Overview
Research Update: Energy Strategies for Dry Cows

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Introduction

- Successful transition = preventing disease and ensuring profitability
- Research focused on pre- and postpartum management strategies, nutritional, housing and preventive procedures to achieve this goal
- As a result of ↓ DMI pre-calving; some authors proposed ↑ energy diets to improve health and production
- DMI was show to increase prepartum with high energy diets, however field experiments show benefits of feeding controlled energy diets prepartum
- Overfeeding energy in the far-off period has more severe negative consequences than overfeeding in the close-up period
- Drackley and Guretzky (2007) advised a high straw, low-energy TMR for the whole dry period
- This paper compares three dietary dry cow strategies.
Experimental Approach

- RBD, 84 Holstein cows, assigned to one of three DC diets at different energy levels:
  - C= controlled energy diet
  - I= intermediate (125% req.) representing a step-up dietary strategy
  - H= high energy diet (150% req.)
Experimental Approach

- After calving, all cows were fed the same fresh cow diet (F) until 42 DIM.

- Samples and testing of: β-hydroxybutyrate (BHBA), Milk yield, colostrum (IgG), TMR, calculations done for (ECM) for 3.5% fat and 3.0% protein.

- Energy balance was estimated in CNCPS (v. 6.1) for each week.
Concentrations of BHBA, before and after calving were highest in group H (fat mobilization)

# cows treated for clinical ketosis; 0 in group C, 4 in group I, 5 in group H

Episodes of ketosis; 13 in group C, 32 in group I and 31 in group H

Concentrations of NEFA were highest in group C prepartum and highest in group H postpartum.

DMI highest in group H and lowest in group C

No differences found in DMI or milk yield postpartum

Highest fat % and ECM in group H and lowest in group C
Effect of Dry Period Energy Level on Colostral Immunoglobulin

- Immunoglobulin G concentration was different for cows in the three treatment groups
- Concentrations were highest in group C and lowest in group H
- Improved colostrum quality on low energy ration
Implications and Conclusions

- Cows fed controlled energy diet throughout the whole dry period mobilized less adipose tissue shown by lower concentrations of NEFA and BHBA postpartum, while milk yield and postpartum DMI intake were not affected.
- Colostrum quality (IgG concentration) was higher in controlled energy diet.
- In conclusion; a controlled energy diet fed throughout the whole dry period showed clear advantages in preventing excessive NEB that could lead to disease and improved colostrum quality without affecting milk yield.
uNDF
UNDERSTANDING PRINCIPLES
Some papers call it iNDF to represent indigestible NDF

- Mertens has pushed for us to call it uNDF for undigestible NDF and uNDF is becoming the de facto standard term

pNDF = NDF – uNDF (potentially digestible NDF)

- uNDF is determined with different time points for forages vs. non-forages
Determined by the Traditional method of Tilley-Terry *in vitro* fermentation with modifications (reported on an organic matter basis - aNDFom).

Forages; 30, 120 and 240 hrs with 240 hr representing uNDF.

Non-forages; 12, 72, and 120 hrs with 120 hr representing uNDF.

The three time points are used to calculate the kd (rate of digestion) for the pNDF.
## Some example data

<table>
<thead>
<tr>
<th>Feed</th>
<th>Lignin x 2.4 (%NDF)</th>
<th>uNDF (%NDF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet pulp</td>
<td>25.2</td>
<td>19.0</td>
</tr>
<tr>
<td>Canola Meal</td>
<td>64.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Whole Cotton</td>
<td>57.2</td>
<td>46.0</td>
</tr>
<tr>
<td>Wheat Middlings</td>
<td>14.3</td>
<td>29.0</td>
</tr>
<tr>
<td>Soy Hulls</td>
<td>11.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>18.4</td>
<td>11.8</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>18.7</td>
<td>10.7</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>17.9</td>
<td>10.9</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>20.7</td>
<td>14.2</td>
</tr>
<tr>
<td>BMR Corn Silage</td>
<td>17.4</td>
<td>31.7</td>
</tr>
<tr>
<td>Mature Grass</td>
<td>20.2</td>
<td>31.4</td>
</tr>
<tr>
<td>Immature Grass</td>
<td>14.2</td>
<td>23.2</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>41.4</td>
<td>46.1</td>
</tr>
</tbody>
</table>
So we have this, correct?
Well, NO we don’t.. pNDF is actually a two pool system

- **Fast pool**
  - Larger fast pool results in
    - Faster eating rate
    - Faster ruminal disappearance
    - Higher intakes
    - More ruminal bouyancy

- **Slow Pool**
  - Larger slow and uNDF pools result in
    - More “ballast”
    - Greater chewing and rumination
    - Lower intake
    - Slower Eating speed
We end up with this
Implementation

- Dynamic $kd$ model
- Determines $kd$ for both pools and then integrates them into a single $kd$ for 6.5

Calculation of rates and pool sizes using in-vitro 30, 120 and 240 hr NDFD data
Further implications

- uNDF and intake appear to be very highly correlated.
- It appears in Holsteins that the cow will reach a steady-state uNDF rumen level:
  - 4-5 kg
  - For her to consume more feed, an equal amount of uNDF must escape the rumen first.
- uNDF has 0 kd so completely regulated by passage rate.
- This has massive potential impact on formulation, procurement, and manufacturing thinking.
Example

- **PKE vs Citrus Pulp**
  - **Citrus Pulp**
    - uNDF: 1.7%
    - Fast pool: 93%, kd 7%/hr
    - Slow pool: 5.3%, kd: 5%/hr
  - **PKE**
    - uNDF: 32%
    - Fast pool: 25%, kd 6%/hr
    - Slow pool: 43%, kd: 4%/hr
  - So PKE larger uNDF, larger slow pool thus lower overall fermentability, lower intake, more fill.
  - Could grinding very fine help move it out faster?
Application of uNDF in Ration Modeling and Formulation

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² Department of Animal Science, Cornell University
³ Department of Veterinary Science, University of Bologna
Both fibre digestibility and indigestibility are important for assessing forage quality.

Assessing true NDF indigestibility requires infinite time, therefore true indigestibility is never reached.

iNDF = indigestible NDF, Mertens coined the term uNDF= undigested NDF as a lab measurement at a specific fermentation time.

The method for estimating iNDF within CNCPS is via the use of acid detergent lignin (ADL) and a fixed factor of 2.4 calculated as ADL*2.4/NDF.
The Cornell group recommends 240 hour in vitro fermentation by means of a Tilley-Terry system with modifications.

The fermentation end point as such is not vital but rather to reach a point where the residue weight does not change significantly with additional hours of fermentation.

Long-term: development of NIR equations, reducing both cost and rate of sample analysis.
Biological Importance of uNDF

- uNDF should be a routine analysis, it is a uniform feed fraction with predictable digestibility (zero)
- uNDF is important because:
  - used to calculate potentially digestible NDF (NDF - uNDF)
  - uNDF fraction together with earlier time points of fermentation can be used to estimate the fast and slow pools of NDF digestion and their Kd’s
  - these values in turn can help explain feeding and ruminating behaviour, especially when chemical compositions (i.e. ADL, NDF, ADF) are similar
  - chewing response to peNDF is related to forage uNDF,
  - estimates of the slow pool of NDF and its rate of digestion plus the uNDF are related to dry matter intake and passage from the rumen
The diagram illustrates the degradation of NDF (% Remaining) over time (Time, h) for two different NDFD levels: High NDFD and Low NDFD. The graph is divided into two main sections:

1. **Fast Pools**
   - Points indicating rapid degradation of NDF at the beginning of the time period.
   - The curve for High NDFD shows a steeper decline compared to Low NDFD.

2. **Slow Pools**
   - Points indicating a slower degradation of NDF later in the time period.
   - The curve for High NDFD remains higher than Low NDFD throughout.

A significant point denoted as uNDF240 marks the remaining NDF after 240 hours, with the High NDFD level consistently higher than the Low NDFD level.
Rumen fibre fill is a combination of; uNDF, slowly fermenting NDF, and undigested fast-pool NDF.

The entire mass of uNDF in the rumen can be better understood as a ballast/baseline of fill which limits the possible NDF flux/turnover.

It is proposed that for ruminal uNDF that there is both a minimum (to maintain rumen health) and a maximum (not to limit intake as a measure of fill), suggesting an optimal mass of digesting NDF within the rumen.

It is believed that uNDF measured at 240 hours of in vitro fermentation (uNDF240) is an accurate assessment of the indigestible component of NDF.
Current Research on uNDF, Rumen Fiber Dynamics and Fill

- Fibre Group;
  - Cornell University,
  - Miner Institute
  - University of Bologna
  - other industry scientists has been established.

- Research from Bologna, Cornell, and Miner Institute focused on uNDF240 and its relationship with chewing behaviour, rumen fill, dry matter intake, and lactation performance

- This paper will summarize current research findings from each of these groups
Miner Institute Research on uNDF: Focus on Level and Digestibility of Corn Silage Fiber

- Objectives: measure the passage kinetics of pools for diets differing in amount and digestibility of NDF

- Corn silage TMR using either standard corn or bmr corn silage (digestibility)

- Four diets;
  - **Low fibre, low digestibility** (std corn)
  - **High fibre, low digestibility** (std corn)
  - **Low fibre, high digestibility** (BMR corn) = DMI increase
  - **High fibre, high digestibility** (BMR corn) = DMI increase, NDF intake increase, SC milk production increase

- DMI increase for diets containing bmr silage, most likely from increased rumen turnover as a result of higher digestibility

- NDF intake was increased for cows fed the bmr corn silage in a high-forage diet.

- Solids-corrected milk production was significantly increased by bmr corn silage when fed in a higher forage diet.
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% of ration DM</th>
<th>LF-LD (Low CS)</th>
<th>HF-LD (High CS)</th>
<th>LF-HD (Low BMR)</th>
<th>HF-HD (High BMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional corn silage</td>
<td>39.2</td>
<td>54.9</td>
<td>36.1</td>
<td>50.2</td>
<td></td>
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<tr>
<td>Brown midrib corn silage</td>
<td>13.4</td>
<td>13.4</td>
<td>36.1</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>Hay crop silage</td>
<td>17.3</td>
<td>1.6</td>
<td>20.4</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Corn meal</td>
<td>30.1</td>
<td>30.1</td>
<td>30.2</td>
<td>30.2</td>
<td></td>
</tr>
</tbody>
</table>

**Chemical composition**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>LF-LD (Low CS)</th>
<th>HF-LD (High CS)</th>
<th>HF-HD (High BMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, % of DM</td>
<td>17.0</td>
<td>17.0</td>
<td>16.7</td>
<td>16.7</td>
</tr>
<tr>
<td>NDF, % of DM</td>
<td>32.1</td>
<td>35.6</td>
<td>31.5</td>
<td>35.1</td>
</tr>
<tr>
<td>Starch, % of DM</td>
<td>28.0</td>
<td>21.2</td>
<td>27.8</td>
<td>23.8</td>
</tr>
<tr>
<td>24-h NDF digestibility, %</td>
<td>56.3</td>
<td>54.0</td>
<td>62.0</td>
<td>60.3</td>
</tr>
<tr>
<td>peNDF, % of DM</td>
<td>17.3</td>
<td>23.1</td>
<td>18.5</td>
<td>21.5</td>
</tr>
</tbody>
</table>
NDF and uNDF composition of the three silages and four diets used in the study. The diets with bmr corn silage contained much less uNDF than the conventional corn silage diets.

<table>
<thead>
<tr>
<th>Item</th>
<th>BMR CS</th>
<th>Conv CS</th>
<th>HCS</th>
<th>LF-LD</th>
<th>HF-LD</th>
<th>LF-HD</th>
<th>HF-HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDFom, % of DM</td>
<td>34.8</td>
<td>36.1</td>
<td>46.2</td>
<td>30.8</td>
<td>33.7</td>
<td>30.7</td>
<td>33.5</td>
</tr>
<tr>
<td>NDFD$_{240}$, % of NDF</td>
<td>62.1</td>
<td>48.6</td>
<td>57.7</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>uNDF$_{240}$, % of NDF</td>
<td>21.9</td>
<td>30.5</td>
<td>30.3</td>
<td>26.7</td>
<td>28.5</td>
<td>22.5</td>
<td>22.6</td>
</tr>
<tr>
<td>uNDF$_{240}$, % of DM</td>
<td>7.6</td>
<td>11.0</td>
<td>14.0</td>
<td>8.2</td>
<td>9.6</td>
<td>6.9</td>
<td>7.6</td>
</tr>
</tbody>
</table>
Diets based on silages, max NDF intake = 10 kg/d or 1.5% of body weight
- Max rumen NDF = 8.5 kg or 1.3% of BW
- Intake of uNDF = Max at 2.6 kg/d or about 0.40% of BW
- Rumen mass of uNDF between 0.48 and 0.62% of BW
- Fecal output of uNDF = uNDF intake

<table>
<thead>
<tr>
<th>Item</th>
<th>LF-LD</th>
<th>HF-LD</th>
<th>LF-HD</th>
<th>HF-HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF&lt;sub&gt;om&lt;/sub&gt; intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg/d</td>
<td>8.87</td>
<td>8.95</td>
<td>8.48</td>
<td>9.88</td>
</tr>
<tr>
<td>% of BW</td>
<td>1.32</td>
<td>1.33</td>
<td>1.27</td>
<td>1.47</td>
</tr>
<tr>
<td>Rumen NDF&lt;sub&gt;om&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg</td>
<td>8.50</td>
<td>8.58</td>
<td>7.82</td>
<td>8.48</td>
</tr>
<tr>
<td>% of BW</td>
<td>1.27</td>
<td>1.28</td>
<td>1.17</td>
<td>1.27</td>
</tr>
<tr>
<td>uNDF&lt;sub&gt;240cm&lt;/sub&gt; intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg/d</td>
<td>2.39</td>
<td>2.63</td>
<td>2.03</td>
<td>2.21</td>
</tr>
<tr>
<td>% of BW</td>
<td>0.36</td>
<td>0.39</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Rumen uNDF&lt;sub&gt;240cm&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kg</td>
<td>3.82</td>
<td>4.16</td>
<td>3.20</td>
<td>3.46</td>
</tr>
<tr>
<td>% of BW</td>
<td>0.57</td>
<td>0.62</td>
<td>0.48</td>
<td>0.52</td>
</tr>
<tr>
<td>Fecal uNDF, kg/d</td>
<td>2.41</td>
<td>2.64</td>
<td>2.04</td>
<td>2.24</td>
</tr>
<tr>
<td>Ratio rumen/intake uNDF</td>
<td>1.60</td>
<td>1.58</td>
<td>1.58</td>
<td>1.57</td>
</tr>
</tbody>
</table>
Bologna Research: Alfalfa and Grass Dry Forage Diets in Parmigiano Reggiano Region of Italy

- Milk for Parmigiano Reggiano cheese; cattle fed rations without fermented silages.
- Forages (alfalfa and grass hays) must be included at a min level of 50% of ration DM in order to preserve milk composition, cheese making properties, health and feeding welfare of the cows.
- dry TMR technique (no H2O) forages finely chopped (2 cm) to avoid sorting
- In these TMRs, peNDF is consistently lower (12-14%) than levels suggested by literature (22-24%), and diets are balanced with forages able to enhance rumen motility (straw)
- Free access to long hay is provided in order to avoid the risk of peNDF shortage (less than 1kg/d if ration is balanced)
- test the effects of dry TMR differing in level of forage inclusion (High, Low) and forage (alfalfa hay) digestibility (High, Low) on: animal performance, ruminal pH, passage dynamics of medium, small, and fecal alfalfa particles, and estimation of total tract fiber digestibility using uNDF240 as the internal marker.
Eight Holstein cows fed 1 of 4 rations for 4 weeks

The four experimental diets;

- HF-HD: High Forage-High Digestibility
- LF-HD: Low Forage-High Digestibility
- HF-LD: High Forage-Low Digestibility
- LF-LD: Low Forage-Low Digestibility

Diets were differentiated in terms of forage NDF (High and Low) using soybean hulls and soybean meal.

All the diets had a lower peNDF vs common dry TMR formulated for Parmigiano Reggiano cheese production.

Low NDF required to better measure any effect due to inadequate long forage particles in the ration.
<table>
<thead>
<tr>
<th>Ingredients: % of ration DM</th>
<th>Diet composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HF-HD</td>
</tr>
<tr>
<td>Alfalfa hay (high digestibility)</td>
<td>46.8</td>
</tr>
<tr>
<td>Alfalfa hay (low digestibility)</td>
<td>---</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>8.6</td>
</tr>
<tr>
<td>Corn meal fine, 50%:flakes, 50%</td>
<td>34.4</td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>3.0</td>
</tr>
<tr>
<td>Soybean meal, 44% CP</td>
<td>4.0</td>
</tr>
<tr>
<td>Cane-beet molasses blend</td>
<td>0.5</td>
</tr>
<tr>
<td>Vitamin and mineral premix</td>
<td>1.9</td>
</tr>
<tr>
<td>Forage content, % of DM</td>
<td>55.4</td>
</tr>
<tr>
<td>aNDFom forages,%</td>
<td>23.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical composition, % of DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
</tr>
<tr>
<td>NDF</td>
</tr>
<tr>
<td>aNDFom</td>
</tr>
</tbody>
</table>
Practical Remarks and Guidelines from Bologna Study

The results of the Bologna study suggest the following conclusions:

- DMI is influenced and improved by forage fiber digestibility and not simply by the uNDF intake per se.
- HF – HD diet (High level of highly digestible alfalfa hay) allowed the higher milk production and the best ruminal pH values.
- When dietary peNDF % is low, high rumination time can be maintained only with high dry matter intake.
- When feeding a dry TMR diet (fine chopped alfalfa and straw) require uNDF intake of 0.48% of live BW to maintain the healthier rumen condition and 0.40% to avoid feeding behaviour disturbances.
- The total amount of potentially digestible fiber (pdNDF) “utilized” by the cow is higher and better digested vs current prediction.
- Main factor for this is not related to the forage fiber digestibility, but rumen ability to retain fibre (even for fine particles).
Cornell Research on uNDF: Non-Forage Fiber Sources of uNDF

- Focus at Cornell; extend the uNDF data on non-forage fibre/ by-product feeds for application in diet formulation and incorporation into the CNCPS.
- Previous data confirmed that the relationship between lignin and NDF as a fixed factor as has been used in the CNCPS is not appropriate and does not describe the digestible pool of NDF in forages.
- As previously suggested forage NDF digestion behaves in a varied manner with two digestible pools and the uNDF determined from a 240-h in vitro digestion.
- Does this apply to non-forage feeds?
- Same methodology as fibre feeds? Same time points?
- Eight by-product were evaluated with multiple time points from 0 to 240 h of fermentation
- The initial experiment reported that fermentable NDF was exhausted by 96 h for most of the feeds and by 120 h for soybean hulls
Residues of NDF after 96, 120, and 240 h of in vitro fermentation.

Digestion completed by 120 h, half the time necessary to identify the uNDF in forages

<table>
<thead>
<tr>
<th>Feed</th>
<th>96 h</th>
<th>120 h</th>
<th>240 h</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet pulp</td>
<td>0.17</td>
<td>0.23</td>
<td>0.20</td>
<td>0.02</td>
</tr>
<tr>
<td>Canola meal</td>
<td>0.41</td>
<td>0.42</td>
<td>0.43</td>
<td>0.04</td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>0.18</td>
<td>0.20</td>
<td>0.20</td>
<td>0.07</td>
</tr>
<tr>
<td>Corn gluten</td>
<td>0.15</td>
<td>0.13</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>0.08</td>
<td>0.13</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Soy Plus</td>
<td>0.09</td>
<td>0.06</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Wheat midds</td>
<td>0.32</td>
<td>0.32</td>
<td>0.28</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Semi-log plot showing the partition of wheat midds into fast, slow, and undigestible NDF pools. The pdNDF fast pool was exhausted by 18 h of fermentation.
Degradation curves were plotted on a semi-logarithm scale to evaluate the partition of NDF into fast degrading pool, slow degrading pool, and undigestible pool.

In some cases, non-forage feeds do not show the partition of NDF into a fast and slow degrading pool, therefore two different equations were used to describe degradation parameters.

In essence creating a dynamic model to predict the degradation of slow and fast pools of NDF.

The dynamic model allows for the use of fewer data points, compared to statistical models, to estimate the desired parameters.
12, 72 and 120 are the best time points to use…..

There are “options” but for commercial laboratory and modelling purposes we need to be consistent

For some by-products the lignin factor greatly over-estimated the indigestible fraction of NDF, this explains why, under certain conditions, more energy is realized from feeding these by-products compared to current estimates (vice versa)
To-date, the combined data sets from Cornell, Bologna, and Miner indicate:

- Daily uNDF intake equals uNDF output in the faeces.
- Maximum uNDF mass in the rumen is approximately 0.48 to 0.62 % of BW.
- Maximum NDF intake is approximately 10 kg/d or 1.47% of BW (range of 1.27 to 1.47)
- Maximum uNDF intake is 0.39 % of BW (Miner data) to 0.48% (Bologna data)
- Ratio of rumen uNDF: intake uNDF is 1.60 regardless of diet
Thank you!
Immune Dysfunction in Periparturient Dairy Cows: Evidence, Causes and Ramifications

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Introduction

- Periparturient period = increased susceptibility to disease and health disorders
- 75% of herd disease occurs shortly post partum
- Studies to better understand cause of parturition related diseases
- The cows ability to resist disease during this period is related to immune system efficiency

Overview: How suboptimal immune responses can fail to prevent disease, and outline current strategies to optimize immune responses in food-animals during times of increased susceptibility to disease.
Overview of the Immune System

An effective immune system protects animals from a variety of pathogenic organisms.

<table>
<thead>
<tr>
<th>Innate Immunity</th>
<th>Adaptive Immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Barriers</td>
<td></td>
</tr>
<tr>
<td>Cell-mediated immunity</td>
<td></td>
</tr>
<tr>
<td>Soluble or Humoral immunity</td>
<td></td>
</tr>
</tbody>
</table>
Overview of the Immune System

→ Innate Immunity

- Dominant host defense system
- Includes nonspecific components
- First line of defense
- At high levels of efficiency can eliminate microbes in hours or minutes
- Components include; physical and mechanical barriers, phagocytes and soluble mediators
- Pattern recognition receptors, sense presence of invading pathogens

Innate Immunity

| Non-specific or generic response
| Immediate following exposure (minutes) |
| Physical & mechanical barriers |
| Cellular and soluble factors |
| No immune memory |
| Inflammation |
Overview of the Immune System

→ Inflammation

- Critical part of innate immunity
- Complex response to local tissue trauma
- Purpose of inflammation
  - remove source of tissue injury
  - Restore immune homeostasis
  - Restore tissue to normal function
- Inflammation results in increased movement of leukocytes and plasma from blood into infected tissues
Overview of the Immune System
→ Adaptive Immunity

- Triggered when innate immune system fails to eradicate a pathogen
- Characterized by antigen-specific lymphocytes and memory cells
- Can take days to develop vs innate system
- Stronger, longer lasting and more effective in eliminating a pathogen
- Is able to recognize self from non-self and react to only foreign antigens

Adaptive Immunity

- Antigen-specific response
- Delayed following exposure (days)
- No physical/mechanical barriers
- Cellular and soluble factors
- Immunological memory
- Antibody response (vaccines)
Periparturient Immune Dysfunction

- Periparturient period = time of dramatic change in the efficiency of the immune system
- Many studies show changes in both innate and adaptive immunity impacting the susceptibility to new diseases in transition cows
- Increased likelihood of infection when exposed to pathogens as well as increased disease severity
- An imbalance between the initiation and cessation of inflammation results in a chronic inflammatory response, causing extensive damage to host tissues. (eg; chronic mastitis in early lactation cows)
Changes in hormones just before calving, directly and indirectly affect the efficiency and ability of immune cell populations. Hormone changes only occur during part of transition period, therefore other factors also contribute to the inflammation dysfunction. Other factors may include; NEB and changes in nutrient metabolism. Experiments concluded that calving and associated changes is not the chief cause of immunosuppressive factor in periparturient cows. But rather it is due to the increase in metabolic demands of early lactation on the impact of immune cell populations. Changes in nutrient metabolism may be the link between immune dysfunction and the increase in metabolic and infectious diseases in periparturient cows.
Benefits of optimizing Immunity

- Optimal defense; when both innate and adaptive immune mechanisms are effective at eliminating pathogenic attacks and return tissues to homeostasis
- Antibiotics remain the primary treatment protocol for infectious diseases, there is a need for alternative and additional therapeutic options that target host immune responses
- Challenge; reducing the harmful responses of the host without lessening the beneficial responses that fight pathogens
- Strategies that target host response will reduce risk of drug residues and the prospect of developing drug resistant bacteria
Activation of the immune system needs energy and thus the immune system competes for nutrients being distributed to growth and production.

The damage to host tissues caused by chronic inflammatory response to pathogens also require nutrients for repair, reducing growth and production.

Adjusting animal nutrition and reducing exposure of animals to infectious pathogens - by improving management - can greatly improve optimization of the immune system and therefore growth and production.
An Update on rbST- Human Safety and Animal Efficiency and Welfare

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Introduction

- Recombinant bovine somatotropin (rbST), the first recombinant protein approved for use in production animals
- Has met with unparalleled scrutiny
- It has been on the market for 20 years on a global scale
- Two studies were conducted in order to update its effect on human safety and animal performance
The Joint Expert Committee on Food Additives (JECFA), is an international expert scientific committee administrated jointly by FAO of the United Nations and the World Health Organization.

JEFCA reviewed the human safety of rbST in 1993 and again in 1998 and concluded both times that: because rbST was given at low levels and that the residues were non-toxic even at much higher levels, there is a large safety margin for humans consuming these products.

It was therefore determined that a “minimum residue level” did not need to be established and that it was not a risk to human health.

In 2013 JEFCA re-evaluated rbST and requested new data and information related to human health and the use of rbST.
Milk Antibiotic Residues

- Antibiotics are used for the treatment of mastitis
- There is a risk of residues in milk if sent to bulk tank before withdrawal period
- Mastitis incidence is related to environmental conditions and management practices.
- As well as a small mastitis increase related to milk production increase on a per cow bases. The FDA concluded that the use of rbST was related an increase in the relative risk of mastitis.
- The 50th JECFA Conference (relationship between rbST use and milk antibiotic residues). They concluded that:
  - rbST use would not increase risk to human health due to antibiotic use to treat mastitis as potential for drug residues in milk could be managed by practices currently in use.
The pattern of milk antibiotic residue violations for the US dairy industry from 1995 to 2012
SCC values provide insight related to milk quality and subclinical mastitis.

Collier and Bauman reported that milk SCC declined steadily from 316k cells/mL in 2001 to 224k cells/mL in 2010 and 206k cells/mL in 2011. There is therefore no evidence for an increase in the SCC for US herds over the interval of rbST use.

Conversely this indicates an increase in milk quality and mammary health.

High SCC counts are an indicator of low quality milk. Herds with 200,000 cells per ml of milk or less had the lowest incidence of antibiotic residues.

Therefore, the inference from SCC data over the last 15 years is that the potential human threat from milk antibiotic residues has declined dramatically.
Insulin-like Growth Factors in Milk

- JEFCA 50th Conference Report concluded that any increase of IGF-1 in milk as a result of rbST usage is of very little amount versus that produced by the animal itself.
- Also that intake of IGF-1 from milk will not increase amounts of it either locally in the gut or systemically. Therefore resulting in no substantial risk for consumers.
- The absorption of orally consumed IGF-1 has been directly examined in humans.
- Results show no evidence that orally consumed IGF-1 is absorbed in humans.
- IGF-I is important for normal growth and development and is synthesised by almost every tissue within the body, however it has also been known to be related to the survival and growth of malignant cells.
- Milk is known to contain a number of components which have anti-carcinogenic effects.
- Studies indicate that the consumption of milk and dairy products reduces the risk against many types of cancer.
Insulin-dependent diabetes research has focused on early introduction of complex foreign proteins in the diet that may lead to β-cell autoimmunity and thereby Type 1 diabetes.

Some reports suggest that infant exposure to cow’s milk protein might increase the risk of Type 1 diabetes.

Whereas other observations found no interconnection.

Regardless, it was established that the use of rbST would not impact the risk of Type 1 diabetes as milk composition is unaltered.

To date no specific dietary factor or food component has been shown to be a risk factor for β-cell autoimmunity.
Milk composition is affected by many factors (genetics, stage of lactation, breed, diet, environment, and season) regardless if animals are rbST supplemented or not.

Increasing knowledge that consumption of dairy is related to improvement in health maintenance and the prevention of chronic diseases

Chronic diseases improved by the consumption of dairy; reduced risk of Type 2 diabetes, improved bone health, lower blood pressure, and reduced risk of cardiovascular disease
Seven variables used to analyse the milk and milk composition responses to rbST: milk yield, % milk fat, % milk true protein, % lactose, 3.5% fat-corrected milk yield, fat yield and protein yield.

Except for % lactose, responses were varied, showing that other factors related to individual studies affect the scale of the response.

Results indicated that yield of milk and milk components were all increased by rbST, whereas fat, protein and lactose were not.
Neither SCC nor mastitis was affected by rbST

Environmental and management factors are the major causes of mastitis

Genetic studies have demonstrated a small positive relationship between mastitis risk and milk production.

But high producing herds are managed better, thereby minimizing the effects of increased milk production
The BCS data used in the meta-analysis consisted of the BCSs obtained during and after rbST administration. nbST treated cows; significantly lower BCS than did the control cows.

1 unit of BCS represents about 50 kg body weight, therefore this difference relates to about 3.2 kg.

This difference would not be visually detected.
5.4% improvement in pregnancy was observed for rbST cows for the first two breeding cycles after the voluntary wait period.

Over the full length of the trial, the pregnancy proportion was reduced 5.5% for the rbST group, expected due to reduced oestrous behaviour.

No effect of rbST on fetal loss, days open, services per conception, twinning, or cystic ovaries.

Lameness was unaffected by supplementation of rbST.
Supplementing rbST to lactating dairy cows, according to directions, resulted in an increase in milk, fat, and protein yields.

With no adverse effects on milk composition, udder health, reproduction, body condition, lameness, or culling

These findings are contrary to a meta-analysis commissioned by Health Canada

but in line with conclusions of various FDA evaluations, numerous scientific reviews, and large-scale studies conducted on commercial dairy operations
Conclusions

- rbST is a technology that allows a litre of milk to be produced using fewer nutrients and a lower a carbon footprint.
- A review of recent advancements confirms earlier conclusions and provides no evidence of possible human health issues related to its use.
- Results show that it increases milk production with no adverse effects on cow wellbeing.
- Overall, these results and 20 years’ experience show that the use of rbST is safe and effective.