Assessment of Early-Stage Thermal Manipulation on Broiler Chicken Muscle Satellite Cell Population Densities at Transfer and at Hatch

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Multi-stage hatching egg incubators are challenging to manage but still common throughout the US broiler industry. It is difficult to satisfy all embryonic temperature requirements in systems where late-stage embryos must be kept from overheating while ensuring early-stage embryos are not at sub-optimal temperatures.

Preliminary data generated by our research group at Auburn University showed improvements in performance and meat yield when incubation temperature was increased to 38.6 °C from embryonic day (ED) 4 to 11 as opposed to lowering it to 36.4 °C compared with a 37.5 °C control. It was hypothesized that incubation temperature differences impacted satellite cell (SC) activity in our previous study and led to the differences in performance and meat yield. Muscle SC are muscle specific stem cells that serve as the rate limiting step in post-hatch hypertrophic muscle growth. Therefore, the objective of this study was to assess the effect of thermal manipulation during early-stage incubation (ESI) on SC heterogeneity in broiler chicks at transfer and hatch to explore the mechanism responsible for increased meat yield in our previous study.

Broiler breeder eggs (n = 2,160) were incubated at 37.5 °C from embryonic day (ED) 0 to 3. On ED 4, COLD incubator setpoints decreased to 36.4 °C, HOT incubator setpoints increased to 38.6 °C, and control incubators remained 37.5 °C (n = 2 incubators per treatment). On ED 11, all incubators were set to 37.5 °C until ED 18 when eggs were transferred to hatchers. At transfer (ED 18) and hatch (ED 21), pectoralis major (PM) and biceps femoris (BF) muscle samples were collected from 6 chicks per treatment. Samples were immunofluorescence stained to facilitate taxonomy of SC populations expressing the myogenic regulatory factors and SC markers, MyoD, MRF4, and Myf5, by fluorescence microscopy.

Data was analyzed as a 1-way ANOVA with the GLIMMIX procedure of SAS. Means were separated at $p \leq 0.05$ with the PDIFF option. Tendencies were declared when $0.0501 \leq p \leq 0.10$. Chicks from COLD incubators had the greatest density of MyoD+:Myf5+ SC in their BF ($p = 0.0261$) and tended to have a greater density of MyoD+:MRF4+ SC in their PM muscle ($p = 0.0562$) compared with chicks from HOT incubators at transfer on ED 18. On ED 21, chicks from HOT incubators had the greatest density of MyoD+:MRF4+:Myf5+ SC in their PM muscle ($p = 0.0406$). Temperature gradients as small as 1.1 °C during ESI altered BF SC populations in chicks at transfer and PM SC populations at both transfer and hatch.

Overall, these results indicate that thermal manipulation during ESI can influence SC population kinetics in both PM and BF muscles of modern, fast-growing, high-yielding broiler chicks at ED 18 and 21. Further investigation is needed to understand the longer-term effects on SC populations and the cell signaling pathways involved over time during the post-hatch grow out period to explain the meat yield responses observed in our previous work.

Statement of Research Advisor

J. Wesley Rogers' work improves our understanding of how relatively small changes in environmental temperatures during broiler chicken in ovo development

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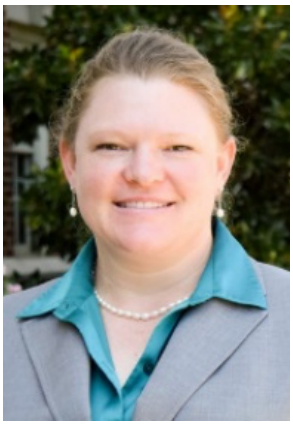
impact skeletal muscle development and growth as well as help provide the foundation for future studies aimed at exploring the role of skeletal muscle stem (satellite) cells in the Wooden Breast meat quality defect currently plaguing the global broiler chicken meat industry.
-Dr. Jessica Starkey, Department of Poultry Science, College of Agriculture

Sample of Authors Biography

J. Wesley Rogers is a senior pursuing a B.S. degree in Animal Sciences with a minor in Poultry Science. He plans to continue his academic career as a master's student in the AU Poultry Science Department studying muscle biology under Dr. Jessica Starkey starting in the summer of 2023. He ultimately plans to earn a Ph.D. and work as a monogastric physiologist.



Dr. Jessica Starkey is an Associate Professor in the Department of Poultry Science. Dr. Starkey's research program is focused on how nutrition, management, and disease impact the cellular and molecular regulation of satellite cell-mediated skeletal muscle growth in domestic livestock.