Metabolic Disease and the Role of Nutrition

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Presentation Outline

• Overview of meeting the transition challenge – historical perspectives on possible causes and solutions
• Our goal for today is to address role of key macronutrients relative to transition metabolism
  o Energy metabolism – carbohydrates and lipids
  o Protein metabolism – the missing link?
• Set stage for guiding principles in formulating macronutrient components for a successful transition
The Transition Challenge

“The transition from the pregnant, nonlactating state to the nonpregnant, lactating state is too often a disastrous experience for the cow...”

J.P. Goff and R.L. Horst. JDS 1997;80:1260-1268

The Transition Problem

- Economic strain on dairy herds due to:
  - Milk losses
  - Milk composition alterations
  - Treatment costs
  - Death and increased involuntary culls
  - Impaired reproduction

More than 50% of all calvings experience one or more health events during transition – highly variable between herds
**Transition Period Goals**

- Support high (efficient) milk production
- Minimize loss ($<0.5$ units) or maintain BCS postpartum
- Low prevalence of postparturient diseases
- Maintain immunocompetency to pathogens
- Control/decrease days to first ovulation and maintain/enhance fertility
- Low stillborn rate and healthy calves

**Identified Nutritional Control Points in Managing Transition Success**

- Minimize drop in prepartum DMI
  - Improved postpartum DMI
  - Minimize increase in NEFA
- Adequate dietary supply of ME and MP
  - Based on observed intake and accounts for variation
- Minimize risk of hypocalcemia
  - Hypocalcemia gateway disease
  - Compromises immune cell function
- Maintain the immune response
What are the impediments to a successful transition?

Intake variation

Grouping strategies

Feeding management

Environmental stressors

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Transition Cow Problems

(Adapted from Erb et al. 1989; Curtis et al. 1995; Correa et al. 1990)
Transition Cow Problems

• Nutritional causes have only been attributed to 15% of problem situations (Nordlund, U. Wisconsin)

• What are the major causes of transition cow problems?
  o Impeding normal cow behaviors
  o Excessive stocking density
  o Too many pen moves

Historical Perspectives

To understand where we are going requires we know where we have been.
Grouping Management Approaches

• “Management by neglect” - “Out on the back 40”
• No separation – fed with low lactation group
• Multiple grouping strategies
  o Far off / Close-up
  o Parity
  o Special needs
• Limited dry period (30-40 days)
• No dry period between lactations

Van Saun, 1993
**Intake and Energy Approaches**

- Maximize intake to ensure adequate energy intake (Bertics et al., 1992)
- Increase dietary NFC content to maximize feed intake (Minor et al., 1998)
- Minimize drop in DMI, restrict rate of feeding (Holcomb et al., 2001)
- Meet, but not exceed energy requirement in far off dry period (Controlled Energy diets; Drackley and Janovick-Guretzky, 2007)

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**Metritis Effects on Intake**

![Graph showing the effect of metritis on dry matter intake.](image)

- Dry matter intake, kg
- Week relative to calving

**Wk x Health**

- Healthy
- Sick

- $P = .02$
- 186 kg
- -0.72 BCS
- 382 kg 4% Milk

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*Van Saun et al., 2006*
Protein Feeding Strategies

• NRC (1989, 2001) requirement < 12% DM
• Maintain minimum of 12% to ensure fiber fermentation (9.5-10.5% RDP)
• Is additional dietary protein advantageous?
  o Many studies show no effect for mature cows
  o Higher protein (14.7%) for heifers
  o Why the differences?
  o What was study end points?
• Need to formulate for metabolizable protein (MP)

Daily Intake Variation

Median : 13.5 kg/d
STD: 3.1 kg/d

Van Saun, 1993
The Transition Challenge

“The well-being and profitability of the cow could be greatly enhanced by understanding those factors that account for the high disease incidence in periparturient cows.”

J.P. Goff and R.L. Horst. JDS 1997;80:1260-1268

Productive State Prioritization

Homeorhetic Regulation

- Maintenance
- Pregnancy – birth weight
- Lactation
- Frame Growth

Mature Cows

Heifers

- Minimal Nutrient Reserves
- Reproductive Cyclicity
- Immune Function

Metabolic and Infectious Diseases
Periparturient Disease

- Inciting causes:
  - Negative energy balance
  - Excessive fat mobilization
  - Inflammation?

- Confounding issues:
  - Excess body condition
  - Insulin resistance (?)
  - Environmental stressors
  - Inflammation?

Disease Incidence (%)
- Low NEFA (741 cows)
- Medium NEFA (435 cows)
- High NEFA (380 cows)

P<.01
P=.03
P=.9
P<.01
P<.01
P<.01

Dyk et al., JDS 1995

Periparturient Disease

Homeorhetic Adaptation from Pregnancy to Lactation

- Glucose
  - Energy currency
  - Insulin regulation of tissues
  - Regulator of ketogenesis

- Fatty acids
  - Excessive mobilization
  - Hepatic processing
  - Insulin sensitivity & stress factors

- Amino acids
  - Gluconeogenesis
  - Hepatic lipid transport
  - Immune function

- Calcium
  - Intake controller
  - Disease contributor

Bell, JDS 73:2804; 1995
Maternal Tissue Nitrogen Partitioning in Pregnant Ewes

McNeil et al., 1997
### Nutrient Intake Comparisons

<table>
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<tr>
<th></th>
<th>Low Protein</th>
<th>Mid Protein</th>
<th>High Protein</th>
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<tbody>
<tr>
<td>DMI, kg</td>
<td>1.02</td>
<td>1.16</td>
<td>1.37</td>
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<tr>
<td>% of BW</td>
<td>1.65</td>
<td>1.87</td>
<td>2.21</td>
</tr>
<tr>
<td>ME, Mcal/kg</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Mcal/day</td>
<td>2.2</td>
<td>2.7</td>
<td>3.3</td>
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<tr>
<td>Crude Protein, %</td>
<td>7.9</td>
<td>11.6</td>
<td>15.7</td>
</tr>
<tr>
<td>g/day</td>
<td>81</td>
<td>141</td>
<td>215</td>
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<tr>
<td>NDF, %</td>
<td>42.9</td>
<td>41.5</td>
<td>39.3</td>
</tr>
<tr>
<td>% of BW</td>
<td>0.71</td>
<td>0.78</td>
<td>0.89</td>
</tr>
</tbody>
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NRC Requirement:
- 1.7 kg DMI
- 3.94 Mcal ME
- 183 g CP
- 2.6% BW
- 2.32 Mcal/kg
- 10.8 %

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**The Transition Challenge**

So, where does this leave us?
Transition Triad

Management
- Body condition, hygiene
- Grouping strategies
- Pen moves
- Feeding management
- Animal evaluations

Environment
- Feed bunk space
- Stall design, comfort
- Social disruption
- Heat abatement
- Overcrowding
- Pathogen exposure

Nutrition
- DMI
- Ca homeostasis
- Energy density
- MP adequacy
- Nutrient balance
- Micronutrient status
- Water

Transition Formulation Guidelines

- Ensure all transition cows have sufficient opportunity to consume a properly balanced diet
- Formulate dietary nutrient density for observed dry matter intake and compensate for variation
  - Increase MP content at average intake
- Formulate dietary carbohydrates to meet but not exceed energy needs (<120% Requirement) especially in far off diet
  - Dietary NDF intake (0.6 – 0.9% BW prefresh); 0.8 – 0.95% BW far off)
  - Do not increase dietary starch from prefresh to fresh diets by more than 10%
- Minimize dietary lipid content (<5% DM)
Consider the following issues:

- Minimize stressor factors
  - Heat stress – heat abatement necessary for dry cows
  - Overcrowding – ensure adequate feed bunk space (30 in+/cow)
  - Social interactions – water #s, regrouping, cow space
  - Cow comfort – stall size, bedding
- Body condition score management
  - Minimize (<10%) fat (>3.75 BCS) and thin (< 3.0 BCS) cows
- Minimize the opportunity for the cows to “make decisions” on what to eat as their diet

What’s to come?

- Provide more detailed information on specific nutrient issues for transition cow diets
  - Carbohydrates – energy delivery and intake limitation
  - Lipids – roles in intake regulation, physiologic functions related to inflammation
  - Proteins – integrative role in metabolism and inflammation
  - Minerals – calcium homeostasis and hypocalcemia control
  - Trace minerals and vitamins – roles in fetal and maternal metabolism, immunity
- Diagnostic approaches to transition cow programs to define role of nutrition