Liver oxygen uptake, triiodothyronine and mitochondrial function vary with feed efficiency in cattle

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INTRODUCTION: Why efficiency?

SOCIAL

AUGUST 1
Earth Overshoot Day 2018

$$$$$$$
INTRODUCTION: Why RFI?

RFI (kg/d) = Feed Intake – Predicted Intake
INTRODUCTION: Why liver?

14 - 26%
INTRODUCTION: liver parameters

- Chemical
- Weight
- Blood $T_3$
- $O_2$ uptake
- Organelle
- Citrate synthase
HYPOTHESIS

The metabolic plasticity of the liver across plethora of biological workloads is also evidenced according to the individual variation in the efficiency of feed utilization.
OBJECTIVES

To determine the relationships between:

• liver chemical composition,
• liver \( O_2 \) uptake,
• \( T_3 \) and
• citrate synthase activity

with feed efficiency in young beef bulls.
MATERIAL & METHODS: bulls & feeding

64 crossbred yearling bulls – fattening phase
MATERIAL & METHODS: bulls & feeding

52.2%: High moisture corn
42.4% Alfalfa silage
5.0% Soybean meal
0.11% vitamin & mineral

44.8% starch
86.5% total digestible nutrients

112 days performance test
MATERIAL & METHODS: performance test

US: body composition

BW: daily gain and size

Every 28 days
MATERIAL & METHODS: FE determination

Predictive Intake (kg/d) = \( \beta_0 + \) 

\[ \beta_1(BW) + \beta_2(ADG) + \{ \text{Body size / Growth rate} \} \]

\[ \beta_3(\text{Back Fat}) + \beta_4(\text{Rump Fat}) + \beta_5(\text{Marbling}) + \{ \text{Fatness} \} \]

\[ \beta_6(\text{Ribeye Area}) + \{ \text{Leanness} \} \]

RFI

\[ RFI \ (kg/d) = \text{Feed Intake} - \text{Predicted Intake} \]

\( R^2 = 0.63 \)
MATERIAL & METHODS: Liver sampling

Krebs-Henseleit buffer: Microcalorimetry

$N_2$: Citrate synthase analysis

-20°C: Crude protein & fat content

Weight

Timing to sample
MATERIAL & METHODS: Liver microcalorimetry

- Water heater
- Chamber
- Oxygen probe
- Software
MATERIAL & METHODS: Liver microcalorimetry

\[
O_{2s} = \frac{\Delta O_2}{\Delta t} \times \frac{(v - wm)}{m} \times \left(\frac{1 \text{ mmol } O_2}{32 \text{ mg } O_2}\right) \times \left(\frac{1000 \text{ } \mu \text{mol}}{\text{mmol}}\right)
\]
MATERIAL & METHODS: **Crude fat and protein**

Crude protein: 
*BCA protein assay reagent*

Crude fat: 
*Extraction with petroleum ether*
MATERIAL & METHODS: **Citrate synthase**

**Cell Lysis Reagent & Protease Inhibitor**

- CS/ gram of tissue
- CS/ whole liver
- CS/ protein content
MATERIAL & METHODS: Total T₃ levels

Blood collection:
During exsanguination

Blood processing:
Plasma extracted and frozen

Total T₃:
solid-phase radioimmunoassay
Categorical analysis:

• **Low-RFI vs. High-RFI**
• **Normality verification**
• **Least square means**

\[ Y_{ijk} = \mu + R_i + B_j + \beta(A_K) + \varepsilon_{ijk} \]

**Example:**

Liver weight = \( \mu + \text{RFI Class} + \text{Breed} + \text{Age} + \text{Error} \)
## RESULTS & DISCUSSION: Performance

<table>
<thead>
<tr>
<th>Trait (unit)</th>
<th>High-RFI</th>
<th>Low-RFI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (d)</td>
<td>395</td>
<td>405</td>
<td>0.16</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>422</td>
<td>406</td>
<td>0.25</td>
</tr>
<tr>
<td>Daily weight gain (kg/d)</td>
<td>2.07</td>
<td>1.98</td>
<td>0.32</td>
</tr>
<tr>
<td>Backfat thickness (mm)</td>
<td>4.33</td>
<td>3.86</td>
<td>0.22</td>
</tr>
<tr>
<td>Rumpfat thickness (mm)</td>
<td>3.87</td>
<td>3.53</td>
<td>0.36</td>
</tr>
<tr>
<td>Ribeye area (cm²)</td>
<td>71.2</td>
<td>70.2</td>
<td>0.62</td>
</tr>
<tr>
<td>Dry matter intake (kg/d)</td>
<td>10.1</td>
<td>8.60</td>
<td>0.01</td>
</tr>
<tr>
<td>Residual feed intake (kg/d)</td>
<td>0.54</td>
<td>-0.57</td>
<td>0.01</td>
</tr>
</tbody>
</table>

300 kg less feed/bull over 112 days
RESULTS & DISCUSSION: Weight & chemical

<table>
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<th>High-RFI</th>
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<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude fat (%)</td>
<td>0.47</td>
<td>0.54</td>
<td>0.42</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>10.16</td>
<td>10.07</td>
<td>0.66</td>
</tr>
</tbody>
</table>

P > 0.05

High-RFI
LW (kg): 7.55
LW (%BW): 1.29

Low-RFI
LW (kg): 7.24
LW (%BW): 1.26
RESULTS & DISCUSSION: **micro-calorimetry**

<table>
<thead>
<tr>
<th>Oxygen uptake</th>
<th>High-RFI</th>
<th>Low-RFI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_2$ per g (μmol/min)</td>
<td>1.48</td>
<td>1.27</td>
<td>0.04</td>
</tr>
<tr>
<td>$O_2$ liver (mmol/min)</td>
<td>12.9</td>
<td>10.7</td>
<td>0.06</td>
</tr>
</tbody>
</table>

↑ Feed Efficiency = ↓ $O_2$ uptake
### RESULTS & DISCUSSION: citrate synthase

<table>
<thead>
<tr>
<th>Citrate synthase (CS)</th>
<th>High-RFI</th>
<th>Low-RFI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS per g (μmol/min)</td>
<td>2.30</td>
<td>2.59</td>
<td>0.001</td>
</tr>
<tr>
<td>CS per g protein (mmol/min)</td>
<td>22.6</td>
<td>25.6</td>
<td>0.001</td>
</tr>
<tr>
<td>CS liver (mmol/min)</td>
<td>18.7</td>
<td>22.9</td>
<td>0.001</td>
</tr>
</tbody>
</table>

↑ Feed Efficiency = ↑ CS activity

*Feed Efficiency:* The feed efficiency is directly proportional to the citrate synthase (CS) activity.
RESULTS & DISCUSSION: $T_3$

<table>
<thead>
<tr>
<th>Thyroid indicator</th>
<th>High-RFI</th>
<th>Low-RFI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total T3 (ng/dL)</td>
<td>94.7</td>
<td>88.0</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Feed Efficiency = ↓ Total T3
RESULTS & DISCUSSION: General

Electron transport chain (ETC)

O₂ → Water

Oxygen concentration → Proton leak → Protonmotive force → ATP

Heat

Total T3

Oxygen wasted

Feed Efficiency

Citrate synthase
The “feed efficient liver”:

- Lower $O_2$ uptake
- Greater CS activity
- Lower T3 levels.

These evidence seems to support energy sparing metabolic pathways in feed efficient cattle to be further understood.

CONCLUSION

Potential biomarkers:
- extensive validation
- technique optimization
ONGOING RESEARCH

Whole body breath gas analysis

Liver biopsy
ACKNOWLEDGEMENTS
MORE ON BIOMARKERS...

Session 24
Tue PM

Cardiovascular monitoring towards novel proxies for feed efficiency in the bovine

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GOT INTERESTED?

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BosTaurus Efficiency