Traditional Objectives of Dairy Calf Feeding – 1950 - ????

• Individual housing
  – Prevent spread of disease
  – Calf hutch, Indoor stalls or elevated crates
• Colostrum management / nurse the dam or hand fed – immediate removal from dam
• Nutrition
  – Limit feed – one lb of milk or MR solids
  – Encourage early starter intake and early weaning.
Motivation for these practices?

• Isolation for disease control
• Encourage early starter intake by limiting milk or MR intake
• Reduce cost
  – Less milk or MR which is $$$$  
    • Milk = $.20 / lb. = $1.60/lb. of DM  
    • Calf starter grain = ~ $.15 - $.20/lb. of DM  
  – Less labor for weaned vs. milk fed calves  
  – Less disease in weaned calves???

Challenges to dairy calf rearing due to traditional management systems

• Dry cow management
• Calving difficulty for Holstein’s
• Calving location
• Colostrum management
• Young calf nutrition
• Housing
• Weaning
Dry cow management

- Body condition of dry cow - 3.25 – 3.5.
  - Impact on calf
  - Body fat content of the calf and body condition of dam
- Qualitative nutrient content of dry cow diets

### Nutrient density of dry cow diet

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Nutrient density conventional - % DM Basis</th>
<th>Nutrient Density Anionic - % DM Basis*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>13 – 14</td>
<td>13 – 14</td>
</tr>
<tr>
<td>Ne, Mcal/lb.</td>
<td>.6 - .64</td>
<td>.6 - .68</td>
</tr>
<tr>
<td>Acid Detergent Fiber</td>
<td>&gt;28</td>
<td>&gt;28</td>
</tr>
<tr>
<td>Neutral Detergent Fiber</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Forage NDF</td>
<td>&gt;27</td>
<td>&gt;27</td>
</tr>
<tr>
<td>Ca</td>
<td>.45 - .55</td>
<td>1.4 – 1.6</td>
</tr>
<tr>
<td>P</td>
<td>.3 - .35</td>
<td>.35 - .4</td>
</tr>
<tr>
<td>Mg</td>
<td>.2</td>
<td>.28 - .32</td>
</tr>
<tr>
<td>K</td>
<td>.8 – 1.0</td>
<td>.8 – 1.0</td>
</tr>
<tr>
<td>S</td>
<td>.2</td>
<td>.35 - .40</td>
</tr>
<tr>
<td>Salt</td>
<td>.25</td>
<td>.25</td>
</tr>
</tbody>
</table>
# Nutrient density of dry cow diets

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Nutrient density – conventional - % of DM</th>
<th>Nutrient density – anionic - % of DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Zinc</td>
<td>70 – 80</td>
<td>70 – 80</td>
</tr>
<tr>
<td>Selenium (added)</td>
<td>.3 ppm</td>
<td>.3 ppm</td>
</tr>
<tr>
<td>Co</td>
<td>20 ppm</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Iodine</td>
<td>.5 ppm</td>
<td>.5 ppm</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1,000 IU/lb of DM</td>
<td>1,000 IU/lb. of DM</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>35 – 35 IU/lb. of DM</td>
<td>35 – 35/lb of DM</td>
</tr>
<tr>
<td>DMI</td>
<td>1.8 – 2.2% of BW</td>
<td>&lt;2.0% of BW*</td>
</tr>
</tbody>
</table>

* Estimate DMI of dry cows!!!!!
Colostrum management

Not colostrum again!

Composition of Colostrum

- 1ml >10^6 maternal immune cells
  - IgG (immunoglobulin G)
  - T and B Lymphocytes
  - Neutrophils and Macrophages
- Nutritional value
  - 23.9% solids
  - 6.7% fat
  - 14% protein
Colostrum composition by milking

<table>
<thead>
<tr>
<th>Item</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>1.06</td>
<td>1.04</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>Solids, %</td>
<td>23.90</td>
<td>17.90</td>
<td>14.10</td>
<td>12.90</td>
</tr>
<tr>
<td>Protein, %</td>
<td>14.00</td>
<td>8.40</td>
<td>5.10</td>
<td>3.10</td>
</tr>
<tr>
<td>Casein, %</td>
<td>4.80</td>
<td>4.30</td>
<td>3.80</td>
<td>2.50</td>
</tr>
<tr>
<td>IgG, g/l</td>
<td>48.00</td>
<td>25.00</td>
<td>15.00</td>
<td>0.60</td>
</tr>
<tr>
<td>Fat, %</td>
<td>6.70</td>
<td>5.40</td>
<td>3.90</td>
<td>3.70</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>2.70</td>
<td>3.90</td>
<td>4.40</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Source: Foley and Otterby

Calf body weight 40 kg
Plasma volume (9% of BW) 3.6 liters
Minimum Plasma concentration 10 g/L
Apparent efficiency of absorption 35 %
Required IgG intake \((3.6 \times 10 / 0.35)\) 103 grams
Colostral concentration 50 g/L
Required amount to feed 2.1 L

**Figure 1.** Estimated colostrum required by a 40 kg calf to achieve minimum plasma IgG concentration of 10 g/L at 24 hours of age.
Colostrum

• Minimum of 100g in 1st 6 hours
• If conditions are ideal!!!!
• Holstein colostrum - 48 g IgG/L
• Jersey colostrum – 66 g IgG/L

Quality

• >85% of 1st milking colostrum over 50 g/liter
• Using colostrometer
  – room temperature – 22°C
  – Adjust readings for temperature
  – Body temperature =+14
  – Refrigerated = - 14
Quality

- >85% of 1st milking colostrum over 50 g/liter
- Using Brix Refractometer
  - Not temperature sensitive
  - More durable than colostrometer
  - Readings > 21 indicate good quality colostrum
  - RID values > 50 mg IgG/mL

Quantity

- 4 liters in 1st 6 - 12 hours
- Bottle feed?
- Tube fed?
Esophageal feeder 101

- Sanitation of esophageal feeder???
- Recent sample
  - >2,500 cfu/in^2
  - Overgrowth with E. coli
- Cuts in the ball

Feeding colostrum with esophageal feeder
– Benefits vs risks

- Benefits – they got it
- Routinely tubing calves with one gallon?
- Consumption of second feeding.
First one there is the winner!

It’s a race between bacteria in the environment or the initial feeding and the antibodies in colostrum.

One reason why it’s important

Early consumption of colostrum before exposure to ???

Colostrum protein
One reason why it’s important!

Early exposure to E. coli without colostrum intake

FIG. 2: Apical rods of several shedding cells from an E. coli exposed calf which had received no colostrum. The microvilli were larger around the sites of E. coli attachment. E. coli were also within the apical crypts (approximately 14,000×).

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

From S. Godden
Serum IgG levels were significantly higher in calves fed heat-treated colostrum

Recent UMN Field Study
M. Donahue, S. Godden

• 1,000 calves / 6 herds
  – ½ fed raw and ½ fed heat-treated colostrum
• Colostrum total plate count and serum IgG – **negative effect**
• Colostrum IgG concentration – **positive effect**
• Heat treatment – **positive** – independent of Total plate count
Heat treated colostrum
Godden et al. 2012

<table>
<thead>
<tr>
<th>Measure</th>
<th>Heat Treated Colostrum</th>
<th>Fresh Colostrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard plate count, cfu/ml</td>
<td>2,000</td>
<td>515,000</td>
</tr>
<tr>
<td>Coliform count, cfu/ml</td>
<td>90</td>
<td>51,500</td>
</tr>
<tr>
<td>Serum IgG – ml/ml</td>
<td>18.0</td>
<td>15.4</td>
</tr>
<tr>
<td>Incidence of scours (%)</td>
<td>16.5</td>
<td>20.7</td>
</tr>
</tbody>
</table>

All calves fed 3.8 Liters within 60 minutes of birth

Colostrum management – three Q’s

• Quantity – 4 liters
• Quality – 50g IgG/liter
• Quickness – As soon as possible

Plasma IgG – 10g/liter

Cleanliness - <50,000 - 100,000 cfu/ml**
Colostrum management – critical points

• Location
  – Calving area
  – Fresh cow milking
  – Calf housing

• People – who is responsible?
  – Fresh cow milking?
  – Colostrum handling?
  – Calf feeding

Disconnect cont’d

• Quality
  – Colostrum handling –
    • Feed immediately or cool as soon as possible
    • Rapid cooling – frozen Coke bottles in bucket.
      – 6 hours at room temp = 6,000,000 cfu/ml
  • Clean containers
    – Luke warm water rinse
    – Hot soapy water
    – Sanitizer
    – SPC / sq. in. < 1,000
Two recent herd visits

• Dairy 1
  – >25,000,000 /ml SPC, >15,000 coliform /ml, E. coli - TNTC
  – 8 calves < 7 days - serum protein – 3.9 – 4.6 g/dl.

• Dairy 2
  – >25,000,000/ml, >15,000 coliform, E. coli TNTC -
  – 9 calves < 7 days – serum protein 3.9 – 5.2 g/dl

Dairy calf nutrition

• How much milk does a beef cow give?
  – 1st week?

• How much milk does a beef calf consume?
Conventional Calf Feeding Program

- 1 lb. / day or one gallon/day
- 20% protein: 20% fat milk replacer
- Calf Starter - 16 – 20% CP.

A more methodical approach to calf nutrition

- What should milk replacers contain?
- Nutrient requirements should be based upon studies which measure growth.
- Define growth
  - Weight
  - Stature
  - Reproductive maturity
- Based upon composition of growth – fat, protein, ash - slaughter studies.
What is nutrient content of whole milk?

<table>
<thead>
<tr>
<th>Milk</th>
<th>DM%</th>
<th>Fat%</th>
<th>Prot%</th>
<th>Lactose</th>
<th>Ash%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>12.3</td>
<td>3.6</td>
<td>3.0</td>
<td>5.0</td>
<td>.7</td>
</tr>
<tr>
<td>Jersey</td>
<td>14.5</td>
<td>5.0</td>
<td>3.8</td>
<td>5.0</td>
<td>.7</td>
</tr>
</tbody>
</table>

Compare whole milk on a powder basis?

<table>
<thead>
<tr>
<th>Liquid feed</th>
<th>DM %</th>
<th>Fat %</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>100</td>
<td>28.8</td>
<td>24</td>
</tr>
<tr>
<td>Jersey</td>
<td>100</td>
<td>34.5</td>
<td>26.2</td>
</tr>
</tbody>
</table>

Body weight gains of conventionally fed calves 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).
Feeding more 20:20?

- 115 lb. Calf – 60°F
- Feed 2 lb/day of powder instead of 1 lb.
- 15% solids

- Milk DMI = 2.0 LB.
- Energy allowable gain = 1.74 lb. / day
- Diet ME – 2.15 Mcal
- Diet CP = 20%
- Diet dig. CP = 18.5%
- ADP allowable gain = 1.29 lb. / day
- Crude protein balance = -52g/day

<table>
<thead>
<tr>
<th>Temp. °F</th>
<th>Body weight, lb</th>
<th>Lb milk or milk replacer/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>59°C</td>
<td>110 (MR)</td>
<td>1.00</td>
</tr>
<tr>
<td>32°C</td>
<td>110 (milk)</td>
<td>0.91 (7.3)</td>
</tr>
<tr>
<td>5°C</td>
<td></td>
<td>1.35 (9.6)</td>
</tr>
</tbody>
</table>

*Lower critical temp. calves less than 21 d age.*

Amount of Milk or Milk Replacer Needed to Meet *Maintenance* Requirements – gaining NO weight!
Cornell research

- >2,000 calves fed at Cornell
- Range in body weight gains pre-weaning - .5 – 2.5 lb. / day
- Reared together after weaning
- Followed through 1\textsuperscript{st} and 2\textsuperscript{nd} lactations.
- Statistically account for source of variation in lactation yield
- 25% of variation in yield due to gains during milk feeding period!

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 Gain/DM intake, 1–42 days</td>
<td>0.52</td>
<td>0.61</td>
<td>0.0001</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>
Calf management 101

- Feed enough solids – 750 – 1000 g
- 20% - 25 % protein – quality
- 10 – 20% fat – depends on season
- Calf environment
  - DRY!!!!
  - VENTILATION
- Calf starter - 20 – 23% protein / palatable

Automatic calf feeders

[Images of automatic calf feeders]
General recommendations for group housing calves.

• Colostrum status and vigor of calves depend on when they are best introduced to the system.
  – Colostrum monitoring – Brix >23
  – Calf Ig status with refractometer - >85% with serum protein >5.5g/dl

• Place on the feeder – 3? – 14 days of age.
  – Less risk of respiratory disease when placed on feeder @10-14 days vs. 6 days (Svennson and Liberg (2006) and Jensen (2008))

• Training to the feeder
  – Skip morning feeder, place in autofeeder pen an lead to nipple.

• Stocking rate < 25 per feeder?

• Milk Allowance
  – 1.5 – 2.5 lb of milk solids / day = 1.4 – 2.3 gallons/day

• Meal size - 1 pint to 1 quart (.14 - .28 lb. solids)
• Meals per day
  – Size of mixing bowl – 1 pt?
  – Example 2.2 lb. of solids / day = 16 meals of one pint.
  – Ability to mix multiple batches if calf is allowed
    • Minimum and maximum amount per meal.
  – Sophisticated systems – 3 – 5 meals per day

Example Feeding program
(Backgrounded 12 days)
Figure – courtesy of T. J. Earleywine
Can we learn something from beef cattle?

• Calving environment
• Nutrition
  – More liberal feeding of calves – 2 – 2.75 lb. milk solids
  – More frequent feeding of calves.
  – Group housing of calves.
• What’s the payback
  – Morbidity
  – Social stress
  – Lactation yield.