatty acids are only or largely provided by animal-derived foods. Thus, the dietary requirements for nutrients lacking or in low concentrations in plants would not be met in a consumable diet. Greenhouse gas emissions by the U.S. agriculture system declined 28%, but the total contribution of agriculture to national greenhouse gas production is only 9%, resulting in a net decline in greenhouse gas of only 2.6% of current U.S. total production. The need to produce synthetic fertilizer to replace animal manures, and other changes in the system partially counterbalanced the removal of animals. The study showed that making changes to a complex system gives rise to unexpected impacts. Recommendations for changes in our agricultural system requires integration of multiple disciplines to adequately evaluate potential impacts.

Anticipated product: Management strategies and programs for improving grazing-land health and sustainability and conservation/return of natural ecosystem services.

Older, low-value hops could be used as a natural, growth-promoting feed additive for cattle.

Inefficient protein metabolism by cattle results in higher costs to the producer to provide sufficient protein to maintain growth, and increased nitrogen contamination (ammonia, nitric oxide) of the environment, which can contribute to algal blooms and other negative consequences. A type of bacteria in the gastrointestinal tracts of cattle and other ruminants causes protein to be degraded and therefore unavailable to the animal, which contributes to environmental contamination (ammonia) and causes the animals to gain less weight. These bacteria can be controlled with a natural compound in the hops plant, but hops are generally too expensive to use in cattle feed. However, there is currently a hops surplus and old hops go unused. ARS researchers in Lexington, Kentucky, discovered that even after 5 years of storage, hops could control the wasteful bacteria in cattle. When the ammonia-producing bacteria are controlled, the animals gain weight more rapidly and efficiently. This result indicates that hops that are no longer useful for beer making are still a valuable byproduct feed additive for improving nitrogen usage in cattle.

Anticipated product: Identification and development of alternatives to antibiotics to decrease pathogens and improve growth performance in livestock and poultry.

New dietary starch method to improve information for consumers.

Accurate information on feed composition is essential for formulating healthy diets for cows and for informing consumers about the nutritional qualities of the animal feeds and pet foods they purchase. Starch is a carbohydrate in feeds that can provide energy to meet an animal's requirements in properly balanced diets, but can cause health disorders if mis-fed. An ARS animal scientist in Madison, Wisconsin, developed a new assay to determine dietary starch concentration, and then tested it in a collaborative study with fourteen state, commercial, and research feed analysis laboratories. The starch method has been approved by the Association of Official Analytical Chemists International (AOAC Official Method 2014.10). The new dietary

starch method received final approval for use in nutritional labeling of animal feeds and pet foods and replaces a previous method that was no longer valid. In 2017, commercial feed analysis laboratories ran dietary starch analyses valued at $1.3 million on over 1.4 million samples. This research provided pet food manufacturers and animal agriculture with an assay to accurately determine the amount of starch in their feeds.

Anticipated product: Development of refined methodology allowing precise real time nutrient evaluation of forages including improved sampling procedures.

Problem Statement 1B: Reducing Reproductive Efficiency

Genetic resources for responsible lamb production.

Number of lambs born per ewe is an important factor influencing the efficiency of sheep production, but this is reliant on sufficient feed resources, which may not always be available on western rangelands. To provide genetic resources to increase lamb production, ARS researchers at Clay Center, Nebraska, evaluated reciprocal crosses between Romanov (>3 lambs per parity) and Rambouillet (~1 lamb per parity) breeds (Romanov male, Rambouillet female versus Rambouillet male, Romanov female). Crossbred ewes sired by Romanov or Rambouillet breeds were roughly equivalent, providing nearly 2 lambs per parity over 5 parities. However, ARS researchers in Dubois, Idaho, in collaboration with Virginia Tech University in Blacksburg, Virginia, tested the limits of lamb production per ewe in the harsh conditions of the U.S. mountainous regions. They established that 2.2 lambs per ewe each year is optimal and going beyond this is of limited value due to the high loss of lambs in ewes rearing triplets. These findings indicate that Romanov x Rambouillet crossbred ewes will be useful in increasing the number of lambs per ewe, with lamb production that is consistent with the harsh environments in the western mountains.

Anticipated products: Data to facilitate appropriate matching of management and production resources with genetic potential of breeding animals with the goal of increasing reproductive rate.

Colostrum deficiency in piglets affects the response of the uterus to pregnancy in adulthood.

The first milk that a pig consumes from its mother is called colostrum. Colostrum is known to contain many hormones and other factors that impact development of multiple tissues and organ systems. Previous research from ARS showed that if female piglets do not get adequate colostrum at birth, their reproductive capacity is diminished. To determine the mechanism behind this reduced fertility, ARS scientists at Clay Center, Nebraska, in collaboration with scientists from Auburn and Rutgers Universities, identified colostrum deficient female piglets and their normal littermates at birth. The piglets were then allowed to mature, and uterine function was measured by comprehensively measuring the genes expressed by the uterus during early pregnancy. They discovered over 1,100 genes that were expressed differently in females that had consumed adequate amounts of colostrum as piglets compared with those that did not. Many of the genes that differed in expression were involved in immunity and in receptivity of

the uterus to the fetus. This research strongly supports the concept that colostrum deficiency on the first day of life alters the development of the uterus with lasting effects on subsequent uterine function during pregnancy as an adult, leading to impaired fertility and litter size. This research reinforces that managing colostrum consumption of newborn females is important for full productivity and profitability of pork production.

Anticipated product: Strategies that optimize male and female contributions to reproductive efficiency.

Cows that demonstrate behavioral estrus during an estrous synchronization protocol are more fertile than cows that do not demonstrate behavioral estrus.

In order to increase the efficiency of genetic selection in beef cattle, cow-calf producers use protocols that synchronize the reproductive cycles of cows so they can be efficiently inseminated by high genetic merit bulls using artificial insemination. However, these protocols often do not result in the same fertility as that obtained when cows cycle without intervention, and the reasons for the reduced fertility is not known. ARS researchers at Clay Center, Nebraska, in collaboration with South Dakota State University, tested the hypothesis that early (day 16 of pregnancy) embryonic mortality was greater in cows that did not demonstrate behavioral estrus after an estrous synchronization protocol followed by timed artificial insemination. Results of this study showed that there was no difference in embryonic survival on day 16 of pregnancy between cows that demonstrated behavioral estrus and cows that did not. In addition, there was no difference in uterine protein or glucose concentrations, measures of uterine function, between cows that did or did not demonstrate behavioral estrus. Serum estradiol concentrations were three times greater in cows that demonstrated behavioral estrus. While there was no difference in embryonic development on day 16, pregnancy rate at day 35 was decreased in cows that did not demonstrate behavioral estrus. These results eliminate aspects of pregnancy up to day 16 of pregnancy as contributing to the reduced fertility, and suggest that estradiol at estrus may influence embryo-uterine interactions such as implantation, needed for embryo survival between day 16 and 35 of pregnancy. Increasing the number of cows expressing estrus after estrus synchronization protocols will lead to better fertility and greater adoption of the technology by cow-calf producers.

Anticipated product: Strategies that optimize male and female contributions to reproductive efficiency.

Problem Statement 1C: Enhancing Animal Well-Being and Reducing Stress

Developed a prediction equation to estimate the core body temperature of chickens from facial skin temperature.

Heat stress in poultry reduces feed intake and rate of growth, and can sometimes result in bird death. Monitoring heat stress in poultry relies on accurate measurement of core body temperature, however, current methods require physical restraint of the birds, which can cause the body temperature to increase and provide inaccurate measurements. ARS researchers in West Lafayette, Indiana, developed a prediction equation to estimate core body temperature from

facial skin temperature in chickens. The equation utilizes the inputs of bird sex, time, and facial skin temperature, which is collected using a thermal camera. This equation is expected to help researchers collect more accurate body temperature data in experiments that explore factors contributing to heat stress, without having to rely on handling animals and manually taking temperatures. In addition, it may have practical applications for poultry producers to determine when their birds are suffering from heat stress or whether their flocks have a fever or illness.

Anticipated product: Improved precision animal management/production systems to better identify compromised animal well-being for individual and groups of animals in conventional production systems.

Banamine transdermal reduces vaginal temperature when administered at time of Bovine Respiratory Disease challenge.

The beef cattle industry continues to utilize significant resources to combat Bovine Respiratory Disease (BRD), with treatment costs estimated to exceed $30 per head. Over 55% of feedlots use a non-steroidal anti-inflammatory drug, or NSAID to reduce the fever associated with BRD. Utilizing a dual-challenge BRD model, ARS scientists in Lubbock, Texas, worked with an industry partner to determine if administering a topical NSAID (as opposed to oral or intravenous administration) would alter the febrile response when administered at various time points prior to the challenge. Results from this study indicated that fever was reduced in calves when the topical NSAID was administered at the time of viral or bacterial challenge, but not 3 days prior to the challenge. Thus, this new product can be a useful tool for producers to apply to calves suffering from BRD induced fever. Its simple method of application, compared to injectable or oral products, will likely increase the appropriate use of the product, reduce stress on the animal associated with application, reduce the potential for residue contamination, and ultimately improve animal comfort and well-being.

Anticipated product: Development of specific management strategies (e.g., time of animal processing and vaccination, use of non-antibiotic supplements, etc.) targeted at reducing animal stress and improving immunity.

Water supply rates for recirculating evaporative cooling systems.

Heat stress in poultry reduces feed intake and rate of growth, and can sometimes result in bird death. One way to manage heat stress and air quality within poultry houses is increased ventilation. Newly constructed poultry houses use increased ventilation rates to further improve cooling, but this has resulted in increased water usage. Recent droughts and increasing municipal water costs have highlighted the need for proper planning and design of water supply systems to ensure peak demand is met. Few estimates of water use are available for recirculating evaporative cooling pad and fan systems, and design guidance has emphasized planning for extreme temperatures, resulting in excessive capacity recommendations and overuse of water. Historical weather data from 732 weather stations across the continental United States was used to estimate the water use rate for differing levels of ventilation system efficiency. Results of this analysis showed that the estimated water supply rates for proper ventilation in areas with dense poultry production including the Southeast, Delmarva Peninsula, and Iowa were approximately

25% lower than current recommendations. These results will reduce the capital and operating costs of installing and running evaporative cooling ventilation systems for new poultry houses.

Anticipated product: Species-specific, cost-effective strategies to mitigate animal stress and improve animal well-being and longevity in conventional production systems.

Component 2: Understanding, Improving, and Effectively Using Animal Genetic and Genomic Resources

Problem Statement 2A: Develop Bioinformatic and other Required Capacities for Research in Genomics and Metagenomics.

None.

Problem Statement 2B: Characterize Functional Genomic Pathways and their Interactions.

Low expression or mutations in the Ikaros gene drive Marek's disease virus-induced transformation in chicken.

Marek's disease is a cancer-causing virus that afflicts poultry, and the worldwide cost of the disease is estimated to be greater than $1 billion annually. Understanding the biological mechanism for Marek's disease virus (MDV) to induce tumors is critical for future control using vaccines or genetic resistance. ARS researchers at East Lansing, Michigan, in collaboration with investigators at Purdue University in West Lafayette, Indiana, and University of California in Davis, California, sequenced DNA and RNA from tumors to identify mutations that are associated with tumor formation. It was determined that most tumors had either low expression or mutations in key regions of the Ikaros gene, which is the master regulator for immune cell development and is known to be associated with tumor suppression. This information will aid future efforts to improve Marek's disease vaccines and to select birds for superior resistance to Marek's disease. Reduced Marek's Disease will improve the health and well-being of poultry, thereby improving production efficiency and reducing poultry wastes.

Anticipated product: Information relating the function and regulation of individual genes and their interaction with environmental and epigenetic effects contributing to economically important traits in food animals.

Problem Statement 2C: Preserve, Characterize and Curate Food Animal Genetic Resources.

None.

Problem Statement 2D: Develop and Implement Genetic Improvement Programs using Genomic Tools.

Lifetime merit indexes for dairy cattle that include health traits.

Genetic economic indexes for dairy cattle are used to improve the efficiency of the national population by ranking animals based on their combined genetic merit for economically important

traits, but health traits had not been included because they were not available. In collaboration with the Council on Dairy Cattle Breeding (CDCB), ARS researchers in Beltsville, Maryland, developed genetic evaluations for disease resistance to the six most common, costly health events for U.S. dairy cattle: clinical mastitis, ketosis (metabolic carbohydrate disorder), retained placenta, metritis (uterine inflammation), displacement of the fourth stomach, and milk fever (acute illness caused by calcium deficiency). Subsequently, these traits were added to lifetime merit indexes. Economic emphasis was added for direct expenses (such as clinical mastitis treatment) while at the same time reducing emphasis on previously correlated traits (such as somatic cell score). The updated indices were adopted and officially released to the dairy industry by the CDBC in August 2018. Selection using the new indexes will produce cows with genes that keep them healthy and more profitable than cows with health conditions that require extra farm labor, veterinary treatment, and medicine. If all breeders select on lifetime merit, the original index was worth $250 million per year, and addition of these health traits provides an increase of $1.4 million/year.

Anticipated product: Genetic prediction tools for traits in food animals related to health, production efficiencies, adaptability, and functionality in varied domestic and international production systems.

Genetic evaluation of beef cattle breed differences in mature weight.

The cow-calf sector of the beef production system produces calves that are then raised to produce beef. With increased selection for faster growth rates in the beef cattle industry, cow mature weight has also increased substantially because some of the same genes contribute to both traits. The increase in mature cow weight has resulted in higher maintenance energy requirements for the national cow herd, and thus higher demand for feed resources. However, heavier cows do not necessarily produce more calves or weaned calf weight over their lifetime. Understanding the genetic relationships between cow mature weight and lifetime production can enable appropriate consideration of weight and productivity in selection decisions. ARS researchers, using data from the germplasm evaluation program in Clay Center, Nebraska, estimated differences in mature weight for 18 beef cattle breeds, and correlations between cow weight and cumulative number of calves and calf weight weaned. They found that mature weight differed among breeds by 125 lbs. This would translate to 2 lbs less feed per day between breeds and is a substantial cost savings over the lifetime of the cow. The genetic relationships between cow weight and productivity were weakly negative. The weak genetic relationship means that the two traits can be selected independently without having a large effect on the other. Thus, these two traits can be incorporated with economic values and genetic relationships among other traits to select cows based on overall economic value. These results will help producers make breeding decisions when choosing sires in commercial cattle production.

Anticipated product: Improved genetic evaluation and genetic selection programs for the food animal industries.

Problem Statement 2E: Improved Techniques for Genetic Modification and Genetic Engineering of Food Animals.

None.

Component 3: Measuring and Enhancing Product Quality and Enhancing the Healthfulness of Meat Animal Products

Problem Statement 3A: Systems to Improve Product Quality and Reduce Variation in Meat Animal Products.

Genetic factors are associated with myoglobin concentration of porcine longissimus muscle.

A recent increase in light colored regions in ham, resulting in reduced consumer acceptance of the product, is a growing concern to the pork industry. Consumers prefer a redder-colored lean which is consistent throughout the product, especially consumers in Asian markets. Myoglobin is the protein in pork that is primarily responsible for the red color. Myoglobin concentrations also vary with muscle fiber type, being greater in some than in others. ARS scientists at Clay Center, Nebraska, conducted a genome-wide analysis to identify genetic markers associated with myoglobin content in pork. Results indicate there are at least two major regions of the genome affecting myoglobin concentration as well as several other regions with minor effects. The results further indicated that a primary factor associated with myoglobin concentration in the pork product is the percentage of the different fiber types present in the meat. This finding contradicts a commonly held belief that fiber type content within muscles is similar across animals. This knowledge will inform selection methods to improve overall pork color and color consistency throughout the product, and subsequent consumer acceptance of pork products.

Anticipated product: Better understanding of the biological mechanisms that control and influence meat product quality, color stability and consistency.

Identified a gene alteration that reduces dark-cutting lean beef.

Abnormally dark red “dark cutting” beef results in reduced consumer acceptance of beef products and results in an annual loss of potential revenue in excess of $70 million. Dark cutting beef is caused by depletion of the animal’s muscle energy stores. However, it was not understood why a group of cattle could all be exposed to identical conditions, but some animals will deplete their muscle energy stores and exhibit the dark red color, while others exhibit a “normal” bright cherry-red color. ARS scientists at Clay Center, Nebraska, discovered a naturally-occurring genetic mutation in cattle that decreases the susceptibility of cattle to the dark-cutting condition. The mutation discovered in this work helps to account for much of the unexplained variation in susceptibility to dark cutting. The DNA sequence associated with susceptibility to dark colored meat is similar across all mammals, and the mutation associated with bright red lean meat appears to have originated in British breeds of cattle. The frequency of the bright red colored meat mutation is variable in different breeds and very low in Holstein steers, which are the primary source of dairy beef. Selection for the favorable allele in this gene should significantly reduce the costly occurrence of dark red colored beef, thereby reducing losses associated with customer refusal to purchase beef with this abnormal color

Anticipated product: Better understanding of the biological mechanisms that control and influence meat product quality, color stability and consistency.

Salmonella migration out of gastrointestinal tract can potentially contaminate ground meat products.

Significant progress has been made over the past 20 years to reduce foodborne pathogens such as *Escherichia coli* from entering the food chain through contaminated meat. However, Salmonella continues to be a problem in cattle, with no reduction in the number of incidences reported for meat contamination by Salmonella. To identify potential sources of Salmonella contamination in cattle, scientists with ARS in Lubbock, Texas, collaborated with Auburn University to determine the potential for Salmonella to move outside the digestive system into lymph nodes and joint fluid, and subsequently contaminate ground meat products. Dairy calves were challenged with Salmonella, and after 5 days various tissues and lymph nodes were collected from one half of the carcass, while the other half was refrigerated for 2 days and then ground. Researchers found that Salmonella was found outside the digestive system in various musculoskeletal lymph nodes. Further, Salmonella was found in some of the ground beef samples. Because Salmonella is found inside these peripheral, yet internalized tissues, it is not eradicated by traditional methods such as topical washes and sprays used to reduce bacterial contamination such as E. coli on beef carcasses, and thus may pose a risk of contaminating various cuts of meat and ground meat products.

Anticipated product: Identification of supply chain critical control points which can be targeted for increasing product quality.

Problem Statement 3B: Improving the Healthfulness and Nutritional Value of Meat Products from Traditional and Non-Traditional Production Systems.

None.

NP101 Projects contributing accomplishments to this report:

PROJECT NO.	PROJECT TITLE	CITY	STATE
2056-31610-006-00D	Enhancing Sheep Enterprises and Developing Rangeland Management Strategies to Improve Rangeland Health and Conserve Ecology	Dubois	ID
3040-31000-095-00D	Improving Lifetime Productivity in Swine	Clay Center	NE
3040-31000-096-00D	Applying Developmental Programming to Improve Production Efficiency in Beef Cattle	Clay Center	NE
3040-31000-097-00D	Improve Nutrient Management and Efficiency of Beef Cattle and Swine	Clay Center	NE
3040-31000-099-00D	Identifying Genomic Solutions to Improve Efficiency of Swine Production	Clay Center	NE
3040-31000-100-00D	Developing a Systems Biology Approach to Enhance Efficiency and Sustainability of Beef and Lamb Production	Clay Center	NE
3040-31430-006-00D	Strategies to Optimize Meat Quality and Composition of Red Meat Animals	Clay Center	NE
3096-32630-008-00D	Nutritional Intervention and Management Strategies to Reduce Stress and Improve Health and Well-being in Cattle and Swine	Lubbock	TX
5020-32000-013-00D	Protecting the Welfare of Food Producing Animals	West Lafayette	IN
5042-32630-003-00D	Optimizing the Biology of the Animal-Plant Interface for Improved Sustainability of Forage-Based Animal Enterprises	Lexington	KY
5090-31000-026-00D	Investigating Microbial, Digestive, and Animal Factors to Increase Dairy Cow Performance and Nutrient Use Efficiency	Madison	WI
6040-31320-010-00D	Enhancing Genetic Resistance to Marek's Disease in Poultry	Athens	GA
6064-32630-008-00D	Enhancing Sustainability and Production Efficiency through Improved Management and Housing Design in Commercial Broilers	Mississippi St	MI
8042-31000-002-00D	Improving Dairy Animals by Increasing Accuracy of Genomic Prediction, Evaluating New Traits, and Redefining Selection Goals	Beltsville	MD