**Multistate Research Activity Accomplishments Report**

**Project/Activity Number**: NC1184

**Project/Activity Title**: Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation

**Period Covered**: 10/01/2021-9/30/2022

**Date of This Report**: 11/28/21

**Annual Meeting Date(s)**: 09/29-09/30/2022

**Station Participants**:

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**Brief Summary of Minutes of Annual Meeting:**

The annual NC1184 technical committee meeting was held mainly in-person, but also had several members attended virtually on Sept 29 and 30, 2022. The meeting was hosted by Dr. Wei Guo of the Department of Animal Science, University of Wisconsin. On Sept 29, the group was welcomed by Dr. Kent Weigel, Chair of the Department of Animal & Dairy Sciences, who shared information about the area, college, and department. The group then began with oral station reports.

On Sept 30 morning, the group had a conference call with Dr. Mark Mirando, USDA/NIFA, who outlined current funding opportunities, the USDA NIFA budget, statistics on the number of proposals submitted annually and funding rates, and the new grant opportunity with NIH: Dual Purpose with Dual Benefit. After the call with Dr. Mirando, the groups continued with station reports.

The group voted to hold the 2024 meeting at the Louisiana State University, to be hosted by Dr. Xing Fu.

The 2023 meeting will be held at the Washington State University, to be hosted by Dr. Min Du.

**Accomplishments:**

**Objective 1: Characterize the signal transduction pathway that regulates skeletal muscle growth and metabolism including the influence of endogenous growth factors and various production practices.**

**California Station:**

1. Using transcriptomic profiling and bioinformatics analyses of pathways active during broiler growth in birds with normal breast muscle and severe white striping, the group was able to pinpoint pathways for intervention of white striping. They are currently running trials with feed ingredients to mitigate white striping severity.

**Connecticut Station:**

1. In their sheep pregnancy study, PCR arrays testing the effects of F0 maternal diet on inflammatory factors on F1 offspring have been completed, demonstrating sex by treatment and treatment effects on gene expression, including GATA3 and Toll-like receptor 1. Samples are being collected for F2 offspring.
2. LPS challenge completed in 7-month-old F2 offspring of over-, restricted-, and control fed F0 ewes. Cytokine assays in progress as of fall 2022.
3. LD samples from 10-month-old F2 male offspring of over-, restricted- and control-fed F0 ewes approximately 75% collected.
4. Anti-oxidant status (superoxide dismutase) and oxidative markers (malondialdehyde) have been measured in LD samples from F1 offspring of control- over-, restricted-fed F0 ewes. Sample collection from F2 offspring and analysis of additional anti-oxidants and markers of oxidative stress is in progress.

**Hawaii Station:**

1. Hawaii station continued to produce recombinant proteins suppressing the bioactivity of myostatin (MSTN), a negative regulator of muscle growth.
2. MSTN propeptide (MSTNpro) is a strong negative regulator of MSTN, thus a study was developed to produce recombinant mouse and human MSTNpro (mMSTNpro and hMSTNpro).
3. mMSTNpro and hMSTNpro cDNAs were synthesized and ligated into the pcDNA3.1+ plasmid (mMSTNpro-pcDNA-3.1+ and hMSTNpro-pcDNA3.1+) commercially. A large scale of mMSTNpro-pcDNA-3.1+ and hMSTNpro-pcDNA3.1+ plasmids were produced from transformed *E. coli* cells.
4. The Expi293™ Expression System (ThermoFisher Scientific, MA, USA) was used to express mMSTNpro and hMSTNpro proteins following the protocol described by the manufacturer.
5. The expressions of the mMSTNpro and hMSTNpro proteins were confirmed by SDS-PAGE and Western blot analyses.
6. mMSTNpro and hMSTNpro were purified by Ni-NTA affinity chromatography with a reasonable yield (about 7 mg/L culture).
7. The two proteins showed MSTN inhibitory capacity comparable to that of the commercially available MSTNpro when their bioactivities were measured using the (CAGA)12-luciferase reporter gene assay. The proteins will be useful in various studies that require MSTN inhibition *in vitro or in vivo*.

**Kansas Station:**

1. The protein kinase NUAK (mammalian ARK5) coordinates with the insulin signaling pathway to control the serial addition of sarcomeres.
2. Dysregulation of calcium release may contribute to Woody Breast myopathy present in broiler breast meat.

**Louisiana Station:**

1. A comprehensive analysis of bovine skeletal muscle gene expression at the single-cell level, identifying muscle-resident and infiltrating cell types and their heterogeneities and differentiation processes.
2. The discovery of multiple fibro/adipogenic progenitor (FAP) subpopulations and their developmental order.
3. The identification of differential cell fate programming between Wagyu and Brahman FAPs.
4. The finding that *CFD* expression – upregulated in adipogenic FAPs and Wagyu FAPs – is a reliable predictor (biomarker) of future intramuscular fat content and the transcriptional regulation of CFD.
5. The identification of *CFD* expression as a marker of intramuscular adipogenesis in aged people and Duchenne muscular dystrophy patients – but not mouse models of intramuscular adipogenesis and the identification of elevated CFD expression in the adipogenic FAP subpopulation of non-human primates.
6. The identification of transcriptional regulation of *CFD* expression by NAB2 and ERG1.
7. The validation of Postn/POSTN expression – upregulated in fibrogenic and Brahman FAPs – as a specific and robust marker for FAP fibrogenic programming across species.

**New Jersey Station:**

1. Studying signaling pathways in mice deleted for Bckdk, a gene important in regulating branched chain amino acid metabolism in skeletal muscle.

**Texas Station:**

1. Trained undergraduate and graduate researchers in methods for characterizing development of muscle quality traits and evaluating muscle and intramuscular fat content in harvested muscle samples.
2. Developed new methods for evaluating intramuscular fat concentration in milligram quantities of skeletal muscle.
3. Developed new methods to quantify cytokine concentrations at pg/mL levels in equine and bovine samples
4. Discovered a novel role of dietary selenium on skeletal muscle mitochondrial capacities
5. Mitochondrial phenotypes in young Brahman steers were found to be related to their product quality at harvest but this relationship was not apparent in young Angus steers. These results may be used to inform management practices in Brahman steers aimed at improving product quality.
6. Discovered that Brahman cattle stressed in utero by transportation had greater circulating, pro-inflammatory cytokines than their non-stressed counterparts, which may impact responsiveness to stressors later in life.

**Utah Station:**

1. Gained important insights into how mitochondria contribute to postmortem proteolysis and tenderization of meat.
2. Described molecular mechanisms contributing to enhanced meat tenderness following ultrasonication.
3. Identified potential protein biomarkers associated with meat tenderness through proteomic analysis.
4. Gained a deeper understanding of how cattle of different breed types respond to anabolic implants.
5. Learned more about the mechanism through which anabolic implants improve growth of skeletal muscle in beef cattle.
6. Deepened our understanding of the relationship between trace minerals and the hormones found in anabolic implants and their relationship to skeletal muscle growth.

**Virginia Station:**

1. Detailing the actions of growth factors on equine satellite cell activation in vitro and in vivo following a hypertrophic signal

**Washington Station:**

1. Continuing to define the impacts of maternal nutrition on embryonic and fetal development, and found that maternal obesity inhibits embryonic muscle development, which involves inhibition of thyroid hormone signaling.
2. Studying the roles of AMPK and TGFb in extracellular matrix deposition and fibrosis during muscle regeneration.

**Wisconsin Station:**

1. RBM20-titin axis regulates fast muscle hypertrophy and slow muscle atrophy and RBM20 knockout leads to decreased body weight with aging
2. RBM20 is a new factor that regulates myogenesis and knockout of RBM20 postpones muscle regeneration and maturation.

**Objective 2: Characterize the cellular and molecular basis of myogenesis**

**Indiana Station:**

1. Used cell and molecular biology techniques, animal models and production animals to study molecular regulation of muscle growth and metabolism.
2. Developed new research techniques and methods; used state-of-art single cell RNA sequencing to illustrate cell dynamics and reveal novel subpopulations in murine and porcine skeletal muscles.

**Iowa Station:**

1. In collaboration with Dr. Rhoads (Virginia Tech) and Dr. White (TAMU), the Iowa Station has been working to better understand metabolic dysregulation and muscle injury caused by heat stress. Their efforts to explore the role of a mitochondrially-targeted antioxidant recently concluded with mixed results. In one investigation they discovered some production aspects were improved via this intervention; however, they were not able to repeat this in another or in cell culture. This experiment also allowed then to explore the role of heat stress on the heart as they are considering more holistically the impact of heat stress on an organism with the underlying premise that total health needs to be optimized to maximize animal production efficiency.
2. In conjunction with Dr. Rhoads (Virginia Tech) and Dr. White (TAMU), they have made further inroads into the role of biological sex on the muscular response to heat stress. They are continuing to work through analysis of phenotypical outcomes and biochemical and histological measures.
3. They have expanded a collaboration with an expert in proteomics technologies to more holistically capture changes to the proteome caused by muscle injury to include investigation of sex effects of heat stress.

**Kansas Station:**

1. The abundance of pivotal metabolic enzymes, including LDH, G6PDH, and GOT2, fluctuate in porcine muscle from 14 to 160 days of age. Muscle-specific changes in pyruvate derived labeling patterns of TCA intermediates occur between 85 and 120 days of age in growing pigs.
2. Overall energy production (mitochondrial respiratory chain and ATP synthase complexes) is up regulated during developmental muscle atrophy.

**Ohio Station:**

In collaboration with the Michigan Station, the Ohio Station studied the effect of thermal stress on pectoralis major satellite sells, including:

1. Poultry selected for growth have an inefficient thermoregulatory system and are more sensitive to temperature extremes
2. Cold temperatures inhibited rates of proliferation and differentiation of p. major muscle satellite cells.
3. If the hot temperature was applied during p. major muscle satellite cell proliferation, it resulted in greater stimulatory effects on differentiation than if the hot temperature was administered only during differentiation. Similarly, cold temperature administered during proliferation tended to have more suppressive effects on differentiation than if the cold temperature was applied only during differentiation.
4. Growth selection has resulted in the p. major muscle satellite cells from the faster-growing commercial turkeys to be more sensitive to hot temperature during both proliferation and differentiation. The increased rates of proliferation and differentiation in vivo may result in a greater potential to accrete more satellite cells to drive myofiber hypertrophy, which could impact post-hatch breast muscle growth and structure.
5. Adipogenic gene expression is more responsive to thermal challenge in proliferating satellite cells than in differentiating satellite cells, and that growth-selection has increased temperature sensitivity of satellite cells.
6. Thermal stress can affect breast muscle hypertrophic potential by changing satellite cell proliferation and differentiation, in part, through the mTOR/S6K pathway in a growth-dependent manner.
7. Thermal stress affects poultry breast muscle growth potential and protein to fat ratio by altering function and fate of satellite cells through the Fzd7-mediated Wnt/PCP pathway in a growth-dependent manner.

**North Carolina Station:**

1. It was demonstrated that Methionine was not necessary to support avian satellite cell proliferation, but it was necessary for myotube hypertrophy.

**Objective 3: Characterize mechanism of protein assembly and degradation in skeletal muscle**

**Arkansas:**

1. Finished one study examining the effects of aging on ability of tRNA in muscle to recruit amino acids.

**Kansas Station:**

1. Proteasome and peptidase proteins are selectively upregulated during developmental muscle atrophy. Thin filament-associated proteins are preferentially degraded before thick filament proteins.
2. A balance between proteolytic degradation and collagen content account for tenderness properties in beef products.

**New Jersey Station:**

1. Studying the regulation of muscle protein synthesis and degradation in mice deleted for *Bckdk*, a gene important in regulating branched chain amino acid metabolism.

**Texas Station:**

1. Presented research findings related to meat quality traits to lay audience at large extension event (Texas A&M Beef Cattle Shortcourse)
2. Published research findings related to proteolysis of skeletal muscle and other meat quality traits – in peer reviewed journals.
3. Graduate researcher training.
4. Presented research findings and applications for meat quality international breeder association (World Zebu Congress, Bolivia).

**Impact Statements:**

1. The Connecticut Station reported that F0 maternal diet impacts F1 offspring basal inflammatory profile in a sex and diet dependent manner. F1 offspring of F0 over-fed ewes had increased tenderness relative to offspring of control- and restricted-fed ewes. F1 offspring of over- and restricted-fed ewes have reduced SOD.

1. In collaboration with Michigan Station, the Ohio Station reported impacts including: 1) Thermal stress may have long-term implication on breast meat quality through changes in muscle development and growth potential. 2) Growth selection plays a role in the response of the breast muscle to thermal stress. 3) Immediate post-hatch thermal stress both cold and hot effects both the proliferation and differentiation of satellite cells required for muscle growth and muscle mass accretion.
2. Research in Indiana Station will lead to fundamental understanding of the cell intrinsic molecules and extrinsic signals that regulate skeletal muscle development, growth, and regeneration. Such knowledge will serve as the foundation for translational approaches to increase meat production and improve meat quality in animal agriculture, and to improve health of the muscular system of humans.
3. Studies in Iowa Station showed that: 1) Direct targeting of mitochondria did not provide consistent production benefits. While disappointing, this helps to move the field forward as other approaches can be prioritized. 2) Heat stress continues to negatively impact swine production and will do so at progressively greater magnitudes should environmental models be accurate and/or pigs continue to be selected for protein accretion. The discovery of a sex effect of heat stress could lead to renewed focus of sexed semen, influence the location of new barn construction, and barrow and gilt management strategies.
4. New Jersey station is continuing to develop technical approaches to investigate skeletal muscle protein homeostasis in response to nutrients and activity, tools that are useful in collaboration with other NC1184 investigators. These approaches include metabolomics, stable isotope tracing, and translatomics assays, as described in the above publications. Efforts to collaborate are currently ongoing.
5. The Virginia station contributed 5 manuscripts to the NC1184 Featured Collection published in the Journal of Animal Science. The papers shared novel information and extended knowledge associated with the 3 scientific objectives of the group. Papers from the Virginia station have been viewed 1,247 times and downloaded by 790 individuals worldwide representing actionable changes in knowledge by the scientific community.
6. The Washington Station reported the effects of maternal nutrition and exercise on the development of embryonic and fetal muscle and adipose tissue, which have implications to both animal production and human health.

**Collaborative Grants:**

1. Strasburg, G., Velleman, S.G., Reed, K. NIFA AFRI, “Turkey Breast Muscle Development: The Biological Response to Thermal Challenge in Production Birds,” $500,000, (4/1/2020-3/31/23)
2. Selsby J. (PI), Baumgard and Rhoads. USDA/AFRI Foundation Grant, Therapeutic approaches to heat stress: targeting mitochondria. $497,000. (1/1/18-12/31/21)
3. Selsby J. (PI), Baumgard, Rhoads, and White-Springer. USDA/AFRI Foundation Grant. Calcium regulation as a contributor to heat stress-mediated skeletal muscle dysfunction. $500,000. (1/1/21-12/31/23)
4. Selsby J. (PI), Baumgard, Rhoads, and White-Springer. USDA/AFRI IDEA Grant, Basic and applied consequences of heat stress in barrows and gilts. $1,000,000. (9/1/20-8/30/25)
5. Selsby J. (PI), and White-Springer. MDA. **Obesity as a modifier of disease progression caused by dystrophin deficiency.** $300,000. (9/2022-9/2025)
6. Thornton KJ (PI), B.M. Murdoch, and G. K. Murdoch. USDA-AG2PI: Impact of breed type on beef production and sustainability. $75,000. (01/22-03/23)

**Collaborative Publications:**

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| 1. Daniels RP, Wicks JC, Zumbaugh MD, Matarneh SK, Venhuizen MD, Elgin J, Bodmer J, Yen CN, El-Kadi SW, Shi H, Silva SL, Gerrard DE. Reduced scald time does not influence ultimate pork quality. Meat Sci. 2022 Aug 27;194:108958.
 |
| 1. Daniels RP, Wicks JC, Zumbaugh MD, Matarneh SK, Venhuizen MD, Elgin J, Bodmer J, Yen CN, El-Kadi SW, Shi H, Silva SL, Gerrard DE. Reduced scald time does not influence ultimate pork quality. Meat Sci. 2022 Aug 27;194:108958.
 |
| 1. Fausnacht DW, Kroscher KA, McMillan RP, Martello LS, Baumgard LH, Selsby JT, Hulver MW, Rhoads RP. Heat Stress Reduces Metabolic Rate While Increasing Respiratory Exchange Ratio in Growing Pigs. Animals (Basel). 2021 Jan 17;11(1):215.
 |
| 1. Jia Z, Chen X, Chen J, Zhang L, Oprescu SN, Luo N, Xiong Y, Yue F, Kuang S\*. 2022. ACSS3 in brown fat drives propionate metabolism and its deficiency leads to autophagy and systemic metabolic dysfunction. Clin Transl Med. 12: e665.
 |
| 1. Jonsson WOJ, Mirek, ET, Wek, RC, Anthony TG. (2022) Activation and execution of the hepatic integrated stress response by dietary essential amino acid deprivation is amino acid specific. FASEB J.
 |
| 1. Kirkpatrick LT, Daughtry MR, El-Kadi S, Shi H, Gerrard DE. O-GlcNAcylation is a gatekeeper of porcine myogenesis. J Anim Sci. 2022 Oct 11:skac326.
 |
| 1. Mayorga EJ, Horst EA, Goetz BM, Rodríguez-Jiménez S, Abeyta MA, Al-Qaisi M, Lei S, Rhoads RP, Selsby JT, Baumgard LH. Rapamycin administration during an acute heat stress challenge in growing pigs. J Anim Sci. 2021 May 1;99(5):skab145.
 |
| 1. Peer-reviewed publication: Li X, Hui S, Mirek ET, Jonsson WO, Anthony TG, Lee WD, Zeng X, Jang C, Rabinowitz JD. (2022) Circulating metabolite homeostasis achieved through mass action. Nat Metab. 2022 Jan;4(1):141-152.
 |
| 1. Reed, K.M., Mendoza, K.M., Strasburg, G.M., and Velleman, S.G. 2022. Transcriptome response of proliferating muscle satellite cells to thermal challenge in commercial turkeys. Front. Physiol. 13:970243.
 |
| 1. Rudolph TE, Mayorga EJ, Roths M, Rhoads RP, Baumgard LH, Selsby JT. The effect of Mitoquinol (MitoQ) on heat stressed skeletal muscle from pigs, and a potential confounding effect of biological sex. J Therm Biol. 2021 Apr;97:102900.
 |
| 1. Vaughn, R.N., K.J. Kochan, A.K. Torres, M. Du, D.G. Riley, C.A. Gill, A.D. Herring, J.O. Sanders, and P.K. Riggs. 2022. Skeletal muscle expression of actinin-3 (ACTN3) in relation to feed efficiency phenotype of F2 Bos indicus - Bos taurus steers. Front. Genet. 13:796038.
 |
| 1. Velleman, S.G., Coy, C.S., and Abasht, B. 2022. Effect of expression of PPARG, DNM2L, RRAD, and LINGO1 on broiler chicken breast muscle satellite cell function. Comp. Biochem. Physiol. PT A. In press.
 |
| 1. Xia W, Qiu J, Peng Y, Snyder MM, Gu L, Huang K, Luo N, Yue F, Kuang S. 2022. Chchd10 is dispensable for myogenesis but critical for adipose browning. Cell Regen. 11(1):14.
 |
| 1. Xu, J., Strasburg, G.M., Reed, K.M., and Velleman, S.G. 2022. Temperature and growth selection effects on proliferation, differentiation, and adipogenic potential of turkey myogenic satellite cells through frizzled-7-mediated Wnt planar cell polarity pathway. Front. Physiol.
 |
| 1. Xu, J., Strasburg, G.M., Reed, K.M., and Velleman, S.G. 2022. Thermal stress affects proliferation and differentiation of turkey satellite cells through the mTOR/S6K pathway in a growth-dependent manner. PLoS ONE 17(1): e0262576.
 |
| 1. Xu, J., Strasburg, G.M., Reed, K.M., and Velleman, S.G. 2022. Thermal stress and selection for growth affects myogenic satellite cell lipid accumulation and adipogenic gene expression through mTOR pathway. J. Anim. Sci. In press.
 |
| 1. Yue F, Oprescu SN, Qiu J, Gu L, Zhang L, Chen J, Narayanan N, Deng M, Kuang S. 2022. Lipid droplet dynamics regulate adult muscle stem cell fate. Cell Rep 38: 110267.
 |

**Book Chapters: None**

**Abstracts, Posters, and Professional Presentations:**

1. Semanchik P, Wesolowski LT, Simons SJ, Freestone A, Rudolph TE, Roths M, Rhoads RP, Baumgard LH, Selsby JT, and White-Springer SH. Heat stress more negatively impacts cardiac muscle mitochondria in female versus male pigs. Experimental Biology, Philadelphia, April, 2022.
2. Semanchik, PL, LT Wesolowski, JL Simons, AD Freestone, TE Rudolph, M Roths, RP Rhoades, LH Baumgard, JT Selsby, and SH White-Springer. 2022. Heat stress more negatively impacts cardiac muscle mitochondria in female versus male pigs. The FASEB Journal. 36(S1):R6228. doi:10.1096/fasebj.2022.36.S1.R6228. Experimental Biology Meeting in Philadelphia, PA.
3. Wesolowski LT, Semanchik PL, Simons JL, Rudolph ET, Roths M, Selsby JT, and White-Springer SH. Heat stress increases mitochondrial complex I capacity in female pigs but favors reliance on complex II in males. Experimental Biology, Philadelphia, April, 2022.
4. Wesolowski, LT, Semanchik, PL, JL Simons, AD Freestone, TE Rudolph, M Roths, RP Rhoades, LH Baumgard, JT Selsby, and SH White-Springer. 2022. Heat stress increases mitochondrial complex I capacity in female pigs but favors reliance on complex II in males. The FASEB Journal. 36(S1): R5245. doi:10.1096/fasebj.2022.36.S1.R5245. Experimental Biology Meeting in Philadelphia, PA.
5. Workshop: Contemporary and Emerging Issues Symposium: Public Policy: Infrastructure Needs for Advancing Research in Animal Agriculture. American Society of Animal Science Annual Meeting, July 2022. (Riggs, Hagen, Murdoch et al.)

**Theses/Dissertations:**

1. Liu Xiangdong, Extracellular matrix in muscle regeneration, adipose tissue function and meat quality. Washington State University.
2. Joseph Yonke, Branched-Chain Amino Acid Metabolism in the Neonatal Pig. Virginia Tech
3. Madison Gonzalez, The effects of tributyrin and butyrate on equine skeletal muscle. Virginia Tech
4. Songah Chae, Apelin-APJ signaling in mediating the beneficial effects of maternal exercise on placental and fetal intestinal development. Washington State University.
5. Therrien, D.A. 2022. Application of molecular genomic analysis tools to assess bacterial genomes and bovine regulatory elements for food safety and meat quality. PhD dissertation, Texas A&M University, College Station, TX
6. Wesolowski, L.T. 2022. Effects of dietary omega-3/omega-6 blend on plasma cytokines and skeletal muscle mitochondria in Thoroughbred horses in race training. MS Thesis, Texas A&M University, College Station, TX

**Other Publications and Presentations:**

1. Kawaida M.Y., D. Gonzalez, J.M. Gonzalez, N. M. Tillquist, A. S. Reiter, B. I. Smith, S. A. Zinn, K. E. Govoni, S. A. Reed. Poor maternal nutrition during gestation decreases shear force and alters the expression of genes involved in muscle growth. National meeting American Society of Animal Science. Oklahoma City, OK. June 2022.
2. Garner RT, Weiss JA, Nie Y, Sullivan BP, Kargl C, Drohan CJ, Kuang S, Stout J, Gavin TP. 2022. Effects of obesity and acute resistance exercise on skeletal muscle angiogenic communication pathways. Exp Physiol. 107:906-18.
3. Sullivan BP, Nie Y, Evans S, Kargl C, Hettinger R, Garner RT, Hubal MJ, Kuang S, Stout J, Gavin TP. 2022. Obesity and Exercise Training Alter Inflammatory Pathway Skeletal Muscle Small Extracellular Vesicle miRNAs. Exp Physiol. 107: 462-75.
4. Figueiredo VC, Roberts LA, Cameron-Smith D, Markworth JF. Editorial: Modulators of skeletal muscle hypertrophy: Mechanisms to Lifestyle Strategies. Frontiers in Physiology. 2022 Apr 26;13:893698.
5. Guzman SD, Judge J, Shigdar S, Paul TA, Davis CS, Macpherson PC, Markworth JF, Van Remmen H, Richardson A, McArdle A, Brooks SV. Removal of p16INK4 expressing cells in late life has moderate beneficial effects on skeletal muscle function in male mice. Frontiers in Aging. 2022 Jan 26;2:821904.
6. Nofal M, Wang T, Yang L, Jankowski CSR, Hsin-Jung Li S, Han S, Parsons L, Frese AN, Gitai Z, Anthony TG, Wühr M, Sabatini DM, Rabinowitz JD. (2021) GCN2 adapts protein synthesis to scavenging-dependent growth. Cell Syst. 2021 Oct 21:S2405-4712(21)00382-3.
7. Martinez W, Zhang Q, Linden MA, Schacher N, Darvish S, Mirek ET, Levy JL, Jonsson WO, Anthony TG, Hamilton KL. Rates of protein synthesis are maintained in brain but reduced in skeletal muscle during dietary sulfur amino acid restriction. Front Aging. 2022 Aug 24;3:975129.
8. L.T. Kirkpatrick, J.M. Elgin, S.K. Matarneh, J.C. Wicks, R.P. Daniels, C-N. Yen, J.S. Bodmer, M.D. Zumbaugh, S.W. El-Kadi, S.L. Silva, H. Shi, & D.E. Gerrard. 2022. Inherent factors influence color variations in semimembranosus muscle of pigs. Meat Science, 185:108721.
9. R.P. Daniels, J.C. Wicks, M.D. Zumbaugh, S.K. Matarneh, M.D. Venhuizen, J. Elgin, J. Bodmer, C-N. Yen, S.W. El-Kadi, H. Shi, S.L. Silva, & D.E. Gerrard. 2022. Reduced scald time does not influence ultimate pork quality. *Meat Science*, 194:108958.