Managing the critical control points of the calf operation

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What are the critical control points?

• Successful passive transfer of immunity
• Meeting the nutrient requirements to achieve the genetic potential for calf growth.

Colostrum management - briefly

• Quality - >85% of colostrum with >50g of IgG/liter
  • >22 on Brix Refractometer

• Low bacteria counts
  • <100,000 cfu/ml – standard plate count

Timing – How fast do bacteria reach the small intestine?

It’s a race between colostrum and bacteria – from colostrum and environment
Total Bacteria Counts in Minnesota Colostrum
(Swan et al. 2007. JDSci. 90)

Median TPC = 615 million cfu/ml (73 to 104 billion)
93% of samples > 100,000 cfu/ml TPC

“We are feeding ‘fat-laden’ manure” Rob Trembley, 2006

Recent UMN Field Study
M. Donahue, S. Godden 2012

• 1,000 calves / 6 herds
  • ½ fed raw and ½ fed heat-treated colostrum
  • Colostrum total plate count and serum IgG – negative
  • Colostrum IgG concentration – positive
  • Heat treatment – positive – independent of Total plate count
  • Colostrum Total Coliform Count and risk of scours – positive.

Characteristics of calf and colostrum

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fresh (n=518)</th>
<th>Heat-treated (n=553)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving ease (1-5)</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Age at 1st feeding (min)</td>
<td>47.5</td>
<td>50.0</td>
</tr>
<tr>
<td>IgG in Colostrum (mg/ml)</td>
<td>63.9</td>
<td>61.1</td>
</tr>
<tr>
<td>TPC in Colostrum (cfu/ml)</td>
<td>515,000</td>
<td>2,100</td>
</tr>
<tr>
<td>TCC in Colostrum (cfu/ml)</td>
<td>51,500</td>
<td>90</td>
</tr>
</tbody>
</table>

Quantity – Mass of Ig to the intestine

• Why the overkill in colostrum feeding?
• When are conditions optimal?

88 lb. calf – 2.1 liter – 2 quarts ????
It's more than IgG

• Maternal cells in colostrum??
• Migrate across the calf intestine
• Found in calf tissues
• Cytokines – small proteins – cell signaling
• Importance?
  • Calves receiving colostrum with maternal cells – fresh vs. frozen colostrum?
    - Activated an immune response sooner
    - Measurable responses to bovine pathogens at day 1.

### Colostrum vs. Milk

<table>
<thead>
<tr>
<th></th>
<th>Colostrum</th>
<th>Milking 1</th>
<th>Milking 6</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter %</td>
<td>24.0</td>
<td>15.3</td>
<td>12.2</td>
<td></td>
</tr>
<tr>
<td>Energy Mcal/lb of milk</td>
<td>0.65</td>
<td>0.41</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Protein %</td>
<td>13.3</td>
<td>4.7</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>IgG%</td>
<td>8.1</td>
<td>.8</td>
<td>&lt; .2</td>
<td></td>
</tr>
<tr>
<td>Fat %</td>
<td>6.4</td>
<td>5.1</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Lactose %</td>
<td>2.5</td>
<td>4.6</td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>

Source: Hamman, 2008

Plasma glucose concentration of calves fed colostrum or milk replacer from birth to 4 days of life.

Steinhoff-Wagner et al., 2010

Villus Height, µm

Steinhoff-Wagner et al., 2010

Buhler et al., 1998
Different amounts of colostrum

![Graph showing villous height (µm) for colostrum (1 wk), colostrum (3 d), and formula (3 d). Data from Blattler et al., 2001.]

Cell proliferation in small intestine after oral IGF-I feeding

![Graph showing cell proliferation after oral IGF-I feeding, comparing milk replacer, IGF-I, and colostrum. Data from Baumrucker et al., 1994.]

What about colostrum replacers?

- 250 g of IgG /calf in two feedings from pooled maternal colostrum (MC) or serum derived colostrum replacer (SCR)
  - -120g/day vs. +51.6g/day
  - Day 0 – 8 – higher ADG calves fed MC
  - > DAY 15 no difference.
  - Higher feed efficiency for calves fed MC, most due to first 8 days.

What about colostrum replacers?

- Two studies feeding 150 - 200 g IgG/calf
  - higher apparent efficiency of absorption for MC vs. SCR. Fidler et al., 2011
  - 457 calves on 12 days fed either 125 g of IgG from SCR or 3.8 L of MC.
  - Higher serum IgG and less passive transfer failure in MC calves
  - No difference in morbidity or mortality.
Evaluating colostrum absorption in calves fed MC or SCR

- Serum total protein = 5.0 – 5.2 g/dl ~ Serum IgG >10mg/ml
- Brix classifies about 85% of samples correctly for MC or Colostrum-derived CR
- Agreements not as good with SCR

Take home message – colostrum management

- Why do we fail? ~ 15 – 20% FPT?
- Management
  - Facilities – close up cows, calving environment, newborn housing
  - Timing of fresh cow milking,
  - Colostrum harvest
  - Feeding the new born
  - Growth of bacteria in colostrum / microbial exposure of the newborn.

- Environment – heat and cold stress on colostrum production and calf absorption.
  - Heat stress - reduced total plasma protein, hematocrit, compromised cellular immune function and passive transfer in calves born to heat stressed vs. cooled dams. (Tao et al. 2012)
  - Due to calf or cow?

- Cold stress and colostrum production and calf absorption???
- Is colostrum influence more than IgG?
  - Cellular immunity?
  - Intestinal development – villous height/enzyme development.
  - Insulin?
Management

- Dam’s own colostrum best – manage for early intake of low bacteria, high IgG colostrum
- Optimize environment for the dry cow and the calf – moisture, heat and cold stress.
- Utilize colostrum replacers when the above is not optimal.

Nutritional management of the preweaned calf

Meeting the nutrient requirements for growth (?), immune function, ?????

Two concerns in meeting nutrient requirements

- What influences the nutrient requirements of the preweaned calf
- How accurately do we mix and deliver the nutrients to the calf?

Nutrient Requirements

- Body size
- Rate of gain desired??
- Environment
- Management
Nutrient requirements

- Maintenance – Maintain body systems – no growth
  - This is not linear relationship with body size!
  - Smaller calves have more surface area and lose heat more quickly
  - Requirements for maintenance are proportionately higher for smaller calves.
  - Temperature influence on maintenance requirements?

Influence of body weight and temperature on maintenance requirements (Mcal NE/day)

<table>
<thead>
<tr>
<th>Body weight</th>
<th>0°F</th>
<th>32°F</th>
<th>68°F</th>
<th>Increase in NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 lb. calf</td>
<td>1.99</td>
<td>1.58</td>
<td>1.02</td>
<td>95%</td>
</tr>
<tr>
<td>90 lb. calf</td>
<td>2.69</td>
<td>2.14</td>
<td>1.39</td>
<td>93%</td>
</tr>
</tbody>
</table>

Source: 2001 NRC, Nutrient Requirements for Dairy

Amount of Milk (lb) Required to Meet Maintenance Requirements

<table>
<thead>
<tr>
<th>Body weight lb</th>
<th>Temperature °F</th>
<th>68</th>
<th>60</th>
<th>32</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>3.6</td>
<td>4.6</td>
<td>5.6</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>6.2</td>
<td>7.8</td>
<td>9.4</td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>165</td>
<td>8.4</td>
<td>10.5</td>
<td>12.9</td>
<td>15.9</td>
<td></td>
</tr>
</tbody>
</table>

Gallon of milk = 8.62 lb.

Do Jerseys require more NE/unit body weight?
• What rate of gain is desired?
  • Week one? Week 4? Week 8?
• What body composition is desired?
  – 3% body fat?
  – 10% body fat?

Baseline = week old, remainder 5 week old Jersey calves

Kidneys from 5 week-old Jersey calves

20:20 milk replacer  Whole milk

BW (kg) on d 1 to d 29 of Holstein females (●), Holstein males (■), Jersey females (▲), and Jersey males (○). Significant breed by time interaction; differences detected on all d. (Mowrey, 2001).
How does management influence nutrient requirements?

- Temperature
- Moisture
- Housing

The newborn calf

Impact of the following?
- Stress of calving
- Calving environment
- Delay in nutrient intake
- Body composition of the calf - % body fat??

Impact on nutrient status of the calf??

Meeting their nutrient requirements

Least squares means of weight gain by housing (kg/d) (P<0.02).
Impact on immune function?

- Newborn Holstein calves fed 50% of maintenance requirements for energy and protein – Griebel et al., 1987
  - Decreased lymphocyte response to stimulation
  - Decreased ability to produce antibody following stimulation.
  - Correction of deficit = normal immune response.

<table>
<thead>
<tr>
<th>Amount of</th>
<th>1 lb</th>
<th>2 lb</th>
<th>1 lb</th>
<th>2 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>lb of protein</td>
<td>lb of fat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20:20 milk replacer</td>
<td>.20</td>
<td>.40</td>
<td>.20</td>
<td>.40</td>
</tr>
<tr>
<td>28:20 milk replacer</td>
<td>.28</td>
<td>.56</td>
<td>.20</td>
<td>.40</td>
</tr>
<tr>
<td>Whole milk (8 lb @ 12.5% DM)</td>
<td>.26</td>
<td>.52</td>
<td>.29</td>
<td>.58</td>
</tr>
</tbody>
</table>

Energy allowable gain whole milk vs. 20:20 CMR
Week 1

<table>
<thead>
<tr>
<th>Calf</th>
<th>Whole milk</th>
<th>20:20 Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 F</td>
<td>32 F</td>
<td>68 F</td>
</tr>
<tr>
<td>80 lb calf – week 1</td>
<td>.85 lb/day</td>
<td>.19 lb/day</td>
</tr>
<tr>
<td>80 lb calf – week 1</td>
<td>1.68 lb/day</td>
<td>1.15 lb/day</td>
</tr>
</tbody>
</table>

Additional challenges influencing nutrient requirements?
Temperature < 32F
Bedding adequacy?

Quality of incoming milk (Scott, 2006)

<table>
<thead>
<tr>
<th>Location</th>
<th>PrePasteurization - Aerobic plate count</th>
<th>Fat %</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>East</td>
<td>300,000</td>
<td>$1 \times 10^4$</td>
<td>1.5%</td>
</tr>
<tr>
<td>West</td>
<td>26,000</td>
<td>$5.9 \times 10^3$</td>
<td>1.2%</td>
</tr>
<tr>
<td>WI</td>
<td>6,000</td>
<td>$7.2 \times 10^2$</td>
<td>2.8%</td>
</tr>
</tbody>
</table>
Variation in milk replacer?

<table>
<thead>
<tr>
<th>Measure</th>
<th>High Value</th>
<th>Low Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plate count - (cfu/ml)</td>
<td>166,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Total coliform count (cfu/ml)</td>
<td>12,000</td>
<td>0</td>
</tr>
<tr>
<td>DM%</td>
<td>14.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Temperature</td>
<td>111</td>
<td>84</td>
</tr>
</tbody>
</table>


Additional challenges to young, preweaned calf?

- Training the new born calf to the bucket from the bottle? Interruption in intake?
- Long intervals between feedings
  - Confounded with amount of daily volume
  - Small volume - impact on metabolism during PM
  - Large volume – don’t consume all of meal after short interval.

Challenge of feeding more with 2 x feeding?

- Volume per feeding?
- Increase solids level from 12.5% to 17%?

Impact of feeding frequency

  - 3 x vs 2x feeding per day
    - 1.8 lb powder 1st week
    - 2.5 lb. powder wk 2 – 6
    - 1.24 lb powder week 7
    - Same amount of powder / calf / day
3X vs. 2X daily Feeding –
Same Total Amount Daily.

<table>
<thead>
<tr>
<th>Item</th>
<th>2x Feeding</th>
<th>3x Feeding</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW Gain (1–42 days), kg</td>
<td>25.1</td>
<td>29.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Hip height gain (1–42 days), cm</td>
<td>8.6</td>
<td>10.3</td>
<td>0.0027</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>0.57</td>
<td>0.61</td>
<td>0.4001</td>
</tr>
<tr>
<td>Gain/DM intake, 1–42 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number weaned</td>
<td>32</td>
<td>34</td>
<td>0.3070</td>
</tr>
<tr>
<td>Number lactating</td>
<td>28</td>
<td>34</td>
<td>0.0250</td>
</tr>
<tr>
<td>Age first calving, days</td>
<td>734</td>
<td>718</td>
<td>0.2278</td>
</tr>
<tr>
<td>ME305, milk production, kg</td>
<td>13053</td>
<td>13568</td>
<td>0.2217</td>
</tr>
</tbody>
</table>

- Impact of ingredient equality
  - Milk replacer protein and fat? Digestion
  - Waste or whole milk quality – SCC, antibiotic level, bacteria count, DM%

Question calf feeding management?
- Colostrum management and feeding?
- Where are weak areas in calf management
  - Nutrient intake – amount of solids and consistency.
  - Environment optimized to reduce maintenance expenses.
  - Adjust for environmental temperature changes