Dietary Strategies to Reduce Nutrient Excretion from Cattle

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Nutrient requirements

• NRC, 1984 1996
  – Give guidelines based on published research
• Levels of nutrients needed beyond guidelines
How do we manage nitrogen?
Nitrogen

- Protein requirements
- Impact of lowering dietary N
Protein Requirements

Crude Protein system

• Assumes all proteins are equal
• Important point: protein is nitrogen
• %N * 6.25, protein is ~16% N
• Does not account for bacterial needs
• It is the system that is used by the cattle feeding industry
Protein Requirements (continued)

Metabolizable Protein system

Feed protein
- urea, corn protein

NH₃ + Carbon = Microbial Protein (BCP)

Click on the video to the right to play it
Protein Requirements (continued)

Metabolizable Protein system

• DIP * TDN * microbe efficiency = BCP
• (degradable N and energy)
• Efficiency dependent on rumen pH, ~8 to 8.5 (optimal pH)
  • Typical rumen pH is 5-6

• BCP*.64 to determine protein at S.I.
• UIP * .80 to estimate protein at S.I.

• BCP + UIP = MP (TAKE HOME MESSAGE)
Protein Level

• How much urea (DIP) is being fed?
  0.8-1.4% of DM usually about 1.0%
• How much escape protein (UIP)?
  – No consistent response to supplementing high grain diets with escape protein, once DIP requirements are met
• Total CP varies from 12.5-13.5% in finishing diets
Protein Level

• Suggested levels based on:
  – Animal weight
  – Energy intake
  – Rate of gain
Protein requirements

Theory for lowering protein

- All excess protein above requirements has no value.
- Excess protein is absorbed in the small intestine.
  - Protein is deaminated in the liver (broken down).
  - Urea is subsequently excreted in urine at the kidney.
Protein requirements (continued)

- Urea is rapidly converted to ammonia following deposition. Therefore,
  - Feeding less protein leads to less urea excretion.
  - Lower urea excretion should decrease ammonia.
Protein requirements (continued)

Predicted requirement over feeding period

Body Weight, lb

<table>
<thead>
<tr>
<th>g/d</th>
<th>MP reqt.</th>
<th>DIP reqt.</th>
<th>UIP reqt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td></td>
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<tr>
<td>400</td>
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<td>1100</td>
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</tr>
<tr>
<td>1200</td>
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<td></td>
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</tbody>
</table>
Protein requirements (continued)

Requirement compared to industry average diets

Body Weight, lb

Protein requirements (continued)
Protein requirements (continued)

Change the diet to match these requirements, i.e. PHASE FEED

Body Weight, lb

MP reqt.
DIP reqt.
UIP reqt.

Protein requirements (continued)
## Performance Impacts

<table>
<thead>
<tr>
<th>ITEM</th>
<th>yearlings</th>
<th></th>
<th></th>
<th>calves</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial wt., lb</td>
<td>Con 694</td>
<td>Phase 697</td>
<td></td>
<td>Con 605</td>
<td>Phase 608</td>
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<tr>
<td>Final wt., lb</td>
<td>1242</td>
<td>1256</td>
<td></td>
<td>1264</td>
<td>1258</td>
</tr>
<tr>
<td>DM Intake, lb·d⁻¹</td>
<td>25.2ᵃ</td>
<td>24.5ᵇ</td>
<td></td>
<td>20.3</td>
<td>20.7</td>
</tr>
<tr>
<td>ADG, lb·d⁻¹</td>
<td>3.98</td>
<td>4.07</td>
<td></td>
<td>3.45</td>
<td>3.40</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>.158ᵃ</td>
<td>.166ᵇ</td>
<td></td>
<td>.170ᵃ</td>
<td>.164ᵇ</td>
</tr>
</tbody>
</table>

Source: Erickson and Klopfenstein, 2001
N Mass Balance

Average diet N, 13.5% CP
Summer-Yearlings

Feedlot pen

72.8 lb intake
7.9 lb animal
64.9 lb excreted
46.0 lb (71%) volatilized
2.1 lb (3%) runoff
16.7 lb (26%) manure

Source: Erickson and Klopfenstein, 2001

Click on the video to the right to play it
**N Mass Balance (continued)**

**PHASE-FED**
Summer-Yearlings

- **Feedlot pen**
- **59.4 lb intake**
- **51.5 lb excreted**
- **18.7 lb (36%) manure**
- **1.5 lb (3%) runoff**
- **31.3 lb (61%) volatilized**
- **7.9 lb animal**

Source: Erickson and Klopfenstein, 2001
N Mass Balance (continued)

PHASE-FED Summer-Yearlings

Feedlot pen

REDUCED 19 %

31.3 lb (61%) volatilized

1.5 lb (3%) runoff

51.5 lb excreted

REDUCED 32.5 %

7.9 lb animal

18.7 lb (36%) manure

59.4 lb intake

Source: Erickson and Klopfenstei, 2001
N Mass Balance (continued)

Average diet N, 13.5% CP
Winter/spring-Calves

Feedlot pen

81.4 lb intake

71.3 lb excreted

10.1 lb animal

29.3 lb (41%) volatilized

2.1 lb (3%) runoff

39.9 lb (56%) manure

Source: Erickson and Klopfenstein, 2001
N Mass Balance (continued)

Diet that does not exceed requirements (PHASE fed)

Winter/spring-Calves

Feedlot pen

24.9 lb (40%) volatilized

62.2 lb excreted

10.0 lb animal

72.2 lb intake

2.2 lb (3%) runoff

35.0 lb (56.5%) manure

Source: Erickson and Klopfenstein, 2001
N Mass Balance (continued)

Diet that does not exceed requirements (PHASE fed)
Winter/spring-Calves

Feedlot pen

REDUCED 15%

24.9 lb (40%) volatilized

62.2 lb excreted

10.0 lb animal

REDUCED 11.3%

72.2 lb intake

2.2 lb (3%) runoff

REDUCED 12.5%

35.0 lb (56.5%) manure

Source: Erickson and Klopfenstein, 2001
N Balance Summary

• Overfeeding protein increases N losses
• Nutrition:
  – may decrease N inputs by 10 to 20%
  – reduces N excretion by 12 to 21%
  – reduces N volatilization by 15 to 33%
• Volatilization is dependent on time of year
• Summer – 60% to 70% of N excreted
• Winter/spring – 40% of N excreted
• Based on annual occupancy, lose 50% of N excreted
Phosphorus

- P metabolism
- P requirements
- Impact of lowering dietary P
Rumen Diet P
15-45 g/d

Saliva P
~30-40 g/d

Serum (~1 g)

Intestine

Rumen

Meat & Organs
~450 g P

Bone
~2000 g P

Fecal P

Saliva P
~30-40 g/d

Diet P
15-45 g/d


700-lb steer example

Click on the video to the right to play it
NRC predicts requirements from .22 to .32% of diet DM
Dietary P in Feedlot Diets

85% corn: .27
85% corn + supplement: .35
byproduct: .52
byproduct + supplement: .59
## P Requirements

### yearlings

<table>
<thead>
<tr>
<th>feed</th>
<th>% of diet DM</th>
<th>% P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry-rolled corn</td>
<td>34.5</td>
<td>.27</td>
</tr>
<tr>
<td>Brewers grits</td>
<td>22.5</td>
<td>.08</td>
</tr>
<tr>
<td>Corn bran</td>
<td>22.5</td>
<td>.10</td>
</tr>
<tr>
<td>Ground cobs</td>
<td>7.5</td>
<td>.04</td>
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<tr>
<td>Molasses</td>
<td>5.0</td>
<td>.08</td>
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<tr>
<td>Animal fat</td>
<td>3.0</td>
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</tr>
<tr>
<td>Supplement</td>
<td>5.0</td>
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</tr>
</tbody>
</table>

Note: \( \text{NaH}_2\text{PO}_4 \) provided in supplement at increments of \(.05\%\) P

Base diet = \(.14\%\) P, and \(.19, .24, .29, .34\)

Source: Erickson et al., 1999
P Requirements (continued)

yearlings

Source: Erickson et al., 1999
P Requirements (continued)

yearlings

Source: Erickson et al., 1999
## P Requirements (continued)

### calves

<table>
<thead>
<tr>
<th>Feed</th>
<th>% of diet DM</th>
<th>% P</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-moisture corn</td>
<td>33.5</td>
<td>.32</td>
</tr>
<tr>
<td>Brewers grits</td>
<td>30.0</td>
<td>.08</td>
</tr>
<tr>
<td>Corn bran</td>
<td>20.0</td>
<td>.08</td>
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<tr>
<td>Cottonseed hulls</td>
<td>7.5</td>
<td>.11</td>
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<tr>
<td>Animal fat</td>
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</tr>
<tr>
<td>Supplement</td>
<td>6.0</td>
<td>.09</td>
</tr>
</tbody>
</table>

Note: NaH₂PO₄ provided as top-dress supplement at increments of .06% P

Base diet = .16% P, and .22, .28, .34, .40

Source: Erickson et al., 1999
P Requirements (continued)
calves

Source: Erickson et al., 1999
P Requirements (continued)
calves

Plasma P, mg/dL
Average d56-204

% P (diet DM)

Source: Erickson et al., 2001
P Requirements (continued)
calves

Source: Erickson et al., 2001
P Requirements
summary

• Cannot determine P requirements, too low
  – Bones, blood, performance

• Does the requirement matter?

• NRC recommendations for feedlot cattle are too high

• Industry has markedly overfed (relative to requirement)
  – Progress has been made

• Implications: $ & environment
Consequence of Lowering Diet P
P Mass Balance (continued)

Summer-Yearlings

.35 % P diet

10.9 lb intake

1.9 lb animal

5.3 lb excreted

Feedlot pen

12.8 lb intake

.24 % P diet

5.3 lb excreted

1.9 lb animal

7.2 lb intake

REDUCED

44 %

Source: Erickson et al., 2000
P Mass Balance (continued)

Winter/spring-Calves

- .40 % P diet
  - 12.5 lb intake
  - 7.5 lb excreted
  - 2.5 lb animal

Feedlot pen

- .26 % P diet
  - 15.0 lb intake
  - 9.9 lb intake
  - REDUCED 33 %
  - 7.5 lb excreted
  - 2.4 lb animal

Source: Erickson et al., 2000
P Balance Conclusions

• Overfeeding P leads to elevated manure P

• Nutrition may:
  – Decrease P inputs by 33 to 45%
  – Reduce P excretion by 40 to 50%
  – Directly reduce acres needed
Other Possibilities

• Phytase
• Low phytate corn
Salt

• NRC 0.2-0.3%

• CSU – two trials 0, 0.125%, & 0.25% salt
  – No difference in growth performance
  – One trial - improvement in dressing % with low or no supplemental salt
  – Feed ingredients and water met sodium requirements w/o supplementing salt
  – Linear increase in fecal sodium as salt level increased
Potassium

- Contributes to soil salinity when manure is applied to farm ground
- NRC 0.5-0.7%
- CSU study 0.4, 0.6, 0.8% K with no supplemental salt
  - No difference in growth performance
  - Improvement in quality grade with lower K
Summary

• Nutrition can have major impact on N and P excretion for feedlot cattle
  – Utilizing MP system may lower N excretion
  – Decreased urinary N excretion does decrease N volatilization losses
  – Volatilization is a concern
• Fine-tuning requirements on the MP system is needed
• Eventually, metabolizable amino acids will be useful similar to ideal protein concept in monogastrics
• Supplementation of P is unnecessary
• Difficult to reduce P level below corn baseline