Measuring skeletal muscle NADH production to assess feed efficiency and milk production

Abstract #2684

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Introduction

- **Opportunity:**
  - Feed is largest single cost in animal production.
  - Feed production accounts for 36% of greenhouse gas emissions associated with dairy production.
- **Improvements in feed efficiency can:**
  - ↓ Feed costs & ↑ producer profits
  - ↓ Carbon footprint of feed production
- **Current technology to improve feed efficiency:**
  - Residual feed intake
    - Labor intensive/specialized equipment
  - Oxygen Consumption
    - Specialized equipment

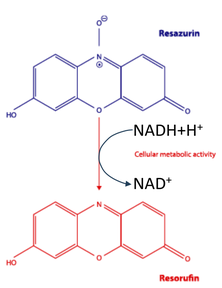
Objectives:

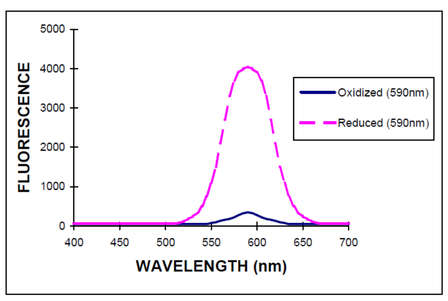
1) Test efficacy of measuring reducing equivalents produced by skeletal muscle biopsy to assess feed efficiency.
2) Assess repeatability & ability of assay to distinguish between stage of production.

Hypotheses:

1) Skeletal muscle reducing equivalent production is inversely related to feed efficiency.
2) Feed efficient cows will produce more milk b/c less dietary energy is going toward maintenance energy requirements.

Principle: Fluorometric Assay of Reducing Equivalents





Methods

Animals

- 36 Holstein cows (BW ± SEM; 662 ± 25 kg)
  - Lactation 1-4
  - Dry, Early, Mid and Late lactation
  - All previous lactation data available
- 12 growing heifers before production (BW ± SEM; 417 ± 8 kg)

Triceps Brachii Biopsy

- Cows sedated with intravenous injection of xylazine HCL
  - 35 ug/kg of BW
- Subcutaneous line block with lidocaine HCL (1 mL).
- 14G hypodermic needle inserted & used to guide Cook® biopsy needle (18G).

- <100 mg of tissue collected from depth of ~4 cm.

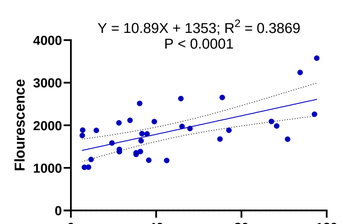
Metabolic Activity of Skeletal Muscle

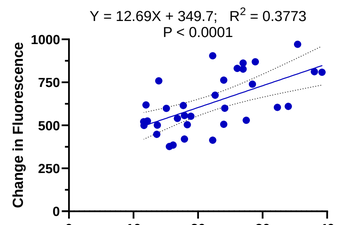
- Biopsies incubated in 96- well plate with sterile media (DMEM/F12 with 1% pen/strep); kept on ice.
- Transferred to test media (DMEM/F12 with 1% pen/strep and 0.01 mg/ml resazurin) within 1h of collection & incubated at 37°C.
- Resazurin based fluorescence (excitation 530 nm; emission 590 nm) measured at 0 and 4h.
- Biopsies digested & corrected for size, based on biopsy DNA (May) or protein (December) content:
  - PicoGreen assay kit (Invitrogen™)
  - BCA assay (ThermoFisher Scientific)

Data Analysis

Larger Biopsies Create More Signal

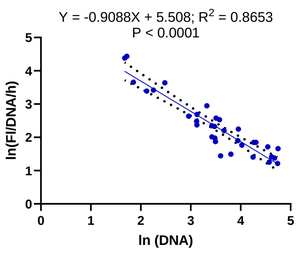
Biopsy DNA content (May) or protein (October) proxies for biopsy size associated with increased resorufin caused fluorescence.

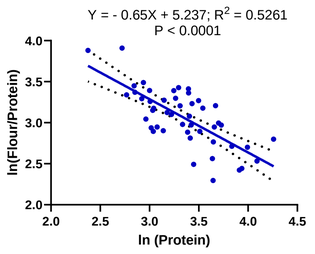




Correct For Biopsy Size

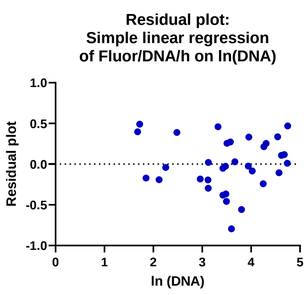
ln(signal/DNA or Protein) regressed on ln(DNA or Protein)

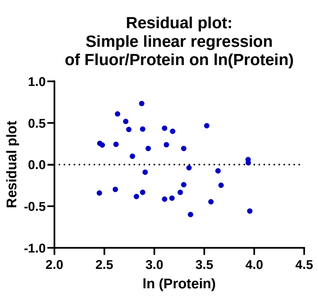




Calculate Residuals From Graphs Above

Residuals are not biased based on biopsy size





Residuals = Relative Metabolic Rate

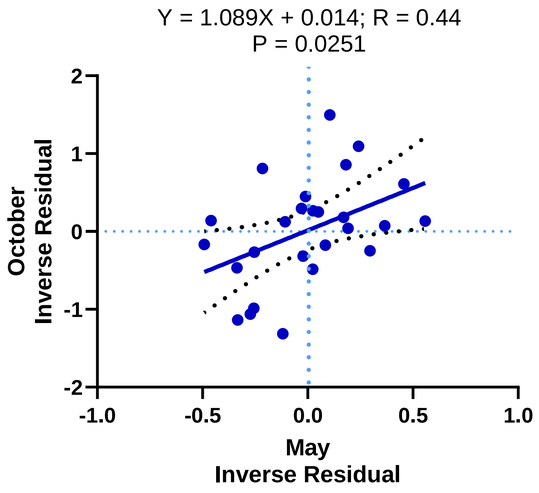
Negative Residuals (Predicted – Actual) = animals that expended less energy than expected

Positive Residuals (Predicted – Actual) = animals that expend more energy than expected

To Ensure that a Positive Efficiency Number is Indicative of a Positive Trait, All Data is Presented as the Inverse Residual

Results

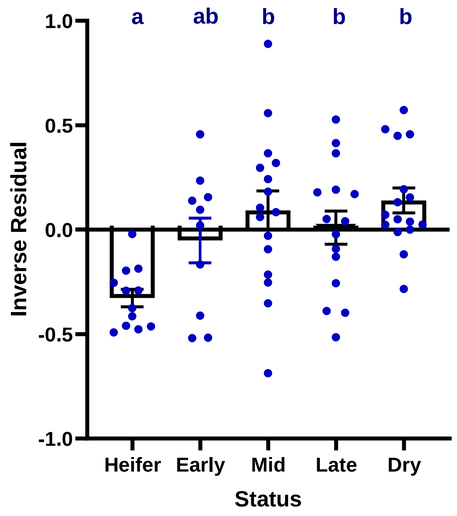
Measurements Taken 7 Months Apart, in the Same Animal, are Correlated Despite Differences in Lactation Status



Results

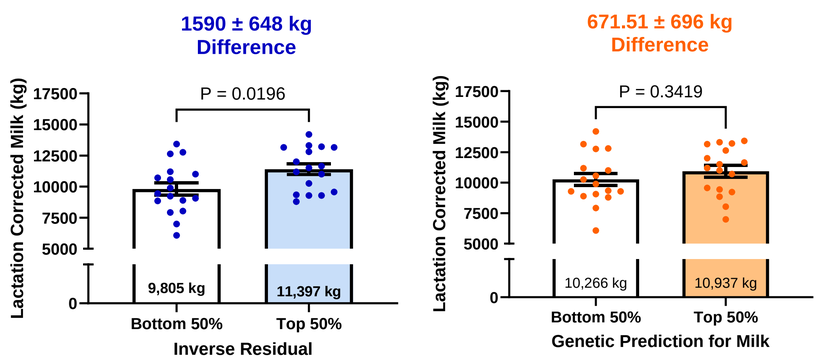
Maturity & Lactation Status

- Skeletal muscle biopsies from growing heifers expend more energy than those from mature cows (P < 0.05).
- Lactation stage does not affect residual (P > 0.50).

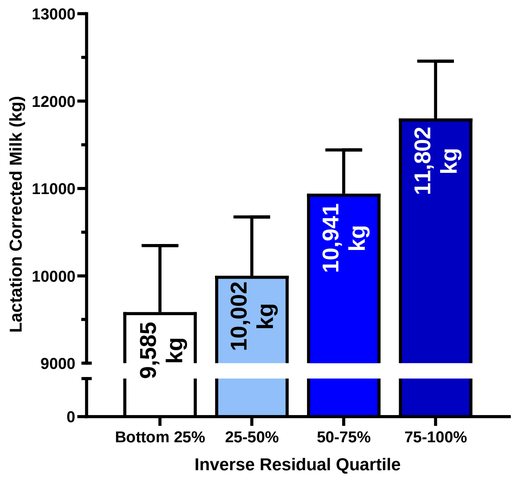


Large variation highlights potential for improvement through selective breeding programs.

Segregating Cows Into High & Low Halves Shows that the Inverse Residual of Skeletal Muscle Metabolic Rate is More Predictive of Milk Production than a Commercially Available Genomic Test for Milk Production.



Milk Production Increased with Quartile of Inverse Residual of Skeletal Muscle Metabolic Rate



Conclusions

1) Skeletal muscle metabolic rate consistent within animal.
2) Growing animals have higher skeletal muscle metabolic rate than mature because they are expending energy for growth & maintenance.
3) Lactation stage does not largely affect skeletal muscle metabolic rate.
4) Cows with a greater inverse residual for skeletal muscle metabolic rate, produce more milk than cows with lower.