Nursery calf feeding and management strategies to promote starter intake and intestinal health

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Fecal Culture Summary From Dairy Calves with Scours

% of total cases

- Cryptosporidium: 66%
- Rotavirus: 34%
- Salmonella: 9%
- Coronavirus: 18%
- Coccidiosis: 5%
- Combinations of Pathogens: 36%
Calf Rumination Time

Average rumination frequency

Week

1 2 3 4 5 6 7
Calf Performance Has Never Been More Important
Enhancing GI tract health and development

• Concepts:
  - Factors in milk replacer and starter that stimulate early gut development and health
    - Starter and MR composition and feed additives
    - Feeding and management strategies
  - Impact of GI tract development on
    • Growth
      - Efficiency of nutrient utilization
    • Rearing costs and return on investment
Effects of a modified intensive milk replacer program fed two or four times daily on nutrient intake, calf growth, and health

A.D. Kmicikewycz¹, D. da Silva¹ and N.B. Litherland¹

¹Department of Animal Science
University of Minnesota
Treatments

1. **STD2 (control):** 20:20, 1.5% of birth BW, fed 2 X (0600 and 1700 hrs)
2. **STD4:** 20:20, 1.5% of birth BW, fed 4 X (0600, 1100, 1400 and 1700 hrs)
3. **MOD2:** 26:18, 2.00% of birth BW, fed 2 X (0600 and 1700 hrs)
4. **MOD4:** 26:18, 2.00% of birth BW, fed 4 X (0600, 1100, 1400 and 1700 hrs)
Treatments

• **MR feeding rates:**
  - Diets were adjusted weekly based on body weight
  - Fed at 15% solids

• **Conventional diets:** 1.5% of birth BW 1–35d
  - 2x diets: 1700h meal dropped at 36d
  - 4x diets: 1400 and 1700h meal dropped at 36d

• **Modified diets:** 1.5% of birth BW 1–10d; 2.0% of birth BW 11–35d
  - 2x diets: 1700h meal dropped at 36d
  - 4x diets: 1400 and 1700h meal dropped at 36d
## Animal Description

<table>
<thead>
<tr>
<th>Treatments</th>
<th>STD2</th>
<th>STD4</th>
<th>MOD2</th>
<th>MOD4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves per Treatment</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Breed</td>
<td>4 Holstein 8 X-bred</td>
<td>5 Holstein 7 X-bred</td>
<td>3 Holstein 9 X-bred</td>
<td>4 Holstein 8 X-bred</td>
</tr>
</tbody>
</table>
Total Protein (mg/dL)

- Total Protein (mg/dL)
  - 1
  - 2
  - 3
  - 4

Total Protein (mg/dL)

- Total Protein (mg/dL)
  - Holstein
  - Cross-bred

Birth Body Weight (kg)

- Birth Body Weight (kg)
  - 1
  - 2
  - 3
  - 4

Birth Body Weight (kg)

- Birth Body Weight (kg)
  - Holstein
  - Cross-bred

Breed $P = 0.1142$

Breed $P < 0.05$

$P = 0.9664$

$P = 0.9054$
Predicted ADG

Assumptions
- 45 kg calf
- 0.90 kg of starter
- 0°F temperature

(NRC, 2001)
ADG (kg/d)

Treatment

STD2  STD4  MOD2  MOD4

ADG d 1-42, kg/d

ADG d 1-56, kg/d

ADG d 1-42; treatment $P = 0.39$
ADG d 1-56; treatment $P = 0.18$
Starter Intake

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter Intake, kg</td>
<td>STD2</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>STD4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOD2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOD4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Starter Intake (kgs) vs Week

(* Treatment x Week interaction P = 0.001)
## Structural Growth Measurements

<table>
<thead>
<tr>
<th>Item</th>
<th>STD2</th>
<th>STD4</th>
<th>MOD2</th>
<th>MOD4</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Height, cm</td>
<td>86.3</td>
<td>85.4</td>
<td>86.5</td>
<td>86.7</td>
<td>0.99</td>
<td>0.82</td>
</tr>
<tr>
<td>Hip Width, cm</td>
<td>20.5</td>
<td>20.0</td>
<td>20.9</td>
<td>21.1</td>
<td>0.37</td>
<td>0.21</td>
</tr>
<tr>
<td>Wither Height, cm</td>
<td>82.3</td>
<td>81.6</td>
<td>82.5</td>
<td>82.8</td>
<td>0.92</td>
<td>0.78</td>
</tr>
<tr>
<td>Heart Girth, cm</td>
<td>91.2</td>
<td>90.6</td>
<td>91.7</td>
<td>92.4</td>
<td>1.34</td>
<td>0.79</td>
</tr>
<tr>
<td>Body Length, cm</td>
<td>71.9</td>
<td>71.4</td>
<td>72.6</td>
<td>72.8</td>
<td>1.05</td>
<td>0.77</td>
</tr>
</tbody>
</table>

- There was a tendency ($P = 0.08$) for a treatment $\times$ week interaction of wither height.
## Estimated Costs

<table>
<thead>
<tr>
<th>Treatment</th>
<th>STD2</th>
<th>STD4</th>
<th>MOD2</th>
<th>MOD4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost ($)</td>
<td>156.47</td>
<td>186.47</td>
<td>209.43</td>
<td>239.43</td>
</tr>
</tbody>
</table>

- **Costs include milk replacer and labor**
  - 3min/calf/feeding ($9.00/hr)
- **20:20 = $1.30/lb**
- **26:18 = $1.46/lb**
Significance

• Feeding 4x: ↑ starter intake when calves were fed a 20:20 MR
  - 5.2 kg additional body weight gain for calves fed 4x vs. 2x daily through day 56

• Calves fed the modified accelerated (MOD2 and MOD4) program showed small growth differences over the conventional milk replacer program
  - Effects of cold stress on nutrient use?
Exploring Milk Replacer and Starter Additives

- **Goal**: Find an additive or a combination of additives that:
  - Consistently and measurably improves calf performance
  - Is palatable and affordable
  - Position additives for optimal effect
Effects of milk replacer and starter additives on dairy calf performance

A.D. Kmicikewycz¹ and N.B. Litherland¹
¹Department of Animal Science
University of Minnesota
ADG

ADG kg/d

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CON</th>
<th>MR</th>
<th>S</th>
<th>MRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG d 1-42, kg/d</td>
<td>0.40</td>
<td>0.35</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>ADG d 1-56, kg/d</td>
<td>0.45</td>
<td>0.40</td>
<td>0.35</td>
<td>0.40</td>
</tr>
</tbody>
</table>

ADG d 1-42; treatment $P = 0.45$
ADG d 1-56; treatment $P = 0.47$
Rumen Fluid Supplementation to Nursery Calves

- 8 mL of RF daily (0 to 6 wk of age)
  - Higher ADG
  - Fewer days scouring

- **Mechanism:**
  - Not a probiotic response (autoclaved)
  - Likely:
    - Bacterial polysaccharides
    - Organic acids

*Muscato et al., 2002*
Prebiotics

• **Definition**- a nondigestible food ingredient that beneficially alters the host by stimulating the growth or activity of bacteria.

• **Summary of literature**:  
  - Some benefits  
  - Inconsistent response  
    • Terre et al., 2007; Heinrichs et al., 2003; Quigley et al., 2002; Donovan, 2002  
  - Impact on immune function is not established
Supplemental Yeast Culture for Nursery Calves

• Yeast culture added to starter
  - 0, 1 or 2% of DM (0 to 42 days)
• 2% YC
  - Improved starter intake
  - Improved ADG by 16%
  - Slight improvements in rumen epithelial development

Lesmeister et al., 2004
Probiotics

- Definition- live microbial feed supplement which beneficially affect intestinal health.

- Summary of Literature:
  - Mode of action is unknown
  - Beneficial in stressed/sick calves
  - Limited research evaluating immune function.
### Effects of Probiotics on Calf Performance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Probiotic</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final BW Kg</td>
<td>77.6(^a)</td>
<td>78.5(^b)</td>
<td>0.24</td>
</tr>
<tr>
<td>ADG: Wk 1 to 8 g/d</td>
<td>610(^a)</td>
<td>626(^b)</td>
<td>4.56</td>
</tr>
<tr>
<td>DMI: Wk 1 to 8, kg</td>
<td>52.2</td>
<td>52.4</td>
<td>0.17</td>
</tr>
<tr>
<td>Feed Efficiency</td>
<td>1.63(^a)</td>
<td>1.52(^b)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Timmerman et al., 2005
Supplemental dried bovine colostrum in milk replacer fed dairy calves

<table>
<thead>
<tr>
<th>g of IgG/d</th>
<th>0</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, kg/d</td>
<td>0.63</td>
<td>0.67</td>
<td>0.65</td>
</tr>
<tr>
<td>Prevalence of Scours d 7-13, %</td>
<td>36%</td>
<td>34%</td>
<td>32%</td>
</tr>
<tr>
<td>Prevalence of Scours d 7-13, %</td>
<td>39</td>
<td>30</td>
<td>35</td>
</tr>
</tbody>
</table>

No difference in fecal shedding of pathogens

Bielman et al., 2009
Varying proportions of MR Fatty Acids

• Compared to whole milk:
  - MR is higher in $C_{16:0}$, $C_{18:0}$, and $C_{18:1}$
  - MR is lower in $C_{4:0}$, $C_{18:2}$, and $C_{18:3}$

• Potential health benefits of
  - SCFA
  - Essential fatty acids
    • Antimicrobial and antiviral properties
    • May alter digestibility and intake
Butyrate

• Butyric acid is a natural organic acid
  – Present in the fore-stomach of ruminants.
  – 0.16 g/L in cows milk
• Functional role:
  – Growth, digestibility, feed efficiency, proliferation, differentiation, and function in the GIT
Sodium-butyrate function in the lower gut:
- Stimulate defense systems
- Modify immune and inflammatory responses
- Influence intestinal micro-flora
## Butyrate Supplementation in Calf Milk Replacers

<table>
<thead>
<tr>
<th>Item</th>
<th>Milk Replacer</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Control</td>
<td>Butyrate</td>
<td>P &gt; F</td>
<td>SE</td>
</tr>
<tr>
<td>BW gain, g/d 0 to 42 d</td>
<td>518</td>
<td>540</td>
<td>0.05</td>
<td>14</td>
</tr>
<tr>
<td>Starter intake, g/d 0 to 42 d</td>
<td>338</td>
<td>347</td>
<td>NS</td>
<td>23</td>
</tr>
<tr>
<td>Abnormal fecal score days 0 to 28 d</td>
<td>10.2</td>
<td>9.0</td>
<td>0.05</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Hill et al., 2007
Lactoferrin

- Iron binding compound normally found in colostrum and milk (Masson and Heremans, 1971)
  - Colostrum contains 2 mg/mL
- Bacteriostatic against *E. Coli* and *Rotavirus*
- Limited data available
  - Roblee et al., 2003
  - Cowles et al., 2006
Conflicting Viewpoints Regarding Elevated Plane of Nutrition

• “Provision of additional nutrients may exacerbate health problems and cause anorexia”. Johnson, 1998

• Additional milk replacer fed to calves challenged with coronavirus:
  - Resulted in greater BW gain
  - Increased incidence of diarrhea
Synergistic effects of additives on calf health and growth

• Combinations of feed additives may provide an additive response.

• Need to identify affordable and effective combinations.
Incomplete List of Factors Impacting Results

• Season
• Calf origin and immune status
• Feeding management
  – Nutrient profile
  – Amount of solids
  – Feeding consistency
• Intensity of measurement
Feeding Management
Am I missing something?
Automated Calf Feeders Offer New Opportunities and Challenges
Interesting changes in the field
New antibiotic use regulations

- **Prior to April 1, 2010**
  - 2:1 ratio of neomycin sulfate:oxytetracycline (NT)

- **Post April 1, 2010**
  - 1:1 NT (0.05 to 0.10 mg/lb of BW)
    - Improved growth efficiency
  - 1:1 NT (10 mg/lb of BW)
    - Treatment of scours (*E. Coli*) and bacterial pneumonia (*P. multocida*)
Positioning Antibiotics in MR

- 2009 Feed Additive Compendium dictates that 1:1 ratio of N:T (1600:1600 g/ton) can be fed:
  - Minimum of 7 days
  - Maximum of 7 days
Impact of new antibiotic regulations on calf performance

- Antibiotics in MR were effective in improving performance and health of calves.
  (Morrill et al., 1977; Quigley et al., 1997; Heinrichs et al., 2003; Berge et al., 2005)
- 57.5% of all operations surveyed used medicated MR
  USDA-NAHMS, 2007
Growth an health of calves pre- and post-weaning fed milk replacers with differing levels of neomycin sulfate and oxytetracycline

N. Litherland¹, D. Carlson², D. Ziegler³, B. Ziegler⁴, D. Schimek⁴, M. Raeth-Knight¹, G. Golombeski¹, H. Chester-Jones³, and J. Linn¹

¹University of Minnesota, St Paul, MN ²Milk Products LLC, Chilton, WI, ³University of Minnesota, SROC, Waseca, MN, ⁴Hubbard Feeds Inc., Mankato MN,
Introduction

• Previous work by our group showed that removal of NT from MR at 14 d reduced growth compared to feeding NT through d 42.
• Does feeding a high rate of NT in MR benefit calves beyond 14 days of age?
Objectives

• Evaluate growth and health of calves fed MR containing varying amounts of NT for varying amounts of time:
  - Day 1-42
  - Day 1-14
  - Day 1-14 and 16-28
# Treatment Time-line

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>TRT2</th>
<th>TRT3</th>
<th>TRT4</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 1-14</td>
<td>400:200 g/ton</td>
<td>Non-med.</td>
<td>1600:1600 g/ton</td>
<td>1600:1600 g/ton</td>
</tr>
<tr>
<td>D 16-28</td>
<td>400:200 g/ton</td>
<td>Non-med.</td>
<td>Non-med.</td>
<td>1600:1600 g/ton</td>
</tr>
</tbody>
</table>
Materials and Methods

- Holstein heifer (N = 100) calves
- Fed 20:20 MR twice daily d 1-35
  - 0.57 kg/d (~1.25% of BW)
- Fed MR once daily d 36-42.
  - 0.28 kg/d (~0.625% of BW)
- 18% texturized calf starter (free-choice)
- Water free choice
Total Body Weight Gain

Means without common superscripts are different at P < 0.05
Average Daily Gain d 1-56

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ADG, kg/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
</tr>
<tr>
<td>3</td>
<td>bc</td>
</tr>
<tr>
<td>4</td>
<td>ac</td>
</tr>
</tbody>
</table>
Bi-weekly ADG, Kg/d

ADG, kg/d

1 > 2,3
P < 0.05

3, 4 > 2,
P < 0.05

Day

1 to 14
15 to 28
29 to 42
43 to 56

Control

2

3

4
Total Starter Intake

SEM = 1.1

SEM = 1.8

Starter Intake, kg

d 1 to 42

d 1 to 56
## Total Dry Matter Intake, Kg

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>TRT2</th>
<th>TRT3</th>
<th>TRT4</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>d 1 – 14</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.01</td>
</tr>
<tr>
<td>d 15 – 28</td>
<td>0.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.04</td>
</tr>
<tr>
<td>d 29 – 42</td>
<td>1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.2&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.05</td>
</tr>
<tr>
<td>d 43 – 56</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Means without common superscripts are different at P < 0.05
Scouring days (days with a fecal score $\geq 3$)

$\text{SEM} = 0.45$
Means without common superscripts are different at $P < 0.05$
Summary

Calves fed increasing amounts and duration of NT and OT:
- Grew more efficiently
- Ate more starter
- Had fewer days scouring
Conclusions

• The future of antibiotics use in MR remains unclear
• Non-medicated MR additives that promote growth and health should be explored
Questions?

Happy calves come from Minnesota!
Effects of Yeast Culture in Nursery Calves fed whole milk

- 2% YC in starter
- Fed pasteurized milk (d 2-60)
- “Almost all calves scoured”
- No difference:
  - Starter intake, ADG, immune function
- YC improved fecal scores
  - Improved income of $48/calf

Magalhães et al., 2008
Effects of changing the fat and fatty acid composition of MR fed to neonatal calves

• Replacing animal fat in MR with butyrate and coconut oil and canola oil
  - Improved growth rates
  - Reduced fecal scour days

• Reasons:
  - Improved gut health
  - Greater starter intake

Hill et al., 2007
Short-chain FA’s may improve lower gut health

- SCFA are produced by normal bacteria in the lower gut
- The presence of SCFA’s in the intestinal lumen are important for:
  - Structural and functional development
  - Nutrient absorption
  - Regulation of osmolarity
Benefits and risks of feeding a higher plane of nutrition

- Accelerated MR and whole milk fed calves:
  - Greater energy for immune function before reductions in growth occur
  - Greater flushing of GI-tract
## Initial Measurements

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>TRT2</th>
<th>TRT3</th>
<th>TRT4</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serum Protein, mg/dL</strong></td>
<td>5.59</td>
<td>5.38</td>
<td>5.47</td>
<td>5.19</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>Initial BW, Kg</strong></td>
<td>40.2</td>
<td>40.3</td>
<td>40.0</td>
<td>39.1</td>
<td>0.81</td>
</tr>
<tr>
<td><strong>Initial Hip Height, cm</strong></td>
<td>81.0</td>
<td>80.8</td>
<td>80.3</td>
<td>80.8</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Total Body Weight, Kg

Day

Control

2

3

4

BW, kg

14 28 42 56

0 10 20 30 40 50 60 70 80 90
Hip-Height Gain d 0-56, cm

SEM = 0.48

Control 2 3 4

HH gain, cm

Treatment
Gain:feed

SEM = 0.04

SEM = 0.03

d 1 to 42

d 1 to 56

Control
TRT2
TRT3
TRT4

a
b
ab