Nutritional, Environmental, and Management Factors that Influence the Health, Growth Rate, and Productivity of the Young Dairy Calf

Robert B Corbett DVM, PAS, dipl. ACAN
Introduction

• Heifer programs are considered to be a major cost with no return until calving
• Rations formulated for least cost per day, should be for lowest cost per kg of gain
• Heifers have tremendous ability to utilize protein for increased growth rates
• Nutrition and management needs to be changed to allow the heifer to grow according to its own genetic potential
The dry cow is often fed the poorest quality feeds on the farm. Often does not have adequate time on the pre-partum ration. Dry matter intake reduced because of overcrowding and poor feed bunk management. Common to be in areas with poor environmental conditions and cow comfort.
Fetal Development

- During late pregnancy fetal metabolic rate is twice that of dam
- Glucose and lactate account for 50 to 60% of metabolic fuel
- Placental transport of fatty acids is limited
- Fetal uptake of acetate accounts for 10 to 15% of metabolic fuel
- Amino acids account for remaining 30 to 40% of energy
Uterine Uptake in Relation to Maternal Supply of Organic Nutrients in Late-Pregnant Cows

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Maternal Supply, g/d</th>
<th>Uterine Uptake g/d</th>
<th>% Maternal Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>1,476</td>
<td>666</td>
<td>46</td>
</tr>
<tr>
<td>Amino Acids</td>
<td>998</td>
<td>718</td>
<td>72</td>
</tr>
<tr>
<td>Acetate</td>
<td>2,196</td>
<td>270</td>
<td>12</td>
</tr>
</tbody>
</table>
Maximizing Immunity in the Newborn Calf

• Minimize stress in the close-up dry cow
• Provide adequate levels of energy and protein for fetal growth, immune system, and colostrum quality
• Optimize calcium metabolism through negative DCAD rations with adequate calcium and magnesium supplementation
Nutrition of the Dry Cow and Fetal Programming

• Negative effects on fetal programming result from anything that reduces nutrient availability to the fetus:
  – Breeding heifers that are too small
  – Multiple fetuses
  – Selection for increased milk production
  – High environmental temperatures, heat stress
  – Poor nutrition, low energy and/or protein
HS Reduced Dry Period by 7 days (38d vs. 45d)
HS Calves born 28.7 lbs lighter (68.3 lbs vs. 97 lbs)
HS Cows produced on avg. 11 lbs less milk/day
YEAR 2

HS Reduced Dry Period by 7 days (39d vs. 46d)

HS Calves born 11 lbs lighter (87 lbs vs. 98 lbs)

HS Cows produced on avg. 18.7 lbs less milk/day

HS – Neutrophils – reduced function @ 2 & 20 DIM – reduced ability of animals to fight off infection (reduced immunity)
University of Florida Research  
Dr. Dahl, et. al. 2004-2007 – 3 year study  

YEAR 3  

HS – Reduced Mammary Gland Cell Proliferation (new cell creation)  
HS Cows produced on avg. 10.6 lbs less milk/day
Milk Production
Calves HT in Utero

From Dr. G.E. Dahl
Placental Development

• Nutrient restriction during days 30-125 of pregnancy resulted in reduced birth weight
• Nutrient restriction during days 125-250 resulted in decreased blood flow to the placenta due to:
  – Reduced capillary area density
  – Reduced capillary number density
  – Reduced capillary surface density
Fetal Sex Organ Development

- Testicular development begins at day 45
- Ovarian development begins at day 50-60
- Day 80- oocyte nest break down to form primordial follicles
  - Represent oocyte supply available to female after puberty, (ovarian reserve)
  - Has a direct influence on reproductive lifespan
Fetal Muscle Development

• Muscle fiber numbers do not increase after birth
• Skeletal muscle very vulnerable to nutrient deficiency, lower priority compared to brain, heart, and other organ systems
• Muscle fibers produced from 2-8 months
• Reduced nutrient intake of dam results in permanent, irreversible loss of muscle mass
Reproductive Performance of Heifers

• Adequate nutrition of the dam resulted in heifer offspring that:
  – Reached puberty at an earlier age
  – Had higher pregnancy rates
Influence of Maternal Nutrition on Progeny Health

- Poor nutrition of the dam resulted in:
  - Reduced birth weights
  - Increased morbidity and mortality rates in young calves
  - Increase in respiratory disease in calves post-weaning
Condition at Birth

• Heifer should be born with adequate body condition
• Thin heifers are born weak with little body reserves (brown fat and muscle tissue)
• Common when dry cows are on pasture without supplementation
• Heifer devotes a major part of early nutrition to building fat and protein reserves that should already be there
• Slows early growth rates
Thin Newborn Calves
Colostrum Management

• Inadequate amounts of colostrum result in increased susceptibility to disease.
• Research indicates calves not receiving adequate colostrum grow at 2/3 the rate of other calves.
• Need 10% of body wt. in colostrum at 1st feeding, followed 5% in 6-8 hours
• Should be from mother and not pooled.
• Freezing destroys White Blood Cells
• Cleanliness affects absorption
The role of colostrum in calf health

- Colostral (maternal) antibody protects neonate for first weeks/months until neonate’s acquired immune system produces protective antibodies.
Colostrum Quality

• Vaccination of the mother important to produce more antibody (5 weeks prior to calving)

• Approximately 50% of mother’s IgG goes into colostrum uniformly

• Milk out all 1st milking colostrum to use for 1st feeding

Colostrum from 1st calf heifers is ok if on a good vaccination program
# Cow-side Tests of Colostrum Quality: Colostrometer or Brix Refractometer

<table>
<thead>
<tr>
<th>Instrument Cutpoint Used</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Cost</th>
<th>Pros / Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colostrometer IgG &lt; 50 g/L (Chigerwe, JAVMA 233: 2008)</td>
<td>Green</td>
<td>75%</td>
<td>87%</td>
<td>Rapid, Simple / Fragile, Temperature dependent</td>
</tr>
<tr>
<td></td>
<td>(recc: cutpoint 70)</td>
<td>(recc: cutpoint 70)</td>
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<td>(recc: cutpoint 70)</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>90.5%</td>
<td>85%</td>
<td>Rapid, Simple, Not temp. dependent</td>
</tr>
</tbody>
</table>

- **Colostrometer**: Sensitivity 75% (recommended cutpoint 70), Specificity 87%, Cost $40.
- **Optical Brix Refractometer**: Sensitivity 90.5%, Specificity 85%, Cost ± $80.
## Cow-side Tests of Colostrum Quality: Colostrometer or Brix Refractometer

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<td>IgG &lt; 50 g/L (Chigerwe, JAVMA 233: 2008)</td>
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<td>$40</td>
</tr>
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<td></td>
<td></td>
<td>Rapid, Simple / Fragile, Temperature dependent</td>
</tr>
<tr>
<td><strong>Optical Brix Refractometer</strong></td>
<td>≥ 22%</td>
<td>90.5%</td>
<td>85%</td>
<td>± $80</td>
</tr>
<tr>
<td>IgG &gt; 50 g/L (Bielmann JDSci. 2010)</td>
<td></td>
<td></td>
<td></td>
<td>Rapid, Simple, Not temp. dependent</td>
</tr>
</tbody>
</table>
Brix Refractometer Examples
(> 22% on Brix scale = Good colostrum)

MISCO Palm Abbe Digital Refractometer
- www.MISCO.com. Cleveland, OH
- Cost: $300+
- Scales:
  - Brix scale (%) for colostrum or serum
  - Serum total protein scale (g/dl)
  - Whole milk total solids estimate (%)

Vee Gee BX-50 Optical Brix Refractometer
- http://www.amazon.com
- Cost: $100
- Scales:
  - Brix scale (%) for colostrum or serum
  or to estimate milk total solids
Nutritional and Endocrine Effects of Colostrum

- Immune components other than IgG
- Nutrients critical for thermogenesis, maintenance and growth
- Epigenetic programming: gene expression related to growth, repro, mammary dev
- Calves with FPT:
  - Delayed time to first calving
  - Decreased adg for first 180 days
  - Decreased milk & fat prod 1st lact
  - 50% less feed efficiency
National Survey of Colostrum Quality  
(Morrill et al., J. Dairy Sci. 2012. 95:3997)

• Sample frame:
  – 827 samples from 67 herds (NE, SE, MW, SW)
  – Fresh frozen & refrigerated samples
  – Holstein, Jersey, other
  – June – October, 2010

• Results
  – IgG = 68.8 g/L (< 1 to 200 g/L; ≈30% < 50 g/L)
  – Factors associated with IgG:
    • Parity
    • Region (best in MW)
Effect of Delaying First Milking on Colostrum Quality
13 cows – 52 quarters

Cause of effect?
- Dilution?
- Reabsorption?
2. QUANTITY FED at FIRST FEEDING

Goal: To achieve Serum IgG ≥ 10 mg/ml, must consume ≥ 100g IgG

Current Recommendations: Feed 10% of body weight at first feeding = 3.8 L (4 qts) for an average 43 kg (90 lb) Holstein calf
Suckling Mom is NOT Recommended

• Very high rate of FPT due to delays in suckling.

<table>
<thead>
<tr>
<th>Lactation num. of dam</th>
<th>% calves not suckled within 6 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11%</td>
</tr>
<tr>
<td>2 +</td>
<td>46%</td>
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• Other disadvantages:
  – Don’t know volume consumed.
  – Increased risk of pathogen exposure
4. COLOSTRUM CLEANLINESS
Critical Control Points to Reduce Contamination

- **Cow**
  - Identify infected cows (MAP)
  - Don’t let calf suckle dam
  - Udder prep
  - Don’t pool raw colostrum

- **Equipment**
  - Sanitation of milking, storage & feeding equipment

- **Proliferation**
  - Feed ASAP (< 1-2 hrs)
  - Refrigerate (< 48 hrs)
  - Freeze
  - Preservatives

- **Replacers, Heat-treating**
Sources of Contamination:

2. Contamination During Colostrum Harvest
(Stewart et al. JDS. 2005. 88)
How often do producers feed contaminated colostrum?

• Goal:
  – total plate count (TPC) < 100,000 cfu/ml
  – total coliform count (TCC) < 10,000 cfu/ml

(McGuirk and Collins. 2004. VCNA Food Animal Practice)

• Wisconsin: 82% of samples exceeded limit
• Minnesota: 93% of samples exceeded limit
• National study: 43% of samples exceeded limit

(Poulsen et al. Proc. ACVIM. 2002. #52; Swan et al. 2007. JDSci. 90; Morrill et al., 2012. JDSci 95:3997)
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
5. Monitoring passive transfer rates

- **Herd level:**
  - Bleed 12+ clinically normal 1-7 d old calves & separate serum

- **STP Refractometer:**
  - Goal: 90% ≥ 5.2 g/dL or 80% ≥ 5.5 g/dL

- **Brix Refractometer:**
  - Goal: 90% ≥ 8.4%
Calf Requirements

Major Inputs Used to Compute Young Calf Requirements

Calf Body Weight: 90 (lbs) Diet ME: 2.15 (Mcal/lbs)
Temperature: 68.0 deg. F Diet NEm: 1.86 (Mcal/lbs)

Calculation of Young Calf Requirements

Allowable Gain

Energy Allowable ADG: 0.51 (lbs/day) ADP Allowable Gain: 0.54 (lbs/day)

Maintenance Requirement Calculations

Total Milk Dry Matter Intake: 1.00 (lbs/day)
Total Starter Dry Matter Intake: 0.00 (lbs/day)
Calf Requirements

Major Inputs Used to Compute Young Calf Requirements

Calf Body Weight : 90 (lbs)  
Temperature : 32.0 deg. F  
Diet ME : 2.15 (Mcal/lbs)  
Diet NEm : 1.86 (Mcal/lbs)  
Diet NEg : 1.49 (Mcal/lbs)

Calculation of Young Calf Requirements

Allowable Gain

Energy Allowable ADG : Weight Loss  
ADP Allowable Gain : Weight Loss

Maintenance Requirement Calculations

Total Milk Dry Matter Intake : 1.00 (lbs/day)  
Total Starter Dry Matter Intake : 0.00 (lbs/day)
28:20 MR 2.63 lbs in 7qts per day
(180 grams/liter 7 liters/Day 0°C)

Calf Requirements

Major Inputs Used to Compute Young Calf Requirements

Calf Body Weight : 90 (lbs)
Temperature : 32.0 deg. F
Diet ME : 2.21 (Mcal/lbs)
Diet NEm : 1.91 (Mcal/lbs)
Diet NEg : 1.53 (Mcal/lbs)

Calculation of Young Calf Requirements

Allowable Gain

Energy Allowable ADG : 2.32 (lbs/day)
ADP Allowable Gain : 2.64 (lbs/day)

Maintenance Requirement Calculations

Total Milk Dry Matter Intake : 2.63 (lbs/day)
Total Starter Dry Matter Intake : 0.00 (lbs/day)
What is Biologically Normal?

• If left on its mother a 100 lb calf will:
  – Nurse 6 to 10 times per day
  – Consume between 16 and 24% of its body wt per day as milk (20% average)
  – Consume 7.2 to 10.6 liters of milk per day
  – Consume 0.9 to 1.4 kg of dry milk solids per day
Milk Replacer Feeding Program

- 21% Protein and 17% Fat is the most common product used.
- Impossible to meet nutritional requirements of milk-fed calves with this product at suggested feeding rate (12% solids & 10% of body weight per day total volume).
- If only product available, must increase the amount of dry matter fed per day by increasing solids content, volume fed, and feeding frequency.
Milk Replacer Feeding Program

Advantages

• Can adjust % solids fed easily
• Lower bacteria counts than unpasteurized non-saleable milk
• Johne’s control programs
• More consistent if proper mixing procedures are followed
• Can mix correct volume as needed per day
Milk Replacer Feeding Program

- Approximately 15% of body weight during the first week of life (3 liters twice per day for the average Holstein calf)
- Increase to approximately 20% of body weight at 8 days of age (4 liters twice per day)
- Increase solids content to at least 15% starting at first feeding
  Maintain at this level until ready to be weaned
Environmental Temperature and Nutritional Requirements

- Thermoneutral range is 50° to 68° F
- High temp & humidity: ↑ energy demands and ↓ appetite
- Low temps: ↑ energy demands and ↓ ability to digest dry matter
- Must increase solids content, volume fed, or number of times fed
- However, if maximizing nutrient intake, program does not have to be changed
Cold Temperatures Management Procedures

• Increase solids content to 15-18%
• Feed 3 times per day
• Warm milk or replacer to 40.5°C
• Free choice water at all times
• Calves at 4°C had 32% increase in energy requirement over calves at 10°C
• At -18°C energy requirement more than doubles
• Inadequate energy results in protein depletion
Increasing Nutrient Intake

- Anything that can be done to increase the amount of protein and energy consumed by the milk-fed calf will result in an increase in growth rate, and a significant improvement in the health and productivity of that calf.
Affects of Plane of Nutrition on Rumen Health and Development

Rumen Pics
Courtesy of Dr. Jill Davidson
Purina Animal Nutrition

A = Full Potential (2.5# DM from CMR)
B = 1.5# DM from CMR
C = 1# DM from CMR
2.5 Pounds DM from Milk Replacer

6030 Cranial Ventral

A: 4 wk of age
1.5 Pounds DM from Milk Replacer

6024 Cranial Ventral

B: 4 wk of age
1 Pound DM from Milk Replacer

C: 4 wk of age
Comparison of 3 Feeding Rates

A: 4 wk of age

B: 4 wk of age

C: 4 wk of age
2.5 Pounds DM from Milk Replacer

6019 Cranial Ventral

A: 8 wk of age
1.5 Pounds DM from Milk Replacer

6023 Cranial Ventral

B: 8 wk of age
1 Pound DM from Milk Replacer

C: 8 wk of age
Comparison of 3 Feeding Rates

A: 8 wk of age

B: 8 wk of age

C: 8 wk of age
Goals for the Growing Calf

• Rumen sufficiently developed to ferment dry feeds efficiently enough to satisfy the nutrient requirements of the weaned calf
• Allow the animal to obtain its maximum genetic potential in growth
• Provide a management program and nutritional program to optimize the health of the calf
Body Condition Scoring
Thin Calf
Accelerated Growth Formulas (Formulas that allow the calf to develop according to their genetic potential)

- Calves on whole milk or replacer fed at 8-10% body wt/day gain 250-300 grams/day
- Calves fed larger volumes of a high quality milk replacer with higher nutrient content should be able to average 900 grams/day
- Easy goal is to double birth weight in 8 wks
- Optimum goal is to increase birthweight by 2.5 times in 10 weeks
Accelerated Growth Formulas

- 24 to 28% protein
- 15 to 20% fat
- Whole milk = 27% protein and 30% fat
- Protein is similar but lower in fat
- Promotes lean tissue gain
- Increases efficiency of gain
- Fat is a satiety agent
Advantages

• Increased growth rate from birth until weaning
• Increased lean tissue to fat tissue ratio
• Increased efficiency of gain
• Increased parenchymal tissue in udder (more mammary tissue for potential future milk production)
• Improved immune response (decreased sickness and death) death loss <1%
Advantages (cont)

- Decreased labor and medicine costs (medicine costs decreased by 80%)
- Decreased age at first calving
- Program does not have to be altered depending on environmental conditions
- Increased 1st lactation milk production approximately 1,700 lbs (773 kg)
What has been the count of births and animals exiting before 6 weeks old, by month of birth?
Long Term Effects of Morbidity

- Calves that experience a disease insult will never catch up to herdmates
- No such thing as compensatory growth
- Age at first service will be delayed
- Calves that experience a disease insult will never be able to reach the same potential milk production as an adult, even though fully recovered
What this means

- The effect of growth rate and thus nutrient intake prior to weaning had a more direct and significant effect on milk yield than genetic selection for production.

- Genetic selection yields ~ 68 – 114 kg milk per lactation.

- Pre-weaning calf nutrition and management can yield 4 to 8 times more milk than genetic selection per lactation.
What this might mean

• When we feed for more nutrient supply above maintenance, we are actually setting the calf up to be a better lifetime milk producer

• Since “stayability” or herd life is primarily correlated to milk production, the implication is we might enhance herd life through better early life nutrition
What about Sickness, Treatments and Milk Yield?

- 1\textsuperscript{st} lactation milk yield was not significantly affected by reported cases of diarrhea.
- However, antibiotic treatment had a significant effect on TDM residual milk.
- Calves that were treated with antibiotics, produced 493 kg less milk in the first lactation ($P > 0.01$) than calves with no record of being treated.
Nutrition and Disease Resistance

- Management and hygiene is extremely important
- Effects of nutrition on immune competency is often ignored
- Minimize environmental and social stress
- Calves have an amazing ability to fight disease if immune system has proper fuel
- Death loss of <1% is obtainable with proper management and nutrition