Nutritional Strategies to Reduce Nutrient Excretion and Odor in Beef, Dairy, and Swine Operations

Dr. Greg Lardy
or

Precision Nutrition for Livestock Feeding Operations
Outline

• Introduction
• What nutrients should we be concerned with?
  • Phosphorus
  • Nitrogen
• Dietary strategies to minimize excretion
Nutritional Strategies in Beef Cattle Operations
P Metabolism in Beef Cattle

P Requirements

- 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
P Mass Balance For a 10,000 Head Feedlot

.35 to .40% P
234,000 lb/yr

15,690 acres

Assume:
50% of surrounding land used
30 lb/ac P applied (agronomic)
10,000 hd feedlot, 90 acres

.22 to .30% P
128,000 lb/yr

8,624 acres

Assume: (same)
Protein Requirements

Crude Protein (CP) System

• Assumes all proteins are equal
• Important point: protein is nitrogen
• %N * 6.25, protein is ~16% N
• Does not account for bacterial needs in ruminants
• Is simple, but incorrect
Protein Requirements

Metabolizable Protein (MP) System

Feed protein
urea, corn protein

RUMEN

NH$_3$ + Carbon = Microbial Protein (BCP)

DIP

UIP

DIP

BCP

BCP

MP $\rightarrow$ SMALL INTESTINE

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Protein Requirements

Predicted requirement over feeding period

Body Weight, lb

MP reqt.
DIP reqt.
UIP reqt.
Protein Requirements

Requirement compared to industry average diets

Body Weight, lb

g/d

- MP reqt.
- DIP reqt.
- UIP reqt.
Protein Requirements

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

Body Weight, lb

MP reqt.
DIP reqt.
UIP reqt.

MP reqt.
DIP reqt.
UIP reqt.
N Mass Balance Phase-Fed Yearlings (Summer)

Intake: 59.4 lb

- Animal: 7.9 lb
- Manure: 1.5 lb (3%)
- Runoff: 31.3 lb (61%)
- Volatilized: 32.5 lb (61%)

Excreted: 51.5 lb

- Manure: 18.7 lb (36%)
- Runoff: 1.5 lb (3%)

Reduction:
- Feedlot pen: 19% Reduced
- Manure: 32.5% Reduced

Source: Erickson and Klopfenstein, 2001
N Mass Balance Phase-Fed Calves in the Winter-Spring

Feedlot pen

PHASE fed

REDUCED 15 %

2.2 lb (3%) runoff

REDUCED 12.5 %

35.0 lb (56.5%) manure

62.2 lb excreted

24.9 lb (40%) volatilized

10.0 lb animal

72.2 lb intake

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%
N balance Summary (continued)

• 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
The Challenge for Dairy Producers

- Properly formulate rations to
  - Optimize milk yield
  - Minimize N, P, and K excretion in urine/manure
Effect of P Intake on P Excretion

- Increasing P content from 0.40% to 0.60% of diet dry matter increases P output from 40 to 69 lbs/cow/year!
- Lactating cows require ~0.40%
Protein Degradability and N Excretion

- RDP: rumen degradable protein
- Diets with high RDP result in greater excretion of N in manure
- Diets need adequate RUP (rumen undegradable protein), or "escape" protein

N excretion (lb)

<table>
<thead>
<tr>
<th></th>
<th>Low RDP</th>
<th>High RDP</th>
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<tbody>
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<td>200</td>
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The Bottom Line

- The amount of N, P, and K in the diet has a HUGE effect on the yearly excretion of these nutrients.
Milk Production and Land Needed

• As milk yield increases, so do nutrient requirements and nutrient excretion

• For herds producing 70 to 100 lbs of milk, a 100-cow group will require 140-170 acres to manage N
  • ~1.5 acres per cow

• Need at least 2.25 acres per cow for P
Dietary N and P: Effect on Land Needed

• 19.5% CP diet (alfalfa, no supplemental RUP) vs. 17.0% CP (using RUP) results in 20% more N in manure and 20% more land needed
  • For 100-cow group, you would need up to 25 acres more land

• Dietary P ranging from 0.43% to 0.52% results in 30% more land needed
  • 100-cow group needs 50 more acres of land
Use Sources of Phosphorus With High Availability

- High availability
  - Monocalcium phosphate
  - Dicalcium phosphate
  - Monosodium or ammonium phosphate
- Medium availability
  - Steamed bone meal
  - Sodium tripolyphosphate
- Low availability
  - Low-fluorine rock phosphate
  - Soft rock phosphate
Phytate Phosphorus

- Phytate-P is not readily available to nonruminants such as swine
  - Generally found in plant forms of P
- Rumen microbes produce phytase
  - Releases P from phytate
- Phytate-P is available to ruminants
RUP and RDP Requirements

• Lactating cows require proper balance of RUP and RDP to meet requirements for metabolizable protein (MP)

• MP is the protein that the cow actually absorbs and uses for production

• Requirement for RUP = 35% to 38% of CP

• Requirement for RDP = 62% to 65% of CP
The Bottom Line

- Are high milk yield and minimal nutrient excretion mutually exclusive?
- No, you can do both!
- Focus on
  - Testing all forages/feeds
  - Properly formulating rations
  - Soil testing
  - Proper soil fertilization
  - Maximizing feed intake
  - Cow comfort and proper grouping
Nutritional Strategies in Swine Operations
Nutrition: The Simple Way to Reduce Nutrient Excretion

• Under field conditions, animals use nutrients with mediocre efficiency:
  – Phosphorus: 30%
  – Nitrogen: 30% to 35%

• Under lab conditions:
  – Phosphorus: almost 100%
  – Nitrogen: 70%

• There is a lot of potential for reducing waste
Feed Waste: An Expensive Waste of Nutrients

- Feed waste:
  - Adherence: pigs take 1.5 g feed away from feeder 60 times per day (~ 4% of “intake”)
  - Spillage: pigs push 3.4% of feed out of feeder (practical range 1.5% to 20%)
Not All Nutrients in the Diet Are Digested

- For a typical diet, 8% of protein and 70% of phosphorus is not digested
  - Indigestible proteins are fermented in large intestines
    - Contribute to odor
    - Remains are excreted
    - Contribute to waste
## Select Highly Digestible Ingredients

<table>
<thead>
<tr>
<th>Feed Ingredient</th>
<th>Protein Digestibility, %</th>
<th>Protein Content, %</th>
<th>Phosphorus Digestibility, %</th>
<th>Phosphorus Content, %</th>
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<tbody>
<tr>
<td>Corn</td>
<td>85</td>
<td>8.5</td>
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<tr>
<td>Soybean meal 48</td>
<td>87</td>
<td>49.0</td>
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<td>Soybean meal 44</td>
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<td>Wheat</td>
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<td>Barley</td>
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<td>Meat &amp; bone meal</td>
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<td>Poultry byproducts</td>
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<td>Fish meal</td>
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<td>Dicalcium phosph</td>
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<td>18.50</td>
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Opportunities to Improve Digestibility

- Processing feed properly
  - Grinding
  - Pelleting
- Addition of exogenous enzymes to improve digestibility
  - Phytase
  - Xylanase or beta-glucanase
    - Wheat or barley based diets
Maintenance Results in Waste

- Feed provided
- Feed consumed
- Intestinal secretions (enzymes, cells)
- Nutrients absorbed

Waste
- Feed waste
- Inefficiencies
- Undigested feed and secretions
- Maintenance

• Maintenance is obligatory
  • Basic function of life
• Nutrients used for “maintenance” are ultimately catabolized (broken down)
  • Maintenance requirement depends on size of animal
Reduce Relative Maintenance Costs by Increasing Gain

• By improving daily lean gain, maintenance waste becomes relatively less important
  • Optimize production
    • Optimize management
    • Optimize animal health
    • Optimize nutrition, etc.
Base Formulations on Available Nutrients

Availability of nutrients is not uniform

- N > P, and Lys > Cys in typical feed
- Presuming all nutrients are equally available increases waste

Diets formulated on total or digestible amino acids
Match Diet to Animal’s Requirement

- Nutritional requirements change with:
  - Maintenance requirement (affected by sex, age, and weight)
  - Gain and composition of gain
  - Health status, environmental conditions, and activity
Match Diet to Animal’s Requirement

- Examples
  - Split-sex feeding
    - Barrows require more energy for maintenance than gilts
    - Increase energy to protein ratio of the feed for barrows
Where Does All of the Waste End Up?

- Feces contain the remnants of the digestive process
  - Undigested feed
  - Endogenous losses
    - Odor
  - Excess zinc and copper
    - Excreted through bile and excreted as feces
  - Uptake of calcium and phosphorus is regulated
    - Excess is excreted in feces
Where Does All of the Waste End Up?

- Urine contains the remnants of metabolism
  - Urea from protein breakdown
  - Some diverted to feces
  - Excess potassium, sodium, and chlorine
Summary

- Nitrogen and phosphorus are key nutrients to focus on
- Nutrient excretion can be reduced by proper nutrition
  - Feed to animal’s requirements
  - Test feedstuffs
  - Reduce feed waste
Questions??
Acknowledgements

This presentation was adapted from the LPES curriculum which is available at:
http://www.lpes.org/