



PROJECT SUMMARY PRODUCT QUALITY

BEEF
RESEARCH

The Influence of Diet on Calcium Flux in Fresh Beef – A Possible Mechanism to Alter Beef Tenderness

E. Kunze, N. Herrera*, K. Domenech-Perez*, M. Chao[†], and C. Calkins**

**University of Nebraska-Lincoln*

[†]California State University

Study Completed

June 2016

This project was funded in part by the Beef Checkoff.



BeefResearch.org



303.694.0305

For more information, contact:
Science and Product Solutions

National Cattlemen's Beef Association • Contractor to the Beef Checkoff Program
9110 East Nichols Avenue • Centennial, CO 80112 • 303.694.0305



Funded by the Beef Checkoff.

The Influence of Diet on Calcium Flux in Fresh Beef – A Possible Mechanism to Alter Beef Tenderness: Project Summary

Background

Calcium plays a significant role in the living muscle, causing contraction and relaxation. Most of the calcium in the cell is contained in the sarcoplasmic reticulum (SR). Mitochondria are secondary calcium-sequestering organelles. After death, calcium seeps from the SR and activates an enzyme system called calpains. Calpains work to degrade muscle proteins and results in higher tenderness. Therefore, calcium flux impacts tenderness.

Research from this lab has found that beef from cattle fed distillers grains is often more tender than cattle fed corn. However, the mechanism for the difference in tenderness has not yet been identified. It is well known that feeding distillers grains increases polyunsaturated fatty acid (PUFA) content in the muscle, and recently this lab demonstrated that feeding distillers grains increases PUFA of the SR itself.

The hypothesis is that PUFA content in the SR membrane would increase as a consequence of feeding distillers grains, which would predispose the SR membrane to oxidation, and cause a greater postmortem release of calcium into the cytoplasm. Cytoplasmic calcium would activate proteolytic degradation via the calpain system and thereby enhance tenderness.


It is hard to measure calcium release within the cell because calcium binds with many different proteins, making it difficult to quantify how much has been released. The best approach is to isolate an organelle containing calcium and quantify calcium release under various conditions. Isolating intact SR proves very challenging, however. The structure of the sleeve-like organelle makes it exceptionally difficult to isolate without damaging its inherent structure. Fortunately, mitochondria are relatively easy to isolate intact and offer the opportunity to study calcium release from an organelle under carefully controlled and tightly defined conditions. In this way, mitochondria can be used as a model system for the SR in the study of calcium flux.

Objectives

The goal of this research was to 1) Help decipher the mechanism by which beef cattle fed distillers grains becomes more tender than beef finished on corn, with an overall goal of improving beef tenderness; 2) Determine the effects of diet (corn vs distillers grain) on fatty acid composition of the membranes of the SR and mitochondria; 3) Evaluate the effects of membrane fatty acid composition (PUFA content) on calcium release; 4) Determine the influence of oxidation on calcium release; and 5) Relate fatty acid composition of the whole muscle to fatty acid composition of the SR and mitochondrial membranes.

Methods

Cattle (n=48) were fed a corn-based finishing diet with or without deoiled, dried distillers grain (50% DM basis). After harvest, strip loins were collected and steaks from each loin were aged for two, eight, 14, and 21 days, powdered, and stored at -80°C for lab analysis. Samples (n=12) were randomly sub-sampled from each diet group for all aging periods. Mitochondria were isolated using high speed ultracentrifuge from day two, eight, and 14. The SR was isolated from each day two sample. Both mitochondria and SR samples were analyzed for PUFA content using gas chromatography, and phospholipid content using thin layer chromatography. Mitochondria from days two and eight were artificially oxidized using an iron and ascorbic acid mixture.



Findings

This study found that oxidation decreases the ability of the mitochondria to retain calcium; more PUFA were found in the SR and mitochondria from cattle fed distillers grains; and, mitochondria from cattle fed distillers grains tended to retain less calcium than mitochondria from cattle fed corn-only.

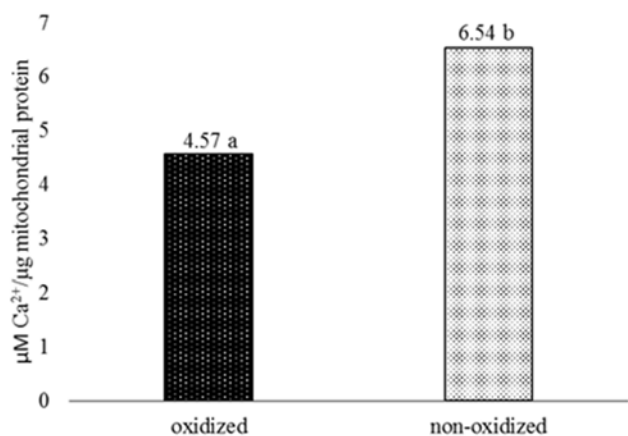
In both the SR and the mitochondria, the distillers grain diet had a higher amount of PUFA compared to corn samples. Day 14 mitochondria had higher PUFA compared to day two and eight mitochondria, as expected from aging of unsaturated fats. Phospholipid content of the mitochondria and SR were unaffected by diet. Oxidized mitochondria retained less Ca than non-oxidized mitochondria. Day two mitochondria retained less Ca than day eight mitochondria. Overall, mitochondria from cattle finished on corn tended to retain more Ca than mitochondria from cattle finished on DG.

Industry Impact

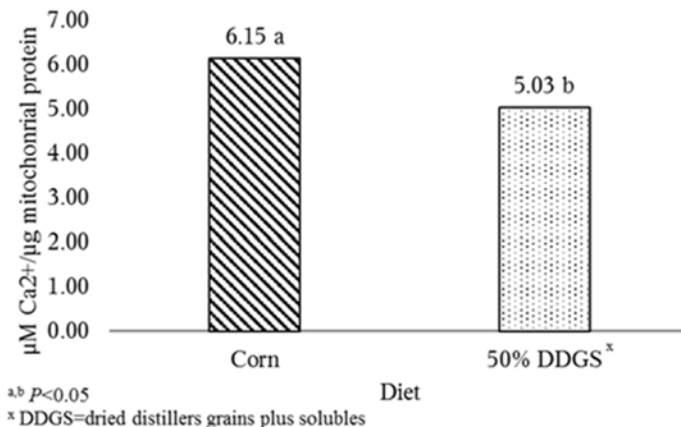
Results indicate that greater PUFA content deposited in organelles may affect Ca flux by increased susceptibility to oxidation. A distillers grain diet may influence Ca flux and ultimate tenderness by this mechanism.

Tenderness is one of the most important attributes of a consumer's eating experience and influences the economic value of beef. Diets, such as distillers grains, have the opportunity to impact the ultimate tenderness of beef. Better understanding of the biology of beef tenderization and how to alter beef tenderness can provide for the development of strategies to optimize tenderness and achieve the highest possible value for beef and consumer satisfaction ratings.

Graphs/Tables



^{ab} P<0.05



^{ab} P<0.05

^x DDGS=dried distillers grains plus solubles

Figure 1. Effects of oxidation on mitochondrial calcium retention. **Figure 2.** Diet effect on mitochondrial calcium retention.

Photos

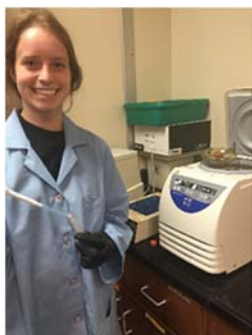


Figure 1. Emery working with mitochondria.



Figure 2. Nicholas working on protein



BeefResearch.org



303.694.0305

For more information, contact:
Science and Product Solutions

National Cattlemen's Beef Association • Contractor to the Beef Checkoff Program
9110 East Nichols Avenue • Centennial, CO 80112 • 303.694.0305



Funded by the Beef Checkoff.