Colostrum: Quality, Management and Options

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Colostrum

- Sets the calf up for a lifetime
  - Calf health
  - Calf growth rates
  - Local gut effects
  - Lifetime health
  - Future milk production
  - Longevity
First one there is the winner!

It’s a race between bacteria
OR
The antibodies in colostrum
Colostrum Management

3 Q’s

- Quantity – 4 litres
- Quality – 50 mg IgG/ litre
- Quickness – ASAP

Time to revisit? More to colostrum management?
Colostrum Management

Pre-partum

Harvest

Storage

Feeding

How do we Evaluate colostrum management program?
Consequences of bacterial contamination of colostrum

- Pathogens may cause disease
  - *E. coli*
  - *Salmonella*
  - *Mycoplasma*
  - *M. avium subsp. Paratuberculosis*

- Bacteria counts are associated with decreased serum IgG concentrations.

James et al., 1981, Johnson et al., 2007
How do bacteria interfere w/passive transfer of IgG?

- Uptake of globulin protein across gut was reduced when bacteria were present.

  James et al., 1981, Staley and Bush, 1985

Proposed mechanisms:

- Antigen-antibody complex forms in gut lumen.
- Damage to villus epithelial cells, reduce permeability
- Replacement of fetal type enterocytes by adult type cells (incapable of macromolecule uptake).

  Corley et al., 1977
Colostrum Composition

- Source of:
  - Immunoglobulins
  - Energy
  - Protein
  - Vitamins/minerals
  - Bioactive peptides
  - Maternal cells
  - Hormones

- Potential pathogens
Colostrum Composition

Overall sample means for IgG, nutrients & bacterial contamination.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgG (mg/mL)</td>
<td>827</td>
<td>68.8</td>
<td>32.9</td>
<td>&lt;1.8</td>
<td>200.2</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>531</td>
<td>5.6</td>
<td>3.2</td>
<td>1.0</td>
<td>21.7</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>542</td>
<td>12.7</td>
<td>3.3</td>
<td>2.6</td>
<td>20.5</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>538</td>
<td>2.9</td>
<td>0.5</td>
<td>1.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Other Solids (%)</td>
<td>544</td>
<td>4.3</td>
<td>0.5</td>
<td>1.1</td>
<td>8.8</td>
</tr>
<tr>
<td>Total Solids (%)</td>
<td>496</td>
<td>22.6</td>
<td>4.7</td>
<td>1.7</td>
<td>33.1</td>
</tr>
<tr>
<td>SCC Log_{10}</td>
<td>548</td>
<td>5.9</td>
<td>0.8</td>
<td>3.8</td>
<td>7.3</td>
</tr>
<tr>
<td>TPC Log_{10}</td>
<td>548</td>
<td>4.9</td>
<td>0.9</td>
<td>3.0</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Morrill et al., 2012
Distribution of IgG concentration

Morrill et al., 2012
### Nutrient, bacterial, IgG and somatic cell count means by breed and lactation

<table>
<thead>
<tr>
<th></th>
<th>Breed</th>
<th>Lactation</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holstein</td>
<td>Jersey</td>
<td>SE(^1)</td>
<td>1</td>
<td>2</td>
<td>3+</td>
</tr>
<tr>
<td>IgG (mg/ml)</td>
<td>74.2</td>
<td>65.8</td>
<td>8.3</td>
<td>42.4(^{a})</td>
<td>68.6(^{b})</td>
<td>95.9(^{c})</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>5.3</td>
<td>5.3</td>
<td>0.5</td>
<td>6.6(^{c})</td>
<td>4.2(^{a})</td>
<td>5.1(^{b})</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>12.5</td>
<td>12.6</td>
<td>0.7</td>
<td>12.4</td>
<td>12.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>3.0</td>
<td>2.9</td>
<td>0.1</td>
<td>3.0(^{ab})</td>
<td>2.8(^{a})</td>
<td>3.1(^{b})</td>
</tr>
<tr>
<td>Other Solids (%)</td>
<td>4.4</td>
<td>4.4</td>
<td>0.1</td>
<td>4.4(^{b})</td>
<td>4.2(^{a})</td>
<td>4.6(^{b})</td>
</tr>
<tr>
<td>Total Solids (%)</td>
<td>22.2</td>
<td>23.0</td>
<td>0.9</td>
<td>23.5(^{b})</td>
<td>20.8(^{a})</td>
<td>23.4(^{b})</td>
</tr>
<tr>
<td>SCC Log(_{10})</td>
<td>5.9(^{b})</td>
<td>5.3(^{a})</td>
<td>0.1</td>
<td>6.0(^{c})</td>
<td>5.6(^{b})</td>
<td>5.3(^{a})</td>
</tr>
<tr>
<td>Coliform Log(_{10})</td>
<td>1.5(^{b})</td>
<td>1.2(^{a})</td>
<td>0.1</td>
<td>1.2(^{a})</td>
<td>1.5(^{b})</td>
<td>1.3(^{a})</td>
</tr>
<tr>
<td>TPC Log(_{10})</td>
<td>4.9(^{b})</td>
<td>4.1(^{a})</td>
<td>0.1</td>
<td>4.5(^{ab})</td>
<td>4.7(^{b})</td>
<td>4.3(^{a})</td>
</tr>
</tbody>
</table>

Morrill et al., 2012
## Pooled vs. Individual samples

<table>
<thead>
<tr>
<th>Nutrient, bacterial, IgG and somatic cell count means of individual samples compared to pooled maternal colostrum samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pooled</strong></td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>n = 734</td>
</tr>
<tr>
<td>IgG (mg/ml)</td>
</tr>
<tr>
<td>Fat (%)</td>
</tr>
<tr>
<td>Protein (%)</td>
</tr>
<tr>
<td>Lactose (%)</td>
</tr>
<tr>
<td>Other Solids (%)</td>
</tr>
<tr>
<td>Total Solids (%)</td>
</tr>
<tr>
<td>SCC Log(_{10})</td>
</tr>
<tr>
<td>TPC Log(_{10})</td>
</tr>
<tr>
<td>Coliform Log(_{10})</td>
</tr>
</tbody>
</table>

\(^{ab}\) Means within a row with different superscripts differ (P < 0.05)

\(^1\) SE = Standard error

Morrill et al., 2012
Quality

How do we define colostrum quality?

- IgG concentration > 50 mg/ml

- Bacteria
  - Total Plate Count < 100,000 CFU/mL
  - Total Coliform Count < 10,000 CFU/mL

No mention of nutrient content
Measuring Colostral IgG

- **63.5%** of operations normally hand-feed colostrum

- **13%** of these farms estimate IgG levels
  - **7.6%** of small farms (<100 cows) estimate IgG
  - **19.8%** of medium farms (100 – 499 cows) estimate IgG
  - **45.2%** of large farms (>500 cows) estimate IgG

(NAHMS, 2007)
Measuring Colostral IgG

In the lab
- Radial immunodiffusion assay
  - 18 – 24 h incubation time
  - Past the time of gut closure
  - Expensive ($10/sample)
  - Limited availability to producers

- ELISA
  - 3 - 4 h incubation time
  - Limited availability to producers
## Methods to Evaluate Colostrum Quality On-Farm

<table>
<thead>
<tr>
<th>Primary method</th>
<th>% Operations</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colostrometer</td>
<td>43.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Appearance</td>
<td>41.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Volume of first milking (lbs)</td>
<td>9.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Other</td>
<td>5.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*(NAHMS, 2007)*
Visual Assessment

- Can be subjective to IgG quality

However...
- Detect colostrum that should be discarded
  - Mastitis
  - Bloody
  - Watery
  - Contaminated

- Visual assessment of the cow
Colostrometer

- Based on specific gravity
- Provide an estimate of relative quality, not actual IgG quantity  
  (Fleenor and Stott, 1980)
- Often inaccurate or utilized improperly  
  (Morin et al., 2001, Mechor et al., 1992, 1993)
- Inexpensive
Refractometer

- Hand held device, can be optical or digital

- Uses light prism to measure protein refraction = refractive index (nD)

  \[ \text{%Brix} = (((((11758.74*}\text{nD}-88885.21)*}\text{nD}+270177.93)*}\text{nD}-413145.80)*}\text{nD}+318417.95)*}\text{nD}-99127.45) \]

  (ICUMSA, 2009)

  (Chavatte et al., 2002)
Refractometer

- Strong correlation between nD and IgG content in colostrum
  - $r = 0.90$ on fresh colostrum (Morrill et al., 2012)

- Decent correlation between %Brix and actual IgG content in colostrum
  - $r = 0.71 - 0.75$ (Biellman et al., 2010; Quigley et al., 2012)

- Not a quantitative test
  - 21% Brix recommended as break-point (Quigley et al., 2012)
What about bacteria???
Colostrum Management

Pre-partum
↓
Harvest
↓
Storage
↓
Feeding

How do we Evaluate colostrum management program?
How Do I know If Colostrum Is Contaminated?

- Currently no test available for on-farm analysis
- Producers must be proactive to reduce potential bacterial contamination
Reducing The Risk Of Contamination

1. Where does the bacteria come from?

2. What can I do to prevent/reduce bacterial contamination?
Where Does Bacteria Come From?

- Infected gland
- Fecal contamination
Where Does Bacteria Come From?

- Dirty equipment
  - Milking equipment
  - Buckets, bottles, esophageal feeders
  - Place of storage
Where Does Bacteria Come From?

- During storage
  - Additional contamination
  - Bacterial Growth
Pre-partum

- Maintain clean and dry facilities
- Dry-off treatment
- Teat sealants
- Identify infected cows
- Don’t let calf suckle
Harvest

- Cow’s teats should be thoroughly cleaned and dried
  - First time in 30-60 days

- All equipment should be well-cleaned and sanitized
  - Milking equipment
  - Buckets

- Don’t pool raw colostrum

- Discard colostrum that is bloody, watery or has fecal contamination
Storage

Storage/feeding equipment should be well sanitized
- Buckets, bottles, nipples, feeders…

Cover colostrum after collection to prevent additional contamination

Colostrum should be fed or cooled within 1 h after collection
- Freeze excess colostrum in flat gallon zip lock bags
How are we doing at feeding quality colostrum?

**IgG > 50 mg/ml**

<table>
<thead>
<tr>
<th>IgG (mg/ml)</th>
<th>Samples</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>243</td>
<td>29.4</td>
</tr>
<tr>
<td>50 - 80</td>
<td>303</td>
<td>36.6</td>
</tr>
<tr>
<td>80 - 100</td>
<td>156</td>
<td>18.9</td>
</tr>
<tr>
<td>100 - 120</td>
<td>75</td>
<td>9.1</td>
</tr>
<tr>
<td>&gt;120</td>
<td>50</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>827</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**TPC < 100,000 CFU/ml**

<table>
<thead>
<tr>
<th>Range (CFU/ml)</th>
<th>Samples</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100,000</td>
<td>409</td>
<td>54.8</td>
</tr>
<tr>
<td>100,000 - 300,000</td>
<td>90</td>
<td>12.1</td>
</tr>
<tr>
<td>300,000 - 500,000</td>
<td>47</td>
<td>6.3</td>
</tr>
<tr>
<td>500,000 - 1,000,000</td>
<td>74</td>
<td>9.9</td>
</tr>
<tr>
<td>&gt;1,000,000</td>
<td>126</td>
<td>16.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>746</strong></td>
<td><strong>100</strong></td>
</tr>
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</table>

Morrill et al., 2012
### Percentage of samples meeting one or both industry recommendations for colostrum quality

<table>
<thead>
<tr>
<th>Quality</th>
<th>Overall Data</th>
<th>Region</th>
<th>Northeast</th>
<th>Southeast</th>
<th>Midwest</th>
<th>Southwest</th>
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<tbody>
<tr>
<td></td>
<td>n  (%)</td>
<td>n  (%)</td>
<td>n  (%)</td>
<td>n  (%)</td>
<td>n  (%)</td>
<td>n  (%)</td>
</tr>
<tr>
<td>&gt; 50 IgG &lt; 100,000 TPC</td>
<td>294 39.4</td>
<td>58 45.3</td>
<td>17 14.9</td>
<td>88 53.7</td>
<td>177 43.2</td>
<td></td>
</tr>
<tr>
<td>&gt; 50 IgG &gt; 100,000 TPC</td>
<td>233 31.2</td>
<td>32 25.0</td>
<td>54 47.4</td>
<td>51 31.1</td>
<td>96 23.4</td>
<td></td>
</tr>
<tr>
<td>&lt; 50 IgG &gt; 100,000 TPC</td>
<td>104 14.0</td>
<td>28 21.9</td>
<td>14 12.3</td>
<td>14 8.5</td>
<td>83 20.2</td>
<td></td>
</tr>
<tr>
<td>&lt; 50 IgG &lt; 100,000 TPC</td>
<td>115 15.4</td>
<td>10 7.8</td>
<td>29 25.4</td>
<td>11 6.7</td>
<td>54 13.2</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>746 100</strong></td>
<td><strong>128 100</strong></td>
<td><strong>114 100</strong></td>
<td><strong>164 100</strong></td>
<td><strong>410 100</strong></td>
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</table>

Morrill et al., 2012
Percentage of samples meeting one or both industry recommendations for colostrum quality by storage method prior to sample collection

<table>
<thead>
<tr>
<th>Quality</th>
<th>Fresh</th>
<th></th>
<th>Refrigerated</th>
<th></th>
<th>Frozen</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Samples</td>
<td>(%)</td>
<td>Samples</td>
<td>(%)</td>
<td>Samples</td>
<td>%</td>
</tr>
<tr>
<td>&gt; 50 IgG &lt; 100,000 TPC</td>
<td>76</td>
<td>42.0</td>
<td>30</td>
<td>18.5</td>
<td>188</td>
<td>46.7</td>
</tr>
<tr>
<td>&gt; 50 IgG &gt; 100,000 TPC</td>
<td>38</td>
<td>21.0</td>
<td>86</td>
<td>53.1</td>
<td>109</td>
<td>27.0</td>
</tr>
<tr>
<td>&lt; 50 IgG &gt;100,000 TPC</td>
<td>21</td>
<td>11.6</td>
<td>38</td>
<td>23.5</td>
<td>45</td>
<td>11.2</td>
</tr>
<tr>
<td>&lt; 50 IgG &lt;100,000 TPC</td>
<td>46</td>
<td>25.4</td>
<td>8</td>
<td>4.9</td>
<td>61</td>
<td>15.1</td>
</tr>
<tr>
<td>Total</td>
<td>181</td>
<td>100</td>
<td>162</td>
<td>100</td>
<td>403</td>
<td>100</td>
</tr>
</tbody>
</table>

Morrill et al., 2012
Additional Options Available

- Heat Treatment of Colostrum
- Colostrum replacement products

Both options have pro’s and con’s and should be evaluated prior to making a major management change.
Heat treatment of colostrum

- 60 °C (140 °F) for 60 minutes

- No viscosity changes
- No change in IgG (mg/mL)
- Significantly reduces or eliminates bacterial pathogens
  - Can regrow if you allow to sit at room temp or place in dirty storage equipment.
Colostrum Management

Pre-partum
Harvest
Storage
Feeding

How do we Evaluate colostrum management program?
Passive Transfer

- Radial Immunodiffusion
  - Adequate passive transfer \( \geq 10 \text{ mg/mL IgG} \) at 24 h
  - Failure of passive transfer \( \leq 10 \text{ mg/mL IgG} \) at 24 h

- Quantitative test

- Challenges:
  - Long incubation time (18 to 48 h)
  - Not “on-farm friendly”
Passive transfer

- Total protein
  - Strong correlation to IgG \( r = 0.80 - 0.84 \)  
    (Quigley et al., 2001; Swan et al., 2007)
  - \(< 5.5 \text{ TP} = \text{Indicative of failure of passive transfer}\)

- Optical or Digital – available for on-farm use.

- Not quantitative
How many farmers are measuring passive transfer in calves?

<table>
<thead>
<tr>
<th>Herdsize</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>1.1%</td>
</tr>
<tr>
<td>100 – 499</td>
<td>2.4%</td>
</tr>
<tr>
<td>&gt;500</td>
<td>14.5%</td>
</tr>
<tr>
<td>Overall</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

(NAHMS, 2007)
Challenges with Serum TP

 Angle of refraction impacted:
  • Protein
  • Electrolytes   Glucose   Urea   Lipids

 Conversion factors needed to account for other compounds as well as amount of N
  • Some use a factor of 6.54% others use 6.25% for calculating amount of N in albumin.
Can we use the same refractometer to evaluate colostrum quality and determine if the calf has achieved adequate passive transfer?

YES!!!
nD of calf serum

- Is the nD correlated to actual IgG concentration?

- Can we develop an equation to estimate actual IgG concentration using serum & a refractometer on-farm?
## Descriptive Statistics

<table>
<thead>
<tr>
<th>Item</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgG (mg/mL)</td>
<td>185</td>
<td>19.0</td>
<td>9.7</td>
<td>3.5</td>
<td>47.0</td>
</tr>
<tr>
<td>Brix (%)</td>
<td>185</td>
<td>8.6</td>
<td>0.9</td>
<td>6.8</td>
<td>11.0</td>
</tr>
<tr>
<td>nD</td>
<td>185</td>
<td>1.34566</td>
<td>0.00140</td>
<td>1.34300</td>
<td>1.34930</td>
</tr>
</tbody>
</table>

$^1$Item: IgG = immunoglobulin G concentration as determined by radial immunodiffusion

(Morrill et al., 2013)
Serum IgG concentration as determined by RID compared to the refractive index (nD) of whole calf serum.

\[ y = 5919.1x - 7946.1 \]
\[ R^2 = 0.7314 \]

r = 0.86
n = 185

(Morrill et al., 2013)
Evaluating passive transfer/colostrum management

- Producers can purchase a digital refractometer that displays actual IgG concentration.
- Samples should be taken 24 – 48 hours after birth.
- < 20% of calves should have FPT

(McGuirk and Collins, 2004)
Take Home Message

- Cleanliness
  - Pre-partum
  - Milking
  - Storage
- Throw away colostrum with visible contamination
- Feed or freeze colostrum within 1 hour of collection

Healthy Calves = Healthy Profits
Conclusions

- Colostrum management on U.S. dairies is poor
  - Less than 40% of US colostrum meets both recommendations.

- Huge opportunities to improve calf and heifer management and profitability
Colostrum Management

Feed high quality colostrum ASAP!!!

- Harvest colostrum in sanitary manner
- Test colostrum
  - Discard poor, dirty, bloody colostrum
- Store correctly
  - Feed fresh or freeze in 1 gallon ziplock bag within 30 min of collection
- Evaluate your Colostrum options
- Follow-up and evaluate FPT rates in calves

CLEANLINESS