Methane emissions and rumen fermentation in beef heifers differing in phenotypic residual feed intake

C. Fitzsimons¹,³, D.A. Kenny¹, M. Deighton², A.G. Fahey³ and M. McGee¹

Animal and Grassland Research and Innovation Centre, Teagasc, Grange¹, Co. Meath, Ireland, Moorepark², Co. Cork, Ireland, School of Agriculture and Food Science, University College Dublin, Ireland
Introduction

- Enteric CH$_4$ production accounts for a significant proportion of anthropogenic CH$_4$ (Crosson et al., 2011)

- CH$_4$ mitigation strategies:
  - Some affect animal performance / no lasting effect
  - Possibly, via selection of feed efficient animals by improved residual feed intake (RFI) (Hegarty et al., 2007)

- $RFI = \text{animal’s actual intake} - \text{predicted intake}$
  - Adjusted for maintenance + growth
  - Negative values = efficient
  - Positive values = inefficient
Introduction

• Some evidence that low RFI cattle produce less CH$_4$ than high RFI cattle

• Feed efficient cattle produced,
  • 25% less CH$_4$ on high conc. diets (Hegarty et al., 2007)
  • 28% less CH$_4$ on high conc. diets (Nkrumah et al., 2006)
  • 27% less CH$_4$ on high quality pasture but NO difference on low quality pasture (Jones et al., 2011)

Objective of this study
• Characterise productivity-related variables, rumen fermentation and CH$_4$ emissions in beef heifers differing in phenotypic RFI
Materials and Methods

**Animals:** 22 Simmental/crossbred breeding beef heifers
- Individually tethered

**Diet:** 2\textsuperscript{nd} harvest grass silage *ad libitum* (DMD 766 g/kg)

**Experimental period:** 120 d

**Measurements:**
- Individual feed intake
- Live weight
- Body condition score
- Ultrasonic fat & muscle depth
- Muscularity scores
- Skeletal
Materials and Methods

Measurements (cont’):
- Selected blood metabolites
- Total tract digestibility (AIA marker technique)
- Rumen fermentation (transeosophageal sampler)
Materials and Methods

**Methane (CH₄) production:**
- Measured two 5-day periods
- Weeks 3 and 11

Calibrated tracer gas - SF₆

Bolus administration
- 6 days prior to CH₄ measurement

SF₆ and CH₄ concentrations determined via gas chromatography (Johnson *et al.*, 2006)
Materials and Methods

• RFI Calculation:

  Predicted DMI
  • Regressed mean daily DMI on ADG and mid-test BW^{0.75}
  • PROC GLM, SAS

  RFI = Actual DMI - Predicted DMI

• Heifers ranked on RFI

• Assigned to high, medium or low RFI groupings
Materials and Methods

Statistical analysis:

• Data were analysed using PROC MIXED, SAS

• Model included
  • Fixed effects of RFI, period and RFI × period
  • Random effect - sire
  • Linear covariate - date of birth

• Also, regression analysis used to examine relationship between RFI and CH₄
# Results

<table>
<thead>
<tr>
<th>Trait</th>
<th>RFI Group</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>DMI (kg/d)</td>
<td>8.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.4&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>RFI (kg DM/d)</td>
<td>0.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.49&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mid-test LW (kg)</td>
<td>483</td>
<td>482</td>
<td>490</td>
</tr>
<tr>
<td>ADG (kg)</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Results

• No effect (P > 0.05) of RFI on:
  • Body composition traits
  • Visual muscularity scores
  • Skeletal measurements
  • Rumen fermentation parameters
  • Total tract digestibility

• Blood plasma metabolite concentrations
  • Glucose and urea higher (P < 0.05)
  • Creatinine lower (P < 0.05)
    in high RFI compared to low RFI heifers
  • Other metabolic variables did not differ (P > 0.05) between RFI groups
## Results

<table>
<thead>
<tr>
<th>Trait</th>
<th>RFI Group</th>
<th>SEM</th>
<th>Sig.¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>CH₄ (g/d)</td>
<td>297ᵃ</td>
<td>275ᵇ</td>
<td>260ᵇ</td>
</tr>
<tr>
<td>CH₄ (g/kg DMI)</td>
<td>35</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>CH₄ (g/kg LW⁰.⁷⁵)</td>
<td>2.9ᵃ</td>
<td>2.7ᵇ</td>
<td>2.5ᵇ</td>
</tr>
</tbody>
</table>

¹No RFI × Period interaction (P > 0.05)
## Results

<table>
<thead>
<tr>
<th>Trait</th>
<th>CH&lt;sub&gt;4&lt;/sub&gt; Production</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period 1</td>
<td>Period 2</td>
<td></td>
</tr>
<tr>
<td>CH&lt;sub&gt;4&lt;/sub&gt; (g/d)</td>
<td>334</td>
<td>220</td>
<td>10.6</td>
</tr>
<tr>
<td>CH&lt;sub&gt;4&lt;/sub&gt; (g/kg DMI)</td>
<td>40</td>
<td>31</td>
<td>1.4</td>
</tr>
<tr>
<td>CH&lt;sub&gt;4&lt;/sub&gt; (g/kg LW&lt;sup&gt;0.75&lt;/sup&gt;)</td>
<td>3.3</td>
<td>2.1</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Results

Regression analysis:

Period 1:
• Relationship between RFI and CH$_4$ not significant (P > 0.05)

Period 2:
• 1-unit increase in RFI
  • 25 g/d increase (P = 0.07; R$^2$ = 0.16) in CH$_4$
  • 2.5 g/kg DMI decrease (P = 0.06; R$^2$ = 0.17) in CH$_4$
Summary

• Feed consumption was less (P < 0.05) in low compared to high RFI groups

• RFI - no effect (P > 0.05) on
  • Performance-related traits measured
  • Total tract digestibility
  • Rumen fermentation

• Daily CH$_4$ emissions were less (P < 0.05) on an absolute basis and relative to weight in low RFI heifers
Conclusion

This study provides evidence that improving feed efficiency in cattle, by way of improved RFI, will reduce CH$_4$ emissions while maintaining animal performance.