Effects of diet digestibility on feed efficiency and impact of diet type and feeding phase on repeatability of feed efficiency phenotype


Introduction

- Cattle grown with roughage-based diets
  - Finished with high concentrate diets
- Measuring DMI, FE: expensive, labor-intensive (Arthur and Herd, 2008)
  - Cattle often FE tested once during growing phase
- FE phenotype repeatable across diet types and feeding phases?
  - How do growth and carcass traits differ between FE phenotypes?

Introducjon

- Castle grown with roughage-based diets
- Finished with high concentrate diets
- Measuring DMI, FE: expensive, labor-intensive
  - Arthur and Herd, 2008
- Castle often FE tested once during growing phase
- FE phenotype repeatable across diet types and feeding phases?
  - How do growth and carcass traits differ between FE phenotypes?

Objective

Determine the influence of growing phase FE classification and diet type on performance of steers fed differing finishing phase diets

Experimental design

- Six groups, 985 steers total
- Growing Phase
  - University of Missouri
  - Dirt lots with Growsafe bunks
    - Corn-based (G-Corn)
    - Roughage-based (G-Rough)
  - 2 d start/end weights
  - Individual DMI measured, 69-89 d
  - Intermediate weights taken 14-28 d

Influence of growing phase feed efficiency on finishing phase growth performance and carcass characteristics of beef steers fed different diet types

**Growing phase diet nutritional analyses**

<table>
<thead>
<tr>
<th>Nutritional analysis, % DM</th>
<th>1, 2, 3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-Corn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, % as-fed</td>
<td>90.7</td>
<td>90.3</td>
<td>88.3</td>
<td>85.1</td>
</tr>
<tr>
<td>NDf</td>
<td>17.8</td>
<td>20.2</td>
<td>21.3</td>
<td>26.4</td>
</tr>
<tr>
<td>ADF</td>
<td>4.4</td>
<td>5.0</td>
<td>4.9</td>
<td>6.5</td>
</tr>
<tr>
<td>CP</td>
<td>17.2</td>
<td>17.9</td>
<td>23.1</td>
<td>20.5</td>
</tr>
<tr>
<td>G-Rough</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM, % as-fed</td>
<td>79.4</td>
<td>68.9</td>
<td>68.3</td>
<td>66.8</td>
</tr>
<tr>
<td>NDf</td>
<td>50.1</td>
<td>46.9</td>
<td>52.3</td>
<td>57.5</td>
</tr>
<tr>
<td>ADF</td>
<td>32.5</td>
<td>26.5</td>
<td>29.0</td>
<td>31.5</td>
</tr>
<tr>
<td>CP</td>
<td>17.2</td>
<td>16.0</td>
<td>22.3</td>
<td>20.8</td>
</tr>
</tbody>
</table>

*Byproduct-based diet was not fed during group 2. Determined from analysis of total mixed rations.

**Experimental design**

**Missouri**

**Growing Phase**

<table>
<thead>
<tr>
<th>Ingredients, % DM</th>
<th>F-Corn</th>
<th>F-Byp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracked corn</td>
<td>75</td>
<td>30</td>
</tr>
<tr>
<td>Dried distillers</td>
<td>14.9%</td>
<td>39.9%</td>
</tr>
<tr>
<td>Brans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Lime</td>
<td>1.54</td>
<td>1.54</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>Vitamin A premix</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Trace mineral premix</td>
<td>0.035</td>
<td>0.035</td>
</tr>
</tbody>
</table>

Nutritional analysis, % DM

| DM, % as-fed | 84.5 | 84.1 |
| NDf          | 24.4 | 42.7 |
| ADF          | 8.0  | 18.7 |
| CP           | 11.2 | 18.4 |

**Iowa State**

**Finishing phase**

First, steers were assigned to finishing phase pens (n=985 total steers, 168 finishing phase pens)

Average growing phase G:F

FE classification

<table>
<thead>
<tr>
<th>After group 6 was completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>985 total steers, 168 finishing phase pens</td>
</tr>
</tbody>
</table>

Average growing phase G:F

- Finishing phase pen
- Covariate - growing phase initial BW

FE classifications assigned within growing phase diet

- Lowly feed efficient (LFE, < 0.5 SD from G:F mean)
- Mid feed efficient (MFE, ± 0.5 SD from G:F mean)
- Highly feed efficient (HFE, > 0.5 SD from G:F mean)

Descriptive statistics of growing phase FE classifications calculated for finishing phase pens

<table>
<thead>
<tr>
<th>Pens (n)</th>
<th>25</th>
<th>41</th>
<th>24</th>
<th>24</th>
<th>34</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-F¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.180</td>
<td>0.218</td>
<td>0.258</td>
<td>0.169</td>
<td>0.196</td>
<td>0.228</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.141</td>
<td>0.203</td>
<td>0.235</td>
<td>0.144</td>
<td>0.185</td>
<td>0.211</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.202</td>
<td>0.233</td>
<td>0.298</td>
<td>0.183</td>
<td>0.208</td>
<td>0.262</td>
</tr>
</tbody>
</table>

¹Growing phase G:F for each finishing phase pen calculated using individual BW and DMI data for each steer housed in a finishing phase pen, and utilizing growing phase initial BW as a covariate in the MIXED procedure of SAS 9.3 (SAS Institute Inc., Cary, NC).
**Finishing phase G:F due to FE classification**

- No interaction effects ($P \geq 0.5$)

![Graph showing G:F due to FE classification]

**Summary-Part I**

- FE relatively repeatable across feeding phases
  - HFE > MFE > LFE
  - Corn-grown steers: DMI drove G:F
  - Roughage-grown steers: ADG drove G:F
- Growth and carcass differences
  - Limited differences in corn-finished steers
  - Differences driven by steers fed fibrous diets
  - Variation in fiber utilization?
**Introduction**

- Positive correlation between diet digestibility and feed efficiency (Nkrumah et al., 2006)
- Greater diet DM digestibility in efficient bulls and heifers (Richardson et al., 1996)
- Is diet digestibility greater in cattle with greater FE?

**Contributors to variation**

- Many physiological mechanisms contribute to FE variation between individuals (Richardson and Herd, 2004)

![Pie chart showing distribution of contributors to variation](chart.png)

**Objectives**

Determine effects of growing phase diet, growing phase FE classification, and finishing phase diet on diet digestibility and finishing phase FE.

**Experimental design**

- Two groups
  - Growing phase
    - University of Missouri
    - Corn-based (G-Corn)
    - Roughage-based (G-Rough)
    - FE phenotyped
    - Finishing phase
  - Iowa State University
    - Corn-based (F-Corn)
    - Byproduct-based (F-Byp)

**Digestibility group 1 selection**

- G-Corn – 97 steers total
- G-Rough – 94 steers total
- 12 greatest FE, 12 least FE from each diet

![Graphs showing G-Corn and G-Rough digestibility](graphs.png)
**Digestibility group 2 selection**

- G-Corn – 88 steers total
- G-Rough – 94 steers total
- 12 greatest FE, 12 least FE from each diet

![Digestibility group 2 selection graph](image)

**Timeline**

**Group 1**
- MU
- Arrival at ISU
- Harvest

**Group 2**
- Growing 70 d
- Rec. 17 d
- Trans 18 d
- Finishing 29 d
- Optaflex 28 d

**FE classification**

- Growing phase G:F values pooled from both groups
- 48 steers/diet (G-Corn, G-Rough)

- Steers ranked by growing phase G:F within diet
  - 24 greatest FE (HFE)
  - 24 least FE (LFE)

**Growing phase diet digestibility as affected by growing phase diet and FE classification**

<table>
<thead>
<tr>
<th>Item</th>
<th>LFE</th>
<th>HFE</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>65.4</td>
<td>65.9</td>
<td>65.5</td>
<td>72.4</td>
</tr>
<tr>
<td>OM, %</td>
<td>67.7</td>
<td>67.5</td>
<td>68.3</td>
<td>74.2</td>
</tr>
<tr>
<td>NDF, %</td>
<td>58.8</td>
<td>56.7</td>
<td>60.4</td>
<td>71.7</td>
</tr>
<tr>
<td>ADF, %</td>
<td>45.7</td>
<td>47.1</td>
<td>58.2</td>
<td>71.3</td>
</tr>
<tr>
<td>CP, %</td>
<td>58.9</td>
<td>57.2</td>
<td>60.4</td>
<td>65.4</td>
</tr>
<tr>
<td>Starch, %</td>
<td>85.9</td>
<td>86.0</td>
<td>91.1</td>
<td>92.8</td>
</tr>
</tbody>
</table>

**Finishing phase performance as affected by growing phase FE classification**

<table>
<thead>
<tr>
<th>Item</th>
<th>LFE</th>
<th>HFE</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW, kg</td>
<td>495</td>
<td>481</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>618</td>
<td>619</td>
<td>5.0</td>
<td>0.8</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>1.75</td>
<td>1.78</td>
<td>0.065</td>
<td>0.6</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>11.8</td>
<td>11.3</td>
<td>0.27</td>
<td>0.11</td>
</tr>
<tr>
<td>G:F</td>
<td>0.149</td>
<td>0.158</td>
<td>0.0045</td>
<td>0.04</td>
</tr>
</tbody>
</table>

**Dry matter digestibility correlations across growing and finishing phases**

<table>
<thead>
<tr>
<th>Growing phase diet</th>
<th>Finishing phase diet</th>
<th>Pearson’s correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Corn</td>
<td>0.49</td>
</tr>
<tr>
<td>Corn</td>
<td>Byproduct</td>
<td>0.25</td>
</tr>
<tr>
<td>Roughage</td>
<td>Corn</td>
<td>0.21</td>
</tr>
<tr>
<td>Roughage</td>
<td>Byproduct</td>
<td>0.68</td>
</tr>
</tbody>
</table>

**Growing phase FE classification had no effect on finishing phase diet digestibility**
**Summary- Part II**

- Is diet digestibility greater in cattle with greater FE?
  - Growing phase diet digestibility greater in HFE vs LFE
    - Driven by roughage-fed cattle
  - No growing phase FE classification effect on finishing phase diet digestibility (P > 0.6, data not shown)
  - Diet digestibility correlated between phases when grown/finished on similar diets

**Overall conclusions**

- FE was repeatable from the growing to finishing phase
  - Corn-grown steers - DMI drove G:F
  - Roughage-grown steers - ADG drove G:F
  - Negative correlation between phases in G-Rough/F-Corn steers

- Variation between FE classifications
  - Limited growth and carcass differences
  - Decreased marbling as FE improved
  - Diet digestibility influences on FE-especially roughage

**Overall implications**

- How can we use this data to manage cattle better?
  - Breeding stock selection
  - Terminal animal management
    - Phenotype
    - Genotype
      - All steers were genotyped
  - Identify cattle that excel under certain conditions
    - Diet, production environment
  - Improve economic and environmental sustainability

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**Questions?**