Stepping up Feeding & Growing a Healthier Calf

Robert James,
Dept. of Dairy Science
What is success? Different perspectives

- Calf
- Feeder
- Owner
Traditional calf management

- Colostrum
  - Focus on grams of Ig intake early in life
- Calf Feeding
  - Limit feed liquid diet to encourage early starter intake and early weaning (<6 wks of age)
  - Individual housing – limit disease transmission
  - Low daily cost
Strategic

• Identification of long-term or overall aims and interests and the means of achieving them.

• What is long term objective for dairy calf enterprise?
  – Longevity of the animal – high lifetime production
  – Lower cost / unit of production.
Critical Control Points

• Colostrum – Ig and other items
• Meeting nutrient requirements to achieve genetic potential for growth and good health.
• Facilities which provide:
  – Nutritional efficiency
  – Labor efficiency and effectiveness
• Success – knowing the “science” and being able to apply the “science” on the farm to provide economical return to the dairy.
Not colostrum again!

- Gallon
- High Ig – 50g/L
- Early in life <6 h
- Clean
Colostrum management - briefly

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

- Low bacteria counts
  - <100,000 cfu/ml – standard plate count (SPC)
The newborn calf

- Calf is sterile at birth
- Early microbial colonization of intestine may influence Ig absorption
- Microbial colonization in the calf is rapid
  - Anaerobic bacteria
  - Some bacteria live in the lumen and some in the intestinal lining.
E. coli entering intestine epithelial cell

Destruction of microvilli

Colostrum fed calf

Higher bacteria levels = earlier onset of closure.
Environment and colostrum can contain high levels of bacteria.
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

Goal is to have TPC less than 100,000 cfu/ml

From - S. Godden
Batch pasteurization

Effect of Temperature on Colostrum IgG Concentrations (mg/ml) (30 unique batches)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Pre-Pasteurized</th>
<th>Post-Pasteurized</th>
</tr>
</thead>
<tbody>
<tr>
<td>145 °F (63 °C)</td>
<td>77.1</td>
<td>46.5</td>
</tr>
<tr>
<td>140 °F (60 °C)</td>
<td>76.4</td>
<td>74.5</td>
</tr>
</tbody>
</table>

% IgG Loss:
145 °F: 39.7%
140 °F: 2.5%

Godden et. al, 2003
### Characteristics of calf and colostrum

**Godden et al. 2012**

<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 1(^{st}) colostrum 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>SPC in colostrum (cfu/ml)</td>
<td>515,000</td>
<td>2,100</td>
</tr>
<tr>
<td>Coliform Count in colostrum (cfu/ml)</td>
<td>51,500</td>
<td>90</td>
</tr>
</tbody>
</table>

**Donahue et al., 2012**
Summary of findings

relationships with calf serum IgG

• Colostrum standard plate count—negative
• Colostrum IgG concentration – positive
• Heat treatment of colostrum – positive – independent of standard plate count
• Colostrum Total Coliform Count and risk of scour – positive.
It’s more than IgG -
Impact of colostrum feeding on intestine absorptive capacity?

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

Time after feeding on day 4, h

Steinhoff-Wagner et al., 2010
Influence of other colostrum components?

- Maternal cells in colostrum?
  - Migrate across the calf intestine
  - Found in calf tissues
  - Enhance activation markers on peripheral blood leukocytes (Reber et al., 2008a)
  - Decrease monocytes in peripheral blood (Reber et al., 2008b)
  - Enhance pathogen clearance (Reidel-Caspari, 1991)
Why does colostrum program fail?

• Management
  – Facilities – Location of close up cows, calving environment, newborn housing
    • Interval between calving and fresh cow milking?
    • Colostrum harvest – clean milking equipment, containers
    • Feeding the new born on a timely basis (<6 – 12 hr. of birth)
    • Growth of bacteria in colostrum / microbial exposure of the newborn.
Achieving success

• Location of close up, calving, milking and calf housing?
• Personnel involved? Chain of responsibility?
• Monitoring
Colostrum management

• Cool or feed within 30 minutes – one hour
Monitors

- **Colostrum management**
  - **Serum protein - >85% are > 5.5 g/dl**
    - Colostrum
    - Colostrum replacer
  - Colostrum quality (4 quarts is overkill)
    - **Periodic SPC - <100,000 cfu/ml**
      - **Frequency?**
        - Brix refractometer – 85% > 22

- **Records**
  - Calving pen – people, volume fed, timing
  - Colostrum quality – volume, brix, SPC
Almost $1500 lost opportunity

- Treatment costs $10.00
- Lower milk production (L2) $677.00
- Lower milk production (L1) $391.00
- Increased culling rate $160.00
- Delayed first calving $140.00
- Mortality $36.00
- Lower feed conversion efficiency $7.32
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???
Traditional calf nutrition

• Limit feed calves
  – 2 liters / feeding
  – Twice daily feeding
    • Interval between feeding?

• Why?
  – Convenience for labor
  – Limit feed to encourage weaning
    – Lower feed cost / day

• Is this biologically normal??
Biology of the calf

• Requirements for maintenance
  – Environmental temperature
  – Environment – moisture, wind, hair coat?

• Requirements for growth?
  – How much should a calf grow? Week 1, 2, 3……?
  – What is growth? Body composition?
Have we forgotten “normal biology”.

Genetics?

Environment and nutrition

This is “normal” biology!
Concerns in meeting nutrient requirements

- How accurately do we deliver the nutrients to the calf?
  - Volume of fluid fed
  - Composition of liquid?
  - Pasteurized waste milk vs. mixing powder and water
  - Feeding schedule
## Amount of Milk (lb...) Required to Meet Maintenance Requirements

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

Gallon of milk = 8.62 lb...
• What rate of gain is desired?
• Week one? Week 4? Week 8?
• What body composition is desired?
  – 3% body fat?
  – 10% body fat?
Are maintenance requirements the same?

- Environmental temperature?
- Moisture in bedding or lack of bedding
- Housing – moisture, ventilation
gms of protein and fat provided by.....

<table>
<thead>
<tr>
<th>Amount of DM intake</th>
<th>500g (1.1 lb)</th>
<th>1000g (2.2lb)</th>
<th>500g</th>
<th>1000g</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>20:20 milk replacer</strong></td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td><strong>28:20 milk replacer</strong></td>
<td>140</td>
<td>280</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td><strong>Whole milk 4L@ 12.5% DM</strong></td>
<td>130</td>
<td>260</td>
<td>150</td>
<td>300</td>
</tr>
</tbody>
</table>

Take home message - g are more important than%
# 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></td>
<td>68 F</td>
<td>32 F</td>
</tr>
<tr>
<td></td>
<td>68 F</td>
<td>32 F</td>
</tr>
<tr>
<td>80 lb...... calf – week 1</td>
<td>.85 lb/day</td>
<td>.19 lb/day</td>
</tr>
<tr>
<td>1 lb...... DMI</td>
<td>.64 lb/day</td>
<td>No gain</td>
</tr>
<tr>
<td>80 lb...... calf</td>
<td>1.68 lb/day</td>
<td>1.15 lb/day</td>
</tr>
<tr>
<td>week 1</td>
<td>1.15 lb...... / day</td>
<td>.85 lb...... /day</td>
</tr>
<tr>
<td>1.5 lb...... DMI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional challenges influencing nutrient requirements?
- Temperature < 32F
- Bedding adequacy?
Comparison of “crates” and hutches
<table>
<thead>
<tr>
<th>Housing Combination</th>
<th>Number of Calves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Milk (WM) + Crate</td>
<td>21</td>
</tr>
<tr>
<td>Waste Milk + Hutch</td>
<td>21</td>
</tr>
<tr>
<td>Balancer (Bal) + Crate</td>
<td>20</td>
</tr>
<tr>
<td>Balancer + Hutch</td>
<td>21</td>
</tr>
</tbody>
</table>

Least squares means of weight gain by housing (kg/d) (P<0.02).

K. L. Machado, 2012

Study conducted
In June – August
Different in Dec.
- February?
35°F with 90%+ humidity
Do Jerseys (smaller calves) require more NE/unit body weight?

Bascom et al., 2007
Baseline = week old, remainder 5 week old Jersey calves

- **20:20 - 450 g DMI/day**
- **Other treatments - 680 g DMI/day**
Kidneys from 5 week-old Jersey calves

20:20 milk replacer
1 lb. solids/day

Whole milk
1.5 lb. solids/day
Question calf feeding management?

- Nutrient intake – amount of solids and consistency. – weigh powder and water
  - Measure temperature for proper mixing and to prevent cold stress. - 105 – 115F
- Environment optimized to reduce maintenance expenses.
- Adjust for environmental temperature changes
  - More solids – up to 15%
  - More volume – extra feeding
Why do we have problems with higher volumes of liquid diet??

• Calves (or any neonate) are not well suited to fewer, larger meals.
• Is the milk replacer/milk the problem or how we feed it?
Challenge of feeding more with 2 x feeding?

- Volume per feeding?
- 2 liters of liquid = 2,000 g@ 12.5% solids = 250 g of solids
- Increase solids level from 12.5% to 17%?
  = 340g of solids
- Risks of higher DM% diets?  High Osmolality – Osmotic diarrhea???
Impact of feeding frequency


• 3 x vs 2x feeding per day
  – 818g powder 1\textsuperscript{st} week
  – 1136g powder wk 2 – 6
  – 560g 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 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>
Economic impact of feeding frequency?

- Value of 6 more heifers freshening??
- Cost of 3x vs. 2x feeding?
- Impact on animal health?
Stepping up nutrition

• Colostrum management

• Meeting nutrient requirements
  – Grams of protein and Mcal of energy to support maintenance and growth – milk or milk replacer
  – Consistency – concentration, volume and schedule.
  – Calf environment – cost effective
Stepping up nutrition

• Delivery of nutrition
  – Buckets or bottles?
  – Hutches, crates, individual pens, group pens?
  – Simple
  – People – environment, skills of feeders
Challenging the paradigm!

• Individual housing – disease prevention vs. labor vs. welfare
• Group housing – environment, colostrum and higher nutritional plane.
  – Mob feeders
  – Autofeeders
Mob feeders

Acidified free choice or meal fed?
Automatic calf feeder systems
Challenges with autofeeder systems

• Preconditioning – colostrum management
• Feeding plans
  – Increase in milk allotment
  – Peak milk allotment – 7 – 15 L/day
  – Weaning – age and length
  – Meal size
• Sanitation – mixer and circuit cleaning
How much should calves be fed?

• 1\textsuperscript{st} week of life? – 4 L – 6L
• Increasing milk intake to peak milk intake? – 8 – 16 L???
• Can young calves tolerate high milk intake?
Intestinal tract of healthy week old Jersey calves fed high plane of nutrition.

- Nutrient digestibility and N retention of Jersey calves
- LPN - 14.5g DM/kg of weight – 20% protein: 20% fat CMR = 0.96 lb..... for 66 lb..... calf
- HPN – 20g DM/kg of weight – 28% protein: 20% fat CMR = 1.3 lb..... for 66 lb..... calf

Liang et al, 2015
<table>
<thead>
<tr>
<th>Item</th>
<th>Low plane nutrition</th>
<th>High plane Nutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal score</td>
<td>1.52</td>
<td>2.01</td>
</tr>
<tr>
<td>Fecal DM%</td>
<td>31.9%</td>
<td>30.9%</td>
</tr>
<tr>
<td>Ave. Daily Gain</td>
<td>-106g</td>
<td>+211g</td>
</tr>
<tr>
<td>Digestible energy efficiency</td>
<td></td>
<td>92.8%</td>
</tr>
<tr>
<td>N retention – 1st period</td>
<td>78.7%</td>
<td>88%</td>
</tr>
</tbody>
</table>

Jersey calves have capability to digest and absorb additional nutrients provided by high plane of nutrition.
Impact of more liberal liquid feeding.

• What is more liberal feeding? >7L/day
• Review of dairy calf nutrition trials with lactation information.
Preweaning growth and health of MN dairy calves fed equal volumes of pasteurized waste milk or 20:20 milk replacer (>400 calves)

<table>
<thead>
<tr>
<th></th>
<th>Past. Waste Milk</th>
<th>20:20 Milk Replacer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Daily Gain</td>
<td>1 lb......</td>
<td>.77 lb......</td>
</tr>
<tr>
<td>Proportion treated</td>
<td>11.6%</td>
<td>32.1%</td>
</tr>
<tr>
<td>Proportion died</td>
<td>2.2%</td>
<td>12.1%</td>
</tr>
<tr>
<td>Energy allowable gain</td>
<td>.8 lb......</td>
<td>.4 lb......</td>
</tr>
</tbody>
</table>

WASTE MILK CALVES RECEIVED MORE DM, ENERGY AND PROTEIN/DAY.

(Godden et al. JAVMA, 2005)
Preweaning Treatment Rate (%)

Reduction in scours and pneumonia for all months

(Godden et al. JAVMA, 2005)
Preweaning Death Loss (%)

Month of Birth

- Winter Months
  - Milk Replacer: 21
  - Pasteurized Milk: 2.3
- Summer Months
  - Milk Replacer: 11.6
  - Pasteurized Milk: 2.7

(Godden et al. JAVMA, 2005)
Impact of better nutrition on immune function?
Preweaning plane of nutrition and Mannheimia and BHV-1 challenge of post-weaned calves.

- 2 planes of nutrition
  - LPN - .98 lb...... milk replacer DM/d
  - HPN – 1.8 lb./d – 1st 10 days, 2.37 lb./d to weaning 54 d

- Bovine Herpes Virus challenge day 81 – 1.5 x 10^8 PFU / ml / nostril

- M. hemolytica challenge 10^6, 10^7, or 10^8 cfu/ml on day 84.

Sharon et al., 2015
• Body wt. at 70 days - 179 lb..... vs. 137 lb.....
• HPN calves consumed more starter during challenge
• Glucose during challenges
  – BHV - 61.1 VS. 57.5 mg/dl
  – MH - 57.8 vs. 53.5 mg/dl
• Plasma urea N higher for LPN @ 72 h post challenge.
• Glucose lower for LPN calves
• NEFA higher for LPN calves during challenge.
Impact of preweaning nutrition on later lactation yields.
<table>
<thead>
<tr>
<th>Study</th>
<th>Milk yield, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foldager and Krohn, 1991</td>
<td>$1,405^{s}$</td>
</tr>
<tr>
<td>Bar-Peled et al., 1998</td>
<td>$453^{t}$</td>
</tr>
<tr>
<td>Foldager et al., 1997</td>
<td>$519^{t}$</td>
</tr>
<tr>
<td>Ballard et al., 2005 (@ 200 DIM)</td>
<td>$700^{s}$</td>
</tr>
<tr>
<td>Shamay et al., 2005 (post-weaning protein)</td>
<td>$981^{s}$</td>
</tr>
<tr>
<td>Davis-Rincker et al., 2011</td>
<td>$416^{ns}$</td>
</tr>
<tr>
<td>Drackley et al., 2007</td>
<td>$835^{s}$</td>
</tr>
<tr>
<td>Raith-Knight et al., 2009</td>
<td>$718^{ns}$</td>
</tr>
<tr>
<td>Terre et al., 2009</td>
<td>$624^{ns}$</td>
</tr>
<tr>
<td>Morrison et al., 2009 (no diff. calf growth)</td>
<td>$0^{ns}$</td>
</tr>
<tr>
<td>Moallem et al., 2010 (post-weaning protein)</td>
<td>$732^{s}$</td>
</tr>
<tr>
<td>Soberon et al., 2012</td>
<td>$552^{s}$</td>
</tr>
</tbody>
</table>
Why is milk yield higher for more liberally fed calves?

- Better calf health - respiratory disease?
- Impact on mammary development?
- Epigenetics?

Is high liquid feeding economically justified?
## Economic comparison

Overton, Corbett, Boomer, 2013

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Conventional</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calf investment at calving</td>
<td>$147</td>
<td>$147</td>
</tr>
<tr>
<td>Age at 1st service (months)</td>
<td>15.1</td>
<td>12.2</td>
</tr>
<tr>
<td>Age at 1st calving (months)</td>
<td>25.8</td>
<td>22.9</td>
</tr>
<tr>
<td>Ave. daily gain (g)</td>
<td>682</td>
<td>895</td>
</tr>
<tr>
<td>Total rearing cost/heifer</td>
<td>$2,449</td>
<td>$2,415</td>
</tr>
<tr>
<td>Ave. cost/day</td>
<td>$31.2</td>
<td>$3.48</td>
</tr>
<tr>
<td>Additional milk 1st lactation</td>
<td></td>
<td>1700</td>
</tr>
<tr>
<td>Culling risk – 1st lactation</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>Addition value milk</td>
<td></td>
<td>$171</td>
</tr>
<tr>
<td>Net cost/heifer</td>
<td>$2,449</td>
<td>$2,244</td>
</tr>
</tbody>
</table>
Does liquid feeding regime influence rumen development?

Rumen of 8 week old calf fed 28:28 MR
Making it pay

• Colostrum management
  – Lower morbidity and mortality
  – Treating calves 2x for respiratory – lower herd life.

• Meeting nutrient requirements
  – Lower morbidity and mortality
  – Enhanced lactation yield
Strategic management

- Key calf management focus
  - Colostrum
    - Facilities and People
  - Feeding to biological potential for growth
    - Commitment for feeding higher solids – Waste milk or milk replacer
    - Commitment for higher quality solids – Waste milk or milk replacer
    - Managing environment – moisture, ventilation
    - Positioning the right people and protocols.